Atlas of alien and translocated indigenous aquatic animals in southern Africa

Irene J de Moor and M N Bruton

A report of the Committee for
Nature Conservation Research
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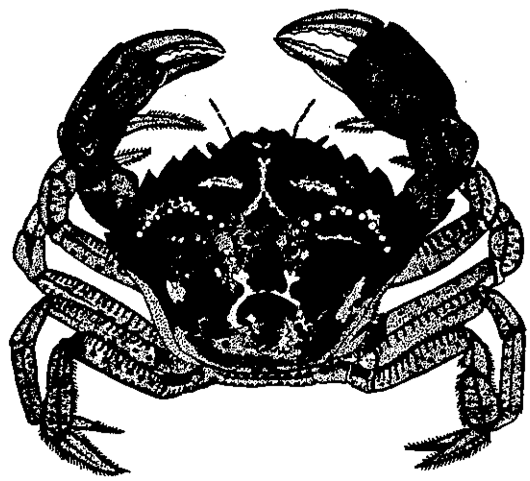

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Compilers' address -

Mrs Irene J de Moor and Professor M N Bruton
J L B Smith Institute of Ichthyology
Private Bag 1015
GRAHAMSTOWN
6140
South Africa

PREFACE

This atlas of alien and translocated aquatic animals in southern Africa is a contribution to a national research programme on the ecology of biological invasions. The programme is administered by the Nature Conservation Research Section of the National Programme for Ecosystem Research of the Foundation for Research Development of the CSIR, and forms part of an international project undertaken by SCOPE (Scientific Committee on Problems of the Environment). A description of South Africa's participation in the SCOPE project was published as number 72 in this series in 1983.

The need for an atlas of alien and translocated aquatic animals in southern Africa was recognized at the meeting of the Working Group for Invasive Biota in May 1984. The compilation of the atlas was made possible by funding from the National Programme for Ecosystem Research and the cooperation of a number of scientists in southern Africa.

The Invasive Biota programme is intended to relate primarily to nature conservation problems and to limit its relevance to invasions of natural and semi-natural habitats. The introduction of aquatic animals into entirely artificial environments eg fish culture ponds, ornamental ponds or aquaria has not been considered unless these translocations are implicated in the wider distribution of the invasive species in natural habitats. Small and large impoundments are regarded as semi-natural habitats which are part of the permanent landscape, and invasions of these environments are therefore considered here.

This atlas constitutes a sequel to the checklist and bibliography of alien and translocated aquatic organisms which was published as number 113 in this series in 1985. In compiling the atlas the insights gained from a more thorough review of the literature has necessitated a complete revision of the species checklists and the criteria used for their categorisation. Effectively the section headed "Categories and checklists of introduced species" supercedes and replaces the checklists in Bruton and Merron (1985).

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ABSTRACT

An introduction to the problem of alien and translocated aquatic animals in southern Africa is given followed by checklists of the different species which have been introduced into or translocated within the subcontinent. Detailed accounts of all alien and translocated species are then given, including an illustration and map of the southern African distribution of each species. An index to the genus and species of all taxa included in the atlas is also provided.

At least 33 species of introduced alien aquatic animals and 25 species of translocated indigenous species have frequently been recorded in natural waterbodies in southern Africa, and of these at least 29 alien species and 23 translocated indigenous species have established populations in natural or semi-natural aquatic habitats. Nine species (8 alien and one indigene) which were previously introduced into natural waterbodies have failed to establish populations and most of these are now locally extinct. An additional 26 alien and 30 translocated indigenous species are suspected to have established populations in natural waterbodies but their status in southern Africa is poorly known. At least 14 alien aquatic species which are currently in captivity in southern Africa could prove to be a nuisance if they escape. Seven alien species have established breeding populations in semi-captive situations but have not established populations in the wild although they have had the opportunity to do so.

All major southern African river systems are inhabited by alien animal species. Whereas freshwater environments have been invaded by 54 species, only 4 alien animal species have invaded the seas surrounding southern Africa, but more are likely to be found when research in this area intensifies. Trout are known to have been introduced into a stream on Marion Island but they have since been eliminated.

Alien species have been introduced and indigenous species have been translocated for a variety of reasons, including sportfishing, aquaculture, biocontrol, increasing the range of rare species, through the aquarium trade, for enhancing fisheries or by accident. The alien species originated mainly from Europe but also from South America, elsewhere in Africa, North America and Asia. The first introductions were made in the eighteenth century but increasing numbers were introduced in the nineteenth and twentieth centuries.

Of the 58 alien and translocated species which are frequently recorded in natural aquatic habitats, 37 are considered to be detrimental, 3 to be beneficial and 18 to be equivocal ie beneficial under some circumstances and detrimental under other circumstances. Of the 55 detrimental and equivocal species, 18 are considered to have had a major detrimental impact on indigenous species and communities. Those alien or translocated species which are increasing their range or impact in natural waterbodies represent a major environmental problem which needs to be addressed more urgently by natural resource managers.

SAMEVATTING

'n Inleiding tot die probleem van uitheemse en verplaasde waterdiere in suidelike Afrika word gegee, gevolg deur oorsiglyste van die verskillende spesies wat in die subkontinent verplaas of ingevoer is. Gedetailleerde opnames van alle uitheemse en verplaasde spesies, insluitende illustrasies en 'n verspreidingskaart van elke spesie word gegee. 'n Indeks tot die genera en spesies van alle taxa in die atlas word ook ingesluit.

Ten minste 33 ingevoerde uitheemse spesies en 25 verplaasde inheemse spesies word dikwels in waterhabitate in Suid-Afrika aangeteken, en dit sluit in minstens 29 uitheemse en 23 verplaaste inheemse spesies wat bevolkings in waterhabitate gevestig het. Nege spesies (8 uitheems en 1 inheems) wat in natuurlike waterliggame ingebring is, het nie bevolkings gevestig nie en die meeste van hulle het plaaslik uitgesterf. Daar word vermoed dat 26 uitheemse en 30 verplaasde inheemse spesies hulle in natuurlike waterliggame gevestig het maar hul status in suidelike Afrika is nog taamlik onbekend. Ten minste 14 uitheemse waterspesies wat tans in beperkte aanhouding in suidelike Afrika is, kan problematies word, indien hulle sou vrykom. Sewe uitheemse spesies het aanwasbevolkings in halfbeperkte toestande gevestig, maar het nog nie vrye bevolkings gevestig nie, alhoewel die kanse hulle wel voorgedoen het.

Al die hoofriviersisteme in suidelike Afrika word deur uitheemse dierespesies bewoon. Alhoewel varswater habitatte deur 54 spesies ingeneem is, het slegs 4 spesies die see om suidelike Afrika ingeneem, maar meer uitheemse spesies sal sekerlik gevind word sodra navorsingspogings vermeerder. Forelle is in 'n stroom op Marion Eiland ingevoer maar is reeds uitgeroei.

Uitheemse spesies is ingevoer en inheemse spesies is verplaas vir 'n verskeidenheid van redes onder andere sportvisvangs, akwakultuur, biologiese beheer, uitbreiding van die verspreidingsgebied van seldsame spesies, deur die akwariumbedryf, vir die verbetering van visserye, of per ongeluk. Die uitheemse spesies kom oor die algemeen uit Europa, maar ook van Noord- en Suid-Amerika, elders in Afrika en Asie. Die eerste invoere het in die agtiende eeu plaasgevind, maar groter hoeveelhede is gedurende die negentiende en twintigste eeue ingevoer.

Van die 58 uitheemse en verplaasde spesies wat dikwels in natuurlike waterliggame gevind word, word 37 as nadelig, 3 as voordelig en 18 as nadelig in sekere en voordelig in ander omstandighede beskou. Daar word gereken dat 18 van die 55 nadelige en dubbelwaardige spesies 'n baie nadelige uitwerking op inheemse spesies en gemeenskappe gehad het. Daardie uitheemse of verplaasde spesies wat hulle verspreidingsgebied of impak in natuurlike waterliggame vergroot het, verteenwoordig 'n groot omgewingsprobleem wat dringend deur bestuurders van natuurlike hulpbronne aangespreek behoort te word.

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NOTES ON THE DESIGN OF THE ATLAS

The aim of this atlas is to provide a review of our knowledge of the origin, distribution, biology, known and/or likely impact and possible methods of controlling aquatic animals which have established breeding populations beyond their native range in southern Africa. Although our knowledge of many species is sparse and scattered widely in the scientific and popular literature, it was felt that a review was timeous as many alien and translocated indigenous species are causing severe environmental problems in the subcontinent. Other species which have been introduced for reasons beneficial to man, such as for biocontrol, aquaculture or sportfishing, have often achieved their primary aim but have caused unexpected and usually detrimental consequences. Conflicting reports on the supposed impacts of different species have caused misunderstandings between resource managers and laymen, and there was clearly a need to clarify the situation.

The atlas provides detailed information on all known aquatic animals which are alien to southern Africa or which have been translocated within the subcontinent to catchments beyond their native range, and which have established breeding populations there. Checklists are also drawn up on a number of different categories of introduced species which have never established populations in natural habitats. These categories are summarised in Table 1 and are discussed in detail in the section on Categories and Checklists of Introduced Species.

Table 1 Introduced species checklists. A summary of the different categories listed in this report

Table Number	Description	Number of species Aliens	Translocated	Total
3	Successful introductions frequently recorded in natural habitats	33	25	58
4	Released into natural waters -have failed to establish populations	8	1	9
5	Recent translocation - requires confirmation		24	24
9	Occasional records of introductions (not established populations)	9	1	10
10	Present in southern Africa. Status as aliens unconfirmed	17		17
11	Uncertain historical translocations		5	5
12	Aliens - presence suspected	6		6
13	Potential problem species presently in captivity	14		14
14	In semi-captive situations. Appear unable to establish in the wild	8		8

It must be noted that certain species appear in more than one checklist.

Although the Working Group for Invasive Biota is mainly concerned with alien invasive species, information on translocated indigenous species has also been included as they are also foreign to their new environments and may cause severe environmental problems there.

Detailed descriptions are given of species which have been successfully introduced (ie have established a permanent presence in natural waters) and of failed introductions (ie species which have been extensively stocked but have failed to establish permanent populations). Because taxonomic relationships are often difficult to determine by the non-specialist, a full classification of these species is given in Tables 3, 4 and 5.

Definitions

The definitions of terms used in this atlas are as follows:

Introduced species - a species which has been distributed intentionally or unintentionally by man to areas beyond its native range of distribution. This term may be used synonymously with the terms alien or exotic and translocated indigenous species, and will be used in this report to include both introduced alien as well as translocated indigenous species.

Alien species - an introduced species from outside the boundaries of southern Africa.

Naturalized or established species - an introduced species which has established self-sustaining populations in areas of natural or semi-natural vegetation or habitat.

Translocated indigenous species - a species naturally found within southern Africa but which has been translocated either intentionally or unintentionally by man into catchments in which it was not naturally distributed.

Invasive species - an alien or translocated indigenous species which, after introduction, has spread unaided into untransformed ecosystems and may be responsible for causing an imbalance there.

Endemic species - a species that is restricted in its distribution to a particular lake, drainage system or biogeographical region.

Indigenous species - a native species which is not necessarily restricted in its distribution to a particular lake, drainage system or biogeographical region. A species which naturally occurs in southern Africa as well as in other parts of Africa is therefore indigenous to southern Africa but not endemic to that region.

Pest species - a species which has a major negative impact on the environment and does not have any desirable attributes.

Nuisance species - a species for which the negative impact generally outweighs any positive attributes which the species may have.

The above definitions were derived after consideration of the various proposals made by Ferrar and Kruger (1983), Courtenay and Stauffer (1984), Laurenson (1984), Shafland and Lewis (1984), Bruton and Merron (1985), Hocutt (1985) and Kruger et al (1986).

Checklists of the species from the different categories in Table 1 appear in the next chapter. The detailed accounts given in this Atlas only cover species appearing in Tables 3, 4 and 5. A summary of the impact of these species as well as a detailed index appears in the Summary of the Status of Introduced Aquatic animals (Tables 12, 13 and 14).

Species accounts

Each detailed species account provides the following information:

* the scientific and common name of the species and notes on recent synonyms

* the classification of the species by Class, Order and Family

* three keywords or phrases which summarise the status of the species and its known impact (see below for explanation)

* a summary of the status of our knowledge of the species

* detailed notes on the distinguishing characteristics, native range, date and purpose of introduction, introduced range, habitat preferences, breeding and feeding habits, impact and behaviour for each species, if known. In addition, control methods are suggested and research recommendations are made.

* a list of references and individual scientists consulted

* a diagnostic drawing of each species as well as a map showing its southern African distribution

Detailed information relating to the dates of initial introductions of certain species into specific localities in southern Africa is given in the Appendix.

The keywords at the head of each species account indicate the status of that species in three categories:

(a) whether it is an alien or translocated indigenous species

(b) whether its impact has been mainly detrimental, mainly beneficial or equivocal ie detrimental under some circumstances or in some localities and beneficial in others. The term "equivocal" can be used to describe some species which are known to be extremely harmful, but may be of some value to certain interest groups. For example, the smallmouth bass is described as having had an "equivocal" impact. Although this species has had a major detrimental impact on indigenous fish, it is valued by some sport fishermen. The term "detrimental" applies to species which are generally viewed as being detrimental by conservationists as well as other interest-groups.

(c) whether the impact of the species, be it detrimental or beneficial, has been major, minor or unknown, or whether it is considered that it will have a potential major impact should it extend its range.

The species accounts are arranged in systematic order. Illustrations and distribution maps are included in the species accounts of animals which have been successfully introduced, but not in the species accounts of failed introductions. The impact of introduced animals as well as the order in which they appear in this atlas are described in the Summary of the Status of Introduced Aquatic Animals.

The detailed distribution records and maps given in each species account (and associated Appendices) have been obtained from the scientific and popular literature, museum records and from personal communications with reputable sources. If there is any doubt about the authenticity of the record, or if specimens have not been recorded for a number of years, then the locality is not plotted on the map, but may be discussed in the text. Only records from natural or semi-natural habitats are recorded in the distribution records and maps. Localities on the map are plotted differently according to the type of information available. The types of information are described below:

Museum Record - specimens are lodged in museums.
Literature Record - record from reliable sources in which the precise locality is given.
Approximate locality record - record from reliable sources in which the approximate locality is given. For example a record of a species occuring in a particular river system is regarded as an approximate locality record.

The geographical area covered in this report includes South Africa, and the recently independent Black states, as well as South West Africa/Namibia, Botswana, Swaziland, and Lesotho, but not Zimbabwe or Mozambique (see Figure 1). Marion Island in the Prince Edward island group in the south-west Indian Ocean (46 50E, 38 00S) is also included.

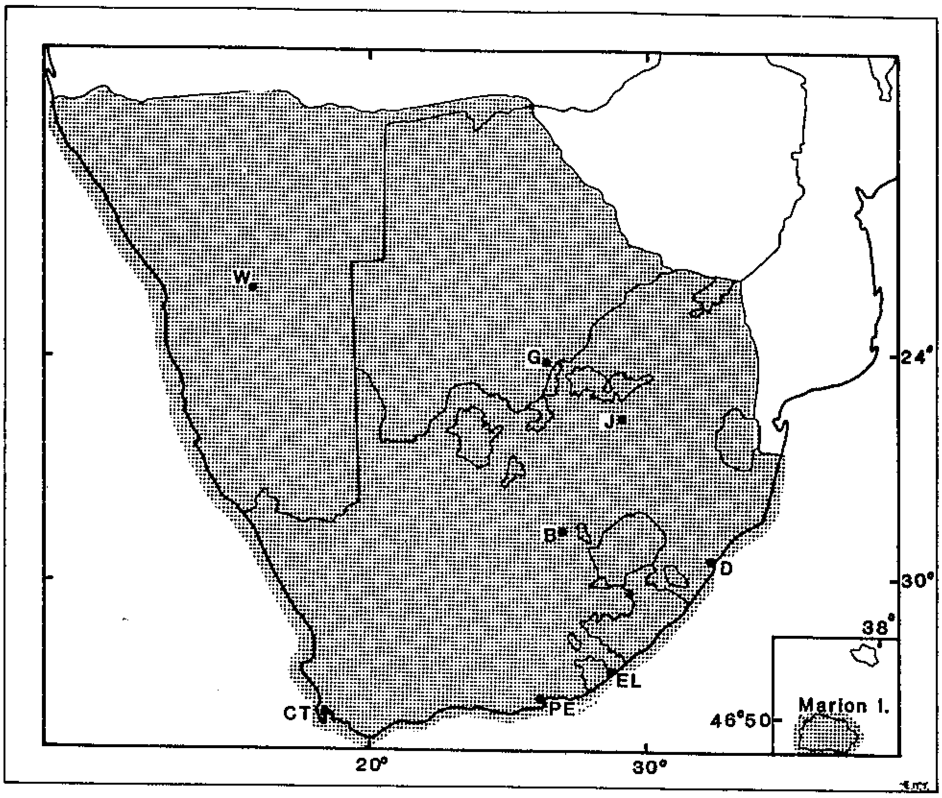

Figure 1: Map of southern Africa and the Prince Edward Islands showing the geographic area covered by this report (shaded).

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INTRODUCTION

The status of alien and translocated aquatic animals which have established breeding populations in southern Africa has recently been reviewed by Bruton and Merron (1985), Bruton and van As (1986) and Ashton et al (1986). This atlas provides a more comprehensive account as well as distribution maps and species illustrations and diagnoses. As the aim of this atlas is to provide details on the distribution, biology and impact of the many different introduced and translocated organisms, analyses of the characteristics of invasive animals, and of the susceptibility of different natural environments to invasion, have not been included and will be published elsewhere.

Alien aquatic animals were introduced into southern Africa by each wave of human colonisation of the subcontinent. The first recorded aliens were "... Japanese goldfish and silverfish..." which Valentyn observed in aquaria in the Governor's house in Cape Town in 1726 (Raidt 1971). The origin of all the alien species has not firmly been established, but it appears that most species came from Europe with lesser numbers from South America, Africa to the north of the Zambezi/Cunene catchments, North America and Asia. The majority of the European and North American species were introduced in the 19th century, with all South American and African aliens being introduced in the 20th century. All three Asian species were introduced in the 18th century (Bruton and van As 1986). The sequence of introduction of alien aquatic organisms into southern Africa is the same as in many other countries ie initial introduction of goldfish for ornament and common carp (and its associated parasites) for food, followed by trout, bass and bluegill sunfish for emotional and recreational reasons, and then more recently, of various fish and invertebrate species for biocontrol, aquaculture and the aquarium trade.

The most frequent reasons for the purposeful introduction of aliens are sportfishing, biocontrol and aquaculture, but most species, especially of invertebrates, entered southern Africa by accident (Table 2). The most frequent reasons for the translocation of indigenous species are sportfishing, stocking impoundments, increasing the range of rare species, aquaculture and biocontrol, although accidental introductions via intercatchment connections are also common (Bruton and van As 1986). Intercatchment connections, such as tunnels and canals, have been an important way of translocating indigenous as well as alien fishes and invertebrates in southern Africa. Almost all major river catchments are connected to adjacent catchments and in some cases entirely different drainage basins are interconnected eg the Vaal to the Tugela and the Orange to the Great Fish River catchments (Bruton and van As 1986). In the case of the Vaal-Tugela scheme it may be possible for aquatic animals to be translocated from the Tugela to the Vaal system and in the opposite direction should the Sterkfontein Dam reach 100% capacity. Although water will normally be pumped from the Tugela into the Vaal system, Mr Druyts of the Department of Water Affairs has explained that during periods of peak electricity demand water will also flow from dams at the top of the escarpment into the Tugela catchment in order to operate electricity turbines for the national grid system. It will however only be possible for water to flow from the Vaal system into the Tugela system when the Sterkfontein dam is filled to more than 95% capacity. In northern South West Africa/Namibia the Eastern National Water Carrier will link the Okavango River with man-made lakes near Windhoek, and the Owambo canal, which was built in 1972, pumps water from the Cunene River to the Olushandja dam in the Cuvelai area.

There has been some confusion in the literature on alien aquatic animals with frequent references being made to species held in captivity or semi-captivity, species which were introduced but have since become extinct, and even some species which were never actually released in southern Africa, but died in transit to the Cape. It was therefore decided to classify the many "introduced" species which have been reported in the literature into a number of different categories according to their status as "aliens" in southern Africa. The checklists of species which are summarised in the section headed "Categories and Checklists of Introduced Species" therefore supercede and replace the checklists of Bruton and Merron (1985).

The impact of invasive aquatic animals and proposals for their management in southern Africa have been reviewed recently by Bourquin et al (1984), Bruton and Merron (1985), Bruton (1986) Bruton and van As (1986) and Ashton et al (1986) and are further mentioned in the species accounts.

TABLE 2 Original reasons for the introduction and translocation of alien and indigenous aquatic animals in southern Africa. This table includes established species as well as species which have not established permanent populations in natural waters. (A = alien, T = translocated indigenous species).

INVERTEBRATA

Parasites of fishes and bivalves (accidental introductions)

Argulus japonicus fish louse (A)
Bothriocephalus acheilognathi fish tape worm (A)
Ichthyophthirius multifilis whitespot(A)
Trichodina acuta trichodina (A)

Free-living invertebrates (accidental introductions including species introduced in association with aquarium plants)

Bedeva paivae (marine, Australian oyster drill) (A)
Carcinus maenas (marine, European shore crab) (A)
Craspedacusta sowerbyi freshwater medusa (A) (aquarium plants)
Helisoma duryi helisoma snail (A)
Lymnaea columella lymnaea snail (A) (aquarium plants)
Physa acuta physa snail (A) (aquarium plants)
Mytilus galloprovincialis (marine, black-brown mussel) (A)

Biological control of water weeds

Cyrtobagous salviniae water weevil (A)
Cyrtobagous singularis water weevil (A)
Neochetina eichhorniae water weevil (A)
Neohydronomus pulchellus water weevil (A)
Paulinia acuminata Kariba weed grasshopper (A)

CHORDATA

Osteichthyes

Fish culture

Clarias gariepinus sharptooth catfish (T)
Cyprinus carpio common carp (A)
Mugil cephalus grey mullet (T)
Myxus capensis freshwater mullet (T)
Oreochromis andersonii threespot tilapia (T)
Oreochromis aureus Israeli tilapia (A)
Oreochromis macrochir greenhead tilapia (T)
Oreochromis mossambicus Mozambique tilapia (T)
Oreochromis niloticus Nile tilapia (A)
Parasalmo mykiss rainbow trout (A)
Sarotherodon galilaeus Israeli tilapia (A)
Tilapia sparrmanii banded tilapia (T)
Tilapia zillii Jordan's St Peter's fish (A)

Table 2 (continued)

Sport fishing (including forage for bass and trout)

Barbus aeneus smallmouth yellowfish (T)
Barbus anoplus chubbyhead barb (T) (forage fish)
Barbus gurneyi redtail barb (T) (forage fish)
Cyprinus carpio common carp (A)
Labeo umbratus moggel (T)
Lepomis macrochirus bluegill sunfish (A) (forage fish)
Micropterus dolomieui smallmouth bass (A)
Micropterus punctulatus spotted bass (A)
Micropterus salmoides largemouth bass (A)
Oreochromis macrochir greenhead tilapia (T)
Oreochromis mossambicus Mozambique tilapia (T)
Perca fluviatilis perch (A)
Parasalmo mykiss rainbow trout (A)
Salmo salar salmon (A)
Salmo trutta brown trout (A)
Salvelinus fontinalis (A) brook trout (A)
Serranochromis codringtoni green happy (T)
Serranochromis robustus jallae nembwe (T)
Serranochromis thumbergi brownspot largemouth (T)
Tilapia rendalli swierstrae southern redbreast tilapia (T)
Tilapia sparrmanii banded tilapia (T) (forage fish) (T)
Tinca tinca European tench (A)

Translocated intentionally for various reasons (eg stocking man-made lakes, increasing the range of rare fishes)

Astatotilapia brevis orange-fringed largemouth (T)
Barbus aeneus smallmouth yellowfish (T)
Barbus anoplus chubbyhead barb (T)
Barbus natalensis scaly (T)
Clarias gariepinus sharptooth catfish (T)
Cyprinus carpio common carp (A)
Kneria auriculata southern kneria (T)
Oreochromis andersonii three-spot tilapia (T)
Oreochromis macrochir greenhead tilapia (T)
Oreochromis mossambicus Mozambique tilapia (T)
Sandelia capensis Cape kurper (T)
Serranochromis angusticeps thinface largemouth (T)
Serranochromis codringtoni green happy (T)
Serranochromis robustus jallae nembwe
Serranochromis thumbergi brownspot largemouth (T)
Tilapia rendalli swierstrae southern redbreast tilapia (T)
Tilapia sparrmanii banded tilapia (T)

Translocated unintentionally via intercatchment connections

Alestes lateralis striped robber (T) *
Austroglanis sclateri striped robber (T)
Barbus aeneus smallmouth yellowfish (T)
Barbus anoplus chubbyhead barb (T)*
Barbus barnardi blackback barb (T) *

Table 2 (continued)

B. bifrenatus hyphen barb (T) *
B. mattozi papermouth (T)*
B. radiatus (T) *
B. tangandensis redspot barb (T) *
B. unitaeniatus (T) *
Clarias gariepinus sharptooth catfish (T)
Coptostomabarbus wittei upjaw barb (T) *
Hemigrammocharax machadoi dwarf citharine (T) *
Labeo capensis Orange River labeo (T)
Labeo molybdinus (T) *
Mesobola brevianalis river sardine (T) *
Micralestes acutidens (T) *
Pharyngochromis darlingi Zambezi happy (T) *
Rhabdalestes maunensis Okavango robber (T) *
Serranochromis giardi pink happy (T) *
Serranochromis macrocephalus purpleface largemouth (T) *
Serranochromis steindachneri Cunene happy (T) *
Serranochromis mellandi (T) *
Serranochromis thumbergi brownspot largemouth (T) *
Synodontis leopardinus leopard squeaker (T) *
Synodontis macrostigma large-spot squeaker (T) *
Synodontis woosnami Upper Zambezi squeaker (T) *
Tilapia rendalli rendalli sungwa (T) *
Tilapia sparrmanii banded tilapia (T) *

* Unconfirmed translocations from the Cunene to the Cuvelai area (van der Waal 1984).

Introduced or translocated through the aquarium trade

Carassius auratus goldfish (A)
Poecilia reticulata guppy (A)
Xiphophorus helleri swordtail (A)

Biological control of nuisance plants and animals

Ctenopharyngodon idellus grass carp (A)
Gambusia affinis mosquito fish (A)
Oreochromis mossambicus Mozambique tilapia (T)
Poecilia reticulata guppy (A)
Tilapia rendalli swierstrae southern redbreast tilapia (T)

REPTILIA

Trachemys scripta elegans red-eared terrapin (A) (aquarium trade)

AVES

Escapees from private collections

Anas platyrhynchos mallard duck (A)*
Cygnus olor mute swan (A)

* This species has never established feral populations

CATEGORIES AND CHECKLISTS OF INTRODUCED SPECIES

The introduced species in southern Africa have been classified into a number of different categories as mentioned in the previous chapter. The checklists of these species appear in this chapter together with general discussions on the possible impact of the species which appear on these checklists.

Species which are frequently recorded in natural waters, most of which have established breeding populations

It is likely that these species have established breeding populations in natural or semi-natural waters (Table 3).

TABLE 3 Alien and translocated indigenous species recently recorded in natural and semi-natural habitats

A = Alien species
T = Translocated indigenous species

Ciliophora

Class: Oligohymenophorea
Order: Hymenostomatida
Family: Ichthyophthiriidae
Ichthyophthirius multifilis Fouquet 1876 (A)

Suborder: Mobilina
Family: Trichodinidae
Trichodina acuta Lom 1961 (A)

Cnidaria

Class: Hydrozoa
Order: Hydroida
Suborder: Limnomedusae
Craspedacusta sowerbyi Lankester 1880 (A)

Platyhelminthes

Class: Cestoda
Order: Pseudophyllidea
Family: Bothriocephalidae
Bothriocephalus acheilognathi Yamaguthi 1934 (A)

Arthropoda

Class: Crustacea
Order: Branchiura
Family: Argulidae
Argulus japonicus Thiele 1900 (A)

Order: Malacostraca

Table 3 (continued)

Family: Patastacidae
Cherax tenuimanus (A)

Family: Portunidae
Carcinus maenas Linnaeus 1758 (A) (marine)

Class: Insecta
Order: Coleoptera
Family: Curculionidae
Cyrtobagous salviniae Calder and Sands 1985 (A)
Cyrtobagous singularis (Hustache 1929) (A)
Neohydronomus pulchellus Hustache 1926 (A)

Mollusca

Class: Gastropoda
Order: Neogastropoda
Family: Muricidae
Bedeva paivae Crosse 1864 (A) (marine)
Littorina saxatilis (Maton 1797) (A) (marine)

Order: Basommatophora
Family: Physidae
Physa acuta Draparnaud 1805 (A)
Family: Planorbidae
Helisoma duryi Weatherby 1879 (A)
Family: Lymnaeidae
Lymnaea columella Say 1817 (A)

Class: Bivalvia
Family: Mytilidae
Mytilus galloprovincialis Lamarck (A) (marine)

Chordata

Subphylum: Vertebrata
Class: Osteichthyes
Order: Dipnoi
Family: Lepidosirenidae
Protopterus annectens brieni Poll 1961 (T)
Order: Salmoniformes
Family: Salmonidae
Parasalmo mykiss (Walbaum 1792) (A)
Salmo trutta Linnaeus 1758 (A)

Order: Gonorhynchiformes
Family: Kneriidae
Kneria auriculata (Pellegrin 1905) (T)

Order: Cypriniformes
Family: Cyprinidae
Barbus aeneus (Burchell 1822) (T)
Barbus anoplus Weber 1897 (T)
Barbus natalensis Castelnau 1861 (T)

Table 3 (continued)

Barbus treurensis Groenewald 1958 (T)
Carassius auratus (Linnaeus 1758) (A)
Ctenopharyngodon idellus (Valenciennes 1844) (A)
Cyprinus carpio Linnaeus 1758 (A)
Labeo capensis (Smith 1841) (T)
Labeo umbratus (Smith 1841) (T)
Tinca tinca Linnaeus 1758 (A)

Order: Siluriformes
Family: Clariidae
Clarias gariepinus (Burchell 1822) (T)

Order: Cyprinodontiformes
Family: Aplocheilidae
Nothobranchius orthonotus (Peters 1844) (T)
Nothobranchius rachovii Ahl 1926 (T)
Family: Poeciliidae
Gambusia affinis (Baird and Girard 1854) (A)
Poecilia reticulata (Peters 1859) (A)
Xiphophorus helleri Heckel 1840 (A)

Order: Perciformes
Family: Centrarchidae
Lepomis macrochirus Rafinesque 1819 (A)
Micropterus dolomieui Lacepede 1802 (A)
Micropterus punctulatus (Rafinesque 1819) (A)
Micropterus salmoides (Lacepede 1802) (A)
Family: Percidae
Perca fluviatilis Linnaeus 1758 (A)
Family: Cichlidae
Astatotilapia brevis (Jubb 1968) (T)
Oreochromis andersonii (Castelnau 1861) (T)
Oreochromis aureus (Steindachner 1864) (A)
Oreochromis macrochir (Boulenger 1912) (T)
Oreochromis mossambicus (Peters 1852) (T)
Oreochromis niloticus (Linnaeus 1758) (A)
Serranochromis (Sargochromis) codringtoni (Boulenger 1908) (T)
Serranochromis (Serranochromis) robustus jallae (Boulenger 1896)(T)
Serranochromis (Serranochromis) angusticeps (Boulenger 1907) (T)
Serranochromis (Serranochromis) thumbergi (Castelnau 1861) (T)
Tilapia guinasana Trewavas 1936 (T)
Tilapia rendalli swierstrae Gilchrist and Thompson 1917 (T)
Tilapia sparrmanii Smith 1840 (T)
Family: Mugilidae
Mugil cephalus Linnaeus 1758 (T)
Myxus capensis (Valenciennes 1836) (T)
Family: Anabantidae
Sandelia capensis (Cuvier 1831) (T)

Class: Reptilia
Order: Chelonia
Family: Testudinidae
Trachemys scripta elegans (Schoepff 1792) (A)

Three species (*Ctenopharyngodon idellus, Myxus capensis* and *Mugil cephalus*) mentioned in Table 3 do not breed in their introduced freshwater environments. Because of the constant restocking of these species and their longevity they nevertheless form a permanent part of the aquatic communities into which they have been introduced. For this reason they have been included in Table 3.

From Table 3 it can be seen that 33 alien species and 25 translocated indigenous species are frequently recorded in natural waters and 52 of these have established breeding populations in natural waterbodies or large impoundments in southern Africa (Tables 12 and 13). Of the 33 alien species, 29 are freshwater and 4 are marine. There are no known translocated marine organisms. Four of the 58 introduced aquatic animals are fish parasites (*Argulus japonicus, Bothriocephalus acheilognathi, Ichthyophthirius multifilis* and *Trichodina acuta*) and two species have the potential to act as carriers of disease - *Trachemys scripta*, a terrapin which is a vector of salmonellosis, and *Lymnaea columella*, a snail vector of fasciolariasis.

Of the animals which are frequently recorded in natural waters, 7 species can be regarded as pests, and a further 5 as nuisance animals (see for "Notes on the design of the Atlas" for definitions of these terms). Twelve species have the potential to have a serious detrimental effect on the environment should their ranges be extended (either intentionally or unintentionally by man or as a result of the invasive abilities of the introduced animal), and a further 13 species have had an unknown but probably detrimental effect on the environment (Tables 12 and 13). A number of species (such as bass, trout and carp) are regarded as "equivocal" ie they may have a negative impact on the environment, but are valued by certain interest groups such as sport fishermen. Some of these species (*Micropterus dolomieui* for example) have nevertheless had an extremely detrimental impact on the environment (Table 12).

Certain alien species such as *Craspedacusta sowerbyii, Helisoma duryii, Littorina saxatilis* and *Physa acuta*, appear to have had few harmful effects on the environment (Table 12).

The impact of several introduced species is regarded as being beneficial. These include the aquatic insects (*Cyrtobagous singularis, C. salviniae* and *Neohydronomus pulchellus*) which have been introduced for the biological control of aquatic weeds, and at least one species (*C. salviniae*) appears to have been a very successful biocontrol agent. The success of these species is understandable as great care was taken prior to their release to check their host specificity and the threat they may pose to endemic plants and animals.

Eight of the 58 introduced species are listed in Skelton's (1987a) Red Data Book. With the exception of the freshwater mullet *Myxus capensis* which has been translocated for aquaculture, and *T. guinasana* which was translocated for unknown reasons, all these species were introduced into new areas in an attempt to improve their chances of survival. It is not expected that any of these translocations will have a significant negative impact on the environment.

Species which were introduced into natural waters but which have failed to establish permanent populations

At least nine aquatic animal species have been introduced into natural or semi-natural waterbodies in southern Africa and have since become extinct or have failed to establish populations in the new environment. In each case large numbers of specimens were released into natural waters, either by deliberate stocking or as escapees from captivity.

Of the species mentioned in Table 4 eight are aliens and one (*Barbus gurneyi*) is an indigenous fish which was translocated beyond its native range. Although these species became locally extinct, this is not necessarily an indication that they are unable to survive under southern African conditions. Three of the species (*Paulinia acuminata, Barbus gurneyi* and *Cygnus olor*) established breeding populations over a number of years. Other species (such as *Neochetina eichhorniae*) may have died out due to events which caused environmental conditions to be temporarily unfavourable for their survival. It appears that four of the "extinct" species (*Sarotherodon galilaeus, Tilapia zillii, Anas platyrhynchos* and possibly *Salmo salar*) were unsuitable candidates to survive in the environments into which they were released. The two tilapiine fishes (*S. galilaeus* and *T. zillii*) both apparently succumbed to the low winter water temperatures in the Cape and would probably survive in the warmer parts of South Africa.

TABLE 4 Species released into natural watercourses which failed to establish permanent populations in natural habitats

Arthropoda

Class: Insecta
Order: Orthoptera
Family: Acrididae
Paulinia acuminata de Geer (A)
Order: Coleoptera
Family: Curculionidae
Neochetina eichhorniae Warner 1970 (A)

Chordata

Subphylum: Vertebrata
Class: Osteichthyes
Order: Salmoniformes
Family: Salmonidae
Salmo salar Linnaeus 1758 (A)
Salvelinus fontinalis (Mitchell 1815) (A)

Order: Cypriniformes
Family: Cyprinidae
Barbus gurneyi Gunther 1868 (T)

Order: Perciformes
Family: Cichlidae
Sarotherodon galileus Israeli tilapia (A)
Tilapia zillii Jordan's St Peter fish (A)

Class: Aves
Order: Anseriformes
Family: Anatidae
Anas platyrhynchos Linnaeus 1758 (A)
Cygnus olor (Gmelin 1789) (A)

A = Alien species
T = Translocated indigenous species

Species which were recently translocated to new catchments. Their translocation needs further confirmation

The Cuvelai area in northern South West Africa does not have permanent streams but there are a number of non-perennial rivers and pans which may connect up during rare floods. The only permanent water in this area is the Oshana Etaka (on which the Olushandja dam is built) which flows into the Oponono pans. During flood years these pans connect up and eventually drain into Etosha pan (van der Waal 1984). Surveys of the fishes in this area have been carried out regularly since 1968, and since 1977 a number of new (Cunene) species have been recorded at the following localities: Ogongo reservoir, Olushandja dam, reservoirs in Oshkati and Ogongo, and canals at Oshkati. These translocations are not stable as the fishes are subject to high mortalities when the temporary waterbodies dry up. As a result, the lists of translocated species reported by van der Waal (1977, 1984), from specimens collected in 1977, 1979 and 1984, are not the same. In addition, the taxonomy of many of the species in question is in a state of flux. A tentative list of likely translocations into Owambo is given in Table 5.

Besides the species listed in Table 5, two other species (*Marcusenius macrolepidotis* and *Petrocephalus catostoma*) were collected by van der Waal (1984) but these were also reported to be present in Owambo prior to the opening of the Cuvelai canal.

Table 5 Recent translocations from the Cunene to the Cuvelai area which require further confirmation

Species	Collections in Owambo	
	1977	1984
OSTEICHTHYES		
Alestes lateralis		*
Barbus barnardi	*	
B. bifrenatus		*
B. mattozi	*	*
B. radiatus		*
B. tangandensis	*	*
B. unitaeniatus		*
Coptostomobarbus wittei	*	
Mesobola brevianalis	*	*
Hemigrammocharax machadoi	*	
Labeo molybdinus	*	*
Micralestes acutidens		*
Pharyngochromis darlingi	*	*
Rhabdalestes maunensis	*	
Serranochromis giardi	*	*
S. macrocephalus	*	
S. steindachneri	*	*
S. mellandi	*	*
S. thumbergi	*	
Synodontis leopardinus	*	*
S. macrostigma	*	*
S. woosnami	*	
Tilapia rendalli rendalli	*	*
*T. sparrmanii***	*	*

* Indicates presence in collections

** There are well-substantiated reports of this species being translocated elsewhere in southern Africa

Occasional records of introduced species in natural habitats. Populations not established.

A number of alien aquatic birds are occasionally recorded in natural habitats in southern Africa (Table 6). These species have not been included in the detailed species accounts as they do not constitute a permanent part of the wild fauna. Two other introduced species (the coypu and the rock catlet) which were not introduced in large numbers, but for which there are single records in natural habitats, are included in this categorie. The coypu was introduced into the country for the purpose of fur farming and there were reports of some specimens having escaped into areas of the eastern Cape (Siegfried 1962). There are no recent records of coypu in the wild. *Austroglanis sclateri* is a small indigenous catfish endemic to the Orange-Vaal system which has been accidently introduced into the Fish River via the Orange-Fish River tunnel. A single specimen was recorded at the outlet of the Fish River tunnel, but since this species is endangered in its natural habitat and is only very rarely found in the Verwoerd dam, it is considered to be unlikely that many specimens will be translocated into the Fish River where they are unlikely to establish a permanent population (Laurenson and Hocutt 1984).

Table 6 Occasional records of introduced species in natural habitats

Species name	Common name
Osteichthyes	
Austroglanis sclateri	rock catfish
Aves	
Aix sponsa	Carolina wood duck
Anas clypeata	European shoveller
Anas rubripes	American black duck
Aythya fulgula	tufted duck
Gallinula comeri	Gough moorhen
Haematopus ostralegens	European oystercatcher
Morus serrator	Australian gannet
Tadorna tadorna	European shellduck
Mammalia	
Myocastor coypus	coypu

It is possible that three of the bird species (*Aythya fuligula*, *Haematops ostralegens* and *Morus serrator*) are "natural migrants" ie they were blown off course during their migration to or from their usual wintering grounds) (A J F K Craig personal communication). *A. fuligula* may also have escaped from captivity (Sinclair 1983). *Anas rubripes*, *Gallinula comeri*, *Anas clypeata* and *Aix sponsa* are thought to have escaped from private collections (Sinclair 1983; Cullen 1984; Clarke 1985). It is uncertain how *Tadorna tadorna* was introduced into southern Africa (Blake 1975) but R K Brooke (personal communication) believes that this species was probably also an escapee from private collections.

Species which are present in southern Africa, but whose status as aliens requires confirmation.

A number of aquatic animal species in southern Africa are suspected to be aliens but their status is uncertain (Table 7). Several of these are fish parasites which now have a cosmopolitan distribution, but it is suspected that they were originally introduced into southern Africa (J G van As personal communication).

Table 7 Aquatic animals present in southern Africa whose status as alien species is uncertain

Species	Common name	Class
Sarcomastigophora		
Ichthyobodo necator	fish parasite	Zoomastigophora
Chilodonella cyprini	fish parasite	Kinetofragminophorea
Chilodonella hexasticha	fish parasite	Kinetofragminophorea
Apiosoma piscicola	fish parasite	Oligohymenophorea
Trichodina nigra	trichodina	Oligohymenophorea
Trichodinella epizootica	fish parasite	Oligohymenophorea
Branchiura sowerbyi	annelid worm	Oligochaeta
Polydora species	bristleworm	Polychaeta
Arthropoda		
Daphnia magna	giant water flea	Crustacea
Lernaea cyprinacea	lernaea fish parasite	Crustacea
Achtheres micropteri	fish parasite	Crustacea
Pilumnoides perlatus	kelp crab	Crustacea
Pilumnus hirsutus	kelp crab	Crustacea
Psychoda alternata	sewerage fly	Insecta
Clogmia albipunctata	sewerage fly	Insecta
Limnophyes pusillus	chironomid fly	Insecta
Mollusca		
Urosalpinx species	oyster drill	Gastropoda

The reasons for the uncertain status of the species appearing in Table 7 are discussed below:

* *Polydora* and *Urosalpinx* species, which are predators of oysters and mussels (A Genade personal communication), appear to have a cosmopolitan distribution.

* *Branchiura sowerbyi*, a freshwater oligochaete worm which has been widely recorded in southern Africa (Brinkhurst 1966) and now has a cosmopolitan distribution. This species may have originated in Asia and was introduced with aquatic plants to various parts of the world (Brinkhurst and Jamieson 1971).

* *Pilumnoides perlatus* and *Pilumnus hirsutus*, two suspected alien kelp crabs, have been recorded on the west coast, and from Saldanha Bay to Durban, respectively (Branch and Branch 1982).

* Two dipteran species, *Psychoda alternata* and *Clogmia albipunctata*, which have aquatic larvae and occur in large swarms at sewerage works, have a cosmopolitan distribution but were probably introduced into southern Africa (B R Stuckenberg personal communication).

* The zooplankter *Daphnia magna* is known to have been introduced into southern Africa from the USA (Anon 1945), but it is probable that the natural distribution of this species is cosmopolitan (R C Hart personal communication).

* The chironomid fly *Limnophyes pusillus* (which has an aquatic larva) presently has a cosmopolitan distribution, but may have been introduced to Marion Island a number of years ago (Crafford 1986).

Uncertain historical translocations

Several aquatic animal species in southern Africa have anomalous distributions which may be explained by early translocations that were not documented in the literature. These are listed in Table 8.

Table 8 Indigenous species which may have been translocated to and established populations in areas beyond their native range, but this is not well documented

Species name	Common name	Class
Chetia flaviventris	canary largemouth	Osteichthyes
Galaxias zebratus	Cape galaxias	Osteichthyes
Phrynomerus bifasciatus	banded rubber frog	Amphibia
Xenopus laevis	platanna	Amphibia
Pyxicephalus adspersus	bullfrog	Amphibia

Chetia flaviventris: Potgieter (1974) suspects that the population in the Hans Merensky dam (Letaba system) is the result of a translocation by anglers as this species occurs naturally in the upper Limpopo system which is separated from the Letaba system by the Drakensberg mountains.

Galaxias zebratus: Harrison (1962/63b) reported that in 1937 approximately 72 "Galaxias" were transferred from an area below a waterfall in the Silvermine (Muizenberg) River to a woody creek above the falls where they had not previously been recorded. In 1946 it was reported that the river below the Silvermine reservoir (but above the waterfall) contained "many Galaxias". It is assumed that the author referred to *Galaxias zebratus* which occurs in this area, and is the only *Galaxias* species in South Africa.

Pyxicephalus adspersus: Specimens of this bullfrog were set free in the Muizenberg mountains by Dr Walter Rose (J C Poynton personal communication). It is not known whether this population has survived and there is no mention of this record in Passmore and Carruthers (1979).

Xenopus laevis laevis: The platanna was introduced into many parts of southern Africa (Anon 1945, 1954) and J C Poynton (personal communication) suspects that most of the population in the Cape Province is derived from translocations. Passmore and Carruthers (1979) include the Cape Province as part of the native range of this species. There is thus some uncertainty about their native range.

Phrynomerus bifasciatus: There is a record of this frog species having been accidentally transported to the Kimberley district with firewood supplied to mine compounds (Siegfried 1962). There have been no further records in this area (Passmore and Carruthers 1979).

Alien species whose presence in southern Africa is suspected but requires confirmation.

Several alien aquatic animals are suspected to have invaded or been introduced into southern Africa but their presence has not as yet been conclusively documented. These species are listed in Table 9.

Four species of dactylogyrid parasites (*Dactylogyrus anchoratus*, *D. minutus*, *D. extensus* and *Pseudacolpenteron pavlovski*) have been introduced into Africa with carp (Paperna 1980). These minute flatworms (0,3 to 1,5 mm total length) attach themselves to the gills and skin of cyprinid fishes. Of the four species, only *D. extensus* is regarded as pathogenic but they may all cause problems under culture conditions. None of these species has as yet been recorded in southern Africa but the widespread distribution of carp in the subcontinent, and the prevalence of dactylogyrids elsewhere in Africa, suggest that they may be present but as yet undetected.

Du Plessis (1948) reported that *Acolopenteron ureteroecetes* (a parasite found in the ureters of largemouth bass *Micropterus salmoides*) was introduced together with bass from the USA into southern Africa. Although there have been no further records, this species may also be present in the subcontinent.

TABLE 9 Alien aquatic animals whose presence in southern African natural and semi-natural waters is suspected but requires proper confirmation

Species	Common name	Class
Platyhelminthes		
Dactylogyrus species	dactylogyrid parasite	Trematoda
Pseudacolpenteron pavlovski	dactylogyrid parasite	Trematoda
Acolopenteron ureteroecetes	dactylogyrid parasite	Trematoda
Mollusca		
Latiaxis mawae	gastropod mollusc	Gastropoda
Harpa ventriculosa	gastropod mollusc	Gastropoda
Thais haemostoma	oyster drill	Gastropoda

The shells of two species of alien marine molluscs, *Latiaxis mawae* and *Harpa ventriculosa*, were recently collected on Shelly beach (near East London), but living specimens were not found (Muller 1985; Muller personal communication). The discovery of two living specimens of another alien marine mollusc *Thais haemostoma* on Durban beach (Kilburn and Rippey 1983) has caused concern as this species has free-swimming larvae. It therefore has the potential to become widespread and would be impossible to control if it becomes established (Kilburn personal communication). *T. haemostoma* preys on oysters and other bivalves and has the potential to be harmful to indigenous bivalves as well as to bivalve cultures. No further specimens of these three mollusc species have been collected in southern Africa.

Potential problem species currently in captivity in southern Africa

A number of alien aquatic organisms which are currently in captivity in southern Africa have the potential to cause problems should they escape (Table 10).

Myxosoma cerebralis: Whirling disease is the cause of severe deformities in trout and is of major economic importance to the trout farming industry in Europe and North America (Paperna 1980). This protozoan is present in trout hatcheries and could spread if it invades natural waters. *M. cerebralis* is reported to be specific to rainbow trout *Parasalmo mykiss* (Hoffman 1970) and is unlikely to infect indigenous fish.

Several potentially harmful freshwater crayfish and prawns can be purchased through the aquarium or aquaculture trades in South Africa, including *Astacus* sp, *Pacifasticus leniusculus*, *Procambarus clarkii*, *Macrobrachium rosenbergii* and *Cherax tenuimanus*. Elsewhere, freshwater crayfish are known to be highly mobile, aggressive invaders which have proved to be extremely harmful in their introduced environments. Several crayfish are hosts of harmful parasites eg *P. leniusculus* is held to be responsible for the introduction of the fungus *Aphanomyces astaci* which had a devastating effect on the crayfish industry in Europe. Freshwater crayfish are frequently omnivorous and tolerant of a wide range of environmental conditions, and readily colonise new habitats where they outcompete indigenous species. Several of the crayfish have the habit of burrowing into mudbanks and may cause severe problems by destabilising river banks and dam walls (Bourquin et al 1984). *Procambarus clarkii* is known to uproot and destroy aquatic vegetation, thereby decreasing food resources and disrupting the habitat of other aquatic organisms. The introduction of *P. clarkii* into Lake Naivasha in Kenya has been linked to a drastic decline in the cichlid and bass fisheries (Hart 1983; van Eeden et al 1983; Bruton personal observation). *P. clarkii* is known to be in the illegal possession of several aquarists in the Orange Free State and there is concern that some specimens may escape or be released into natural watercourses (van Eeden et al 1983).

Table 10 Alien aquatic organisms currently in captivity in southern Africa which have the potential to cause problems should they escape and establish populations in natural or semi-natural waters

Species	Common name	Class
Myxozoa		
Myxosoma cerebralis	whirling disease	Myxosporea
Arthropoda		
Astacus species	European crayfish	Crustacea
Pacifastacus leniusculus	signal crayfish	Crustacea
Procambarus clarkii	red swamp crayfish	Crustacea
Macrobrachium rosenbergii	giant freshwater prawn	Crustacea
Cherax tenuimanus *	marron	Crustacea
Chordata		
Serrasalmus nattereri	Natterer's piranha	Osteichthyes
Clarias batrachus	walking catfish	Osteichthyes
Ictalurus punctatus	channel catfish	Osteichthyes
*Oreochromis aureus**	Israeli tilapia	Osteichthyes
*Oreochromis niloticus**	Nile tilapia	Osteichthyes
Oreochromis spiluris niger		Osteichthyes
*Sarotherodon galilaeus**	Israeli tilapia	Osteichthyes
*Tilapia zillii**	Jordan's St Peter's fish	Osteichthyes

* These species have been released into natural waters but they did not establish breeding populations, or their ranges are at present very restricted.

Two of the crayfish mentioned in Table 10 (*Procambarus clarkii* and *Cherax tenuimanus*) spend their entire life-cycle in freshwater (Hart 1983; Cubitt 1985) whereas the other species survive in freshwater but breed in the sea. *C. tenuimanus* is kept in captivity in a number of fish farms around the country and has also been captured in the Buffalo River. A detailed description of this species is given in the section on successful introductions.

Natterer's piranha *Serrasalmus nattereri* is on display in the aquarium at the National Zoological Gardens in Pretoria. Although these voracious predators are kept under strict security, there is nevertheless the risk that they may be stolen or that their eggs may escape in effluent water. Although piranhas are unlikely to survive in the immediate vicinity of Pretoria, they may survive if they are released into the lowveld tributaries of the Limpopo River.

The cichlid fish species listed in Table 10, as well as various hybrids such as the red tilapia (*Oreochromis niloticus* X *O. mossambicus*) pose a threat of genetic contamination to indigenous fish stocks in areas where closely related species occur.

The walking catfish *Clarias batrachus*, which has become a serious pest in the southern states of the USA (Idyll 1969) and the channel catfish *Ictalurus punctatus*, which has invaded west Africa, can both be purchased through the aquarium trade in South Africa although they are banned. Both species represent a severe threat to indigenous aquatic communities and species.

In addition to the species mentioned in Table 10, at least 300 different species of freshwater organisms are imported into southern Africa each year through the aquarium trade. Many of these species may also pose a threat but, in general, their biology and likely impact are unknown.

Alien species in semi-domesticated situations which appear to be unable to establish breeding populations in natural habitats.

A number of aquatic animals are only found in semi-captive situations in southern Africa (Table 11).

Table 11 Alien aquatic species present in southern Africa in semi-domesticated situations which have had the opportunity to escape but which have not established breeding populations in natural habitats

Species	Common name	Class
Mollusca		
Crassostrea gigas	edible oyster	Bivalvia
*Helisoma duryi**	helisoma snail	Gastropoda
Chordata		
Aix galericulata	Mandarin duck	Aves
Anas platyrhynchos	mallard	Aves
Anser anser	domestic goose	Aves
Cairina moschata	muscovy duck	Aves
*Cygnus olor***	mute swan	Aves
Cygnus atratus	black swan	Aves

* This species has established a single population in the Liesbeeck River.

** This species did establish a wild breeding colony which later became extinct.

The Pacific oyster *Crassostrea gigas* is being cultured at several hatcheries along the west and south coasts of the Cape Province but does not appear to have colonised the sea shore. All the bird species listed in Table 11 are common in parks and in domestic and farming situations (Liversidge 1985). *C. olor*, *A. platyrhynchos* and *C. moschata* are regularly recorded in semi-natural situations (Siegfried 1962; Clancey 1980; Macdonald and Birkenstock 1980; Woods 1980). *C. atratus* (the black swan) and *Anser anser* (domestic goose) and some other anatid species are common in situations where they are free to escape but, with the exception of *C. olor*, none has established feral populations (Brooks personal communication). *C. olor* established a breeding population in the Kromme River estuary for many years but has now become locally extinct.

The mallard duck, *Anas platyrhynchos* is very widespread and is capable of interbreeding with three indigenous duck species (*Alophen aegyptiaca*, *Anas undulata* and *A. erythrorhyncha*). This species can therefore be regarded as a potential danger even though it has not established feral populations. Because of the current controversy surrounding the mallard, a detailed description of this species has been included in the atlas.

SUMMARY OF THE STATUS OF INTRODUCED AQUATIC ANIMALS

The species which are described in detail in this Atlas are listed in Tables 12, 13 and 14 together with a summary of their impact on natural habitats. The page on which the species account is given in the atlas is also indicated.

Table 12 The present status of alien species introduced into southern Africa with a summary of their impact on natural communities in southern Africa. The pages on which the detailed species accounts appear are also indicated.

Species name	Impact	Degree of impact	Status	Page
Ichthyophthirius multifilis	detrimental	major	established, pest	26
Trichodina acuta	detrimental	major	established, pest	29
Craspedacusta sowerbyi	detrimental	little	established	32
Bothriocephalus acheilognathi	detrimental	major	established, pest	35
Argulus japonicus	detrimental	major	established, pest	38
Cherax teniumanus	detrimental	potential	not known	41
Carcinas maenas	detrimental	potential	established	46
Cyrtobagous salviniae	beneficial	major	established	49
Cyrtobagous singularis	beneficial	little	established	53
Neohydronomus pulchellus	beneficial	major	established	56
Bedeva paivae	detrimental	potential	established	59
Littorina saxatilis	detrimental	little	established	62
Physa acuta	detrimental	unknown	established	65
Helisoma duryi	detrimental	little	established	68
Lymnaea columella	detrimental	major	established, pest	71
Mytilus galloprovincialis	detrimental	major	established, nuisance	75
Parasalmo mykiss	equivocal	major	established	78
Salmo trutta	equivocal	major	established	87
Carassius auratus	equivocal	major	established	94

Table 12 (continued)

Ctenopharyngodon idellus	equivocal	major	non-breeding	99
Cyprinus carpio	equivocal	major	established, nuisance	103
Tinca tinca	equivocal	little	established	111
Gambusia affinis	detrimental	unknown	established	114
Poecilia reticulata	detrimental	potential	established	117
Xiphophorus helleri	detrimental	potential	established	121
Lepomis macrochirus	detrimental	major	established, pest	124
Micropterus dolomieui	detrimental	major	established, nuisance	128
Micropterus punctulatus	equivocal	unknown	established	135
Micropterus salmoides	detrimental	major	established	138
Perca fluviatilis	detrimental	little	established	147
Oreochromis aureus	detrimental	potential	not known	150
Oreochromis niloticus	detrimental	unknown	not known	153
Trachemys scripta	detrimental	potential	established, nuisance	157

Table 13 The present status of translocated indigenous species with a summary of their impact on natural communities in southern Arica. The pages on which the detailed species accounts appear are also indicated.

Species name	Impact	Degree of impact	Status	Page
Protopterus annectens brieni	equivocal	little	established	160
Kneria auriculata	equivocal	little	established	163
Barbus aeneus	detrimental	unknown	established	166
Barbus anoplus	detrimental	unknown	established	170
Barbus natalensis	detrimental	unknown	established	174
Barbus treurensis	equivocal	little	established	177

Table 13 (continued)

Labeo capensis	detrimental	unknown	established	180
Labeo umbratus	detrimental	major	established, pest	184
Clarias gariepinus	detrimental	potential	established	188
Nothobranchius orthonotus	equivocal	little	established	193
Nothobranchius rachovii	equivocal	little	established	196
Astatotilapia brevis	equivocal	little	established	199
Oreochromis andersonii	detrimental	unknown	established	202
Oreochromis macrochir	detrimental	potential	established	205
Oreochromis mossambicus	equivocal	major	established	208
Serranochromis codringtoni	detrimental	unknown	established	214
Serranochromis r. jallae	detrimental	equivocal	established	217
Serranochromis angusticeps	detrimental	potential	established	221
Serranochromis thumbergi	detrimental	potential	established	224
Tilapia guinasana	equivocal	unknown	established	227
Tilapia rendalli swierstrae	equivocal	major	established, nuisance	230
Tilapia sparrmanii	detrimental	major	established	235
Mugil cephalus	equivocal	unknown	non-breeding	239
Myxus capensis	equivocal	unknown	non-breeding	242
Sandelia capensis	detrimental	potential	established	245

Table 14 The potential impact of introduced species which have failed to establish permanent breeding populations in their introduced environments. The pages on which detailed accounts of these species appear are also indicated.

Species	Potential impact	Page
Paulinia acuminata	beneficial	248
Neochetina eichhorniae	beneficial	250
Salmo salar	equivocal	252
Salvelinus fontinalis	detrimental	254
Barbus gurneyi	detrimental	256
Sarotherodon galilaeus	detrimental	258
Tilapia zillii	major detrimental	260
Anas platyrhynchos	major detrimental	262
Cygnus olor	major detrimental	265

SPECIES ACCOUNTS

ICHTHYOPHTHIRIUS MULTIFILIS Fouquet 1876

ich, whitespot disease **alien, detrimental, major impact**
ik, witkolsiekte

Phylum: Protozoa - single-celled animals
Class: Ciliata - ciliates
Family: Ichthyophthiridae

SUMMARY

Status: An alien fish parasite accidentally introduced into southern Africa in association with aquarium fish. White spot is very widespread in southern Africa and has infected a number of indigenous species.

Research: Excellent. Their life cycle and impact on infected fish has been studied in detail by Paperna (1980) and their ditribution in southern Africa has been documented by van As and Basson (1984).

SPECIES DATA

Distinguishing characteristics: White spots (pustules) on the skin of fish. A unicellular, ciliated organism 0,06 to 0,7 mm in diameter. Has a large crescent-shaped macro-nucleus and a small cytostome. Cilia uniformly cover the body in dense rows (Paperna 1980).

Native range: Uncertain. The present distribution is cosmopolitan (Basson personal communication) as a result of active introductions of fish such as trout, goldfish and carp (Paperna 1980). Hoffman and Schubert (1984) postulate that this species probably originated in Asia.

Date and purpose of introduction: Accidental. Date of introduction unknown. Associated with the introduction of a number of aquarium and angling fish (particularly trout, goldfish and carp) (Hoffman 1970; Paperna 1980).

Southern African distribution: Widespread (Paperna 1980), having been found in the following localities in southern Africa: Turfloop dam, Seshego dam (northern Transvaal), Lowveld Fisheries Research Station (Marble Hall), Tompi Seleka Fisheries Station, the Provincial Fisheries Institute (Lydenburg) (all above localities in the Transvaal) and also in the Kei River (van As and Basson 1984) and the Keiskamma River (Paperna 1980). Whitespot is very widespread in aquaria throughout the country.

Habitat preferences: *I. multifilis* has been found on the following species of fish: In Africa: *Oreochromis leucostictus, O. niloticus, O. mossambicus, Tilapia zillii, Clarias carsoni, Ctenopoma murieri, Cyprinus carpio, Barbus amphigramma, B. aeneus, Anguilla mossambica, Parasalmo mykiss* and others (Paperna 1980). In southern Africa: *Oreochromis mossambicus, Barbus aeneus, B. paludinosus, Cyprinus carpio, Anguilla mossambica* and *Parasalmo mykiss* (van As and Basson 1984).

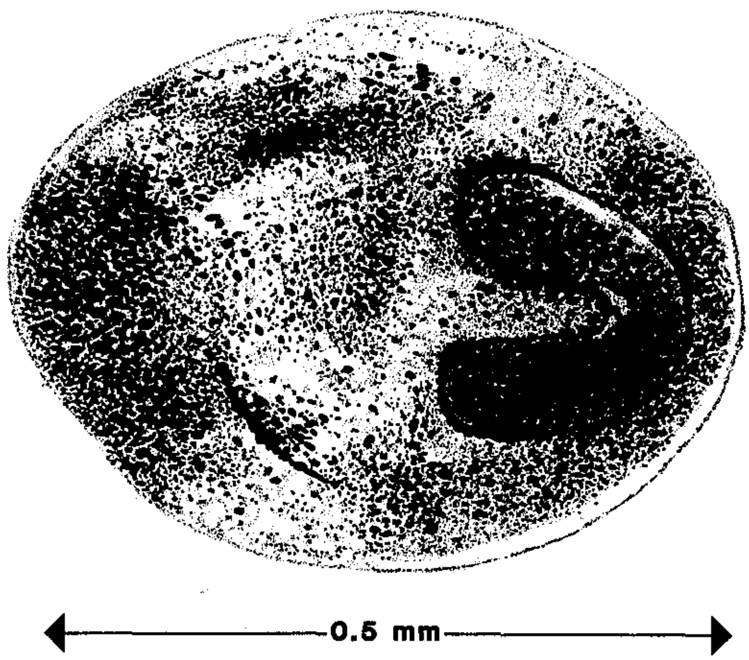
Breeding: The mature "trophozoite" adult leaves the host, settles on a suitable substrate and forms a cyst. It then undergoes binary fission within the cyst to form 250 to 2000 "tomites". After 15 to 20 hours the cyst bursts and the released tomites actively swim and seek a new host. The length of the life cycle depends on the water temperature and is completed within 3 to 5 days at 20°C, 7 to 14 days at 15 to 17°C and 21 to 35 days at 10°C. Larger, more fecund individuals develop at lower temperatures (Paperna 1980).

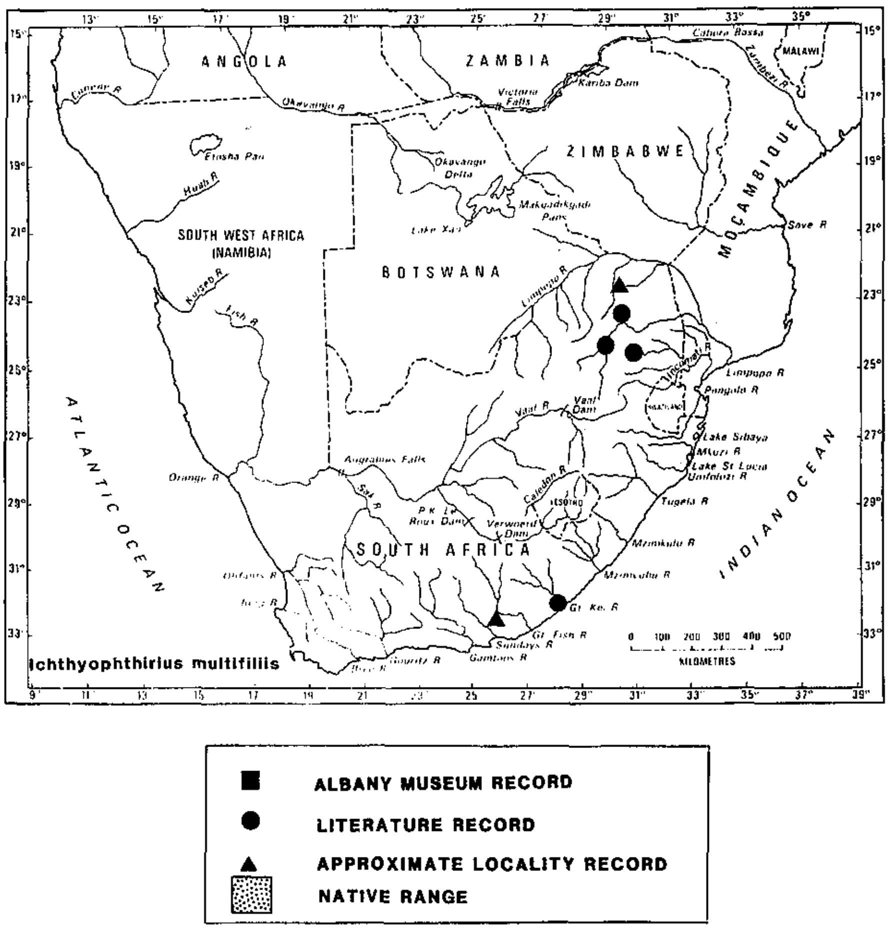
Feeding: Parasitic. Feeds on the epidermal tissues of the host (Paperna 1980).

Behaviour: Parasite, solitary (Paperna 1980).

ICHTHYOPHTHIRIUS MULTIFILIS Fouquet 1876

FIGURE 2. Whitespot disease, *Ichthyophthirius multifilis* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Impact: Generally carp and other cyprinids are the most susceptible fish, but this parasite also affects other species. This is of some epizootological importance as the less susceptible host species may act as reservoirs for the parasite and thus more effectively spread the disease to new areas. Mortalities (from 75% to 93%) from this disease have been reported from certain trout hatcheries in South Africa, and in a Grahamstown hatchery 70% of the glass eels and 47% of the elvers were infected (Paperna 1980). Infection has also spread in the wild; 6,4% of glass eels captured from the Keiskamma River were found to be infected (Paperna 1980).

Infection results in a proliferation of mucous cells. In advanced conditions the epidermis disintegrates, thus exposing the dermis. In the gills a proliferation of the interlamellar epithelium occurs. Spontaneous recovery due to acquired immunity sometimes occurs even in the most susceptible species. Optimal growth conditions and high temperatures accelerate the acquisition of resistance. Fish are often most susceptible to the disease during Spring (Paperna 1980).

Hoffman and Schubert (1984) describe *I. multifilis* as being one of the most damaging parasites of fish because of its lack of host specificity.

Control: Recommended concentrations of chemical agents to be used in ponds: 200 ppm formalin for 1 hour or 15 to 40 ppm applied to ponds, or 0,05 ppm Malachite Green mixed with 50 ppm formalin. These chemicals may not eliminate the cysts at the bottom of the pond so treatment should be repeated at suitable intervals (considering the length of the life cycle at the prevailing temperature) to eradicate emerging tomites (Paperna 1980).

Research recommendations: It is important that the South African research community remains in contact with international research efforts on this important parasite so that we can benefit from control techniques developed elsewhere. Control methods specific to South African conditions need to be developed and tested locally. Fish farmers should bring infestations to the attention of conservation authorities and researchers.

Remarks: The further introduction of whitespot disease through fishes imported for the aquarium trade and for angling and fish farming is a serious threat to indigenous fish species. Strict measures should be introduced to control the spread of this detrimental alien parasite.

REFERENCES

Hoffman and Schubert (1984); Paperna (1980); van As and Basson (1984)

Personal communication: L Basson

TRICHODINA ACUTA Lom 1961

trichodina
trichodina

alien, detrimental, major impact

Phylum: Protozoa - single-celled animals
Class: Ciliata - ciliates
Family: Trichodinidae

SUMMARY

Status: An alien protozoan parasite/commensal which was probably introduced in association with carp. *T. acuta* has the potential to become a major pest in aquaculture, but infestations are unlikely to cause mortalities or major loss of condition in fish in natural habitats.

Research: Good. Paperna (1980) has reviewed research on the effects of trichodiniasis and the various means of controlling infestations in fish ponds. Basson et al (1983) and van As and Basson (1984) have documented the distribution of *T. acuta* in southern Africa.

SPECIES DATA

Recent synonyms: *Trichodina domerguei* cf *acuta* (Basson personal communication).

Distinguishing characteristics: A protozoan fish parasite. Cup-shaped with a ventrally located ring of denticles as an attachment organelle (Paperna 1980). A medium-sized trichodinid with a flattened disc-shaped body. Adhesive disc concave, surrounded by a finely striated border membrane. The centre of the adhesive disc shows a characteristic circle (Basson et al 1983).

Native range: Cosmopolitan distribution. Native range uncertain, but *T. acuta* has been associated with carp (Basson personal communication) and may have originated in Asia (Paperna 1980), although there is a possibility that carp also originated from Europe (Balon 1974).

Date and purpose of introduction: Unknown. Since *T. acuta* was originally associated with carp, it may have been introduced into southern Africa with this species (Basson personal communication).

South African distribution: Collected from the following localities in the Transvaal: Amalinda, Hartbeespoort dam, Lowveld Fisheries Research Station, Nylpans, Orlando dam, Pietersburg dam, Tompi Seleka, Boskop dam, Doorndraai dam, Mooi River, Sterkstroom, Vaal River (Basson et al 1983). Also recorded in the Vaal dam (van As and Basson 1984).

Habitat preferences: Found on the gills and skin of the following fish species in the Transvaal: *Oreochromis mossambicus, Pseudocrenilabrus philander, Tilapia rendalli, T. sparrmanii, Barbus trimaculatus* and *Cyprinus carpio* (Basson et al 1983). In European nurseries this species is also known to parasitise catfish fry and carp (Paperna 1980).

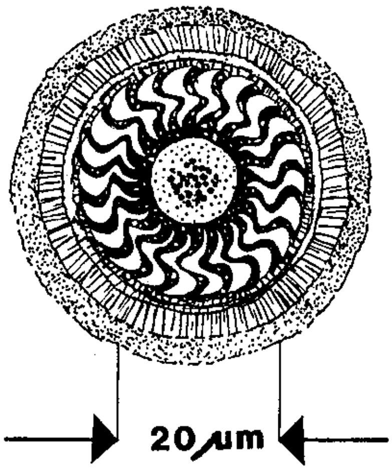
Breeding: Asexual by binary fission (Barnes 1974).

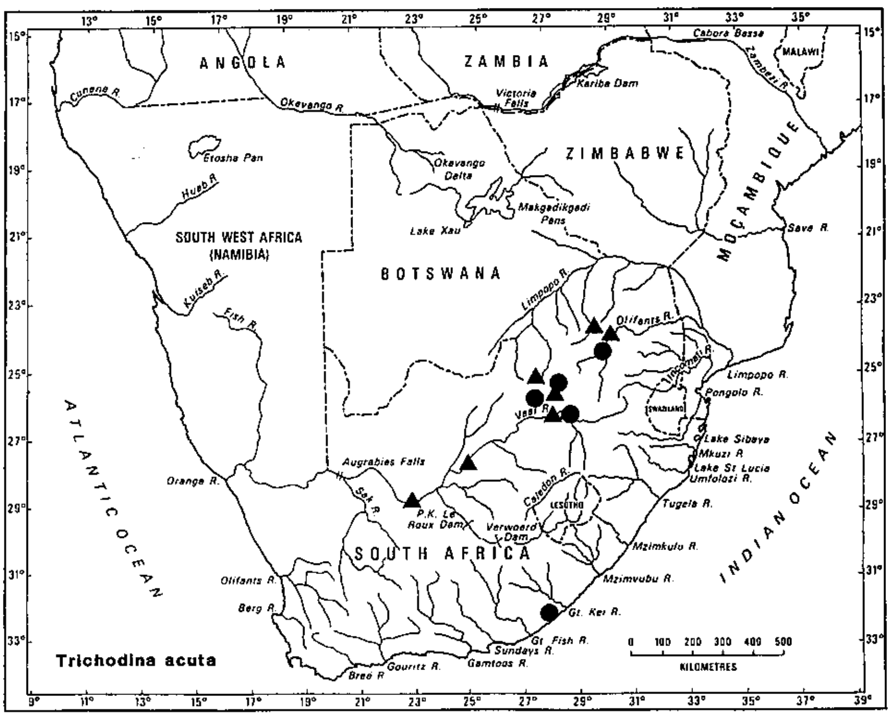
Feeding: The oral denticles are used for attachment to the integumentary tissues of the host. They feed on host tissues and exudates (Paperna 1980).

Behaviour: Usually has a commensal relationship with the host (Basson personal communication).

TRICHODINA ACUTA Lom 1961

FIGURE 3. The trichodina fish parasite *Trichodina acuta*, with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■ ALBANY MUSEUM RECORD

● LITERATURE RECORD

▲ APPROXIMATE LOCALITY RECORD

NATIVE RANGE

Impact: In hyperinfections certain skin changes occur in the host such as abnormal coloration, loss of refraction of colour into a greyish-white sheen in scaly fish, red sores, eroded scales and excessive mucus production. Infected fish often respond by "fleshing" (rubbing) (Paperna 1980). Mortalities due to trichodiniasis were reported by van As et al (1984) in *Cyprinus carpio* and *Oreochromis mossambicus* fry in fish ponds at the Lowveld Fisheries Research Station (Marble Hall). This species is usually regarded as a commensal rather than a parasite, and only becomes a problem to the host when fish fry are under stress (Basson personal communication).

Control: Immersion of parasitised fish in a 1 to 2.5% salt bath for 10 to 20 minutes (Lombard 1968) or the application of 15 to 25 ppm of formalin (Paperna 1980) is usually effective. Van As et al (1984) recommend immersion for 24 hours in the following concentrations of formalin: 25 mg/l for *Cyprinus carpio*, 45 mg/l for *Oreochromis mossambicus* fry.

Research recommendations: The distribution of this species in southern Africa is poorly known and needs to be investigated. Factors which cause hyperinfections should be determined.

REFERENCES

Balon (1974); Barnes (1974); Basson et al (1983); Lombard (1968); Paperna (1980); van As and Basson (1984); van As et al (1984).

Personal communication: L Basson

CRASPEDACUSTA SOWERBYI Lankester 1880

freshwater medusa
varswater medusa

alien, detrimental, little impact

Phylum: Cnidaria - jellyfish, sea anemones and corals
Class: Hydrozoa - hydroids
Family: Limnomedusae

SUMMARY

Status: An alien freshwater planktonic species which was accidentally introduced before the late 1970's. Although this species has a high predation rate it has apparently had little or no impact on the indigenous planktonic fauna. Recorded in Midmar dam in Natal.

Research: Fair. Apart from the record at Midmar dam (Rayner 1981) there are no other distribution records although it is suspected that *C. sowerbyi* may be more widespread in southern Africa.

SPECIES DATA

Distinguishing characteristics: A bell-shaped, free-swimming medusa 3 to 8 mm in diameter. The margin of the bell projects upwards to form a shelf (the velum) and a number of tentacles hang downwards from the margin of the bell. The ventral mouth opens from the manubrium in the centre of subumbrella (the lower surface of the "bell"). Rhythmic pulsations of the bell serve as a means of propulsion. The life cycle alternates between the medusoid (free-swimming) and the polyp (sessile) stage. In this species the medusoid stage is dominant (Barnes 1974). The lobed gonads are situated on the radial canals (Rayner 1981). The polyps are approximately 2 mm in height (Payne 1924).

Native range: Northern hemisphere (Rayner 1988).

Date and purpose of introduction: This species has extended its range into the southern hemisphere in the past few decades. Rayner (personal communication) believes that *C. sowerbyi* was introduced into southern Africa, probably in association with aquatic plants. First recorded in the late 1970's to 1980 from Midmar dam (Rayner 1981).

Southern African distribution: Midmar dam (Umgeni catchment, Natal).

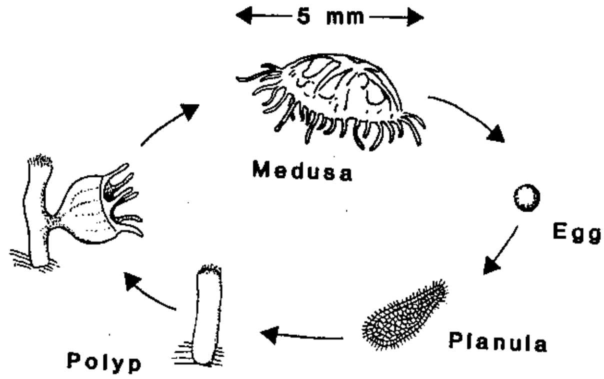
Habitat preferences: A freshwater planktonic species. The medusae are limnetic, whereas the polyp stage is attached to a substratum (Barnes 1974). The polyps may fail to bud off medusae in turbid water. *C. sowerbyi* has been found in rivers as well as impoundments in other countries (Rayner personal communication).

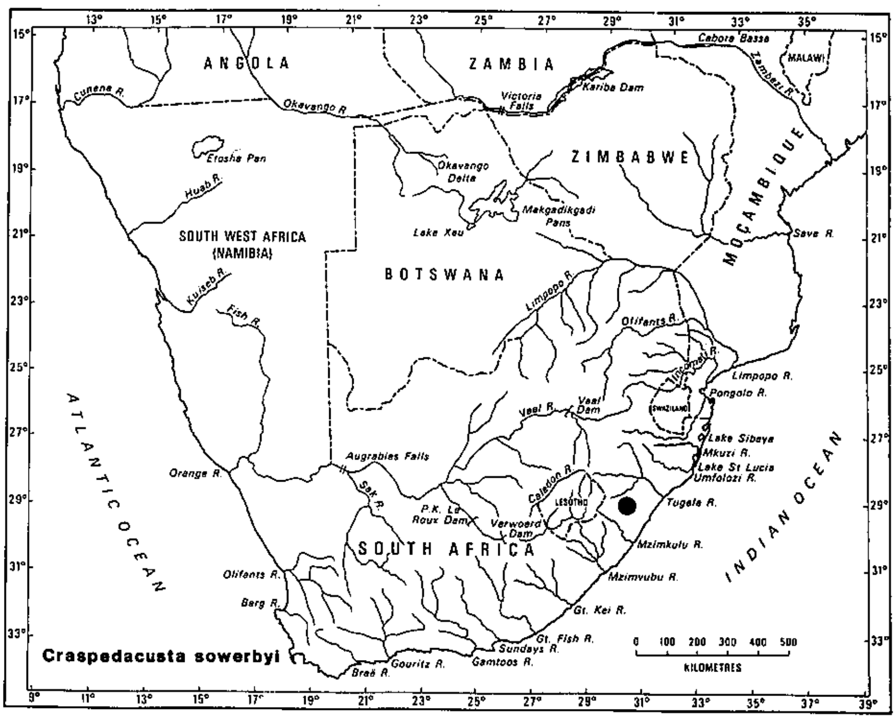
Breeding: The sexes are separate. Gonads form in the epidermis of the medusa. After fertilisation the eggs are released into the water and the free-swimming planula larva develops. After a few days the larva settles on a substratum and a small solitary polyp develops. The medusae form as "buds" on the polyp. These detach from the polyp and become free-swimming. The medusoid form is dominant (Barnes 1974). Medusae which develop from the same polyp are all of the same sex (Rayner personal communication).

Feeding: A zooplankton predator. The prey is captured with the tentacles and brought to the ventrally-located mouth. Davis (1955) found that on average individual medusae contained 6,5 *Daphnia longispina*, 3,7 *Diaphanosoma* species and 2,6 colonies of the rotifer *Conochilus unicornis*. Digestion was completed in 1,5 hours. From these figures feeding rates over a 24 hour period can be calculated.

CRASPEDACUSTA SOWERBYI Lankester 1880

FIGURE 4. The freshwater medusa *Craspedacusta sowerbyi* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■ ALBANY MUSEUM RECORD

● LITERATURE RECORD

▲ APPROXIMATE LOCALITY RECORD

NATIVE RANGE

Behaviour: Solitary, free-swimming in the medusa stage (Barnes 1974).

Impact: Based on Davis' (1955) figures it appears that this species is a voracious predator. However Rayner (1981) calculated that their known rates of predation do not significantly affect population levels of other zooplankton in Midmar dam. This is probably because of the very high productivity of the prey species in this lake. The spread of *C. sowerbyi* is likely to be restricted as all medusae developing from one polyp are of the same sex, and a suitable substratum is required for polyps to develop.

Control: There are no known means of controlling this species.

Research recommendations: There is no urgency to find a means of controlling this species, but it would be of interest to investigate its historical and present distribution as well as obtain more precise information regarding its classification and its relationship to another species, *Limnocnida*, which has also been recorded throughout Africa. Ms N Rayner is involved in this research.

Remarks: Stricter control needs to be exercised over the importation of aquatic plants in order to prevent further introductions of associated alien invertebrates.

REFERENCES

Barnes (1974); Davis (1955); Payne (1924); Rayner (1981, 1988).

Personal communication: N Rayner.

BOTHRIOCEPHALUS ACHEILOGNATHI Yamaguthi 1934

fish tape worm
visluntwurm

Alien, detrimental, major impact

Phylum: Platyhelminthes - flatworms
Class: Cestoda - tapeworms
Family: Bothriocephalidae

SUMMARY

Status: An alien fish parasite accidentally introduced from Europe in 1975. This species has had a major detrimental impact on fishes in fish farms, and has infected two indigenous species of fish. *B. acheilognathi* has spread rapidly to new river catchments.

Research: Good. Distribution records have been collated by van As and Basson (1984) and Brandt et al (1981) have investigated the infection prevalence.

SPECIES DATA

Recent synonyms: *B. gowkongensis, B. opsariichthydis* (Brandt et al 1981).

Distinguishing characteristics: An internal parasite. Segmented flatworm. Two deep lateral grooves on the elongated scolex. Single prominent terminal disc. Well-developed segmentation and distinct secondary segmentation of proglottids in strobila. The shape of the terminal disc and the shape of the proglottids varies according to the state of contraction of the worm during fixation by formalin. This must be borne in mind during species identification as the morphology of these organs is an important diagnostic characteristic (Brandt et al 1981). Body length up to 20 cm (Needham and Wootten 1978).

Native range: Probably Asia. First discovered in the intestine of a young grass carp cultured in fish farms in south China (Hoffman and Schubert 1984).

Date and purpose of introduction: There is strong evidence to suggest that this parasite was associated with grass carp introduced in 1975 from West Germany to the Fisheries Research Station at Marble Hall, eastern Transvaal. The fish were introduced as part of a programme for water hyacinth control (Brandt et al 1981).

Present distribution: *B. acheilognathi* has been recorded in the following localities: 1 Lowveld Fisheries Research Station on *Cyprinus carpio*. 45% of the pond fish were infected (Brandt et al 1981). 2 Vaal dam in 1978, on *Barbus kimberleyensis* (Brandt et al 1981). 3 Komatipoort, on *Cyprinus carpio* (Boomker et al 1980). 4 Boskop dam (a reservoir on the Mooi River near Potchefstroom), on *Cyprinus carpio* and *Barbus trimaculatus* (van As et al 1981).

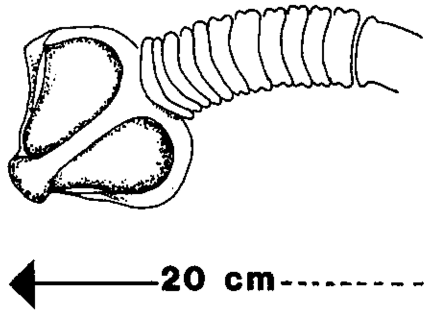
Habitat preferences:. A parasite of cyprinids. So far has been found on *Cyprinus carpio, Barbus kimberleyensis, B. trimaculatus* and *B. mattozi* in South Africa (Brandt et al 1981).

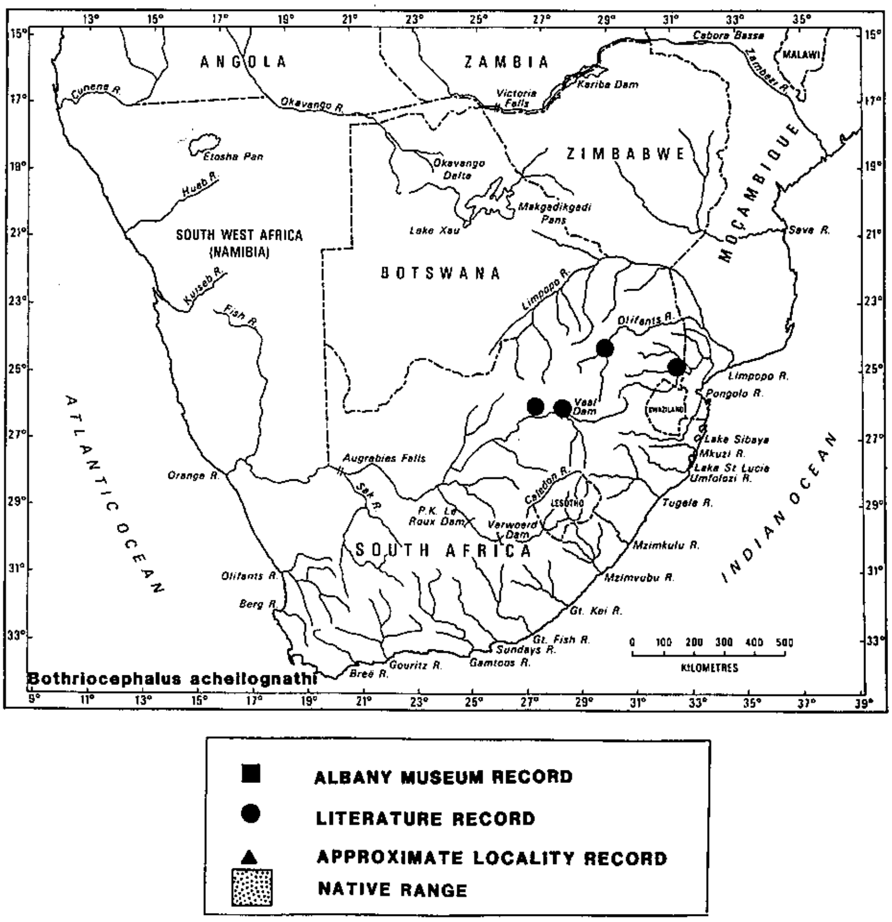
Breeding: An hermaphrodite. The fertilised eggs are released from the uterus into the intestine of the host and then into the surrounding water. A free swimming coracidium larva develops which is ingested by a copepod, probably *Thermocyclops oblongatus* (van As et al 1981). In the copepod the parasite continues to develop in the body cavity to form an elongated procercoid larva. The infected copepod is then ingested by a fish and the adult stage of the parasite develops in the intestine of the fish (Brandt et al 1981).

Feeding: Feeds on tissues in the intestinal wall of the host fish (Brandt et al 1981).

BOTHRIOCEPHALUS ACHEILOGNATHI Yamaguti 1934

FIGURE 5. The fish tape worm *Bothriocephalus acheilognathi* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Behaviour: A solitary parasite.

Impact: Reported to be the cause of heavy mortalities of common carp in fish farms in Europe (Brandt et al 1981). Of 20 specimens of *Barbus kimberleyensis* caught in the Vaal dam, 19 were infected and as many as 1000 tapeworms were found in a single fish (Brandt et al 1981).

Control: This would only be possible in a fish pond. Brandt et al (1981) recommend the use of Lintex (2' 5' Dichloro-4'-nitrosalicylanilide) which is incorporated into fish pellets and administered for 7 days at a dosage of 50 mg active ingredient/kg of fish. This treatment results in the complete eradication of the parasite from the treated fish (Brandt et al 1981). The same authors also recommend that all carp should be given medicated feed prior to overwintering and in early spring, that fry be treated with medicated fish feed before release to farmers, and that ponds are periodically drained and treated with lime.

Research recommendations: Distribution records should be kept up to date and an assessment made on the impact of this parasite on indigenous fish. Fish farmers should be alerted to the dangers of this species and requested to bring any infestation to the attention of the conservation authorities and researchers.

Remarks: It is very disturbing to note the rapid spread of this parasite since its introduction to Marble Hall in 1975. From there it has spread to the Vaal dam (1978) and then downstream to Boskop dam. It is highly probable that it will soon find its way into the Orange River. It is also disturbing to note that two indigenous species, *Barbus kimberleyensis* and *B. trimaculatus* have been infected.

REFERENCES

Boomker et al (1980); Brandt et al (1981); Hoffman and Schubert (1984); Needham and Wootten (1978); van As et al (1981); van As and Basson (1984).

ARGULUS JAPONICUS Thiele 1900

fish louse **alien, detrimental, major impact**
visluis

Phylum: Arthropoda - arthropods
Class: Crustacea - crabs, crayfish, prawns and relatives
Family: Argulidae

SUMMARY

Status: An alien fish parasite which probably originated from Asia and / or Europe. Accidentally introduced prior to 1983, probably in association with ornamental fish from Europe. This species has had a major detrimental impact and has the potential to become a serious pest in fish farms. *A. japonicus* has been recorded from a number of localities in the western and central Transvaal.

Research: Good. Kruger et al (1983) conducted a detailed study of infestations in Barberspan and Bloemhof dam.

SPECIES DATA

Distinguishing characteristics: A 3 to 8 mm long flattened transparent crustacean which attaches loosely to the skin of its host. Abandoned attachment sites are often marked with a red circular depression and a marginal welt of raised tissue. Carapace flattened and laterally extended (horse-shoe shaped) to cover the flattened abdomen. Trunk cylindrical. Head appendages ventral and modified to form suckers for attachment. Each thoracic segment has a pair of bifid swimming legs. The males are similar to the females but legs 2, 3 and 4 are modified for clasping and the testes are found on the abdominal lobes (Fryer 1982).

Date and purpose of introduction: An accidental introduction prior to 1983. There is no record of their presence in southern Africa in Barnard's (1955) paper on freshwater Crustacea. First recorded by Kruger et al (1983). Probably associated with ornamental fish and cyprinid (especially carp) introductions from Europe (Basson personal communication).

Native range: Uncertain. *A. japonicus* has been associated with carp and may have originated in Asia (Paperna 1980) although there is a possibility that carp also originated from Europe (Balon 1974).

Southern African distribution: Bloemhof dam (27°40´S 26°0´E) and Barberspan (26°35´S 25°35´E) (Kruger et al 1983). Van As and Basson (1984) list the following localities at which *A. japonicus* has been found in southern Africa: Roodeplaat dam, Bloemhof dam, Barberspan, Boskop dam, Hartbeespoort dam and the Provincial Fisheries Institute, Lydenburg.

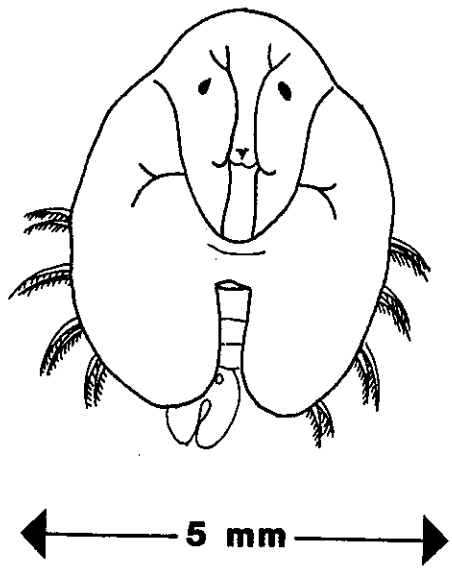
Habitat preferences: Temporary parasites of a wide variety of cyprinid, clariid, cichlid and salmonid fishes. In southern Africa *A. japonicus* has been recorded on the following species: *Barbus aeneus, B.kimberleyensis, Clarias gariepinus, Cyprinus carpio, Labeo capensis, L. umbratus* and *Tilapia sparrmanii* (Kruger et al *1983), Oreochromis mossambicus, Barbus marequensis, B. mattozi* and *Parasalmo mykiss* (van As and Basson 1984).

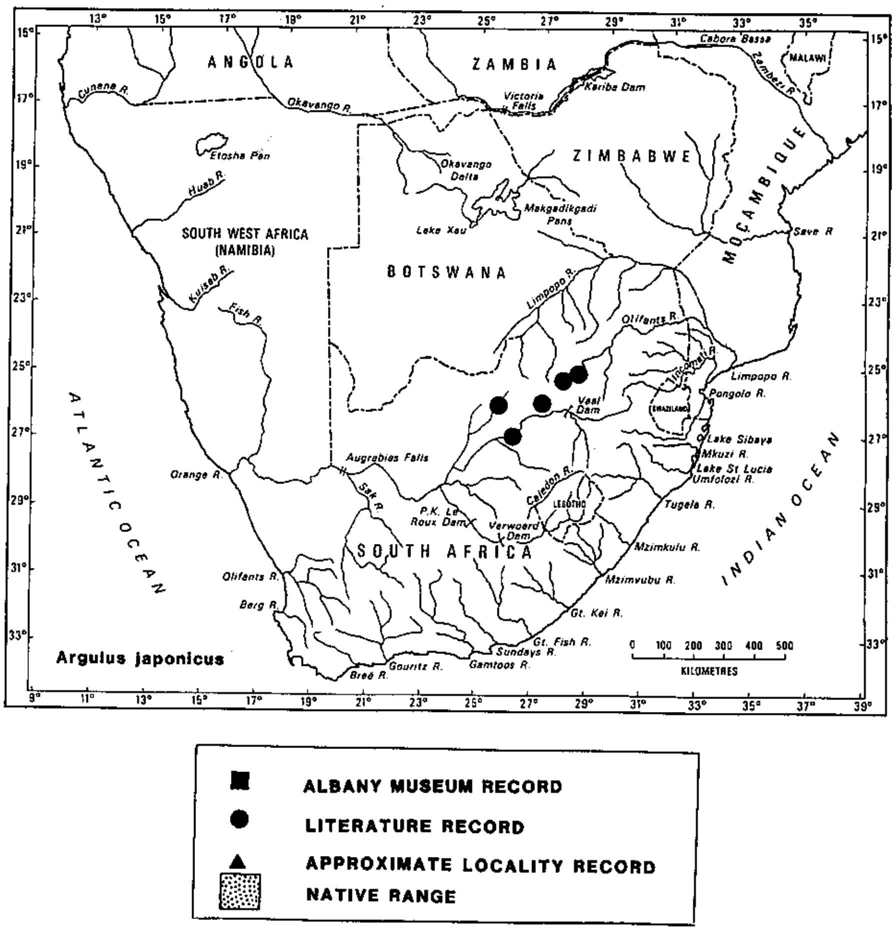
This external parasite has no specific attachment site on the host's body but is usually less prevalent on the head (Kruger et al 1983). *A. japonicus* has a preference for lacustrine rather than riverine conditions (Fryer 1968) and is tolerant of hypoxic environments (Paperna 1980).

Breeding: The sperm are stored in the spermathecae of the female. A single mating is sufficient to fertilise all

ARGULUS JAPONICUS Thiele 1900

FIGURE 6. The fish louse *Argulus japonicus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





the eggs ever laid (Fryer 1982). The female leaves the host to oviposit on a firm substratum. The developing young pass through a number of copepoid and nauplioid stages during development. All stages are capable of free swimming but are, by preference, parasitic. The female produces 100 to 400 eggs at a time. The development rate of the eggs depends on temperature (hatching occurs after 12 days at 30°C and after 60 days at 15 C) (Paperna 1980).

Feeding: The fish louse attaches by means of suckers to the host. Attachment is assisted by hooks on the antennules and antennae. They suck up the body fluids of the fish, probably mucus and cellular detritus rather than blood (Fryer 1968). *A. japonicus* can crawl on the surface of the host. Usually each individual has more than one host in its lifespan.

Impact: Kruger et al (1983) reported that infection prevalences of all species collected at Barberspan and Bloemhof dam were greater than 90% except for *Clarias gariepinus* (infection prevalence 78% at Barberspan). As many as 250 individual parasites were found on a single host fish. The damage by a single individual is seldom great. Heavy infestations (which usually occur in crowded conditions such as in fish ponds) may result in growth retardation and sometimes in death. Secondary infections from fungi and bacteria may result from wounds initially made by this parasite. *A. japonicus* may therefore pose a serious problem to fish farmers, but has also caused severe problems in natural waterbodies (eg in Bloemhof dam where some species are heavily infested; Kruger et al 1983).

Control: Infections can only be effectively controlled in fish ponds and not in natural lakes. The chemical treatment of the parasite may also harm the host; as a result attempts have been made to control the free-swimming stages of the parasite. Successive applications of Lindane (a form of benzene hexachloride) resulted in resistant strains of *Argulus* species in Israel (Fryer 1968). These strains were also resistant to Endrin. *A. japonicus* was more successfully controlled in Israel through the use of biodegradable organophosphates such as Malathion, Dipterex (Dylox), Neguvon, or the commercial products, Masoten and DDVP. These were applied at a dose of 0,25 ppm to ponds (Paperna 1980). Fryer (1968) mentions the possibility of control of *Lernaea cyprinacea* through the introduction of some free-living copepods which feed on the nauplioid larvae. It may be possible that the larvae of *A. japonicus* could be controlled in a similar way.

Research recommendations: The possibility of biological control by free-living copepods needs to be investigated.

Remarks: Although this species was originally a parasite of cyprinids it has now been found on a wide variety of indigenous species of other families (Kruger et al 1983).

REFERENCES

Barnard (1955); Balon (1974); Fryer (1968, 1982); Kruger et al (1983); Paperna (1980); van As and Basson (1984).

Personal communications: C C Appleton; L Basson.

CHERAX TENUIMANUS (Smith 1912)

marron | **alien, detrimental, potential impact**
varswater kreef

Phylum: Arthropoda - arthropods
Class: Crustacea - crabs, crayfish, prawns and relatives
Family: Parastacidae

SUMMARY

Status: An alien freshwater crayfish imported from Australia for aquaculture purposes. This species was accidentally released into the Buffalo River but may have become locally extinct. Marron are kept in captivity in various aquaculture enterprises around the country and have the potential to become a serious pests if released into some natural waters in certain areas of the Cape.

Research: Good. The biology and aquaculture potential of this species has been studied in Australia by Morrissy (1976) and in southern Africa by Cubitt (1985), Read (1985) and Walmsley (ed) (1988). The potential impact of marron on natural ecosystems in southern Africa has been investigated by Coetzee (1985) and Bok (1988)

SPECIES DATA

Distinguishing characteristics: A moderate-sized robust freshwater crayfish which can reach a mass of 2,7 kg (Cubitt 1985). The rostrum ends in a sharp spine and is deeply excavated in the middle, with strong upstanding lateral keels. Lateral serrations are present on either side of the rostrum. The carapace has a distinct prominence running back from the postorbital spine (Smith 1912).

Native range: South-western western Australia (Cubitt 1985).

Date and purpose of introduction: Imported into Natal in circa 1976 by a private fish farmer for the purpose of aquaculture (Bourquin et al 1984). The first successful marron farm was established near George in 1982. This farm later moved to the Wilderness area where it became established as the Amanzi Marron Farm (Walmsley 1988). In 1986 advertisements from this farm offered live marron for distribution to farmers (Anon 1986b). Recent reports however indicate that the Amanzi Marron farm is no longer in operation (Walmsley 1988)

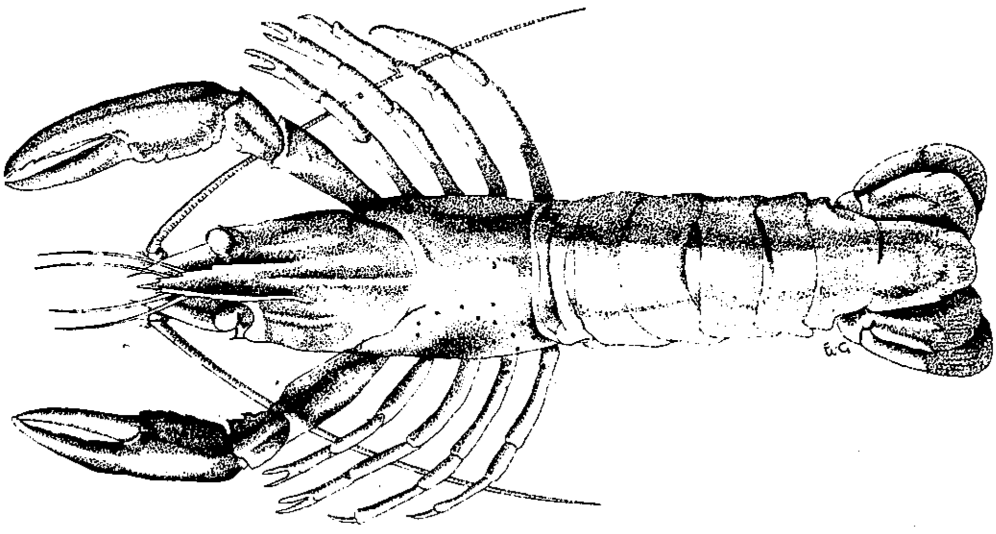
Marron are also kept in captivity at the Pirie Hatchery (Kingwilliamstown) from where a number escaped into the Buffalo River in circa 1983/84 (O'Keeffe and Read personal communication).

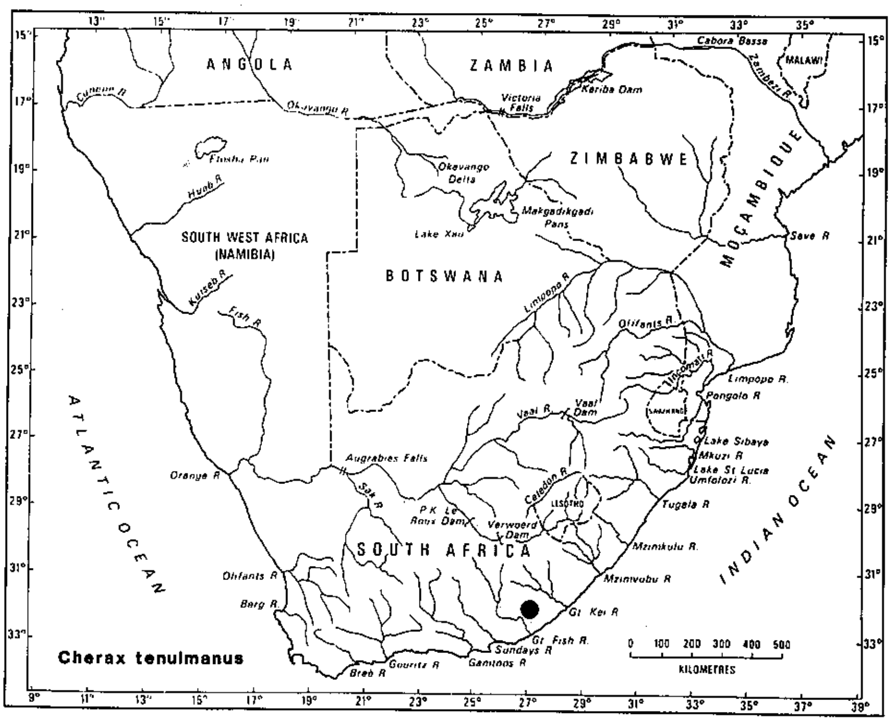
Southern African distribution: The populations kept in captivity are mentioned above. Marron escaped into the Buffalo River in circa 1983/84 (Read and O'Keeffe personal communication) and the remains of a marron carapace was found in the vicinity of Maden dam in 1986 (Palmer personal communication). Marron have also recently (in 1988) been recorded in the Buffalo River below the outlet furrow from the Pirie Hatchery (approximately 500 m downstream of Rooikrans dam). Specimens were not captured but the marron were clearly seen by three researchers in the field (Bok personal communication). It is not certain whether or not marron have established breeding populations in the Buffalo River. Their presence may be the result of periodic escapes from the Pirie Hatchery which does not appear to be sufficiently secure to prevent such escapes (Bok personal communication).

Habitat preferences: A freshwater crayfish which can tolerate salinities of 50% seawater (17000 ppm) (Cubitt 1985). Normally found in the deeper areas of permanent streams and rivers (Coetzee 1985). Marron are described by Read (1985) as being a "temperate" species. Although the minimum and maximum lethal limits are

CHERAX TENUIMANUS (Smith 1912)

FIGURE 7. The marron *Cherax tenuimanus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■ ALBANY MUSEUM RECORD

● LITERATURE RECORD

▲ APPROXIMATE LOCALITY RECORD

NATIVE RANGE

8 C and 30 C respectively, growth ceases below 12 C and the optimum temperature is about 17 C (Cubitt 1985). Coetzee (1985) noted that adults were less vulnerable to low temperatures than juveniles.

Marron cannot tolerate very low oxygen tensions and, since it is a bottom-dwelling species which cannot swim to the surface, it cannot survive in deep ponds in which oxygen concentrations at the bottom of the pond are very low. Because of this requirement the optimum pond shape is one with gradually sloping sides so that there is a large area of shallow water to which the marron can crawl should oxygen levels become depleted. They cannot survive in nutrient-enrinched conditions (Cubitt 1985). Marron prefer acidic waters and have been bred in South Africa at pH levels between 5 and 6,5 (Safriel and Bruton 1984).

Breeding: Marron breed in spring (September/October). The females carry their eggs attached to the pleopods (swimmerets) beneath the tail. After hatching the larvae pass through two developmental stages and remain attached to the pleopods. Twelve to sixteen weeks after spawning free-swimming juveniles which resemble the adults are released. Marron usually start spawning in their second year (Safriel and Bruton 1984). The number of eggs produced per female depends on the size of the adult and can vary between 95 and 900 young (Coetzee 1985). All stages of the life cycle are completed in fresh water (Cubitt 1985).

Under culture conditions marron can attain 2 to 3 tons/ha/annum (Read 1985) and in natural conditions in Australia they are known to attain productivities of 400 to 600 kg/ha/annum (Bell personal communication).

Feeding: An omnivorous species. In its natural environment marron feed on riverine detritus derived mainly from leaf litter. The detritus is made up of decomposed plant material and micro-organisms (Read 1985). Marron also feed on water plants (Coetzee 1985).

Behaviour: Marron are known to be aggressive and territorial. They can move about on dry land but appear to be less inclined to leave the water than freshwater crabs such as *Potamonautes perlatus*, an indigenous species which occupies a similar niche in southern Africa (Coetzee 1985). Marron normally hide under stones and tree stumps during the day and are able to move very rapidly when threatened, by means of a sudden contraction of the tail (Coetzee 1985).

Impact: It is not certain whether marron have established populations in the Buffalo River. The specimen seen by Dr Bok may have been a single chance escapee from the hatchery and no specimens of marron have been encountered during extensive collecting expeditions (for small stones-in-current invertebrates) by Dr J O'Keeffe in the Buffalo River. This however is not an indication that marron are not present in the river as the apparatus used by Dr O'Keeffe is not suitable for the capture of marron.

After a few specimens were kept in outdoor ponds at the Jonkershoek Hatchery for 2 years Coetzee (1985) concluded that this species would be able to survive in the western Cape should it escape into natural waters. Since marron can tolerate high salinites it would also be expected to invade the upper reaches of estuaries (Coetzee 1985).

It is difficult to make predictions concerning the possible impact of alien species should they become established in new environments, but considering its size, breeding habits and the effects which closely related species have had on the environment into which they have been introduced, there is a danger that the introduction of *C. tenuimanus* could be a threat for the following reasons:

1. Another species of freshwater crayfish *Procambarus clarkii*, which is also a detritivorous species which sometimes feeds on macrophytes, has been linked to the dramatic decline in the fishery in Lake Naivasha in Kenya. It was noted that *P. clarkii* had destroyed the aquatic vegetation, thereby decreasing food resources and destroying the habitat for other species (Hart 1983; Bruton personal observation). Since *C. tenuimanus* has a similar diet there is a danger that this species may have a similar environmental impact to that of *P.* clarkii.

2 There is a possibility that marron will eat the eggs and young of other aquatic animals. Alien crustaceans imported into the USA pose a threat to indigenous fish for this reason (Coetzee 1985).

3 Considering its large size and aggressive behaviour, *C. tenuimanus* would be expected to compete with indigenous decapod species such as shrimps and crabs. After conducting experiments on this species in captive conditions, Coetzee (1985) concluded that marron would probably compete with and oust the indigenous crab,

Potamonautes perlatus. He also noted that *C. tenuimanus* may be kept under control by indigenous predators such as otters and mongeese, but this is not certain. Because of their sedentary diurnal behaviour and efficient escape tactics (described above) marron may prove to be efficient at avoiding predators. Should the marron displace the indigenous crab *P. perlatus* from sections of a river, and at the same time succeed in avoiding predation by indigenous predators, it could have a detrimental effect on a number of organisms higher in the food chain. *P. perlatus* is eaten by several freshwater fishes, more than 20 species of birds (including the giant kingfisher which feeds extensively on crabs) and at least five mammals. These species could all be adversely affected by the introduction of marron (Coetzee 1985).

Bok (1988) however reports that marron are susceptible to predation by otters and cormorants. Taking this into consideration as well as its lack of tolerence to high temperatures and low dissolved oxygen levels, Bok considers marron to have a low invasive potential in southern Africa.

4 Since marron are known to be susceptible to fungal infection they may act as a carriers of diseases (Bragg 1986). Coetzee (1985) points out that *C. tenuimanus* is resistant to a number of diseases. This high resistance may enable this introduced species to act as an effective vector of diseases which may have a debilitating effect on indigenous species which are more susceptible. This was the case when the plague fungus, *Aphanomyces astaci*, was introduced together with *Pacifastacus lenuisculus*, the red signal crayfish, from the USA into Europe. The parasite had a devastating effect on the indigenous freshwater crayfish, *Astacus astacus*, which is highly susceptible to the disease (Bourquin et al 1984).

Marron from the Amanzi Marron Farm were found to carry a number of different parasite species which have not as yet been identified (Bok personal communication).

Control: It is unfortunate that marron were imported into southern Africa before their potential impact had been fully assessed. The restrictions which are now in force in southern Africa appear to be inadequate considering that this species has already escaped into a natural water-course.

If importations are to be made they should only be from certified suppliers of disease-free animals. These regulations apply in Britain (Bourquin et al 1984).

The Cape Department of Nature Conservation stipulates that permits are required in order to keep this species in captivity. Permits will only be issued after an official has inspected the installation which must be enclosed in such a way that marron cannot escape even during flood conditions. The transport of live animals is also subject to control. Newly imported animals must be kept under quarantine to prevent the introduction of diseases (Bell personal communication). In the Transvaal the transport of live marron is forbidden.

Research recommendations; A survey of the Buffalo River needs to be undertaken with the specific purpose of sampling marron in the area below the Pirie Hatchery.

A careful quantitative study needs to be performed in properly enclosed outdoor pools on the biology and invasive ability of marron in southern Africa, and on the extent of their likely competition with local decapod species. The burrowing behaviour of marron also needs to be studied.

Remarks: Because of its large size, its high processing yield (amount of edible flesh recovered from the total mass of the animal) and its tolerance of a wide range of salinities marron are considered to be a desirable species for aquaculture. Marron were rated as a high potential candidate species for aquaculture in South Africa by Safriel and Bruton (1984). They could provide a viable alternative to marine crayfish, over which they have a number of advantages as culture animals, especially the lack of a pelagic larval stage. Marron feed mainly on plant detritus which is low on the food chain (and is therefore cheap and easy to obtain). They also have the highest processing yield of any freshwater crayfish and their popularity in Australia has increased markedly in recent years (Safriel and Bruton 1984).

Although there are about 300 species of freshwater crayfish worldwide, none are indigenous to Africa. The decision whether or not to allow the continued importation of marron into South Africa and adjacent states is a classic dispute between the benefits of short-term economic gain and the possibility of longterm ecological disruption. The best solution would be to permit the importation of marron under strict control, and to place the onus on the importer to eradicate any specimens which escape and be liable to severe penalties should the alien species establish breeding populations in natural waters.

REFERENCES

Anon (1986b); Bok (1988); Bourquin et al (1984); Bragg (1988); Cubitt (1985); Coetzee (1985); Hart (1983); Morrissy (1976; Read (1985); Safriel and Bruton (1984); Smith (1912); Walmsley (1988).

Personal communications: E Bell; A H Bok; J O'Keeffe; A Palmer; G Read.

CARCINUS MAENAS Linnaeus 1758

European shore crab
Europese strand krap

alien, detrimental, potential impact

Phylum: Arthropods - arthropods
Class: Crustacea - crabs, crayfish, prawns and relatives
Family: Portunidae

SUMMARY

Status: An alien crab accidentally introduced prior to 1983. Their distribution is restricted to Cape Town harbour and the Bloubergstrand on the western Cape coast. *C. maenas* has the potential to become a major pest if it is translocated to suitable quiet harbours and estuaries.

Research: Good. Joska and Branch (1986) have studied the feeding behaviour in the laboratory and are keeping distribution records.

SPECIES DATA

Distinguishing characteristics: A moderate-sized shore crab which reaches a carapace width of about 10 cm (Barrett and Younge 1972). The dorsal surface is grey-green, often with two semicircles of white dots on either side. Ventral surface pale yellow, sometimes an orange-red. Juveniles variable in colour. This species can change colour to match the surroundings. Anterior edge of carapace with a series of spines, three between the eyes and five on each side between eyes and outer edge of the carapace. Terminal segments of the last pair of walking legs flattened. Males and females similar but males have larger chelae (Joska and Branch 1986).

Date and purpose of introduction: First recorded in 1983. An accidental introduction probably associated with oil rigs which first came to southern Africa in 1969 (Joska and Branch 1986).

Native range: Europe (Joska and Branch 1986).

Southern African distribution: There is a well-established population at the Table Bay docks. This species has recently been caught at Bloubergstrand, 15 km north of Cape Town on the west coast (Joska and Branch 1986; Hodgson personal communication).

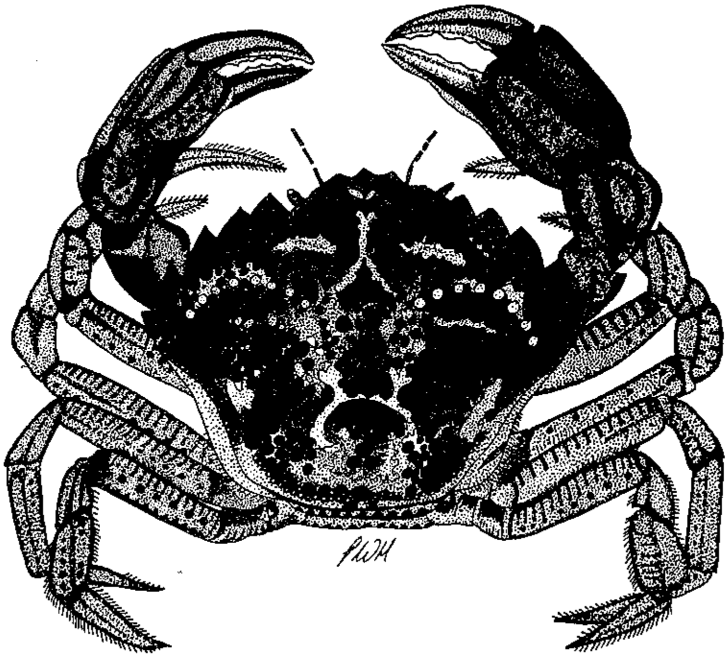
Habitat preferences: In Europe this species occurs among intertidal and subtidal rocks except those subject to extreme wave action. Also common in estuaries and calm sandy bays. *C. maenas* lives and reproduces over a wide range of temperatures, salinities and depths (Joska and Branch 1986).

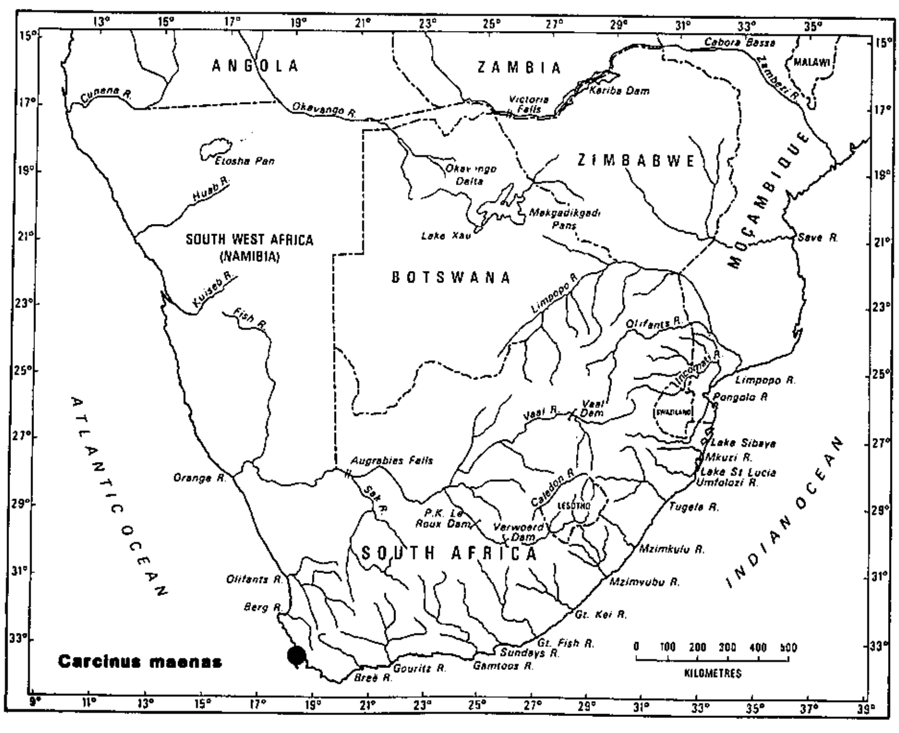
Breeding: Females are in berry (carrying eggs) between June and December. Produces 200 000 eggs at a time (Joska and Branch 1986). They practice internal fertilisation with the pleopods on the abdomen of the male being modified to form a hollow tube which functions as a penis. The eggs hatch into planktonic zoeae larvae which float in the ocean and later metamorphose into megalopa larvae before settling and metamorphosing into adults. *C. maenas* can disperse rapidly over a wide range (Branch and Branch 1981). In south east Australia this invasive species took 80 years to spread 500 km along the coast (Joska and Branch 1986).

Feeding: This shore crab preys on a wide range of organisms and comes upshore with the rising tide to forage over most of the intertidal zone (Joska and Branch 1986). In controlled laboratory experiments they consumed the following indigenous molluscs: the black mussel (*Choromytilus meridionalis*), ribbed mussel (*Aulacomya ater*), three species of periwinkels (*Oxystele variegata, O. tigrina* and *O. silensis*), small barnacles (*Notomegabalanus aigcola*) and small alikreukels (*Turbo sarmaticus*) (Joska and Branch 1986).

CARCINUS MAENAS Linnaeus 1758

FIGURE 8. The European shore crab *Carcinus maenas* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■ ALBANY MUSEUM RECORD

● LITERATURE RECORD

▲ APPROXIMATE LOCALITY RECORD

NATIVE RANGE

Behaviour: Feeds at night (Joska and Branch 1986).

Impact: Since this species is an aggressive predator it can be expected to have some impact on shore life in the intertidal zone and has become a pest in other countries which it has invaded. In the USA it was regarded as a threat to the soft-clam industry. However introduced populations in Australia and New Zealand have not thus far proved to be a major threat to local populations of molluscs. Its establishment is likely to be restricted to sheltered harbours, dock areas and estuaries. *C. maenas* may prove to be a pest in areas such as Langebaan Lagoon and the Knysna estuary (Joska and Branch 1986).

Control: No practical method of eradication is known without adversely affecting indigenous organisms (Joska and Branch 1986).

Research recommendations: The impact of this crab on indigenous animals needs to be established. Any increases in range should be carefully monitored. Contact should be retained with Australian researchers in order to benefit from their experience.

Remarks: *C. maenas* was regarded as a delicacy in Europe in the last century and is still eaten there (Joska and Branch 1986). It would however be inadvisable to initiate aquaculture ventures with this species due to its potential to invade local estuaries and lagoons.

REFERENCES:

Barrett and Younge (1972); Branch and Branch (1981); Joska and Branch (1986).

Personal communication: A N Hodgson.

CYRTOBAGOUS **SALVINIAE** Calder and Sands 1985

salvinia weevil
salvinia kalander

Alien, beneficial, major impact

Phylum: Anthropoda - anthropods
Class: Insecta - insects
Family: Curculionidae -weevils

SUMMARY

Status: A small aquatic weevil introduced in 1983 and 1985 which has had a major beneficial impact in the control of the alien aquatic weed *Salvinia molesta* in the Caprivi.

Research: Excellent. Detailed studies on the feeding and population dynamics have been done in Australia where *C. salviniae* has been introduced for weed control (Thomas and Room 1986). Schlettwein (1985a, 1985b) has studied the impact of this species in eastern Caprivi.

SPECIES DATA

Distinguishing characteristics: Curculionid beetles are characterised by a globular head produced into a slender rostrum which is used to feed on deep-lying plant tissues. Body well sclerotised and hard. The larvae are C-shaped, whitish and usually legless grubs. Weevils which live exclusively on aquatic plants belong to the subfamily Erirhininae (Oberprieler and Louw 1985). For a detailed description of the species see Calder and Sands (1985) and May and Sands (1986).

Native range: South eastern Brazil (Thomas and Room 1986).

Date and purpose of introduction: Introduced to control *Salvinia molesta* which has become a pest plant in the eastern Caprivi area and elsewhere in southern Africa. Three major introductions were made:

1. Specimens associated with *Salvinia molesta* plants were obtained from Australia and introduced into the Caprivi area in 1983 (Schlettwein personal communication, Schlettwein 1984a).

2. Releases were made into the Letaba River in 1985 jointly by the South African Directorates of Water Affairs and Agriculture (Cilliers personal communication; Schlettwein personal communication).

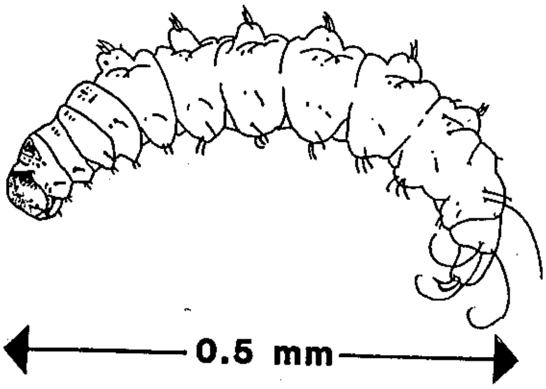
3. Introduced in early 1986 to Xini lagoon south of the Moremi Game Reserve, Okavango Delta (Merron 1987).

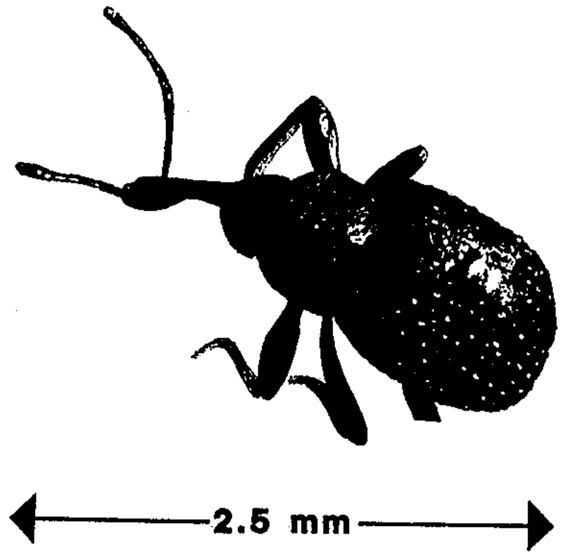
Southern African distribution: *C. salviniae* established at numerous release sites in Caprivi: along the Chobe River, at Lisikili near Katima Mulilo, at numerous points in the floodplains at the confluence of the Chobe and Zambezi Rivers, in the north-eastern arm of Lake Liambezi, and at Balelwa and Tjoi Sitwa in the western Caprivi (South West Africa Water Quality Division 1985). Populations in the northern Transvaal have become established (Cilliers personal communication). Also present in the Xini Lagoon south of Moremi Game Reserve (Merron 1987).

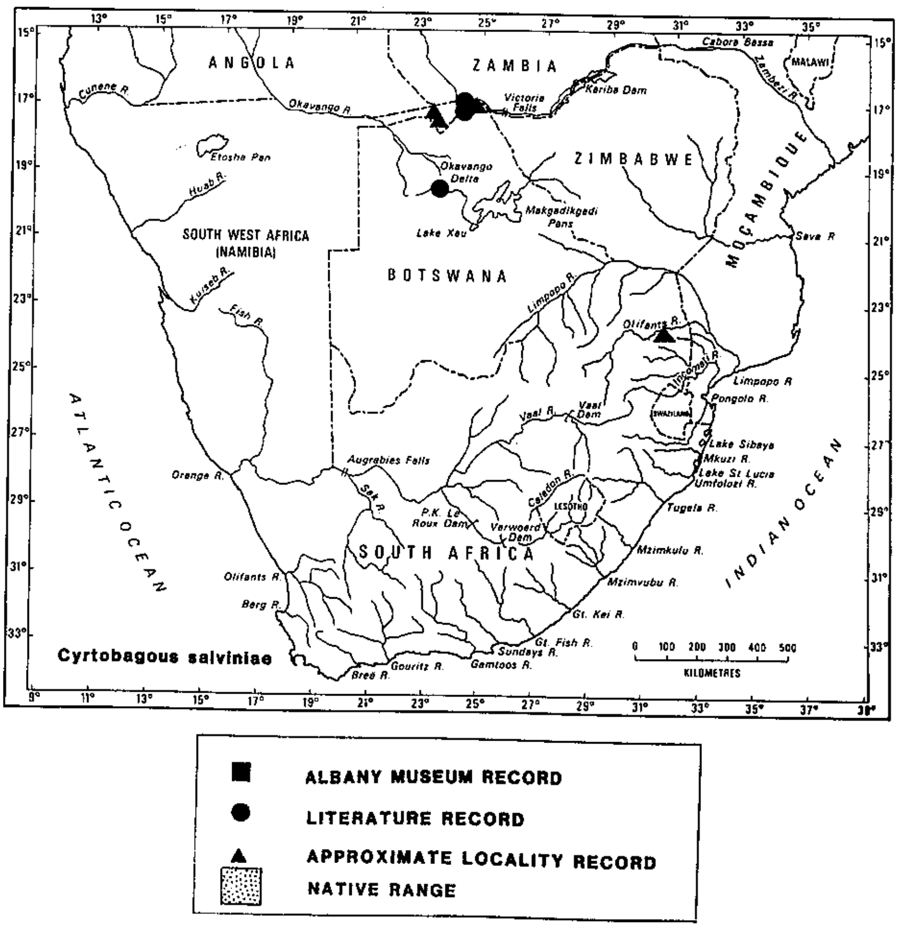
Habitat preferences: This species is highly specific at all stages of the life cycle to host plants of the genus *Salvinia* . *C. salviniae* is adversely affected by low levels of nitrogen. There is evidence that damage to the plant by the feeding activities of beetles increases nitrogen levels in the remaining tissues. This means that at low nitrogen levels a critical density of insects will ensure the establishment of the insect. Populations below this

CYRTOBAGOUS SALVINIAE Calder and Sands 1985

FIGURE 9. The salvinia weevil *Cyrtobagous* species with the distribution of *C. salviniae* southern Africa (excluding Zimbabwe and Mozambique)







critical level may die out due to lack of nitrogen. For populations above the critical level the overall impact of a large number of insects feeding at once on the same plant results in an increase in nitrogen levels in plant tissues which should be sufficient for the nitrogen demands of insects feeding on the same plant at a later stage. It may be necessary to apply fertilisers at release sites until critical population densities are reached in order to ensure that the insect populations became established. (Thomas and Room 1986).

Breeding: A holometabolous insect. The eggs only hatch at temperatures above 19°C (Thomas and Room 1986).

Feeding: Feeds on *Salvinia molesta* plants. The larvae tunnel through the rhizomes and the adults feed selectively on the growing points (Thomas and Room 1986).

Impact: *C. salviniae* has become established at numerous release sites in Caprivi and effectively controls *Salvinia molesta* at these sites (Schlettwein 1985a, 1985b). It is expected that both *C. salviniae* and the host salvinia plants will continue to occur in low numbers in the area (Giliomee 1986). Host specificity tests carried out so far indicate that *C. salviniae* only feeds on plants of the genus *Salvinia* (Thomas and Room 1986) and it therefore seems unlikely to cause any significant environmental damage to other species. The tunnelling activities of the larvae in the rhizomes destroys vascular tissue and vegetative propagation is hampered by the feeding of the adults on growing points. This is the only means of propagation as the plant is sterile (Thomas and Room 1986). Eventually the plant dies and sinks to the bottom of the lake. This could result in a release of nutrients into the water column with a subsequent bloom of algae, but was not observed in Lake Moondarra in Queensland, Australia, where *Salvinia* was successfully controlled by *Cyrtobagous* (Room et al 1981).

Since *C. salviniae* cannot survive at temperatures above 19°C it is unlikely to be an effective means of control of *S. molesta* in colder areas. The plant continues to grow at 10°C and can survive light frosts (Thomas and Room 1986).

The impact of *C. salviniae* on *Salvinia molesta* at the release sites in the northern Transvaal has not as yet been assessed (Cilliers personal communication).

The *Salvinia* infestation in the Okavango Delta has been effectively controlled through a combined programme involving the use of *Cyrtobagous salviniae*, the isolation of affected lagoons and extensive pumping to dry out lagoons (Anon 1986). There have been no further reports on population levels of *C. salviniae* in the area.

Control: *Cyrtobagous* is a beneficial biocontrol agent which does not, at this stage, need to be controlled.

Research recommendations: It is essential that there is careful monitoring of *C. salviniae* populations in order to update distribution records, assess the effectiveness of control measures on *S.molesta* and to monitor any possible unforeseen harmful effects on the environment (see also remarks on *C. singularis*).

Additional research is necessary on the nitrogen requirements of *C. salviniae* to facilitate the introduction of this species into low-nitrogen areas.

Remarks: *Salvinia molesta* spread to the Chobe from the Zambezi system in the 1950's and by 1972 was found to occur continuously from the Zambezi to the Chobe with extensive mats established on Lake Liambezi and in the Linyandi River. This weed has proved to be a serious pest as it leads to rapid terrestrialisation, hampers stream flow, and creates blockages that affect flood levels (Schlettwein 1984b). Numerous attempts have been made to control *Salvinia* since the early 1970's which have either proved to be too costly (aerial spraying of herbicides) or were of limited success (introductions of *C. singularis* and *Paulinia acuminata*).

Differences in the feeding behaviour and population dynamics of *C. salviniae* and *C. singularis* account for the success and failure of these two species in controlling *Salvinia molesta*. In contrast to *C. salviniae*, the adults and larvae of *C. singularis* feed randomly on the exterior of the plant. This method of feeding does less damage to the plant. Populations of *C. salviniae* also tend to increase until the supply of food runs out whereas *C. singularis* populations appear to stop increasing at an earlier stage (Thomas and Room 1986).

REFERENCES:

Anon (1986); Calder and Sands (1985); Giliomee (1986); May and Sands (1986); Merron (1987); Oberprieler and Louw (1985); Room et al (1981); Schlettwein (1984a, 1984b, 1985a, 1985b); S W A Water Quality Division (1985); Thomas and Room (1986).

Personal communications C Cilliers; C Schlettwein.

CYRTOBAGOUS SINGULARIS (Hustache 1929)

Salvinia weevil
Salvinia kalander

alien, beneficial, minor impact

Phylum: Arthropoda - arthropods
Class: Insecta - insects
Family: Curculionidae

SUMMARY:

Status: An alien insect introduced since 1972 for the biological control of Kariba weed (*Salvinia molesta* and *S. auriculata*). *C. singularis* established breeding populations but has had little effect on the spread of the target species.

Research Excellent. Schlettwein has studied the distribution and impact of this species in the Caprivi area (Schlettwein 1985a, 1985b).

SPECIES DATA

Distinguishing characteristics: The general characteristics of curculionid beetles are described in the account on *C. salviniae*. Calder and Sands (1985) provide a detailed description of the genus and species.

Native range: South America (Thomas and Room 1986).

Date and purpose of introduction: Introduced into southern Africa by the Plant Protection Research Institute to control *Salvinia* (Room et al 1981; Schlettwein 1984a, 1984b).

1. Approximately 1300 individuals were released at various points along the Chobe/ Linyandi Rivers between 1972 and 1974 (Schlettwein 1985a and b).

2. 250 adults were released at Pon Pon (approximately 10 km west of Shaile in the Caprivi area) in 1976 (Edwards and Thomas 1977).

Southern African distribution: *C. singularis* is established in the eastern Caprivi, along the Zambezi and its backwaters, throughout the Chobe/Linyandi system and on the Kwando at least as far north as Balelwa. Collections were made at the following localities: Ngoma (24 51 E 17 55 S); Lisikili (24 21 E 17 29 S); Linyandi (24 01 E 17 29 S); Muyako (24 31 E 17 46 S) (Schlettwein 1985b)

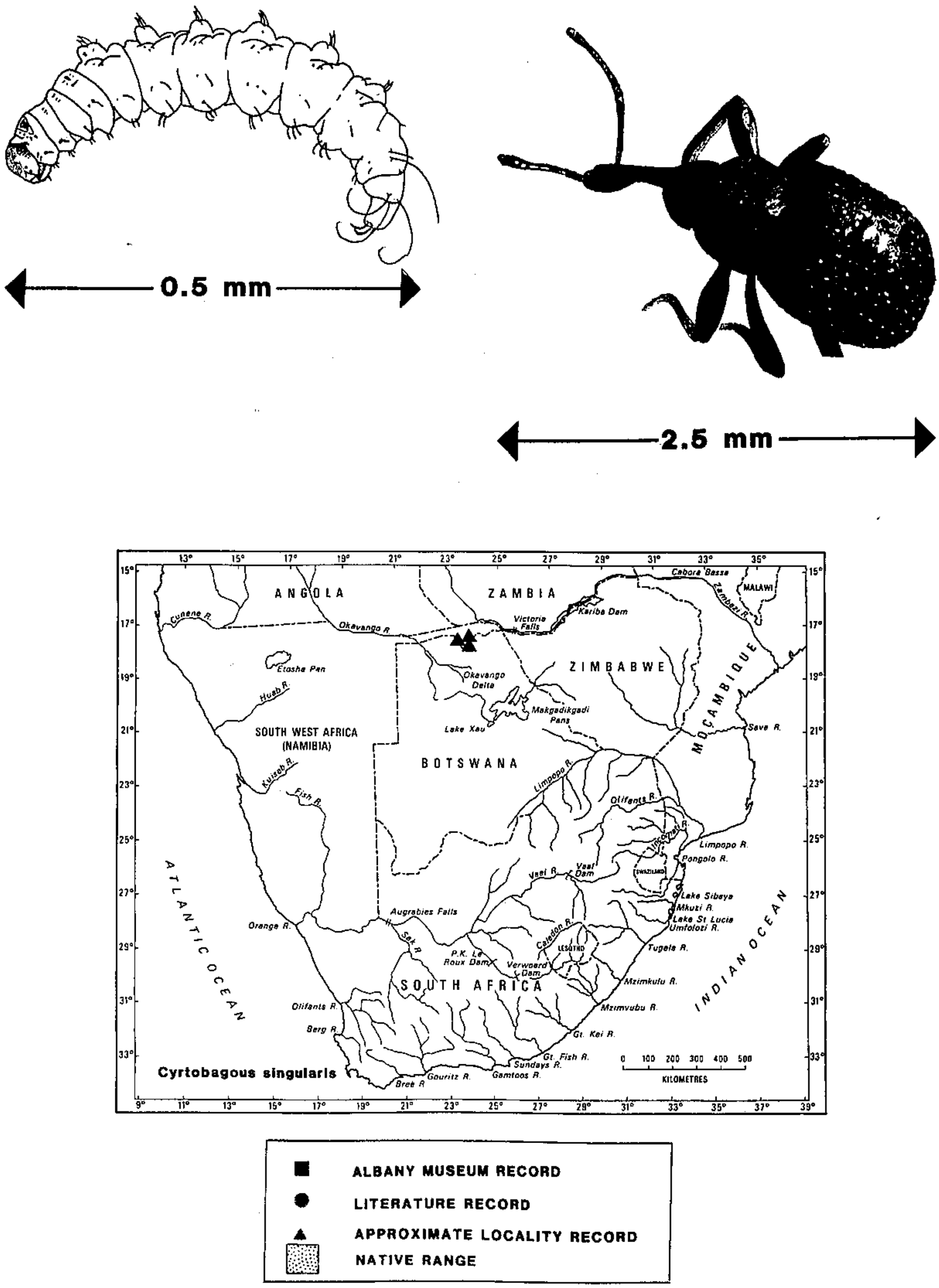
Habitat preferences: This species lives on floating aquatic macrophytes and is adversely affected by low levels of nitrogen in the host plant (Schlettwein 1985b; Thomas and Room 1986). Their optimum temperature range is from 20 to 32°C (Schlettwein 1985b).

Breeding: A holometabolous insect which has a larva, pupa and adult stage. The entire life cycle is spent on aquatic plants (Thomas and Room 1986).

Feeding: *C. singularis* only feeds on *Salvinia* species and appears to favour *S. auriculata* over other species, but also feeds on *S. molesta* (Schettwein 1985; Thomas and Room 1986). Both adults and larvae feed externally and randomly on all parts of the plant. This contrasts with the feeding habits of *C. salviniae* (Thomas and Room 1986).

CYRTOBAGOUS SINGULARIS (Hustache 1929)

FIGURE 10. The salvinia weevil *Cyrtobagous* species with the distribution of *C. salviniae* in southern Africa (excluding Zimbabwe and Mozambique)



Behaviour: Nocturnal (Edwards and Thomas 1977).

Impact: Schlettwein (1984a) reports that this species has become established in the wild but apparently has little effect on *S. molesta* infestations. The density of adults on plants was low (highest density: 8,9 adults/ kg wet weight of plant) compared with population figures of up to 101 adults / kg wet weight from Australia. This is probably because this species appears to have a preference for *S. auriculata* over *S. molesta* (Schlettwein 1985b).

C. singularis is not as successful as the congeneric *C. salviniae* in the control of *S. molesta* (Schlettwein 1985a and b; Thomas and Room 1986). There were reports that a particular strain of this species was successful in the control of *S. molesta* in Queensland, Australia (Room et al 1981). It was later discovered that this strain was actually a different species of weevil *C. salviniae* (Thomas and Room 1986).

It is not expected that *C. singularis* will have a negative impact on non-target organisms. The policy of the Plant Protection Research Institute regarding the introduction of alien species for biological control is discussed fully in the section on *Neohydronomus pulcellus*.

Control: In view of its host-specificity it is unlikely that it will be necessary to control the spread of *C. singularis*.

Research recommendations: Regular surveys of population levels should continue to be carried out in the Caprivi area.

REFERENCES

Calder and Sands (1985); Edwards and Thomas (1977); Room et al (1981); Schlettwein (1984a, 1984b, 1985a, 1985b); Thomas and Room (1986).

NEOHYDRONOMUS PULCHELLUS Hustache 1926

water weevil
water kalander

alien, beneficial, major impact

Phylum: Arthropoda - arthropods
Class: Insecta - insects
Family: Curculionidae

SUMMARY

Status: A small alien beetle imported from Australia in 1985 for the control of the water lettuce, *Pistia stratiotes*. Populations have become established in some pans in the Kruger National Park and have had a major beneficial impact in controlling the target plant species.

Research: Good. The host specificity and general biology has been studied by DeLoach et al ((1976) and Cilliers (1987) has been closely monitoring populations in the Kruger National Park.

SPECIES DATA

Distinguishing characteristics: Curculionid beetles are characterised by a globular head which is produced into a slender rostrum used to feed on deep-lying plant tissues. Body well sclerotised and hard. The larvae are C-shaped, whitish and usually legless grubs. Weevils which live exclusively on aquatic plants belong to the subfamily Erirhininae (Oberprieler and Louw 1985). *N. pulchellus* adult males are about 1,8 mm TL. The colour varies from brown to bluish-grey, and some individuals have spots on the dorsal thorax and elytra where patches of the dense covering of scales have rubbed off. The rostrum measures 0,44 mm from the apex to the eye and is nearly straight in the lateral aspect and strongly constricted ventrally at the base. Females are generally larger than males (TL 2,1 mm) (DeLoach et al 1976).

Native range: Their original range is uncertain, but probably includes South America. Presently has a worldwide distribution (Cilliers 1987).

Date and purpose of introduction: Introduced for the biological control of the pest waterweed, *Pistia stratiotes*. Imported in 1985 by the Plant Protection Research Institute from the CSIRO, Brisbane, Australia (Cilliers personal communication). Released into the Nhlangaluwe pan in the Pafuri area of the Kruger National Park in December 1985. Also released into the Dakamila pan in the same area at a later date (Cilliers 1987).

Southern African distribution: Established in the above-mentioned pans in the Pafuri area of the Kruger National Park (Cilliers 1987).

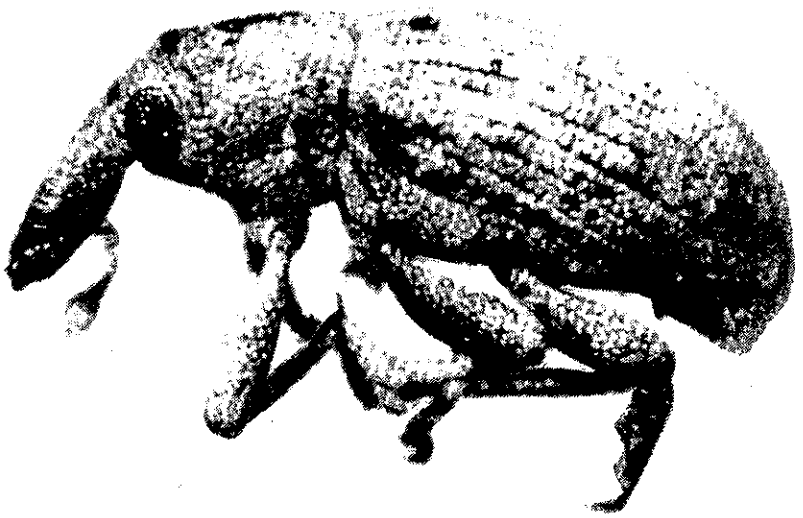
Habitat preferences: All stages of the life cycle are found exclusively on the water lettuce *Pistia stratiotes* (DeLoach et al 1976).

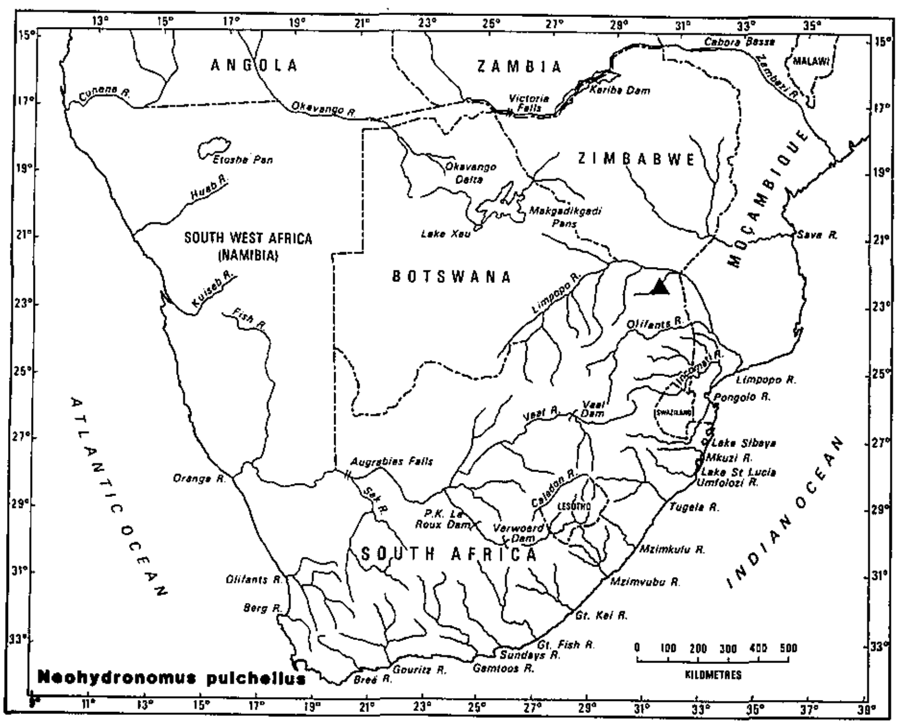
Breeding: A holometabolous insect which passes through larval and pupal stages during its life cycle. Females deposit eggs singly beneath the leaf epidermis, usually on the upper surface near the margins. The rate of deposition in the field is about 1 egg per female per day and eggs hatch in 3 to 4,2 days. Laboratory tests at 25 C indicated that there are three larval instars and that larvae take about 11 to 14 days to develop to pupae. The total generation time is about four to six weeks (DeLoach et al 1976).

Field tests indicated that the summer generation time was approximately the same as for laboratory animals kept at 25°C, but spring and autumn generations took longer to develop. It was also found that *N. pulchellus*

NEOHYDRONOMUS PULCHELLUS Hustache 1926

FIGURE 11. The water-weevil *Neohydronomus pulchellus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■	ALBANY MUSEUM RECORD
●	LITERATURE RECORD
▲	APPROXIMATE LOCALITY RECORD
░	NATIVE RANGE

had three generations per year. This species probably overwinters in the adult stage (DeLoach et al 1976).

Feeding: *N. pulchellus* is highly host specific to the waterlettuce *Pistia stratiotes*. Adult weevils make round holes in the leaf surface ca. 1,4 mm in diameter. They feed on both the thick central and basal part of the leaf as well as along the border of the leaf. The larvae feed internally on the leaves. It appears that the crown and roots of the plant are not favoured by this species (DeLoach et al 1976).

Impact: In laboratory tests on the feeding behaviour of *N. pulchellus* DeLoach et al (1976) found that plants with high weevil populations (128 weevils per plant) were severely damaged after only 3 days and died in about 9 days. There was a small amount of feeding on other plants species in the laboratory but this was in the nature of occasional "test bites" and there was no significant damage caused to these plants. In the field the maximum damage was caused to the plants during midsummer when population densities reached 250 to 600 adults per square metre and produced 1.6 feeding spots per square centimetre of leaf surface (DeLoach et al 1976).

In the Kruger National Park Cilliers (1987) found that by October 1986 (ie 10 months after their release) *N. pulchellus* had destroyed most of the *Pistia stratiotes* in Nhlangaluwe pan (Cilliers 1987). Due to its strong host specificity it is not expected that this species will have any harmful effects on non-target plants.

Control: *N. pulchellus* is a beneficial biocontrol agent which does not, at this stage, need to be controlled.

Research recommendations: There needs to be constant monitoring of population levels in areas where this weevil has been released.

Remarks: It is expected that the population from the Dakamila pan will eventually spread to the Sabie River which is also infested with *Pistia stratiotes* (Cilliers 1987).

REFERENCES

Cilliers (1987); DeLoach et al (1976); Oberprieler and Louw (1985).

Personal communication: C J Cilliers.

BEDEVA PAIVAE Crosse 1864

Australian oyster drill
Australiese oester boorder

alien, detrimental, potential impact

Phylum: Mollusca - snails, bivalves and relatives
Class: Gastropoda - slugs, snails and limpets
Family: Muricidae

SUMMARY

Status: An alien mollusc accidentally introduced from eastern Australia prior to 1968. Thus far only found in the Buffalo River mouth in East London harbour. This species has the potential to cause serious damage to oyster and mussel beds if it is translocated to new areas.

Research: Poor. There have not been any detailed publications on the impact of this species, but the population is being monitored by Mrs S Muller of the East London Museum.

SPECIES DATA

Distinguishing characteristics: A medium-sized brown gastropod snail with regular spiral ridges without main chords; axial ribs, 7 to 8 per whorl, form a distinct shoulder; entire surface covered by minute, crinkly axial threads. Brown, usually with a pale line around the shoulder. Aperture purplish-brown. Maximum length 27 mm (Kilburn and Rippey 1982). The males are smaller than the females (Black 1976).

Native range: South Australia (Kilburn and Rippey 1982).

Date and purpose of introduction: Probably introduced on the hull of a ship prior to 1968 (date of first South African record) (Kilburn and Rippey 1982).

Southern African distribution: Buffalo River mouth at East London (Kilburn and Rippey 1982).

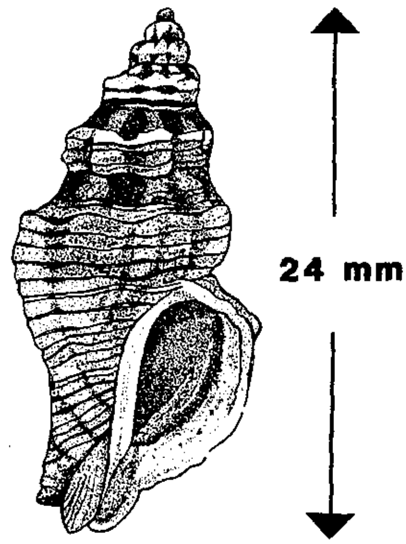
Habitat preferences: The population is concentrated around the low-water spring tide zone mostly on the underside of loose rocks where a surface layer of muddy silt is present (Kilburn and Rippey 1982). Since the native range extends from Tasmania to Queensland it appears to tolerate a fairly wide temperature range and Kilburn (personal communication) expects that it could survive as far north as Durban and as far west as False Bay. Prefers sheltered harbours or estuaries away from areas directly exposed to wave action (Muller personal communication).

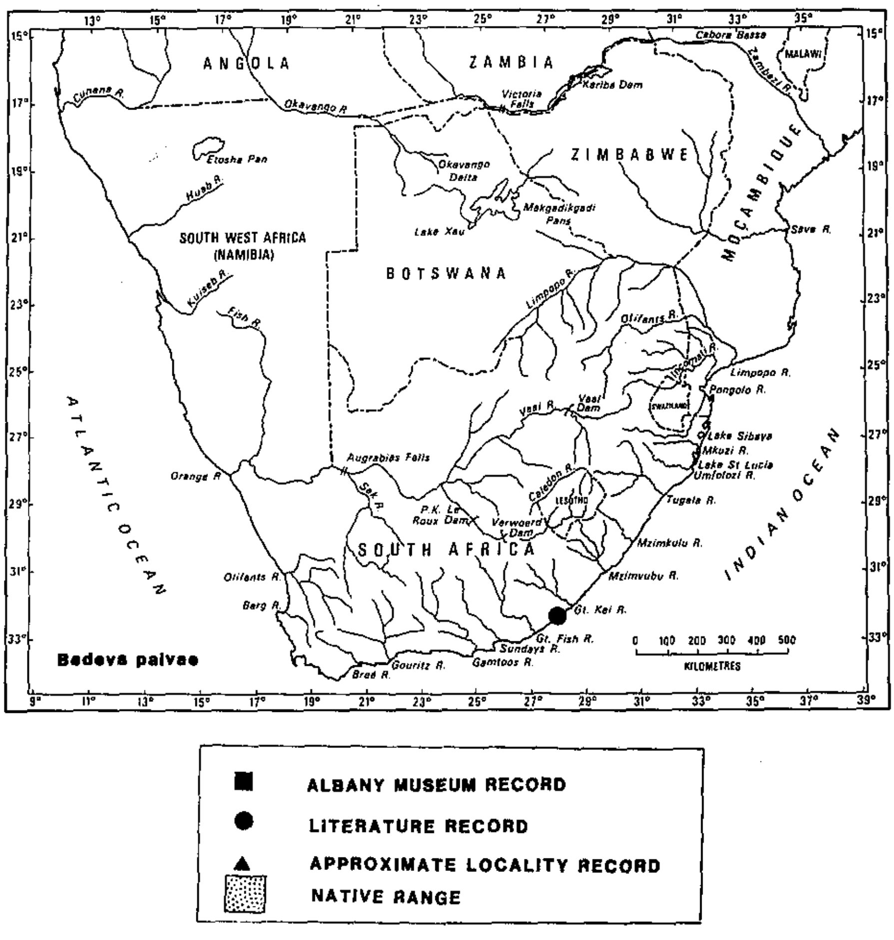
Breeding: Sexes separate. Internal fertilisation. The eggs are laid in capsules approximately two months after copulation (Black 1976). A pedal gland attaches the capsule to a substrate. The egg capsule contains 6 to 16 eggs (Black 1976) as well as numerous nurse cells which provide nourishment for the developing embryos (Kilburn and Rippey 1982). A specimen observed in captivity laid eleven capsules in eight days and returned to the site of original capsule-deposition to lay subsequent capsules (Black 1976). The development of the veliger larvae takes place inside the egg capsules (Black 1976). Hatching occurs after approximately one month (Kilburn and Rippey 1982).

Feeding: An active predator. Muricid snails normally feed on other molluscs and barnacles. To gain access to the soft tissue of the prey, secretions from the "accessory boring organ" at the anterior end of the foot are applied to the shell of the prey and appear to loosen the calcium crystals. The softened particles of shell are then scraped away by the radula. This process may take as long as several days (Kilburn and Rippey 1982). In its natural range they normally prey on oysters. In South Africa *B. paivae* was reported to be preying on

BEDEVA PAIVAE Crosse 1864

FIGURE 12. The Australian oyster drill *Bedeva paivae*, and its distribution in southern Africa (excluding Zimbabwe and Mozambique)





barnacles (Bourquin et al 1984) and gastropods such as *Haminoea alfredensis* and *Siphonaria capensis* (Kilburn and Rippey 1982).

Impact: Their impact on prey populations in the Buffalo River has not as yet been assessed. The population in the Buffalo River is extremely dense (up to 72 individuals per cubic meter) but shows no sign of spreading (Kilburn and Rippey 1982). They may however pose a threat to indigenous species if they are translocated to other estuaries. Their introduction into the Knysna and Swartkops estuaries could have a disastrous effect on the oyster culture industries. As this species has spread from Australia to South Africa we can also expect that it will eventually spread to the Knysna and Swartkops estuaries unless strict control measures are introduced.

Control: Since this species is restricted to the Buffalo River estuary and there are no free swimming stages in its life-cycle it may be possible to physically remove the whole population. Egg capsules can be collected and dried out. This method has been used to control *Urosalpinx cinera* (another oyster drill) in Britain (Hodgson personal communication). Applications of molluscicides are not always successful in controlling the target species and may also be damaging to the environment (Hodgson personal communication). However Kilburn (personal communication) considers this species to have the potential to be a very serious pest and recommends that any opportunity to destroy the founder population in the Buffalo River should be taken even if this means temporarily destroying local indigenous animals.

Research recommendations: Mrs S Muller of the East London Museum is currently involved in a detailed study of the biology and habitat preferences of this species as well as an assessment of its impact on the environment. The results of this study should indicate the best method of control.

Remarks: The possibility exists that this species could spread to other harbours in southern Africa by way of attachment to the hulls of ships. Alien "oyster drills" have posed serious problems to commercial oyster and mussel farming operations in Britain and have proved to be extremely difficult to control (Kilburn and Rippey 1982).

Recent floods in the Buffalo River have had a detrimental effect on the population of *B. paivae*. It remains to be seen whether recolonisation of the previous habitat will occur (Muller personal communication).

REFERENCES:

Black (1976); Bourquin et al (1984); Kilburn and Rippey (1982).

Personal communications: A N Hodgson; R Kilburn; S Muller.

LITTORINA SAXATILIS (Maton 1797)

lagoon snail
lagune slak

alien, detrimental, little impact

Phylum: Mollusca - molluscs
Class: Gastropoda - slugs, snails and limpets
Family: Littorinidae

SUMMARY

Status: An alien marine mollusc accidentally introduced from Europe prior to 1974. This species is apparently restricted to sheltered lagoons and has had little or no discernible impact on indigenous communities.

Research: Good. Hughes (1979) has performed surveys on the southern African populations.

SPECIES DATA

Recent synonyms: *Littorina ruddis* (Hughes personal communication).

Distinguishing characteristics: The Littorinidae are small aquatic or semi-aquatic molluscs which are usually found high up on the shoreline. Kilburn and Rippey (1982) describe the family characteristics as follows: Shell small, ovate-conical, base rounded. Surface smooth or with a spiral or nodular sculpture. For a detailed description of this species see Fretter and Graham (1962).

Native range: Europe, the Mediterranean and the West African coast (Hughes 1979).

Date and purpose of introduction: An accidental introduction, probably brought in by shipping. Dispersal via flotsam from estuaries further north on the West African coast is unlikely as the Benguella current flows in a northerly direction. Furthermore there are no suitable habitats for this species on the coast of South West Africa (Hughes 1979). In 1974 Day reported finding *L. saxatilis* in Knysna and Langebaan lagoons (Hughes 1979).

South African distribution: During an extensive survey carried out in 1975 along the coast from Lamberts Bay in the west to Cape Vidal on the east coast, *L. saxatilis* was only found in the Knysna and Langebaan lagoons (Hughes 1979).

Habitat preferences: *L. saxatilis* inhabits salt marshes in sheltered lagoons. In Knysna and Langebaan this species is found part way up the stems of *Spartina capensis* and among loose stones on man-made embankments. The tidal range of this species is centered around the mean high water neap zone. This species is absent from all rocky shores and open coastal areas (Hughes 1979).

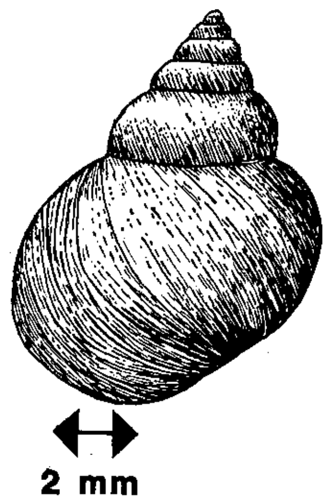
Breeding: Sexes separate, internal fertilisation. The embryos are retained in the brood pouch of the female. There are no free-swimming stages in the life cycle (Kilburn and Rippey 1982). Sexual maturity is reached at a shell length of 4 mm. Large females can carry approximately 220 embryos (Hughes 1979).

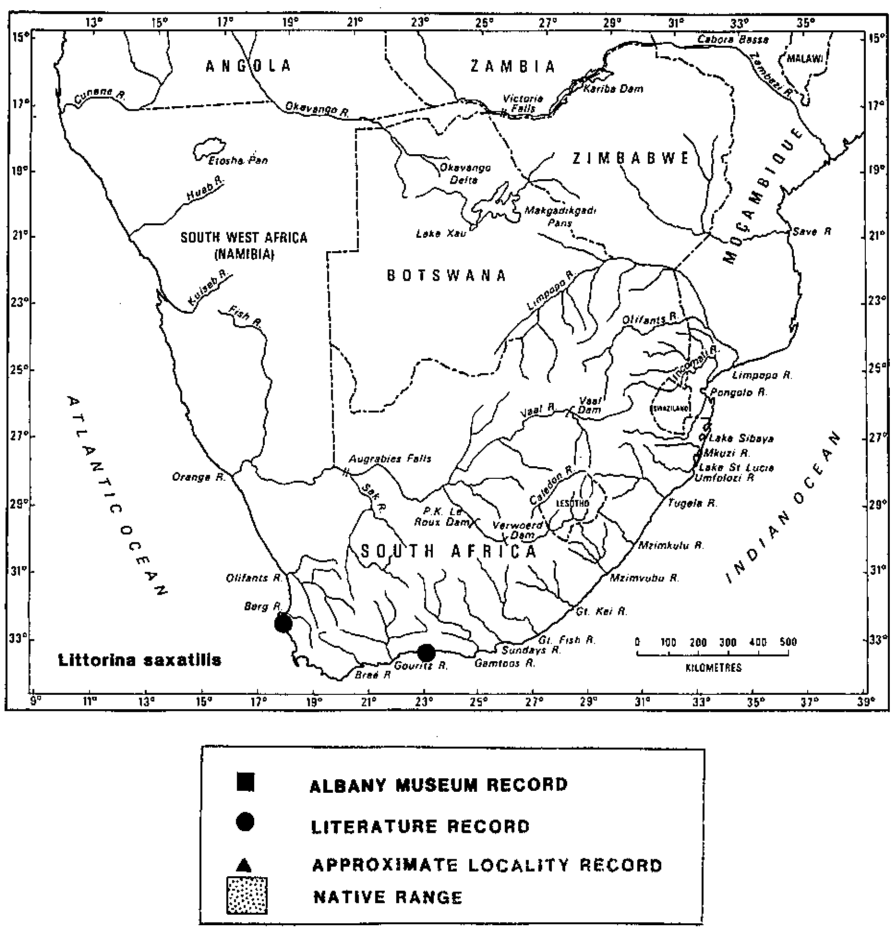
Feeding: Littorinid snails feed on encrusting algae (Kilburn and Rippey 1982).

Impact: This species is unlikely to have a significant negative impact on the environment since it does not disperse rapidly (there are no free swimming stages in the life cycle), and there are very few suitable habitats for colonisation along the Cape coast (Hughes 1979). Within its restricted habitat it is not envisaged that *L.*

LITTORINA SAXATILIS (Maton 1797)

FIGURE 13. The lagoon snail *Littorina saxatilis* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





saxatilis will do much damage since it is a sedentary animal which feeds on algae.

Control: No control measures have been proposed. Mechanical removal is probably the only effective method of control.

Research recommendations: Research on this species is not a priority unless it expands its range or increases in abundance. Field workers should be on the lookout for this species in estuaries other than Knysna and Langebaan eg in the tidal marshes of the Swartkops, Kariega and Great Fish Rivers, and should bring any distribution records to the attention of the nature conservation authorities and researchers.

Remarks: The mean shell thickness is less for the southern African populations than in *L. saxatilis* populations collected in north Wales. This is consistent with the very sheltered habitats of the southern African populations and suggests that predation risk from crabs is low (Hughes 1979).

REFERENCES:

Fretter and Graham (1962); Hughes (1979); Kilburn and Rippey (1982).

Personal communication: R N Hughes.

PHYSA ACUTA Draparnaud 1805

physa snail
physa slak

alien, detrimental, unknown impact

Phylum: Mollusca - molluscs
Class: Gastropoda - slugs, snails and limpets
Family: Physidae

SUMMARY

Status: An alien freshwater snail which was accidentally introduced prior to 1956, probably in association with aquatic plants imported through the aquarium trade. A highly invasive species with a rapidly expanding range. Widely distributed, particularly around major urban centres, but their impact on indigenous species is unknown.

Research: Poor. Their distribution has been well documented by Hamilton-Attwell et al (1970) and other workers, but there have been no detailed studies on the impact of this species on the indigenous fauna or on natural ecosystems in southern Africa.

SPECIES DATA

Distinguishing characteristics: A glossy, transluscent medium-sized snail. Shell sinistral (aperture on the left side). Copulatory organ with a large prepupital gland visible externally. Similar to *Bulinus* but has a more sharply pointed apex and a smoother surface that lacks ribs (van Eeden 1960; Brown 1980). Considerable variability is found in the shell shape and other features. The diagram indicates the most common form (Hamilton-Attwell et al 1970).

Native range: Probably North America (Brown 1967).

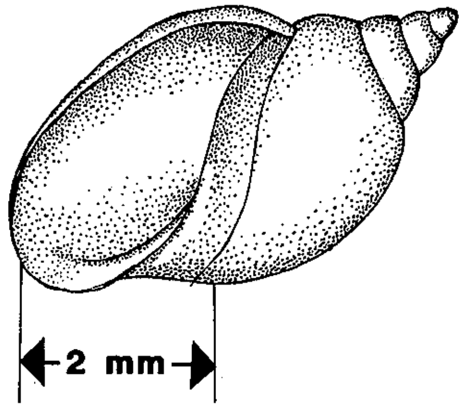
Date and purpose of introduction: Hamilton-Attwell et al (1970) report that this species was not recorded by Connolly in his (1939) monograph. The first reference to its presence in South Africa was in 1956 (Brown 1978), but the first definite record was in Pretoria in 1966 (van Bruggen 1966). By 1970 *P. acuta* was reported to be present in a number of widely separated localities in southern Africa and this led Hamilton-Attwell et al (1970) to believe that the snail had been introduced a number of times (between 1939 and 1956) in association with the importation of water plants by aquarists. This view conflicts with that of van Bruggen (1966) who suggests that this species was introduced through the activities of waterbirds.

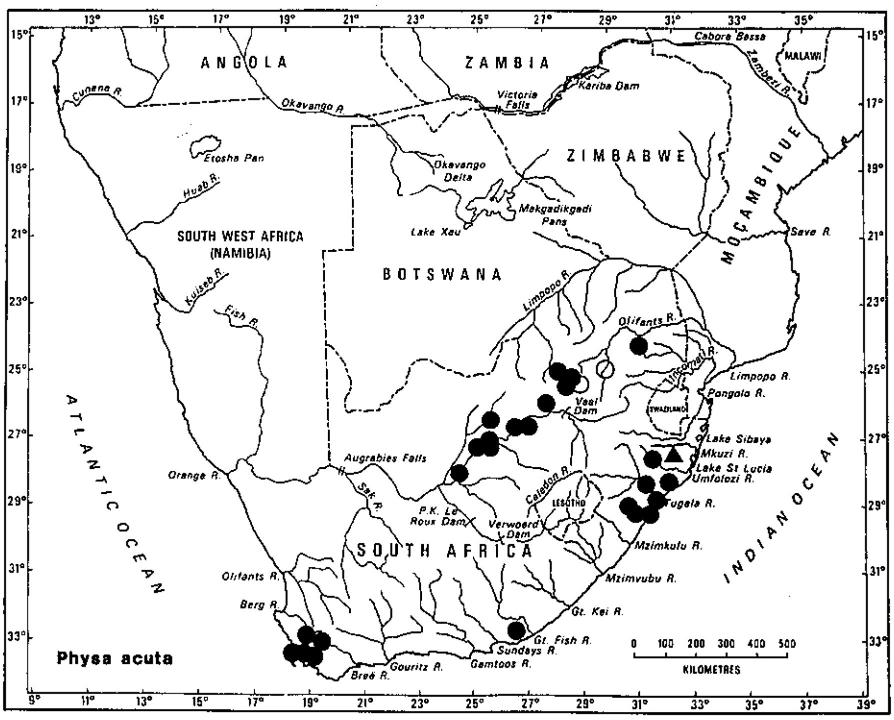
Southern African distribution: The distribution map drawn up by Hamilton-Attwell et al (1970) (see Figure 14) indicates that *Physa acuta* is concentrated in the north-eastern Transvaal and around the main urban centres (the Pretoria-Witwatersrand-Vereeniging area, Durban, Port Elizabeth and Cape Town). There are a number of later records in the western Cape (east to the Bree River), Durban and central Natal, Johannesburg north to the Crocodile River and in the Vaal River downstream of Potchefstroom as well as isolated localities in Lydenberg and the south eastern Cape (Brown 1978). Van Eeden et al (1980) studied the distribution of snails in the Mfolosi River catchment and recorded a single locality for *P. acuta* at Futululu Research Station (Hlabisa district). Pretorius et al (1980) recorded this species at the following localities in the Olifants River catchment: Bronkhorstspruit dam (Bronkhorstspruit district), Olifantsfontein, Waaikraal (Cullinan district), Loskop dam (east bank) (Middelburg district), Groenvallei and the northern bank of Loskop dam (Witbank district).

Habitat preferences: *P. acuta* has been found in almost every naturally occurring habitat type in fresh water

PHYSA ACUTA Draparnaud 1805

FIGURE 14. The physa snail *Physa acuta*, with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





- ● DISTRIBUTION PRIOR TO 1970 (AFTER HAMILTON-ATTWELL 1970)

ADDITIONAL RECORDS

- ○ LITERATURE RECORD
- ▲ APPROXIMATE LOCALITY RECORD

(Hamilton-Attwell et al 1970). Brown (1978) classifies this species as being in the "eurythermal" and "broadly tropical" group of snails, so presumably it can tolerate a wide range of temperatures. Often found in localities associated with sewerage. Brown (1978) suggests that the pollution of inland waters probably favours the establishment of this species.

Breeding: Hermaphrodite. The eggs are deposited in irregularly rounded masses (Brown 1980).

Impact: This species is now sufficiently abundant to have had considerable effects on the indigenous fauna, but no observations have been reported (Brown 1978).

Control: No control measures have been proposed as yet.

Research recommendations: There is an urgent need to study the impact which this species has on indigenous plant and animal communities. Aspects of the life history of *P. acuta* also need to be investigated in order to develop effective control measures.

Remarks: The distribution pattern has many features in common with that of another alien snail, *L. columella*. Hamilton-Attwell et al (1970) ascribe this to similar methods of entry into the country.

Physa acuta may act as an intermediate host for the rat lung nematode worm, *Angiostrongylus cantonensis*, which is widespread in south-east Asia and is the cause of eosinophilic meningitis in man. Man is not the normal host and the larval worms degenerate in the central nervous system. Rats become infected through ingesting molluscs which contain the third stage larva. If conditions are moist the eggs survive in the faeces and are then eaten by a mollusc. The infective third stage larva develops in the mollusc which must be eaten for the disease to develop in man. This infective larva has been found in *Physa acuta* (Brown 1980). The disease has not as yet been recorded in Africa but conditions are suitable for its transmission (Brown 1980).

REFERENCES

Brown (1967, 1978, 1980); Hamilton-Attwell et al (1970); Pretorius et al (1980); van Bruggen (1966); van Eeden (1960); van Eeden et al (1980).

HELISOMA DURYI Weatherby 1879

helisoma snail
helisoma slak

alien, detrimental, little impact

Phylum: Mollusca - snails, bivalves and relatives
Class: Gastropoda - slugs, snails and limpets
Family: Planorbidae

SUMMARY

Status: An alien freshwater snail which was accidentally introduced prior to 1969. It is widespread in artificial environments, but appears to be incapable of establishing populations in natural waters except for one record in the Liesbeeck River (Cape Town). *H. duryi* has had little impact on indigenous freshwater communities.

Research: Good. Madsen (1984) has reveiwed research on the general biology of this species. Their distribution in southern Africa has been described by Appleton (1977a).

SPECIES DATA

Recent synonyms: *Planorbis duryi* (Madsen 1984). A species complex of *Helisoma (Seminolina) duryi* is recognised with two races, *duryi* and *seminole* described by Pilsbry (1934) and Baker (1945) respectively (Appleton 1977a).

Distinguishing characteristics: Medium to large snails which reach 20 mm in diameter. Shape discoid or with a moderately elevated spire. Spiral shell greater than 6 mm high, prostrate lobes bunched together, copulatory organ with an accessory preputial organ connected by a duct to the penis sheath. Closely resembles *Biomphalaria pfeifferi* (Brown 1980). Probably at least two different species are present in southern Africa (van Bruggen 1974). Not all specimens have been satisfactorily identified as in some cases only the shells were available and the genital anatomy is important in the identification of different species (Appleton 1977a).

Native range: North America (Appleton personal communication).

Date and purpose of introduction: An accidental introduction probably associated with the aquarium trade (Appleton personal communication). Known in South Africa since 1969.

South African distribution: Cape Town (Liesbeeck River), Cape Point, Mandini (Natal), Johannesburg and Namibia (Spitzkoppen) (Appleton 1977a). Also recorded in Empangeni and Amanzimtoti (Appleton presonal communication). All these records except for the one from the Liesbeeck River are from artificial impoundments (Appleton 1977a).

Specimens from various localities within southern Africa may be of different species or different races of the same species. Appleton (1977a) identified specimens from Johannesburg and Cape Town as being *H. (Seminolina) duryi duryi*. Tentative identifications based on shell characteristics only were made by van Bruggen (1974) as follows:

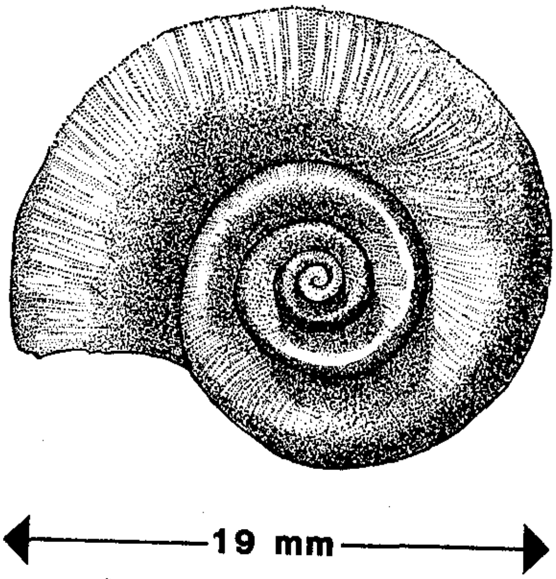
1. Namibia specimens: *H. (Seminolina)* cf *duryi seminole* (Pilsby 1934)

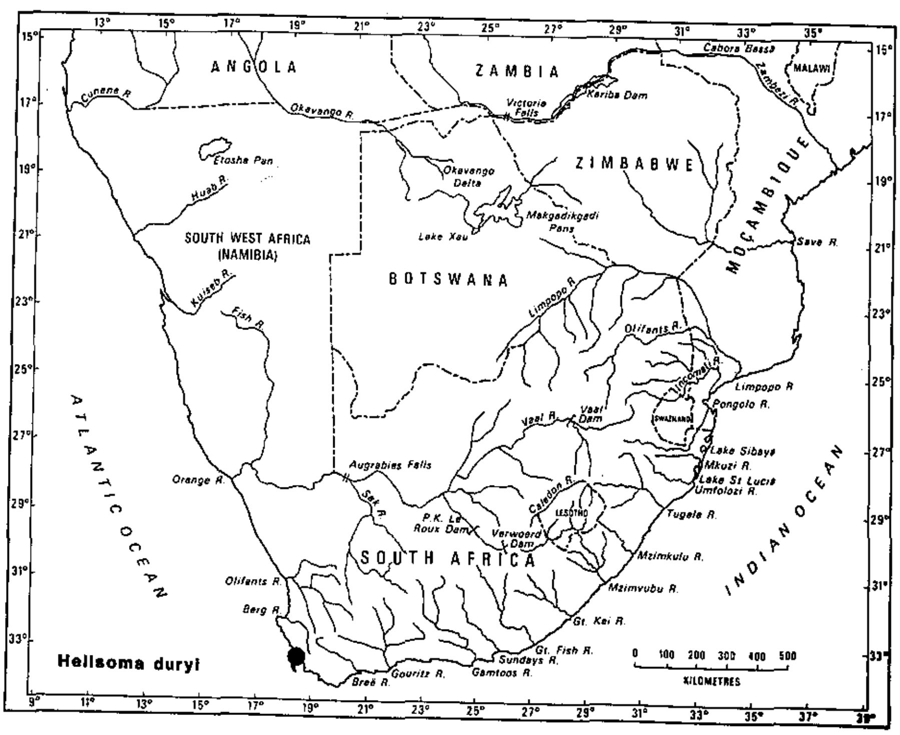
2. Specimens from Mandini and Cape Point: *H. (Pierosoma) pilsbyi*, Baker 1926.

Habitat preferences: Outside its native range this species has usually been recorded in artificial impoundments

HELISOMA DURYI Weatherby 1879

FIGURE 15. The helisoma snail *Helisoma duryi* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





- ■ ALBANY MUSEUM RECORD
- ● LITERATURE RECORD
- ▲ APPROXIMATE LOCALITY RECORD
- NATIVE RANGE

(usually small concrete-lined ponds) which are often subjected to periodic cleaning and hence cannot support permanent populations. There is probably continual recruitment into these environments from escapees from aquaria (Appleton 1977a). *H duryi* tolerates low dissolved oxygen concentrations and is capable of secreting anaerobic metabolites from the tissues (Madsen 1984). In Florida this species lives in small limestone pools but has also been recorded in small streams, protected backwaters and irrigation canals. These waterbodies often contained dense growths of aquatic plants. Populations in artificial impoundments do not usually spread to new areas (Madsen 1984).

The optimal temperature for growth and egg-laying is 26 to 28°C and no egg-laying has been recorded at temperatures below 12,5°C. Adult snails easily survive temperatures up to 35°C, but development of the larval stages is not completed at temperatures above 35°C (Madsen 1984).

Breeding: A hermaphroditic species which is not capable of reproducing by means of self-fertilisation. The egg masses are first laid when the shell diameter reaches 7 to 8 mm and there are usually 20 to 50 eggs per mass. These are deposited on various objects such as stones and plants. At temperatures of 26 to 30°C the embryo takes approximately 7 days to develop and under optimal conditions the reproductive age is reached in 3 to 5 weeks. Growth rates and egg-laying are strongly influenced by environmental conditions and population density (Madsen 1984).

Feeding: Algae and detritus have been recorded from stomach contents (Madsen 1984).

Impact: *H duryi* can be a nuisance in artificial ponds. In Mandini paper mills this species was found in sufficiently high numbers to impede the flow of water from the pond to filters. There is little to indicate that this species or species complex could become widespread in natural habitats in southern Africa.

Control: No specific control measures have been proposed.

Research recommendations: Should this species be considered as a candidate for the biological control of schistomiasis (see remarks), a thorough investigation of their potential impact on the natural environment should be made.

Remarks: Appleton (1977a) reviewed the findings of a number of workers who have suggested that species which are closely related to the vectors of schistosomiasis (ie *Biomphalaria* and *Bulinus* species) can be used in the biological control of this disease. Laboratary and field studies led many workers to suggest that, when the population density of *Biomphalaria sudanica* (a schistosome host snail) reaches very high levels, toxic substances are secreted by the snails which inhibit further population growth. The toxin only reaches sufficiently high concentrations when the population density of the snails is very high. Further laboratory observations on *H. duryi* suggest that this species may secrete a similar toxin which could suppress the growth and fecundity of *Biomphalaria pfeifferi* without affecting its own population levels. It has also been demonstrated that snails not susceptible to *Schistosoma mansoni* which were kept in the same aquaria as *Biomphalaria glabrata* reduced the infection rate of the latter. Apparently the non-target snails interfered with the host location mechanism of the miracidia larvae of *S.mansoni*. Should the population density of the non-target species be sufficiently high, this could result in a decrease in the frequency of infection of susceptible species in the same habitat (Appleton 1977a).

REFERENCES

Appleton (1977a); Baker (1945); Brown (1980); Madsen (1984); van Bruggen (1964).

Personal communication: C C Appleton

LYMNAEA COLUMELLA Say 1817

lymnaea snail
lymnaea slak

alien, detrimental, major impact

Phylum: Mollusca - molluscs
Class: Gastropoda - slugs, snails and limpets
Family: Lymnaeidae

SUMMARY

Status: An alien freshwater snail which was accidentally introduced prior to 1944, probably in association with aquarium plants. *L. columella* is an aggressively invasive species and has rapidly expanded its range in southern Africa into all major catchments except the upper Orange River. The invasion of this species has facilitated the further spread of fascioliasis, a disease in cattle for which it is an intermediate host.

Research: Good. There have been numerous surveys on the distribution of this species (van Eeden and Brown 1966; Pretorius et al 1980) and the general biology and role in spreading fascioliasis in Africa has been studied by Appleton (1975, 1977b, 1980) and Brown (1980). There have however been no studies on the impact of this species on the indigenous fauna.

SPECIES DATA

Distinguishing characteristics: A moderate-sized freshwater snail. Spirally coiled dextral shells (aperture to the right). Aperture relatively large and wide. Labrum thin without denticular processes. Never more than one fold on the columella. Only one pair of flat triangular tentacles with eyes situated at their bases (van Eeden 1960).

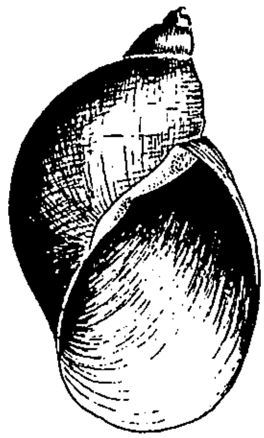
Native range: North America (Appleton personal communication).

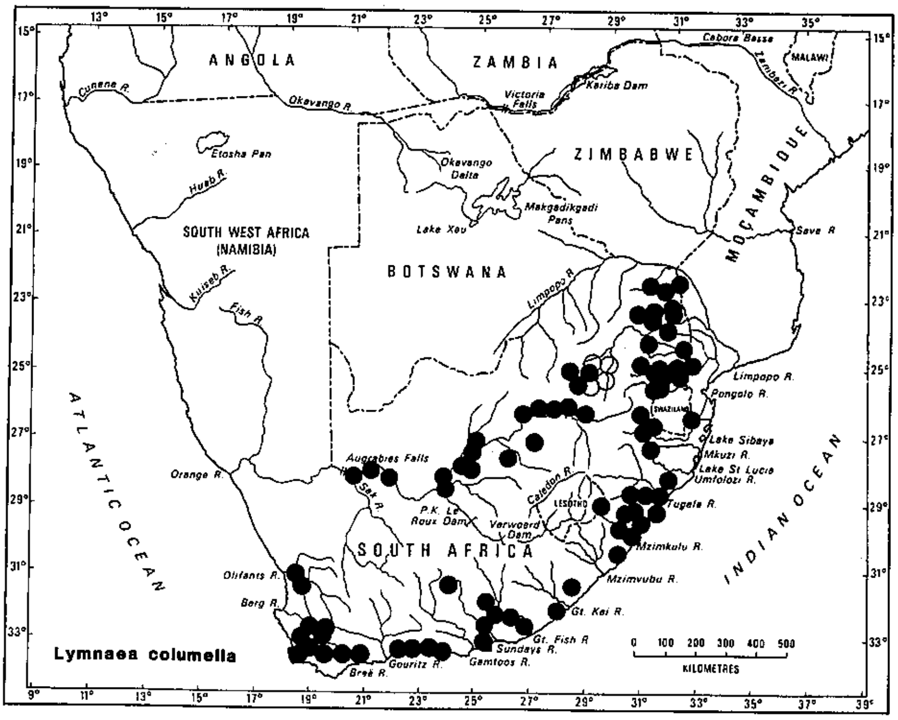
Date and purpose of introduction: Probably introduced in association with aquarium plants and fishes. Not known to Connolly who thoroughly reviewed the freshwater mollusca of southern Africa in 1939 (van Eeden and Brown 1966). The first recorded specimens were found on the Cape flats by Barnard in 1944. There were earlier reports on their presence in Somerset West in 1942 (Brown 1980). Based on the distribution pattern of this species, van Eeden and Brown (1966) proposed that a number of introductions were probably made via all the major ports after which the species was transported to Johannesburg from where it spread into the Orange-Vaal system.

Southern African distribution: The distribution map of van Eeden and Brown (1966) indicates a widespread occurrence of this species in the sub-contintent, being particlarly concentrated around the main urban centres (Johannesburg, Durban, East London, Port Elizabeth and Cape Town) as well as in the north-eastern and eastern Transvaal. There is some doubt about the authenticity of the record in the upper highland tributaries of the Umkomaas River (marked "A" on the map). It is unlikely that *Lymnaea columella* would survive at this altitude (Appleton personal communication). The following records have been added to those of van Eeden and Brown (1966): *L. columella* is widespread in the Crocodile River basin and abundant in the Nelspruit/Malelane/ White River areas. Also present in northern Swaziland (Schutte and Frank 1964), Kruger National Park (Oberholzer and van Eeden 1967), Mgobezeleni lake and estuary (in Maputaland adjacent to Sodwana Bay Park) (Bruton and Appleton 1975), Phongolo floodplain in Msinyeni pan (Pretorius et al 1975), Balgowan and Shongweni dam (Natal), Port Elizabeth, Stellenbosch and Cape Flats (van Bruggen 1964). This species is expected to extend its range into Mozambique and most parts of Africa (Brown 1978). The map of van Eeden and Brown has been reproduced together with more recent distribution records in the Olifants River catchment which were described by Pretorius et al (1980). These include the catchments of the Olifants

LYMNAEA COLUMELLA Say 1817

FIGURE 16. The lymnaea snail *Lymnaea columella* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





● DISTRIBUTION PRIOR TO 1966 (AFTER VAN EEDEN AND BROWN 1966)

ADDITIONAL RECORDS

○ LITERATURE RECORD

River and the Wilge, Bloed and Bronkhorstspruit Rivers. *L. columella* was found in the following localities: Bronkhorstbaai, Bronkhorstspruitdam, Groenfontein, Loopspruit, Malanspruitvlei, Witpoort (Bronkhorstspruit district); Tweedespruit, Wagendrift, Doornkraal, Kafferskraal, Kameelpoortnek, Klipfontein, van Dykspruit, Zonderwater, Zustershoek (Cullinan district); Olifantsfontein, Rietvallei, Waaikraal (Delmas district); Haasfontein, Loskop dam (Middelburg district); Doornpoort, Groenvallei, Klipfontein, Loskop dam, Naaupoort, van Dyksdrift and Witbank on the Olifants River (Witbank district). Van Eeden et al (1980) studied the distribution of snails in the Umfolosi River catchment and found *L. columella* in the following areas: Moordplaats (Babanago district), Futululu Research Station (Hlabisa district) and in a dam and a river in the town of Vryheid.

Habitat preferences: A eurythermal species with a wide climatic tolerance (Appleton 1975). In South Africa this species has often been found in association with *L. natalensis* (Brown 1978). Harrison and Agnew (1962) reported that *L. columella* prefers alkaline streams and was not present in the acid streams of the Table Mountain Sandstone system. However Harrison and Elsworth (1958) recorded *L. columella* in the Great Berg River (which flows over Table Mountain Sandstone) at pH levels of 6,3 to 6,9 (Appleton personal communication). The highest recorded current speed (in a small stream in the eastern Transvaal) at which this species occurred was 1,7 m/s (Appleton 1975).

Lymnaea columella can exist either submerged in water or in moist mud close to water (van Eeden and Brown 1966).

Breeding: An oviparous hermaphrodite. *L. columella* has two genital openings on the right hand side which can produce eggs and sperm simultaneously. This species is therefore capable of self fertilisation although it does possess copulatory organs and cross fertilisation usually occurs. The eggs are laid in a gelatinous capsule. There is often a marked difference in the growth rate of different eggs found in the same capsule (Brown 1978). This species usually breeds predominantly in the cool season and has one generation per year (Appleton 1977b).

Behaviour: *L. columella* has the habit of crawling out of the water onto fringing vegetation (Brown 1978).

Impact: *L. columella* is an intermediate host of the liver fluke parasites *Fasciola hepatica* and *F. gigantica*, which are found in the bile ducts and gall bladders of grazing animals (Brown 1980). *F. hepatica* has also been known to occasionally infect man (Appleton 1980). The eggs of these parasites are passed out in the urine and must reach water in order to survive. A miracidium larva hatches from the egg and after 12 days infects the snail host where it passes through a number of larval stages before the release of the cercaria larvae into the water. These larvae then encyst onto a suitable substrate which is then ingested by a grazing animal. The whole cycle from cattle to cercaria can be as short as 21 days at 27°C (Brown 1980). The presence of *L. columella* in southern Africa is believed to have resulted in an increase in the incidence of fascioliasis in livestock (Brown 1980). This is probably because *L. columella* is more widespread than *L. natalensis* which is the natural intermediate host of *F. gigantica*.

The habit of *L. columella* of crawling onto fringing vegetation also makes this parasite more available to grazing bovine hosts as it is more likely to form a cyst high up on vegetation than *L. natalensis* or *L. truncatula*.

Fascioliasis causes considerable financial loss to farmers in Africa (Brown 1980) but there has been no assessment of the loss due to this disease in South Africa. There is a moderate prevalence of fascioliasis in wild ruminants but in general infection rates are low. *F. gigantica* has been found in buffalo, wildebeest, kob, eland, hartebeest and warthog, and deaths in wild animals due to this disease have been reported in eland, kudu, wildebeest, grey duiker and reedbuck in Zimbabwe (Brown 1980).

Lymnaea columella is sufficiently abundant to have caused a major impact on the indigenous fauna, but this has not as yet been quantitatively assessed (Brown 1978).

Control: Any attempts at control must be justified in terms of costs as these snails are an economic rather than a medical problem. The use of molluscicides such as Niclosamide (Bayluscide) or N- tritylmorphine (Frescon) could be considered. However this method has had only limited success in the control of *Bulinus* species and is also an environmental hazard as molluscicides are not specific to target organisms. There are many predators of lymnaeaid snails including firefly larvae (Lampyridae), dragonfly larvae (Odonata), water scorpions (Belostomatidae), ostracods and freshwater crabs (*Potamonautes* species). Vertebrate predators include the open-billed stork (*Anastomus lamelligerus*) and various freshwater fish. It may be feasible to consider the use of one or more of these species in the biological control of snails (Brown 1980). There is also the possibility of control through the use of introduced molluscs. *Marisa cornuarietis* (a large prosobranch mollusc native to South America) has been found to have an adverse effect on other snail populations through predation on the gelatinous egg masses and, in some cases, through predation on adult snails as this species has been observed preying on *Biomphalaria alexandrina, Bulinus truncatus, B. nasutus* and *Lymnaea natalensis*. However *M. cornuarietis* is omnivorous and there is some concern that it may damage rice plants or other important vegetation (Brown 1980).

Helisoma species have also been considered as a agents for the control of undesirable molluscs. *Helisoma duryi* appears to establish an ascendency over other snails partly through its high reproductive capacity and possibly by emitting substances which inhibit growth in other snails (Brown 1980). There is however some doubt as to whether *H. duryi* is capable of establishing permanent populations in natural waters in southern Africa (Brown 1980). Considering some of the undesirable (and usually unforeseen) consequences which can result from the introduction of alien species, this method of control should be treated with extreme caution. It is doubtful whether *L. columella* poses enough of a problem to justify such drastic control measures.

Research recommendations: The impact which *L. columella* has on indigenous animals needs to be more thoroughly investigated. At the same time more information concerning the habitat preferences of this species may become available. This could prove to be useful in the future planning of possible control measures. It would also be useful to conduct a thorough assessment of the economic losses to livestock farmers as a result of fascioliasis.

Remarks: It is of interest to note that food availability is believed to limit the population size of a north American species of *Lymnaea* (Brown 1978).

REFERENCES

Appleton (1975, 1977b, 1980); Brown (1978, 1980); Bruton and Appleton (1975); Harrison and Agnew (1962); Harrison and Elsworth (1958); Oberholzer and van Eeden (1967); Pretorius et al (1975, 1980); Schutte and Frank (1964); van Bruggen (1964); van Eeden (1960); van Eeden and Brown (1966); van Eeden et al (1980).

Personal communication: C C Appleton

MYTILUS GALLOPROVINCIALIS Lamarck

Mediterranean mussel
Mediterreense mossel

Alien, detrimental, major impact

Phylum: Mollusca - molluscs
Class: Lamellibranchia - bivalve molluscs
Family: Mytilidae

SUMMARY

Status: An alien mussel which was accidentally introduced from Europe prior to 1972. *M. galloprovincialis* has become common in the intertidal zone on the west coast of southern Africa and has had a major detrimental impact on indigenous species.

Research: Good. This species was only recently identified as being separate from *Choromytilus meriodionalis*. Studies on the ecology and distribution are being carried out by Dr P Hockey at the University of Cape Town, but the results have not yet been published. Grant et al (1984) and Grant and Cherry (1985) have studied the biochemical differences between the two species.

SPECIES DATA

Distinguishing characteristics: A bivalve mollusc. Superficially resembles the brown mussel *Perna perna* and the black mussel *Choromytilus meridionalis* (Grant et al 1984). This species has a similar broad shape to *P. perna*, but the dark shell colour resembles *C. meridionalis* (although a light colour morph comprises approximately 2% of the population). *M. galloprovincialis* has an anterior adductor muscle which is absent from either of the two indigenous species (Grant 1987). A detailed biochemical, genetic and morphological examination of the new species confirmed that western Cape populations were a geographic race of *M. galloprovincialis* (Grant and Cherry 1985).

Native range: European species. *M. galloprovincialis* occurs from Ireland, across the Mediterranean, to the Black Sea. Has also been recorded in Japan (Suchanek 1985).

Date and purpose of introduction: The absence of this species from Koi San middens (which pre-dated colonisation by Europeans) suggests that *M. galloprovincialis* was introduced into southern Africa (Grant and Cherry 1985). *M. galloprovincialis* was also absent from pre-1970 dredging records in museum collections (Hockey personal communication). The first confirmed reference was in 1972 and Grant and Cherry (1985) hypothesise that the introduction occurred within the last two decades.

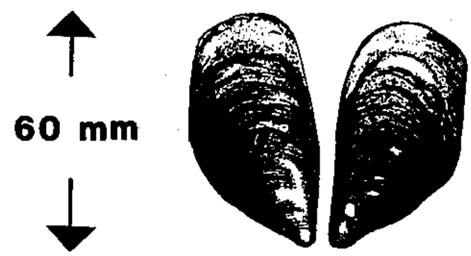
Southern African distribution: Distributed along the west coast of southern Africa from Cape Agulhas to Walvis Bay. This distribution is almost identical to that of the black mussel *Choromytilus meridionalis* (Grant et al 1984). *M. galloprovincialis* has also recently (in 1988) been collected in Algoa Bay (Hockey personal communication).

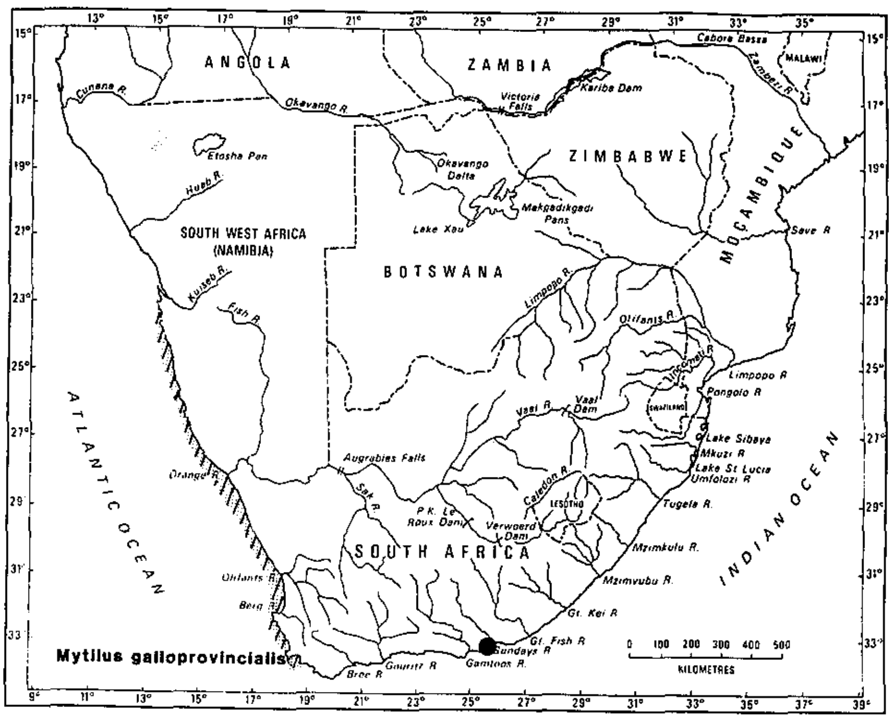
Habitat preferences: Marine species. The Mediterranean mussel prefers the mid and low intertidal zones on wave-exposed rocky shores, but is also found sub-tidally (Grant and Cherry 1985; Hockey personal communication). *M. galloprovincialis* apparently tolerates a wide range of temperatures. Although it has been found in cold west-coast waters (where temperatures are often as low as 11 C), it also occurs in warm waters in the Mediterranean Sea (Hockey personal communication).

Breeding: As is the case with all bivalve molluscs, the eggs and sperm are released into the water. External fertilisation is followed by the development of a free-swimming trochophore larva which later develops into a veliger larva. This larva eventually settles on rocky shores and metamorphoses into a sessile adult (Branch and

MYTILUS GALLOPROVINCIALIS Lamark

FIGURE 17. The Mediterranean mussel *Mytilus galloprovincialis* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■	ALBANY MUSEUM RECORD
●	LITERATURE RECORD
▲	APPROXIMATE LOCALITY RECORD
░	NATIVE RANGE

Branch 1981).

Feeding: A filter feeder on small particles suspended in the water (Branch and Branch 1981).

Behaviour: Adults fasten onto the substrate by means of byssus threads produced from a gland in the foot. Sessile during the adult part of the life cycle (Branch and Branch 1981).

Impact: The ribbed mussel *Aulacomya ater* which occurs in the intertidal zone on the west coast of southern Africa has been largely replaced by *M. galloprovincialis* and it is likely that *M. galloprovincialis* has had a serious effect on other intertidal invertebrates (Hockey personal communication). It appears however that *M. galloprovincialis* has not had a major detrimental effect on the indigenous black mussel, *Choromytilus meridionalis* (Grant and Cherry 1985). In areas where these two species co-exist the latter species is found in low intertidal pools, whereas the Mediterranean mussel is found on rocky surfaces in the mid-intertidal zone (Grant 1987). It is likely that these two species occupy slightly different niches, thereby avoiding direct competition (Grant 1987).

Control: Since the two larval stages are free-swimming it would be virtually impossible to control the spread of this species.

Research recommendations: Further information is required on the life history parameters of the Mediterranean mussel so that its invasive qualities can be assessed.

Remarks: *M. galloprovincialis* is the most abundant alien organism which has invaded the marine environment in South Africa. Considering its wide temperature tolerence, it is likely to succeed in establishing populations on the east coast should it be introduced into these regions (Hockey personal communication).

REFERENCES:

Branch and Branch (1981); Grant et al (1984); Grant and Cherry (1985); Grant (1987).

Personal communications: P A R Hockey; R N Hughes.

PARASALMO MYKISS (Walbaum 1792)

rainbow trout
reenboog forel

alien, equivocal, major impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Salmonidae

SUMMARY

Status: An alien species imported for angling purposes from England in 1897. Although from the angling and aquaculture points of view the introduction of this species can be regarded as a success, rainbow trout have had a detrimental effect on a number of indigenous species.

Research: Excellent. Internationally, many studies have been carried out on the biology of this popular angling fish (summarised by Scott and Crossman 1973). In southern Africa detailed records of the initial stocking and subsequent status of trout in various localities have been kept by Harrison (numerous publications between 1938 and 1978). Studies on the impact on indigenous species have been carried out by Gaigher (1979), Pott (1981) and others.

SPECIES DATA

Recent synonyms: *Salmo gairdneri* (Skelton 1986c). Since *P. mykiss* is such a variable species it has been suggested that there is no utility in subspecies names (Scott and Crossman 1973). A number of different common names (eg steelheads, kamloops and shasta trout) are used by anglers to describe different strains of this species (Scott and Crossman 1973).

Distinguishing characteristics: A famous angling fish which is now common in cool waters throughout the world. Scales small, on body only. Small lobe-like adipose fin posterior to the dorsal fin, mouth large with canine teeth. Similar to the brown trout, but spots smaller and never red. A broad iridescent reddish-mauve lateral band is diagnostic, though less marked in young fish (Bruton et al 1982). There is extreme variability in form in populations from different environments. "Sea run" trout assume a bright silvery colour and are known as "steelheads" (Harrison 1959/60a).

The Kamloops strain is less spotted, more slender and normally has more scales than other strains of "rainbows" (Crass 1968).

Native range: The western seaboard of the USA, Canada and north western Mexico (Welcomme 1981).

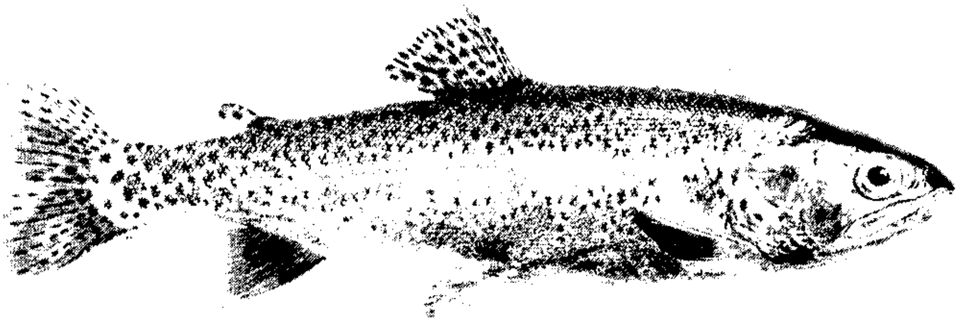
Date and purpose of introduction: Introduced for angling purposes (Safriel and Bruton 1984). The first successful import of eggs arrived at Jonkershoek Hatchery in 1897. These were used as breeding stock and consignments of ova were sent to various parts of southern Africa from 1899 onwards (Anon 1944). By 1930 a number of trout hatcheries had been established in various parts of southern Africa eg Tetworth (Natal) from 1903 (Pike 1980b) and Lydenburg (Transvaal) from 1915 (du Plessis 1961). The Pirie Hatchery near Kingwilliamstown was started in the 1890's. Numerous difficulties were encountered in establishing this hatchery and the first fry were only available for distribution in 1901 (Harrison 1954c).

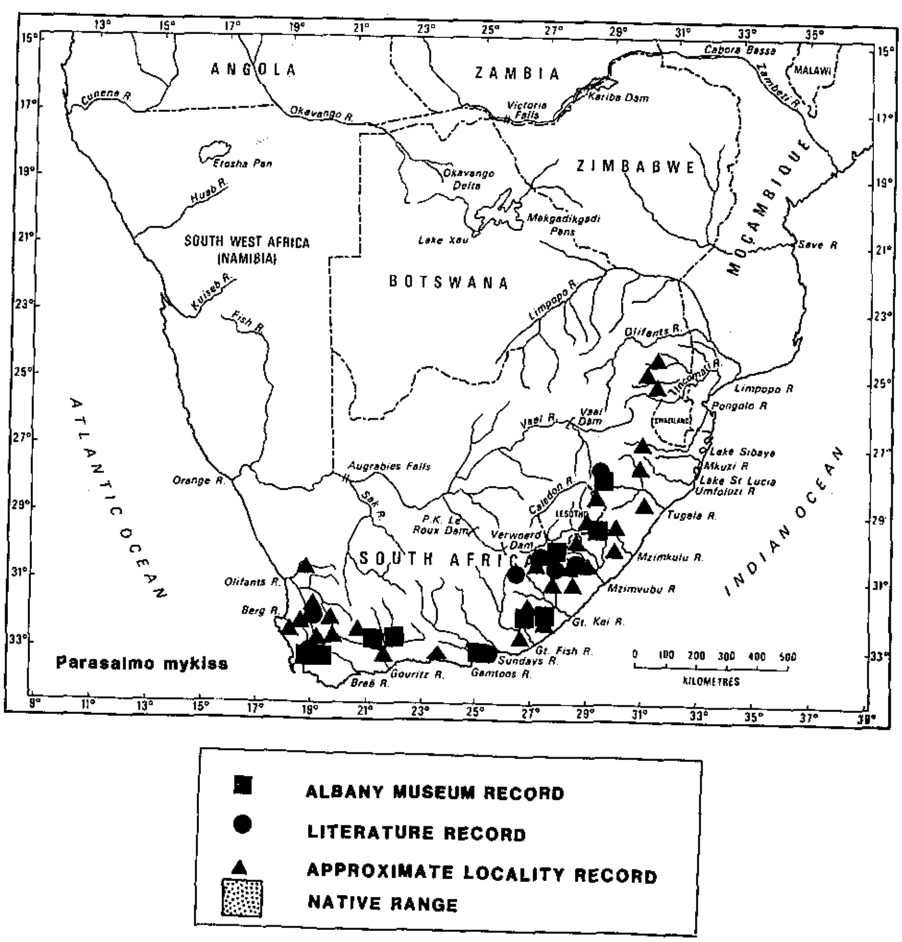
The following strains of this species have been imported into southern Africa:

1. "Shasta" trout - imported from Britain to the Pirie Hatchery in the late 1930's. This race, which originates from Mount Shasta, California, breeds in the late autumn or winter months and reportedly has less tendency to

PARASALMO MYKISS (Walbaum 1792)

FIGURE 18. Rainbow trout *Parasalmo mykiss* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





migrate than other forms. A few specimens were also sent to the Jonkershoek Hatchery (Harrison 1977/78). Their tendency for early spawning gradually disappeared with succeeding generations (Hey 1952). There are no records of the localities into which this strain was introduced (Harrison 1977/78).

2. "Kamloops" strain from Pennask Creek, British Columbia - imported to Natal Parks Board hatcheries in 1966 and stocked in various waters in Natal in 1966 (Crass 1968).

3. "Danish" strain, which is characterised by their fast growth rate and late spawning, were imported to the Glendean Trout Farm, Nottingham Road, in 1966 and to the Natal Parks Board Hatchery in 1968 (Crass 1970).

A detailed account of the first releases in specific localities is given in Appendix 1.

Southern African distribution: This species is regularly stocked in many river systems and the following account of their distribution (as well as the distribution map) does not necessarily indicate that self-sustaining populations exist in the localities mentioned. In some cases populations have been described as "established" in the literature. It is not certain whether the authors used this term in its strict scientific sense (ie that a breeding population exists). The account of the distribution given below is not complete as this species has been stocked in many localities which have not been recorded in the literature.

Early distribution

Before 1940: Established in Ibisi and Gungununu Rivers (East Griqualand) from 1923 but had disappeared by 1948 (Harrison 1948b). In 1932 *P. mykiss* was reported to be flourishing in the Ingwangwana, Umzimkulu, Umzimouti, Ushiayke and Umtshezana Rivers in Natal (Day 1932a). In the Transkei rainbow trout were described by Hey (1926) as being present in the following rivers of the Umzimvubu system: Tsitsa, Little Pot and Big Pot, Tina, Tinana, Mvenyani, Umzimhlava, Ginqoskoi, Ibisi, Ncweleni, Mnceba and Cancele Rivers. Also present in the Gora and Manina Rivers (Bashee system) and the Engcobo River (Engwali system). Rainbow trout were established in the main Umtata River until 1926 but were later washed away (Hey 1926).

Established in the Potspruit and Sterkspruit (Lydenberg district) by the mid-1920's (du Plessis 1961).

1949 distribution

West and south Cape: Liesbeeck River and lake, Steenbras reservoir (where they are continually stocked and do not breed), Eerste, Lourens, Upper Berg, Wemmer and Dwars Rivers. Also in the lower Breede and the following tributaries of the Breede system: Smalblaar, Holsloot, Dwars, Hex and Elands Rivers (Harrison 1949).

Eastern Cape and Transkei: Tyume, Keiskammahoek, Upper Buffalo, Upper Kubusie, Langkloof and Kraai Rivers (near Barkly East), Indwe, upper Tsomo and Bashee Rivers, Umtata, the Tsitsa River and tributaries near Maclear and Ugie, upper Tina, Luzi and Tinana Rivers (Mount Fletcher), Kenegha, Ceyata, Mabela and Mvenyana Rivers near Matatiele, upper Umzimvubu and Krom Rivers in this area. In East Griqualand found in the following rivers in 1949: Umzimhlava River (Mount Ayliff), Bizana River (East Pondoland), and the Umzimhlava, Umzimvubu, Ibisi, Gungununu, Ndowana and Ingwangwana Rivers in the Kokstad district (Harrison 1949). The decline in the trout population at this locality was reported to be due to the introduction of carp (Anon 1958). Since this species was established in the Lydenburg district in the mid-1920's (du Plessis 1961), it is likely that they were still present in this and possibly other localities in the Transvaal in 1949.

Present distribution

Present in the mountainous parts of the Cape, the upper Orange system of Lesotho, the eastern Transvaal and the mountainous parts of Natal (Crass 1969a). In the Cape, rainbow trout survive in most colder non-acid streams of the south coast drainage system and in the Olifants system in the western Cape (Smith personal communication). They are only found in a few localities in the Eastern Cape as most of the rivers in this area are too acidic for the survival of trout (Jubb 1965).

As *P. mykiss* is regularly stocked in many areas it is not certain which populations are "established" (ie self-sustaining populations) and which are not. Self-sustaining populations are known to exist in the following areas:

West and south Cape: Olifants system: breeding populations are found in the main stream above the Leerkloof River and in the Leerkloof, Riet, Twee, Middeldeur, Kromme and Driehoek tributaries. Also present in many farm dams in the Koue Bokkeveld (Smith personal communication). In the western Cape *P. mykiss* is found in the Wemmershoek reservoir and Wemmer River (Harrison 1966/67, Smith personal communication), the Eerste, Lourens, Berg (from La Motte upwards) as well as in the Dwars, Smalblaar, Molenaars, Elandspad, Holsloot, Witels, Elands and Jan du Toits Rivers of the Bree River system (Smith personal communication).

Eastern Cape: Upper Tyume River (Gaigher 1975a), Bulk River dam (Port Elizabeth) (Donnelly 1965).

Natal: Umtamvuna, Weza (Umtamvuna system), Ndowana, Slang (upper Vaal system) and Pivaan Rivers (Crass 1964) and the upper reaches of the Umvoti, Umzimkulu, Umkomaas, Tugela, Buffalo and Phongolo Rivers (Crass 1966).

Lesotho: Upper reaches of the Moremoholo, Senqu and Tsoelikane Rivers (Pike and Tedder 1973; Gephard 1977; Cambray personal communication).

Transvaal: Established in some rivers in the Lydenberg area (du Plessis 1961).

Orange Free State: Upper Orange and Caledon Rivers (Skelton 1986b).

Populations are known to exist in the following localities but it is not certain whether or not these are self-sustaining as regular stocking occurs in most of these localities:

Western and southern Cape: Hex River and Voelvlei (Hutchings 1985). Gouritz (Skelton 1987a) and Breede Rivers (Cambray and Stuart 1985).

Eastern Cape and Transkei: Buffalo (Gaigher 1975a), Wolf, Upper Klipplaat, Tsomo, Bashee, Tsitsa, Wildebees, Mooi, Pot, Little Pot, Tsitsana, Tina, Luzi and Tinana Rivers (Mzimvubu system) (Smith personal communication). Also the Kraai and Karringmelkspruit (Orange system), Slang (Umzimvubu system) and Holspruit (Orange system) Rivers (Pirie Hatchery records from Pitt personal communication). Impoundments: Gubu (Kubusie River, Great Kei system, Bok personal communication), Maden, Rooikrans and Waterdown Berry (Buffalo), Moffat dam (Port Elizabeth) (Davies personal communication), municipal dam (Lady Grey), Sports Club and Airport dam (Maclear and Ugie), Jamieson and Milner dams (Grahamstown), Sand River dam (Uitenhage), municipal dam (Molteno) (Pirie Hatchery records from Pitt personal communication).

Transvaal: Blyde and Treur Rivers (Pott 1981), tributaries of the Crocodile River (Incomati system) (Kleynhans personal communication) and rivers in the Lydenburg district (du Plessis 1961). Coetzee (personal communication) described the distribution as being "throughout the Eastern Transvaal escarpment in the Lydenburg, Pilgrims Rest, Belfast and Machadadorp districts."

Orange Free State: Sterkfontein dam (Wilge River, Vaal system) (OFS Nature Conservation 1983).

Swaziland: Rainbow trout were present in the Komazane River and in Usutu Pulp Mill reservoirs in 1960 but it is uncertain whether populations still exist in these localities (MacCrimmon 1971).

There are probably many other localities where regular stocking occurs which are not mentioned above as these are not recorded in the literature.

Habitat preferences: Rainbow trout require cold, unpolluted, well-oxygenated waters (Bruton et al 1982; Safriel and Bruton 1984). Found in upland waters but favour the larger, less precipitous streams (Crass 1969a). Cannot normally tolerate summer temperatures higher than 20°C and the eggs die at temperatures above 16°C (Bruton et al 1982: Crass 1986).

Rainbow trout have a preference for steady, flowing rivers with adequate shelter in the form of submerged rocks, undercut banks and overhanging terrestrial vegetation (Crass 1986). They are adversely affected by drought and excessive abstraction of water for irrigation and Harrison (1948b) noted a decline in population levels in rivers of the Maclear district during the 1947 drought. It appears that *P. mykiss* is more tolerant of low water levels than *Salmo trutta* as the latter species was replaced by *P. mykiss* in the Wemmershoek River after the building of the irrigation reservoir (Louw 1979).

Harrison (1950) concluded that the peat-stained, acidic waters of the southern Cape (from False Bay to Port Elizabeth) were unsuitable for the establishment of trout. He also found that *P. mykiss* was able to survive but could not breed in the Steenbras reservoir (Harrison 1964). Since the pH of the water affects a range of water quality parameters, the problem is more complex than it first appears. Lloyd and Jordan (in Alabaster and Lloyd 1982) found that the survival of *P. mykiss* at low pH levels depends largely on the concentration of free carbon dioxide. In waters with concentrations of less than 10 mg/l free carbon dioxide, the median lethal pH value was 4,5 after 15 days; at 20 mg/l the lower lethal pH was 5,7. It is also likely that low pH levels would adversely affect many of the invertebrates on which trout feed and this could also have a detrimental effect on trout populations (Davies personal communication).

In Lesotho streams *S.trutta* appears to be more dominant and to reach a larger size than *P. mykiss*. In Natal rivers the latter species has tended to exclude *S. trutta* from many rivers and is able to tolerate lower altitudes than *S. trutta* (recorded at about 760 m in the Wesa River and about 900m in the Umzimkulu River). A number of factors adversely affect trout at lower altitudes: higher temperatures, increased siltation, and other forms of pollution (Crass 1964). It therefore appears that *P. mykiss* has a higher tolerance of these adverse conditions than *S. trutta*.

Parasalmo mykiss is able to survive in the sea and populations from the Eerste River have migrated into False bay (Anon 1959a). It is obvious therefore that this species is able to adapt to living at high salinities. The ability to excrete salt develops when the fish move into saline waters but the change from fresh to salt water must be gradual and the fish lose weight during the acclimatisation process (Harrison 1978). The Eerste River appears to be the only suitable outlet to the sea in the southern Cape (Harrison 1958). During the "sea run", *P. mykiss* probably remains in the sandy shallow waters close to estuaries (Hewitson 1966). Bruton et al (1987) have commented that it is surprising that anadromous fishes (which migrate from the sea into freshwater to breed) are not more common in the western Cape as ideal conditions for anadromy occur there (ie high nutrient levels in the sea for the feeding stage of the life cycle).

Details of the environmental tolerance limits of trout are given in the account on *Salmo trutta* (McVeigh 1979b).

Breeding: Spawning takes place in running water. Lake dwelling populations move into feeder streams and riverine forms usually migrate upstream before breeding. In the northern hemisphere this migration is usually associated with a rise in the water level. Spawning takes place in rapidly flowing (but not turbulent) sections of rivers at moderate depths. Rainbow trout require gravel-bottomed, silt-free, well-aerated areas (often called "redds") for the construction of their small nests. During the breeding season the male develops a hook on its lower jaw and there are certain colour changes which vary in different populations. The female arrives at the "redd" first, selects a suitable site and excavates a depression in the gravel. Both male and female then "lie" in the nest and simultaneously extrude sperm and eggs. The female then moves to a site immediately upstream and begins digging the next nest. The displaced gravel covers the eggs in the first nest. The young fry have large yolk sacs when they hatch and while resorbing the yolk they burrow into the gravel and avoid light (Frost and Brown 1967). The eggs hatch in 4 to 7 weeks and the alevins take 3 to 7 days to absorb the yolk sacs. A single female may lay from 200 to 4400 eggs (Scott and Crossman 1973). *P. mykiss* has a shorter lifespan than *S. trutta* (Crass 1969b).

Feeding: Juveniles feed almost entirely on invertebrates. The adults are primarily piscivorous but their diet is supplemented with invertebrates (Newdick 1979).

Behaviour: Rainbow trout move downstream as they grow, in search of larger pools (Crass 1964). There is also a tendency for regular downstream migrations. Some fish may move downstream towards larger waterbodies until the effects of the tide are felt. Others, which are in rivers open to the sea, may have a "sea run". Different populations of *P. mykiss* (and other salmonids) display varying degrees of anadromous behaviour from fish that are obligatory anadromes to fish which make occasional brief forays into the sea. In their native environment anadromous and resident forms often occupy the same river system. *P. mykiss* may also colonise new rivers by means of saltwater excursions. This is unlikely to be the case in southern Africa due to the lack of suitable rivers with cool downstream reaches (Hewitson 1966).

The growth rate in the sea is more rapid than in fresh water and specimens returning upstream in autumn are silvery in colour (referred to as "steelheads") and are usually in good condition (Harrison 1959/60a and b). A number of captures in False Bay during spring and autumn suggest that some specimens from the Eerste River have a sea-run during these times of the year. Harrison (1959/60b, 1978) noted that only a small proportion of the population was involved in this migration and there was no evidence that it followed a regular annual pattern.

Hamman (1980) has noted that there is an annual migration of trout (both *P. mykiss* and *S.trutta*) from the upper reaches of the Orange River into the Verwoerd dam. Most of these fish appeared to be in poor condition.

Parasalmo mykiss is highly valued as an angling fish because it readily takes a fly, provides an excellent fight and leaps frequently (Scott and Crossman 1973).

Impact: In general the rainbow trout is not regarded as such a serious threat to indigenous species as some other introduced predators such as *Micropterus dolomieui* and *M. salmoides*. Skelton (1987a) lists predation and /or competition by *P. mykiss* as being one of the threats to the status of the following fish species listed in the Red Data Book: *Barbus burgi* (endangered) (Berg, Eerste and Bree Rivers); *B. phlegethon* (endangered) (Clanwilliam Olifants River); *B. andrewi* (vulnerable) (Berg and Breede Rivers); *B. treurensis* (vulnerable) (Blyde and Treur Rivers); *B. trevelyani* (vulnerable) (tributaries of the Keiskamma and Buffalo Rivers); *B. burchelli* (rare) (Breede River); *B. tenuis* (rare) (Gourits and Keurbooms Rivers); *Oreodaimon quathlambae* (endangered) (highland tributaries of the Orange River); *Sandelia bainsii* (vulnerable) (Kowie, Koonap, Kat, Keiskamma and Buffalo Rivers); *Kneria auriculata* (rare) (tributaries of the Crocodile River, Incomati system).

It must be noted that in most cases habitat destruction has been the most important contributing factor leading to the decline of these species and predation by *P. mykiss* is usually regarded as a minor contributing factor. There are however some instances where the presence of trout has been regarded as a major threat. A detailed discussion on the impact which *P. mykiss* has had on indigenous species in certain river systems is given below:

1. The Treur River, Limpopo system. Introduced between 1957 and 1981 (Pott 1981). The combined effect of the introduction of trout and smallmouth bass and the concomitant introduction of white spot disease are thought to have contributed to the local extinction of *Barbus treurensis*, which proved to be very susceptible to white spot. *B. treurensis* are now only found in a section of the Blyde River bounded by two waterfalls and in 1977 it was found that the entire population was confined to one deep pool (Pott 1981).

2. Eerste, Lourens and Berg Rivers. Introduced in 1901 and 1902. Harrison (1950) reported that the decline in numbers of *Barbus burchelli* in the Eerste and Lourens Rivers was due to the presence of "trout". However *B. burchelli* is endemic to the Breede River system. It is likely that Harrison had confused this species with *B. burgi* which closely resembles *B. burchelli* and occurs in the Eerste and Berg Rivers (Jubb 1967). Skelton (1987a) attributes the decline of *Barbus burgi* in most of its range as being due to general environmental degradation as well as predation by bass and trout. *B. burgi* is however probably extinct in the Eerste River as it has not been collected in this locality since the 1930's. Although *Micropterus* species have probably been introduced into this river (via overflows from the many dams which are stocked in the catchment) it appears that conditions are unsuitable for bass and until very recently bass were not known to occur in this river (Smith personal communication, see also account on *M. salmoides*). It appears therefore that predation by "trout" alone is a major contributing factor leading to the extinction of *B. burgi* in the Eerste River.

3 Tsoelikane River, Lesotho. Introduced in 1943 (Pike and Tedder 1973). The presence of *P. mykiss* poses a threat to *Oreodaimon quathlambae* in this river. The habitat preferences and diets of these two species are very similar. It can therefore be expected that there would be competition between the two species for limited resources. *O. quathlambae* coexists with trout in the Tsoelikane River and yet was eliminated from the Umkomazana River in Natal after the introduction of *S. trutta*. This was probably because in the latter case excessive siltation and environmental degradation had taken place and it has also been suggested that the lower

altitude Umkomazana River is a marginal habitat for this species (Jubb 1971b; Pike and Tedder 1973; Cambray and Meyer in press).

Cambray and Meyer (in press) point out that there has been very little scientific evidence of trout predation on *O. quathlambae*, probably because this aspect has not been studied in detail. Rondorf examined the stomachs of 142 trout (greater than 25 cm Total Length) and did not find any traces of *O. quathlambae* (Cambray and Meyer in press). There is however some evidence to suggest that it is mainly the early life stages which are preyed on by trout and these quickly become indistinguishable in the stomach contents. During sampling of the Tsoelikane River Cambray and Meyer (in press) found that young-of-the-year fish were present at three sites where trout did not occur, but were absent from a fourth site where trout had been introduced.

4. Buffalo and Tyume Rivers, Eastern Cape. Introduced into the Buffalo River in 1901. *Barbus trevelyani* was originally found in both rivers. The introduction of trout into the upper reaches (above the Rooikrantz dam) and bass below the dam may have contributed to the disappearance of *B. trevelyani* from the lower reaches of the river and it was thought to be extinct until eleven specimens were found in the stomach of a large *P. mykiss* specimen from the upper reaches of the Rooikrantz dam. A small population therefore still exists in the Buffalo River, but it is severely threatened by the presence of *P. mykiss*. In 1970 another small population of *B. trevelyani* was discovered in the Tyume River (Jubb 1979). This population is severely threatened by the general degradation of the habitat. Heavy siltation worsens the effects of competition and predation as both trout and *B. trevelyani* then become restricted to smaller and smaller sections of the river. Water extraction from the river also forces *B. trevelyani* out of their preferred habitat (rocky rapids) into areas where they become easy prey to the trout. Therefore the combined effect of the introduction of trout and bass, water extraction, siltation and damming of rivers has forced this species out of its preferred habitat into marginal areas where it survives under stress (Gaigher 1979).

Trout stocking in this area decreased in the late 1970's and the drought of 1979/1980 also reduced trout populations. *B. trevelyani* populations appeared to recover during this period. The Ciskei authorities have now resumed their trout stocking programme (Skelton 1987a).

5. Olifants River (Clanwilliam). Introduced in 1897. Although trout are thought to have been implicated in the general decline of species endemic to this system (Skelton 1987a), the drastic reductions in a number of these species were only noted after the introduction of *Micropterus* species (see *M. dolomieui* section).

6. Wilgekraalspruit, a tributary of the Crocodile River (Lydenburg district, Incomati system). Rainbow trout were introduced between 1976 and 1977 (Kleynhans personal communication). Kleynhans (1984) believes that the disappearance of *Kneria auriculata* from this stream was a direct consequence of the introduction of trout. In 1971 this stream was sampled four times over an annual cycle using seine nets and an electrofisher. The presence of *Kneria auriculata* was recorded on each occasion but no trout were found in any of these samples (de Moor 1971). In collections made in the same stream between 1977 and 1979 the presence of *P. mykiss* was noted but the *K. auriculata* population had disappeared (Kleynhans 1984). During a survey in 1985 *K. auriculata* were again found in the stream but trout had disappeared. During the period of 1971 to 1985 there were no noticeable alterations to the habitat and the stream was probably re-colonised by *K. auriculata* from a very small tributary after the disappearance of trout (Kleynhans personal communication). Kleynhans (1984) noted that slight differences in rainfall can profoundly influence the character of small streams. He also noted that *K. auriculata* was found in streams with maximum water temperatures of 26°C. *P. mykiss* has a preferred temperature maximum of 20°C (Bruton et al 1982) but an eastern Cape strain tolerates water temperatures as high as 26°C (Bruton and Safriel 1985). Kleynhans also noted that the ideal habitat for *K. auriculata* was in small streams which include numerous small shallow pools which are probably too small for trout. It appears therefore that there is some niche overlap between *P. mykiss* (which occurs in pools and small streams but not in fast-flowing rapids) and *K. auriculata* (which prefers the same habitat but has a higher temperature tolerance and is found in smaller streams and pools than trout). A slight modification to the habitat, such as the building of a small weir, or natural events such as sustained high flow levels, would favour colonisation by trout.

Three species of fish parasites have been recorded on *P. mykiss* collected from natural habitats (van As and Basson 1984). Of these *Argulus japonicus* is alien, one may be alien (*Dactylogyrus* species) and the third is indigenous. It is unlikely that *P. mykiss* was solely responsible for the introduction of any alien parasites into southern Africa as *A. japonicus* has been recorded on many other species of fish.

Day (1932b) commented that *P. mykiss* was less successful than *S. trutta* in colonising many Natal streams and he theorised that this was probably due to preferential predation by *Barbus natalensis* on the former species. It was noted that indigenous *Barbus* species move upstream with the advent of the spring rains. *P. mykiss* spawns after this migration while *S. trutta* tends to spawn before the migration. Thus the latter species is less susceptible to predation on their eggs by the *Barbus* species. Day (1932a) compared populations of *P. mykiss* which were released into Merthley lake (Greytown) to those in the Henley reservoir (Umzindusana River). Indigenous *Barbus* species were not present in the lake but were present in the Henley reservoir and after a few years it was found that trout had established in Merthley lake but not at Henley. Day (1932a) took this as evidence that *P. mykiss* was not able to co-exist with large *Barbus* species in Natal rivers. Bush (1933 from Hey 1971b) also reported that *B. natalensis* preyed on the ova and alevins of *P. mykiss*. Crass (1964) proposed that *P. mykiss* was more successful than *S. trutta* in colonising many Natal streams and reported that the former species had replaced *S. trutta* in most streams with a mixed stock. For example the Polela River contained brown trout for a number of years but after the introduction of rainbow trout the stock of brown trout gradually declined and eventually disappeared (Crass 1964).

Crass (1956, 1960) concluded that trout had not had a significant effect on invertebrate populations in Natal streams. There is, however, some controversy over his interpretation of the data (see account on *S. trutta*).

The introduction of *P. mykiss* together with *Barbus anoplus* has led to the spread of piscivorous birds into new areas of the Natal uplands (particularly in the Himeville and Nottingham Road districts) where they had not previously been recorded. These birds include the following species: kingfishers, white-breasted cormorants, reed cormorants, darters, fish eagles and osprey (Alletson 1985).

Control: The Cape Department of Nature and Environmental Conservation has recently introduced a change to existing legislation which would remove the protected status of trout in Cape inland waters. At the same time additional protective measures will be given to a number of rare and endangered indigenous species. It has also been proposed that all inland waters be classified into "sensitive waters" (where viable populations of threatened indigenous species occur) and "non-sensitive waters" (where alien species are established). Stocking of alien aquatic organisms will only be allowed in "non-sensitive" waters. These measures should afford some protection to rare or endangered indigenous species in the Cape Province (Hamman 1986). There have been no similar changes to the regulations in the other provinces of South Africa where some indigenous species have been threatened by the presence of trout eg in the Transvaal where there is strong evidence that *P. mykiss* has posed a threat to surviving populations of *Kneria auriculata* and *Barbus treurensis*.

Research recommendations: A study of animal communities in the numerous small streams in the Lydenburg area could provide a unique opportunity to gain an understanding of the impact of an alien predator on indigenous species. Baseline data are available from de Moor's (1971) study and interesting comparisons could be made between these streams.

Further studies are also needed on the effect of alien fish species (such as trout) on invertebrate stream communities. It may be of interest to compare the communities from streams where trout have replaced indigenous fish species to those in which indigenous species (such as *K. auriculata* or *O. quathlambae*) are still present. The extent of the disruption by trout needs to be more carefully documented by conducting quantitative surveys and lodging representative specimens in recognised museums.

Remarks: By 1940 there had already been a deterioration of trout waters, especially in the southern Cape, due to industrial pollution and the abstraction of water from rivers by irrigation schemes (Harrison 1940a). There has also been a similar decline in populations in Lesotho, and Gephard (1977) recommend that in order to preserve trout populations in Lesotho an intensive attempt must be made to prevent soil erosion, especially in five top priority watersheds (Makheleng, Malibamatso, Khubelu, Mokotlong-Sanqebethu and Liqooa Rivers).

Alletson (1985) found that there are high levels of predation on trout by cormorants, especially the white-breasted cormorant (*Phalacrocorax carbo*) which could take up to 27% of the trout crop in farm dams. Prior to the introduction of trout very few fish were present in streams in the Drakensberg area. Alletson (1985) recommends the provision of more cover in dams and the stocking of alternative prey fish species as a means of protecting trout populations. This proposal must, however, be treated with caution as stocking of more alien species may have a detrimental impact on the environment.

Rainbow trout have been in southern Africa for over 90 years and are well-established in the upper reaches of many river systems. An important recreational angling industry has developed around these fishes which provides healthy entertainment for a large number of people. Trout farming is also well-established in South Africa and has the highest yield of any one species in the aquaculture industry (Safriel and Bruton 1984). Clearly, trout have a permanent place in the economy and ecology of South Africa. We must not, however, lose sight of the fact that they are alien fishes and that it is our unique and primary responsibility to safeguard the future of our own indigenous fishes.

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Personal communications: J A Cambray; A Coetzee; M T T Davies; C J Kleynhans; R Pitt; A Smith.

SALMO TRUTTA Linnaeus 1758

brown trout **alien, equivocal, major impact**
bruinforel

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Salmonidae

SUMMARY

Status: An alien European species first imported into southern Africa in 1892 for the purpose of sport fishing. Brown trout are present in the eastern, southern and south-western mountainous regions of southern Africa but are not as widespread as rainbow trout. *S. trutta* has had a major detrimental impact on certain indigenous species particularly *Oreodaimon quathlambae* in the Umkomazana River in Natal.

Research: Excellent. This popular angling species has been studied by many workers throughout the world. In southern Africa the distribution, general biology and impact on indigenous animals has been studied by Harrison (numerous publications between 1940 and 1978), Crass (publications between 1960 and 1969), Pike and Tedder (1973), Gaigher (1975), McVeigh (1979b) and many other workers.

SPECIES DATA

Synonyms: *S. fario, S. levenensis*. These junior synonyms are sometimes used as subspecies ie *S. trutta fario, S. trutta levenensis* but are now regarded as being varieties of *S. trutta* (Scott and Crossman 1973).

Distinguishing characteristics: The following description is of the inland water or "brook form" of this species: scales small, on body only; small lobe-like adipose fin present; mouth large with canine teeth. In old males the lower jaw turns up into a "kype", the upper jaw being notched to accept it. Adipose fin relatively large compared to that of other salmonids. Body silvery-brown with prominent large reddish spots on the flanks (Bruton et al 1982).

Native range: Europe and western Asia (Welcomme 1981).

Date and purpose of introduction: Introduced for angling purposes (Bourquin et al 1984). In 1890 ova were imported to the Boschfontein Hatchery (Balgowan, Natal) from Scotland (Pike 1980a). The first importations into the Cape were in 1892 when ova were imported from Surrey (England) and these were released into a small river near Stellenbosch (Anon 1944 1962/63b). Many of the early accounts of introductions of trout into the Cape refer to the "Loch Leven" strain of the brown trout. However this soon merged with the "common brown trout" stocks at Jonkershoek Hatchery (Anon 1962/1963).

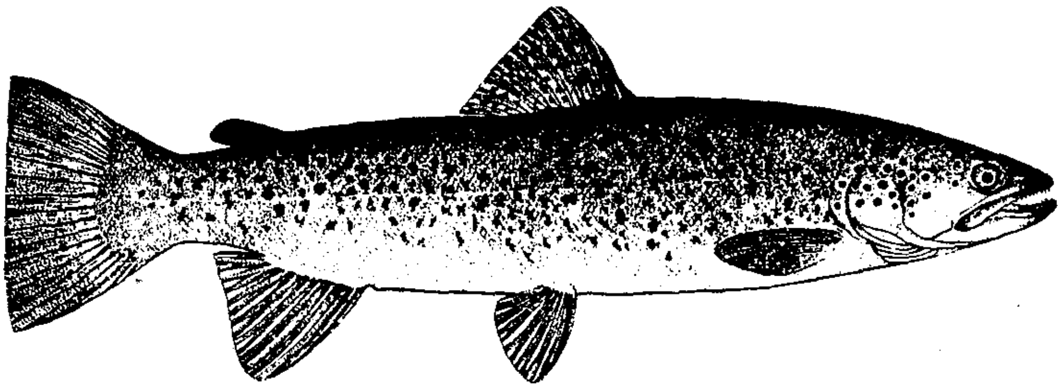
Many unsuccessful attempts were made to introduce brown trout into the Pirie Hatchery (Kingwilliamstown). The first stripping of ova took place in 1897 (Harrison 1940a).

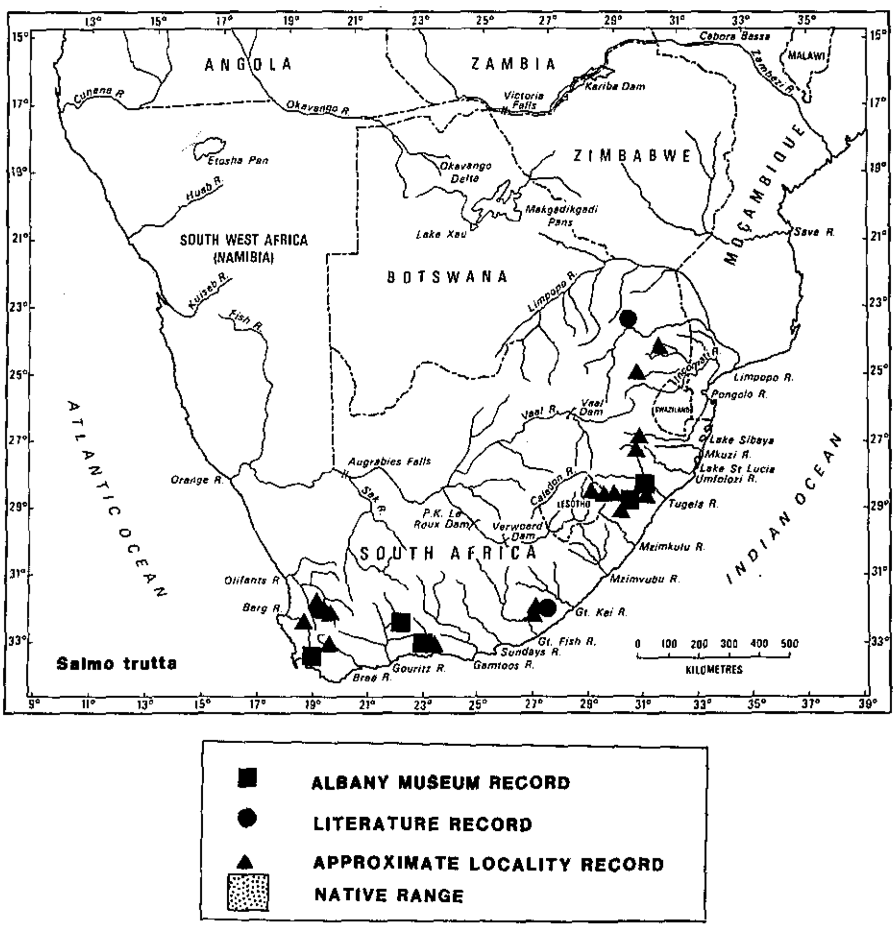
Appendix 2 gives a detailed summary of specific localities and dates of first releases.

Southern African distribution: This species has regularly been stocked in many river systems and the following account of their distribution does not necessarily indicate that breeding populations exist in the localities mentioned. In some cases populations have been described as "established" in the literature but it is not certain whether the authors used this term in its strict scientific sense (ie that a breeding population exists). Where details concerning the degree of "establishment" of populations were given, these are mentioned. The account of brown trout distribution given below is probably not complete as this species has been stocked in many

SALMO TRUTTA Linnaeus 1758

FIGURE 19. The brown trout *Salmo trutta* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





localities which have not been recorded in the literature.

Historical distribution

Before 1930: In the Mooi, Bushmans, Umgeni and Loteni Rivers in Natal as well as the Umzimhlava River (East Griqualand) (Bennion 1923). Bennion also refers to the presence of "trout" in the Elandspruit River (near Machadadorp, eastern Transvaal), the Helpmekaar and Broederstroom River (northern Transvaal), the Wemmer, Eerste and Hex Rivers (Cape), the rivers near Himeville (Natal), and the Wildebeeste and Little Pot Rivers of East Griqualand. It is uncertain which of these rivers contained *S. trutta* but this species was reported to be "the only species of trout in the Mooi River." Brown trout were also present in the White River (Bain's kloof), Cedarberg streams east of Uitkyk Pass (Olifants system), the Buffalo, Keiskamma and Tyume Rivers in the eastern Cape and in the Ginqiskodo River (Umzimkulu district).

1949: Present in the following localities in the Cape: Steenbras reservoir (where they survive but do not breed), Lourens River, Upper Berg and the Wemmer and Dwars Rivers (tributaries of the Upper Berg). Also in the Smalblaar, Witte and Witels Rivers of the Breede River system and the Keiskammahoek and upper Buffalo Rivers of the eastern Cape. "Trout" (species not given) were also reported from the upper tributaries of the Olifants River system and in the Ndowana and Ingwangwana Rivers (Harrison 1949). At an earlier date Barnard reported that *S. trutta* was "present but struggling" in the Gwaayang River near George (Harrison 1951). This was the only colony of these fish in the acid coastal rivers between Mossel Bay and the western end of the Tsitsikama.

There are no further records of their distribution in 1949 outside of the Cape. Brown trout were probably still present in areas where they had been established by 1923.

Present distribution

Brown trout are generally well established in the mountainous parts of the Cape, the upper Orange River system in Lesotho, the eastern Transvaal and the mountainous parts of Natal (Crass 1969a).

Natal: In the upper reaches of the following river systems: Umkomaas, Umgeni, Umvoti, Tugela, Upper Bushmans, Buffalo and Phongolo Rivers (Crass 1966). Also in the Midmar dam (Umgeni River) (Heeg 1983) and the Highmoor dam (Pike and Wright 1972). The population in the Upper Bushmans River, which was reported to be well-established and self-sustaining, was found at an altitude of 1200 to 2000 m (Crass 1969b).

Lesotho: In most of the highland waters, particularly in the Tsoelikane River (Jubb 1972b) and the Moremoholo and Senqu Rivers (altitudes of 2560 m and 2740 m respectively) (Rondorf 1976). Also in the Mokhotlong, Sanqebethu and Khebelu Rivers (Gephard 1977).

Cape: Present in the Breede River (Skelton 1987a). Their range in the Buffalo River has declined and brown trout are now only present in the Maden dam (Jackson 1982). Also in the Tyume River (Gaigher 1975a), the Cata River (Pitt personal communication) of the Keiskamma system and in Gubu dam (Kubusie River, Kei system) (Bruton personal observation). Present but very infrequently found in Lake le Roux (Jackson et al 1983). Also found in the Keurbooms River (Davies personal communication), and in the headwater tributaries of the Orange and Caledon Rivers. The population in the Gwaayang River was reported to be present in 1966 but it is uncertain whether this species is still present in this river (Harrison 1966a). Survives but does not breed in the Steenbras reservoir (Harrison 1960/61 and 1964). Present in the Wemmershoek River and reservoir (Louw 1979). Self-perpetuating populations are present in the Witte River (Bain's kloof) and the Witels River (in Mitchell's Pass, Smith personal communication).

The population in the Olifants system has declined and a survey of the main (south-western) Olifants River conducted in 1963 and 1964 indicated that no brown trout were found in the mainstream or in the following tributaries: Ratel, Hex, Jan Diesels, Doorn, Thee, Boontjies, Rondegat and Kunjes Rivers. Trout had been stocked in many of these tributaries at earlier dates (van Rensburg 1966b). At present breeding populations of *S. trutta* occur in the following localities in the Olifants system: (all localities from the Leerkloof River upwards): In the Riet, Twee, Middeldeur, Matjies (tributaries Kromme and Driekloof) and Leerkloof Rivers (Smith personal communication). Smith commented that the Leerkloof River population appeared to be self-perpetuating.

Gilchrist in 1904 recorded a *S. trutta* female from the sea, caught in a seine net off Muizenberg beach about 26 km from the Eerste River mouth (Harrison 1958).

The Jonkershoek Hatchery stopped production of brown trout in 1983 so it is expected that populations will decline in areas which relied on regular stocking (Smith personal communication).

Transvaal: Breeding populations are still present in the following areas: Limpopo system: inlets to the Ebenezer and Dap Naude dams (Letaba system) and the upper Blyde River. Also in Dullstroom (Crocodile River, Incomati system) (Coetzee personal communication). The Lydenburg Hatchery ceased stocking this species in about 1972.

Habitat preferences: Confined to cold upland waters. Their tolerance limits of environmental extremes are lower than those of rainbow trout. Brown trout requires cold well-oxygenated water (Bruton et al 1982) and favours the larger, less precipitious streams in the mountainous areas with adequate cover in the form of submerged rocks, undercut banks and overhanging vegetation (Crass 1969a, 1986). Survive but do not breed in the Steenbras reservoir where pH levels are sometimes as low as 4,2 (Harrison 1960/61). The acid peat-stained coastal streams from False Bay to Port Elizabeth have been described as "unsuitable for trout" (see account on *Parasalmo mykiss*) (Harrison 1950). A "thriving" population of *S. trutta* was recently reported by Davies (personal communication) to be present in the Keurbooms River which is generally described as being a "peat-stained acid stream". The question of pH tolerance is complex and has been discussed more fully in the section on *P. mykiss*.

In recent years the range of both this species and *Parasalmo mykiss* in Lesotho has been restricted because of excessive soil erosion (Gephard 1977).

Salmo trutta is reported to be less tolerant than *P. mykiss* of adverse environmental conditions such as higher temperatures, excessive water abstraction from rivers and high siltation levels. Populations in the Bushmans River (Natal) declined during the drought of 1946-1947 and the upper river was almost depopulated during this period (Crass 1969b).

The habitat preferences of trout (both *S. trutta* and *P. mykiss*) are summarised below: Turbidity: Waters must be clear to a depth of approximately 3 meters. Since trout are visual predators they require clear waters in order to see their prey (McVeigh 1979b). Water temperature: Optimum 16 to 18°C. Beyond 21°C oxygen transfer becomes difficult and the maximum temperature which can be tolerated for short periods of time is 30°C. Spawning occurs in cold waters of 4 to 6°C. Eggs die if the water temperature exceeds 16°C (McVeigh 1979b; Crass 1986). Oxygen requirements: Require very high oxygen levels for successful spawning and development of ova. Minimum lethal limit is 45% oxygen saturation (eg 4,5 ppm) at 17°C. The sublethal effects of low oxygen levels are sluggish movements, decreased metabolic rate and susceptiblity to disease (McVeigh 1979b). pH and carbon dioxide levels: In acid waters carbon dioxide exists in a free form and at high alkalinities it is bound as hydroxide ions. Carbon dioxide concentrations are thus closely related to pH levels in the water. Brown trout can normally tolerate pH values of 5 to 9 (with extreme limits of 4,2 to 11,0) and carbon dioxide levels under 36 ppm. These figures vary with temperature and pH (McVeigh 1979b). Brown trout have a high tolerance of high salinity levels and can move from freshwater to the sea (McVeigh 1979b).

Breeding: Brown trout ascend to the higher reaches of rivers in order to spawn in clear gravelly streams during winter (Holcik and Mihalik 1968, Bruton et al 1982). Large orange eggs (about 4mm in diameter) are shed onto the gravel and covered with sand by the female. The eggs hatch after about 20 days at 1 to 2°C and in a shorter period at higher temperatures. Young fry receive nutrients from their yolk sacs for about 20 days before beginning to feed (Holcik and Mihalik 1968).

Feeding: Young fry feed on microscopic animals in the water whereas adults feed mostly on benthic invertebrates (insect larvae, molluscs and small crustaceans), as well as on fish eggs, small fishes and amphibians. The European sea trout feeds on herrings, sprats and molluscs (Holcik and Mihalik 1968). A specimen caught in the sea at False Bay had two small mullet and a gurnard in its stomach (Harrison 1958).

Behaviour: The Eerste River population appears to have a "sea-run" into False Bay during spring and autumn (Harrison 1958) (see account of *P. mykiss* for details). In Europe it has been found that inland populations lose their migratory instinct, but may regain this instinct after a number of generations if they are placed in estuaries with free access to the sea. The opposite effect is noted if "sea trout" populations are placed in a lake environment (Holcik and Mihalik 1968). The amount of time spent in the sea by the Cape populations is not known but it appears that only a relatively small proportion of the population moves into the sea and it is unlikely that these populations can be compared with the "sea trout" of Europe (Harrison 1958).

Hamman (1980) noted that there was an annual migration of trout (both *P. mykiss* and *S.trutta*) from the upper reaches of the Orange River into the Verwoerd dam. Most of these fish appeared to be in poor condition and many probably died off later in the season due to the high summer temperatures experienced in the dam.

In the Wemmershoek reservoir it was noted that both *S. trutta* and *P. mykiss* moved to deeper, cooler waters in summer when temperatures increased. When surface temperatures cooled in winter the fish would again move to the surface and also began to move upstream to breed (Louw 1979).

Impact: Generally brown trout are not regarded as such a serious threat to indigenous species as some other introduced predators such as bass. *S. trutta* is not as widespread as *P. mykiss* and has not had as much impact as the latter species. Skelton (1987a) lists predation and/or competition by *S. trutta* as being one of the threats to the status of the following species listed in the Red Data Book: *Barbus bergi* (Berg, Eerste and Breede Rivers, endangered); *B. andrewi* (Berg and Breede Rivers, vulnerable); *Barbus burchelli* (Breede River, rare). Predation by *S. trutta* in the above cases is usually regarded as a minor contributing factor leading to the decline of these species, habitat destruction being the most important factor.

Pike and Tedder (1973) regard the introduction of *S. trutta* as one of the contributory factors leading to the decline and eventual extinction of *Oreodaimon quathlambae* from the Umkomazana River in Natal. The diet of *O. quathlambae* is very similar to that of *S. trutta* (mainly aquatic insects such as mayflies and caddis flies). It is likely that there is competition between the two species for the same food resource. Prior to the introduction of trout *O. quathlambae* was the only fish species present and was confined to the upper section of the river (separated by a waterfall from the main Umkomaas River). No baseline collections were done before 1910, but the superintendent of the Umkomaas Hatchery observed (in 1938) that *O. quathlambae* had been very common in the river prior to the introduction of trout. There was a sharp decline in this species in the first half of the century and, despite concerted efforts, no specimens have been collected in this river (the type locality) since 1938 (Jubb 1966a; Greenwood and Jubb 1967).

It was also noted that there was considerable deterioration of the habitat during the first half of the century due to the denudation of the catchment resulting in an increase in the severity of floods after heavy rains. The degraded habitat as well as the presence of *S. trutta* probably both contributed to the disappearance of *O. quathlambae* from the Umkomazana River (Jubb 1966a). It was thought that *O. quathlambae* was extinct until it was rediscovered in the Tsoelikane River, Lesotho, in 1970 (Pike and Tedder 1973). Other populations were later discovered in the Moremoholo and Senqu Rivers (Rondorf 1976). In the latter two rivers the populations of *O. quathlambae* were confined to sections of the river above waterfalls. Trout were found below these falls but had not been able to colonise the rivers above the falls. Rondorf (1976) mentions that *P. mykiss* and *S. trutta* were found in the lower Morehomolo River, but does not mention the species of trout found in the Senqu River. He also comments that one of the probable reasons for the continued survival of *O. quathlambae* in these rivers was the fact that waterfalls had prevented the colonisation of the upper river by trout, thus providing a refuge for *O. quathlambae*. It was also noted that there was very little soil erosion in the area. Skelton (1987a) mentions that at present the population in the Tsoelikane River is the only one which is threatened by the presence of *P. mykiss* (*S. trutta* does not occur in this river, Cambray personal communication).

Contrary to the above findings, Crass (1960) suggests that since *O. quathlambae* and *S. trutta* co-existed in the Umkomazana River for 20 years, the presence of trout could not have been an important factor leading to the local extinction of *O. quathlambae*.

In his discussion on the effect of introduced trout on stream communities, Crass (1960) noted that a number of studies carried out in Kenya and New Zealand had suggested that the introduction of trout had no significant effect on the total quantity of bottom fauna in rivers. Productivity in most short-lived insect populations is very high and population densities are usually limited by conditions such as available food and space as well as intraspecific competition which accounts for high mortalities in young larvae. These insects have also adapted to survive catastrophic events such as droughts and floods, and have the capacity to rapidly re-colonise areas when conditions are favourable. Thus these species are easily able to adjust to the introduction of a new predator and predation by large long-lived species such as trout would have very little effect on the population levels of insects. Availability of food and space are likely to be the most important limiting factors to population growth. Increased predation levels will probably only serve to decrease intraspecific competition (Crass 1960).

Crass (1960) compared benthic faunal populations in Natal streams where trout had been introduced to those which had not been stocked with trout. It was noted that "observations have failed to indicate that fewer nymphs are to be found in places where trout occur than in similar situations from which trout are absent" (Crass 1960).

F C de Moor (personal communication) commented that generally in benthic stream communities predation by fish and other vertebrates is less effective in limiting invertebrate prey population size than predation by invertebrates which tend to have a higher productivity than trout. While it is clear that the introduction of trout would probably have little effect on the total biomass of benthic invertebrates, species composition is likely to be affected and it can be expected that cryptic and reclusive species would probably replace the more active and visible species preyed on by trout.

In a study carried out on a moorland stream Macan (in Healey 1984) found significant changes in the species composition of stream invertebrates after the introduction of *S. trutta*. There was a sharp decline in a dragonfly nymph (*Lestes sponsa*) which had been plentiful before the introduction of trout but was later restricted to small areas of the pool in which cover existed. Some dytiscid larvae and one water beetle species (*Rhantus exsoletus*) disappeared after the introduction of trout. These species had been rare, but were consistently encountered in samples. Similarly a number of hemipteran species were reduced in number and restricted to shallow nearshore areas with cover. Overall, the introduction of *S. trutta* resulted in a decline in the number of species encountered and a restriction of their distribution with rare and occasional species being eliminated.

Apart from Crass' study there have been no comparable detailed studies in southern Africa on the effect of trout introductions on invertebrates. It is probable that trout would have differing impacts in different streams depending on the composition of indigenous fish species present prior to the introduction of trout. Significant changes in invertebrate community structure would probably result if trout replaced indigenous species with a dissimilar diet (eg *Kneria auriculata*) whereas replacement by trout of a species with a similar diet (eg *Oreodaimon quathlambae*) would probably not result in major changes to the benthic community.

Crass (1960) also reported that although tadpoles are frequently found in the stomachs of trout there is no evidence that frog populations have been seriously affected by the introduction of trout into Natal rivers. Large populations of frogs have been found in trout hatcheries and certain species such as *Bufo regularis* appear to be unpalatable to trout.

While certain indigenous species of fish such as *O. quathlambae* may have been adversely affected by trout, others such as *Amphilius natalensis* have apparently been unaffected and large populations have been noted to exist in streams where trout are numerous (Crass 1960).

Salmo trutta is not as widespread as *P. mykiss* in southern Africa (Welcomme 1981) and appears to be adapted to survive at higher altitudes than the latter species.

Control: The policy of declaring some rivers as "sensitive" and banning the introduction of alien species into these systems should be encouraged. At the same time, some of those systems which are already well stocked with trout should continue to support a recreational fishery. These stretches of rivers could even be "improved" for trout by installing bank stabilisation structures and shelters, as is done in North America. The concept of river sanctuaries and catchment authorities is starting to be introduced into South Africa and will hopefully result in the zoning of rivers into different usage zones according to the intrinsic qualities of the river.

Brown trout are sufficiently widely stocked in southern Africa to serve the needs of recreational fishermen and should not be stocked into further rivers or streams. The locations of trout farms and the measures taken to avoid escape by trout ova and adults should be carefully monitored by the nature conservation authorities.

Research recommendations: Research is urgently required on the effect of brown trout on invertebrate and fish communities.

Remarks: Brown trout are regarded as the most esteemed of all trout by fly-fishermen (Bruton et al 1982).

S. trutta has the ability to transform into a "smolt stage" before entering the sea. The fish becomes a bright silvery colour, presumably as a protective adaptation for life in marine and estuarine waters. This transformation is controlled by an alteration in levels of thyroid hormones (Harrison 1959/1960). The "sea trout" bears a close resemblance to the salmon (*Salmo salar*) and was once regarded as a separate species to the "brown trout", but it has now been shown that they are two different forms of the same species (Holcik and Mihalik 1968)

An indirect result of the difficulty which was initially experienced in introducing trout has been the restrictive legislation introduced to prevent poaching. The netting of any trout has been prohibited except under permit from the provincial authorities. This has had a restrictive effect on the development of fish culture and may have contributed to the overpopulation of carp in many waters (Jackson 1973a).

Hybrids of *Salmo trutta* females and *Salvelinus fontinalis* males are referred to as "tiger trout". A batch of these hybrids was bred at the Jonkershoek Hatchery and released in the Steenbras reservoir (in the Hottentots-Hollands mountains) in 1960. They initially appeared to thrive (Harrison 1960/61) but later recoveries were poor (Harrison 1970/71). Releases were also made into the Wemmershoek reservoir (western Cape) in 1964 (Anon 1966; Harrison 1969).

The "tiger trout" is reported to be a better fighting fish than the brook or brown trout (Harrison, 1960/61) and was reputed to be more tolerant of acid waters than brown trout (Harrison 1960/61) but this has not proved to be the case in the Cape.

REFERENCES

Anon (1944, 1945, 1952b, 1956a, 1961/62, 1962/63, 1966); Bell (1961/62, 1962/63); Bennion (1923); Bourquin et al (1984); Bruton et al (1982); Clay (1972); Crass (1960, 1966, 1969a, 1969b, 1986); Day (1932a); Gaigher (1975a); Gephard (1977); Greenwood and Jubb (1967); Hamman (1980); Harrison (1940a, 1948a, 1949, 1950, 1951, 1955, 1958, 1959/60, 1960/61, 1962/63b, 1963a, 1964, 1966a, 1969, 1970/71, 1971, 1972/73, 1975, 1976a, 1977/78); Healey (1984); Heeg (1983); S A Hey (1926); Holcik and Mihalik (1968); Jackson (1973a, 1982); Jackson et al (1983); Jubb (1966a, 1972b); Louw (1979); McVeigh (1979b); Pike (1980a); Pike and Tedder (1973); Pike and Wright (1972); Rondorf (1976); Scott and Crossman (1973); Skelton (1987a); van Rensburg (1966b); Welcomme (1981).

Personal communications: J A Cambray; A Coetzee; M T T Davies; F C de Moor; R Pitt.

CARASSIUS AURATUS (Linnaeus 1758)

goldfish
goudvis

alien, equivocal, major impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An alien species indigenous to eastern Asia which was originally imported for ornamental purposes. The presence of goldfish in the Cape was first recorded in 1726. Although only a few self-sustaining populations of goldfish are established in natural waters, and these have apparently had few detrimental effects on indigenous species, goldfish have had a major detrimental impact on indigenous communities through the introduction of harmful fish parasites.

Research: Good. This well-known species has been widely studied by aquarists.

SPECIES DATA

Recent synonyms: *Cyprinus carassius*, *Carassius gibeloides* (Nichols 1943). A number of fancy morphs such as comets, veiltails and shubunkins have been developed for the aquarium trade (Sterba 1962).

Native range: Eastern Asia. Seeley (1886) records the native range as being "China, the islands of China and Japan". Since this species has been kept in captivity for a number of centuries (Sterba 1962), it is likely that there were some early translocations within this area.

Distinguishing characteristics: A small attractive cyprinid fish. Body stout, rather high, compressed. Abdomen rounded. Head small, slightly depressed dorsally. Snout blunt. Mouth terminal, small, oblique, cleft not extending to anterior margin of eyes. Eyes large, superior. Lips thick and fleshy. Lower jaw protractile, more or less projecting. No barbels present. Dorsal fin inserted ahead of pelvic fins. Anal fin short. Caudal fin forked, both lobes equal. Scales semi-cycloid. Dorsal fin edge straight. Caudal fin forked (Jayaram 1981).

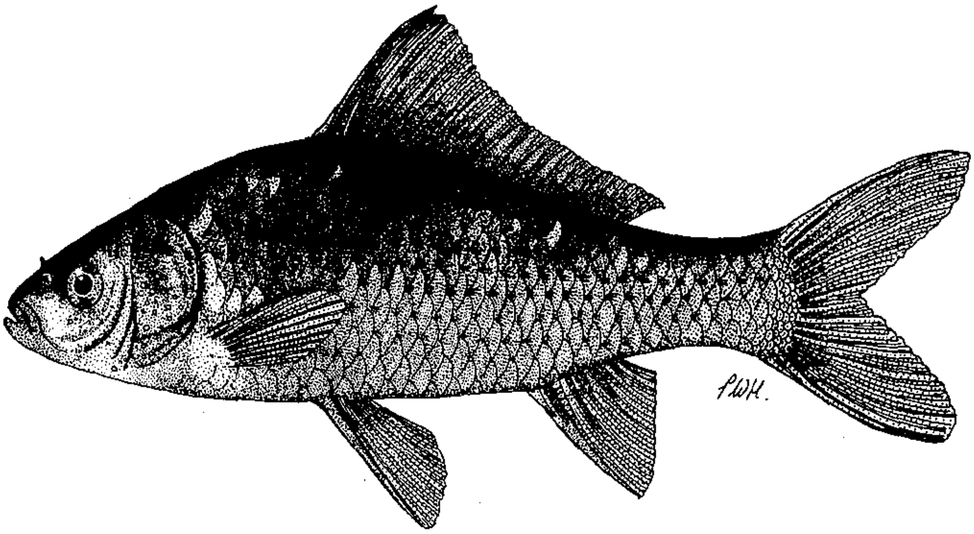
Date and purpose of introduction: Goldfish were recorded as early as 1726 in the Cape by Valentyn who mentioned that he saw them in a tank at the Governor of the Cape's house (Raidt 1971; Skelton and Skead 1984). It is not certain whether these fish were released into natural waters. The first record in a natural environment is from Castelnau's (1861) list of the freshwater fishes from the Cape Colony which included the species *Cyprinus longicaudis*. Examination by P H Greenwood of the original type specimen in the British Museum (Natural History) indicated that the specimen is correctly named *Carassius auratus*. These fish were probably brought to the Cape colony by sailors returning to Britain from India (Jubb personal communication). There were probably numerous importations during the 19th century from vessels trading with the east (Jubb personal communication).

In 1941 the Jonkershoek Hatchery started supplying this species to various parts of South Africa for ornamental purposes and for mosquito control (Anon 1944). *C. auratus* was also introduced into southern Africa from Mauritius in 1953 for aquacultural purposes (Welcomme 1981). Goldfish were illegally introduced into the Liesbeeck Dam (Cape peninsula) during the early 1950's (Anon 1958).

Southern African distribution: Table 15 summarises the known distribution of *C. auratus*.

CARASSIUS AURATUS (Linnaeus 1758)

FIGURE 20. The goldfish *Carassius auratus*, with its distribution in southern Africa (excluding Zimbabwe and Mozambique)



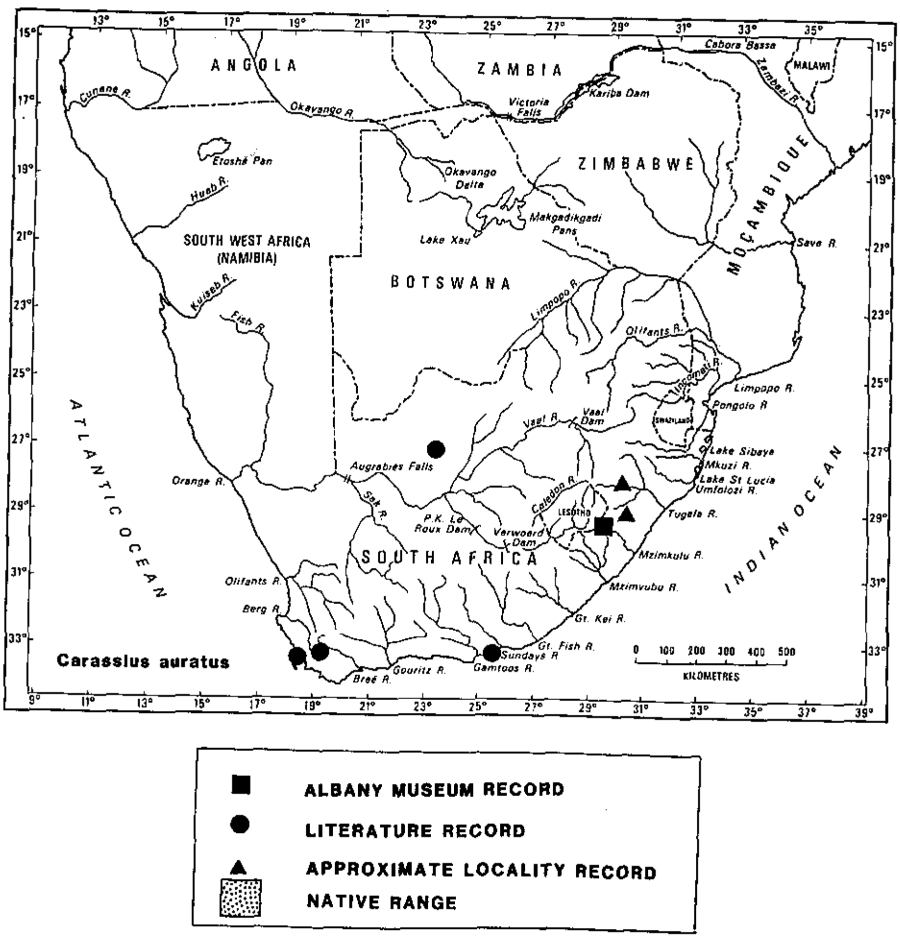


Table 15. Distribution records of *Carassius auratus* in southern Africa

Date	Locality	Remarks	Reference
1938	Breede R system (near Robertson)		Harrison (1938)
1938	Brandvlei Lake (western Cape)		Harrison (1938)
1949	Liesbeeck River (western Cape)	Probably escapees from garden ponds	Harrison and Lewis (1968/69)
?	Little Princess vlei (Heathfield)		Harrison (1976b)
1983	Baakens R (eastern Cape)		King and Bok (1984)
1974	Kowie River (Port Alfred)		Albany Museum record
1983	Gansvlei R and Klein Riet R (Sak R, Orange system)	In catch basins of windmills	Hocutt and Skelton (1983)
?	Aapies R (Pretoria)	Unconfirmed report	Kleynhans (personal communication)
?	Umsindusi R (Umgeni system) (Pietermaritzburg)		Crass (1964, 1966)
?	Upper Tugela River		Crass (1966)
1987	Nthuseleni stream (Umzimkulu system-Underberg area)		Albany Museum record

C. auratus has also been reported to occur in "ponds and dams in Natal" (Crass 1964) and in the "east coast drainage basin in southern Africa" (Bowmaker et al 1978). Hamman (personal communication) confirmed that this species has recently been collected in the Liesbeeck and Black Rivers in the Cape peninsula and in Brandvlei lake.

The two records from the Sak River were from "Windmill catchbasins" (presumably reservoirs) and were not recorded in the main channel of the river. There is a possibility that they could spill over into the natural watercourse (Hocutt and Skelton 1983). The records from the Umsindusi and Aapies Rivers need further confirmation. It is also doubtful that this species would survive in the saline conditions prevailing in the lower Kowie River. Therefore the record from this locality must be treated with circumspection. It is probable that this was a chance record of a single (possibly moribund) specimen which may have escaped from a garden pond.

Habitat preferences: Goldfish prefer impoundments or slow-flowing rivers and are not generally considered to be open water fish (Crass 1964). They are not as resistant as indigenous *Barbus* species to the effects of flash-floods (Heard and King 1981).

Breeding: Optimal temperatures for breeding in aquaria are 22 to 23°C. Young hatch after 5 to 7 days and initially attach to plants or the side of the tank (Sterba 1962). *C. auratus* is a prolific breeder in favourable environments (Crass 1964).

Feeding: Omnivorous, feeding on both plants and animals (Sterba 1962).

Impact: *C. auratus* has been associated with the spread of the following species of fish parasites in different parts of the world:

Protozoa: *Ichthyophthirius multifilis, Mitraspora cyprini, Pleistophora hyphessobryconis, Sphaerospora carassii, Trichodina reticulata, T. subtilis, Trichodinella epizootica.*

Monogenea: *Dactylogyrus anchoratus, D. baueri, D. formosus.*

Branchiura (Crustacea): *Argulus japonicus, Lernaea cyprinacea*

Nematoda: *Philometra sanguinea.* (Hoffman and Schubert 1984).

Many of these parasities are also found on other species of fish, particularly carp, and as a result it is not always certain which species of fish was the carrier of the parasite (Hoffman and Schubert 1984).

Of the species listed above *I. multifilis, A. japonicus* and *L. cyprinacea* have been found in southern Africa. The method of entry of *I. multifilis* is uncertain since this parasite has been associated with many different introduced species of fish. The importation of *A. japonicus* is probably associated with both *C. carpio* and *C. auratus* and it is uncertain whether *L. cyprinacea* is actually an introduced species (Bruton and Merron 1985). If it is shown to be an alien species, it was almost certainly introduced with *C. auratus* (Hoffman and Schubert 1984). There are also other Protozoan species (*Chilodonella cyprini, C. hexasticha, Cryptobia branchialis, C. carassii, Hexamita* spp., *Ichthyobodo necatrix* and *Oodinium pillularis* which have been associated with goldfish and carp which may have been introduced into different parts of the world, but their status as aliens is uncertain (Hoffman and Schubert 1984). Of these, the following species have been found in southern Africa: *Chilodonella cyprini, C. hexasticha* and *I. necatrix* (Bruton and Merron 1985).

Besides the possibility that this species may have introduced a number of parasites into South Africa, it appears that their impact on freshwater ecosystems has not been significant. Although there must have been many opportunities for specimens to escape into natural watercourses, there are not many established self-sustaining populations present in natural waters.

Control: Any new importations, whether for aquarists or otherwise, should be carefully screened for parasites. The introduction of goldfish into natural waters should be strictly prohibited.

Remarks: Harrison (1938) noted that the wild population of this species in the Breede River system had reverted to a grey-brown colouration. He also commented that *C. auratus* was of little value as an angling fish or for eating.

There are at least four commercial goldfish farms in South Africa (two in the Transvaal and two in the western Cape).

REFERENCES

Anon (1944, 1958); Bowmaker et al (1978); Bruton and Merron (1985); Castelnau (1861); Crass (1964, 1966);

Harrison (1938, 1976b); Harrison and Lewis (1968/69); Heard and King (1981); Hoffman and Schubert (1984); Hocutt and Skelton (1983); Jayaram (1981); King and Bok (1984); Nichols (1943); Seely (1886); Skelton (1983); Skelton and Skead (1984); Sterba (1962); Raidt (1971); Welcomme (1981).

Personal communications: J A Cambray; P H Greenwood; K C D Hamman; R A Jubb; C J Kleynhans.

CTENOPHARYNGODON IDELLUS (Valenciennes 1844)

grass carp | **alien, equivocal, major impact**
graskarp

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An alien carp introduced for aquaculture purposes and as a means of controlling aquatic weeds. *C. idellus* has escaped into the Umgeni River in Natal but is unlikely to breed in any South African rivers. Grass carp may be a useful species for weed control, but if overstocked may denude natural vegetation in dams. Because of the concomitant introduction of an extremely dangerous fish parasite, *Bothriocephalus acheilognathi*, the introduction of grass carp has had a major detrimental effect on indigenous species.

Research: Excellent. Many studies have been done on the general biology of this species and its impact on the environment when introduced into the USA and other countries. In South Africa Pike (1980b, 1986) has done detailed studies on their impact on aquatic plants.

SPECIES DATA

Distinguishing characteristics: A large herbivorous cyprinid fish. Body cylindrical. Colour dark above and silvery below. Height of body approximately equal to length of head. Snout obtuse and depressed. Scales large with radiating striae. Origin of dorsal fin in advance of ventral fin. Ventral fins shorter than pectorals. Anal fin with unserrated spines. Caudal fin deeply incised, shorter than the head (Mohasin and Ambak 1983).

Native range: Asia. Found in the Amur region (Siberia and Manchuria), China and the USSR in the lower reaches of the Amur River (Jayaram 1981). The rivers containing native populations of *C. idellus* run into the Pacific Ocean between 50°N and 23°N (Pike 1986).

Date and purpose of introduction: Introduced for fish culture (Bourquin et al 1984) and also as a means of controlling excessive aquatic vegetation in impoundments (Brandt et al 1981).

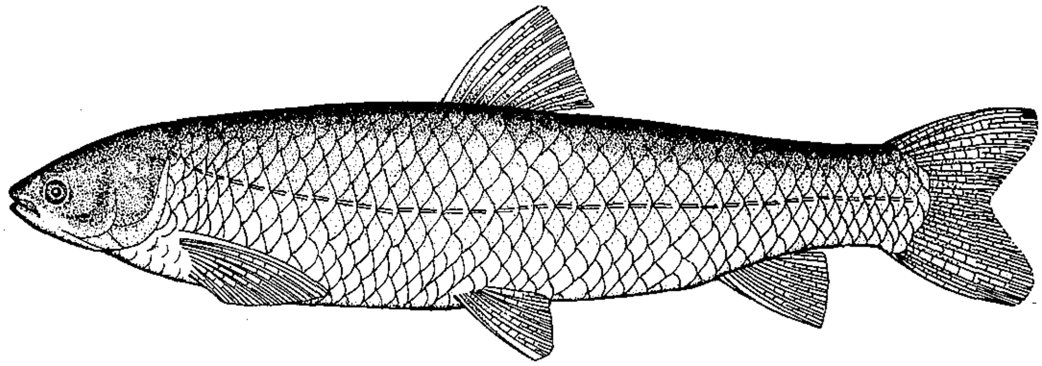
Imported to the Umgeni Hatchery (Natal) in 1967 from Batu Berendam Research Station, Malaysia (Pike personal communication). Numerous farm dams in Natal at altitudes between 125 and 1525 meters were stocked in 1985 and 1986 for experimental purposes and weed control (Pike 1986, Pike personal communication). Fish later escaped from a dam on the farm Edmore in the Umgeni catchment which had been stocked in 1977. Recorded in the Nagle dam (lower Umgeni River) in 1985 (Pike personal communication). Released into Victoria lake in Germiston (Vaal system) in 1983 and into some dams "on the (Transvaal?) escarpment" for the purpose of weed control (Kleynhans personal communication).

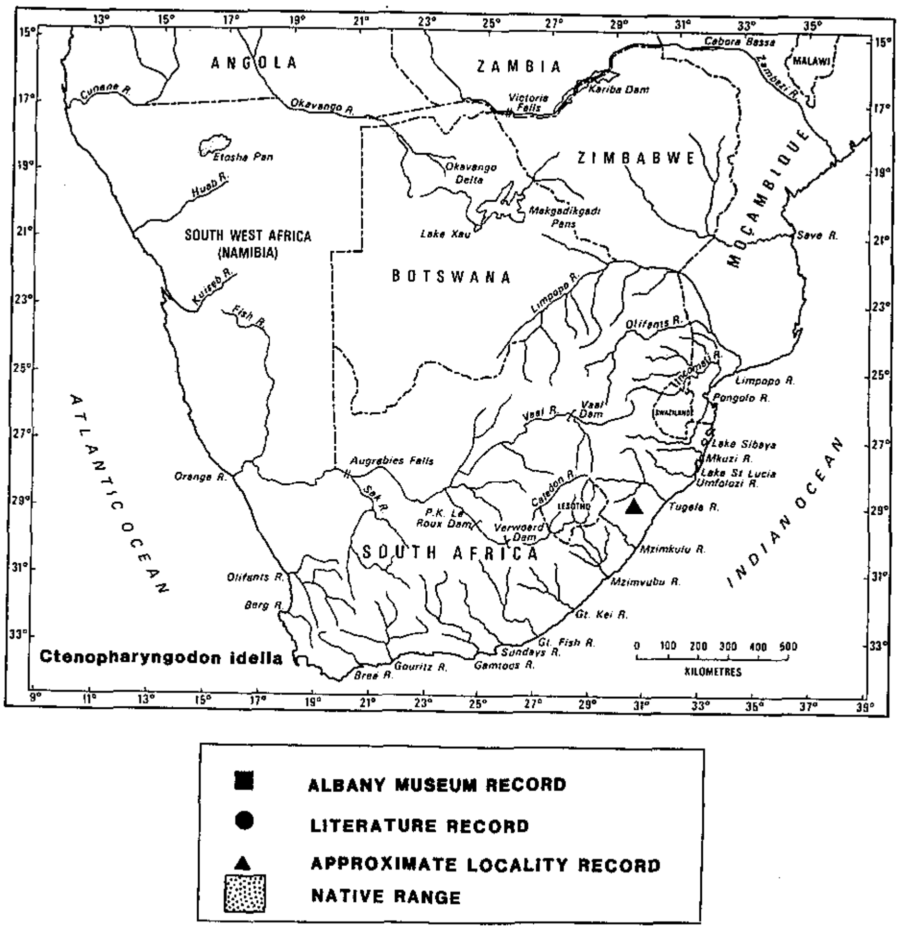
Southern African distribution: Umgeni River above Nagle dam (Pike personal communication) and Victoria Lake (Germiston) (Vaal system). Also present in numerous farm dams in Natal and the Transvaal (Pike and Kleynhans personal communication).

Habitat preferences: *C. idellus* can survive in eutrophic conditions (Safriel and Bruton 1984). Large slow-flowing rivers are required for successful breeding. This species can tolerate a wide range of temperatures (from 0 to 35°C, Pike 1980b). Adult fish have a preference for densely vegetated inshore areas 1 to 3 m in depth (Shireman and Smith 1983).

CTENOPHARYNGODON IDELLUS (Valenciennes 1844)

FIGURE 21. The grass carp *Ctenopharyngodon idellus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Breeding: In order to induce spawning this species requires an increase in the level of the river together with a simultaneous increase in water temperature and possibly a sudden change in electrolyte concentrations (Jackson 1973a). Eggs are semi-buoyant and must remain in suspension until hatching, which usually occurs approximately 20 hours after fertilisation at a water temperature of 24°C. The newly hatched larvae are then carried by the water current for 5 or 6 days. The river flow must be gentle and shocks sustained in large rapids or waterfalls would probably kill the young larvae. Within the geographical region covered by this publication no rivers approach these conditions and it is unlikely that this species will breed naturally in southern Africa (Jackson 1973a). Pike (1986) however considers that there is a small possibility that breeding could be successful in the lower sections of the Phongolo and Usutu Rivers. It should be noted that the successful breeding of *C. idellus* in the USA and Europe was once considered to be very unlikely. This species has since established breeding populations in the Mississippi and the Danube Rivers (Welcomme 1984) as well as in the Tone River (Japan), a number of rivers in the USSR, the Rio Balsas system in Mexico, as well as in the Philippines and Taiwan (Shireman and Smith 1983).

Grass carp spawn in the primary channels of rivers during peak high-water periods. The pelagic larvae migrate downstream and eventually enter associated lakes or floodplains which serve as nursery areas. Juveniles may later move out of these areas back into the main channel and migrate upstream or downstream as far as 1000 km from their original spawning grounds (Shireman and Smith 1983).

Grass carp have a long lifespan. Adults may attain an age of 10 to 15 years (Bruton and Merron 1985).

Feeding: Feeds mainly on aquatic vegetation, consuming large quantities of soft-leaved fresh plant material. *C. idellus* has an inefficient digestive system as only approximately 65 % of ingested material is digested and assimilated. Large fish can consume as much as their own body mass of plant material per day at temperatures between 28 to 38°C (Pike 1986). Pike (1980b) found that they have a preference for soft-leaved aquatic plants such as *Potamogeton* and *Lagarosiphon* species over emergent species such as *Eichhornia*.

Behaviour: Pike (1980b) noted in a hatchery and dams that smaller fish congregate in shoals close to the water surface which made them easy prey for piscivorous birds.

Impact: Stocking dams with *C. idellus* results in the control of the following plant species *Chara* sp, *Myriophyllum spicatum, Najas pectinata, Nymphaea* spp, *Potamogeton crispus, P. octandrus, P. pectinatus, P. pusillus, P. trichoides, Utricularia gibba, Vallisneria spiralis* and filamentous algae. Some of the more serious pest plants ie *Eichhornia crassipes, Salvinia molesta* and *Phragmites australis* were not eaten to any noticeable extent. Marginal sedges (Cyperaceae) and bullrushes (*Typha* spp) were slightly reduced (Pike 1980b, 1986).

Ctenopharyngodon idellus was unable to exert any significant control over *Eichhornia* species which increased in dams where *C. idellus* had been stocked (Pike 1980b). Therefore it can be expected that where a number of species of aquatic plants occur together, the introduction of *C. idellus* would probably lead to the eventual dominance of less palatable species such as *Eichhornia crassipes* over other submerged soft-leaved forms.

The dense stocking of *C. idellus* in dams may result in the total eradication of submerged plants and an increase in the turbidity of the water (Pike personal communication). This may be due to a plankton bloom which would result after an increase in nutrient levels in the water subsequent to the eradication of macrophytes.

Shireman (1984) reported that an increase in potassium concentration has been observed in some lakes following the introduction of *C. idellus* and the subsequent elimination of macrophytes. In some cases this has led to a phytoplankton bloom in the lake.

Mitchell (1986) found that stocking of *C. idellus* in a small lake in New Zealand resulted in an almost complete removal of aquatic plants. This had a multiplicity of effects: the elimination of cover resulted in an increase in predation by piscivorous birds. The diet of two indigenous species of fish (*Retropinna retropinna* and *Gobiomorphus cotidianus*) changed from being predominantly zooplankton to predominantly *Chironomus* species (a benthic organism). This was probably a reflection of a change in the species composition of invertebrates as these two species of fish are known to be opportunistic predators of invertebrates which show little dietery specialisation. There was also a dramatic decline in recruitment of *R. retropinna* and Mitchell postulated that this was due to a decrease in water quality which resulted in reduced egg and/or larval survival. *G. cotidianus* was apparently better able to withstand the habitat modifications following the introduction of *C. idellus*. Mitchell concluded that the response of fish populations to the introduction of *C. idellus* paralleled the effects of eutrophication in a lake (ie a change in diet, change in recruitment and an increase in the relative proportion of the more tolerant species of fish).

Shireman (1984) found that the impact of grass carp on other fish depends very largely on the degree of elimination of vegetation. There is a general concensus among experts in the field that *C. idellus* is the most effective species (of fish) to use for the biological control of submerged aquatic weeds. Shireman also concluded that excessive phytoplankton blooms could probably be prevented if systems were not overstocked and some macrophytes were allowed to remain.

Grass carp have been held responsible for the introduction of many different species of fish parasites throughout the world (Hoffman and Schubert 1984). In South Africa the fish tape worm (*Bothriocephalus acheilognathi*) was accidently introduced together with grass carp into the Fisheries Research Station at Marble Hall, eastern Transvaal, in 1976 and has since been found in some indigenous fish in the Vaal system (Brandt et al 1981) (also see section on *B. acheilognathi*).

Control: Since it is unlikely that this species will be able to breed in South African rivers, complete control could easily be effected through the prohibition of further stocking of dams. Even though grass carp may not breed, they may be resident in rivers for many years and have a detrimental impact.

It must be strongly emphasised that *C. idellus* has been known to be a carrier of many species of fish parasite into different parts of the world and its importation into southern Africa should be subject to extremely strict quarantine controls. Imported stocks should also be obtained from certified "disease free" suppliers.

Research recommendations: New distribution records of this species in natural waterways should be brought to the attention of conservationists and researchers. The slight possibility of *C. idellus* breeding in large rivers such as the Tugela, Phongolo, Usutu, Vaal and Orange should not be ignored.

Remarks: *C. idellus* can be stimulated to spawn in captivity through hormonal induction (Pike 1986).

Pike (1986) regards this species as a more desirable agent for aquatic weed control than *T. rendalli* as the latter species often breeds prolifically, resulting in an overpopulation of stunted fish and a complete obliteration of aquatic plants. It may be possible to use *C. idellus* in conjunction with certain species of weevil such as *Neochitina eichhorniae* (which feeds specifically on *Eichhornia*) as an effective means of biological control of aquatic weeds.

REFERENCES

Bourquin et al (1984); Brandt et al (1981); Hoffman and Schubert (1984); Jackson (1973a); Jayaram (1981); Mitchell (1986); Mohasin and Ambak (1983); Pike (1980b, 1986); Safriel and Bruton (1984); Shireman (1984); Shireman and Smith (1983); Welcomme (1984).

Personal communications: C J Kleynhans; T Pike.

CYPRINUS CARPIO Linnaeus 1758

common carp
karp

alien, equivocal, major impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: The common carp was introduced into southern Africa from Europe in the last century and has had a major impact on natural ecosystems. It is widely regarded as a pest, and is held responsible for the introduction of numerous fish parasites and for major habitat alterations brought about by increases in turbidity levels of natural waters. This species, which is an aggressive invader, is very widespread, occurring in six major catchments in the region covered by this publication, and is more successful in the temperate southern half of the country than in the subtropical northern areas. *C. carpio* is also of value as a desirable angling fish and as a cheap source of protein with considerable aquaculture potential.

Research: Excellent. The introduction of this species and its distribution in South Africa has been well documented by a number of workers. Numerous studies (reviewed by Sarig 1966) have been done in other countries on their impact on natural ecosystems and there are a number of publications on their habitat preferences, behaviour and aquaculture potential. In South Africa various aspects of their general biology have been studied by Harrison (1948b, 1956), Mulder (1971 and 1986), Pike (1973) and Jackson (in press). However there have been no detailed studies on their impact on southern African ecosystems.

SPECIES DATA

Distinguishing characteristics: A large cyprinid fish. A serrated spine in the anal fin is distinctive. Mouth toothless, with one prominent pair of barbels. Dorsal fin long with a serrated spine. Colour variable, usually olive above and cream or yellowish below; lower caudal and anal fins reddish. Three varieties are found: a full scale, or common carp, with normal scales: mirror or king carp with scattered large scales, and leather carp without scales. Maximum size 36 kg but the southern African angling records are 24,42 kg (mirror carp) and 16,9 kg (common variety) (Bruton et al 1982). These forms revert to the normal full-scaled form after a period of breeding in the wild (Harrison 1956).

Jackson (1980b) describes two strains of wild carp: *C. carpio carpio* from the Danube River in Europe and *C. carpio haematopterus* from Siberia and China. The former strain was originally introduced into southern Africa. Balon (1974) reports that there is strong evidence to suggest that the modern domestic variety originated from the rheophilic Danube wild carp.

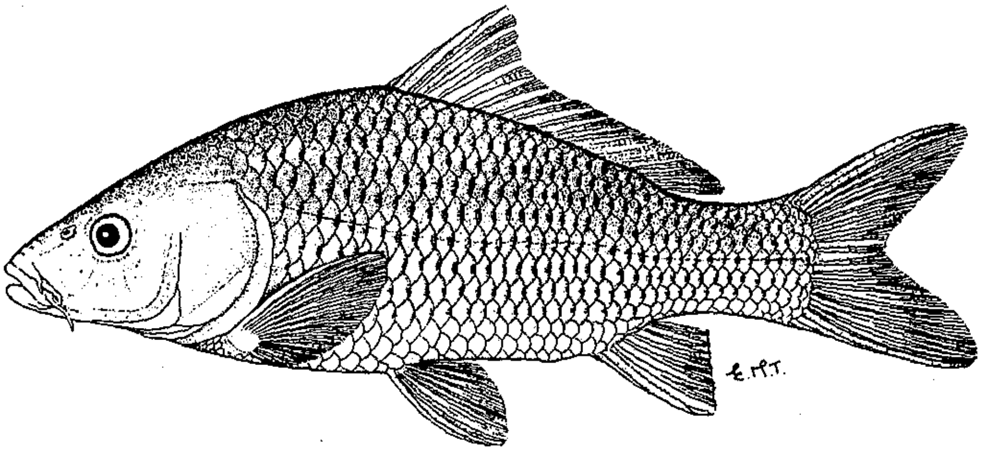
There are also numerous laboratory-reared varieties: the Dinkelsbuhl- Auschgrund carp is a fast-growing form distinguished by a high "hump" on the dorsum. This strain, developed in West Germany, and the DOR 70 variety from Israel are both used in aquaculture (Lombard 1961; Safriel and Bruton 1984).

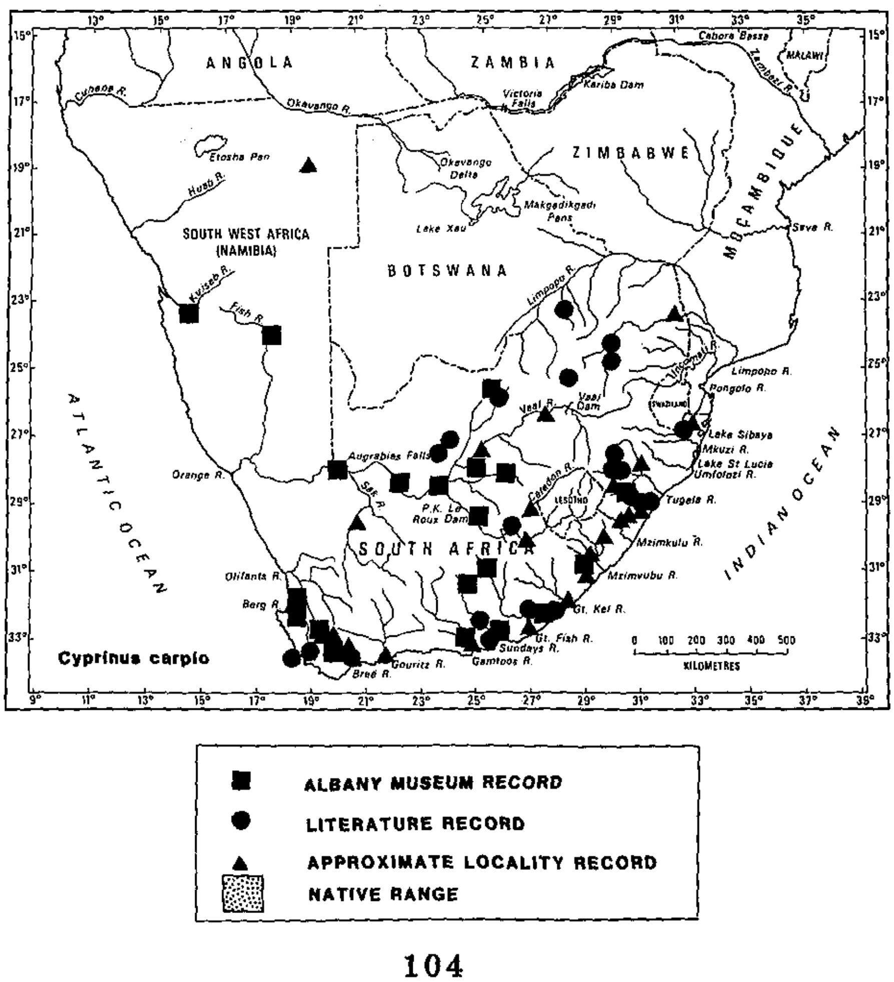
Native range: Carp were thought to have originated in Asia, having been introduced into Europe approximately three centuries ago (Jubb 1959a). However Balon (1974) examined historical and other material and now suggests that ancestral wild carp originated in central Asia and naturally spread east into China and west as far as the Danube River.

Date and purpose of introduction: Introduced into southern Africa in the 18th century as an ornamental fish (Bruton and Merron 1985; Bruton and van As 1986). The Cape Argus, 15th September, 1859 contained a

CYPRINUS CARPIO Linnaeus 1758

FIGURE 22. The common carp *Cyprinus carpio* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





report of the importation of six carp from England by a Mr C A Fairbridge, a member of the Cape Legislative Assembly. His purpose was "to make our ... barren rivers ... a source of food" (Coke personal communication). These fish were released into the reservoir at the Botanical Gardens in Cape Town (Anon 1959b). In March 1866 an article in the South African Advertiser and Mail reported that a Mr Ekstein of Rondebosch had procured three carp from England which were placed in a pond on his estate. After some time (the period was not stated) he netted 391 fish from this pond and offered to distribute 100 to "any gentleman having a place fit for their reception". There are no further reports on the fate of these fish (Harrison 1966b). There were probably numerous other introductions during the 19th century and Dr Gilchrist reported that "carp were in fair abundance in the dam at Beaufort West" when he first arrived in South Africa in 1895 (Harrison 1956). There is also an early record of "carp" being seen in the Eerste River circa 1800 (Skelton and Skead 1984). The first official introduction from England to the Jonkershoek Hatchery (Stellenbosch) was in 1896 (Anon 1944). Stocking and distribution to various farm dams in South Africa began in 1900 (Anon 1944) and continued until 1921 when the breeding stock was destroyed and attempts were made to check the spread of carp by legislation (Harrison 1959).

In October 1896 109 "carp and tench" were imported from Dumfries, Scotland, to the Pirie Hatchery, Kingwilliamstown. The fate of these fish was not recorded (Anon 1950c). Aischgrund carp (Dinkelsbuhl variety) were imported from West Germany to the Fisheries Research Station at Marble Hall in 1955 (Lombard 1961).

Details of initial introductions and dates of first records in various localities are given in Appendix 3.

Southern African distribution:

Natal: Recent reports indicate that carp have established in the following areas:

Impoundments: Chelmsford, Spioenkop, Wagendrift, Midmar, Albert Falls, Nagle, Klipfontein, Verdruk, Tom Worthington, McHardy, Bloemveld, Tweediedale, Kandaspunt prison, Durnacol mine, Mount Edgecombe experimental station, Paulpietersburg Municipality and Hlobane mine dams (Pike and Coke personal communication). Also recently reported in the Pongolapoort dam (La Hausse de Lalouviere 1986).

Rivers: Umgeni, Bushmans, Umkomaas, Umzimkulu, Umzimvubu, Umlaas and Umzimhlava Rivers (Pike and Coke personal communication). Carp occur in these rivers but are not necessarily well established in all of them: they are relatively rare in the main Tugela and Umgeni Rivers but are reported to be abundant in the Umkomaas River (Coke personal communication). Carp appear to be abundant in many of the impoundments on the Tugela and Umgeni Rivers and are reported by Heeg (1983) to comprise 30,8% of all anglers catches at the Midmar dam.

Since carp occur in the Pongolapoort dam there is also the possibility that they could have invaded the Phongolo River above the dam (Pike personal communication). The Department of Cooperation and Development recently (January 1988) caught a single specimen from Tete Pan in the Phongolo floodplain (Merron personal communication).

Cape: Carp have been recorded in the following areas: the Baakens River (eastern Cape) (Heard and King 1982; King and Bok 1984), the Breede River at the Bontebok National Park (Braack 1981), Rondevlei (Harrison 1948b), the lower reaches of the Berg, Breede, Gouritz, Kromme, Gamtoos, Swartkops, Sundays, Fish, Keiskamma, Buffalo, Nahoon, Kei and Umtata Rivers (Jubb 1965), the Sak River (Orange system) (Hocutt and Skelton 1983), Zeekoeivlei and the Liesbeeck dam (Cape Town area) (Anon 1958), Liesbeeck lake (Anon 1958), the Grassridge dam (31°45´S; 25°28´ E) (Fish R) (Cambray et al 1977), Sandvlei (western Cape) (Begg 1976), Paardevlei, Princessvlei, Voelvlei and Misverstand (Picketberg), Brandvlei and Hospital dam (Worcester) and in many farm dams in the Worcester, Robertson, Ashton, Bonnievale and Swellendam areas (Smith personal communication) and in Lake Mentz on the Sundays River (Coke personal communication). Also in the Kei River estuary (Plumstead et al 1985), the Taung district (Vaal-Hartz scheme) (Anon 1960b). Also present in the "Oog" fountain at Kuruman (Ribbink personal communication). Common in rivers of the Transkei and south eastern Cape below altitudes of 800m (Jubb 1973b).

Carp are not mentioned in the list of alien species in the (Clanwilliam) Olifants River system and appear to be absent from this river (Anon 1982).

Transvaal and Orange Free State: Recorded in the following localities in the Limpopo system: Hans Strijdom dam on the Mogol River (Kleynhans 1983), the Olifants River (in the Kruger National Park) (Pienaar 1978c), Loskop dam (Kruger 1971), Hartbeespoort dam (Crocodile River) (Cochrane 1983), Rietvlei dam (south east of Pretoria) (Smith 1983) and the Doorndraai dam (near Potgietersrus) (Batchelor 1974).

Although this species is absent from most of the Incomati system there is a record from the Klipplaatdrift dam (in the Elands River system near Marble Hall) (van der Waal personal communication).

Within the Orange-Vaal system carp have been recorded in the following localities: the Vaal dam (du Plessis and le Roux 1965), Barberspan (western Transvaal) (Goldner 1967), Boskop dam (western Transvaal) (Koch and Schoonbee 1980), the lower Vaal River at Warrenton and the Vaal Hartz Weir (personal observation), the Caledon River (near the confluence with the Orange River) (Marshall 1972), Lake le Roux (Jackson et al 1983) and the Verwoerd dam (Hamman 1980). Skelton (1986b) records that this species occurs in the following areas of the Orange-Vaal system: Upper Orange and Caledon, the Vaal River system, the middle Orange River (where it is rare), the southern tributaries of the Orange and the upper Fish River (SWA). Absent from the headwater tributaries in the Drakensberg and from the lower Orange River.

South West Africa: Carp have been recorded in the following localities: the Kuiseb canyon (Dixon and Blom 1974), Von Bach dam (Swakop River system) (Skelton and Merron 1984), Hardap dam (Fish River) (Gaigher 1975b), and are reported to be widespread in farm dams and freshwater systems in SWA (Skelton and Merron 1984). Widely distributed in the catchment area of the Omuramba Omatako drainage system and thus pose a threat of invasion of the Okavango system (Schrader 1985; Bruton and van As 1986).

To summarise, carp have been found in the following major catchments: South coastal rivers (from the Berg River in the western Cape to the Umtamvuna in Natal), Orange/Vaal, Natal coastal (Umtamvuna to the Tugela), Phongolo, Limpopo, Incomati and in dams in South West Africa / Namibia (Bruton and van As 1986). Within these catchments carp appear to be most successful in the southern Cape and in the Orange-Vaal catchments and least successful in the Incomati system and the lowveld areas of the Limpopo catchment where there are only a few scattered records in some tributaries. There is only one record of carp in the Incomati system (in the upper Elands River). Carp are plentiful in some impoundments such as the Hartebeespoort dam (Ashton et al 1985) in the upper tributaries of the Limpopo River.

It appears that carp have recently extended their range into Natal. The present distribution appears to be far more extensive than that described by Crass (1966) who reported that carp had only established in the Buffalo catchment (Tugela system) and a few dams along the coast. The main Tugela River and the Umgeni River (where it is highly probable that carp had been introduced) had previously proved to be unsuitable for carp and no breeding populations were reported. Although carp are said to be rare in many of the Natal rivers where it is reported to occur (Coke personal communication), they are plentiful in most of the impoundments (such as Midmar dam; Heeg 1983) on these rivers. Until very recently there were no records of carp in the Phongolo River or in Maputaland. They have now been recorded in the Pongolapoort dam and there is a single record from Tete pan in the Phongolo floodplain.

There is a noticeable absence of carp from the (Clanwilliam) Olifants River in the western Cape which is remarkable considering the success of this species in other southern Cape rivers. It is highly probable that carp have been introduced into this river from overflowing dams in the catchment.

Habitat preferences: Du Plessis and le Roux (1965) found that, although this species thrives in rivers and dams, their relative abundance was higher in the Vaal dam than in the river suggesting that carp have a preference for lacustrine rather than riverine environments. Carp favour vegetated areas in dams and rivers where the substrate is muddy (Jubb 1959a). They tolerate a wide range of environmental conditions: dissolved oxygen above 20% saturation, pH range of 5,5 to 11,0. Their ideal temperature range is 20 to 30°C although lower and higher temperatures can be tolerated for extended periods (Safriel amd Bruton 1984). They survive at salinities of up to 2 parts per thousand. When oxygen levels decrease carp can rise to the surface to gulp air. Carp have been known to survive in the mud of dams which have almost completely dried up (Jubb 1973b).

Jackson et al (1983) noted that this species was relatively more abundant in the flooded estuaries of rivers entering lakes than along open lake shores.

Carp are essentially a freshwater fish and will not tolerate high salinities in estuaries. In 1945 there was a mass mortality of carp in the Bot River following a sudden increase in salinity (Hey and Harrison 1946). They are not as resistant as indigenous *Barbus* species to the effects of flash floods (Heard and King 1981) and Crass (1964) regarded this as the probable reason why carp failed to establish permanent breeding populations in the mainstream Tugela and Umgeni Rivers.

Cochrane (1983) noted that this species, as well as *Oreochromis mossambicus* and *Clarias gariepinus*, were more able to withstand low oxygen concentrations and excessively eutrophic conditions in Hartbeespoort dam than the indigenous *Barbus* species.

Breeding: Carp breeds in late spring (October, November) when water temperatures reach approximately 18°C. Apparently the additional stimulus of an influx of fresh water is required in order to initiate spawning. Pike (1973) noted that even though temperatures were suitable, spawning in Midmar dam (in the early 1970's) was delayed for 4 months until after the onset of rain which caused the river to flood. The presence of soft submerged vegetation in a shallow area is essential for this species to breed successfully. The size of the spawning bed has been calculated to be 50 square meters for each 3 to 6 kg female (Sarig 1966).

Males pursue the female for approximately two days. The female then lays a large number of transparent eggs which are fertilised by the male. These eggs are adhesive and settle on submerged aquatic vegetation and hatch within 3 to 6 days. Eggs which fall to the bottom of the pond are not viable (Lombard 1959; Crass 1964). In culture conditions females are inclined to eat their own eggs (Lombard 1959).

Cyprinus carpio is noted for its very high fecundity: a single 2 kg female has on average 400 000 eggs in the ovaries and a 7,5 kg female as many as 2 000 000 eggs (Jubb 1978b).

Feeding: Omnivorous. Often feed on the spawn of other fish. Forage for food in the bottom sediments of ponds. (Anon 1944). Mud is taken into the mouth and later ejected after the food (consisting of vegetable matter, worms, shrimps and aquatic insects) has been extracted (Jubb 1959a).

Behaviour: While this species is regarded by some as a valuable angling fish, it often does not take a hook, particularly in the case of older fish (Jackson 1973a).

Impact: Carp have a destructive impact on the environment and there have been many reports of the detrimental effect which carp have on other species of fish. This is due to competition for the same food source, their habit of eating the spawn of other fish and also because of the habitat changes which they cause. The habit of grubbing in the mud for food has led to the destruction of vegetation, rooting up of marginal vegetation and the disturbance of bottom sediments. This has the overall effect of making the pond bottom soft and increasing the turbidity of the water (Anon 1944). Welcomme (1984) reports that the feeding activities of carp also increase suspensoid levels indirectly through ingestion of organisms from the phosphate-rich substrate and later excretion of the phosphate in a soluble form which is more available to algae. This results in a phytoplankton bloom which serves to increase the turbidity of the water. There is then less light penetration which adversely affects submerged aquatic plants which die and decay, releasing suspensoids into the water.

High suspensoid loads in the water result in a multiplicity of effects on the ecosystem: there is a decrease in light penetration and a subsequent decrease in photosynthesis resulting in reduced primary productivity, reduced visibility of pelagic food, reduced availability of benthic food due to smothering, and a clogging of gillrakers and gill filaments of fish. Thus there is a general decrease in food availability with resultant decreases in growth rates, fecundity and recruitment of fish. Ultimately this results in a decrease in habitat niche diversity and a decrease in productivity and population sizes of fish (Bruton 1985).

An increase in sediment loading also has many effects on benthic invertebrates. In lotic environments this has the general effect of reducing the abundance and the number of species of Ephemeroptera, Plecoptera, Trichoptera and Coleoptera. Certain other burrowing and deposit-feeding invertebrates such as Oligochaeta and some Chironomidae may be favoured by such an alteration in habitat (Wiederholm 1984).

While the presence of carp in a river will not increase the total loading of suspensoids in the system, the stirring up of bottom sediments probably exacerbates the adverse conditions resulting from increased suspensoid loading as a result of excessive erosion.

The above comments summarise the effects which have been observed when carp are introduced into various countries, and the general effect of increased sediment loading in freshwater ecosystems. However there have been no detailed studies done in South Africa on the specific effects of carp on freshwater environments where it has been introduced. There have been some casual observations which are summarised below:

The rivers of the eastern Cape such as the Sundays and the Buffalo naturally carry a high silt load and the presence of carp together with *Labeo umbratus* (which was probably translocated into the Buffalo River) has resulted in an increase in the turbidity of the water. In rivers where these two fish predominate, few other fish except the eel, *Anguilla mossambica*, can exist. These three turbidity-tolerant species are therefore often found in association with one another in this area (Jubb 1959a).

Carp are reported to have been responsible for the deterioration in the trout fishery in the Umzimvubu and Umzimhlava Rivers in East Griqualand (Harrison 1948b).

The presence of carp in Rondevlei resulted in the virtual eradication of "Nitella" plants by 1948. There has also been a subsequent increase in turbidity making the lake less suitable for the introduction of bass (Anon 1948).

Mulder (1973a) noted that increases in turbidity levels in the Vaal River restricted the ability of piscivorous species such as *Barbus kimberleyensis* to see its prey and proposes that this was partly the reason for the decline of this species in the Vaal River. Mulder (1971, 1986) also noted the presence of *C. carpio* throughout the length of the river. Likewise Marshall (1972) reported that the Caledon River (into which carp have been introduced) was very silted up and turbid whereas local residents remember a time when the river consisted of deep clear rocky pools. As described earlier, the increase in turbidity is mostly the result of excessive soil erosion, but the presence of carp in these rivers has probably exacerbated the adverse conditions. The potential of *C. carpio* to silt up waters in mild climates (as in South Africa) is probably greater than in temperate climates since feeding continues throughout the year (Harrison 1956).

Populations of waterfowl have been noted to decline from many vegetated vleis (particularly Rondevlei in the Cape) into which carp have been introduced. Carp destroy the habitat of these birds (aquatic vegetation) and also compete with waterfowl for food (aquatic organisms) (Harrison 1948b, 1956).

Disturbance of the substrate due to the feeding activities of carp could be expected to disrupt nest building activities of cichlids and other fish at the Kuruman Oog and in other areas (Ribbink personal communication).

It was once thought that the presence of the tigerfish *Hydrocynus forskahlii* would prevent the spread of carp into rivers in the tropical regions of southern Africa (Jubb 1973b). Conversely, there are now fears that carp could oust the tigerfish from these rivers as the latter species favours well-aerated, clear waters where prey can be seen (Pienaar 1978c). *C. carpio* has now been recorded in the Olifants River (Limpopo system) and it appears that it may be able to co-exist with tigerfish. However Coetzee (personal communication) has pointed out that carp have not invaded the low-altitude areas of the Limpopo system to any large extent and where they do occur, population numbers are low. It is not certain whether this is a result of the presence of tigerfish or because of some other factor such as an intolerence of high temperatures.

Crass (1964) suggested that carp had not established successful populations in many large Natal rivers such as the Umgeni and Tugela because of an inability to withstand the effects of flash-floods. In recent years carp have become established in many impoundments in Natal and are occasionally recorded in some of the large rivers such as the Umgeni. It seems possible that there has been a change in habitat which has resulted in these rivers becoming more suitable for colonisation than they were in previous years. It is likely that the building of more impoundments on these rivers has had a moderating effect on flow rates, making them more suitable for colonisation by carp.

Jackson (in press) disagrees with many of the views expressed above concerning the destructiveness of carp and states that "there is no evidence of any adverse effect upon the local populations. In the Orange River, where *C. carpio* have been established for probably a hundred years or more, they (*C. carpio*) are still heavily outnumbered by indigenous cyprinid species". Ashton et al (1986) regard carp's reputation for having eliminated more desirable fish and fouling up water as being exaggerated and they point out that the increase in eutrophication of impoundments in southern Africa has merely favoured *C. carpio* and other detrivorous fish.

The introduction of carp into new countries has resulted in the spread of fish parasites, and it is probable that the following species have been translocated throughout the world in association with carp (Hoffman and Schubert 1984):

Protozoa: *Ichthyophthirius multifilis, Mitraspora cyprini, Sphaerospora carassii, Thelohanellus dogieli, T. hovorakai, T. nikolskii,*.

Monogenea: *Dactylogyrus extensus, D. minutus, Gyrodactylus cyprini, Pseudacolpenteron pavlovskyi* and *Dactylogyrus achmerovi*.

Branchiura (Crustacea): *Argulus japonicus*

Cestodes: *Khawia sinensis* -

Nematodes: *Philometroides lusiana*

Many of the above-mentioned species are also parasites of *Carassius auratus* and it is uncertain whether *C. auratus* or *C. carpio* has been responsible for their spread.

Bruton and van As (1986) state that "common carp have been implicated in the introduction of at least seven alien or suspected alien fish parasites into southern Africa (*Ichthyobodo necator, Chilodonella cyprini, C. hexasticha, Apiosoma piscicola, Trichodina acuta, T. nigra* and *Trichodinella epizootica*)". The native ranges of these parasites are not always known and many may have a cosmopolitan distribution. However it is fairly well established that two of these species *Ichthyophthirius multifilis* and *Trichodina acuta* are aliens. Another alien parasite *Argulus japonicus*, which is fairly widespread in the Transvaal (van As and Basson 1984), has also been associated with carp and goldfish (*Carassius auratus*) introductions around the world (Hoffman and Schubert 1984). Both these alien fish species could have been responsible for the introduction of this parasite, but since *C. carpio* is more widespread than *C. auratus* in the localities where *A. japonicus* occurs in South Africa (van As and Basson 1984), it seems likely that carp was responsible for their introduction.

Four species of dactylogyrid parasites (*Pseudacolpenteron pavlovski, Dactylogyrus anchoratus, D. minutus,* and *D. extensus*) have been introduced together with carp into Africa (Paperna 1980). These do not appear on the checklist of fish parasites (van As and Basson 1984) and have apparently not been found in the subcontinent as yet.

In spite of the overall negative impact which carp may have on the environment there are some positive consequences from the introduction of this species into southern Africa. Carp are valued as an angling species and are one of the most frequently caught fish by freshwater anglers in South Africa, as shown by the following angling statistics: in the Transvaal carp comprise 28,9% of all fish caught, in Lake Midmar 30,8% and in Verwoerd dam they are reported to form the largest portion of the ichthyomass and are frequently caught by anglers. In Lake le Roux carp are reported to be relatively uncommon but were nevertheless frequently caught by anglers (Bruton and van As 1986).

Control: Harrison (1956) recommended the use of rotenone to eliminate carp from certain areas. A trial of "Noxfish" (an emulsifiable commercial form of rotenone) on a 1,08 ha dam in East Griqualand was carried out in April 1956. The piscicide was applied at a rate of 1 ppm to the dam. The water temperature was 15,6°C and within a few hours 335 moribund carp were collected and dead fish continued to rise on the following day. By December 1956 it was reported that the carp appeared to have been totally eliminated from the dam and that the water quality had improved (Harrison 1956).

However, considering the disastrous results of some carp-poisoning programmes in the USA, it is wise to treat such proposals with caution. In an attempt to rid the Rock River of carp, a 231 mile stretch was treated with antimycin and rotenone resulting in a decline in the number of species from 26 to 6 and a massive kill of indigenous bivalve molluscs (Bourquin 1985).

Jackson (1973a) states that "there is .... no possibility that our wild carp populations will ever be eliminated". As this fish is not always fully exploited by anglers, excessively high populations could be netted using gill and seine nets. While their populations will not be eliminated in this way, this method may reduce the environmental damage in small farm dams whilst also exploiting a valuable food resource (Jackson 1960, 1973a, 1980b).

It is recommended that very strict control measures should be applied to any new importations of carp for aquaculture to eliminate the danger of introducing new parasites. Details of recommended inspection and quarantine measures to be applied are given by Hoffman and Schubert (1984). A recommended protocol for deciding on the advisability of introducing alien fish into southern Africa is proposed by Bruton and van As (1986).

Serious consideration should be given to the possibility of eradicating carp, largemouth bass and *Oreochromis mossambicus* from the Omatako Omuramba area in South West Africa to prevent the spread of these species into the Okavango system.

Research recommendations: The impact of carp on freshwater ecosystems in southern Africa needs to be studied. It may be of interest to compare the susceptibility of different types of ecosystem to invasions by carp.

The feasibility of controlling carp populations in the Omatako Omuramba area should be investigated.

Remarks: Jackson (1973a) noted that legislation against the introduction of carp has been promulgated in all four provinces. Little has however been done to encourage netting of carp populations and this has probably contributed to the unnecessary spoiling of farm dams. Legislation against, and discouragement of, the use of nets has also meant that in times of drought massive fish kills have occurred in dams overpopulated with carp. Jackson (1973a) reported that carp (particularly the Aischgrund variety) were being widely used in aquaculture in southern Africa. Carp have proved to be valuable components in polyculture systems in waste-water aquaculture as they can tolerate cooler temperatures than many indigenous species and feed on benthic organisms such as chironomid larvae and annelids which are usually very abundant in these systems (Jackson 1980c).

REFERENCES

Anon (1944, 1948, 1950a, 1958, 1959b, 1960b, 1982); Ashton et al (1986); Balon (1974); Basson et al (1983); Batchelor (1974); Begg (1976); Bennion (1923); Bourquin (1985); Bourquin et al (1984); Bourquin and Mathias (1984); Braack (1981); Bruton (1985, 1986); Bruton et al (1982); Bruton and Merron (1985); Bruton and van As (1986); Cambray et al (1977); Cardieux (1980); Cochrane (1983); Crass (1964, 1966); Croeser (1979); Dixon and Blom (1974); du Plessis and Combrinck (1947); du Plessis and le Roux (1965); Eccles et al (1983); Gaigher (1975b); Goldner (1967); Hamman (1980); Hamman and Gaigher (1979); Harrison (1936, 1938, 1948b, 1956, 1959, 1966b); Heard and King (1981, 1982); Heeg (1983); Hey (1925/26, 1926); Hey and Harrison (1946); Hocutt and Skelton (1983); Hoffman and Schubert (1984); Jackson (1960, 1973a, 1976, 1980b, 1980c, in press); Jackson et al (1983); Jubb (1959a, 1965, 1973b, 1978b, in press); King and Bok (1984); Kleynhans (1983); Koch and Schoonbee (1980); Kruger (1971); la Hausse de Lalouviere (1986); Lombard (1959, 1961); Marshall (1972); Mulder (1971, 1973a, 1986); Nichols (1943); Paperna (1980); Pienaar (1978c); Pike (1973, 1980a); Plumstead et al (1985); Prinsloo and Schoonbee (1984); Safriel and Bruton (1984); Sarig (1966); Schrader (1985); Skelton (1986b); Skelton and Cambray (1981); Skelton and Merron (1984); Skelton and Skead (1984); Smith (1983); van As and Basson (1984); van Schoor (1963); Welcomme (1981, 1984); Wiederholm (1984).

Personal communications: M M Coke; A Coetzee; D Curle; G S Merron; T Pike; A J Ribbink; A Smith; B C W van der Waal.

TINCA TINCA Linnaeus 1758

tench
seelt

alien, equivocal, little impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An alien species introduced from Europe in 1910 for angling purposes. Stocked in numerous rivers and dams in the Cape but failed to establish in most areas. Populations still exist in Paardevlei and other isolated areas.

Research: Good. The tench is a well known European fish that has been studied by many workers.

SPECIES DATA

Recent synonyms: *Tinca vulgaris* (Jackson 1973a).

Distinguishing characteristics: Scales very small, about 95 to 110 along the lateral line. Head 3,75 to 4 times the standard length. Mouth terminal with a single maxillary barbel on each side. Origin of the dorsal fin slightly posterior to that of the ventral fin. Colour varies from deep olive-green to a dark green-brown with lighter underparts. In Europe this species attains 4 kg (Jubb 1967).

Native range: Europe (except northern Scandinavia) as well as western Asia (Welcomme 1981).

Date and purpose of introduction: Introduced from Surrey (England) in 1910 and 1911 supposedly as a forage fish for largemouth bass (Anon 1944). This however seems an unlikely reason since the latter species was only introduced into southern Africa in 1933. Distribution of fry to farm dams in various parts of the country began in 1912 (Anon 1944).

In October 1896 109 "carp and tench" were imported from Dumfries, Scotland, to the Pirie Hatchery, Kingwilliamstown. The fate of these fish was not recorded (Anon 1950a).

The dates of initial introductions into various localities in southern Africa are summarised in Appendix 9.

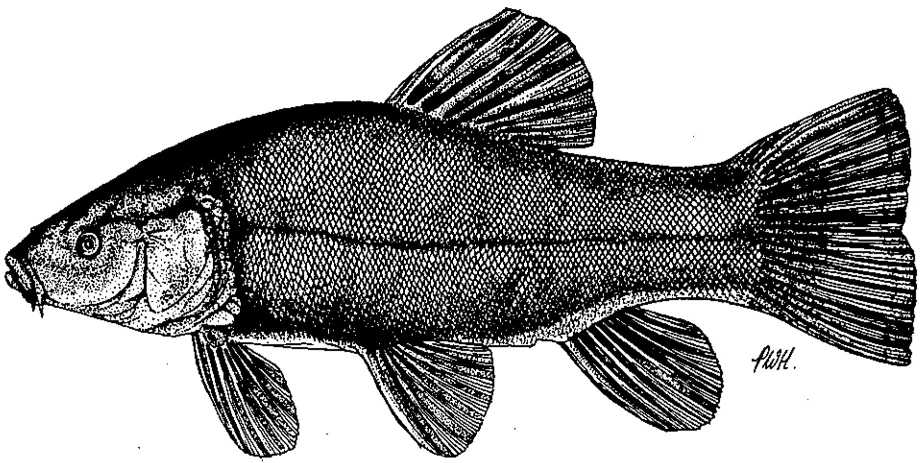
Southern African distribution: Tench have not been very successful colonisers in southern Africa. There is evidence that they established a breeding population at Paardevlei but there have been very few records from this locality: large specimens (5,79 kg and 4,25kg) were found dead in 1968 and 1976 respectively (Anon 1975/1976) and two small specimens were found in the stomach contents of bass in 1935 (Harrison 1936). Tench are reported to still be present in Paardevlei and the Helderview dams in the Cape (Smith personal communication), in the Breede River at the Bontebok National Park (Bredasdorp) (Jubb 1978b; Braack 1981) and a specimen was caught on Mr Austin's farm dam near Grahamstown in December 1987 (Nuewjaars River, Bushmans system) (James personal communication). Also present on a few farm dams in the Zwartberg-Franklin districts (Natal) (Pike personal communication).

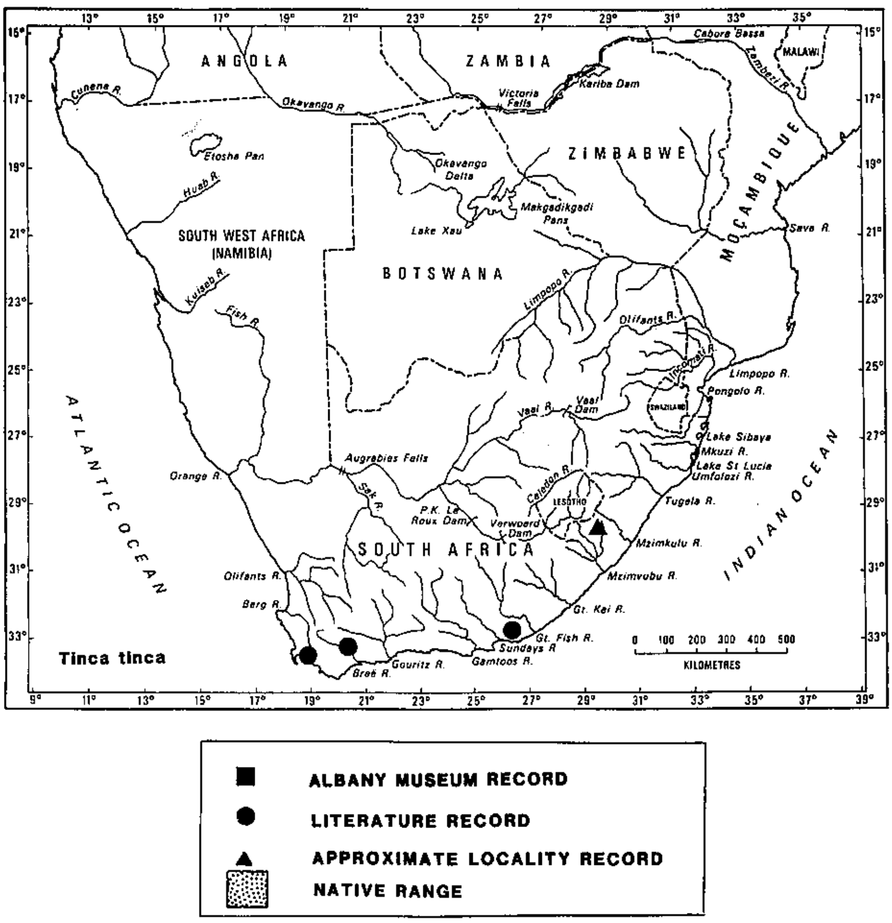
There was no record in the Otjikoto sinkhole (South West Africa) during a recent (1988) expedition (Ribbink personal communication). Tench were introduced into this sinkhole in 1908.

Habitat preferences: Tench prefer waters in which there is abundant submerged aquatic vegetation (Anon

TINCA TINCA Linnaeus 1758

FIGURE 23. The tench *Tinca tinca* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





1944). They normally inhabit lotic waters but are also found in slow-moving rivers which are not subject to violent floods (Hey 1971b).

Breeding: In Europe tench spawn from April to July in shallow areas with abundant submerged vegetation. With each spawning between 100 and 200 eggs are laid, and the eggs hatch within 4 to 8 days (Holcik and Mihalik 1968).

Feeding: The small fry feed on plankton and larger fish feed on insect larvae, worms, crustaceans and molluscs. The tench is a bottom feeder (Holcik and Mihalik 1968) which also takes freshwater snails (Anon 1944) and aquatic vegetation (Jubb 1965). Noted by Harrison (1936) to be feeding on the freshwater snail, *Physopsis africana* in Paardevlei.

Behaviour: Described by Hey (1971b) as being "a quiet indolent fish, fond of lying on the bottom of the pond or on hot calm days among the weeds at the surface". During winter in Europe the tench retreats to deeper waters and remains almost immobile until Spring (Holcik and Mihalik 1968).

Impact: Tench are responsible for a certain amount of stirring up of bottom sediments but are not as disruptive in this regard as carp. There was a general deterioration in water quality and a decline in submerged aquatic plants after the introduction of this species into Paardevlei, but this change was partly due to an increase in the water level of the lake (Anon 1944).

Control: The tench is a passive invader which has not shown any tendency to invade new localities or dominate ecosystems in which it is present. They appear to be responsible for some habitat deterioration but their impact seems to be insufficient to justify economically or ecologically costly eradication campaigns.

Research recommendations: The reasons why tench are not successful colonisers in southern Africa would be a useful subject for study. Bruton (1986) noted that tench and perch exhibit invasive dormancy in South Africa in that they have remained a relatively insignificant element of their host community over long periods of time.

Remarks: After the introduction of this species into Paardevlei the condition of the bass improved (Harrison 1968).

Tench are valued as an eating and as an angling fish (Holcik and Mihalik 1968).

REFERENCES

Anon (1944, 1950a, 1975/76); Bennion (1923); Braack (1981); Harrison (1936, 1968, 1976a); Hey (1971b); Holcik and Mihalik (1968); Jackson (1973a); Jubb (1965, 1967, 1978b); Welcomme (1981).

Personal communications: M Coke; N James; T Pike; A J Ribbink; A Smith.

GAMBUSIA AFFINIS (Baird and Girard 1854)

mosquito fish, gambusia
muskietvis

alien, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Poeciliidae

SUMMARY

Status: An alien species first introduced in 1936 for the purpose of mosquito control. Populations are established in the Transvaal and the southern Cape. These mosquito fish do not appear to have had a major impact on indigenous species, but their impact has not been studied quantitatively in southern Africa.

Research: Good. The general biology has been studied by Myers (1965) and the impact on indigenous communities in countries into which it has been introduced has been reviewed by Myers (1965), Welcomme (1981), Contreras and Escalante (1984) and McKay (1984, 1986).

SPECIES DATA

Taxonomy: Two subspecies exist, *G. affinis affinis* and *G. affinis holbrooki* (Hubbs and Lagler 1947).

Distinguishing characteristics: A small live-bearing mosquito fish, seldom larger than 50 mm. Anal fin in the male placed far forward and modified to form a gonopodium, an intromittent sex organ (Jubb 1976/77).

Native range: South eastern and central North America (Lee et al 1980). *G. affinis affinis* occurs in southern Illinois, southern Indiana to Alabama and the mouth of the Rio Grande. *G. affinis holbrooki* occurs in eastern Alabama, Florida and New Jersey (Hubbs and Lagler 1947).

Date and purpose of introduction: Introduced for the purpose of mosquito control and as a forage fish for bass (Jubb 1976/77). There were probably numerous importations by private individuals prior to 1944. There was no official importation of this species to Jonkershoek but stocks of *G. affinis affinis* and *G. affinis holbrooki* were obtained from private individuals in 1936 and 1944 respectively (Anon 1944). Consignments of both subspecies were sent to various parts of southern Africa (Anon 1944, 1945). A detailed account of releases into specific localities is given in Appendix 7.

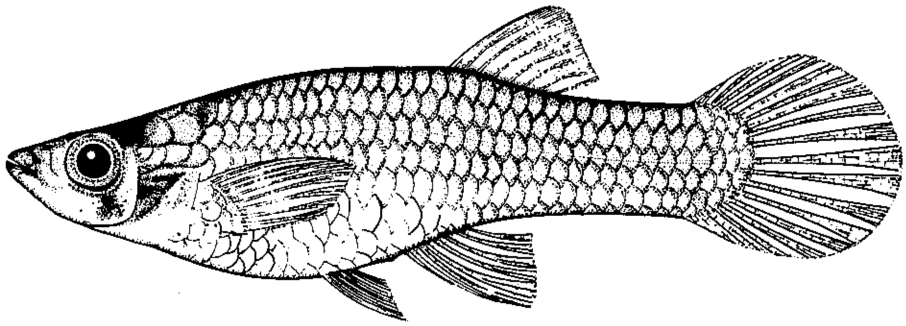
Southern African distribution: Recently recorded in Groenvlei (near Knysna) (van der Merwe 1970; Ratte personal communication) and Victoria lake in Germiston (Vaal catchment) (Kleynhans personal communication), Maryvale reed swamp (Blesbokspruit, Vaal system), Knysna and Hoekraal River systems and the Platkloof River (Berg River system) (Albany Museum records). There are also older (pre-1975) Museum records from the following localities (dates of collection in brackets): Limpopo River (Messina area, 1965). Princess Vlei (1965), Karatara River (Sedgefield) (1972). Populations probably still exist in these localities.

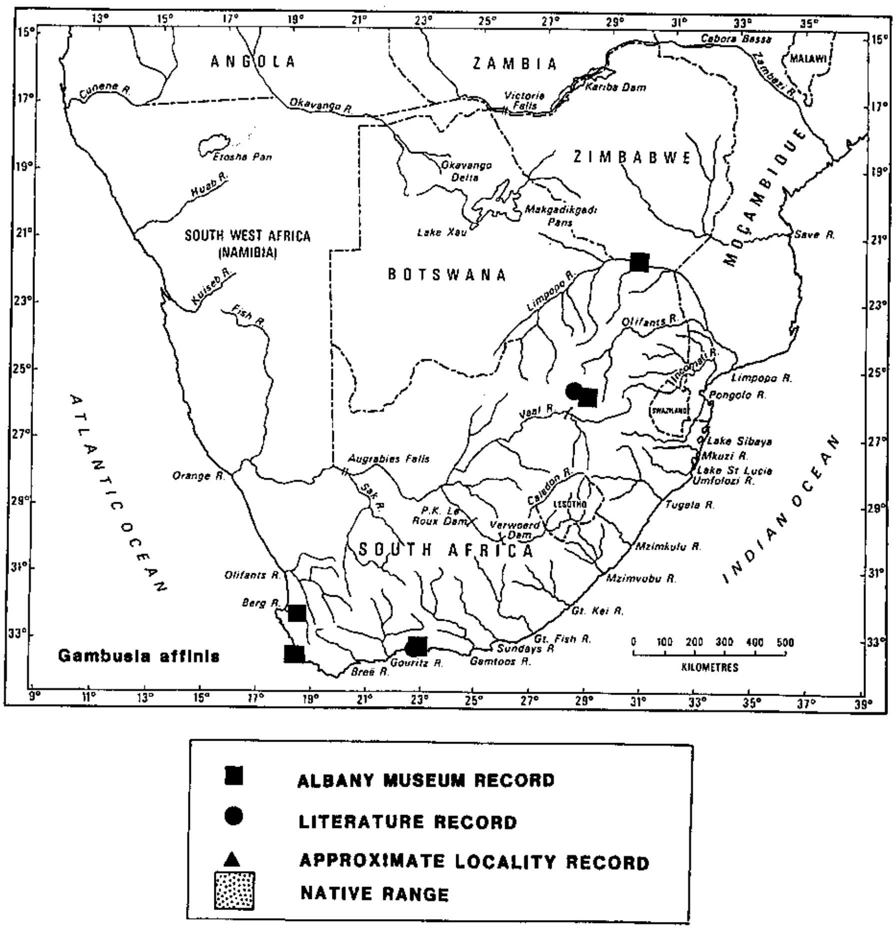
Habitat preferences: A hardy fish that can withstand a wide range of temperatures from 4,5°C to 38°C. Live mostly in the shallows (Hey 1971b). Unable to withstand dessication as is the case with some other "mosquito fish" (Myers 1965).

Breeding: Internal fertilisation. The females incubate the eggs internally and release fully developed fry (Jubb 1976/77).

GAMBUSIA AFFINIS (Baird and Girard 1854)

FIGURE 24. The mosquito fish *Gambusia affinis* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Feeding: This species feeds primarily on zooplankton and insect larvae but also on the eggs and larvae of other fish and they have been known to nip the fins of large fish (McKay 1984). In South Africa they are known to feed on the young of bass (Hey 1971b).

Impact: *G. affinis* has been introduced into many countries for mosquito control and has established populations in Africa (Madagascar, Egypt, Sudan), Europe (Greece, Hungary, Italy and Yugoslavia), Latin America (Argentina, Bolivia, Chile, Mexico and Puerto Rico) as well as in Oceania (Australia; New Zealand and New Guinea) (Welcomme 1981, Contreras and Escalente 1984, McKay 1986). *G. affinis* is regarded as a pest in many of these countries and has been held responsible for the local extinction of native surface-dwelling fish in Mexico, Greece and Australia (Myers 1965, Contreras and Escalente 1984, McKay 1986). By causing the local extinction of other small indigenous mosquito-destroying fish gambusia has often exacerbated the mosquito problem and has also proved to be unsuccessful as a forage fish for bass as it preys on bass fry (Myers 1965).

Gambusia may alter the ecosystem (particularly in small lakes) by reducing the populations of zooplankton and aquatic insect larvae (McKay 1984).

Although this species is regarded as a pest internationally (Welcomme 1981), their impact in southern Africa does not appear to have been severely detrimental to native populations. Despite widespread stocking, there are not many self-perpetuating populations present in southern Africa and in Groenvlei, where an established population of *G. affinis* has been present for many years, it does not appear to have had a detrimental effect on two small indigenous species *Atherina breviceps* and *Gilchristella aestuarius* which are still present in large numbers (Ratte personal communication). Their impact in other areas of southern Africa where they have established has not been assessed.

In an artificial outdoor fish pond in Grahamstown, *G. affinis* was observed to prey on the young of *Tilapia sparrmanii*. The parents which were guarding the juvenile fish appeared to be incapable of protecting them from the frequent attacks of *Gambusia affinis* (Jackson personal communication).

Behaviour: Cannot penetrate thickly matted aquatic plants (a common habitat for mosquito larvae). In its natural range there are other species of fish which assist *Gambusia* in controlling mosquitoes by helping to penetrate such areas (Myers 1965).

Control: The presence of indigenous topminnows (*Aplocheilichthys* spp) and killifish (*Nothobranchius* spp) in the subtropical regions of southern Africa makes it unnecessary to introduce an alien fish for mosquito control. Stockings in these areas should be strictly prohibited. The voracious predatory habits of *G. affinis* would suggest that the further introduction of this species into other areas should also be prohibited.

Research recommendations: Studies of larval predation by *G. affinis* in southern Africa need to be conducted. The efficiency of *G. affinis* in mosquito control needs to be compared with that of indigenous species.

Remarks: Because it cannot always penetrate vegetation in order to reach mosquito larvae and because it has to be re-introduced into temporary pools each time they dry up, *G.affinis* has proved to be ineffective as a means of controlling mosquitoes (Myers 1965). Annual species which survive desiccation by laying aestivating eggs would probably be more effective in mosquito control (Myers 1965). It would be desirable to consider indigenous species such as *Nothobranchius orthonotus* as candidates for the biological control of mosquitoes in southern Africa.

REFERENCES

Anon (1944, 1945); Coetzee (1977); Contreras and Escalante (1984); Harrison (1939, 1977a); Hewitt Ivy (1955); Hey (1971b); Hubbs and Lagler (1947); Jubb (1976/77); Lee et al (1980); McKay (1984, 1986); Myers (1965); van der Merwe (1970), Welcomme (1981).

Personal communications: J A Cambray; P B N Jackson; C J Kleynhans; W Ratte.

POECILIA RETICULATA (Peters 1859)

guppy **alien, detrimental, unknown impact**
guppy

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Poeciliidae

SUMMARY

Status: A small alien fish which is popular in the aquarium trade. This species has probably been repeatedly released into natural waters by aquarists or as escapees from ornamental fish farms but they have only been recorded in natural waters in isolated localities in northern Natal, the Kalahari and South West Africa. Guppies are widely regarded as pests in other countries into which they have been introduced.

Research: Good. Numerous studies have been performed on captive aquarium populations. Their impact on indigenous populations has been studied in many countries (Welcomme 1984; MacKay 1986) but not in South Africa.

SPECIES DATA

Recent synonyms: *Lebistes reticulatus* (Welcomme 1981).

Distinguishing characteristics: A small colourful fish which is popular in the aquarium trade. Males are more colourful than females (Dussault and Kramer 1981). In males the anal fin is modified to form a gonopodium for internal fertilisation. A wide variation in colour is found even in wild populations (Axelrod et al 1980). There are a large number of varieties within the native range of this species (Jacobs 1971). In natural populations average sizes are: females - 30 mm TL, males - 22 mm TL (Dussault and Kramer 1981).

Native range: South America north of the Amazon River (northern Brazil, Guyana, Venezuela), Barbados and Trinidad (Jacobs 1971).

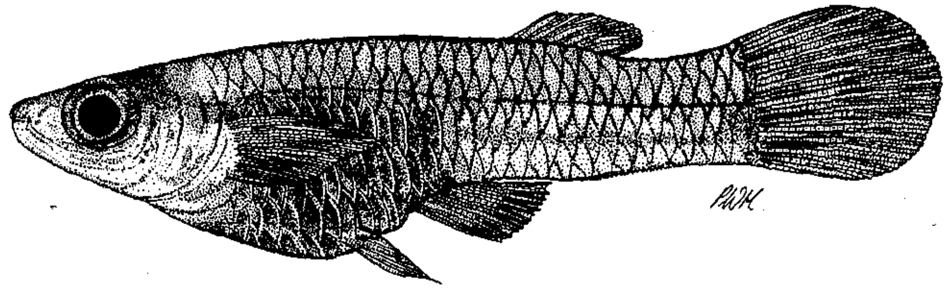
Date and purpose of introduction: Widely distributed through the aquarium trade and as a mosquito control agent (Dussault and Kramer 1981). Imported to the Jonkershoek Hatchery from Barbados in 1912 for mosquito control but did not survive the Cape winter (Harrison 1939; Siegfried 1962). Populations in Natal are probably the result of releases into natural watercourses by aquarists or escapees from ornamental fish farms. Catastrophic floods such as those of 1987 in Natal may result in the escape of fishes from ornamental fish farms into natural waters.

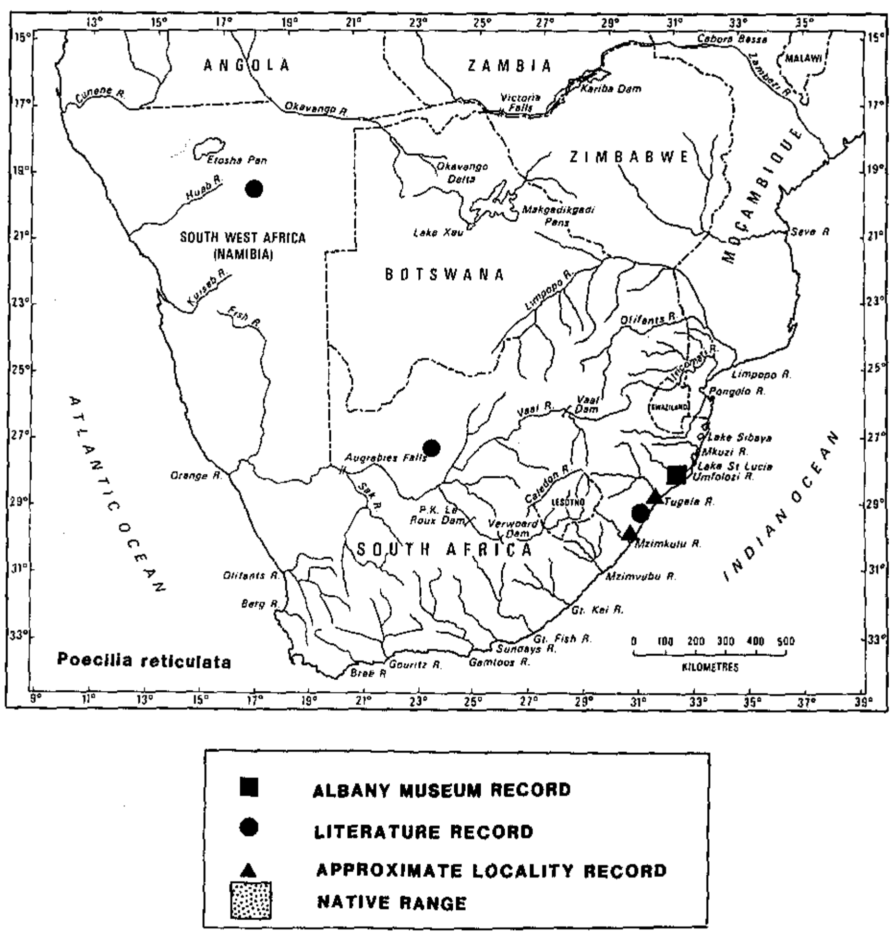
Southern African distribution: One specimen was caught in the Kranzkloof Nature Reserve (Natal) in 1986 (Pike personal communication). Guppies have also been recorded in the Kenneth Stainbank Nature Reserve (Natal) (Bourquin personal communication). There is a 1986 museum record (JLB Smith Institute of Ichthyology) of specimens from a stream in Empangeni (Zululand) and this species is reported to be plentiful in numerous small streams in the area (Reavell personal communication). Also recorded at the Kuruman Oog and Lake Otjikoto sinkholes (20 km west of Tsumeb, SWA) during recent expeditions (May 1988) (Ribbink personal communication).

Habitat preferences: Fresh and brackish slow-flowing waters, tributaries, streams and ditches (Jacobs 1971). The ability of guppies to absorb oxygen at the water surface enables them to tolerate low oxygen tensions (Kramer and Mehegan 1981). Their optimum temperature range is from 22 to 24°C but they can tolerate temperatures of 15°C for short periods (Sterba 1962). Because of its ability to tolerate brackish conditions this species is easily able to colonise estuaries (MacKay 1986).

POECILIA RETICULATA (Peters 1859)

FIGURE 25. The guppy *Poecilia reticulata*, with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Breeding: Ovoviviparous. The eggs are retained by the female until they are fully developed, hence they are sometimes erroneously regarded as "live bearers". Polygamous, and show no parental care (Dussault and Kramer 1981). Guppies are very prolific breeders which are capable of producing young every four weeks (Brymer 1967) with 20 to 70 fry being produced in each batch (McInery and Gerard 1966). The females have the ability to store sperm in the ovary from a previous mating. Because of the ovoviviparous habit the fry are relatively large and well developed and are thus able to commence feeding immediately (MacKay 1986).

Feeding: Traditionally regarded as "a carnivorous surface feeding" fish. However laboratory studies by Dussault and Kramer (1981) as well as evidence from other workers indicate that guppies can feed on a wide range of food items including benthic invertebrates, zooplankton (including *Cyclops, Artemia* and *Daphnia*), *Drosophila* floating on the water surface, as well as various mixtures of dried foods containing both plant and animal material. They occasionally cannibalise their own young (Dussault and Kramer 1981). Their diet may change in different habitats. The diet of populations in some Indonesian lakes is predominantly zooplankton and phytoplankton whereas in other lakes they feed mainly on benthic invertebrates, algae and organic detritus. Algae are apparently an important component of their diet. Their capacity to exploit different types of food may change with size and during different periods of sexual activity (Dussault and Kramer 1981).

Behaviour: During hypoxic conditions guppies may obtain oxygen by means of aquatic surface breathing during which a position is adopted in which the head is in contact with the water surface and the jaws open just beneath the surface. Oxygen is absorbed from the surface film (Dussault and Kramer 1981).

Impact: The impact of this species in southern Africa has not been assessed but guppies are listed by Welcomme (1984) as being one of 27 species widely classified as a pest where introduced. According to MacKay (1986) the guppy "is rapidly becoming the most widespread aquarium fish in the world." Their adaptability to different diets, ability to withstand low oxygen levels and tolerence of a wide range of salinity levels means that guppies are well adapted to invade a wide range of shallow freshwater and estuarine habitats. Their invasive ability is also enhanced by their ability to produce relatively large young which are less vulnerable to predation than most fish fry and are able to commence feeding immediately. The ability of female guppies to store viable sperm for long periods means that single female specimens can colonise new areas in the absence of males.

Since this species is apparently unable to tolerate low temperatures, its potential distribution range in southern Africa is restricted to subtropical regions.

Control: The danger of releasing guppies and other potentially harmful fish into natural waters should be the subject of an educational campaign. Consideration should be given to banning the trade in *P. reticulata* in Natal and the eastern Transvaal. Indigenous mosquitofish, such as *Aplocheilichthys* species, should be used for mosquito control.

Research recommendations: The distribution and abundance of *P. reticulata* needs to be accurately determined, as well as the extent to which they prey on the young of indigenous species.

Remarks: *P. reticulata* is internationally regarded as a pest animal (Taylor et al 1984; Welcomme 1984; Bruton and van As 1986). They have successfully invaded natural waters in Mexico, Hawaii, Oceania, Puerto Rico, Australia and warmwater effluents in Canada, England, The Netherlands, Italy and New Zealand, and typically outcompete indigenous species in competitive climax communities (Bruton 1986; MacKay 1986).

P. reticulata has thus far only been recorded in natural waters in some areas of Natal and at Lake Otjikoto and the Kuruman Oog (which are isolated from river systems), but the success of this invader in other continents provides a warning that it may spread more widely in southern Africa. It can be predicted, for instance, that guppies could successfully invade the lower reaches and floodplains of the Umfolozi, Mkuze, Phongolo, Maputo, Incomati and Limpopo Rivers as well as the Kafue and Okavango Swamps and Lake Liambezi. Their disruption of these valuable natural systems would be irreversible.

REFERENCES

Axelrod et al (1980); Bruton (1986); Bruton and van As (1986); Brymer (1967); Dussault and Kramer (1981); Harrison (1939); Jacobs (1971); Kramer and Mehegan (1981); MacKay (1986); McInery and Gerard (1966); Siegfried (1962); Sterba (1962); Taylor et al (1984); Welcomme (1981, 1984).

Personal communications: O Bourquin; T Pike; P Reavell; A J Ribbink

XIPHOPHORUS HELLERI Heckel 1840

swordtail
swaardstert

alien, detrimental, potential impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Poeciliidae

SUMMARY

Status: Swordtails were introduced into South Africa via the aquarium trade and have been recorded in isolated natural waterbodies in the eastern Transvaal and Natal south coast. This species has the potential to become a major pest if its range is extended into northern Natal, Maputaland and the Transvaal lowveld.

Research: Poor. While many studies have been done on captive aquarium populations (Sterba 1962; Axelrod et al 1980), very little is known of its general biology in natural ecosystems.

SPECIES DATA

Recent synonyms: *Xiphophorus jalapae* (Regan 1972).

Distinguishing characteristics: A popular, brightly coloured aquarium fish. In males the lower rays of the caudal fin are very strongly extended to form a "sword". The anal fin rays of the male are modified to form the gonopodium (an intromittent organ for internal fertilisation). No "sword" is present in females, and the upper edge of the dorsal fin is rounded. There is great variability in colour ranging from the wild "green" form to the red "Montezuma" variety (Banister 1979). The green form is characterised as follows: dorsum olive-green, flanks green-yellowish, belly yellowish. A dark violet or purple to cinnabar zig-zag band extends from the tip of the snout across the eye to the root of the tail accompanied above and below by a narrow brilliant greenish zone which is further delimited by a more or less distinct carmine-red line. Scales edged with delicate brown. Fins yellow-greenish. Dorsal fin with fine red to brownish streaks and blotches. Length: female to 12 cm; male (without sword) to 8cm (Sterba 1962).

Native range: The Atlantic slopes of southern Mexico and Guatemala (Sterba 1962).

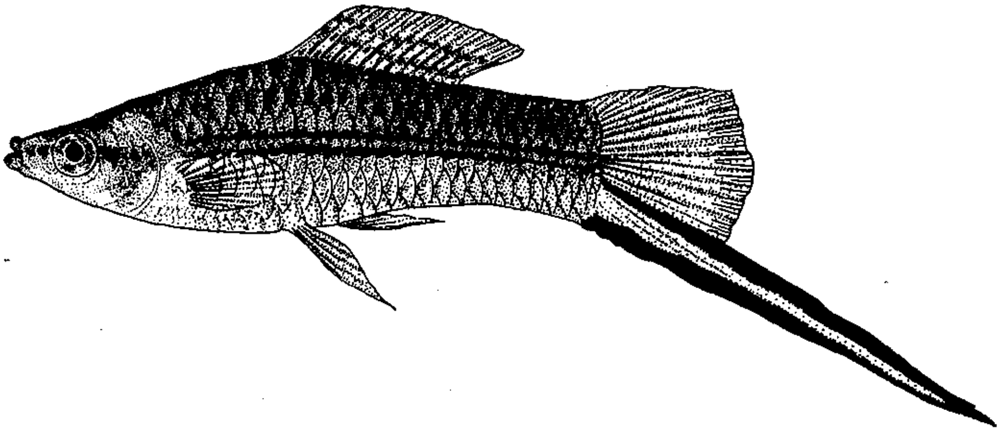
Date and purpose of introduction: The first record in southern Africa was in 1974 when a specimen was collected from a tributary of the Crocodile River in the Transvaal lowveld (Anon 1974; Jubb 1976/77). The exact locality of this record was not given, but it is assumed that it is the Gladdespruit, a locality where *X. helleri* was subsequently collected by Appleton (1974). There are also more recent records in Natal, which probably arise from a number of different releases by aquarists.

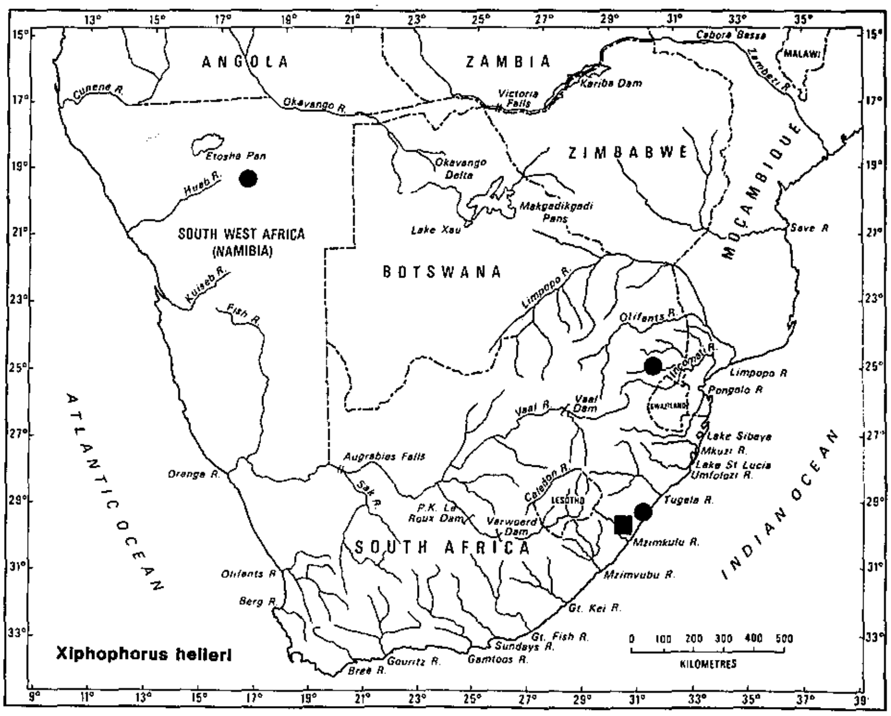
Southern African distribution: *X. helleri* is established in the lower reaches of the Gladdespruit, a tributary of the Crocodile River (Incomati system) (Appleton 1974). Also in semi-natural ponds in Congella Park (Durban) and in the Umpambinyoni River in Natal (Skelton personal communication). Recently (May 1988) collected at the Lake Otjikoto sinkhole in South West Africa (20 km west of Tsumeb) (Ribbink personal communication).

Habitat preferences: Their native range extends from near sea level to altitudes of 1600 m. *X. helleri* occurs in almost every type of freshwater habitat, from rock pools to flowing streams and swamps (Axelrod and Gordon 1985). The ideal temperature given for aquarists is 21 to 27° C (Axelrod et al 1980) but this species can probably tolerate lower temperatures in its natural habitat.

XIPHOPHORUS HELLERI Heckel 1840

FIGURE 26. The swordtail *Xiphophorus helleri* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





- ■ ALBANY MUSEUM RECORD
- ● LITERATURE RECORD
- ▲ APPROXIMATE LOCALITY RECORD
- NATIVE RANGE

Breeding: A live-bearer with internal fertilisation. The eggs are incubated internally by the female and the young fry are released (Jubb 1976/77). They are prolific breeders, the females producing up to 180 young at one time. *X. helleri* has a tendency to undergo sex reversal (from female to male) under certain environmental conditions (Sterba 1962).

Feeding: An omnivorous feeder (Sterba 1962) which is also known to consume the young fry of other fish (Jubb 1976/77).

Impact: The impact of this species has not as yet been assessed in South Africa. Since it is known to consume the fry of other fish it could become a pest if it spreads to new areas (Jubb 1976/77). The population in the tributary of the Crocodile River (presumably the Gladdespruit) is confined to a pool which is isolated from the rest of the river by a series of waterfalls (Anon 1974).

In Australia *X. helleri*, together with *Gambusia affinis*, has been held responsible for the disappearance or decline of a number of indigenous fish, particularly small surfacing-dwelling species (MacKay 1984).

Control: Because of the potential threat posed by this species, it would be sensible to attempt to exterminate the known populations in Gladdespruit and Natal. *X. helleri* is regarded internationally as a pest (Welcomme 1984) and has successfully colonised parts of Sri Lanka, Puerto Rico, Australia, Mexico and the USA (Florida, Montana and Nevada) (Welcomme 1981; Contreras and Escalante 1984; Courtenay et al 1984).

Research recommendations: Surveys are required to determine the range of *X. helleri*. The nature of the swordtail's impact on the environment also needs to be established. The behaviour of this species in natural waters is poorly known and a better understanding of this aspect of its biology would allow us to determine its likely impact.

Remarks: It is essential that aquarists are made aware of the potential threat posed by this species if it escapes into natural waters.

REFERENCES

Anon (1974); Appleton (1974); Axelrod et al (1980); Axelrod and Gordon (1985); Banister (1979); Contreras and Escalante 1984); Courtenay et al (1984); Jubb (1976/77); MacKay (1984); Regan (1972); Sterba (1962); Welcomme (1981, 1984).

Personal communications A J Ribbink; P H Skelton.

LEPOMIS MACROCHIRUS **Rafinesque 1819**

bluegill sunfish, bluegill | **alien, detrimental, major impact**
bloukiev sonvis

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Centrarchidae

SUMMARY

Status: An alien species introduced from the USA in 1938 as a forage fish for bass. Breeding populations are now widespread in the eastern, southern and south-western Cape. *L. macrochirus* has had a major detrimental impact on indigenous species and is widely regarded as a pest, particularly because of its habit of overpopulating waters with dwarfed individuals.

Research: Good. The general biology of this species in its native range has been comprehensively studied (see review by Scott and Crossman 1973).

SPECIES DATA:

Recent synonyms: *L. megalotis* (Scott and Crossman 1973).

Distinguishing characteristics: An attractive deep-bodied fish with a single lateral line. Dorsal and anal fins large, caudal fin slightly forked. The gill cover has a small black flap on the dorsal corner. Dorsal surface olive, flanks orange, and belly pale olive or orange. Five dark vertical bars may show on the flanks. Throat iridescent blue. Juveniles silvery grey with pronounced vertical bars. Maximum size 1 kg, usually less than 200 g (Bruton et al 1982).

Native range: Eastern and central North America (Scott and Crossman 1973).

Date and purpose of introduction: Imported as a forage fish for bass and also for angling purposes. Reported to be a good secondary species for stocking dams in conjunction with largemouth bass (Anon 1944). Imported from Maryland, USA in 1938 to the Jonkershoek Hatchery (Stellenbosch) and Natal hatcheries (Harrison 1939, 1952e). Of the Natal consignment 19 were transferred to the Howick Hatchery and 8 to a pond on the farm "Everdon". *L. macrochirus* was reported to be breeding successfully by 1940 (Anon 1964). The progeny of these initial stocks were then distributed to other areas (Anon 1944).

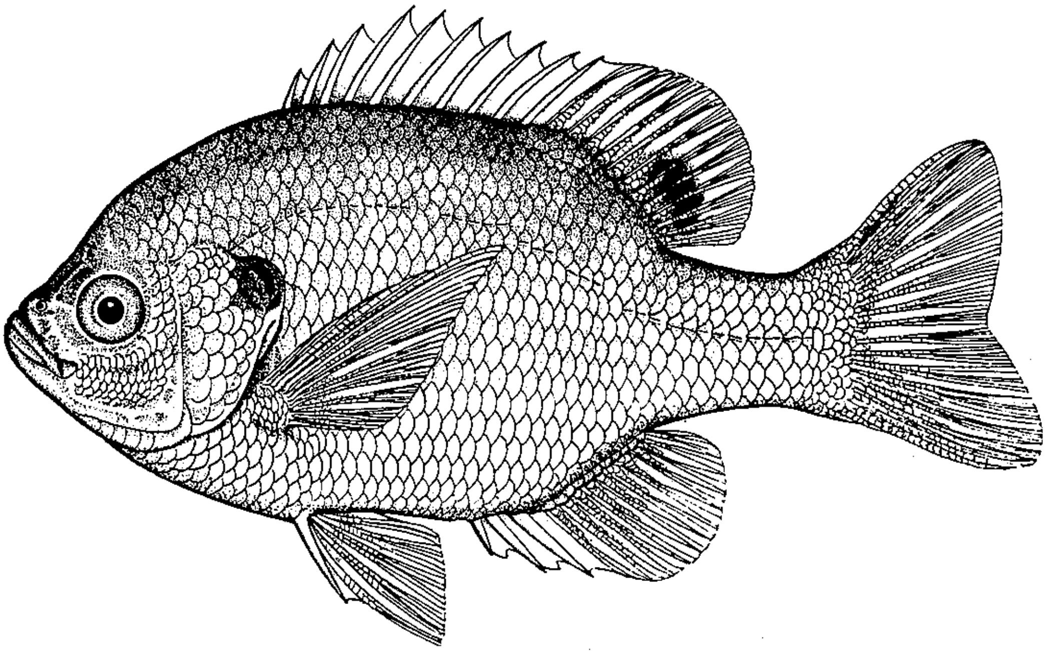
Appendix 6 summarises the first introductions into various localities in southern Africa.

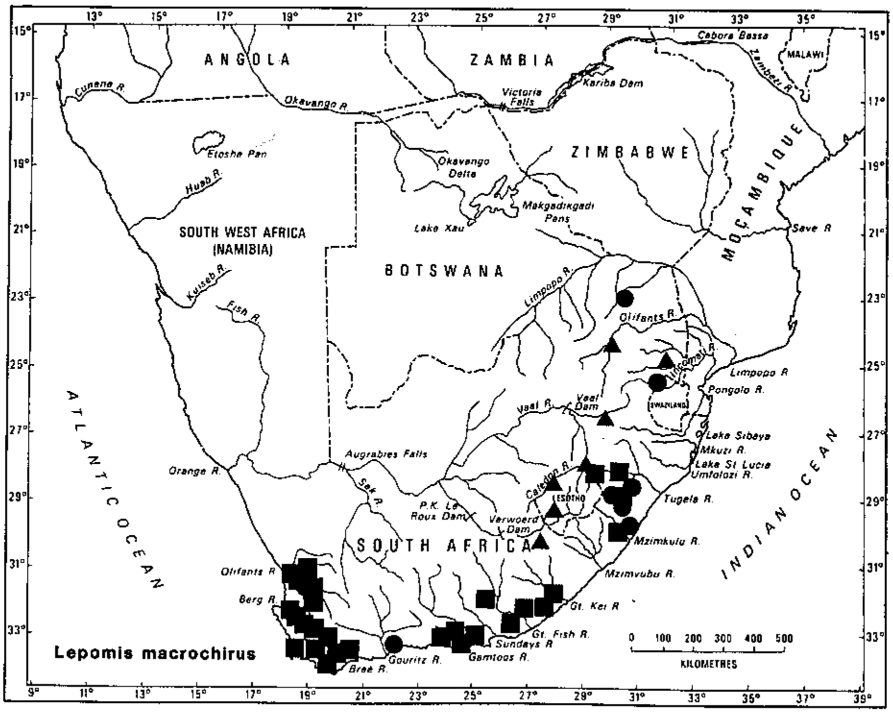
Southern African distribution: The bluegill has a widespread distribution, particularly in the Cape. Populations are established in the following localities:

Cape: In the dams of the Orange River catchment, but not in the river systems feeding the Verwoerd dam (Jubb 1972b). Also present in the Kromme River (Jubb 1959b), the Breede River (Cambray and Stuart 1985), Voelvlei, the Berg River, Riviersonderend system, dams in the Eerste River catchment (Smith personal communication), Groenvlei (Knysna) (van der Merwe 1970), and Tyume River (Keiskamma system) (Gaigher 1975a). There are recent reliable anglers reports of populations in the Kraai River (southern tributary of the upper Orange River) (Benade personal communication). In a survey of the Olifants River conducted in 1963/64 it was noted that this species was not present in the river at Keerom but there was a large population in the Clanwilliam dam and further north in the river. Also recorded in the Doorn and Rondegat tributaries of the Olifants River (van Rensburg 1966b). Recent surveys indicate that this species is found in the Clanwilliam dam and downstream from this point including the lower reaches of the Doring River (Smith personal

LEPOMIS MACROCHIRUS Rafinesque 1819

FIGURE 27. The bluegill sunfish *Lepomis macrochirus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■	ALBANY MUSEUM RECORD
●	LITERATURE RECORD
▲	APPROXIMATE LOCALITY RECORD
▒	NATIVE RANGE

communication). Albany Museum records (see map) indicate a wider distribution in this river system. Some of these records are old and may represent distributions which are no longer valid.

Natal: In standing waters in the Natal midlands, but usually absent from coastal rivers (Crass 1964). Present in the following localities: Umzimkulwana River (Oribi Gorge)(Bourquin and Mathias 1984), dam at Vernon Crookes Nature Reserve (Umzinto River), near Park Rynie (Bourquin and van Rensburg 1984) and in the upper Umgeni River (Crass 1966). Also present in the Midmar, Wagendrift and Craigieburn dams in Natal (McVeigh 1984).

Transvaal and the Orange Free State: Reported by McVeigh (1984) as not being widespread in the Transvaal; only known to occur in some farm dams along the Crocodile River downstream from Nelspruit, in the Amersfoort district and in the Shiljjalongubo dam near Barberton (on a tributary of the Lomati River, Incomati system) (McVeigh 1984). Bluegill have also been recorded in Sterkfontein dam (Wilge River, Vaal system) (OFS Nature Conservation 1983) and in the Klipplaatdrift dam (Elands River, tributary of the Olifants River, Limpopo system) and in a dam (23 0 S, 30 8 E) on the Levubu River (Limpopo system) (van der Waal personal communication). In the Orange Free State *Oreochromis mossambicus* was used as a forage fish for bass and there are no definite records of *L. macrochirus* occurring in this province although there is a possiblity that it may occur in the Clocolan and Ficksburg districts (McVeigh 1984).

Within the Orange-Vaal system bluegill have been recorded in the upper Orange and Caledon Rivers (Skelton 1986b). It is uncertain whether or not it has been found in the Vaal system, but bluegill appear to be absent from the main Orange River as they have not appeared in collections from the Verwoerd dam (Hamman 1980) or Lake le Roux (Jackson et al 1983).

South West Africa: A bluegill was caught in a dam in Windhoek in 1966 (Beneke personal communication).

Habitat preferences: Prefers well-vegetated, shallow warm waters. Found in large and small lakes, ponds and densely vegetated, slow-flowing sections of rivers. In North America *L. macrochirus* usually retreats to deeper, warmer waters during winter where they continue feeding throughout the colder months (Scott and Crossman 1973). Bluegill appear to prefer artificial impoundments rather than rivers and streams (Crass 1969a).

Breeding: *L. macrochirus* have a high fecundity. A single 20 cm female may produce over 20 000 eggs. Spawning takes place throughout the warmer months. Large numbers of fish may breed within a small area (Crass 1964). The males build saucer-shaped nests (about 45 cm in diameter and about 30 cm deep) in gravel (if available), but otherwise in sand or hard mud. The aggressive, territorial male guards the nest, the eggs and the young and frequently defends the nest against larger fish. The eggs take 3 days to hatch and the young fry are guarded for a few days. Sexual maturity is attained between 2 and 4 years (Scott and Crossman 1973).

Feeding: Predator. Feeds on insects, shrimps and fish fry (Bruton et al 1982). In North America *L. macrochirus* was noted to feed more extensively at the surface of the water than other sunfish, with mature insects constituting a large proportion of their diet (Scott and Crossman 1973).

Impact: *L. macrochirus* tends to overpopulate most waters where it is stocked, resulting in large numbers of dwarfed individuals of little angling value (Bruton et al 1982). Preys on the young of more desirable fish (Jubb 1965) and also competes with indigenous fish for food (Jubb 1959b).

Lepomis macrochirus has co-evolved with certain North American centrachids (such as bass) and is likely to be less "naive" to bass than indigenous southern African fishes. The presence of bass in a system may therefore enhance the fitness of bluegill over indigenous species since the latter will more often be selected as prey.

Jubb (1959b) found that population levels of *Barbus senticeps (B. afer)* in the Kromme River had declined in areas where *Micropterus salmoides* and bluegill had been stocked (above and below the Churchill dam). Similarly, large sections of the Kouga River where bluegill had been stocked were found to be virtually devoid of indigenous *Barbus* species. In contrast, rivers in which indigenous predators such as eels were present, but had not been stocked with alien species, supported thriving populations of *Barbus* species.

There has been a marked decline in many indigenous species of *Barbus* in the Clanwilliam Olifants River, largely as a result of the introduction of alien fishes (Gaigher 1981, see also the section on *Micropterus salmoides* and *M. dolomieui*). The combined effect of stocking two or more alien species (such as bass and bluegill) on indigenous species is probably more devastating than if either were stocked alone. The indigenous *Barbus* species have to cope with predation of young and adults from the bass and bluegill, while also having to compete with bluegill for food and other resources. At the same time the presence of bass means that bluegill may have an added selective advantage over indigenous species (as suggested above).

Bluegill appear to be vulnerable to predation by indigenous predators such as the sharptooth catfish *Clarias gariepinus* and have also been excluded from many impoundments by the introduction of the Mozambique tilapia *Oreochromis mossambicus*. Although the Mozambique tilapia usually feeds on diatoms and organic matter in the detritus, large specimens have been reported to prey on small fishes (Bruton and Boltt 1975). This may be the reason why *L. macrochirius* has been unable to establish populations in many Natal coastal rivers where the above mentioned indigenous species are present (Crass 1964). *L. macrochirus* has also failed to establish populations in most parts of the Transvaal. This may be due to predation by catfish, yellowfish, tigerfish and other species (McVeigh 1984).

Control: It may be possible to control bluegill through the introduction (where possible) of *O. mossambicus, Clarias gariepinus* and / or *Barbus kimberleyensis*. The possible impact of the latter introductions would have to be carefully assessed before proceeding with this course of action.

Research recommendations: It would be of interest to conduct a detailed study on the relationship between bass, bluegill and indigenous *Barbus* species. Even though it is impossible to conduct "baseline" studies on rivers where aliens were stocked a number of years ago, gut content analyses can still be done on museum specimens collected prior to the stocking of aliens. A study of this nature would provide further understanding of the effects which aliens have on the environment. This knowledge is important in assisting legislators to decide whether or not to allow the introduction of an alien species into the country.

Remarks: The bluegill is regarded internationally as a pest species (Welcomme 1984) and concerted efforts need to be made to reduce its introduced range and its impact on indigenous species in southern Africa.

REFERENCES

Anon (1944, 1964); Bourquin and Mathias (1984); Bourquin and van Rensburg (1984); Bruton et al (1982); Bruton and Boltt (1975); Cambray and Stuart (1985); Clay (1972); Crass (1964, 1969a); Deathe (1962); C M Gaigher (1981); I G Gaigher (1975a); Hamman (1980); Harrison (1939, 1952e, 1954d, 1962/63a, 1962/63b, 1963a, 1977a, 1977/78); Jackson et al (1983); Jubb (1959b, 1965, 1972b); O F S Nature Conservation (1983); Potgieter (1974); Scott and Crossman (1973); Skelton (1986b); van der Merwe (1970); van Rensberg (1966b).

Personal communications: B Beneke; B Dekker; A Smith; B van der Waal.

MICROPTERUS DOLOMIEUI Lacepede 1802

smallmouth bass
kleinbek baars

alien, detrimental, major impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Centrarchidae

SUMMARY

Status: An alien species imported from the USA in 1937 for sport fishing. The smallmouth bass is an aggressive invader and has had a major negative impact on a number of endemic species, particularly in the Clanwilliam Olifants River where it has been implicated in the disappearance of six rare endemic species from major sections of the river. *M dolomieui* has established populations throughout the southern, south western and eastern Cape and the eastern Transvaal.

Research: Good. The general biology, distribution and impact on natural communities in southern Africa has been studied by many workers including Harrison (in numerous publications between 1937 and 1966); van Rensburg (1963, 1966b); Hey (1971b); I Gaigher (1973); Jubb (1979); McVeigh (1979a); Gaigher et al (1980), C M Gaigher (1981); Pott (1981); Kleynhans (1983) and Cambray and Stuart (1985).

SPECIES DATA

Distinguishing characteristics: A predatory centrarchid fish. Distinguished from the largemouth bass by the smaller mouth, less deeply notched dorsal fin and smaller scales. Colour dark olive above, lighter on flanks with faint vertical bars, fins light olive, belly dusky white, eyes red. Reaches 2 kg but usually less than 500 g (Bruton et al 1982).

Native range: Eastern Canada and the USA from Minnesota and southern Quebec south to the Tennessee River system in Alabama and west to eastern Oklahoma (Lee et al 1980).

Date and purpose of introduction: Introduced for angling purposes. It was hoped that this species would "fill the position left vacant in the present distribution of imported game fish and would improve the fishing waters which lie between the upper trout waters and the sluggish lower reaches held by the largemouth species" (Harrison 1940a). In 1937 fish were imported from the Lewistown Hatchery (Maryland U S A). Twenty nine survived the journey to the Jonkershoek Hatchery (Anon 1944; Harrison 1953a). The Umgeni Hatchery (Natal) opened in 1952 and was involved with breeding and stocking of this species to various water bodies in the province (Pike 1980a).

A detailed record of specific introductions into various parts of southern Africa is given in Appendix 7.

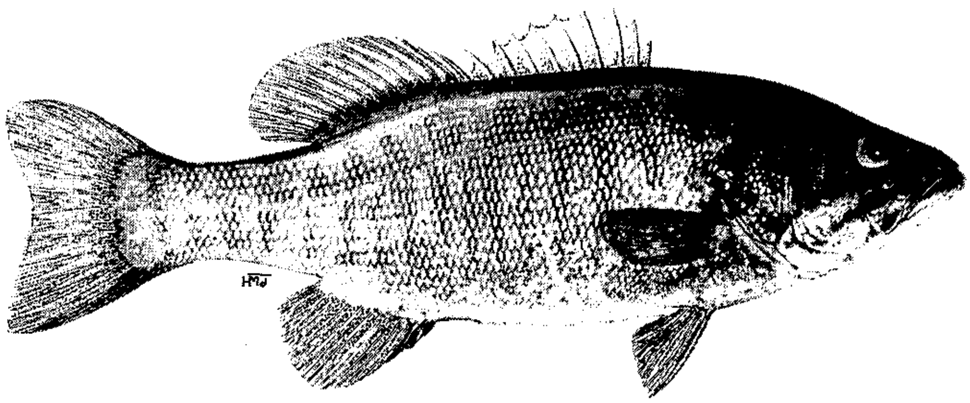
Southern African distribution:

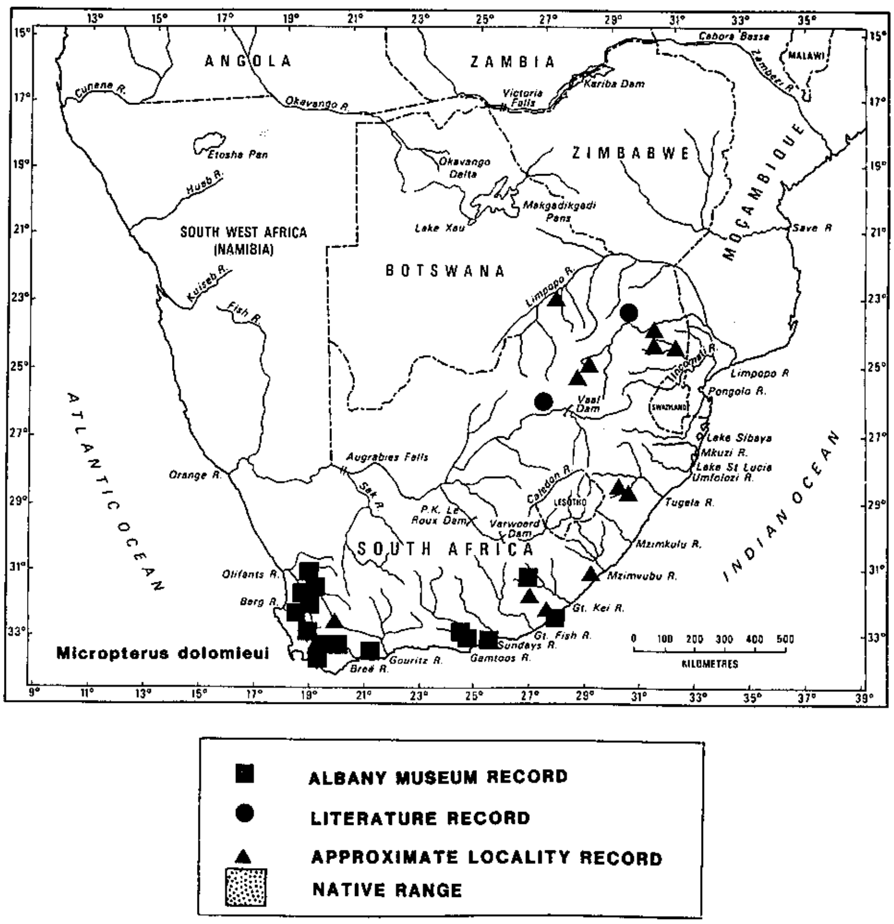
Historical distribution

In 1949 smallmouth bass were reported to be present in the following areas in the Cape: Steenbras reservoir (where, unlike the trout, this species is able to breed), the Lower Berg River, the Dwars River (Breede River system), the Lower Breede River, the Olifants River, the Buffalo River below the trout area, the upper and lower Kubusie and in the lower Umtata Rivers (Harrison 1949).

MICROPTERUS DOLOMIEUI Lacepede 1802

FIGURE 28. Smallmouth bass *Micropterus dolomieui* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Recent distribution

Very widespread. Established in the following areas:

Cape: Olifants, Berg, Breede and Umtata Rivers (Jubb 1965). In the Bontebok National Park (Breede River system, Bredasdorp) (Braack 1981). Established in the Buffalo River below Rooikrantz dam, especially in Laing dam, but not very abundant in other sections of this river (Jubb 1979; Jackson 1982). Also present in the Bongolo dam (Swart Kei, Great Kei system) (Albany Museum records, Bok personal communication). Also in the Gamtoos system (Albany Museum records). Present in many dams in the Orange River catchment but not in the main Orange River (Jubb 1965). Also in the Baviaanskloof River and the Paul Sauer dam (tributaries of Coega River, Gamtoos system) (Davies personal communication). "American black bass" (presumably this species) are (or were) found in the Elands, Swartkops and Kromme Rivers (Jubb 1971c).

It was recently reported (Smith personal communication) that this species had established in the riverine areas throughout virtually the whole of the Olifants system in the western Cape. However populations "are not doing well" in many parts of these rivers due to lack of food. Smallmouth bass appear to thrive in areas where *Tilapia sparrmanii* and *Lepomis macrochirus* are capable of establishing themselves. *M. dolomieui* also congregate below natural barriers above which indigenous species occur and feed on "spill-over" fish (Smith personal communication).

Populations in the Berg and Bree Rivers are reported to be "doing much better than in the Olifants system", probably because of the abundance of *Cyprinus carpio, T. sparrmanii* and *L. macrochirus* in the former rivers (Smith personal communication). Smallmouth bass have not managed to establish in the Hex River as it partially dries up, cutting itself off from the Breede River. Also occurs in the Smalblaar and Holsloot Rivers in the Cape (Smith personal communication).

Natal: Umgeni River near Howick, Mooi River downstream from Rosetta, Bushmans River below Estcourt (Crass 1964).

Transvaal: Headwaters of the Mogol River (Limpopo system) (Kleynhans 1983), Sabie River (Incomati system), Roodeplaat dam, (Pretoria, Limpopo system) (Viljoen and van As 1985), Rietvlei dam (Pretoria) (Smith 1983), Blyde and Treur Rivers (Limpopo system) (Pott 1981) and the Ebenezer dam (Letaba River) (van Loggerenberg personal communication). Present in the Boskop dam near Potchefstroom (Mooi R, Vaal system). This species was heavily stocked in the Boskop dam (20000 introduced between 1969 to 1977) but very few were captured during a survey in 1974. It is therefore uncertain whether a breeding population exists in this dam (Koch and Schoonbee 1980).

Habitat preferences: Readily adapts to riverine conditions (Bourquin et al 1984). Prefers "clear rivers, too warm for trout and too rapid for large mouth bass." Can also survive in acid waters (Anon 1944). Reported to breed in the Steenbras reservoir (a peat-stained lake with a pH between 4,2 and 6,0) although the growth rate was very slow in this environment (Harrison 1960/61). Although this species has been reported as being predominantly a riverine fish it can also thrive in dams (as in the Verlorevlei and Clanwilliam dam) (Smith personal communication).

Smallmouth bass are probably adversely affected by heavy summer floods and are therefore not as successful in the summer rainfall regions as in the winter rainfall areas of southern Africa (Crass 1964).

Smallmouth bass are generally found in slightly cooler waters than *M. salmoides*. Survive in a temperature range between 4 and 35°C with an optimum temperature of about 25°C. Require temperatures of 15 to 20°C for spawning and become lethargic and cease to feed below 10°C. Adversely affected by high siltation levels as their ability to see prey is impaired and spawning sites may become smothered by silt (McVeigh 1979a).

In general smallmouth bass can adapt to a wider range of conditions than trout, but cannot tolerate very polluted waters (Hey 1971b).

Breeding: Breeds in early summer (Bruton et al 1982). Under certain conditions breeding may be delayed until late summer (January) (Harrison 1953b). Nests are built in shallow water where spawning takes place.

According to Jubb (1965) the males guard the eggs and fry until shoals form, but McVeigh (1979a) states that "males continue to protect their young during the shoaling period" and only leave the fry after the shoal begins to break up.

Males require a hard surface on which to deposit their eggs, preferably small water-worn stones. The eggs adhere to the stones. They normally breed in backwaters but can also make use of sheltered areas in the main stream during periods of low flow (Harrison 1953c). A study in Perch lake, Ontario, indicated that sexual maturity is reached in 4 to 6 years and that some individuals live as long as 15 years. Growth in warm waters is faster (Harrison 1965/66a).

Feeding: Predator. Feeds on insects, crustaceans and small fish (Bruton et al 1982). Very young fry depend on small zooplankton for food (eg rotifers and copepods) and then progress to feeding on larger zooplankton (eg *Daphnia* species) before taking larger live food (Harrison 1962/63a).

Behaviour: Smallmouth bass do not make extensive use of protective cover as is the case with *M. salmoides* (McVeigh 1979a).

Impact: The introduction of *M. dolomieui* has had a devastating effect on indigenous species in various parts of southern Africa. Although there are many reasons for the decline in indigenous fish such as general environmental degradation, Skelton (1977, 1987a) lists predation by alien species as an important factor which threatens nine of the twelve threatened freshwater fishes in the Cape, and Gaigher (1978) considers *M. dolomieu* to be the most destructive predator of all the introduced species. A description of the effect which *M. dolomieu* has had in various river systems in southern Africa is given below:

1. Olifants system, Clanwilliam. Introduced in 1943 and 1945. Prior to the introduction of bass a survey of the river (by Harrison in 1937/38) indicated that *Barbus capensis* and other indigenous species were plentiful (Harrison 1961). The effects of the introduction of "bass" were noticed as far back as 1949 when Thomas Brooks (one of the men responsible for the introduction) wrote "For the past two seasons I have looked in vain for the shoals of yellowfish and other indigenous fingerlings. In previous season the shallows (of both the Olifants and Jan Diesels River) were black with these fingerlings ...... If, as I think, the bass are destroying the "yellows", then I regret my part in introducing the bass" (Gaigher 1981).

Van Rensburg (1963) reports that a 1949 survey indicated that *B. capensis* was plentiful in the river, but subsequent surveys in 1960 and 1963 indicated that this species had declined drastically but that *Barbus serra* and *Labeo seeberi* were still plentiful in certain parts of the river (van Rensburg 1963). In 1963-64 *Barbus capensis* and other small endemic species were hardly ever found in the same environment as *Micropterus salmoides* or *M. dolomieui* (van Rensburg 1966b). A survey carried out in January 1973 indicated that populations of *B.capensis, B. serra* and *Labeo seeberi* had all declined drastically and their distribution in the river system was severely restricted by the presence of alien predators. *Barbus calidus* and *Barbus phlegethon* were eliminated from the main stream (the type locality for these two endemic species) and *B. phlegethon* was considered to be in serious danger of extinction. *B.capensis* and *B.serra* were able to spawn successfully in less accessible local streams at Keerom. Endemic species were only able to survive in areas where natural barriers prevented invasion by smallmouth bass or in areas where higher temperatures prevented colonisation by trout (Gaigher 1973). The distribution of *Austroglanis gilli* and *Barbus erubescens* were also affected by the presence of "exotic predators". *B. erubescens* was reported to be confined to two small streams separated from the rest of the system by a waterfall (Gaigher et al 1980).

Eight endemic species from the Olifants system have been listed in the South African Red Data Book (Skelton 1987a). Their status is summarised as follows: *Austroglanis barnardi*, endangered; *A. gilli*, rare; *Barbus capensis*, rare; *B. calidus*, rare; *B. erubescens*, vulnerable; *B. phlegethon*, endangered; *B. serra*, vulnerable; *Labeo seeberi*, rare. Predation by *Micropterus* species is regarded as a major threat to the status of *B. phlegethon, B. calidus* and *B. serra*. Habitat deterioration is regarded as the major threat to the future conservation of *A. barnardi, B. capensis, B. erubescens* and *L. seeberi* but predation by alien species (particularly *M. dolomieui*) is also considered to be a serious threat.

It therefore appears that predation by alien species, general environmental degradation and excessive siltation of rivers have played a major role in the decline of these indigenous species. Van Rensburg (1963) also mentioned that the building of the Clanwilliam dam (in 1935) and the Bulshoek barrage (1922) could have hampered breeding migrations by *B. capensis* and this could also have contributed to the decline of this species. Harrison (1963a:28) also noted that in 1938 "shoals of yellowfish, sawfin and sandfish massed below the barrages at the time of the spring spawning run". However since the population of indigenous species was noted to be plentiful at that time (1937; Harrison 1961), some years after the building of the Bulshoek barrage, it seems that the construction of these dams did not seriously affect the status of these species.

Trout (both *Parasalmo mykiss* and *Salmo trutta*) were introduced into the Olifants River as early as 1897 and 1906 and the serious detrimental effects on indigenous species (described above) were first noticed in 1949 (after the introduction of bass). This suggests that the effect of predation by trout was minimal compared to that of the two bass species.

Angling pressure on *B. capensis* may also have contributed towards the decline of this species. As late as 1962 there was a closed season for bass in the Olifants River from September to December during the breeding season but there was no such closed season for indigenous *B. capensis* (Scott 1982). For this reason angling pressure on *Barbus capensis* was much greater than on the two *Micropterus* species.

2. Berg River. Smallmouth bass were introduced in 1938/39. A survey of this river in 1934 indicated the presence of a large population of indigenous fish comprising *Barbus andrewi, Barbus burchelli, Sandelia capensis* and *Galaxias zebratus*. Eels were not present in the river. The introduction of *M. salmoides* in 1930 apparently did not seriously affect populations of indigenous species in the fast-flowing sections of the river. It was thought that the large population of *B. andrewi* had been the major factor preventing the establishment of trout in this river and the introduction of *M. salmoides* had "done very little to improve the angling prospects in the stony parts of the Berg River" (Harrison 1940a). However by 1943/44 it was noted that populations of "coarse fish" had declined after the introduction of *M. dolomieui* , *B. andrewi* and *S. capensis* having both been eradicated from fast-flowing sections of the river. After the decline in these indigenous species trout were apparently more successful at colonising this river (Harrison 1952a, 1953c).

Barbus burgi populations have also declined in the Berg River and this species is now described as "endangered" (Skelton 1987a). The reason for the decline in this and other indigenous species is largely excessive pollution and extraction of water for irrigation, but predation by *Micropterus* and trout are also listed as contributory factors (Skelton 1987a). Harrison (1940b) records that there was some mortality of fish at Wellington after effluent with a pH of 2,8 had entered the river.

3. Breede River. Smallmouth bass were introduced in 1939/1940. In a survey of this river in 1977/78 Cambray and Stuart (1985) report that there had been a drastic decline in indigenous species. There are many reasons for this: drawing-off of water for irrigation, excessive siltation, pollution from pesticides, increased salinity, canalisation of the river and other factors. The presence of *M. dolomieui* and other alien predators has contributed to the decline of indigenous species. It was noted that no *B. burchelli* have been collected at the same site as either bass or *P. mykiss* and that no indigenous species could be found in the mainstream of the river (Cambray and Stuart 1985). *B. burchelli* is listed as "rare" by Skelton (1987a).

4. The Buffalo River. Smallmouth bass were introduced before 1949. *Barbus trevelyani* was described from this river in the last century. After the introduction of "black bass" into the river below the Rooikrantz dam this species disappeared from the lower section of the river (Jubb 1979).

5. Smallmouth bass are present in the upper reaches of the Mogol River (Limpopo system) but the date of introduction is not known. The presence of *M. dolomieui* may explain why no other fish species were sampled from these streams and it is expected that *M. dolomieui* will pose a threat to local populations of *Barbus brevipinnus* (Kleynhans 1983).

6. Treur River, Limpopo system. Smallmouth bass were introduced between 1957 and 1981. *Barbus treurensis*, which is endemic to the Blyde and Treur Rivers, was only discovered in 1957. The combined effect of the introduction of trout, smallmouth bass and the concomitant introduction of white spot disease are thought to have contributed to the marked decline in populations of *B. treurensis*. This species is now extinct in the Treur River (the type locality) and only occurs in an isolated section of the Blyde River bounded by two waterfalls, where no alien species occur. Therefore it appears that predation by aliens was the most important factor

contributing to the decline of this species (Pott 1981). Skelton (1987a) classifies *B. treurensis* as a "vulnerable" species and mentions that besides the negative impact of predation by aliens, the planting of alien pine trees in its habitat may also have had an adverse effect on this species, possibly by reducing the water table.

7. Eerste River. Bourquin et al (1984) report that the introduction of *M. dolomieui* into this river has resulted in the complete disappearance of *B. burgi* from the system. There are however no other references to *M. dolomieui* being present in the Eerste River and this locality was not listed in Jubb's (1967) distribution for *M. dolomieui*. Thorne (personal communication) of the Cape Department of Nature Conservation reports that until very recently bass were not known to occur in the Eerste River (although there are very recent reports of *M. salmoides* entering the river via the Theewater tunnel, see account of *M. salmoides*). Therefore the report of Bourquin et al (1984) needs to be treated with caution.

8. Natal. *M. dolomieui* has not been as successful in Natal as in the Cape. Crass (1964) suggests that this may be due to the inability of bass to survive the effects of "flash floods" but could also be due to their inability to tolerate the higher water temperatures in Natal. In the few areas where *M. dolomieui* has established Crass (1964) reports that it has not significantly affected indigenous fish such as *Barbus natalensis*, and *M. dolomieui* has not been able to establish in rivers where *Clarias gariepinus* is present. This may be due to predation on the young by catfish. Hey (1971b) comments that the breeding habits of bass (compared to trout) ensure that young fry are protected against predation by many larger indigenous fish. A small parent *M. dolomieui* is unlikely to be able to defend its nest against a large carp or catfish or against large shoals of small fish such as bluegill.

In the Berg, Breede and Olifants (Clanwilliam) Rivers *M. dolomieui* was introduced after the introduction of largemouth bass which in each case had become the dominant fish in the river. However after the introduction of *M. dolomieui* the latter species rapidly assumed dominance in the riverine environment (Harrison 1963a).

Many of the studies outlined above emphasise that it is the combined effect of environmental degradation and the presence of *M. dolomieui* which has resulted in the decline of indigenous species. The degradation of habitat may however exacerbate the effects of alien predators by making the prey more vulnerable to predation. Gaigher et al (1980) point out that effects such as heavy siltation or water extraction may force fish out of their natural refuges, thus facilitating capture by the predator. Heavy siltation would, of course also have a negative effect on *M. dolomieui* as it requires sections of river with scoured out, hard stony bottoms in order to make nests for breeding.

Control: The introduction of *Clarias gariepinus* may help to control populations of *M. dolomieui* but the probable impact of the former species would have to be assessed before proceeding with this proposal.

Research recommendations: Quantitative studies on the dietary preferences of smallmouth bass in different rivers in southern Africa are urgently needed, as well as an assessment of their impact on different indigenous species.

Remarks: Gaigher (1973) recommends that all further stocking of alien fish in the Clanwilliam Orange River should be banned and that the small streams within this river system where endemics still exist should become protected sanctuaries. Stockings of alien fish (except trout in some restricted upland streams) in the Clanwilliam Olifants River have been banned since 1976 (Gaigher 1981). A hatchery was established in 1978 on the banks of the Olifants River near Clanwilliam with the initial intention of breeding and restocking the Clanwilliam yellowfish (*B. capensis*). At a later stage attempts may be made to breed and re-stock other species of *Barbus* (Gaigher 1981). Jubb (1979) recommended that certain other rivers where small populations of endangered fish exist should be declared reserves.

Some of these recommendations have been carried out. The Tyume River (a tributary of the Keiskamma River system) has been declared a reserve with the stocking of all aliens prohibited. This is one of the few sites where *Barbus trevelyani* is still found (Skelton 1987a).

Certain researchers believe that *M. dolomieui* may have a beneficial effect on dams which are overpopulated with undesirable indigenous species. Koch and Schoonbee (1980) recommend that *M. dolomieui* should be stocked on a regular basis into the Boskop dam (Mooi River, Vaal system) in order to control excessive populations of *Labeo capensis* and *L. umbratus* which are undesirable angling species and which constitute approximately 95% of the population of larger fish in the dam. Since *M. dolomieui* already occurs in the dam and apparently does little to control excessive populations of *Labeo* species it seems unlikely that further stocking will improve the situation. It is probable that higher bass populations would further deplete the population of *B. aeneus*, a desirable angling species which occurs in low numbers in the dam.

An associated parasite, *Achtheres micropteri*, was reportedly imported into southern Africa together with *M. dolomieui* (Fryer 1968; Paperna 1980). There have however, been no confirmatory records that *A. micropteri* is in southern Africa and it is not listed in van As and Basson's (1984) checklist.

REFERENCES

Anon (1944, 1948, 1949, 1950, 1952a; Bourquin et al (1984); Braack (1981); Bruton et al (1982); Cambray and Stuart (1985); Clay (1972); Crass (1955, 1964); Deathe (1962); Fryer (1968); C M Gaigher (1981); I G Gaigher (1973, 1978); I G Gaigher et al (1980); Harrison (1940a, 1940b, 1948a, 1948b, 1949, 1951, 1952a, 1953b, 1953c, 1954d, 1961, 1960/61, 1962/63a, 1962/63b, 1963a, 1965/66a); Hey (1971b); Jackson (1982); Jubb (1965, 1967, 1971c, 1979); Koch and Schoonbee (1980); Kleynhans (1983); Lee et al (1980); McVeigh (1979a); Paperna (1980); Pike (1980a); Potgieter (1974); Pott (1981); Scott (1982); Scott and Crossman (1973); Skelton (1977, 1987a); Smith (1983); van As and Basson (1984); van Rensburg (1963, 1966b); Viljoen and van As (1985).

Personal communications: A H Bok; M T T Davies; A Smith; S Thorne; N van Loggerenberg.

MICROPTERUS PUNCTULATUS (Rafinesque 1819)

spotted bass
spikkelde baars

alien, equivocal, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Centrarchidae

SUMMARY

Status: An alien species imported from the USA in 1939 for sport fishing. This species failed to establish in most areas into which it was introduced despite extensive stocking in Natal and the Cape. Isolated breeding populations are still found in the Natal midlands.

Research: Good. Spotted bass have been comprehensively studied in the United States (McClane 1965). The reasons for the failure of this species to establish in most areas into which it has been introduced in southern Africa have not been studied.

SPECIES DATA

Distinguishing characteristics: Similar to *M. dolomieui* in size of mouth but colouration different. Dark patch present at posterior edge of the gill cover and dark diamond-shaped markings often occur along the side of the body, but these may coalesce to form a continuous band. Belly silvery, dorsal surface olive green. Scales on lower flank spotted with dark pigment and markedly ctenoid and rough to the touch. Record length in South Africa: 42 cm (Crass 1964). There are three subspecies in North America: *M. p. punctulatus* (from the northern areas of its native range) *M. p. henshalli* (in the Alabama area) and *M. p. wichitae* (in West Cache creek, Oklahoma) (Lee et al 1980). There is no mention of these subspecies in early reports on the importation of *M. punctulatus* into southern Africa. Harrison (1954b) referred to the initial importation as being from "Ohio stock" which suggests that it was the northern race, *M. punctulatus punctulatus*, which was originally imported into southern Africa.

Native range: Southeastern USA (Lee et al 1980).

Date and purpose of introduction: Introduced for angling purposes. The intention was to stock rivers which were too silted and/or subject to flooding to suit other species of *Micropterus* (Welcomme 1981). Imported from Ohio (USA) by the Cape Piscatorial Society and the Natal Provincial Administration in October, 1939. These fish were distributed into parts of Natal and the eastern and south western Cape (Harrison 1964/65a; Jubb personal communication). A large number were released into farm dams in the Cape (Harrison 1964/65a).

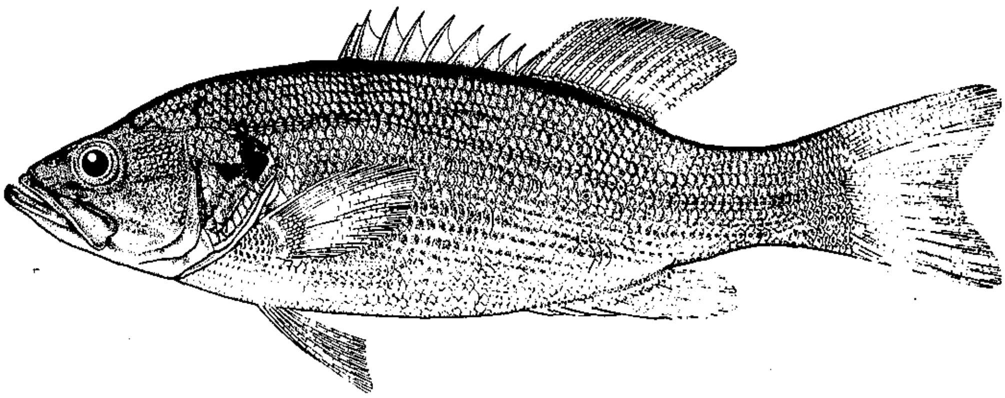
Appendix 8 summarises the first introductions of this species into various localities in southern Africa.

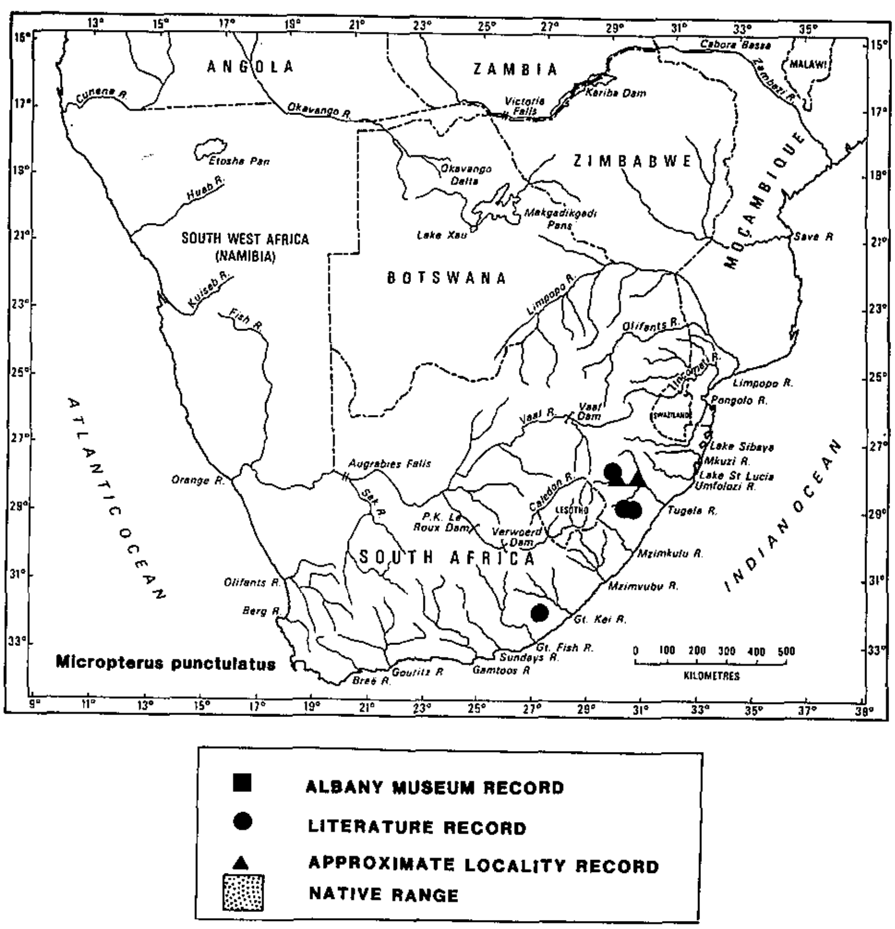
Southern African distribution: Failed to establish in most of the localities into which it was introduced. However there have been some records of the presence of this species in the following localities:

Cape: There are old records from the following localities: Dunbar dam, Buffalo River (Harrison 1954b) and the lower reaches of the Elandskloof River (Cape Agulhas) (Harrison 1964/65a). *M. punctulatus* is no longer kept in the Cape Department of Nature Conservation hatcheries and there have been no records from natural water courses in the Cape for the past 10 years (Hamman personal communication); this species has probably died out in most areas. However there is a possibility that populations are still present in the Buffalo River. Some specimens have recently (February 1988) been caught in the Kubusi River (Kei system) 6 km below Stutterheim

MICROPTERUS PUNCTULATUS (Rafinesque 1819)

FIGURE 29. The spotted bass *Micropterus punctulatus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





and positively identified as *M. punctulatus* (Bok personal communication; Cambray personal communication).

Natal: Present in the Umgeni River and its tributaries, the Lions and Karkloof Rivers, at altitudes between 900 and 1200 m. Also in the Klip River (Tugela system) and a few farm dams in Natal (exact localities not given) (Crass 1964). Pike (personal communication) recently confirmed that this species is still present in the Umgeni River, and that a fairly large population is established in the Midmar dam. Present in the Wagendrift dam (Bushmans River, Tugela system, near Estcourt). This water is slightly discoloured (Smith 1984).

Habitat preferences: Tolerates temperatures to about 32°C (Hey 1971b). In the northern areas of the USA spotted bass are usually found in deep silted pools in sluggish rivers (McClane 1965). Lee et al (1980) report that the subspecies *M. p. punctulatus* has a preference for larger rivers.

Harrison (1954b) noted that the surviving population in the Dunbar dam on the Buffalo River had survived periods of extreme drought culminating in the drying up of the river in 1949 when fish populations were restricted to deep pools. Between 1949 and 1954 the river was in spate a number of times. This species had therefore resisted drought, spate and very turbid conditions (Harrison 1954b).

All introductions into the acidic south coastal streams in the Cape have failed, with the notable exception of the lower Elandskloof River which flows over limestone rocks. The pH in the lower reaches of this river is quite high (about 8,5) (Harrison 1964/65a). It therefore appears that this species cannot survive at low pH levels.

Breeding: Spotted bass migrate upstream into shallow waters where nests not greater than 40 cm in diameter are constructed on the stream bed. Appears to prefer gravel but will also use sand or clay bottoms. After nest building is complete the female spawns and a few hundred eggs are laid at a time. The eggs are adhesive and stick to the bottom of the nest. Often many females spawn in a single nest. The male guards the nest until a short time after the emergence of the young (McClane 1965).

Feeding: Young fish feed on small crustaceans and midge larvae but larger fish eat insects, larger crustaceans, frogs, worms and grubs as well as small fish (McClane 1965).

Impact: The impact of this species is unknown, but its relatively narrow tolerances of pH will exclude it from the South coastal drainage rivers of the Cape where a number of endemic threatened redfin minnows and other indigenous species occur.

Control: Further stocking of this species should not be allowed.

Research recommendations: The diet of spotted bass in southern Africa needs to be studied, and an assessment made of their impact on indigenous species.

Remarks: The high turbidity tolerance of spotted bass may ensure their continued survival in southern African rivers which have turbidity levels elevated beyond the norm due to poor management practices in the catchment.

REFERENCES

Anon (1948, 1949); Clay (1972); Crass (1955, 1964); Deathe (1962); Harrison (1948b, 1951, 1954b, 1954d, 1963a, 1964/65a, 1977b); Hey (1971b); Lee et al (1980); McClane (1965); Smith (1984); Smith-Vaniz (1968); van Rensburg (1963); Welcomme (1981).

Personal communications: A H Bok; J A Cambray; K C D Hamman; R A Jubb.

MICROPTERUS SALMOIDES (Lacepede 1802)

largemouth bass **alien, equivocal, major impact**
grootbek baars

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Centrarchidae

SUMMARY

Status: An alien species imported from the UK in 1928 for the purpose of sport fishing and aquaculture. This species rapidly colonised many southern Cape rivers where it has had a major detrimental impact on indigenous species. *M. salmoides* is widespread in the western, southern and eastern Cape as well as in Natal and the Transvaal.

Research: Excellent. Scott and Crossman (1973) have reviewed the many studies on this species in its native range. In southern Africa the original stocking of this species as well as later distribution records and their impact on indigenous communities, has been well documented by Harrison (in numerous publications between 1936 and 1977), Jubb (1973a), Cambray and Stuart (1985), Mayekiso (1986) and other workers.

SPECIES DATA

Distinguishing characteristics: Distinguished from the smallmouth bass by the larger mouth (with the posterior border extending beyond the eye), more deeply notched dorsal fin and larger scales. Colour dark olive above, lighter on flanks with a series of dark blotches, fins olive, belly white, eyes red. In juveniles the dark lateral blotches merge to form a band (Bruton et al 1982).

The subspecies (*M. salmoides floridanus*) from the Florida peninsula is characterised by its rapid growth rate and the large size (up to 9,5 kg) of adults (Lee et al 1980; Anon 1981).

Native range: The freshwaters of the lower great lakes in North America, the central part of the Mississippi River system south to the the Gulf coast, Florida, and northwards along the Atlantic coast to Virginia (Scott and Crossman 1973).

Date and purpose of introduction: Imported for angling purposes. It was hoped that this species together with *Lepomis macrochirus* would become established in farm dams and standing waters (Jackson 1973a). Largemouth bass were primarily recommended for use in aquaculture (Hey 1971b). In 1928 *M. salmoides* (which had been bred in Holland) were imported from the Surrey trout farm (in England) to the Jonkershoek Hatchery. Their distribution to localities in the Cape began in 1930 (Anon 1944).

The Umgeni Hatchery in Natal opened in 1952 and was stocked with largemouth bass which were later distributed to various water bodies in Natal (Pike 1980a).

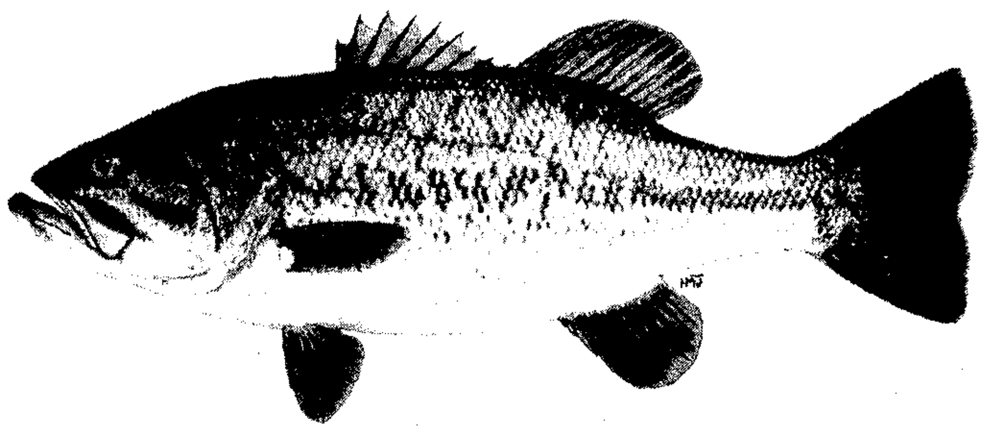
A consignment of "Florida bass", the subspecies *M. salmoides floridanus*, was imported to the Umgeni Hatchery in June 1980, initially for experimental purposes (Anon 1981).

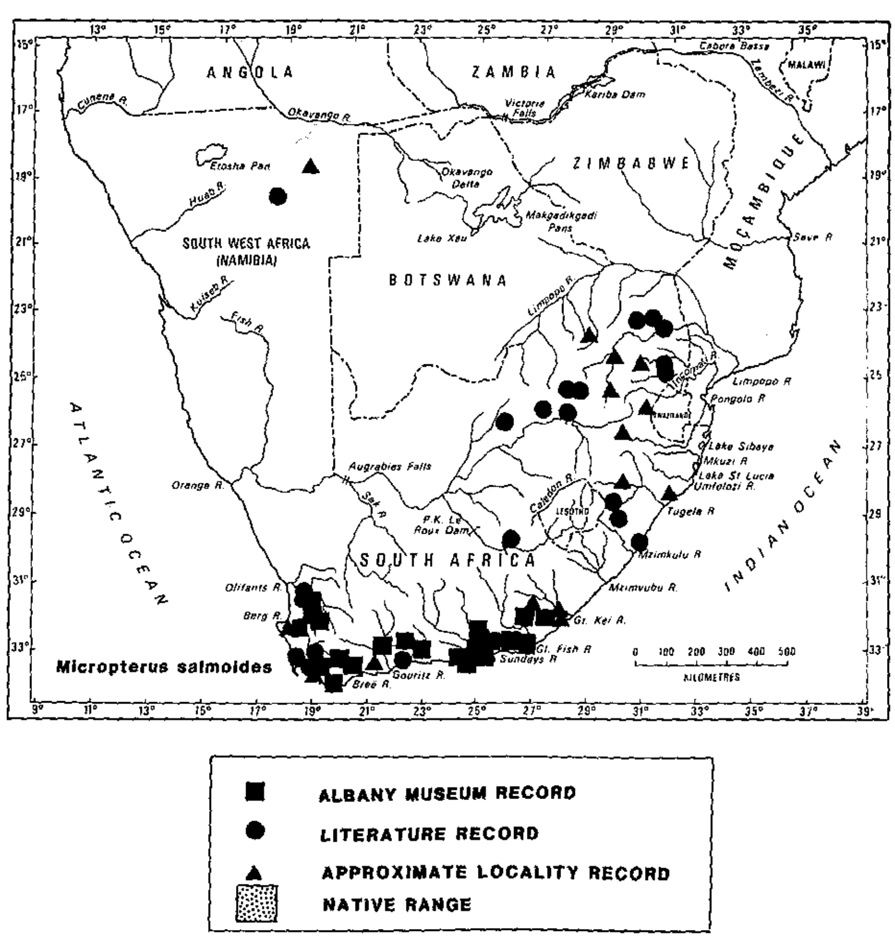
There were many introductions into South West Africa between 1944 and 1949, and since 1983 this species has been supplied to farmers within SWA without the requirement of a permit. Supplies are made available by the Freshwater Fish Institute at Hardap dam (Schrader 1985).

Appendix 9 summarises the first recorded introductions of largemouth bass into various waters in southern

MICROPTERUS SALMOIDES

FIGURE 30. The largemouth bass *Micropterus salmoides* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Africa.

Harrison (1936) reports that at that time "the following rivers of the Cape Province .... have either been stocked direct with bass or receive the overflow of stocked enclosed waters: Olifants River (Bulshoek dam), Berg River, Hout Bay stream, Palmiet River; Bot River (possibly from Caledon and direct stocking projected); Klein River; Zonder End River (possibly from Vygeboom, or ascending Riversdale); Dwyka or Gamka River (from Oukloof dam, Prince Albert), and Kamanassie River (direct and from dam), and both possibly to the Gouritz River; Sundays River (from Graaff-Reinet and Caesar's dam, Lake Mentz); Kowie River; Fish River (from Cradock and Somerset East); Buffalo River; Golongi or Lower Toise; and possibly the Umzimvubu system from Matatiele."

Southern African distribution: The extraordinary lengths taken by early anglers and "conservationists" to stock largemouth bass in remote waters is illustrated by the account of a one-armed man who drove over 250 km from Mbabane in Swaziland to Lake Sibaya in northern Zululand in 1935 to stock the lake with 29 bass. He negotiated trackless, fever-ridden country to introduce bass into a lake where few sportsfishermen ever ventured, but to no avail as none of the bass have been caught or seen again (Harrison 1936; Bruton 1979e, 1980).

Early records:

Cape: Between 1935 and 1936 it was confirmed that bass had become established in the following localities: Breede River, Princess Vlei (Heathfield), and Olieblom Vlei. They failed to establish in Sandvlei (Lakeside) (Harrison 1975, 1976b).

In 1949 largemouth bass were reported to be present in the following localities in the Cape: Clanwilliam and Bulshoek dams (Olifants system), the Lower Berg River, the Lower Breede system, Groenvlei Lake at Knysna, below the trout area in the Buffalo River, the Lower Kubusie River at Stutterheim and the Nqabara River (Harrison 1949); the lower reaches of the Sonderend River, the Palmiet and Kaffirkuils Rivers (Harrison 1940a).

Recent records:

Cape: Present in dams and pools throughout virtually the whole of the Olifants system in the western Cape (Smith personal communication). Present in the following localities: Paardevlei (Somerset West), Kaffirkuils, Kromme, van Staadens, Elands, Wit and Kariega Rivers (Jubb 1967). Also in the Kubusie and Klipplaats Rivers (Great Kei system), in Cintsa dam (Cintsa River, north of East London) (Jubb 1967 and Bok personal communication) and in the Tyume and Keiskamma Rivers (Mayekiso 1986). Largemouth bass are present but scarce in the Berg and Breede Rivers, but present in most impoundments in these rivers. They are present but not thriving in Brandvlei (they are probably adversely affected by the introduction of carp into this impoundment) (Smith personal communication). Also in most parts of the Buffalo River except in the estuary and the cold headwaters (Jubb 1967; Jackson 1982). Present in the Baakens River until 1981 but may have been eliminated at a later date by floods during and after 1981 (Heard and King 1981); in the Swartkops River from Despatch to the upper reaches (Jubb 1967, Barrow 1971); Groenvlei near Knysna (Jubb 1967; van der Merwe 1970); in all rivers in the Albany district except the Great Fish River which is an unsuitable habitat for this species (Coetzee 1977); in a large dam on the farm Rozendal near Stellenbosch (van Schoor 1969b). Collected in 1986 in the Groot River (Gamtoos system, 33 34 S, 24 39 E) (Cambray personal communication). There are also museum records from the Gamtoos and Gouritz systems (Albany Museum records).

Largemouth bass have a widespread occurrence in dams in the Riviersonderend and Eerste River catchments (particularly in the Theewaterskloof). Until very recently this species was not found in the Eerste River itself (Thorne personal communication) but they are now entering the river via the Theewaterskloof tunnel. The Eerste River appears to be unsuitable for bass since they must have been introduced on many occasions from overflow from dams in the catchment (Smith personal communication). Also present in Stettynskloof (upriver from Rawsonville). It has been noted that largemouth bass do not occur in the following dams: Wemmershoek, Steenbras, Lakensvlei (outside Ceres), Keerom and Fairy Glen (outside Worcester). Although *M. salmoides* occurs in the Olifants, Berg and Breede Rivers, they are relatively scarce there, especially in comparison with *Micropterus dolomieui*. However they do occur in the vast majority of impoundments in the catchments of the Berg and Breede Rivers where carp and/or bluegill have not been stocked. The population in Brandvlei lake is also reported to be "not doing well" probably due to the presence of carp in this impoundment (Smith personal communication).

Orange Free State: Present in the dams in the Orange River catchment, but there are no records in the rivers feeding the Verwoerd dam (Jubb 1972b). Not present in collections made in Lake le Roux (Jackson et al 1983) or the Verwoerd dam (Hamman 1980) but have been observed in the Bethulie dam in the Caledon River (Cambray personal communication). It is probable that the water in the main Orange River and especially in the large dams is too turbid for this species and the dams which were referred to above by Jubb (1972b) were small farm dams in the Orange River catchment.

Skelton (1986b) records that within the Orange-Vaal system the only definite records for this species are from the upper Orange and Caledon Rivers.

Transvaal: Widespread throughout the Transvaal (Coetzee personal communication). Present but "not doing well" in the Doorndraai dam (Sterk River, Limpopo system, near Potgietersrus) (Batchelor 1974). Also present in the Klipplaatdrift dam (Elands River, a tributary of the Olifants River, Limpopo system) and dams in the Levubu catchment (Limpopo system) (van der Waal personal communication). Largemouth bass have been recorded on very rare occasions in the Hartbeespoort dam (Cochrane 1983).

First recorded in the Vaal system in 1956 when a specimen was caught near Ermelo although stocking in the catchment dams had occurred prior to this date (du Plessis and le Roux 1965). It is uncertain whether or not largemouth bass still occur in this locality. They were recently reported to be present in many farm dams in the Amersfoort area of the Vaal catchment (van Loggerenberg personal communication). Not listed as being present in the Vaal River by Mulder (1986), but this information was based on surveys carried out prior to 1971. Largemouth bass have now been recorded in the Vaal River at Vereeniging. This is apparently the result of fish escaping into the river after a "bass dam" had burst "a few years ago" (prior to 1983) (Joubert 1984). Van Loggerenberg (personal communication) recently confirmed that this population is well established. Present in Rietvlei dam (Limpopo system, south east of Pretoria) (Smith 1983). Also present in the Boskop dam (Mooi R, Vaal system, Potchefstroom), the Ebenezer, Fanie Botha and Hans Merensky dams (Letaba system), the Mala Mala dam (Phalaborwa, Olifants River, Limpopo system) and the Braam Raubenheimer dam (Lydenburg, Crocodile River, Incomati system) (van Loggerenberg personal communication). Also regularly stocked in the following dams: the Longmere, Klipkoppies, da Gama and Primkop dams (Nelspruit/ White River districts), Nooigedacht, Vygeboom, Westoe and Morgenstond dams (Carolina area), the Jericho dam (Ermelo district) and the Witbank and Rondebosch dams (Witbank/Middelburg districts) (Coetzee personal communication).

Natal: Established in the upper reaches of the Tugela system and in a coastal tributary of the Umhlatuzi River in Natal (Crass 1966); in natural pools in the Nyengelezi valley (Umzinto River catchment, Vernon Crookes Nature Reserve) (Bourquin and Sowler 1980). "Bass" (probably this species) are known to occur in the Albert Falls dam and Craigieburn dam (half way between Mooiriver and Greytown). *M. salmoides* does occur in the Wagendrift dam (on the Bushmans River, Tugela system, near Estcourt) (Smith 1984). "Bass" (probably this species) are present in the Midmar dam (Umgeni River) (Heeg 1983).

Swaziland: Widely distributed in most reservoirs in Swaziland (George 1976).

South West Africa: Widespread throughout the area. Also present in the sensitive catchment of the Omatako Omuramba system and therefore pose a threat of invasion to the Okavango system. However the high turbidity of seasonal rivers as well as the specialised breeding requirements of this species limit its distribution in South West Africa (Dixon and Blom 1974; Schrader 1985). Present in many stretches of the Swakops River including the von Bach dam (Skelton and Merron 1984).

Habitat preferences: Prefers lakes or artificial impoundments to rivers and streams (Crass 1969a). Survives in rivers but is less suited to this environment than *M. dolomieui*. After the initial stocking in the Breede, Berg and Olifants Rivers *M. salmoides* rapidly established populations and in each case initially appeared to be the dominant fish in the river until the stocking of *M. dolomieui* which rapidly assumed dominance followed by a rapid decline in *M. salmoides* populations (Harrison 1963a). Harrison (1940a) doubts the ability of *M. salmoides* to breed in rivers subject to summer floods.

M. salmoides tolerates temperatures from 5 to 36,5°C with the optimum temperature at 28°C. Inactive at temperatures below 10°C. Temperatures below 14,4°C are lethal to incubating eggs (Hey 1971b).

Although *M. salmoides* is slightly more tolerant of turbid waters than *M. dolomieui* (McVeigh 1979a), neither species survives in very turbid conditions. *M. salmoides* is uncommon in areas where high populations of *Labeo umbratus* occur, for example in the lower reaches of the Bushmans River, but occurs down to the ebb and flow of the Kariega River where *L. umbratus* does not occur (Jubb 1973a). (*L. umbratus* tends to stir up bottom sediments thereby increasing turbidity levels, Jubb 1966b).

Largemouth bass are reported to be more tolerant of peat-stained, acid waters than trout. They are abundant in the Sonderend River which has a very marked peat stain and also present in the acid streams of the Palmiet River (Elgin) and the Kafferskuils system (Riversdale) (Harrison 1940a). Not as able as indigenous *Barbus* species to withstand flash-floods (Heard and King 1981).

In Zimbabwe it has been found that largemouth bass are usually absent from rivers below dams in which they flourish. This is particularly the case when tigerfish *Hydrocynus forskahlii* are present in the river, so it appears that these two species cannot co-exist (Jubb 1973a).

Although *M. salmoides* normally co-exists with *Lepomis macrochirus* in the USA (Hey 1971b), it is often absent from areas where heavy populations of *L. macrochirus* occur in southern Africa (eg in the upper Kariega River) (Jubb 1973a).

Breeding: Males construct saucer-shaped nests of 15 to 30mm in diameter in sand or gravel. Largemouth bass cannot breed successfully if the substrate is too silty (McVeigh 1979a).

Largemouth bass breed in spring (Jubb 1965) or when water temperatures reach 16 to 18°C and tend to nest in open areas. There is always one male per nest, but many females may spawn in the same nest. Females lay eggs which are 1 mm in diameter and adhere to the substrate where they are laid. The female is then driven away from the nest by the male who guards the eggs, cleaning them of silt and fanning the nest to ensure a continuous flow of fresh water. At 18°C eggs hatch in approximately 8 to 10 days and feed off the yolk sacs for about 10 days. The fry are initially protected by the male and at this stage they move about in the shallows in shoals until they reach 25 mm T L when the male deserts the young and the shoal disbands (McVeigh 1979a).

Feeding: Predators on other fish (Bourquin et al 1984). Analyses of gut contents from Lake Kyle (Zimbabwe) indicate that fish constituted 87% of their stomach contents, the remaining 13% being the remains of invertebrates. It was also found that *Tilapia* and *Barbus* species were taken in almost equal quantities. Predation on *Xenopus laevis* by this species has also been observed (Jubb 1973a).

After its introduction into Paardevlei lake (Somerset West) in 1930 *M. salmoides* fed almost exclusively on the Cape kurper (*Sandelia capensis*) and was reported to be in very good condition. In 1931 tench (*Tinca tinca*) were also found in bass stomachs (Harrison 1954d). By January 1934 the Cape kurper population had been destroyed and it was noted that the gut contents of *M. salmoides* contained some of their own young as well as insect larvae, water snails, frogs (*X. laevis*) and crabs. Furthermore, the condition of the bass had deteriorated. This indicates that other food was ignored while the favoured forage fish (kurper) was still available (Harrison 1952a). Largemouth bass also preyed on *L. macrochirus* when this species was introduced into the lake at a later date. The condition of the bass was then noted to improve (Harrison 1954d).

In experiments conducted in artificial ponds Webb (1986) studied the vulnerability of four different species of prey to attacks by *M. salmoides*. He concluded the following: a) captures were only successful if strikes were near the centre of mass of the prey, b) the presence of spines did not substantially affect the predator's strike at the prey, c) a large body depth in the prey resulted in a misdirection of attack away from the centre of body mass and increased the probability of prey escaping, d) prey with high acceleration speeds were more likely to escape and e) prey with a low threshold response to predators (ie the time elapsed before prey reacts to the presence of a predator) were more likely to escape. It was also found that low threshold responses correlate with high acceleration speeds in prey species. To summarise, it is apparent that the body form and locomotor performance of prey species affects its vulnerability to attack. Locomotor performance probably also correlates with feeding behaviour. Species which feed on small items for long periods of time probably have high threshold responses to the presence of predators (as reacting to the presence of predators too often in one day would interrupt feeding too much). Conversely, fish eating larger items for shorter periods of time would be less likely to have food consumption reduced by escape behaviour and could afford to have a low threshold response to the presence of a predator.

It must be borne in mind that the above study was conducted in an artificial environment and other important factors such as camouflage and mimicry in prey fish were not taken into account.

Crass (1964) noted that other North American centrarchids such as *Lepomis macrochirus* are better adapted to avoid predation by *M. salmoides* than indigenous southern African species. This can probably be attributed to some of the factors mentioned above (eg *L. macrochirus* is a deep-bodied fish compared to some indigenous *Barbus* species). Other factors, such as the threshold response time, probably contribute to make *L. macrochirus* more adapted to avoid predation by *M. salmoides*.

Behaviour: Largemouth bass can be taken on artificial lures (Jubb 1967) and are regarded as a good "fighting" fish. In Crass' opinion their behaviour since being introduced into southern Africa has not lived up to its "fighting" reputation in North America. The bass became sluggish at temperatures below 16°C (Crass 1964) and tend to move to areas where there is a good growth of aquatic vegetation. This habitat provides both food and cover from other predators (McVeigh 1979a).

Impact: Due to its predatory behaviour this species has had a negative impact on numerous indigenous species in southern Africa, especially in areas (such as in sections of the Olifants River) where no large indigenous predators occurred previously.

Detailed descriptions of the impact of *M. salmoides* in various localities are given below:

1. Paardevlei lake (Somerset West) (introduced in 1930). Reported to be responsible for the complete extermination of the Cape kurper (*Sandelia capensis*) population from this lake (Anon 1944; Harrison 1952a, 1954a; Jubb 1965). However Jubb (1965) remarks that *S. capensis* does not appear to be as vulnerable as many small indigenous *Barbus* species to predation by *M. salmoides* and other alien predators in a riverine environment.

2. Groenvlei lake (Knysna) (introduced in 1934). Prior to its introduction a survey carried out in 1933 indicated that only one indigenous species, *Gilchristella aestuaria*, existed in the lake in great abundance (Harrison 1951). After the release of *M. salmoides* into the lake it was noted that fish caught by anglers were in very good condition up until 1939 but declined after 1940. A survey in 1940 indicated that *G. aestuaria* was still abundant in the shallow-water areas. However the decline in the condition of the bass led Nature Conservation officials to believe that the supply of prey had decreased and this then prompted the introduction of *L. macrochirus* and *Gambusia affinis* into Groenvlei (Harrison 1977a).

Ratte (personal communication) has found that both *G. aestuaria* and another indigenous species, *Atherina breviceps* (which superficially resembles *G. aestuaria*) are plentiful in Groenvlei in spite of the fact that both species are extensively preyed on by bass. It is also of interest to note that even though *A. breviceps* appears to be the preferred prey of the bass (from stomach content analyses done on bass) this species is more abundant than *G. aestuaria* (Ratte personal communication).

3. Olifants River (Clanwilliam) (introduced in 1933 to the lower Olifants and in 1936/37 to the upper Olifants River, above and below the Clanwilliam dam). *M. salmoides* and *M. dolomieui* are thought to be responsible for a drastic decline in the populations of ten indigenous species of minnow in the Olifants River system in the western Cape Province (Bourquin et al 1984). Eight of these species are now listed in Skelton's (1987) Red Data Book: *Austroglanis barnardi* (endangered), *A. gilli* (rare), *Barbus calidus* (rare), *B. capensis* (rare), *B. erubescens* (vulnerable), *B. phlegeton* (endangered), *B. serra* (vulnerable), *Labeo seeberi* (rare).

In most instances environmental degradation is the most important factor leading to the decline in the conservation status of these species. Predation by bass is however considered to be a major contributing factor (Skelton 1987a). Since *M. salmoides* is less adaptable to riverine conditions than *M. dolomieu*, it is thought to have played a minor predatory role (Bourquin et al 1984). (Also see section on *M. dolomieui*).

4. Swartkops River (date of first introduction unknown). *M. salmoides* is thought to be responsible for the decline of redfin minnow (*Barbus afer*) populations in the Swartkops River (Barrow 1971).

5. Kromme, van Staadens and sections of the Elands River (eastern Cape) (dates of introduction unknown). The decline in population levels of indigenous *Barbus* species in these three rivers has been ascribed to the presence of *M. salmoides* together with the bluegill (*Lepomis macrochirus*). Rivers in the south eastern Cape where no alien predators had been introduced were found to support thriving populations of indigenous *Barbus* species in contrast to the Kromme River where the indigenous species, *Barbus afer,* was restricted to a few shallow tributaries (Jubb 1959b).

6. Breede River system (introduced from 1930 to 1932). A number of factors relating to general environmental degradation have led to a drastic decline in population levels of *Barbus burchelli* in the Breede River system, but the presence of alien predators including *M. salmoides, M. dolomieui* and *Parasalmo mykiss* has probably also contributed to this decline. In a survey of this river system carried out from 1978 to 1983 it was noted that no specimens of *B. burchelli* were collected at the same site as bass or trout and that this endangered species is confined to small tributaries. In contrast it was noted that the two indigenous species *Sandelia capensis* and *Galaxias zebratus* both occurred together with *B. burchelli* in various localities in the river although the former species is sometimes predatory on other fish (Cambray and Stuart 1985).

7. Keiskamma and Tyume Rivers (date of introduction unknown). Five alien and translocated indigenous species have been introduced into these rivers: (*M. salmoides, P. mykiss, Clarias gariepinus, Tilapia sparrmanii* and *L. macrochirus*). These species have been found to be predominantly distributed in the following sections of the Tyume River:

Upper river: *P. mykiss*

Upper middle river: *T. sparrmanii, P. mykiss*

Middle river: *T. sparrmanii, C. gariepinus*

Lower middle river: *M. salmoides, T. sparrmanii, L. macrochirus* and *C. gariepinus* (Mayekiso 1986).

Two indigenous species, *Barbus trevelyani* and *Sandelia bainsii*, occur predominantly in the upper and middle reaches respectively. The presence of *P. mykiss* is thought to be a threat to the status of *B. trevelyani* in the upper reaches. *S. bainsii* has a very similar diet to both *M. salmoides* and *P. mykiss* but avoids competition with the two alien species as its distribution is affected by altitude and the distribution of these two aliens. It is feared that *M. salmoides* and *P. mykiss* may establish in sections of the river where *S. bainsii* is abundant and would adversely affect the latter species through predation and competition. The effect of *C. gariepinus* (which was first recorded in the Tyume River in 1985) on *S. bainsii* has not been assessed (Mayekiso 1986).

Besides their direct negative effect due to predation, it can also be expected that the presence of bass in a river will serve to enhance the negative effect which *L. macrochirus* will have on indigenous species (see section on *L. macrochirus*).

The following species have been introduced into various areas in southern Africa as "forage for bass":

Alien species: *Lepomis macrochirus, Gambusia affinis, Oreochromis niloticus* and *Tilapia zillii*. A Cape Provincial Administration report (Anon 1944) also mentions that *Tinca tinca* was introduced as a forage fish for bass, but this species was actually imported into southern Africa in 1911, well before the introduction of bass.

Translocated species: *Barbus gurneyi, Tilapia sparrmanii* and *Oreochromis mossambicus*.

he introduction and translocation of these species can be described as an indirect effect which the ıtroduction of bass has had in southern Africa. Many of these species (such as *L. macrochirus* and *O. ıossambicus*) have had serious negative environmental effects in the areas into which they have been ıtroduced.

:ontrol: The Cape Department of Nature Conservation now discourages fishermen from returning any alien ɛh into the Olifants River and is also involved in artificially breeding and restocking indigenous fish, especially *:. capensis* (Scott 1982).

'he presence of largemouth bass and other alien species including *O. mossambicus* and *Cyprinus carpio* in the)matako Omuramba area of South West Africa poses a serious threat of invasion into the Okavango system. ;erious consideration should be given to means of eliminating these fish from this area (see comments in the ection on *O. mossambicus*).

lesearch recommendations: It may be interesting to conduct a more detailed literature study on the state of vater bodies in the Cape before and after the introduction of *M. salmoides*. This would require a search hrough the archives of the Cape Department of Nature Conservation. Of particular interest would be a :omparison between Paardevlei and Groenvlei. The indigenous species *S. capensis* was exterminated from ?aardevlei after the introduction of bass, whereas indigenous *Gilchristella aestuaria* and *Atherina breviceps* ›opulations in Groenvlei survived, and recent surveys by Mr W Ratte of the Cape Department of Nature Conservation have confirmed that these species are still plentiful in the lake in spite of constant predation by *M. :almoides* and the presence of other aliens in the lake (*M. salmoides, Lepomis macrochirus, Gambusia affinis* and *Oreochromis mossambicus*) (Ratte personal communication). Groenvlei Lake is completely isolated from other water bodies, with no river inlet entering the lake, as the water supply comes from seepage and direct precipitation on surrounding dunes. Detailed studies of these lakes may provide some insight into the relationship between an introduced predator and indigenous prey species. It may also be interesting to investigate the relationship between *M. salmoides* and *L. macrochirus* in southern African lakes. These two species have probably co-evolved as they have very similar native ranges in North America (Lee et al 1980). Comparisons could then be made between the following relationships: introduced predator-indigenous prey, indigenous predator-indigenous prey and introduced predator-introduced prey.

Remarks: Population levels of *M. salmoides* in southern Africa have been reduced by *Lepomis macrochirus* which preys on their eggs and young (Jackson 1973a). The ability of *L. macrochirus* to avoid predation by *M. salmoides* has already been noted above. It should also be noted that *M. salmoides, M. dolomieui* and *L. macrochirus* have very similar native ranges in North America (Lee et al 1980). This suggests that these three species co-evolved and explains why *L. macrochirus* is adapted to avoid excessive predation by *M. salmoides*.

Although *M. salmoides* has been used in aquaculture, their yield is not high compared to plant-eating species such as carp (Hey 1971b). Largemouth bass are sometimes cultivated together with tilapias (such as *Tilapia rendalli*) as they perform a useful function in preventing overpopulation in production ponds by consuming the smaller fish (Lombard 1959, Pike 1983b).

Scott (1982) notes that even anglers have not benefitted from the introduction of bass into the Olifants River as the only areas where good bass fishing is to be found are in the large impoundments. In smaller rivers large populations of small fish thrive whereas previously large specimens of *Barbus capensis* (a highly desirable, "fighting" indigenous angling fish) could be found in these streams.

REFERENCES

Anon (1944, 1948, 1949, 1950b, 1951b, 1980, 1981); Barrow (1971); Batchelor (1974); Bourquin and Sowler (1980); Bourquin et al (1984); Bruton (1979e, 1980); Bruton et al (1982); Cambray and Jubb (1977a, 1977b); Cambray and Stuart (1985); Clay (1972); Cochrane (1983); Coetzee (1977); Commission for Inland Fisheries of Africa (1985); Crass (1964, 1966, 1969a); Deathe (1962); Dixon and Blom (1974); du Plessis and le Roux (1965); Gaigher (1973); George (1976); Hamman (1980); Harrison (1936, 1938, 1940a, 1940b, 1949, 1951, 1952a, 1953b, 1953c, 1954a, 1954b, 1954d, 1963a, 1964/65a, 1975, 1976a, 1976b, 1977a); Heard and King (1981); Hecht and Scholtz (1983); Heeg (1983); Hewitt Ivy (1955); Hey (1971a, 1971b); Hyde (1956); Jackson (1973a, 1982);

Jackson et al (1983); Joubert (1984); Jubb (1959b, 1965, 1966b, 1967, 1972a, 1972b, 1973a); Lee et al (1980); Lombard (1959); Mayekiso (1986); McVeigh (1979a); Mulder (1986); Pike (1980a, 1980b, 1983b); Potgieter (1974); Schrader (1985); Scott (1982); Scott and Crossman (1973); Skelton (1986b, 1987a); Skelton and Merron (1984); Smith (1983, 1984); van der Merwe (1970); van Schoor (1969a, 1969b); Webb (1986).

Personal communications: A H Bok; J A Cambray; A Coetzee; M M Coke; B Dekker; F C de Moor; W Ratte; A Smith; S Thorne; B C W van der Waal; N van Loggerenberg

PERCA FLUVIATILIS Linnaeus 1758

perch
Europese baars

alien, detrimental, little impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Percidae

SUMMARY

Status: An alien species introduced from Europe for angling purposes in 1915. Widely stocked in the Cape Province, but failed to establish in most localities. Still present in Paardevlei and some areas of the eastern Cape.

Research: Good. The general biology of this species in its native range has been thoroughly researched (Wheeler 1969) and distribution records in southern Africa have been well documented.

SPECIES DATA

Distinguishing characteristics: Scales small, 58 to 68 along the lateral line. Perch can be recognised by their split dorsal fin, the anterior dorsal fin having 13 to 17 spines, the posterior mostly soft rays. The ventral fins are in the thoracic position and have a pronounced spine. Live fish are dark olive-green on the dorsal surface, the sides and belly having about 6 vertical bars. The ventral, anal and lower lobe of the caudal fin are orange towards their extremities (Jubb 1967). Body somewhat compressed and moderately elongated, tapering posteriorly, with the back more or less humped between the occiput and the dorsal fin. Upper part of head smooth and scaleless while the whole body is covered with small rough scales. Operculum ends in a sharp point (Hey 1971b).

Native range: Europe and Asia but absent from Scotland, Spain, Italy and Norway (Holcik and Mihalik 1968).

Date and purpose of introduction: Introduced for angling purposes. It was hoped that this species would become a game fish in waters too warm for trout (Jackson 1973a). Imported from England in 1915 to the Jonkershoek Hatchery. Difficulties were encountered in breeding these fish in ponds, but their distribution to "suitable waters" in the Cape began in 1927 (Anon 1944).

The following introductions have been recorded in the literature:

1. Paardevlei (western Cape) in 1928, prior to the release of bass into this lake. The perch survived but did not flourish (possibly because of predation on the young by *Sandelia capensis*). After the introduction of *Micropterus salmoides* and later *Lepomis macrochirus*, the *S. capensis* population was eliminated and it was noted that *P. fluviatilis* was able to breed successfully (Anon 1944).

2. Berg River (western Cape) in 1929. Failed to establish (Harrison 1953b).

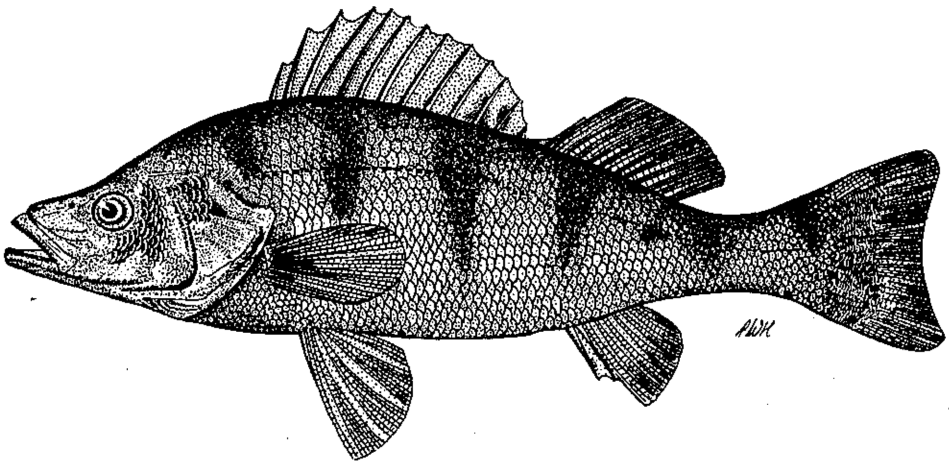
3. Clanwilliam dam (Olifants system, western Cape). Failed to establish (Scott 1982).

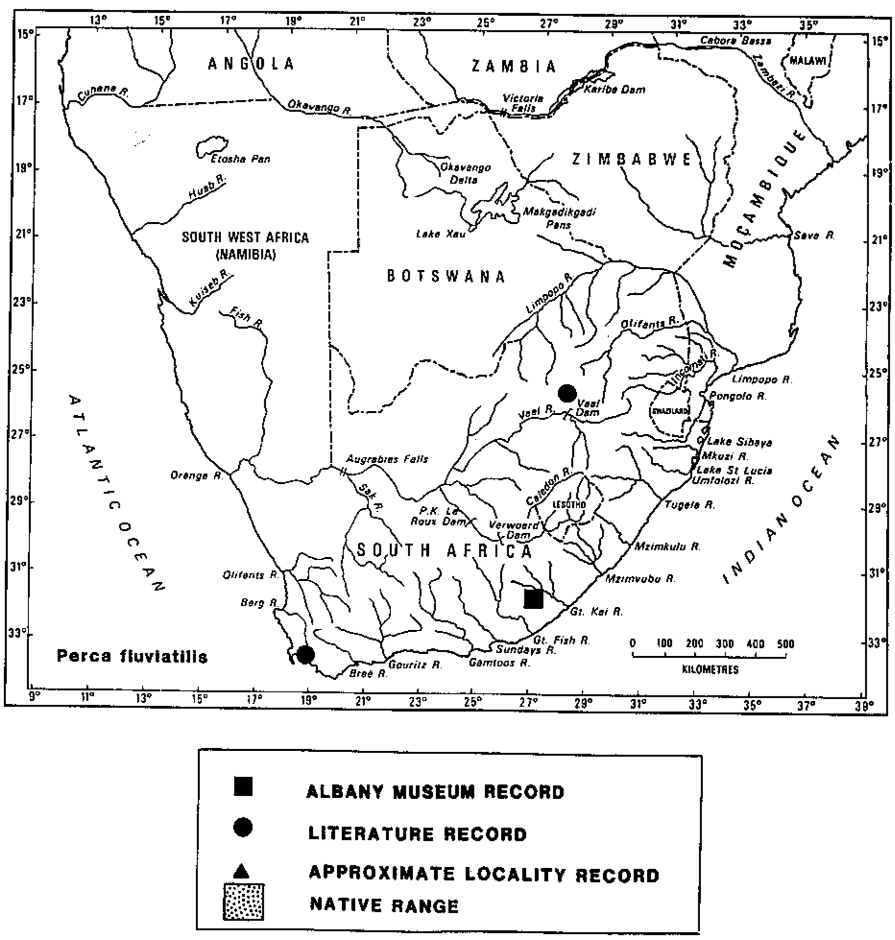
4. A single specimen was recorded in the Little Princess vlei (Heathfield) in 1936. The exact date of introduction into this lake is not known (Harrison 1977a).

South African distribution: Most introductions were unsuccessful but perch were reported by Harrison (1952b)

PERCA FLUVIATILIS Linnaeus 1758

FIGURE 31. The perch *Perca fluviatilis*, with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





to be present in Paardevlei and in dams near Cathcart. They were recently reported to still be present in the following localities: in Paardevlei (Jubb personal communication), in the "Downs Farm dam" near Cathcart (Albany Museum records) and in the Roodepoort dam (Vaal system) in 1982 (Kleynhans personal communication).

Habitat preferences: In Europe perch are normally found in slow-flowing rivers, deep lakes and ponds. They can also survive in brackish water and usually attain a large size in this environment (Hey 1971b). Perch avoid cold, fast-flowing waters but may penetrate into but not breed in such waters (Holcik and Mihalik 1968). Normally found lying close against or amongst obstacles in the water (Wheeler 1969).

Breeding: In Europe perch spawn in April and May. Females lay their eggs in long ribbons on submerged stones and branches and hanging roots. The number of eggs produced per female depends on size but varies between 20 to 200 000 (Holcik and Mihalik 1968). Perch spawn in the shallows in weeds or over other submerged obstacles. Each female is accompanied by several males and swims in narrow arcs through the weeds, shedding spawn in long threads. Eggs hatch in about eight days at 13°C (Wheeler 1969).

Feeding: A predatory species. During the first few months of life juveniles feed on zooplankton, bottom invertebrate fauna and other perch fry. When zooplankton is abundant perch juveniles feed predominantly on copepods and cladocerans, but when these populations decline, the perch will also prey on bottom-living food such as leeches, ephemeroptera, chironomids and freshwater shrimps. Larger fish prey on both invertebrates and other fish, particularly sticklebacks, perch, roach and minnows (Wheeler 1969).

Behaviour: A gregarious species which lives in shoals (Holcik and Mihalik 1968).

Impact: Perch have posed no apparent threat to other fish (Bourquin et al 1984). In the few areas where perch are established they are only marginally successful (Welcomme 1981).

Control: Perch do not appear to pose an immediate threat and no control measures have been proposed.

Research recommendations: The present distribution of perch in southern Africa needs to be properly documented, and their diet in southern African waters needs to be determined.

Remarks: It would be interesting to establish the reasons why perch have not been able to colonise southern African waters as this would shed light on the characteristics of an unsuccessful invader.

REFERENCES

Anon (1944); Harrison (1952b, 1953b, 1977a); Hey (1971b); Holcik and Mihalik (1968); Jackson (1973a); Jubb (1965, 1967); Scott (1982); Welcomme (1981); Wheeler (1969).

Personal communications: R A Jubb; C J Kleynhans.

OREOCHROMIS AUREUS (Steindachner 1864)

Israeli tilapia
Israelse tilapia

alien, detrimental, potential impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An alien species introduced from Israel for aquaculture purposes. Stocks were released into natural waters in Natal and the western Cape and populations are probably still present in these areas. The impact of this species in its new environment has not been assessed but it could become a major pest if its range is extended.

Research: Excellent. Detailed studies have been done on the taxonomic status and general biology by Trewavas (1983) and Philippart and Ruwet (1982). However distribution records in southern Africa are poor and no impact assessment studies have been done in its introduced environment.

SPECIES DATA

Synonyms: *Chromis aureus, Tilapia aurea, Sarotherodon aureus, Chromis niloticus, Tilapia nilotica, Tilapia affinis, Tilapia monodi* (Trewavas 1983).

Distinguishing characteristics: Similar to *O. niloticus* except that the vertical bars on the fins are replaced by a network of clear spots. Edge of caudal fin also strongly rose-coloured (Holden and Reed 1972). Breeding males assume an intense metallic blue colour on the head, sometimes extending as a paler blue on the body. Also have a vermillion edge to the dorsal fin and a more intense pink on the caudal margin. Chin and chest may be blue-black. In the breeding female the edges of the dorsal and caudal fins are a paler, more orange colour. Breeding behaviour (see below) is also an important identification criterion for this genus (Trewavas 1983).

Native range: Senegal River, Middle Niger as far south as Busa, upper tributaries of the Benue River, Lake Chad and the lower Shire and Logone Rivers, lower Nile from near Cairo to the delta lakes, Na'amen River, Yarkon River near Tel Aviv, Lake Huleh and Lake Kinneret, Jordan River system and the oasis of Ain Fashkha on the shore of the Dead Sea (Trewavas 1983).

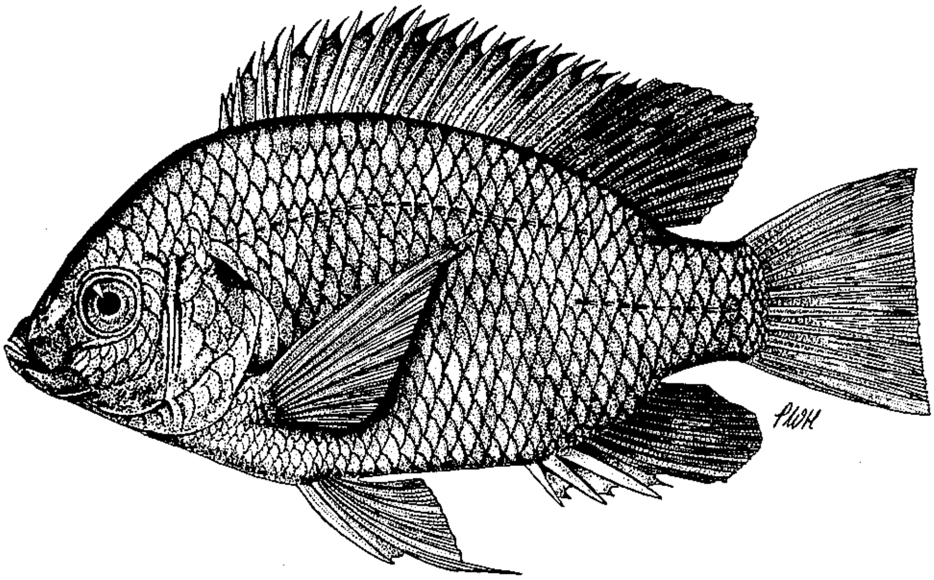
Date and purpose of introduction: First introduced into southern Africa for experimental purposes to the Jonkershoek Hatchery (Stellenbosch) in 1910. Later introduced into Natal and held at the Natal Parks Board Umgeni Hatchery and other research institutions (Bourquin et al 1984). The following introductions have been recorded in southern Africa:

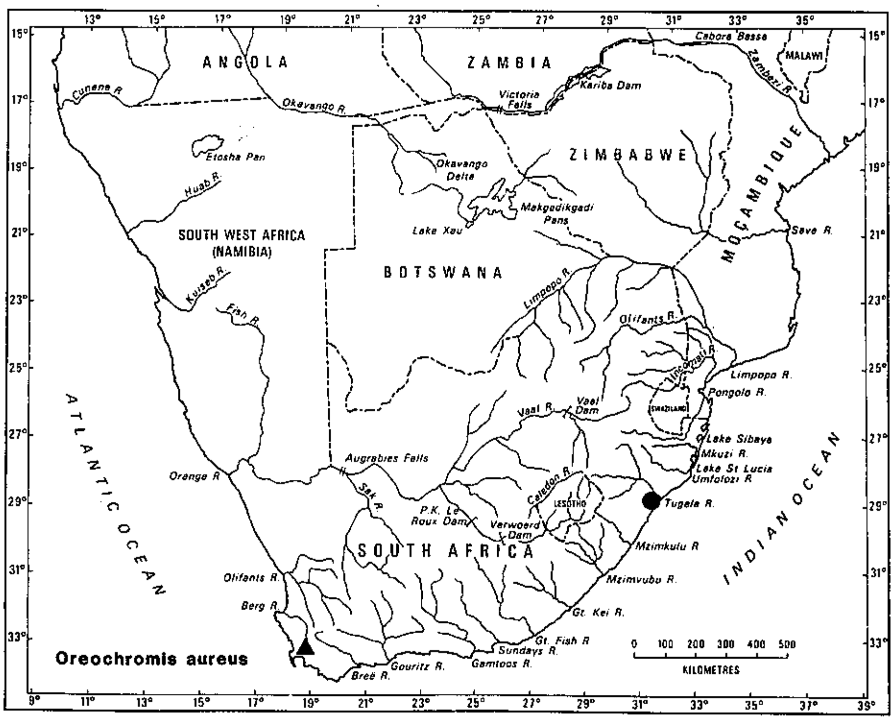
1. In 1965 '*Tilapia aureus*' and '*Tilapia galilaea*' were stocked in experimental ponds at Jonkershoek Hatchery. There is no record of these fish being stocked in farm dams, but there was a later observation in 1967 that a dam on the farm Rozendal near Jonkershoek "already contained large flourishing populations of largemouth bass and *Tilapia aurea* and a smaller population of *Tilapia mossambica*" (van Schoor 1969a). It is not known when *O. aureus* was introduced into this dam.

2. In 1978 *Oreochromis aureus* and *Oreochromis niloticus* were transported from the Fisheries Development Corporation Hatchery at Amatikulu to a small dam in northern Natal. This stock was later destroyed.

OREOCHROMIS AUREUS (Steindachner 1864)

FIGURE 32. The Israeli tilapia *Oreochromis aureus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■ ALBANY MUSEUM RECORD

● LITERATURE RECORD

▲ APPROXIMATE LOCALITY RECORD

NATIVE RANGE

3. In 1982 *O. aureus* and *O. niloticus* were released into the Dudley Pringle dam in the Wewe River catchment by the Tongaat Sugar Company (Bruton and van As 1986; Pike personal communication).

Southern African distribution: This species is probably still present in the Wewe catchment in Natal. *O. aureus* was recorded in a dam on the farm Rozendal (Stellenbosch district) (van Schoor 1969a). It is not certain whether or not it still occurs on this farm, but Smith (personal communication) reports that populations still exist in dams on the farms "Somerlust" and "Vergenoeg- Lynedoch". *O. niloticus x O. aureus* hybrids left at the Amatikulu Research Station by the Fisheries Development Corporation have all been destroyed (Pike personal communication).

Habitat preferences: *O. aureus* tolerates fairly brackish conditions. The normal temperature tolerance range of this species in natural habitats is from about 13 to 32°C, but they can tolerate extreme temperatures as low as 6,5°C (Philippart and Ruwet 1982). Younger fish are more tolerant of low temperatures than older specimens. *O. aureus* requires a minimum temperature of about 20°C for breeding (Trewavas 1983).

Breeding: In Israel breeding commences between March and May depending on the water temperature and perhaps other factors. In the Nile delta breeding continues until November with a peak during early summer. Mature males establish individual territories which they defend by means of aggressive displays. The male then digs a spawning pit. In Alabama it was noted that nests were dug in water about 60 cm deep on a sandy substrate. The male then swims out to passing schools of mixed sexes and leads a female to the nest. Eggs are laid in batches and are taken into the female's mouth soon after fertilisation. The female then moves to a deeper area and the male renews spawning activities with another female. Incubation time is about 13 to 14 days at 25°C. Young fry remain in a small school near the parent's head for a few days, re-entering the female's mouth at any sign of danger. The fry usually leave the parent after 5 days (Trewavas 1983).

Feeding: Phytoplankton and small quantities of zooplankton are the main diet. Young fish have a more varied diet which includes large quantities of copepods and cladocerans (Trewavas 1983).

Impact: There is a possibility that *O. aureus* will hybridise with *O. mossambicus* which is indigenous to the Wewe catchment in Natal. This is however a very small catchment and it is unlikely that *O. aureus* or its hybrids would spread further without further translocations (Bruton and van As 1986; Pike personal communication).

Control: *O. aureus* should be regarded as a potentially deleterious alien fish which should not be translocated into natural waterways. If this species is kept on fish farms it is imperative that adequate precautions are taken to prevent their escape. South Africa and Mozambique probably have the only genetically pure stocks of *O. mossambicus* in the world and every effort should be made to prevent hybridisation between alien tilapias, such as *O. aureus*, and the indigenous species.

Research recommendations: Research needs to be undertaken to test whether *O. aureus* is a superior species to *Oreochromis mossambicus* in aquaculture in order to justify the further importation of the former species.

Remarks: The female *O. niloticus* x male *O.aureus* hybrid has been used to produce all-male progeny for aquaculture purposes (Safriel and Bruton 1984).

Considering the confusion over the taxonomy of this species and the many synonymies given by Trewavas (1983), there is some doubt that it was *O. aureus* that was introduced into Jonkershoek in 1910. The introductions into Natal at a later date probably were this species but need further confirmation. It is important that conservation authorities and aquaculturists should have specimens of unknown identity classified by trained taxonomists in museums. These identified specimens should then be lodged in museums for future reference.

REFERENCES

Bourquin et al (1984); Bruton and van As (1986); Holden and Reed (1972); Philippart and Ruwet (1982); Safriel and Bruton (1984); Trewavas (1983); van Schoor (1969a, 1969b).

Personal communications: T Pike; A Smith.

OREOCHROMIS NILOTICUS (Linnaeus 1758)

Nile tilapia
Nyltilapia

alien, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An alien species which was introduced from Israel in circa 1959 and in 1978 as a forage fish for bass and for aquaculture purposes. Released into farm dams in the Stellenbosch area and in northern Natal. Although there have been no further records, this species is probably still present in these areas.

Research: Excellent. Because *O. niloticus* has been widely used in aquaculture and has been introduced into many areas beyond its native range, there have been many studies on the habitat preferences, taxonomic status and impact on indigenous communities. These studies have been reviewed by Lowe-McConnell (1982) and Trewavas (1983).

SPECIES DATA

Recent synonyms: Trewavas (1983) divides this species into a number of subspecies. Since the original importation into southern Africa was from Israel it is assumed that it was the subspecies which occurs there, *O. niloticus niloticus*, which was introduced into the Cape. The synonyms listed below and the description which follows are therefore for this subspecies: *Tilapia nilotica* (part), *Sarotherodon niloticus* (Trewavas 1983).

Distinguishing characteristics: Body colour a pattern of dark vertical bars and two horizontal dark bands, often represented by two or three mid-lateral blotches, and a blotch on top of the caudal peduncle. Regular dark vertical stripes on the caudal fin are characteristic of the species. Breeding males with a rose-red colour on the head and lower parts of the body. In populations from Israel there is a marked difference between the sexes at breeding time whereas this is not the case for populations from the Nile (Trewavas 1983). Maximum length 630 mm in Lake Rudolph (Kenya) but normally smaller (Holden and Reed 1972). The size of the adults and relative size of sexes varies according to the locality and condition of the fish (Lowe-McConnell 1982).

Native range: Yarkon River (Israel), the Nile from below the Albert Nile to the delta, Jebel Marra between Lake Chad and the Nile, Lake Chad basin and the rivers Niger, Benue, Volta, Gambia and Senegal. May also be native to the Jordan Valley (Trewavas 1983).

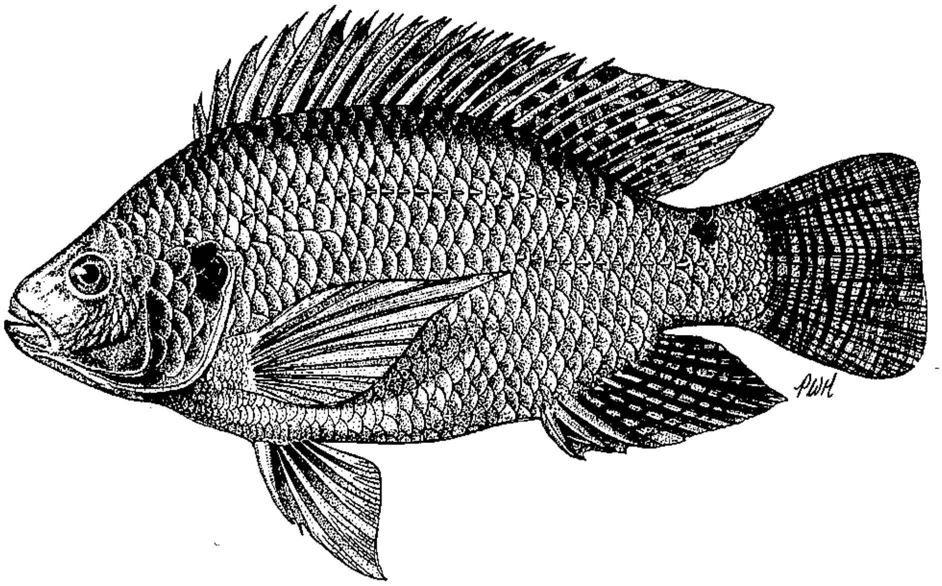
Date and purpose of introduction: Introduced for aquaculture purposes.

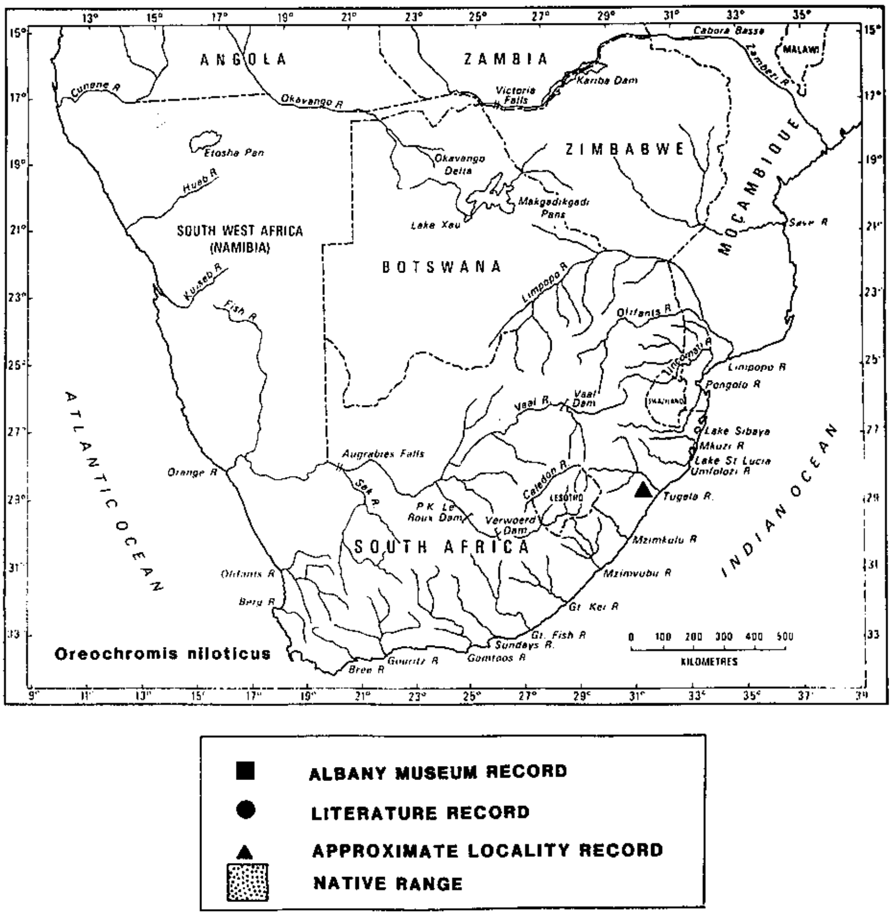
1. Imported to Jonkershoek Hatchery from Israel prior to 1955 and in 1959 as a forage fish for bass and for experimental purposes (van Schoor 1966). It was hoped that a suitable alternative to the two indigenous tilapias would be found i e a species (or a hybrid) with wider temperature tolerances than *O. mossambicus* and a faster growth rate than *T. sparrmanii*. In circa 1959/ 1960 *O. niloticus* were stocked in 15 farm dams in the Eerste and Lourens River valleys (van Schoor 1966). Surveys done in 1964 confirmed that *O. niloticus* was flourishing in 11 of these dams (van Schoor 1966).

2. In 1978 *O. niloticus* was stocked (together with *O. aureus*) from the Amatikulu Hatchery into a small dam in northern Natal by the Fisheries Development Corporation. This stock as well as the stock from the hatchery was later destroyed (Pike personal communication).

OREOCHROMIS NILOTICUS (Linnaeus 1758)

FIGURE 33. The Nile tilapia *Oreochromis niloticus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





3. *O. niloticus* were introduced together with *O. aureus* into the Dudley Pringle dam (Wewe River catchment) in 1982 by the Tongaat Sugar Company (Bruton and van As 1986; Pike personal communication).

Southern African distribution: Probably present in the Wewe River catchment in Natal, but no definite distribution records are available (Pike personal communication). Since this species appeared to be well established in farm dams in the Eerste and Lourens River catchments in 1964 (van Schoor 1966), it is probable that populations still exist in that area.

Habitat preferences: *O. niloticus* is less tolerant of high salinities than other cichlids such as *Sarotherodon galileus, O. aureus* and *Tilapia zillii*. Their upper lethal temperature limit is 39 to 40°C (Trewavas 1983). In the Nile *O. niloticus* is rarely found in deeper parts of the river and usually favours well-vegetated canals (Trewavas 1983). Philippart and Ruwet (1982) report that the range of temperatures in the natural habitat of this species is from 14 to 33°C, but that it can tolerate extreme conditions from 7 to 40°C in some habitats and culture ponds.

In spite of the fact that there was a fairly high mortality, large numbers of *O. niloticus* survived the winter in outdoor ponds in the Jonkershoek valley (van Schoor 1966) and the populations in 11 of the 15 farm dams which were stocked with this species were said to be "flourishing" four years after the initial stocking (van Schoor 1966). The minimum winter temperatures at Jonkershoek are probably close to the lower lethal limit for this species (van Schoor 1966).

Breeding: A maternal mouthbrooder. Nests are built in firm sand at a water depth between 0.6 and 2.0 m. Schools of ripe females gather at the surface above the nesting territories of the males. From time to time a female descends to the substrate with a male in order to spawn. Both the male and the female then throw out sand and "clean" the nest before spawning commences. The eggs are laid in approximately 20 batches during a period of 45 minutes to 2 hours. The eggs are picked up by the female as they are laid, before, during or after fertilization. The females leave the territory of the male with the brood (Trewavas 1983). The number of ripe ovarian eggs in a female ranges from 340 to 3700 depending on size (Trewavas 1983).

Oreochromis niloticus is fairly generalised in its substrate requirements for spawning grounds. In Lake Victoria (into which it was introduced) they spawn in muddy areas at the edges of lagoons and on harder substrates in deeper sheltered gulfs. Well-aerated water is required for spawning (2 to 4 ppm dissolved oxygen) (Lowe-McConnell 1982). In equatorial waters Nile tilapia may breed at any time of the year but peak spawning usually coincides with the rainy seasons. At higher latitudes *O. niloticus* also spawns during the rainy season (Lowe-McConnell 1982).

Feeding: *O. niloticus* is capable of utilizing a wide range of food materials, but from 5 cm TL this species is almost entirely herbivorous. The young fry are omnivorous, feeding on copepods, aquatic and terrestrial insect larvae, aufwuchs and detritus. As they grow phytoplankton becomes a progressively more important component of the diet. Chironomids are occasionally consumed as well as macrophytes and epiphytic algae (Trewavas 1983).

Behaviour: Noted to feed mostly during the day in Lake George (Trewavas 1983). *O. niloticus* is apparently a difficult fish to catch using rod and line and other fishing methods (van Schoor 1966).

Impact: Produces fertile hybrids when crossed with *Oreochromis mossambicus* (van Schoor 1966). *O. niloticus* is therefore likely to genetically contaminate indigenous *O. mossambicus* populations in the Wewe River catchment and elsewhere on escape (Pike personal communication). In the hatchery ponds at Jonkershoek a dense population of this species was able to clear an excessive growth of *Limnanthemum* plants. In ponds with lower population densities there was no significant reduction of aquatic weeds (van Schoor 1966). After its introduction into Lake Victoria, *O. niloticus* competed with indigenous species for spawning grounds and may do so in southern Africa as well.

Control: The further importation and translocation of *O. niloticus* in southern Africa needs to be strictly controlled. If permission is granted for this species or its hybrids to be used in fishfarming, strict measures will have to be taken to prevent their escape. Trading in this species by aquarists should not be allowed.

Research recommendations: Collecting should be conducted in the Wewe River catchment to determine whether this species is still present in the area.

Remarks: There was some doubt about the identification of the species imported to Jonkershoek. Van Schoor (1966) remarks that a separate species, referred to as "*Tilapia* blue," had been discovered in Israel. The fish imported to Jonkershoek may have been of this species and not "*T. nilotica*", but this was not altogether certain. This uncertainty points to the need to have imported species identified by trained taxonomists.

Oreochromis niloticus and *O. leucostictus* were accidently introduced together with *T. zillii* into Lake Victoria in 1954. From 1964 onwards these alien cichlids became abundant in the lake. *O. niloticus* became dominant in the areas where *Oreochromis esculentus* (an indigenous species) had previously occurred. Even though the habitat requirements of *O. niloticus* for spawning are fairly generalised, there was competition between this species and the indigenous *O. esculentus*. There appeared to be little competition for food between adults of the alien species and the indigenous species that they replaced. The strongest competition was apparently for breeding grounds (Lowe-McConnell 1982).

Hybridisation between female *O. niloticus* and male *O. aureus* has been used to produce all-male progeny for aquaculture purposes (Safriel and Bruton 1984). When this hybridisation was attempted in Natal not all the progeny were males and some were fertile, so the experiment was abandoned and most of the stock were destroyed (Alletson personal communication).

REFERENCES

Bruton and van As (1986); Holden and Reed (1972); Lowe-McConnell (1982); Philippart and Ruwet (1982); Safriel and Bruton (1984); Trewavas (1983); van Schoor (1966).

Personal communications: J Alletson; T Pike.

TRACHEMYS SCRIPTA ELEGANS (Schoepff 1792)

American red-eared terrapin | **alien, detrimental, potential impact**
Amerikaanse waterskilpad

Phylum: Chordata - chordates
Class: Reptilia - reptiles
Family: Testudinidae

SUMMARY

Status: An alien species imported on a regular basis from North America through the aquarium trade. Their impact on indigenous communities has not been assessed, but since *T. scripta elegans* is the carrier of human salmonellosis, it does present a potential health hazard.

Research: Fair. Their general biology and distribution in southern Africa has been summarised by Newbery (1984). Their impact in southern Africa has not been assessed.

SPECIES DATA

Recent synonyms: *Pseudemys scripta* (Newbery 1984), *Chrysemys scripta* (Boycott and Bourquin 1988).

Distinguishing characteristics: A freshwater terrapin. Hind feet clawed and extensively webbed (Ditmars 1936). The young animals are brightly coloured. The basic colouration is green with a wide red stripe behind the eye, with narrow chin stripes and a transverse yellow stripe on each costal scute on its upper shell. Ventral shell pattern with a dark eye-spot on each scute. Older animals are a uniform dull grey-brown colour. Adult males are slightly smaller than females and reach a length of 28 cm (Newbery 1984, Branch personal communication). Melanism progresses with age and males are usually darker than females (Conant 1958).

Native range: South-eastern USA from New Mexico northwards to Iowa (Conant 1958).

Date and purpose of introduction: Red-eared terrapins are imported as pets through the aquarium trade and are normally sold as attractive brightly coloured hatchlings of 3 to 4 cm TL. The larger, less attractive adults are often released into the wild once they have outgrown their aquarium. There have, as a result, been numerous introductions into various parts of the country (Newbery 1984).

Southern African distribution: Dams and rivers around Pretoria (the Moroeletta spruit), Johannesburg (Zoo Lake) and the Bluff Nature Reserve in Durban (Newbery 1984).

Habitat preferences: The red-eared terrapin tolerates a wide range of environmental conditions. It is found in most freshwater habitats but has a preference for standing waters, pans and vleis with muddy substrates and an abundance of aquatic vegetation as well as areas suitable for basking (Newbery 1984).

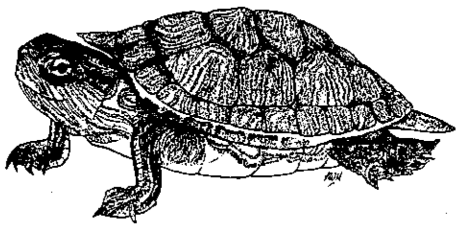
Breeding: Males reach sexual maturity at about 10 cm TL, and females at 17cm TL. The eggs are laid in damp, friable soil, usually near rivers, but the adults are capable of moving a considerable distance from water to dig nests . The average clutch size is 8 to 10 eggs but can be as high as 23. The eggs hatch 2,5 to 3 months after laying. In South Africa *T. scripta elegans* breeds from August to February (Newbery 1984).

Feeding: The juveniles feed on tadpoles, insects, snails and spiders. The adults are omnivorous feeders on small fish, amphibians, water plants and molluscs. They are capable of surviving for months without food (Newbery 1984).

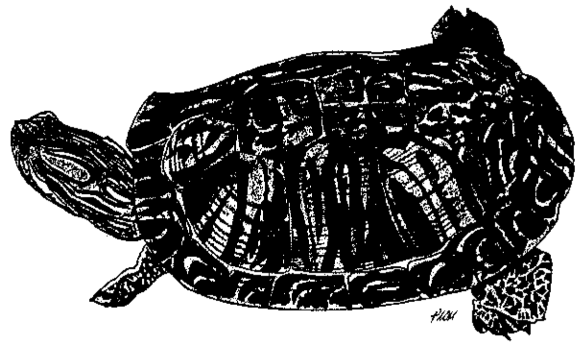
TRACHEMYS SCRIPTA ELEGANS (Schoepff 1792)

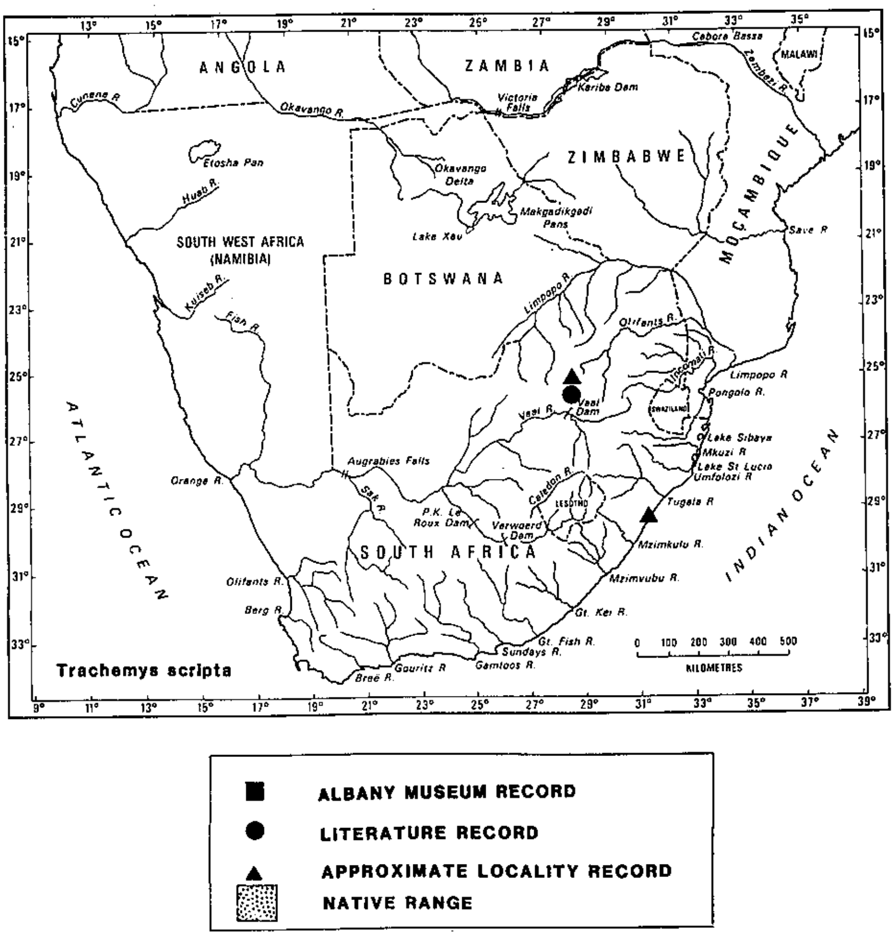
FIGURE 34. Adult and juvenile red-eared terrapins *Trachemys scripta elegans* with their distribution in southern Africa (excluding Zimbabwe and Mozambique)

(A)



(B)





Behaviour: Active feeding usually takes place in the early morning and late afternoon. A large part of the day is spent basking in the sun and they may also bask while floating on the water. These terrapins are inactive at water temperatures below 10 C and may hibernate in hollow logs, disused burrows and sometimes under water (Newbery 1984).

Impact: Their habitat preferences are very similar to those of the indigenous Cape terrapin, *Pelomedusa subrufa*, and *T. scripta elegans* could compete with this species (Newbery 1984). It is also a danger to a relict population of the Mashona terrapin (*Pelusios rhodesianus*) in the Bluff Nature Reserve, Durban (Branch personal communication).

This species, like many other terrapins, may be a carrier of a number of *Salmonella*, and a potential vector of salmonellosis (a form of food-poisoning). Salmonellosis could be transferred as a result of humans drinking water in which the terrapins had been transported (Newbery 1984).

Control: The red-eared terrapin is internationally regarded as a pest animal (Welcomme 1984, Bruton and van As 1986). It is important that this species should be eliminated from the wild in southern Africa. Red-eared terrapins and other terrapins have been implicated in over 300 000 cases of human salmonellosis in the USA (Wells et al 1973) but no incidences have as yet been reported in southern Africa. Because of its known invasive abilities and potential threat to human health, it is recommended that further trade in this species should be prohibited and that the public should be informed that it is illegal to keep these terrapins in captivity.

Research recommendations: If invasive populations of this terrapin persist, it will be necessary to study their breeding and feeding biology and demography in order to formulate a management strategy.

Remarks: In most provinces of South Africa permits are required to import or to keep this species. The release of alien animals such as the red-eared terrapin into the wild is prohibited in all provinces (Comrie-Greig 1984).

REFERENCES

Boycott and Bourquin (1988); Bruton and van As (1986); Comrie-Greig (1984); Conant (1958); Ditmars (1936); Newbery(1984); Welcomme (1984); Wells et al (1973)

Personal communication: W R Branch

PROTOPTERUS ANNECTENS BRIENI Poll 1961

lungfish
longvis

indigenous, equivocal, little impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Protopteridae

SUMMARY

Status: Indigenous species classified as vulnerable in Skelton's Red Data Book (1987a). In South Africa the lungfish is only found in the Kruger National Park. In order to enhance its conservation status this species has been translocated to some pans where it did not previously occur.

Research: Fair. Has not been studied in South Africa but some aspects of its biology and ecology have been summarised by Jubb (1967) and Greenwood (1986).

SPECIES DATA

Distinguishing characteristics: Distinctively tapered, elongated body with soft, partially embedded scales and filamentous pectoral and pelvic fins. The head is rounded with small eyes and short restricted gill openings. The maximum size reached is 90 to 100 cm but such specimens are rare. The young are characterised by feathery external gills. Colour usually a pale to dark greyish-olive-brown with irregular dark brown spots (Skelton 1987a).

Native range: In swampy, low-lying areas along the middle and lower Zambezi, Pungwe, Buzi, Save and Limpopo Rivers. In South Africa this lungfish has been found in one locality in the Pumbe sandveld on the eastern border of the Kruger National Park (Skelton 1987a).

Date and purpose of introduction: The single site where this species was collected in the Kruger National Park was considered to be vulnerable because of possible destruction by traffic. Lungfish were therefore translocated for the purpose of improving their chances of survival in South Africa as they are classified as "vulnerable" by Skelton (1987a). They were transferred to the Machai Pan (south of Pafuri), and to a pan north of the Sabie River (both localities within the Kruger National Park) (Skelton 1987a).

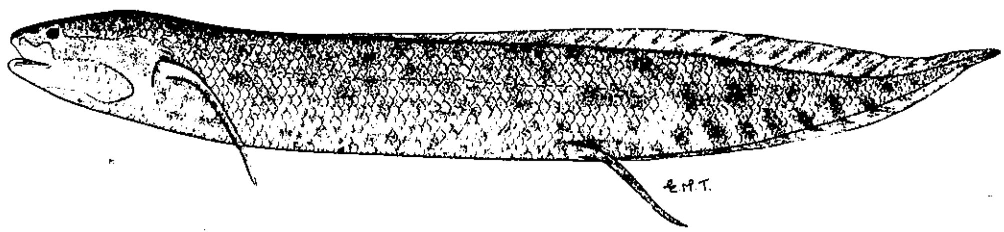
Present distribution: As for native range and in the pans in the Kruger National Park mentioned above.

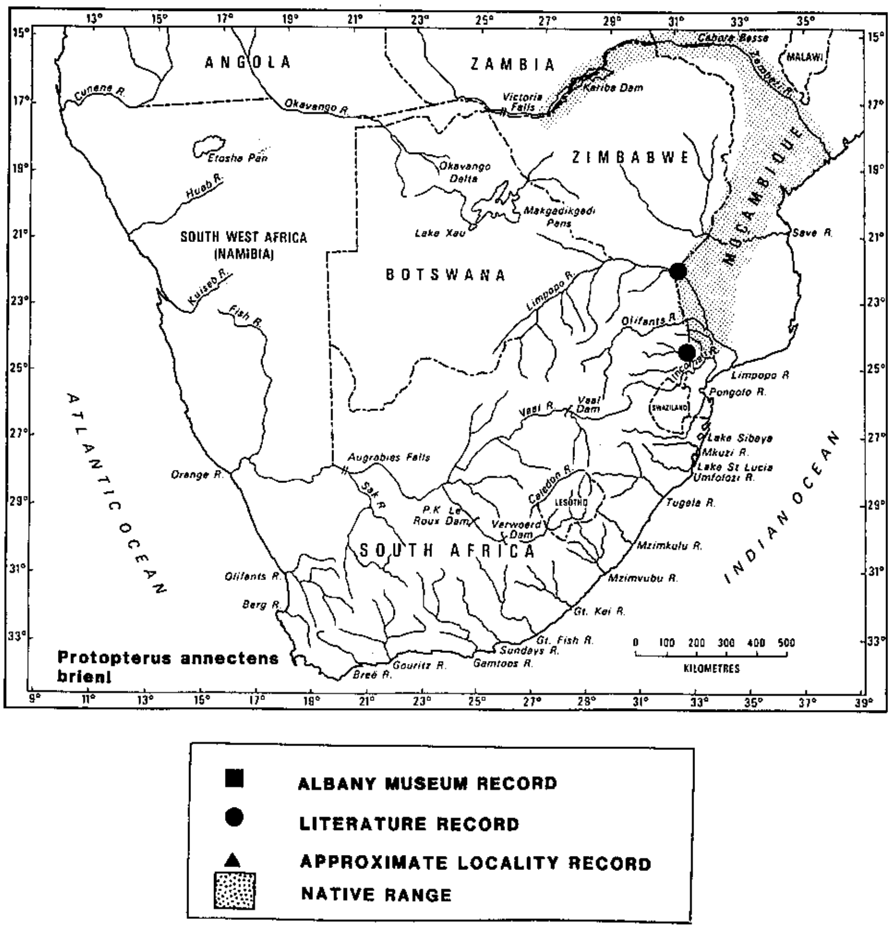
Habitat preferences: Swamps, floodplains and seasonal pans characterised by having abundant aquatic vegetation and muddy substrata. Survives during the dry season when temporary pans dry up by aestivating in a cocoon formed in the bottom muds of the pan (Jubb 1967; Skelton 1987a). During the wet season the lungfish is usually found in the flood plains of rivers (Jubb 1967). When the water level drops some specimens return to the river but others start burrowing into the mud (Jubb 1967).

Breeding: Breeding nests or burrows, which are larger and more complicated than those used for aestivation, are constructed (Greenwood 1986). Although Jubb (1967) reports that the male is responsible for building the nest, Greenwood (1986) comments that there is no information on how the nest is made or on the sex of the individual responsible for construction. The nest is built in shallow water amongst weeds and grass, is enlarged at the bottom, and extends to about 30 cm below the mud surface (Jubb 1967). There are reports that males may spawn with two or three females in each season. After spawning the males aerate the nest by means of

PROTOPTERUS ANNECTENS BRIENI Poll 1961

FIGURE 35. The lungfish *Protopterus annectens brieni* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





body movements and stirring the surface with the tail. Males protect the young fry (Jubb 1967). There are no reliable figures on the number of embryos and young present in the nest. Embryos hatch after about 8 days and probably leave the nest after about a month when the young are 30 to 35 mm TL (Greenwood 1986). Very little is known about the biology of the young fry after leaving the nest, but it is probable that some time is spent living within matted papyrus roots or amongst the root systems of semi-aquatic grass (Greenwood 1986).

Feeding: Described by Greenwood (1986) as an omnivorous carnivore. A wide variety of prey is taken including molluscs, crustaceans and larval insects but the diet is prodominantly comprised of molluscs. Vertebrates, especially fish, are consumed to a lesser extent. *Protopterus* species employ a slow stalking approach to their prey, or else lie in wait for the prey which is then "sucked in" by means of a powerful suction generated through the depression of the hyoid apparatus by the recti cervicus muscles. Food is normally taken from the substrate but may occasionally be taken from the surface (Greenwood 1986).

Behaviour: The burrows are constructed by means of biting and chewing the mud and expelling the mixture of mud and water through the gill opening. A vertical burrow is made which is widened at the base to enable the fish to turn. When the water level drops a porous lid is usually constructed at the entrance. With further drying copious mucous is secreted. This mixes with the mud and hardens to form a cocoon, the top of which is moulded like a cap with an air-vent enabling the fish to breathe air. *P. annectens* aestivates throughout the dry season and during this period metabolism drops to a low level and the fish remains stiff and emaciated. When the area again becomes flooded the lungfish breaks away from the cocoon and rises to the surface of the water to breathe air. Until it becomes fully active it continues to return to the burrow after each ascent to the surface.

During wet seasons when swamps become inundated, lungfish frequently rise to the surface for air and and may "drown" if prevented from doing so (Jubb 1967).

Protopterus annectens is probably more active during the day than at night (Greenwood 1986).

Impact: Translocation is not expected to have any significant negative impact on the environment as the Machai Pan is within the broad native range of this species.

Research recommendations: Greenwood (1986) remarked that some aspects of the breeding biology and behaviour of this and other congeneric species need to be investigated.

Remarks: The translocation of the lungfish is justified as their conservation cannot be guaranteed in their native range. Attempts should be made to conserve the pans in the native range of this species in the Kruger National Park.

REFERENCES

Greenwood (1986); Jubb (1967); Skelton (1987a).

KNERIA AURICULATA (Pellegrin 1905)

southern kneria
suidelike skulpoortjie

indigenous, equivocal, little impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Kneriidae

SUMMARY

Status: An indigenous species which is classified as rare in Skelton's Red Data Book (1987a). In South Africa *K. auriculata* is restricted to a few small upper tributaries of the Crocodile River (Incomati system) but has been translocated to small streams close to the native range in order to improve its conservation status. Unlikely to have a detrimental impact in its introduced environment.

Research: Good. Kleynhans (1984) has done a detailed study on the general biology and conservation status of this species.

SPECIES DATA

Distinguishing characteristics: Slender small minnow-like fish. Minute scales and a cup-shaped process on the operculum of the male are characteristic features (Skelton 1977). Dorsal surface mottled with dark blotches above a thin lateral stripe. Also a few small dark blotches on the lateral line towards the caudal peduncle. In some specimens there is a dark spot at the base of the ventral and anal fins. Origin of dorsal fin equidistant from the front of the eye and the base of the median rays of the caudal fin. Ventral fins originate slightly anterior to the origin of the dorsal. Maximum length approximately 7,5 cm (Jubb 1967). This small sucker-like mouth enables this fish to climb damp rocks (Jubb 1972a).

Native range: In South Africa this species is only found in a few tributaries of the Crocodile River (Incomati system). Further north it is found in the Save-Runde (upper Save) system, the Zambezi River system in Zimbabwe and Zambia and in the upper Zaire system in Katanga (Zaire) and Zambia (Skelton 1987a). In the Crocodile River it occurs at altitudes between 1100 and 1400 m (Kleynhans 1984).

Date and purpose of introduction: Translocated for the purpose of improving the conservation status of this rare species. In 1981 between 200 and 300 fish were translocated from Alexanderloop to a small stream on the farm Weltevreden 336 (Crocodile River) (a tributary of the Elands River near Waterval-Onder) (Kleynhans personal communication). Both rivers are in the Incomati system but *K. auriculata* was not previously found in the Elands River.

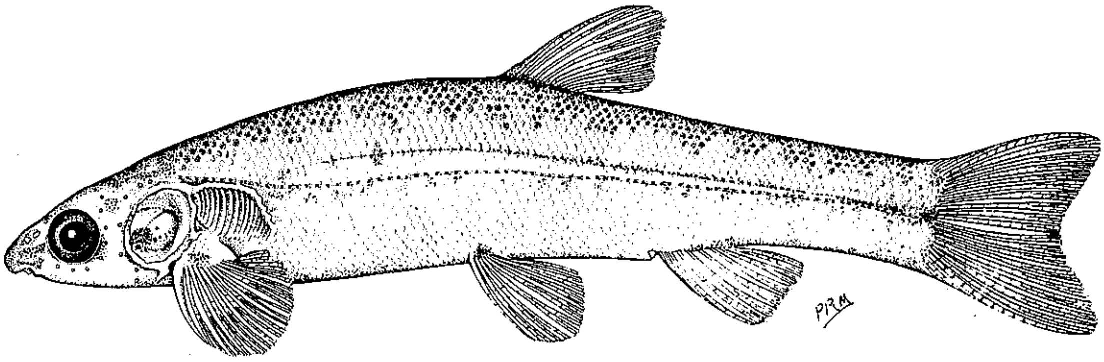
Present distribution: As for native range and also in tributaries of the Elands River. Kleynhans (1984) noted that this species had disappeared from some small streams where it had previously been recorded by de Moor (1971).

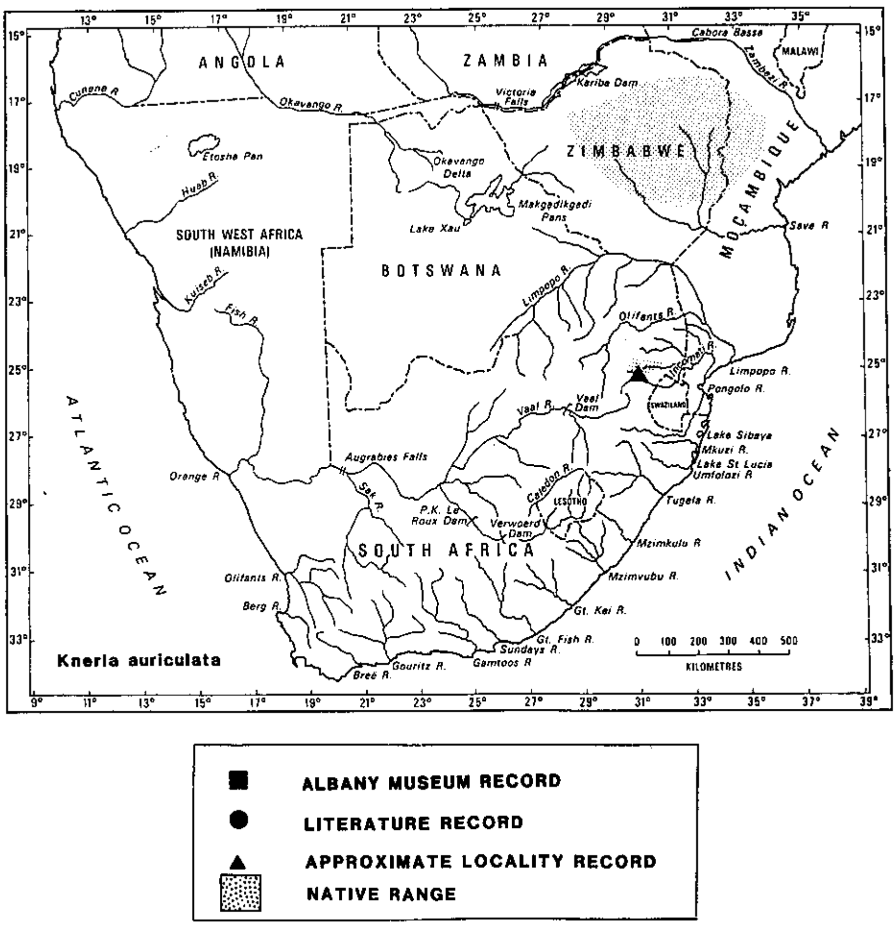
Habitat preferences: Clear, fast-flowing small rocky streams with temperatures ranging from 9 to 26°C (Skelton 1987a). This species is unlikely to survive in deeper (lentic) habitats (Kleynhans 1984) and can tolerate living out of water for fairly long periods (Jubb 1967).

Kneria auriculata occurs naturally in streams where no indigenous fish predators (besides *Anguilla mossambica*) occur although it is preyed on by *Xenopus laevis* and some piscivorous birds (Kleynhans 1984). The habitat requirements are very specific. Kleynhans (1984) conducted a detailed study of two small streams, one in which *K. auriculata* occurred and one which had not been colonised by this species. (There were no obstructions impeding colonisation). He found no significant differences in water quality and concluded that *K. auriculata*

KNERIA AURICULATA (Pellegrin 1905)

FIGURE 36. The southern kneria *Kneria auriculata* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





had failed to colonise the second stream because it had slightly deeper pools and a greater proportion of pools / interconnecting streams than the first stream which appeared to be the ideal habitat for this species. From this study it is obvious that very slight modifications to the environment would render a habitat unsuitable for *K. auriculata*.

Breeding: *K. auriculata* breeds during summer from October to April. The fecundity varies from 700 to 1 500 ova (Skelton 1987a). Kleynhans (1984) commented that this species has a low fecundity.

Feeding: The principal component of the diet is aufwuchs (a mat of algae growing on the surface of rocks and other substrates). The aufwuchs usually grows on rocks in fast-flowing streams or on rocky shores where there is strong wave action (Kleynhans 1984).

Behaviour: *K. auriculata* can ascend damp rock surfaces using the sucker-like mouth as a means of attachment. Also found in stagnant pools, coming to the surface to gulp air (Jubb 1967).

Impact: *K. auriculata* is likely to have a minimal impact in its introduced environment.

Control: No control is necessary due to the minimal impact which this species is likely to have.

Research recommendations: The demography of *K. auriculata* populations needs to be studied in more detail.

Remarks: *K. auriculata* is recorded as a rare species in Skelton's Red Data Book (1987a). Because of the lack of fish predators in its native range and its low fecundity, *K. auriculata* is probably vulnerable to predation by aliens, particularly *Parasalmo mykiss* (Kleynhans 1984). It was expected that the presence of wattle trees on the banks of streams in the area where this species occurs would result in increased bank erosion and siltation of the river. Kleynhans (1984) found that erosion had occurred but that there has not been a significant buildup of silt in pools as periodic floods washed the silt away and it appears that the habitat remains suitable for *K. auriculata*. Nevertheless the further spread of wattles along river banks will probably result in a reduction in the number of suitable habitats available for *K. auriculata*.

REFERENCES

Bruton et al (1982); de Moor (1971); Kleynhans (1984); Jubb (1967, 1972a); Skelton (1977, 1987a).

Personal communication: C J Kleynhans.

BARBUS AENEUS (Burchell 1822)

smallmouth yellowfish
kleinbek-geelvis

translocated, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An indigenous species endemic to the Orange-Vaal catchment which has been translocated into the following catchments beyond its native range: Great Fish, Great Kei, Gouritz, Kariega and Limpopo. The impact of these translocations has not been assessed.

Research: Good. The general biology has been studied by many workers (Mulder 1973a; Gaigher 1978; Hamman 1980). Cambray and Jubb (1977a, 1977b) and Laurenson and Hocutt (1986) have commented on their impact.

SPECIES DATA

Recent synonyms: *Cyprinus aeneus, Barbus holubi, B. gilchristi, B. mentalis, B. capensis* (Daget et al 1984).

Distinguishing characteristics: A relatively large yellowfish (maximum size 7,8 kg) with a strong bony spine on the dorsal fin and long leading rays in the anal fin. Two pairs of barbels. The lips vary from a thin "chiselmouth" form to a thick "rubber lip" variety, depending on how and where the fish feeds. Scales with parallel striations. Fry and juveniles silvery with dark blotches, adults plain silvery but later develop a silvery-golden-olive colour (Bruton et al 1982). Differs from *Barbus kimberleyensis* in that the distance from the eye to the opercular/ preopercular groove is less than the length of the snout. The head profile is also more "convex" than that of *B.kimberleyensis* which has a distinctly flattened profile (Jubb 1965).

Native range: Endemic to the Orange-Vaal system (Jubb 1963).

Date and purpose of introduction: Introduced into the following areas:

1. Calitzdorp dam (Gamka River tributary, Gouritz River system) in 1953 (Jubb 1963).

2. Settlers dam (Kariega River) in 1964 (Skelton 1972).

3. Olifants River (Transvaal) and possibly other tributaries in the Limpopo system after 1953 (Jubb 1971a).

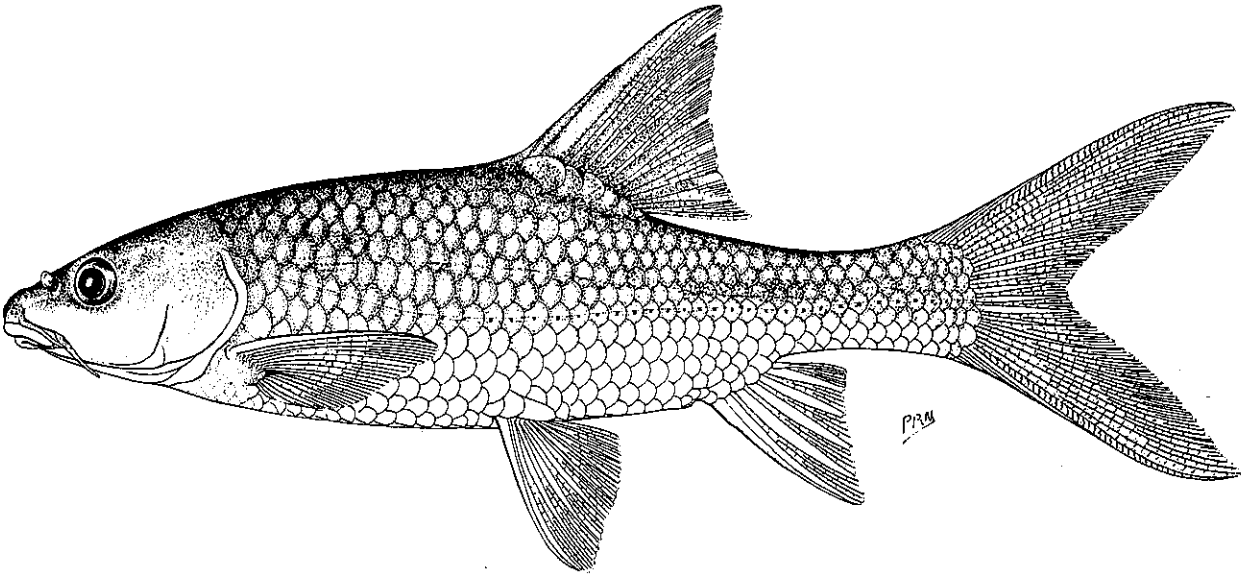
4. Tsomo River (tributary of the Great Kei River) in 1963 (Jubb 1966/67). Also found in the Kubusie and Klipplaats Rivers (tributaries of the Swart Kei River, Great Kei system) (Bok personal communication).

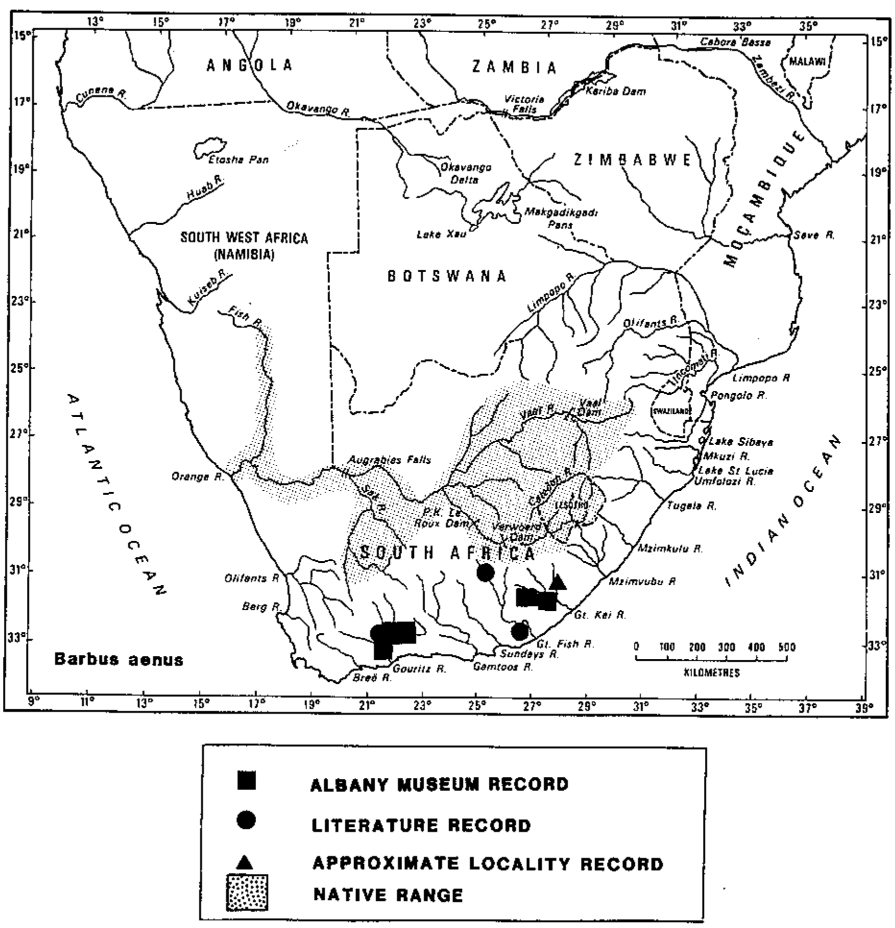
5. Accidentally introduced into the Great Fish River system via the Orange-Fish tunnel which was opened in 1975. First recorded in the Grassridge dam (on the Great Brak River, Fish River system) in 1976 (Cambray and Jubb 1977a, 1977b). This species is expected to spread to the Sundays system via the Cookhouse tunnel (which connects the Great Fish River to the Vogel River) (Cambray and Jubb 1977a).

6. Its presence in the Sterkfontein dam (on the Wilge River, Vaal system) (OFS Nature Conservation 1983) means that there is a possibility that this species may be translocated into the Tugela system. This, however,

BARBUS AENEUS (Burchell 1822)

FIGURE 37. The smallmouth yellowfish *Barbus aeneus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





depends on whether the Sterkfontein dam is ever filled to its maximum capacity.

The above introductions were presumably all made for sportfishing, except that into the Great Fish River which was accidental.

Present distribution: As for the native range and also in the following areas: the Calitzdorp dam (Jubb 1963; Louw 1969), Grassridge dam (Great Fish River system) (Cambray and Jubb 1977a, 1977b), Gouritz River (Skelton 1987a), Tsomo and Thomas Rivers (Great Kei system) (Jubb 1966/1967) and recently in the Kubusie and Klipplaats tributaries of the Swart Kei River (Bok personal communication).

B. aeneus is reported to be "flourishing" in the northern Transvaal but detailed localities are not recorded (Jubb 1963). Skelton (1972) reported that the population in Settlers dam (Kariega River system) had survived but doubted if they would be able to breed successfully due to a lack of suitable breeding sites and the presence of other predatory species in this locality.

Habitat preferences: *B. aeneus* is able to survive in impoundments and rivers (Jubb 1961/1962) but requires very specific conditions for successful spawning (Jubb 1966/1967).

Population levels increased after the building of the Verwoerd dam (Hamman 1980). Mulder (1973a) found that, because of its omnivorous feeding habits, this species was not as severely affected as the congeneric species, *B. kimberleyensis*, by turbid conditions in the Vaal River resulting from increased soil erosion. The latter species was found to be more exclusively piscivorous and as a result turbid conditions adversely affected its ability to see its prey.

The presence of *B. aeneus* in the Sak River (Orange system) suggests that it can tolerate extreme conditions. This river seldom flows and during droughts it dries up into a series of pools which are subject to extreme conditions of temperature and salinity, and are often eutrophic and anaerobic (Hocutt and Skelton 1983). During droughts fish manage to survive in pools which act as refuges for future colonisation of the river when conditions improve (Hocutt and Skelton 1983). Generally fish in this genus can tolerate low temperatures and Crass (1969a) describes the large *Barbus* species as being the most usual dominant indigenous fish in upland rivers. In this environment they are often associated with large *Labeo* species.

Breeding: *B. aeneus* migrates upstream to spawn in well-oxygenated sections of the river where water flows over clean gravel beds. After the eggs are laid the adults gradually disperse downstream. There is no parental care of the young. Breeds from October to January. Shoals of fry remain in calm shallow sections of the river. This species may not always be able to spawn in impoundments. In large impoundments wave action along gravel shores may simulate natural spawning conditions (Gaigher 1978). The minimum temperature required to initiate breeding is approximately 18,5°C. Courtship was observed during daylight, but spawning probably occurs before sunrise. The eggs develop in approximately 5 days at a temperature of 20 to 22°C. The young fry commence swimming approximately 6 days after hatching (Groenewald 1961). *B. aeneus* has a slow growth rate and a long life span. Le Roux (1963) reports that some specimens have been caught which are about 12 years old.

Feeding: Bottom feeder, omnivorous (Jubb 1966/1967). Diet includes water fleas (*Daphnia* spp.), plankton, small mussels, snails, insects and small fish (Bruton et al 1982).

Behaviour: *B. aeneus* is considered to be a good "fighting" fish for anglers (Bruton et al 1982).

Impact: This species may have a negative impact on small localised populations of *Sandelia bainsii* and *Barbus pallidus* (Laurenson and Hocutt 1986). Although habitat destruction is considered to be the major factor which threatens the status of *B. tenuis* in the Gouritz River, the presence of *B. aeneus* is also considered by Skelton (1987a) to be a threat to the former species.

B. aeneus is sometimes considered to be a favourable alternative to bass or trout in the stocking of rivers and dams as it is not an aggressive predator of other fish and would therefore not be expected to have such a deleterious effect on indigenous fish populations (Skelton 1972). However Gaigher (1978) has warned of the danger of this species interbreeding with *B. natalensis* should it be introduced into Natal. This possibility now exists with the building of the Vaal-Tugela water exchange scheme.

Four different species of parasite have been found on *B.aeneus* in various localities in southern Africa and of these, two (*Ichthyophthirius multifilis* and *Argulus japonicus*), are aliens (van As and Basson 1984). It is possible that the translocation of *B. aeneus* into new localities may facilitate the spread of parasites into these areas.

Control: Further stocking of *B. aeneus* beyond its native range should be stopped until the impact of this species on natural communities is known. A public education programme on the potential harm which this species may cause should be launched.

Research recommendations: More recent studies of age, growth, instantaneous rate of increase and fecundity should be carried out in order to assess the invasive qualities of this species.

The Tugela system should be monitored regularly to ascertain whether *B. aeneus* has been translocated into this catchment.

Fairly extensive sampling had been carried out in the Grassridge dam prior to the opening of the Orange-Fish tunnel (Cambray and Jubb 1977b). It would therefore be of interest to conduct a detailed study to assess the environmental impact of the translocation of *B. aeneus* and other species in the Fish River system.

Remarks: This species is regarded as a highly desirable angling fish. In the late 1950's it was noted that the numbers of *B. aeneus* were declining, probably due to an increase in siltation and pollution in the Vaal River (Groenewald 1961).

It is possible to breed *B. aeneus* artificially by providing a gravel bed with a strong through-flow current (Jubb 1966/1967). Skelton (1972) recommends that it will be necessary to undertake annual stockings in Settlers dam in order to build up populations for angling purposes. This recommendation probably applies to other small impoundments as well.

Should this species be introduced into other catchments, there is a danger of interbreeding with congeneric species such as *B. kimberleyensis* in the upper Fish River (South West Africa/ Namibia), B. polylepis in the east-flowing rivers of the Transvaal, *B. natalensis* in Natal and *B. capensis* of the Olifants River (western Cape) (Gaigher 1978).

REFERENCES

Bruton et al (1982); Cambray and Jubb (1977a, 1977b); Crass (1969a); Daget et al (1984); Gaigher (1978); Groenewald (1961); Hamman (1980); Hocutt and Skelton (1983); Jubb (1961/62, 1963, 1965, 1966/67, 1971a); Laurenson and Hocutt (1986); le Roux (1963); Louw (1969); Mulder (1973a); OFS Nature Conservation Annual Report (1983); Skelton (1972, 1987a), van As and Basson (1984).

Personal communication: A H Bok.

BARBUS ANOPLUS Weber 1897

chubbyhead barb
dikkop ghieliemientjie

indigenous, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An indigenous species with a widespread natural distribution in southern Africa. This species has been translocated into the Kuiseb system in South West Africa and into the Umzimkulu and Mooi Rivers in Natal.

Research: Good. The general biology and distribution has been studied by a number of workers particularly Jubb (1965), Dixon and Blom (1974), Cambray et al (1977) and Cambray (1983).

SPECIES DATA

Recent synonyms: *Barbus karkensis, B. cernuus, B. anoplus cernuus, B. anoplus oraniensis* and *B. anoplus anoplus* (Daget et al 1984).

Harrison (1952b) describes three forms of this species:
1. forma *typica*, Barnard (Gouritz River chubby-head).
2. forma *oriensis* Barnard (Orange River chubby-head).
3. forma *cernuus* Barnard (Clanwilliam chubby-head).

Jubb (1965) also describes the form, *karkensis*, from the Great Fish River, eastern Cape, and in the rivers towards the north-east into Natal.

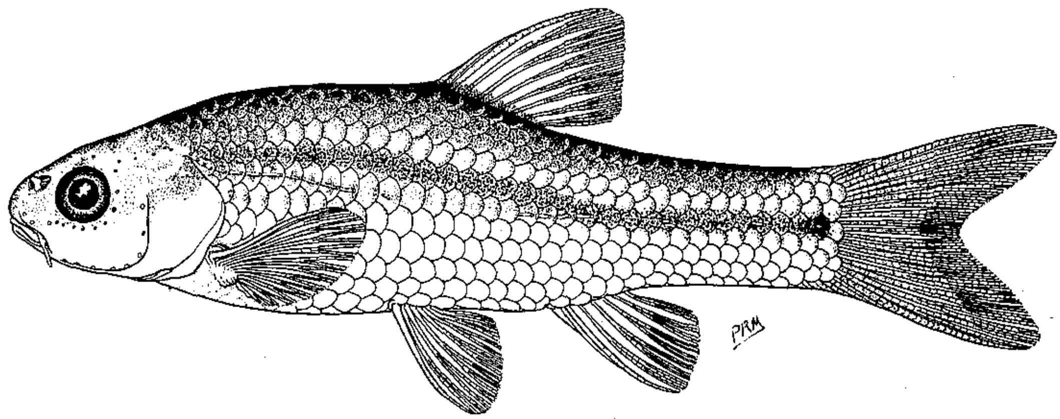
Distinguishing characteristics: A small cyprinid fish. All fin rays soft and flexible. Mouth small and terminal with (usually) only a single pair of short barbels on either side. Silvery or brilliantly golden (breeding males) with a broad darkish band sometimes present. A small dark spot at the base of the tail is distinctive. Maximum size 130 mm TL (Bruton et al 1982). Harrison (1952b) and Jubb (1965) provide more detailed descriptions of the different forms of this species.

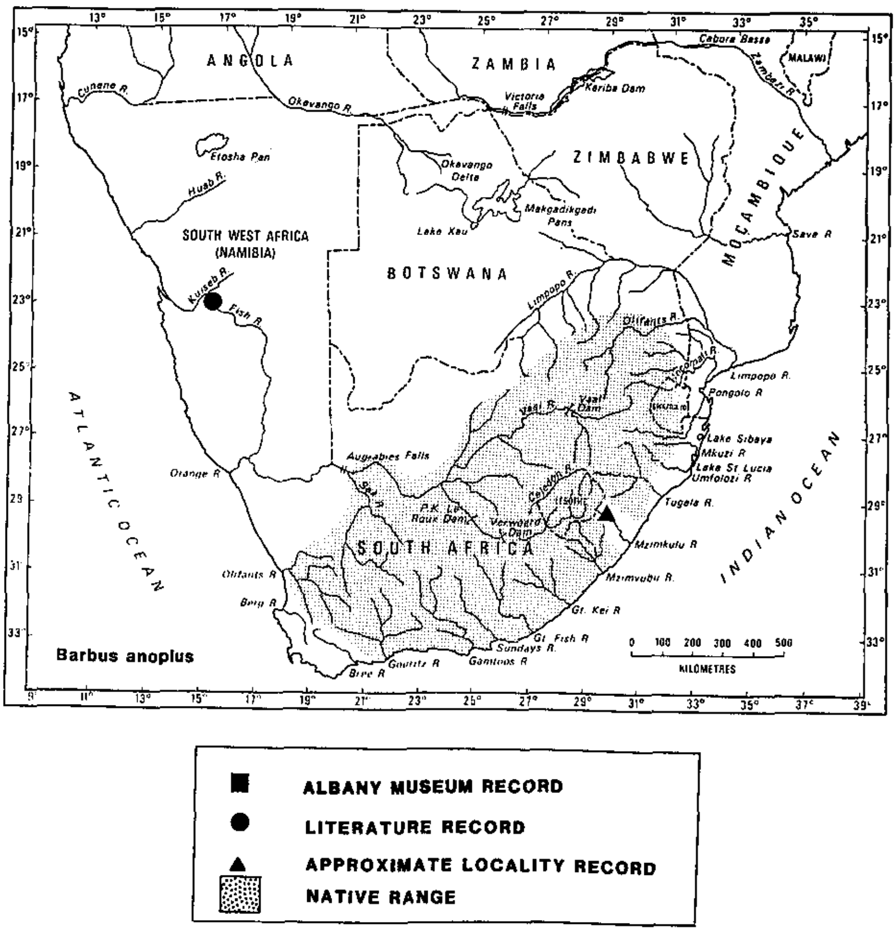
Native range: In the Cape *B. anoplus* is confined to the Orange-Vaal system above the confluence of these two rivers (Skelton and Cambray 1981), Clanwilliam Olifants, Gouritz (Harrison 1952b), Gamtoos and Sundays Rivers (Jubb 1968a), the Great Fish River and rivers towards the north-east into Natal (Jubb 1965). Absent from the Berg and Breede Rivers as well as the coastal rivers of the south-west and south Cape (Jubb 1965) and the lower Orange River (Skelton and Cambray 1981).

In Natal *B. anoplus* is widely distributed at altitudes from 1230 to 1525 meters but there are gaps in the distribution. Found in the Umtamvuna, Umzimvubu, Illovo, tributaries of the Umgeni, Upper Tugela basin, foothills of the Drakensberg drained by the Tugela, and the main Buffalo River catchment. Absent from the Umzimkulu and Umkomaas catchments and from the Mooi and Bushmans Rivers (the major southern tributaries of the Tugela) (Crass 1964).

In the Transvaal *B. anoplus* is present in the headwaters of the Steelport River (Limpopo system) and the Crocodile and Sabie Rivers (Incomati system) (Jubb 1968a).

FIGURE 38. The chubbyhead barb *Barbus anoplus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Date and purpose of introduction: Populations in the Gaub River pools (Kuiseb system, South West Africa) are probably the result of introductions by local farmers from the Orange or Olifants River in the Cape (Dixon and Blom 1974).

Introduced into various streams and lakes in the foothills of the Drakensberg (in the Underberg-Himeville and Kamberg-Nottingham Road districts) as a forage fish for trout (Alletson 1985). The exact localities of these introductions are not known but probably lie in the Umzimkulu and Mooi River catchments, the latter being a southern tributary of the Tugela system. *B. anoplus* does not occur naturally in either of these systems.

The opening of the Orange-Fish tunnel in 1975 has almost certainly resulted in a genetic contamination of the *karkensis* form from the Great Fish River with the *oriensis* form from the Orange River (Cambray and Jubb 1977b; Cambray personal communication).

Present distribution: As for native range. Also in some streams in the foothills of the Drakensberg and in the Gaub River pools (Kuiseb system) (Dixon and Blom 1974). *B. anoplus* has also been recorded in the main Kuiseb River (Jubb 1967), but this is probably not a permanent population (Dixon and Blom 1974).

Habitat preferences: *B. anoplus* can survive in a wide range of habitats from small streams to large impoundments. Usually found near vegetation except when the water is turbid. Occurs naturally in the arid parts of southern Africa (Bruton et al 1982). Its presence in the Sak River (Orange system) suggests that this species can tolerate extreme conditions. This river seldom flows and during droughts dries up into a series of pools which are subject to extreme conditions of temperature and salinity, and are often eutrophic and anaerobic (Hocutt and Skelton 1983). Its presence in the pools of the Gaub River confirms this observation.

Breeding: Several males "drive" a gravid female and spawn around submerged vegetation, often in small pools (Bruton et al 1982).

Feeding: An opportunistic feeder with large variations in its diet in different habitats. In a study performed in Lake Le Roux it was noted that their diet in open-water habitats was comprised mainly of copepods and cladocerans whereas in small streams it was more varied, mostly consisting of aquatic insect larvae. Their feeding habits also varied in different seasons. In small fish benthic feeding was observed during spring and midwater feeding during summer. Larger fish preyed on corixid bugs in summer but switched to chironomid larvae and zooplankton in winter. They normally feed during the day with peak periods in midmorning and at dusk (Cambray 1983).

Behaviour: This species enters new waters during wet seasons and withdraws from them during a drought. It is capable of jumping in order to ascend rapids, especially after spring rains (Bruton et al 1982).

Impact: Cambray et al (1977) noticed the presence of some exceptionally large specimens (now lodged in the Albany Museum) in the Grassridge dam (Great Fish River system) prior to the opening of the Orange-Fish tunnel. Cambray (personal communication) commented that this may have been due to the lack of large predators in the system or it may have been a genetic characteristic of the "karkensis" form. The effects of genetic contamination from the *oriensis* form are difficult to predict, but could result in the loss of favourable characteristics (such as large-sized fish) from the Great Fish River population.

The introduction of *B. anoplus* together with trout has led to the spread of piscivorous birds (including kingfishers, white-breasted cormorants, reed cormorants, darters, fish eagles and osprey) into new areas of the Natal uplands where they had not previously been recorded (Alletson 1985).

Control: If this species is found to displace less ubiquitous indigenous minnows it will be necessary to restrict their stocking as forage for trout.

Research recommendations: The impact of introduced *B. anoplus* on local minnow populations needs to be established.

Remarks: It would be risky for *B. anoplus* to be exported through the aquarium trade to other warmwater countries as it is likely to be a successful invader there. *B. anoplus* is an efficient coloniser and it will be extremely difficult to control its movements through man-made intercatchment connections such as tunnels, pipes and irrigation canals.

REFERENCES

Alletson (1985); Bruton et al (1982); Cambray (1983); Cambray and Jubb (1977b); Cambray et al (1977); Crass (1964); Daget et al (1984); Dixon and Blom (1974); Harrison (1952b); Hocutt and Skelton (1983); Jubb (1965, 1967, 1968a); Skelton and Cambray (1981).

Personal communication: J A Cambray.

BARBUS NATALENSIS Castelnau 1861

scaly
Natalse geelvis

indigenous, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An indigenous species which has a widespread distribution in Natal. Translocated into sections of Natal rivers which were previously inaccessible due to the presence of waterfalls. The impact of this species in the areas into which it has been introduced has not been assessed.

Research: Good. The habitat preferences of this species have been described by Wright and Coke (1975a and b). No studies have been carried out on the impact of this species.

SPECIES DATA

Recent synonyms: *B. tugelensis* and *B. marleyi* (Daget et al 1984).

Distinguishing characteristics: A large, popular angling species (maximum size 4,6 kg). Dorsal fin origin anterior to origin of pelvic fins. Scales with closely set parallel striations. Like most other yellowfish, the scaly is variable in mouth form and has two pairs of barbels. Colour differs according to water conditions. Juveniles and fry silvery with darker blotches. Adults darker above, bluish to olive green with silvery or light golden flanks and pale belly (Bruton et al 1982).

Native range: In all major Natal rivers from the Mkuze in the north to the Umtamvuna in the south up to altitudes of 1500m. Waterfalls have prevented their access to the upper reaches of some rivers such as the Umzimkulu and Ingwangwana Rivers (Crass 1964).

Date and purpose of introduction: In Natal artificial spawning of fry and stocking into numerous farm dams began in 1972 (Crass 1969a; Wright and Coke 1975a). Most of this stocking was within the native range of this species. Introduced into sections of the Polela River (Umzimkulu catchment) and Little Mooi River (Tugela catchment) which were previously inaccessible to this species due to waterfalls (Crass 1964).

Present distribution: As for native range and in the upper Polela and Little Mooi Rivers.

Habitat preferences: It was previously assumed that *B. natalensis* could tolerate high silt loads because of its survival in highly silted sections of the Tugela River. However Wright and Coke (1975b) found that fry were susceptible to high silt loads and they therefore assumed that, in the Tugela River, spawning and larval development must take place in tributaries where silt levels are lower. This species requires fast-flowing, algae-free areas for spawning (Wright and Coke 1975b).

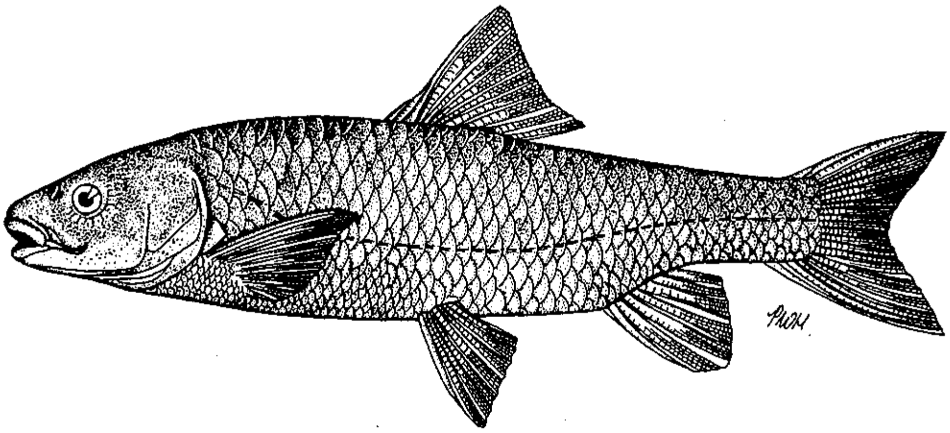
Breeding: Spawns in fast-flowing stretches of rivers that are algae-free. The optimal temperature for spawning is about 19°C (Wright and Coke 1975a).

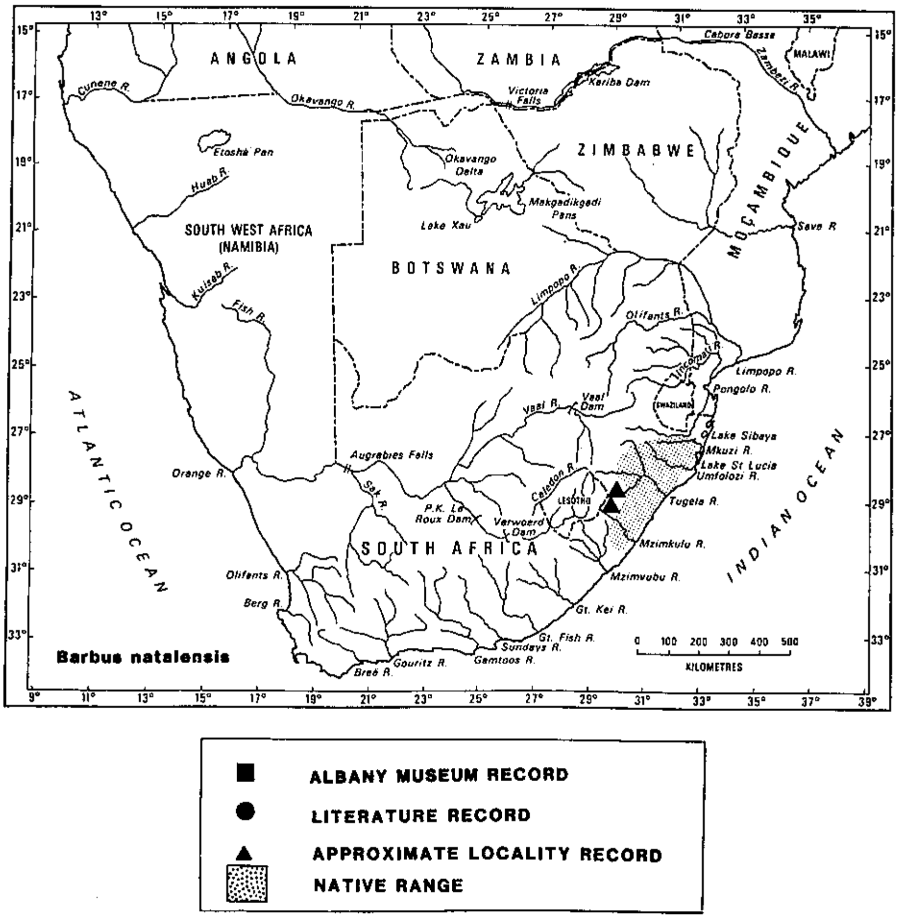
Feeding: Omnivorous. Feeds on algae, insect larvae and crabs (Bruton et al 1982).

Behaviour: *B. natalensis* often occurs in shoals and migrates upstream during spring and summer (Bruton et al

BARBUS NATALENSIS Castelnau 1861

FIGURE 39. The scaly *Barbus natalensis* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





1982). Larvae bred under artificial conditions exhibit burrowing behaviour which starts soon after hatching and persists for several days. They also display a negative phototropic response. It is probable that, until the completion of development of pigmentation in the skin, ultraviolet light is detrimental to the larvae (Wright and Coke 1975b). *B. natalensis* shows a preference for warmer areas of rivers and often congregates at the inlets of small tributaries where the temperature of the tributary is higher than that of the main river (Crass 1964).

Upstream migrations occur after the first spring rains. Large shoals move up the river in unison. These are not described as spawning runs as many juveniles are usually included in the shoals. When temperatures fall in autumn the fish move back to the warmer downstream areas of the river (Crass 1964).

Impact: The impact of *B. natalensis* in the upper reaches of the rivers into which it has been introduced is not known.

Control: No further translocations should be made until the impact of this species on communities in target localities is known.

Research recommendations: The impact of *B. natalensis* on natural communities in environments into which it has been introduced needs to be established. The invasive qualities of the yellowfish and the vulnerability to invasion of upstream invertebrate and vertebrate communities needs to be taken into account before further introductions are made. The effect of hybridisation by translocated *B. natalensis* stocks also needs to be assessed.

Remarks: This species is a popular angling fish and an important component of riverine communities in Natal. It is therefore important that the fitness of the species is not reduced by genetic contamination as a result of unnecessary translocations.

REFERENCES

Bruton et al (1982); Crass (1964, 1969a); Daget et al (1984); Wright and Coke (1975a, 1975b).

BARBUS TREURENSIS Groenewald 1958

Treur River barb | **indigenous, beneficial, little impact**
Treurrivier-ghieliemientjie

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An indigenous species which is classified as threatened in Skelton's (1987a) Red Data Book. The Treur River barb has been translocated to areas where it did not previously occur to enhance its conservation status.

Research: Good. The distribution, general biology and conservation status of this species has been studied by Pott (1981) and Kleynhans (1984).

SPECIES DATA

Distinguishing characteristics: A fusiform cyprinid minnow which reaches about 108 mm TL. The mouth is sub-terminal and there are two pairs of well-developed simple barbels. The unbranched dorsal ray is flexible. The scales are moderately large and their pigmentation is relatively inconspicuous with some irregular dark spots on the dorsal surface and caudal peduncle (Skelton 1987a)

Native range: Endemic to the Blyde and Treur Rivers (Limpopo system) (Pott 1981; Kleynhans 1984).

Date and purpose of introduction: Because of the endangered status of this species (Skelton 1977) it was decided to translocate specimens to a safe refuge where alien fish had not been introduced in order to enhance its chances of survival. *B. treurensis* has been stocked in the Treur River above the New Chum waterfall. It was not previously recorded in this section of the river (Pott 1981).

Present distribution: *B. treurensis* has disappeared from much of its former range. At present the only known population in the native range is restricted to a 4,5 km stretch in the upper reaches of the Blyde River (Limpopo system) (Skelton 1987a). Also now present above the New Chum waterfalls in the Treur River (Pott 1981).

Habitat preferences: *B. treurensis* is found mainly in small pools and behind rocks in flowing runs of clear, flowing mountain streams. *B. treurensis* co-exists with the small amphiliid catfish *Amphilius natalensis* (Skelton 1987a).

Breeding: *B. treurensis* is a total spawner and breeds from October to December. The number of eggs laid with each spawning varies from 350 to 2040 depending on the size of the female, the fecundity increasing with age. During the breeding season adult males and females both develop nuptial tubercles on the head. This suggests that *B. treurensis* may be a group spawner (Skelton 1987a).

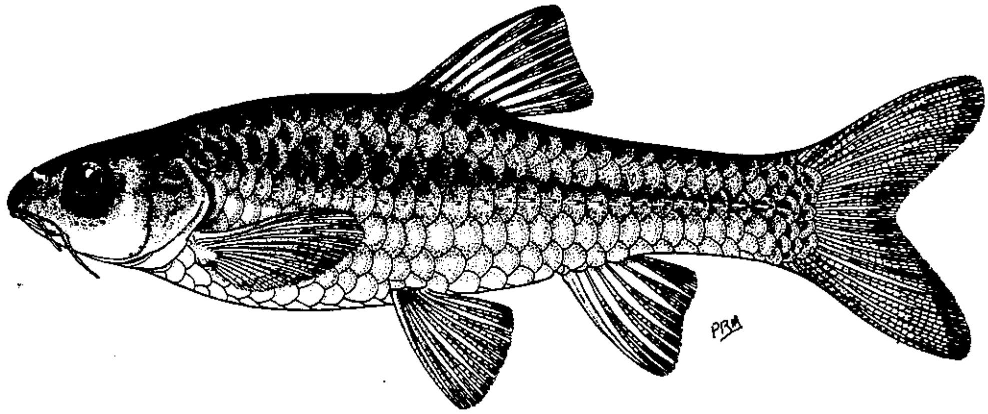
Feeding: Their diet consists of aquatic invertebrates, particularly insects (Skelton 1987a).

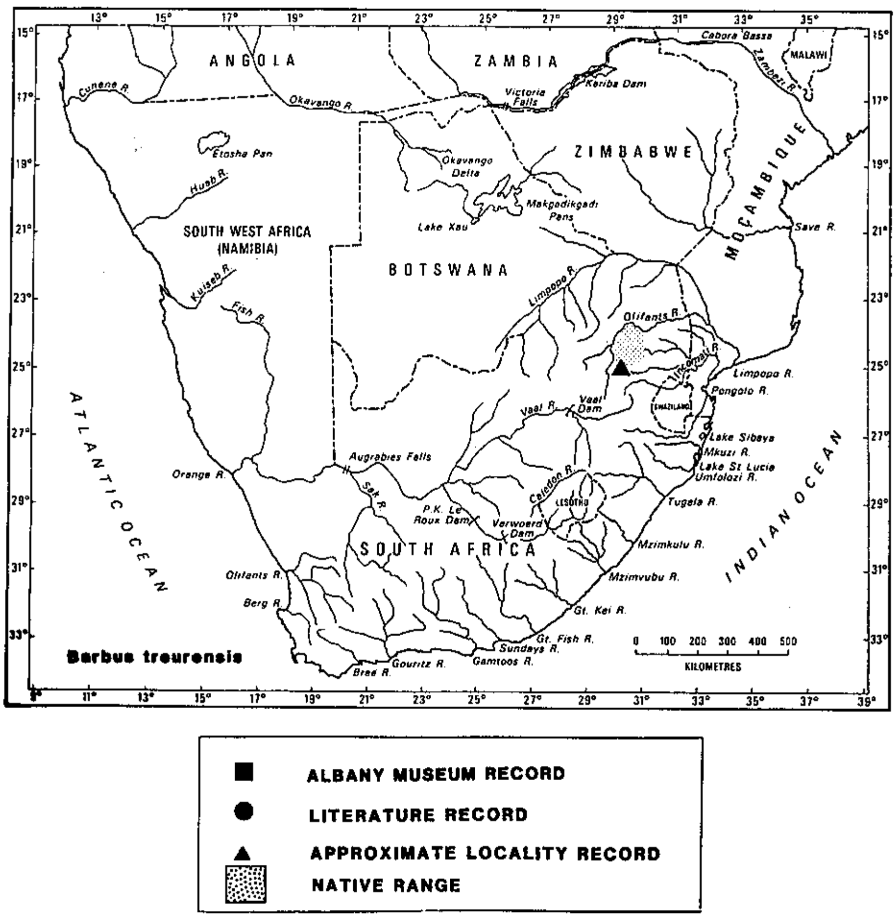
Impact: The presence of *B. treurensis* may affect the composition of the aquatic invertebrate community in the area into which it has been translocated.

Control: Future introductions need to take into account the potential impact of the introduced species.

BARBUS TREURENSIS Groenewald 1958

FIGURE 40. The Treur River barb *Barbus treurensis* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Research recommendations: Research and management should concentrate on restoring the habitat in the native range of this species so that further translocations are unnecessary.

Remarks: *B. treurensis* was originally classified as an endangered species (Skelton 1977). The habitat of the population in the Blyde River is presently in excellent condition and many measures have been taken to conserve the species. As a result, the conservation status has now been revised to "vulnerable" (Skelton 1987a). The introduction of *Parasalmo mykiss* and *Micropterus dolomieu* into the Blyde and Treur Rivers has been held responsible for the reduction in the natural range and the decline in the status of this species (Skelton 1987a).

REFERENCES

Kleynhans (1984); Pott (1981); Skelton (1977, 1987a)

LABEO CAPENSIS (Smith 1841)

Orange River labeo
Oranjerivier labeo

indigenous, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An indigenous species endemic to the Orange-Vaal system which has been accidentally introduced into the Great Fish River system via the Orange-Fish tunnel. The impact of this translocation has not as yet been assessed.

Research: Excellent. The general biology has been studied by Jackson et al (1983), Tomasson et al (1983b) and Cambray (1985).

SPECIES DATA

Distinguishing characteristics: A large powerful cyprinid fish. Large adults have a humped shoulder and prominent sickle-shaped fins. Tail large and powerful. Mouth inferior with well-developed lips fringed with papillae and two pairs of short barbels. Snout prominent, without tubercles. Scales moderately small. Colour silvery to mottled grey, fins often darker. Maximum size 500 mm FL, 3 kg (Bruton et al 1982).

Native range: Originally endemic to the Orange-Vaal system above and below the Aughrabies Falls (Jubb 1965).

Date and purpose of introduction: Translocated to the Great Fish River system with the opening in 1975 of the Orange-Fish tunnel. First recorded in the Grassridge dam (Great Fish River system) in 1976 (Cambray and Jubb 1977a and b). In 1980 a specimen was caught further downstream at a farm, Bekkersdal, near Fort Brown (Fogarty 1980). Expected to be translocated from the Fish to the Sundays system with the opening of the Cookhouse tunnel (Cambray and Jubb 1977b).

The presence of *L. capensis* in the Sterkfontein dam (on the Wilge River, Vaal system) (OFS Nature Conservation 1983, 1984) means that there is a possibility that this species will be translocated into the Tugela system should the Sterkfontein dam ever be filled to capacity.

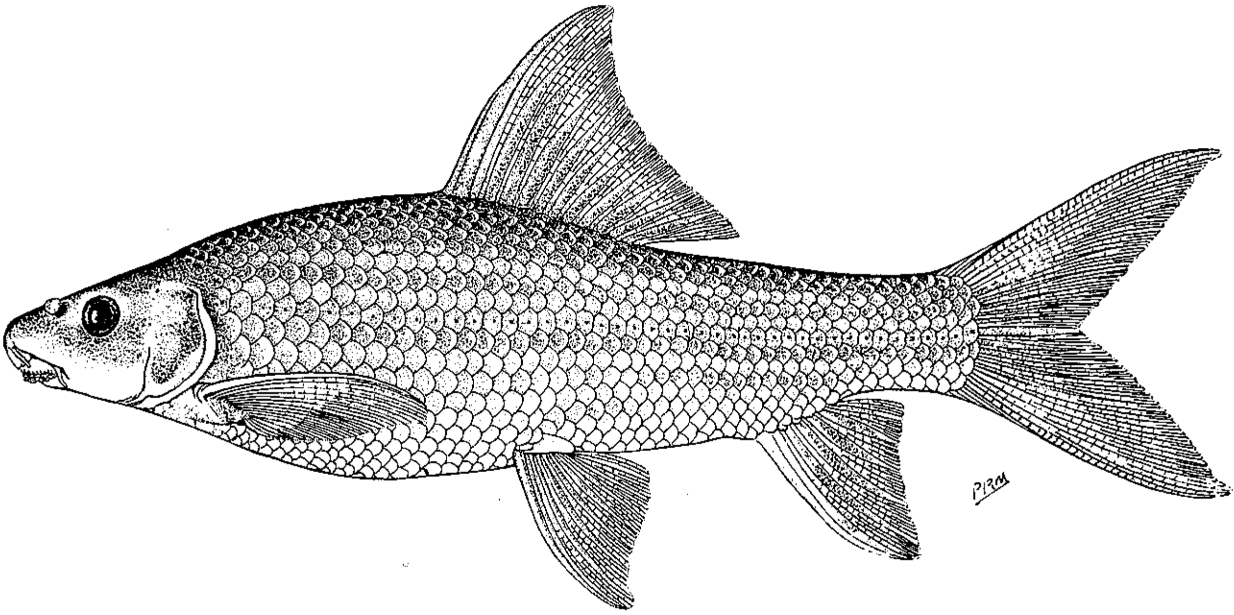
Present distribution: As for native range. Also in the Grassridge dam (Cambray and Jubb 1977a and b) and at the farm "Bekkersdal" further downstream on the Great Fish River (Fogarty 1980).

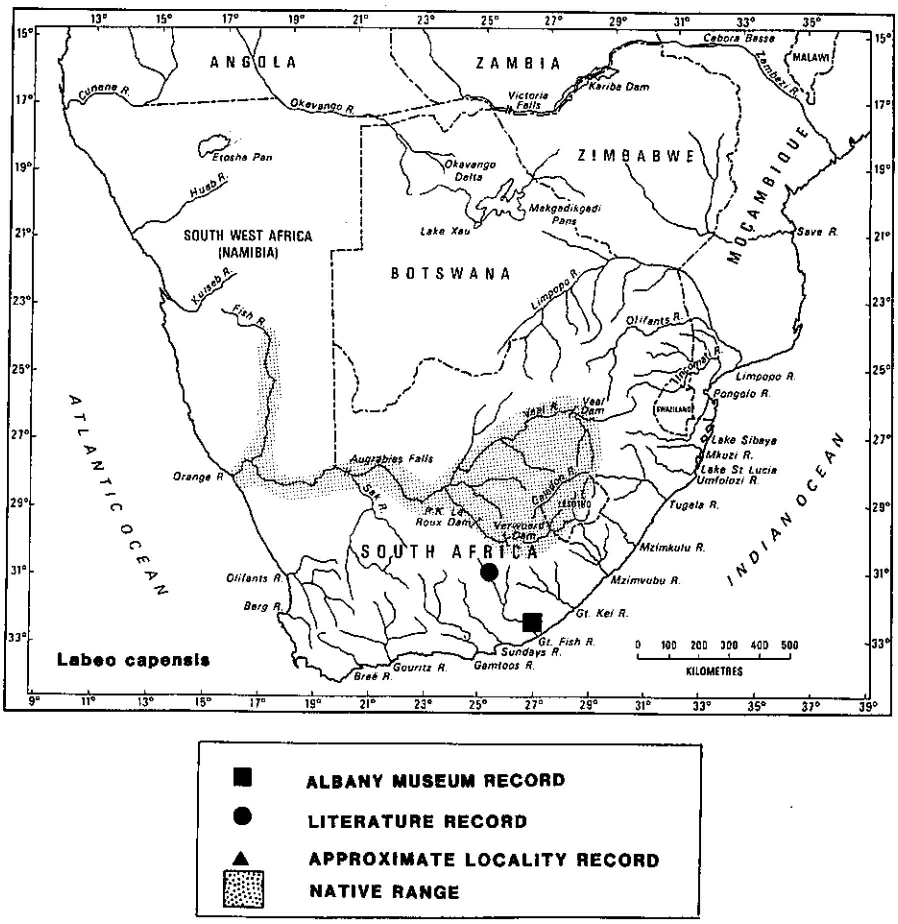
Habitat preferences: Found in a variety of habitats: quiet well-vegetated backwaters, standing open waters, flowing open waters, sandy-rocky stretches and rocky rapids. Their preferred habitat is flowing rocky channels (Skelton and Cambray 1981). Population levels increased after the building of the Verwoerd dam; this species is obviously able to adapt to living in large impoundments (Hamman 1980). Occurs in both lotic and lentic habitats (Cambray and Jubb 1977b). In Lake le Roux juveniles were found along the shores of the lake and early survival appeared to be dependent on the presence of newly flooded areas. Larger species were found further offshore in relatively shallow areas where they continued to feed on the substrate (Jackson et al 1983).

Breeding: This species has a prolonged breeding season from spring into summer. During this time several spawnings may take place, but each individual female only spawns once per season. Normally spawns on recently inundated floodplains and in Lake le Roux was observed to spawn in suitable inflowing rivers.

LABEO CAPENSIS (Smith 1841)

FIGURE 41. The Orange River labeo *Labeo capensis* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Requires local flooding in order to initiate spawning (Tomasson et al 1983a) and elevated water levels are necessary to ensure a good survival of juveniles (Tomasson et al 1983b). The eggs have a non-adhesive membrane and spawning takes place over clear areas with either a rocky or muddy substratum (Cambray 1985).

Labeo capensis is a relatively fecund species with the females carrying up to 257 000 eggs at a time. The incubation time is short with hatching occurring within 48 hours of fertilisation. After hatching the larvae repeatedly swim up into the water column before sinking again (Tomasson et al 1983a). The parents do not guard the young (Cambray 1985).

Cambray (1985) concluded that spawning normally occurs with the annual flooding of rivers but in the highly regulated lower Orange River there is little seasonal difference in the flow rate, and spawning is then more dependent on other factors such as temperature and photoperiod ie in this habitat it does not appear to be essential to have rain in order to initiate spawning in this species.

Feeding: Bottom feeder. Grazes algae and organic detritus (Bruton et al 1982).

Behaviour: This species is relatively sedentary and is not readily caught with a hook. In Lake le Roux a sudden increase in turbidity, which resulted in food shortages, was followed by a dispersal of juveniles into new areas where they had not previously been found (Tomasson et al 1983b).

Impact: *L. capensis* may have a negative impact (through strong competition) on small localised populations of *Sandelia bainsii* and *Barbus pallidus* in the Great Fish River (Laurenson and Hocutt 1986).

It is difficult to predict the effect which the introduction of *L. capensis* will have on the Great Fish River population of *Labeo umbratus*. Cambray and Jubb (1977b) noted that where *L. capensis* and *L. umbratus* occur together in the Orange-Vaal system, *L. capensis* tends to occupy both lotic and lentic habitats whereas *L. umbratus* is found predominantly in lentic conditions. In the Great Fish River (in the absence of competition from *L. capensis*), *L. umbratus* is found in both lotic and lentic habitats and has developed different mouth forms suitable for feeding in these different habitats. It could therefore be expected that the establishment of *L. capensis* in the Great Fish and the Sundays River systems will probably exclude *L. umbratus* from certain habitats.

Should *L. capensis* be translocated into the Tugela catchment there is a possibility that it may interbreed with *Labeo rubromaculatus* which is endemic to the Tugela system and is closely related to *L. umbratus* (Jubb 1967; Skelton personal communication).

In van As and Basson's (1984) checklist, five species of parasite have been recorded on *L.capensis*. Of these one (*Argulus japonicus*) is an alien to southern Africa. The translocation of *L. capensis* into new areas has probably facilitated the spread of parasites into new localities.

Control: *L. capensis* is a hardy, mobile species which will readily take advantage of man-made intercatchment connections and spread into new river systems. It is essential, therefore, that adequate screening devices are fitted in tunnels and irrigation canals in order to block the passage of this and other fish species.

Research recommendations: Cambray and Jubb (1977b) remarked that it would be of interest to follow the conflict between *L. capensis* and *L. umbratus* after the colonisation of the Fish and Sundays Rivers by the former species.

We recommend that the holding dam of the Tugela-Vaal scheme should be regularly sampled in order to determine whether *L. capensis* has been translocated into the Tugela catchment.

Remarks: Jackson (1980a, 1980c) recommends the use of this species (or *L. umbratus*) in wastewater aquaculture / polyculture together with *Cyprinus carpio, Oreochromis mossambicus, Hypophthalmichthys molitrix, Aristichthys nobilis* and *Xenopus laevis*. *L. capensis* (or *L. umbratus*) could fill the role of detritus-algae feeder.

REFERENCES

Bruton et al (1982); Cambray (1985); Cambray et al (1977); Cambray and Jubb (1977a, 1977b); Fogarty (1980); Hamman (1980); Jackson (1980a, 1980c); Jackson et al (1983); Jubb (1965, 1967); Laurenson and Hocutt (1986); OFS Nature Conservation (1983, 1984); Skelton and Cambray (1981); Tomasson et al (1983a and b); van As and Basson (1984);

Personal communication: P H Skelton.

LABEO UMBRATUS (Smith 1841)

mud mullet
moggel

indigenous, detrimental, major impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An indigenous species which occurs naturally in the Orange-Vaal system and eastern Cape rivers. Accidentally translocated into the Tweefontein dam (Olifants River, Limpopo system) where it has had a major detrimental impact on sport fisheries.

Research: Good. The biology of this and other cyprinid species in Lake le Roux has been studied by Tomasson (1983) and Tomasson et al (1984). The translocations of this species are not well documented and their impact on indigenous communities has not been studied in detail.

SPECIES DATA

Distinguishing characteristics: A large labeo (maximum size 500 mm SL, 2,8 kg) with a markedly rounded head, fleshy snout and small eyes. Mouth ventral and lips moderately developed with numerous papillae. Two pairs of short barbels present. Body cylindrical and scales small. Basic colouration grey with darker marbling, belly light grey or white (Bruton et al 1982).

Native range: Orange-Vaal system above and below the Aughrabies Falls as well as the Gouritz, Gámtoos, Sundays, Bushmans, Fish, and Keiskamma Rivers (Harrison 1952b; Gabie 1965; Jubb 1966b; Skelton and Cambray 1981; Skelton 1986a).

Date and purpose of introduction: There have been a number of translocations of this species beyond its native range. There were various reasons for these introductions, which are discussed below:

1. The presence of *L. umbratus* in the Buffalo River (Kingwilliamstown) was ascribed to a translocation by fishermen for use as bait (Jubb 1964, 1967).

2. Du Plessis (1963) reported that prior to 1953 this species was introduced into the Tweefontein dam near Witbank (Olifants River, Limpopo system) by anglers who had mistaken it for *B. aeneus*. By 1958 it was well established in this dam and in the Olifants River above the Witbank municipal dam (Jubb 1965, 1966b).

3. The presence of *L. umbratus* in the Keiskamma River may be the result of an introduction. Barnard (1943: 149) quoted from an earlier survey report (No 1, 1926:66) of Hey's in which there was a description of a "bony mudfish" (probably this species) being translocated from the Kat River into a dam in the Tyume River catchment. From there it found its way into the Tyume River and later into the Keiskamma River where it became well established "to the detriment of the mullet which is a far more edible and desirable fish".

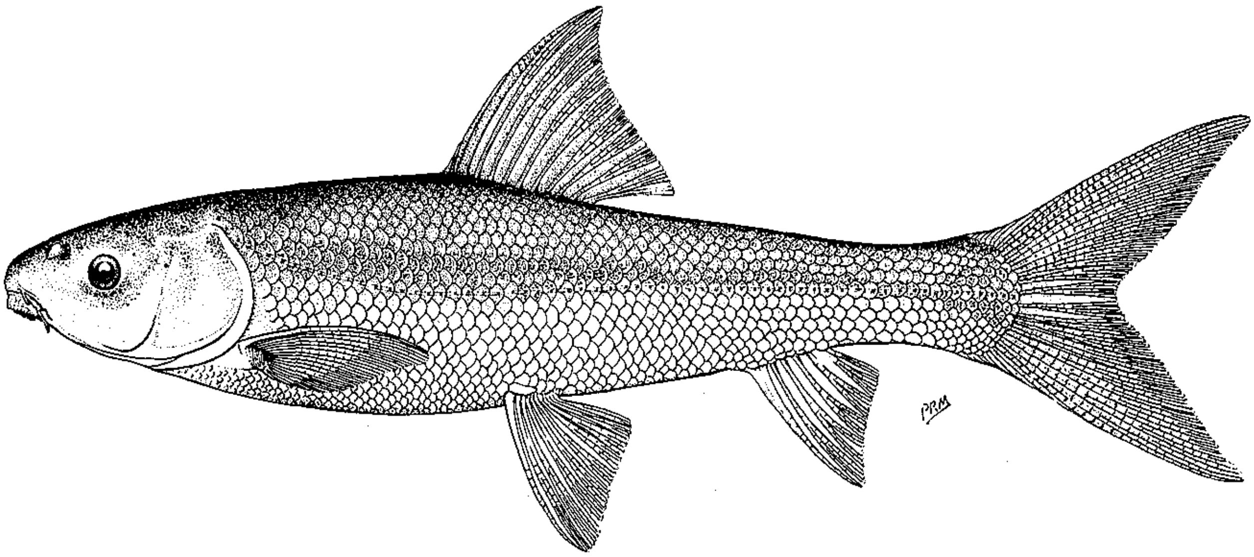
4. There are some unsubstantiated reports of this species being translocated into the Nahoon River (Gaigher et al 1980).

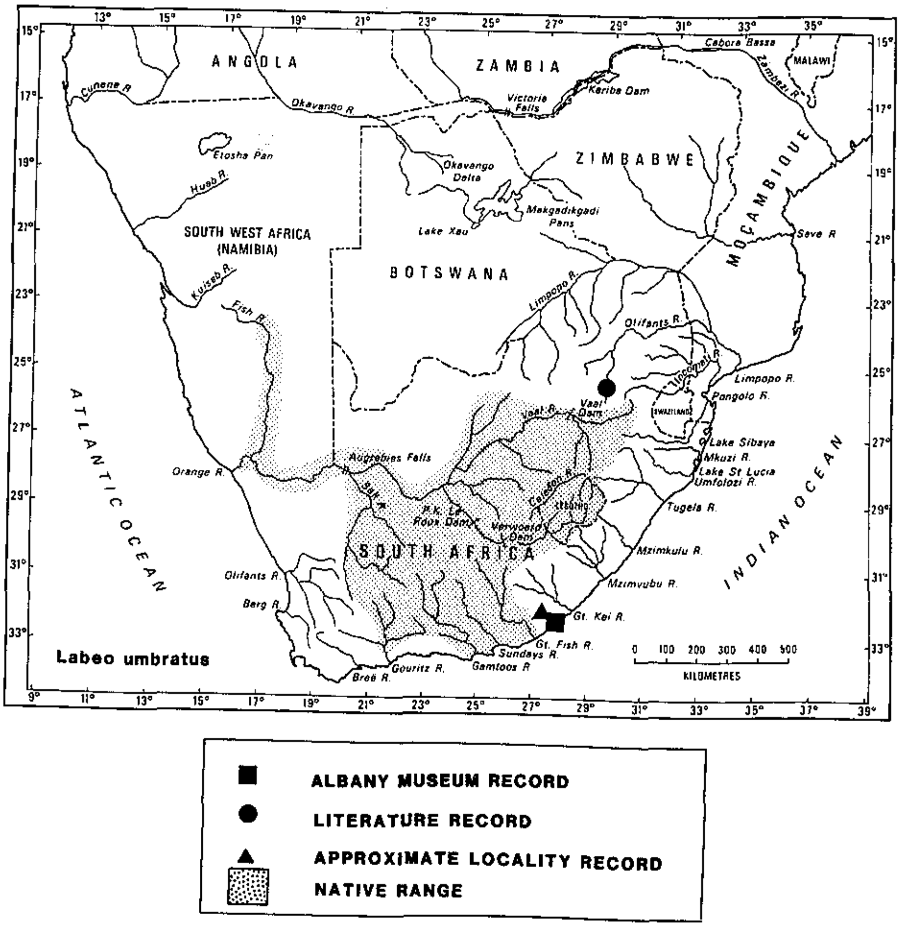
5. The presence of *L. umbratus* in the Sterkfontein dam (on the Wilge River, Vaal system) (OFS Nature Conservation 1984) means that there is a possibility of it being translocated into the Tugela system in the future.

Present distribution: As for native range. Also in the Buffalo and Keiskamma Rivers in the eastern Cape, and

LABEO UMBRATUS (Smith 1841)

FIGURE 42. The mud mullet *Labeo umbratus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





the Olifants River (Limpopo system) in the Transvaal (Jubb 1967). Its presence in the Nahoon River (eastern Cape) may also be outside its native range (Gaigher et al 1980).

Habitat preferences: *L. umbratus* tolerates a wide range of water temperatures and water qualities (Jubb 1965). Survives temperatures below 10 C but the critical minimum is not known (Safriel and Bruton 1984). Favours standing waters and thrives in shallow dams (Bruton et al 1982). In large impoundments such as Lake le Roux this species favours the muddy shallow areas (Tomasson et al 1983a).

Mass mortalities sometimes occur in impoundments for unknown reasons (Safriel and Bruton 1984).

Labeo umbratus has been found in the Sak River (Orange system) in an arid part of the Karroo. This river is subject to periodic drying up when the fish are confined to small pools in which extreme conditions of temperature, salinity and oxygen depletion prevail (Hocutt and Skelton 1983).

Skelton and Cambray (1981) found that *L. umbratus* is not particularly successful in a lotic environment (especially in competition with *L. capensis*) and is more suited to a lentic environment. Hamman (1980) noted that *L. umbratus* and *L. capensis* share the same breeding sites, but *L. umbratus* spawns on gravel in semi-lotic conditions, whereas *L. capensis* can utilise a wider range of breeding conditions. There is probably some interspecific competition between these species for breeding sites, especially in impoundments such as the Verwoerd dam.

Breeding: *L. umbratus* migrates upstream and spawns on floodplains (Jackson and Coetzee 1982). In Lake le Roux this species migrates upstream into tributaries to spawn and therefore requires more local rainfall in order to initiate spawning than *L. capensis* which breeds on the shoreline after a rise in water level (Tomasson et al 1984).

On average mature females produce over 250 000 eggs which are laid on submerged vegetation in shallow water (Bruton et al 1982; Safriel and Bruton 1984). Mature ovaries contain one size range of eggs but these are not always spawned simultaneously (Safriel and Bruton 1984). The fertilised eggs are neutrally buoyant and usually hatch within one to three days after fertilisation (Tomasson et al 1984). The larvae repeatedly swim up into the water column before sinking again (Mulder 1973b). The neutrally buoyant eggs and the larval swimming behaviour mean that the juvenile stages can readily drift in the current, an adaptation which prevents the eggs and larvae from becoming stranded in the spawning grounds which are usually of a temporary nature. The eggs and the larvae are small and larvae have their first external meal soon after hatching (Tomasson et al 1984). There is no parental care of the young (Jubb 1966b).

Labeo umbratus can multiply prolifically in impoundments (Jubb 1965). Mulder (1973b) ascribed its success in these habitats to its fast growth rate, early maturity and high fecundity.

Feeding: Juveniles probably feed on small invertebrates. The adults feed on detritus and mud taken off soft bottom sediments (Tomasson et al 1983a). The bulk of the nutrients is probably obtained from diatoms, bacteria and free amino acids. Digestion is aided by the presence of enteric bacteria in the gut (Safriel and Bruton 1984).

Behaviour: *L. umbratus* does not readily take a hook and is seldom caught by anglers (Jackson 1973a).

Impact: The feeding habit of dredging up the bottom sediments often leads to an increase in the turbidity of the water and a decline in the stability of bottom sediments. Therefore this species has been regarded as a pest in enclosed waters (Jubb 1966b). The long term effects resulting from increases in the turbidity of the water have been described in the section on *C. carpio*.

Labeo umbratus has been known to deplete bass populations in farm dams when populations levels are high (Jackson 1973a).

The Koornfontein dam (Olifants River, Limpopo system) was noted to have been so overrun with this species that carp (which are considered to be a more favourable angling fish) decreased in numbers (McC Pott personal communication).

It is difficult to predict the impact which *L. umbratus* would have on indigenous freshwater communities should it be translocated into the Tugela River via the Vaal-Tugela scheme. There is a possibility that it would interbreed with *L. rubromaculatus* (Skelton personal communication) which is endemic to the Tugela system (Jubb 1967).

Three species of parasite have been recorded on *L. umbratus* (van As and Basson 1984) and of these *Argulus japonicus* is alien. The translocation of *L. umbratus* into new catchments may facilitate the spread of this parasite.

Control: Jackson (1973a) recommends the use of seine and gill nets together with line fishing as a means of efficiently utilising food resources while still catering for the needs of the sport fisherman. Dense populations of *L.umbratus* could be controlled in this way.

Research recommendations: We recommend that the Tugela River should be sampled regularly to determine whether this species has been translocated into this catchment.

Remarks: Because it often multiplies very rapidly in municipal reservoirs *L. umbratus* could become a nuisance as large scale mortalities may occur during drought conditions with the consequent pollution of municipal water supplies (Jubb 1965). In many ways *L. umbratus* is the indigenous equivalent of *Cyprinus carpio* and appears to have similar effects on systems into which it is introduced.

Labeo umbratus is not valued by sport anglers but it is an important and nutritious food source (Bruton et al 1982). Jackson (1980c) recommends that either this species or *L. capensis* should be used in combination with other aquatic organisms in wastewater aquaculture.

REFERENCES

Barnard (1943); Bruton et al (1982); du Plessis (1963); Gabie (1965); Gaigher et al (1980); Hamman (1980); Harrison (1952b); Hey (1926); Hocutt and Skelton (1983); Jackson (1973a, 1980c); Jackson and Coetzee (1982); Jubb (1964, 1965, 1966b, 1967); Mulder (1973b); O F S Nature Conservation Annual Report (1984); Safriel and Bruton (1984); Skelton (1986a); Skelton and Cambray (1981); Tomasson (1983); Tomasson et al (1983a); Tomasson et al (1984); van As and Basson (1984).

Personal communications: R Mc C Pott; P H Skelton.

CLARIAS GARIEPINUS (Burchell 1822)

sharptooth catfish
skerptandbarber

indigenous, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Clariidae

SUMMARY

Status: An indigenous catfish which has been translocated via the Orange-Fish River tunnel into the Fish and Sundays River catchments. Also introduced into the Eerste and Kuils Rivers in the western Cape and the Tyume and Swart Kei Rivers in the eastern Cape. The impact of these introductions has not been assessed.

Research: Excellent. Detailed studies have been carried out on the general biology and behaviour of this species by Bruton (1979a, 1979b, 1979c, 1979d, 1980) and Bruton and Kok (1980). There have however been no detailed studies on the impact of *C. gariepinus* on natural communities into which it has been introduced.

SPECIES DATA

Recent synonyms: *Clarias lazera, C. capensis, C. mossambicus* (Daget et al 1984).

Distinguishing characteristics: The common and ubiquitous catfish or barbel in southern Africa. Head large and bony with small eyes. Dorsal and anal fins long. No adipose fin. Pectoral fin with a stout serrated spine, used for defence and for "walking" overland. Mouth terminal, large. Four pairs of barbels present. Colour varies from sandy-yellow through grey to olive with dark greenish-brown markings, belly white. A tree-like air breathing organ is located at the back of the head (Bruton et al 1982).

Native range: This species has an almost pan-African distribution extending through the Middle East into eastern Europe. In southern Africa occurs in the Limpopo, Orange-Vaal, Okavango and Cunene River systems (Daget et al 1984). Jubb (1967) describes its native range as being as far south as the Orange River system in the west and the Umtamvuna River in the east. Found at altitudes up to 1400 m in northern Natal and up to 500m in southern Natal (Crass 1964).

Date and purpose of introduction: This species has been accidently translocated into a number of catchments beyond its native range:

1. Translocated from the Orange-Vaal system into the Great Fish River system via the Orange-Fish River tunnel which was opened in 1975 (Cambray and Jubb 1977b; Laurenson and Hocutt 1986). It could also reach the Sundays system via this water scheme, but Cambray and Jubb (1977b) report that it was translocated into Lake Mentz (Sundays system) prior to the opening of the tunnel. First reported to have reached the Grassridge dam (Great Fish system) in 1976 (Cambray and Jubb 1977a, 1977b).

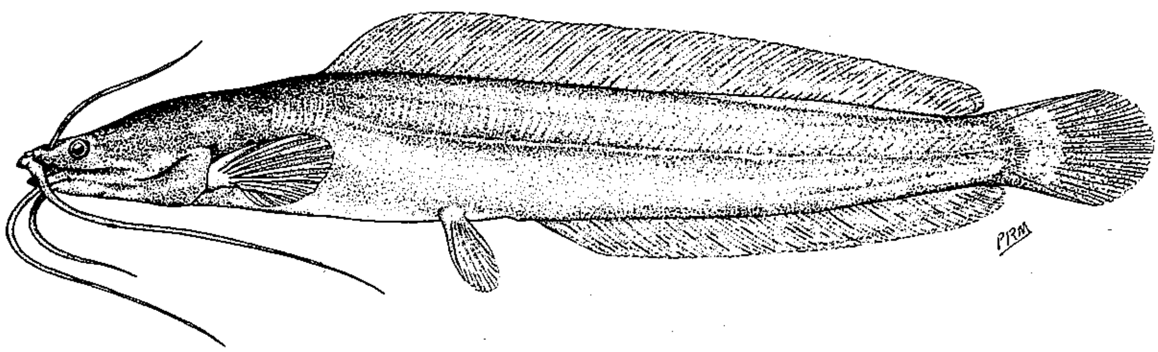
2. *C. gariepinus* has escaped into the Eerste River from the Jonkershoek Hatchery (Gaigher et al 1980).

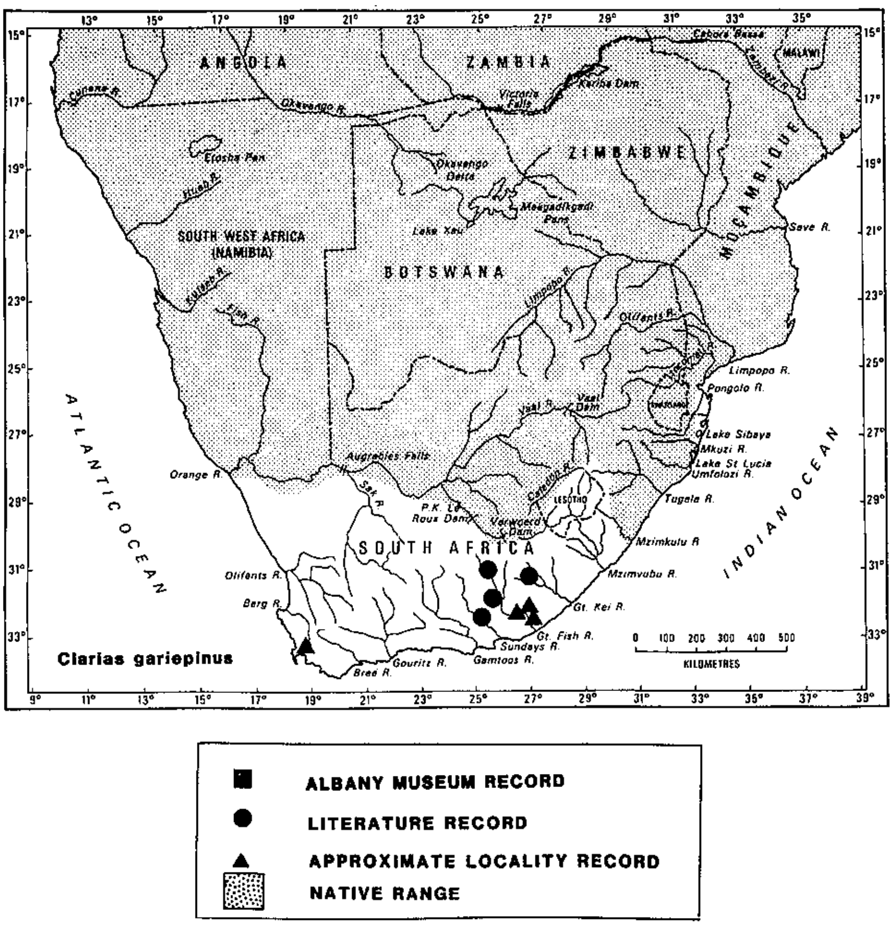
3. Recently collected in the Bongolo dam (Swart Kei River, Kei system) (Bok personal communication). It is not certain when or how *C. gariepinus* escaped into this river system.

4. Recorded in the Tyume River (Keiskamma system) in 1985 (Mayekiso 1986). This translocation is most likely the result of fishes escaping from the experimental farm at Fort Hare University into the river during flood

CLARIAS GARIEPINUS. (Burchell 1822)

FIGURE 43. The sharptooth catfish *Clarias gariepinus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





periods.

5. There is a recent unconfirmed report of this species being caught in the Nuwejaars dam (Bushmans River system, Alicedale) (Davies personal communication).

6. There are unconfirmed reports of *C. gariepinus* being translocated from the Orange River into farm dams in the northern areas of South West Africa. Although South West Africa is within the native range of *C. gariepinus*, the populations in this area have been isolated from the Orange River population for a long period (Schrader 1985). This translocation may therefore have resulted in the "genetic contamination" of two different strains of this species.

Present distribution: As for native range and in the following areas: reported by Laurenson and Hocutt (1986) to have spread throughout the main channel of the Great Fish River system. Also now present in the Sundays River (Bruton et al 1982), the Kuils River, the lower reaches of the Eerste River (Gaigher et al 1980; Hamman personal communication), the Bongolo dam (Swart Kei River; Kei system) (Bok personal communication), and in farm dams in the Eerste River catchment (Smith personal communication). Also in the Tyume River (Keiskamma system) (Mayekiso 1986). The record from the Nuwejaars dam (Alicedale) needs confirmation.

Habitat preferences: Widely tolerant of extreme environmental conditions. The sharptooth catfish tolerates low oxygen concentrations, water temperatures from 8 - 35 C, salinities of 0 to 10‰ and a wide pH range (Safriel and Bruton 1984). The presence of an accessory breathing organ enables this species to breathe air when very active or under conditions of desiccation. In these circumstances the fish remain in the muddy substrates of ponds and occasionally gulp air through the mouth (Jubb 1978a). They may survive in moist sand or in burrows with an air-water interface, but are unlikely to survive in dried mud or sand (Bruton 1979c). They appear to have a preference for riverine conditions (du Plessis and le Roux 1965), but also thrive in impoundments (Hamman 1980). In Lake Sibaya *C. gariepinus* was one of the few species found in benthic, pelagic and littoral habitats (Bruton 1980). They typically moved to shallow inshore areas at night in order to scavenge (Bruton 1979d).

Breeding: Large numbers of catfish migrate upstream or to lake shores prior to breeding. Courtship, spawning and egg deposition take place at night usually after rain in recently inundated marginal areas (Bruton 1979b). The eggs are adhesive and stick to submerged aquatic plants. Hatching occurs after 24 to 36 hours, the larvae swim after 50 hours and begin to feed at 80 hours. The fry live in inshore vegetated zones (Bruton and Kok 1980). The average fecundity is approximately 45 000 eggs for a 2 kg fish (Bruton 1979b).

C. gariepinus has a high growth rate and a relatively long life-span (Bruton and Allanson 1980) and is known to reach extremely large sizes. Although few specimens exceed 30 kg, the record is a specimen weighing 58,9 kg which was caught in the Vaal River (Bruton 1976).

Feeding: *C. gariepinus* will feed on insects, crabs, plankton, snails and fish, but may also take young birds, rotting flesh, plants and fruits (Bruton 1979a; Bruton et al 1982). *C. gariepinus* is normally an individual bottom forager, but their feeding habits are adaptable and they occasionally feed in groups at the water surface (Bruton 1979a). Young specimens (of less than 200 mm) feed mostly on small invertebrates which are abundant in the shallow inshore areas which they inhabit (Bruton 1979b). Merron (1988) has found that *C. gariepinus* undertakes massive feeding migrations in the upper Okavango Delta when they prey mainly on mormyrid fishes.

Behaviour: *C. gariepinus* is an expert social hunter. They either swim in a regular formation on the water surface, or in a claw-like formation close to shore. In the latter instance the tightly-packed group moves slowly inshore herding a mass of cichlid prey towards the shallow water where they are more easily caught by the catfish which may make use of their pectoral spines to "walk" and the accessory respiratory organ for air-breathing (Bruton 1980).

Bruton (1979d) has demonstrated that in Lake Sibaya this species exhibits a regular diel periodicity, remaining in the deeper areas of the lake during the day and moving into the shallower areas to hunt at night.

During extreme drought conditions *C. gariepinus* survive by breathing air and thrashing the bottom of the pool with their tails in order to deepen the pond (Bruton 1979c).

Impact: Since this species has such generalised feeding habits and is a highly mobile predator, it could pose a threat to indigenous fish and invertebrate populations in areas outside its native range (Hecht 1985). This may especially be the case when *C. gariepinus* is introduced into rivers where endemic species, or species with restricted distributions occur. The presence of *C. gariepinus* in the Tyume River may pose a threat, through competition and predation, to the indigenous rocky, *Sandelia bainsii*, which has a very restricted distribution (Mayekiso 1986) (see section on *Micropterus salmoides* for a detailed description of indigenous and translocated species in this river). Likewise, *C. gariepinus* may have a negative impact on small localised populations of *Sandelia bainsii* and *Barbus pallidus* in the Great Fish River (Laurenson and Hocutt 1986).

Cambray et al (1977) noted that shortly after the opening of the Orange-Fish River tunnel (but prior to the first records of *C. gariepinus* in the Great Fish River) there was a large population of crabs (*Potamonautes perlatus*) present in Grassridge dam. The population levels of *Cyprinus carpio, Labeo umbratus* and *Barbus anoplus* were also very high (Cambray personal communication). Since these three fish species successfully co-exist with *C. gariepinus* in other river systems in southern Africa, it is not expected that their conservation status will be seriously threatened by the introduction of *C. gariepinus* into the Great Fish River but their population densities may decline. Similarly, it can be expected that the introduction of *C. gariepinus* will result in a decline in *Potamonautes perlatus* populations in the Great Fish River. *P. perlatus* successfully co-exists with *C. gariepinus* in Natal rivers (vide Barnard 1950 for distribution of *P. perlatus*).

Since the opening of the Orange-Fish River tunnel the composition of the invertebrate community in the Great Fish River has changed dramatically as a result of the new water flow regime (O'Keeffe and de Moor 1988). It would therefore be difficult to reach conclusions regarding the impact of the introduction of *C. gariepinus* on the invertebrate fauna (F C de Moor personal communication). The findings of Weir (1972) in central Africa suggest that the introduction of *C. gariepinus* can have profound effects on aquatic insect communities. A comparison between the invertebrate fauna of two artificial ponds, into one of which *C. gariepinus* had been introduced, indicated that insect diversity was reduced by 78% in the Coleoptera and by 66% in the Hemiptera in the pond which contained the introduced predator (Weir 1972).

Van As and Basson (1984) have recorded twenty parasite species associated with *C. gariepinus*; of these, one is alien to South Africa (*Argulus japonicus*). The translocation of *C. gariepinus* to new catchments may facilitate the spread of this parasite to new areas.

Control: *C. gariepinus* is very difficult to control because of its omnivorous diet, airbreathing habits, ability to move overland and its burrowing capability. The rapid spread of the walking catfish, *Clarias batrachus*, in the south-eastern states of the USA is testimony to the colonisation ability of clariid catfishes. Fishfarms holding *C. gariepinus* need to be secured with the fence buried at least 30 cm underground to prevent their escape. Catfish farming should be strictly prohibited in the catchments of rivers in which they do not naturally occur. An especially vulnerable area is the catchments of the southerly draining rivers of the southern Cape coast (from the Keiskamma River in the east to the Olifants River in the west). The escape of *C. gariepinus* into these rivers (it is already in the Keiskamma system) will severely threaten the indigenous species flock of redfin minnows, *Pseudobarbus* species. This southern Cape ichthyofauna includes 3 endangered, 3 vulnerable and 7 rare species (Skelton 1987a) and should be strictly protected from invasive predatory fish such as *C. gariepinus*.

Research recommendations: Hecht (1985) recommends that predator/prey impact assessment studies need to be undertaken to quantify the harm this species may cause in areas outside its native range. Hecht has also suggested research into the possibility of developing all-male progeny of this fish through hormonal sex reversal or hybridization so that specimens escaping into natural water courses would not be able to breed. Hybrid crosses between two species are usually sterile and these could be used for aquaculture. Hecht and Lublinkhof (1985) have successfully crossed vundu (*Heterobranchus longifilis*) males with *C. gariepinus* females. Should the hybrid fry be sterile and suitable for aquaculture it would be preferable to introduce this hybrid into new areas. More research needs to be done in this field.

The availability of information on invertebrate and fish communities in Grassridge dam prior to the artificial connection of the Orange and Fish River systems makes this an ideal site for studies on the impact of catfish predation on prey communities in South Africa.

Remarks: The sharptooth catfish is an important and nutritious food source in Africa and is an ideal species for aquaculture because of its catholic feeding habits, hardiness, rapid growth, easy handling and pleasant tasting flesh (Bruton et al 1982). Schoonbee et al (1980) have artificially induced spawning and successfully hatched eggs in an artificial environment. *C. gariepinus* is recommended by Jackson (1980a) as being a suitable species for use in polyculture.

REFERENCES

Barnard (1950); Bruton (1976, 1979a, 1979b, 1979c, 1979d, 1980); Bruton and Allanson (1980); Bruton and Kok (1980); Bruton and van As (1986); Bruton et al (1982); Cambray and Jubb (1977a, 1977b); Cambray et al (1977); Crass (1964); Daget et al (1984); du Plessis and le Roux (1965); Gaigher et al (1980); Hamman (1980); Hecht (1985); Hecht and Lublinkhof (1985); Jackson (1973a, 1980a); Jubb 1967, 1978a); Kruger (1971); Laurenson and Hocutt (1986); Mayekiso (1986); Merron (1988); O'Keeffe and de Moor (1988); Safiel and Bruton (1984); Schoonbee et al (1980); Schrader (1985); Skelton (1987a); van As and Basson (1984); van der Waal (1985); Weir (1972).

Personal communications: A H Bok; J A Cambray; M T T Davies; F C de Moor; K C D Hamman; A Smith.

NOTHOBRANCHIUS ORTHONOTUS (Peters 1844)

spotted killifish
spikkel-kuilvissie

indigenous, equivocal, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Aplocheilidae

SUMMARY

Status: An indigenous species which is found in a few isolated temporary pans in the Kruger National Park and northern Natal. In order to enhance the conservation status of this rare species it has been translocated to pans in the Kruger National Park where it had not previously been recorded. The impact of these translocations has not been studied.

Research: Good. Since this is a well-known aquarium species it has been studied in captivity. Pienaar (1978a) has detailed records of the translocations of this species in the Kruger National Park.

SPECIES DATA

Recent synonyms: *Cyprinodon orthonotus, Fundulus orthonotus* (Daget et al 1986).

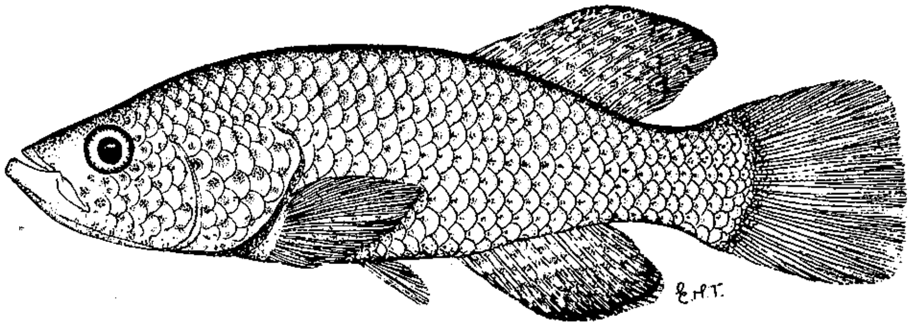
Distinguishing characteristics: An attractive killifish which lays drought resistant eggs. Dorsal fin with 15 to 16 rays, anal fin with 14 to 16 rays, the dorsal fin originating slightly ahead of the anal fin. Lateral line a series of pits. Mouth armed with small teeth and directed upwards when closed. Males an iridescent blue-green colour with maroon or liver-red margins to the scales, the cheeks, dorsal, anal and ventral fins heavily dotted with maroon spots. Dorsal and anal fins edged with white. Females uniformly olive in colour. Both sexes have a golden iris (Jubb 1967). Maximum size 60 to 90 mm (Pienaar 1978a).

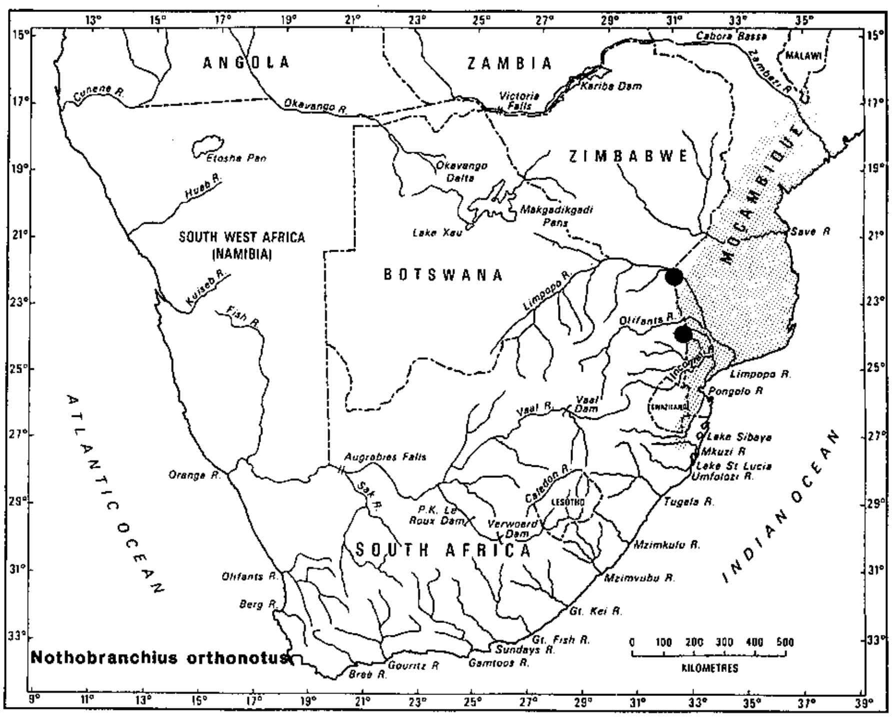
Native range: In scattered localities in the following drainage systems: Lower Shire River in southern Malawi; the Montepuex, Luala, lower Zambezi, lower Limpopo, Pungwe and Incomati Rivers in southern Mozambique; Buzi, Guluene, Sabi, Lundi, Phongolo, lower Limpopo, Mkuze, Mtomene and Incomati Rivers in southern Africa; and the Limpopo and Gueluene systems in south-eastern Zimbabwe (Daget et al 1986). In South Africa *N. orthonotus* has been recorded in the headwaters of the Mtomene River and a small pan at Pumbe picket in the Kruger National Park and the Mkuze River in Natal. This species has also been collected recently in Mboneni Pan in Mkuzi Game Reserve and in the following areas from the Phongolo floodplain: Ndumu Game Reserve, Lake Nhlanjane, Ngwema rainpool, temporary pools in the Nomathasa area, an affluent of Lake Mayazela north-east of Jozini, and near the Makatini Experimental Farm (Skelton 1987a).

Date and purpose of introduction: Translocations were carried out to improve the chances of survival of this rare, endangered species. In April 1975 a number of adults were transferred from the Mtomene pools to a pan at Pumbe beacon and to a pool in the headwaters of the Nhlangulene spruit of the Nwanedze section. In April 1976 about 80 fish were transferred from the pan at Pumbe picket to two Nwambiya pans and one Machayi pan in the Nyandu sandveld (all within the Incomati system in the Kruger National Park). Surveys in March 1977 and February 1978 revealed that this species had successfully colonised both the Nwambiya pans (Pienaar 1978a). These translocations have all been carried out in drainage systems within the native range of this species, but to pans where they had not previously been recorded. Since this species occurs in scattered isolated pans and not in the actual streams of a river system, these transfers can be regarded as translocations (Skelton personal communication).

NOTHOBRANCHIUS ORTHONOTUS (Peters 1844)

FIGURE 44. The spotted killifish *Nothobranchius orthonotus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■ ALBANY MUSEUM RECORD
● LITERATURE RECORD
▲ APPROXIMATE LOCALITY RECORD
NATIVE RANGE

Present distribution: As for native range. Also in the following areas: a pan at Pumbe beacon, a pool in the headwaters of the Nhlangulene spruit of the Nwanedze section, in two Nwambiya pans and one Machayi pan in the Nyandu sandveld. All these localities are within the Kruger National Park in the Incomati catchment.

Habitat preferences: *N. orthonotus* occurs in temporary pans or swamps (Jubb 1981a). The pH levels of the ponds in rhyolitic soils of the Lebombo mountains where this species occurrs are considerably lower (6,7) than those of most of the other ponds in the Kruger Park which are usually alkaline (pH levels up to 8,5 in stagnant pools). This species is found in both running and still water but is particularly partial to low-lying pans or swampy pools (Pienaar 1978a). Daget et al (1986) describe the habitat preferences as being temporary pools, swamps, floodplains, ricefields, ditches and small streams.

Breeding: An annual fish ie the life cycle lasts for less than one calendar year. The fry grow very rapidly and usually reach sexual maturity within 8 to 10 weeks of hatching. A cyclical desiccation of 6 to 8 months appears to be essential as the survival of viable eggs in permanent waters is very low. Spawning takes place as the dry season approaches. The eggs remain in the mud after the pond dries up and only hatch after the onset of rain (Jubb 1981a). Elephants may assist in dispersing the eggs to new areas by means of mud sticking to their hides after bathing in temporary pans (Jubb 1981a). Development may be arrested over several seasons (Bruton and Kok 1980).

Feeding: Their diet consists of mosquito larvae, small crustaceans and other aquatic organisms (Pienaar 1978a).

Behaviour: A slow-moving fish, usually found in sections of a river where marginal and aquatic vegetation provide some cover (probably as a means of avoiding predators) (Pienaar 1978a).

Impact: Their translocation is unlikely to have a serious detrimental impact and is probably desirable because of their rare status.

Control: When translocating this and other indigenous fish species which typically live in endorheic basins, care should be taken to avoid unnecessary mixing of gene pools, which could result in the loss of distinctive population characters.

Research recommendations: Further research should be conducted on the biology of natural populations of *N. orthonotus*.

Since this species is listed as rare in Skelton's (1987a) Red Data Book it may be worthwhile to further promote its popularity in the aquarium trade so that additional breeding populations can be established in captivity. This would at least ensure the species survival in captivity. It is recommended that translocations to catchments outside the native range of this species should be avoided.

Remarks: This species has been introduced into swamplands in other countries (locality not given) as a means of controlling mosquitoes (Pienaar 1978a). See also the account on *N. rachovii* for comments on the survival of species in swampy habitats.

REFERENCES

Bruton and Kok (1980); Daget et al (1986); Jubb (1967, 1981a); Skelton (1987a); Pienaar (1978a).

Personal communication: P H Skelton

NOTHOBRANCHIUS RACHOVII Ahl 1926

blueband killifish
blouband-kuilvissie

indigenous, equivocal, little impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Aplocheilidae

SUMMARY

Status: An indigenous species found in isolated pans in the Kruger National Park. Translocated to some pans where it had not previously been recorded in order to improve the conservation status of this rare species. It is not expected to have a detrimental impact on its new environment.

Research: Good. This species has been intensively studied by aquarists, and translocations in the Kruger National Park have been documented by Pienaar (1978a).

SPECIES DATA

Recent synonyms: *Adinops rachovii, Nothobranchius rachowi* (Daget et al 1986).

Distinguishing characteristics: An attractive killifish which is very popular with aquarists. Upturned protractile mouth, dorsal fin set far back on the body (Jubb 1967). Males brilliantly coloured with a bluish-green iridescence over the dorsal surface and a shimmering greenish-gold lateral surface. Iris golden, throat and chest suffused with crimson. Pectoral fins tipped with white. A series of irregular slanting crimson bars often present over the lateral surface. Dorsal and anal fins with blue marginal zones spotted with irregular dark blue or indigo blotches. Caudal fin in mature males with a distinctive sub-terminal, broad, bright red crescent bordered distally by a marginal deep blue band. Breeding males very dark, almost black. Females a uniform olive or yellowish-brown with a slight greenish iridescence (Pienaar 1978a). Maximum total length 60 mm (Skelton 1987a).

The geographic isolation of populations has resulted in some variation in colouration in specimens from different areas (Jubb 1981b).

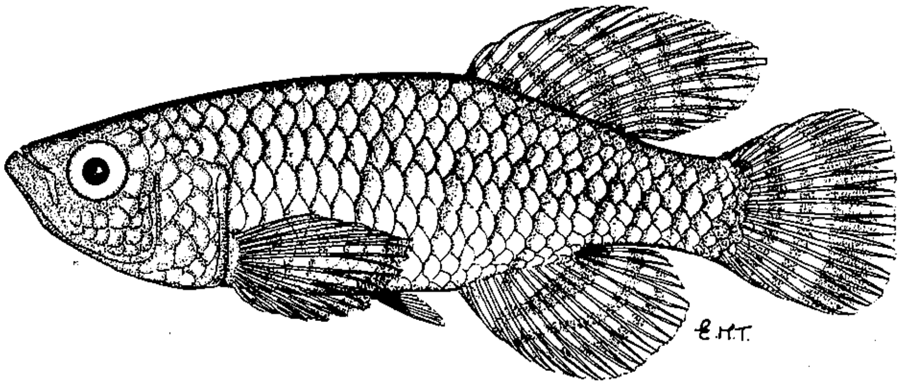
Native range: In scattered localities in the following drainage systems: coastal rivers between (and including) the Zambezi and Limpopo Rivers and the lower Limpopo and lower Olifants River drainages (Daget et al 1986).

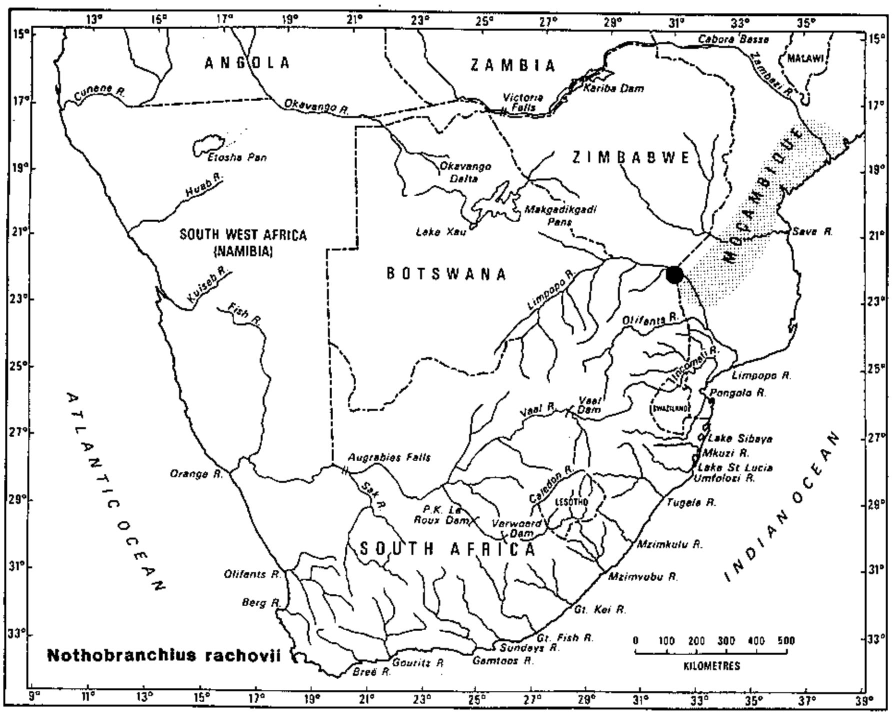
Date and purpose of introduction: This species was translocated to new areas of the Kruger National Park to improve their chances of survival. Recorded from a number of shallow pans in the Pumbe picket area in northern Kruger National Park. In April 1976 thirty fish were transferred from these pans to three pans in the northern Nyandu sandveld area in the Kruger National Park. A survey of this area in March 1977 indicated that the population had not survived as no specimens were collected. In February 1978 about 250 fish were transferred from the Pumbe area to the Nwambiya and Shirombe pans in the northern Nyandu sandveld area (Pienaar 1978a). Although all these localities are within drainage systems which are part of the native range of this species, the fish were transferred to pans where they had not previously been recorded and this can therefore be regarded as a translocation (Skelton personal communication).

Present distribution: In South Africa *N. rachovii* is only found in the northern Kruger National Park in the areas described above. These localities represent the southernmost point of their distribution (Pienaar 1978a).

NOTHOBRANCHIUS RACHOVII Ahl 1926

FIGURE 45. The blueband killifish *Nothobranchius rachovii* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





- ■ ALBANY MUSEUM RECORD
- ● LITERATURE RECORD
- ▲ APPROXIMATE LOCALITY RECORD
- ▒ NATIVE RANGE

Habitat preferences: Shallow natural pans with sandy or pebbly substrata choked with aquatic vegetation (Pienaar 1978a). Temporary pools and swamps (Daget et al 1986).

Breeding: As is the case in all *Nothobranchius* species, this is an "annual" fish. The eggs can withstand desiccation and hatch the following season after rain (Jubb 1981b). Breeding appears to be in March and April (Pienaar 1978a). During spawning the male "embraces" the female with the dorsal and anal fins. The eggs are laid in soft peat or sand, are relatively small, and hatch within five or six months with or without desiccation, or later if kept dry. *N. rachovii* reaches maturity in seven to eight weeks and may live from six to eighteen months in captivity (Skelton 1987a). The dispersal of eggs may be effected by means of elephants transporting eggs (encased in mud) to new pans after a mud bath (Jubb 1981a).

Feeding: The diet consists of mosquito larvae and other small aquatic organisms such as ostracods, crustaceans and small insect larvae (Pienaar 1978a).

Behaviour: Take refuge between fronds of submerged vegetation and forage for food in the small patches of open water around the edges of pans (Pienaar 1978a).

Impact: Their translocation is unlikely to have a serious detrimental impact and is probably desirable because of their rare status.

Control: When translocating this and other indigenous fish species which typically live in endorheic basins, care should be taken to avoid unnecessary mixing of gene pools, which could result in the loss of distinctive population characters. Care should also be taken to avoid the spread of parasites.

Research recommendations: Further research should be conducted on the biology of natural populations of *N. rachovii*. Since this species is listed as rare in Skelton's (1987a) Red Data Book it may be worthwhile to further promote its popularity in the aquarium trade so that additional breeding populations can be established in captivity. This would ensure the species' survival in captivity. It is recommended that translocations to catchments outside the native range of this species should be avoided.

Remarks: These fish are particularly susceptible to man-made changes in the environment. Destruction of its habitat through the draining of swamps as well as the spraying of these waters with toxicants for mosquito control have threatened the continued existence of this species (Jubb 1967).

REFERENCES

Daget et al (1986); Jubb (1967, 1981a, 1981b); Pienaar (1978a); Skelton (1987a).

Personal communication: P H Skelton

ASTATOTILAPIA BREVIS (Jubb 1968)

orange-fringed largemouth
Oranjerand-grootbek

indigenous, beneficial, little impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An indigenous species classified as rare in the Red Data Book (Skelton 1987a). *A. brevis* is endemic to the Incomati system and has been translocated to some tributaries where it had not previously been recorded in order to enhance its conservation status.

Research: Good. Kleynhans (1984) has assessed the conservation status of this species.

SPECIES DATA

Synonyms: *Chetia brevis* (Greenwood 1979).

Distinguishing characteristics: A freshwater cichlid fish. Live males are olive-brown on the dorsal surface, blending to pale silvery olive on the belly. Vertical bars and other body markings dark greenish-brown, top of dorsal fin fringed with orange, the spots and the soft portion of the dorsal fin being the same colour. Spots on anal fin bright vermilion. The females are more silvery in colour and lack the orange fringe to the dorsal fin and spots on the anal fin. The total length of males is between 135 and 150 mm (Pienaar 1978a).

Native range: Incomati River system, confined to the Lomati and Komati Rivers below altitudes of 460 m. Not in the main Incomati or Crocodile Rivers (Pienaar 1978b). *A. brevis* has also been recorded in coastal lakes between the mouths of the Limpopo and Incomati Rivers in Mozambique (Skelton 1987a).

Date and purpose of introduction: Habitats in the limited native range of this species are being degraded by excessive water abstraction, siltation and pollution from agriculture. For this reason some specimens were translocated to protected areas, within the Incomati system but beyond the native range, in order to ensure the survival of the species (Pienaar 1978a; Skelton 1987a). Pienaar (1978a) recorded the following releases within the Kruger National Park:

1. During 1975 100 specimens were transferred from dams bordering the Lomati River to the Stolznek dam (Mlambane spruit, a tributary of the Crocodile River).

2. *A. brevis* were also released into Newu and Mpondo dams at a later date.

Southern African distribution: As for the native range and also present in the Stolznek, Newu and Mpondo dams in the Kruger National Park (Pienaar 1978a and b). The translocated populations in the Kruger National Park are reported to be flourishing (Skelton 1987a).

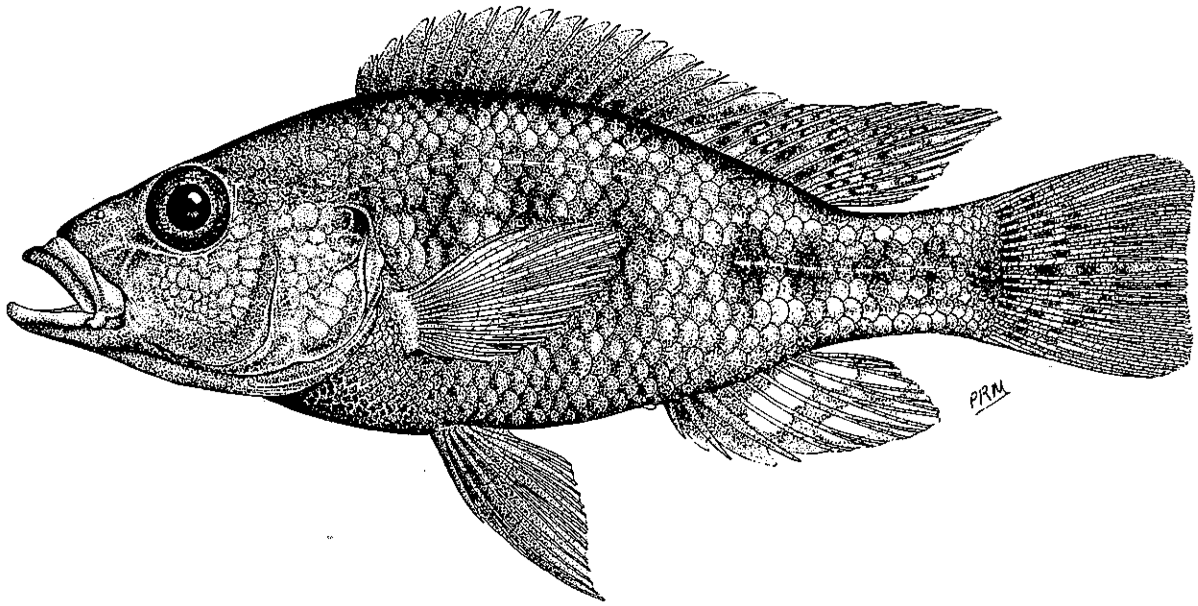
Habitat preferences: *A. brevis* has a preference for pools and quiet stretches of rivers with sandy substrates and dense marginal vegetation (Skelton 1987a).

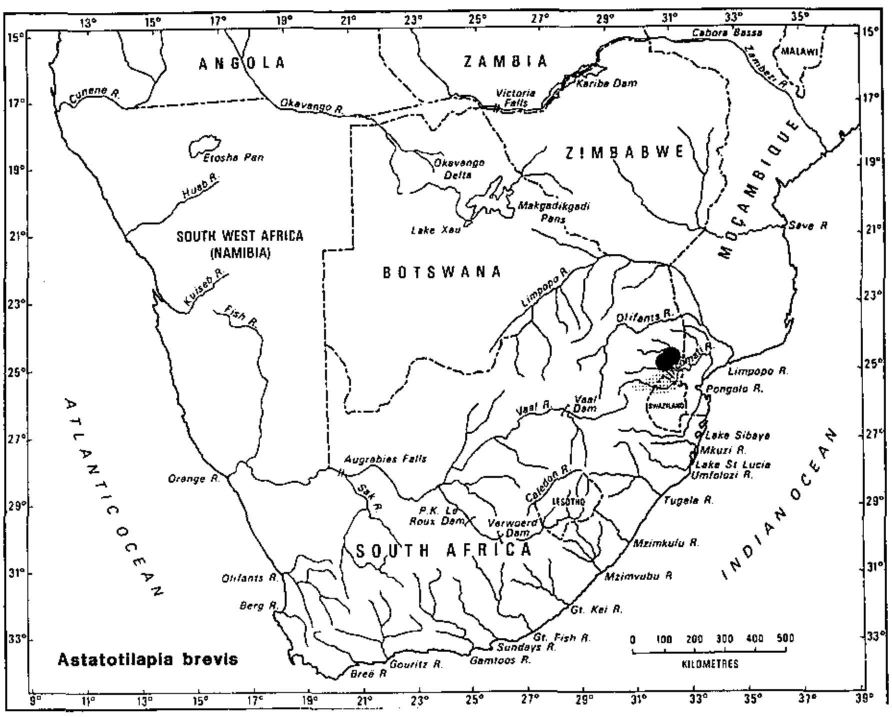
Breeding: *A. brevis* is a maternal mouthbrooding species. The female carries about 80 eggs per brood. Some brooding specimens have been collected in May, but this species is likely to breed throughout the warm months of the year (Pienaar 1978a; Skelton 1987a).

Feeding: *A. brevis* feeds on small fish and aquatic insects (Pienaar 1978a).

ASTATOTILAPIA BREVIS (Jubb 1968)

FIGURE 46. The orange-fringed largemouth *Astatotilapia brevis* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■	ALBANY MUSEUM RECORD
●	LITERATURE RECORD
▲	APPROXIMATE LOCALITY RECORD
(stippled box)	NATIVE RANGE

Impact: The impact of their translocation has not been assessed. Since the translocations are within the same river system as the native range of this species, it is unlikely that they have had a detrimental impact on the introduced environment.

Control: It is not considered that control measures will be necessary.

Research recommendations: The success of the translocations needs to be determined.

Remarks: This translocation is justified as the species is vulnerable to extinction and the introduced range is within the same river system as the native range in the Kruger National Park.

REFERENCES

Greenwood (1979); Kleynhans (1984); Pienaar (1978a, 1978b); Skelton (1987a).

OREOCHROMIS ANDERSONII (Castelnau 1861)

three-spot tilapia
driekol tilapia

indigenous, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An indigenous species which occurs naturally in central Africa as far south as the Zambezi and the Okavango systems. This species was translocated into the Shashi dam (Limpopo system) in Botswana in circa 1973/74 probably for angling purposes.

Research: Good. The numerous studies which have been carried out on this species were reviewed by Philippart and Ruwet (1982).

SPECIES DATA

Recent synonyms: *Tilapia andersonii* (Skelton et al 1985).

Distinguishing characteristics: A large tilapia with three dark spots along the side of the body. Profile of the head nearly straight compared to that of *Oreochromis mossambicus*. General colour greenish above with sides and belly a blue-grey colour. Edges of dorsal and caudal fin red in the breeding season. The lateral spots are more pronounced in smaller specimens. Very small fish are usually silvery-grey with 6 to 8 vertical bars. With growth the colour darkens and the bars blend in with the general colour except for the three spots (Jubb 1967).

Native range: Upper Zambezi, Cunene, parts of upper Zaire (Jackson in press), the Okavango drainage system (Skelton et al 1985) and Lake Liambezi (van der Waal 1985). Occurs in Central West Africa from 12 to 21 S (Philippart and Ruwet 1982).

Date and purpose of introduction: Introduced for aquaculture and angling purposes.

1. Present in the Shashi dam (Botswana) (Shashi River, Limpopo system) (Gilmore 1978). This is not in its native range and *O. andersonii* was not recorded from this locality by Jubb (1967). Probably introduced by the Fisheries Section of the Botswana Ministry of Agriculture in 1973/74 from the Okavango River system (Gilmore 1978). The purpose of this translocation was probably to improve angling.

2. Since 1983 this species has been bred at the hatchery at Hardap dam (SWA) and distributed to the northern parts of that country (Schrader 1985), probably for sport fishing or as a forage fish for bass. Some of these introductions may have been beyond the southern limit of its native range.

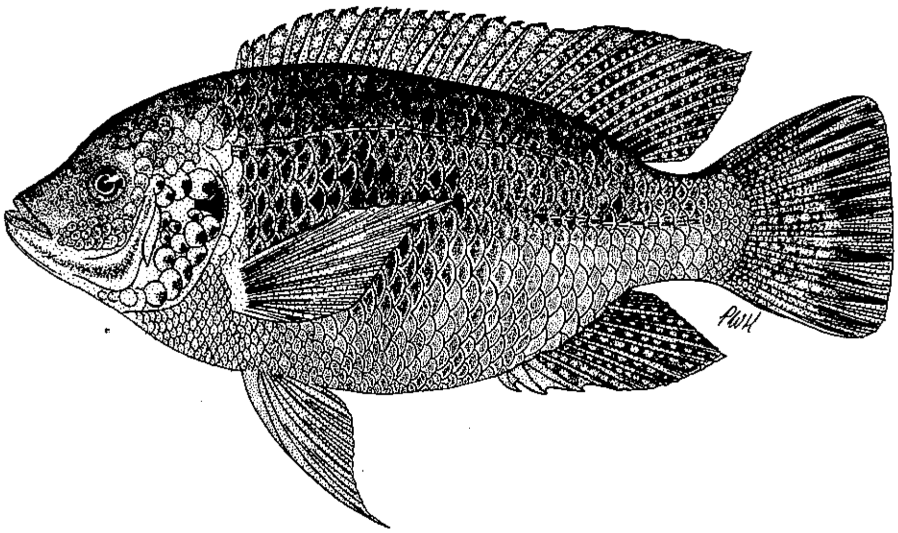
3. Introduced in the region of the confluence of the Vaal and Orange Rivers. The date of introduction was not given, but the fish apparently died out because they were unable to tolerate the low winter temperatures in this region (Philippart and Ruwet 1982).

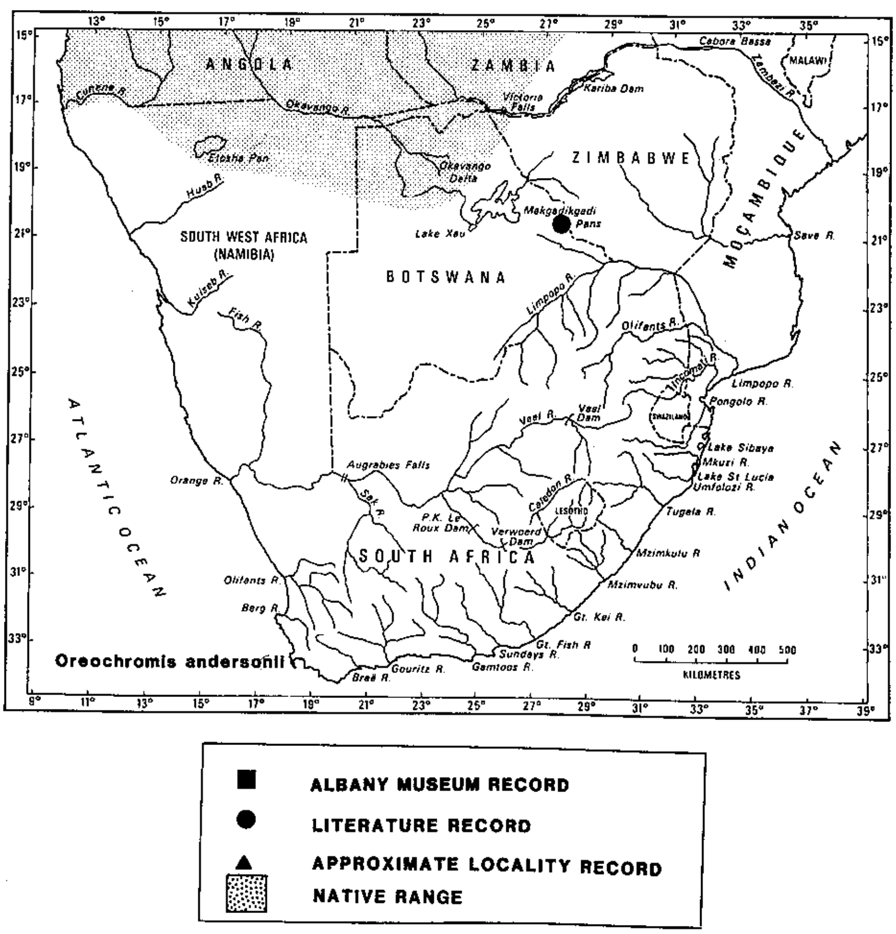
Present distribution: As for the native range and in the Shashi dam (Botswana). May also be in some areas of South West Africa which are south of its native range.

Habitat preferences: Generalised habitat preferences. Widespread in both river and swamp habitats in the

OREOCHROMIS ANDERSONII (Castelnau 1861)

FIGURE 47. The three-spot tilapia *Oreochromis andersonii* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Okavango system (Skelton et al 1985) and one of the first species to colonise newly inundated habitats (Bruton personal observation). Their temperature tolerance in the native range is about 18 to 33°C (Philippart and Ruwet 1982). Essentially a freshwater species and cannot tolerate salinities above 20‰ (Philippart and Ruwet 1982). *O. andersonii* is adapted to fairly fast-flowing rivers and is found in sections of the Kalomo River (Zambezi system) with average slopes of 2,21% and 5,73 % but is absent from areas which are very steep (Philippart and Ruwet 1982).

Breeding: Female mouthbrooder. Nests are saucer-shaped depressions constructed in water between 0,5 to 3 meters deep with up to 40 nests being found together (Merron 1988). In Lake Liambezi females contained ripe ovaries in November, December and March. The main spawning occurs in early summer with a small second spawning at the end of summer (van der Waal 1985). In the Kafue River Chapman et al (1971) found that spawning began at the onset of the rainy season between October and December.

Feeding: A detritivore which feeds on fine particulate matter (Merron 1988). Philippart and Ruwet (1982) describe *O. andersonii* as being an omnivorous feeder in comparison with *Oreochromis macrochir*. There is a great variability in the feeding regime with the diet changing according to the availability of food.

Impact: *O. andersonii* may spread to the Limpopo River but it is not expected to spread far south due to its inability to tolerate low water temperatures. *O. andersonii* is a very adaptable species which thrives in permanent swamps and large rivers as well as in newly inundated shallow pools and small streams. This eurytopy probably means that this species would be a successful invader of new habitats which are within its range of environmental tolerances (Bruton 1986). It is possible that this species could compete with *O. mossambicus* as their habitat and feeding preferences are similar. The danger of interbreeding with other indigenous cichlids such as *O. mossambicus* is real and should be avoided as pure genetic stocks of both species should be conserved.

Control: *O. andersonii* should not be introduced beyond its native range and especially not into catchments in which *O. mossambicus* occurs. Every effort should be made to avoid interbreeding between *O. andersonii* and *O. mossambicus*, which are both ecologically and economically important species in southern Africa.

Research recommendations: Sampling should be carried out in the Shashi dam and upper Limpopo River to ascertain whether this species is present there.

Remarks: *O. andersonii* has been described by Jubb (1967) as a fine angling and table fish.

REFERENCES

Bruton (1986); Gilmore (1978); Jackson (in press); Jubb (1967); Merron (1988); Philippart and Ruwet (1982); Schrader (1985); Skelton et al (1985); van der Waal (1985).

OREOCHROMIS MACROCHIR (Boulenger 1912)

greenhead tilapia
groenkop tilapia

indigenous, detrimental, potential impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: The native range of this central African species extends as far south as the Okavango system. In 1973/74 specimens were translocated from the Okavango system into Shashi dam (Limpopo system). The impact of this species in its new environment has not been assessed, but it may have a major detrimental impact if its range extends further into the Limpopo system.

Research: Good. The general biology has been reviewed by Philippart and Ruwet (1982).

SPECIES DATA

Recent synonyms: *Tilapia macrochir, Sarotherodon macrochir* (Skelton et al 1985).

Distinguishing characteristics: Deep-bodied with a light green body, dark green head with black spots and steep rounded forehead. Juveniles silver-grey with yellowish pelvic and anal fins and 6 to 8 dark vertical bars. Maximum size 2,6 kg (Bruton et al 1982).

Native range: Extends from central Africa as far south as the Cunene, Okavango and upper Zambezi systems (Philippart and Ruwet 1982; Skelton et al 1985).

Date and purpose of introduction: This species has been translocated to new areas for angling purposes.

1. *O. macrochir* was first recorded in the Shashi dam (Botswana) (Shashi River, Limpopo system) in 1977, probably the result of an introduction by the Fisheries Section of the Botswana Ministry of Agriculture in 1973/74 from the Okavango River system (Gilmore 1978).

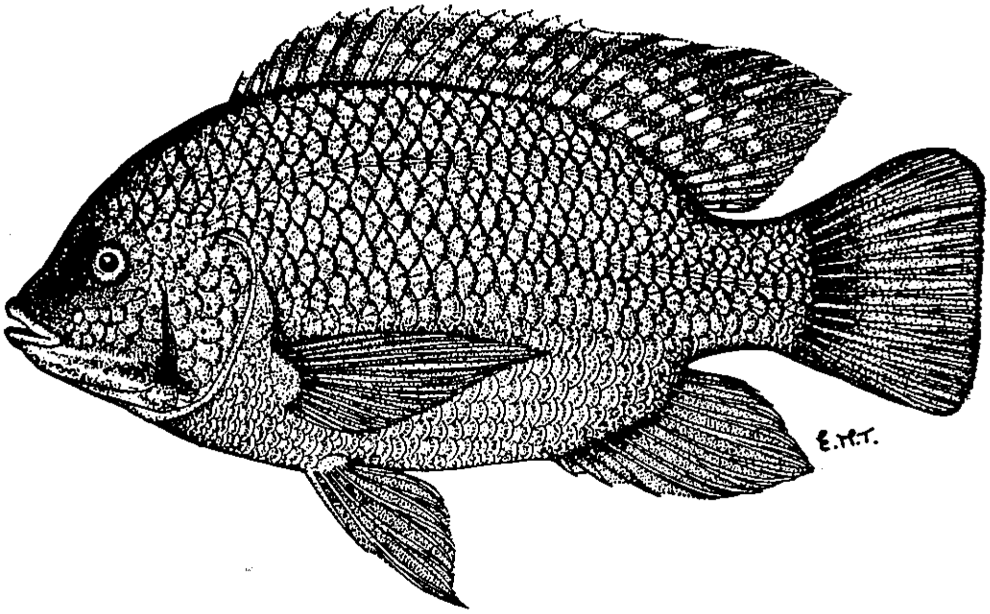
2. Since 1983 *O. macrochir* has been bred at the hatchery at Hardap dam in South West Africa and is available for distribution to the northern parts of SWA (Schrader 1985).

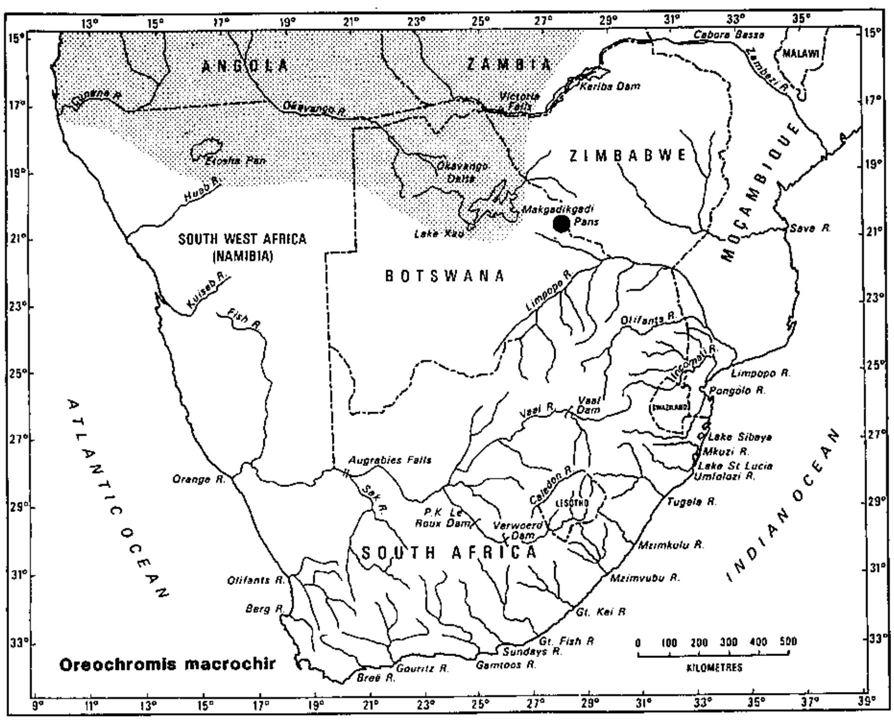
Present distribution: As for native range but also in the Shashi dam (Botswana). Possibly also in northern SWA.

Habitat preferences: Prefers larger permanent waters (Bruton et al 1982). Their optimum temperature range is about 23 to 24°C. In its native range *O. macrochir* is found at temperatures between 18 and 35°C but can tolerate extreme temperatures as low as 11°C in some habitats and in culture ponds. Cannot tolerate salinities of more than 20‰, so this is essentially a freshwater species. *O. macrochir* has been found in fairly saline lakes, but usually migrates to less saline sections of the lake or takes refuge in rivers feeding the lake when salinity levels are very high. *O. macrochir* has also been known to survive in lakes with extremely low salinities (Philippart and Ruwet 1982). The lower lethal limit for dissolved oxygen concentrations is about 0.36 ppm (Chapman et al 1971).

OREOCHROMIS MACROCHIR (Boulenger 1912)

FIGURE 48. The greenhead tilapia *Oreochromis macrochir* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





■ ALBANY MUSEUM RECORD

● LITERATURE RECORD

▲ APPROXIMATE LOCALITY RECORD

NATIVE RANGE

Breeding: *O. macrochir* is a maternal mouthbrooding species. The male constructs a volcano-shaped nest and then attracts the female by displaying in front of the nest. Males court a number of females in succession and females may have more than one mate in the breeding season (Bruton et al 1982). In Lake Liambezi there is evidence that this species can spawn up to six times per year if temperatures remain above 21°C. There are also some indications of an overlap in generations as females which are incubating eggs often have fully developed eggs in their ovaries (van der Waal 1985).

Feeding: Feeds mainly on detritus, finely divided organic material (including protozoa and bacteria), blue-green algae and diatoms (van der Waal 1985). Philippart and Ruwet (1982) regard *O. macrochir* as a fairly specialised feeder on phytoplankton and epilithic algae, and are not as flexible in their feeding habits as many other tilapias.

Behaviour: Migrating schools of *O. macrochir* have been observed in Lake Mweru. It is thought that changes in salinity in certain sections of fairly saline lakes provide the stimulus for such migrations (Philippart and Ruwet 1982).

Impact: *O. macrochir* may spread further into the Limpopo system from the Shashi dam in Botswana. Their southward invasion would probably be checked by their relative intolerance of low temperatures, but the area available for invasion would still be large eg the warmer reaches of the Limpopo, Incomati, Usutu, Phongolo and Mkuze systems. There is a danger that *O. macrochir* may interbreed with economically important fishes such as *Oreochromis mossambicus*. *O. macrochir* is also likely to compete with detritivores, such as tilapias and mullet, for food.

Control: The translocation of *O. macrochir* into catchments beyond its natural range should be prohibited. The threat posed to the Limpopo system by further stockings of Shashi dam should be pointed out to the relevant authorities in Botswana.

Research recommendations: Sampling needs to be done in the Shashi and Limpopo Rivers to ascertain their distribution in southern Africa.

Remarks: *O. macrochir* is regarded as a good eating fish and is used in aquaculture (Bruton et al 1982)

REFERENCES

Bruton (1979e); Bruton et al (1982); Chapman et al (1971); Gilmore (1978); Philippart and Ruwet (1982); Schrader (1985); Skelton et al (1985); van der Waal (1985).

OREOCHROMIS MOSSAMBICUS (Peters 1852)

Mozambique tilapia
Mosambiek-tilapia, bloukurper

indigenous, equivocal, major impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An indigenous species which occurs naturally in the northern and eastern low-altitude areas of southern Africa. Has been translocated for aquaculture and sport fishing and is now widespread in the central highveld areas, southern Cape and northern South West Africa.

Research: Excellent. Since *O. mossambicus* is internationally valued for its aquaculture potential, detailed studies have been done on the general biology, habitat preferences and taxonomic status of this species. This work has been comprehensively reviewed by Trewavas (1983) and Philippart and Ruwet (1982). In South Africa the general biology has been studied by Bruton and Allanson (1974); Bruton and Boltt (1975), Bowen (1978, 1979), Bruton (1979e) and Bowen and Allanson (1982). Detailed assessments of their impact outside their native range have not been done in southern Africa.

SPECIES DATA

Recent synonyms: *Tilapia mossambica, T. natalensis, Sarotherodon mossambicus* (Trewavas 1983).

Distinguishing characteristics: Body depth very variable according to food availability. Colour bottle green above with silvery flanks and belly greyish-white. Three black spots usually visible on flanks. Juveniles silvery with "tilapia spot" on dorsal fin. Breeding males black with white chest, edges of unpaired fins scarlet. Large males with concave snout. Gill rakers short, 17 to 19 on lower part of gill arch. Maximum size 3,3 kg (Bruton et al 1982).

Native range: From the lower Zambezi southwards to the Brak River in the eastern Cape (Jubb 1967; Bruton et al 1982). Occurs far inland in the Transvaal in the Limpopo system, but not in the Orange-Vaal system (Anon 1944).

Date and purpose of introduction: Translocated widely for aquaculture purposes, sport fishing, as a forage fish for bass and as a agent for the biocontrol of macrophytes and chironomids (Anon 1945; Begg 1976; Jackson 1973a; Jubb 1968b; Ashton et al 1986).

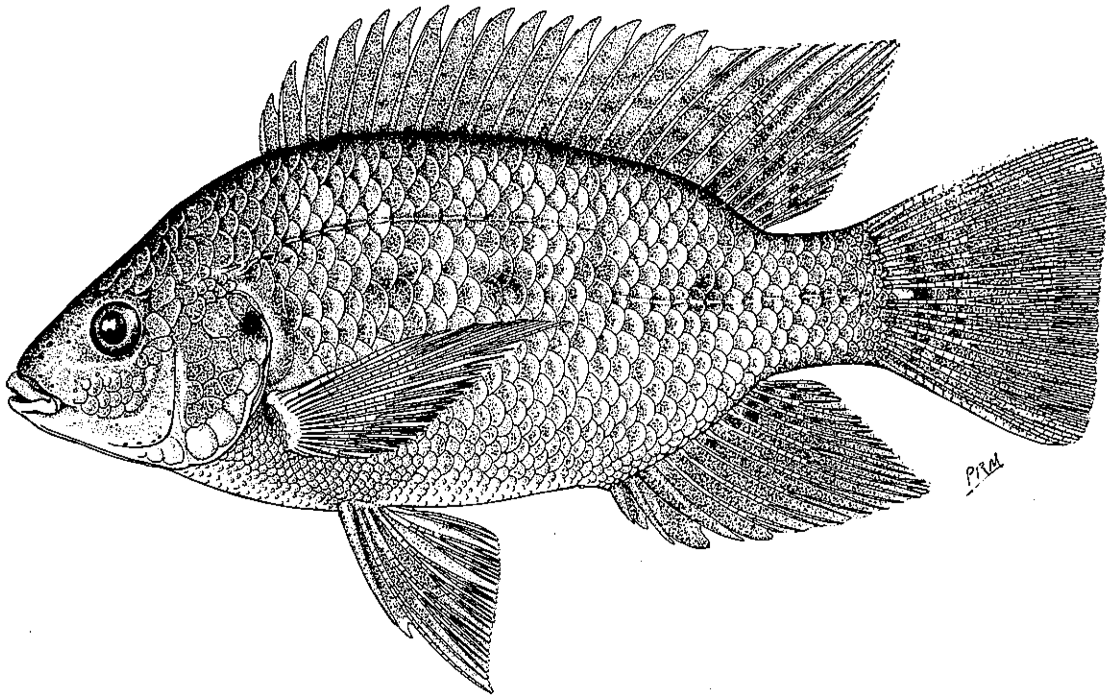
In 1936 *O. mossambicus* were transferred from the Transvaal to farm dams in Malmesbury (Cape). In 1940 some of these fish were transferred to the Jonkershoek Hatchery to be used as breeding stock (Anon 1945). Other hatcheries which have been involved in the breeding and distribution of this species are: Umgeni Warmwater Hatchery (from 1955) (Pike 1980a), the Amalinda Hatchery (East London) (from 1967) (Hamman and Gaigher 1979), Lydenburg Hatchery (from 1950), and the Lowveld Fisheries Research Station (from 1954) (Jubb personal communication). Appendix 10 summarises the initial introductions into various localities in southern Africa:

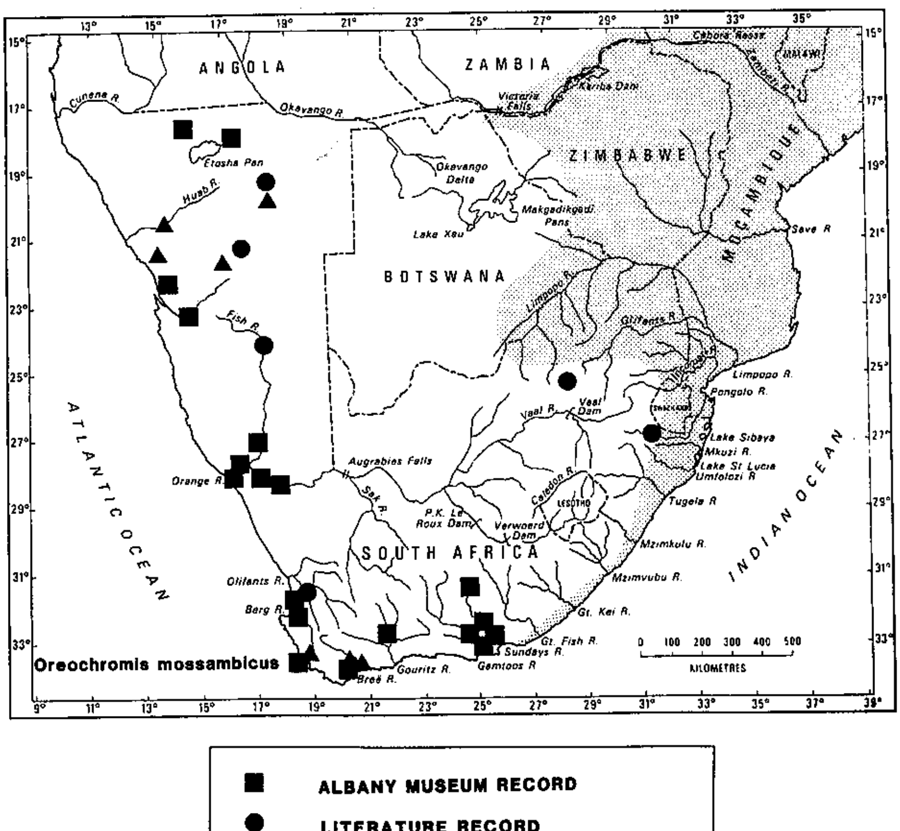
Present distribution: As for native range and in the following localities:

Cape: *O. mossambicus* has not been found in the Orange system except at Vioolsdrift (lower Orange) and in the Fish River tributary (Skelton and Cambray 1981). Present in Sandvlei and Marina canals (Begg 1976), in many impoundments in the lower lying areas of the Eerste, Berg, Bree and Verlorenvlei catchment areas

OREOCHROMIS MOSSAMBICUS (Peters 1852)

FIGURE 49. The Mozambique tilapia *Oreochromis mossambicus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





(Smith personal communication) and on the farm "Rozendal" and the Plant Quarantine Research Station dam (Stellenbosch district) (van Schoor 1969b). *O. mossambicus* were present in North End lake (Port Elizabeth) in 1968 (Jubb 1968b).

In the Olifants system *O. mossambicus* is reported to be present in the Clanwilliam dam and in two farm dams on the Jakkals River. There are also unsubstantiated reports of their presence in the Bulshoek barrage (Smith personal communication). Although this species was recorded in the Jan Diesels River (Crass 1969a), it is not certain whether or not it is still present in this locality.

South West Africa: In six localities in the Kuiseb, Omaruru and Ugab Rivers (central Namib) (Dixon and Blom 1974), Hardap dam (Fish River, Orange system) (Skelton 1981). Widespread in South West African farm dams including the Omatako Omuramba catchment (Shrader 1985), the von Bach dam (Swakop system) and the Omatoko dam (Okavango system) (Skelton and Merron 1984).

Other areas: Their presence in the Hartebeespoort dam (Crocodile River, Limpopo system) (du Plessis and Groenevald 1953; Ashton et al 1985) may be the result of a translocation. *O. mossambicus* occurs naturally in the Crocodile River, but probably would not be present at this altitude. However the building of impoundments has a moderating effect on temperature; *O. mossambicus* was thus able to extend its range. This species may have been translocated into the Hartbeespoort dam after the wall had been completed.

There were reports of *O. mossambicus* being present in the Thamalakane River (Philippart and Ruwet 1982, citing Jubb and Gaigher 1971) and there was an Albany Museum record from this locality. However, a careful examination of Jubb and Gaigher's (1971) paper failed to reveal any reference to a specimen of *O. mossambicus* from the Thamalakane River and when the Albany Museum record from this locality was checked it was found to be an *O. macrochir* which had been mis-identified (Cambray personal communication). It is therefore doubtful that this species does occur in this locality. Merron (personal communication) also doubts the authenticity of the Thamalakane record as this species has not yet been found in the Okavango Swamps despite extensive sampling over the past five years (Skelton et al 1985). It is possible that the population in the Nata River (Botswana) is the result of an early translocation (Jubb and Gaigher 1971).

Habitat preferences: A eurytopic species which is found in rivers, lakes, lagoons and estuaries throughout its range (Bruton et al 1982) but is rarely found in the open sea (Heemstra 1986). *O. mossambicus* tolerates high salinities. Populations in the Brak River were found in water of the same salinity as the sea and in Lake St Lucia at salinites of 120‰. *O. mossambicus* cannot tolerate rapid changes in salinity and is usually absent from estuaries which are permanently open to the sea (Jubb 1965; Philippart and Ruwet 1982). However there are recent reports of a population being established in an open tropical lagoon at Fanning Atoll, Line Islands in the Pacific) (Maciolek 1984). The transition from fresh to saline waters must be gradual for the fish to survive (Crass 1964).

Oreochromis mossambicus favours warm waters (Bruton et al 1982) and is not normally found at high altitudes (Crass 1969a). Their optimum temperature range is from 16 to 30°C and they breed at temperatures of about 20 to 24°C (du Plessis and Groenewald 1953). There have been a number of studies on the limits of temperature tolerance of this species and there are many differences in the results with the lower lethal limit being calculated to be between 11 and 14°C and the upper lethal limit about 38°C. These discrepancies are probably due to different degrees of acclimatization of stocks and also because tolerance to lower temperatures is strongly influenced by the salinity of the water (Trewavas 1983). In a freshwater lake connected to Lake St Lucia mass mortalities occurred at a sustained temperature of 13°C whereas an equally low temperature was tolerated by populations occurring in brackish waters (Bruton and Taylor 1979). A cold-tolerant strain of *O. mossambicus* which can survive temperatures as low as 6 to 8°C occurs in the eastern Cape (Bruton and Safriel 1985; James and Bruton 1986).

The construction of impoundments has a moderating effect on water temperatures (Potgieter 1974). This has probably resulted in *O. mossambicus* extending its range to areas where it would not previously have occurred. Many populations occur in regions which should be beyond the temperature range (eg in the Hartbeespoort dam, Ashton et al 1985). In these areas periodic mass mortalities occur, but apparently sufficient fish survive the winter to breed the following summer (Cochrane 1983).

Oreochromis mossambicus tolerates low dissolved oxygen levels (the minimum lethal limit is about 2,5 ppm) and can utilise atmospheric oxygen when dissolved oxygen levels in the water drop (McVeigh 1980a).

The survival of *O. mossambicus* in isolated pools in the Namib Desert suggests that it is able to tolerate extreme conditions of temperature. Dixon and Blom (1974) noted however that many individuals in these populations showed signs of malnutrition.

Breeding: Breeding starts in spring when nests are excavated by males on the inshore sandy terraces of lakes. In Lake Sibaya during the initial nest-establishment phase of the breeding cycle the males move into the shallow terrace areas of the lake and commence aggressive conflicts prior to nest excavation. Small males are repulsed and return to deeper areas of the lake. The nests are simple hollows in the sand and occur on the deep edge of the terrace among sedges. After a brief courtship the female leaves the nest and mouthbroods the eggs and fry for 14 to 22 days. These are then released as fry into the extreme shallows where they form large shoals. Sexual maturity is reached at a length of between 80 and 120 mm. Nests are usually grouped together in arenas (Bruton and Boltt 1975; Bruton 1979e, 1980).

Feeding: Young *O. mossambicus* feed on zoobenthos and zooplankton whereas adults are mainly detritus feeders but may also take advantage of plankton (Trewavas 1983). There is evidence that juveniles are predominantly bottom-feeders, whereas adults may alternate between bottom-feeding and suspension-feeding. The benthic detritus on which they feed is a mixture of diatoms, bacteria and amorphous material (Bowen 1978, 1979). *O. mossambicus* is also an opportunistic feeder and may feed on aquatic macrophytes, terrestrial flying insects (particularly Coleoptera and Hymenoptera) and planktonic crustacea (Bruton and Boltt 1975). It also feeds on other fish and occasionally cannibalises its own young (Trewavas 1983). De Moor et al (1986) found that at certain times up to about 22% of the gut content was comprised of fish remains. The trophic plasticity of *O. mossambicus* was demonstrated by Bowen and Allanson (1982) who found in Lake Sibaya that *O. mossambicus* moved into a number of different habitats in response to a rising water level and the presence or absence of predators (see "Behaviour" section below). These changes in habitat also coincided with changes in diet.

Behaviour: The fry and juveniles swim in large shoals which normally enter the shallows to feed during the day and retreat to deep water at night. The adult males defend nests in arenas throughout the summer. The mouth-brooding females may form shoals immediately prior to fry release. In common with other tilapias, this species often basks on the water surface on warm days (Bruton 1979e, personal observation).

Bowen and Allanson (1982) found that this species displays considerable behavioural and trophic plasticity. In Lake Sibaya the normal diel pattern of behaviour was for *O. mossambicus* to move into the shallows to feed during the day and to move back to deeper waters at night, but when the lake level rose this pattern of behaviour was reversed, probably as a means of avoiding the principal predator, *Clarias gariepinus* which, after the rise in water level, had begun to move into the newly inundated shallow areas during the day. Later, when the lake level rose even further, *O. mossambicus* again moved into the inundated marginal grassland areas where fish predators did not occur.

Impact: Crass (1969a) has observed that *O. mossambicus* competes with indigenous *Barbus* species in the Jan Diesels River, and Gaigher et al (1980) reported that *O. mossambicus* had a "detrimental effect on angling and probably the other (indigenous) species" in Cape rivers. Other than these casual observations there have been no detailed studies on the impact of *O. mossambicus* in areas into which it has been introduced in southern Africa.

Twenty five species of parasites have been found on *O. mossambicus* in southern Africa. Of these the following are probably alien parasites recently introduced into southern Africa: *Ichthyobodo* species, *Ichthyophthirius multifilis, Trichodina acuta* and *Lernaea cyprinacea* (van As and Basson 1984). It is possible that the introduction of *O. mossambicus* into new localities has also assisted the spread of these parasites.

The introduction of *O. mossambicus* into North End lake (Port Elizabeth) resulted in the successful control of excessive populations of chironomids. The numbers of Cladocera were also noted to decrease (Jubb 1968b). This was probably due to the feeding of *O. mossambicus* on floating scums of algae in which chironomid larvae are found, as suggested by Trewavas (1983). An increase in the populations of piscivorous birds, particularly the white-breasted cormorant (*Phalacrocorax carbo*), the southern black-backed gull (*Larus dominicanus*) and little egret (*Egretta garzetta*) at the lake, was also noted. Populations of *O. mossambicus* in this lake later declined because of excessive pollution and other factors (Jubb 1968b).

There is a danger of hybridisation between *O. mossambicus* and other closely related species in the areas into which it has been translocated. There have been no definite records of hybrids in natural waters but there is a possibility that *O. mossambicus* will interbreed with *O. macrochir* and *O. andersonii* in the northern river systems of South West Africa. Competition with indigenous cichlids for spawning grounds and for food would also be likely (Schrader 1985).

Since *O. mossambicus* is present in the Omatako dam as well as in many isolated pans in the Omatako Omarumba drainage (which is linked to the Okavango River during flood conditions), it is probable that this species will reach the Okavango drainage system. This is likely to result in hybridisation with *O. andersonii* and subsequent genetic pollution of stocks of the latter species in the Okavango system (Skelton and Merron 1984).

Oreochromis mossambicus is one of the most phenotypically plastic fishes, if not vertebrates, known and it has proved to be a most successful and vagile invader (Bruton 1986). Breeding populations have become established beyond its natural range in many parts of Africa and Asia, as well as in North and South America, Australia and Oceania (Welcomme 1981). This species has caused considerable damage to indigenous species in many parts of the world where it has escaped into natural watercourses (Trewavas 1983), and is internationally classified as a pest (Welcomme 1984).

Although the translocation of this species into new areas is generally considered to be undesirable for conservation purposes, it must be noted that *O. mossambicus* is a very popular angling fish, being the favoured fish amongst 26,1 % of anglers surveyed in the Transvaal (Ashton et al 1986). The translocation of *O. mossambicus* into new areas may be favourable for sport fishing.

Control: *O. mossambicus* together with carp and largemouth bass are all present in pans in the Omatako Omuramba area of northern South West Africa and all three species pose a serious threat to the Okavango system. Serious consideration should be given to the elimination of these fish by means of rotenone.

Translocations of *O. mossambicus* within southern Africa should be avoided as it is important to retain the genetic integrity of local stocks.

Research recommendations: A comprehensive survey of the pans in the Omatako Omuramba area should be carried out in order to establish the precise distribution of this species as well as *C. carpio* and *M. salmoides* which are also present in the area. The feasibility of eliminating these fish from this area should be assessed.

More detailed studies need to be conducted on the impact of *O. mossambicus* in areas where it has been translocated, particularly in the Jan Diesels River.

Remarks: Because of its rapid growth, excellent palatability and catholic diet, *O. mossambicus* is highly valued for aquaculture and has been introduced into many parts of the world (Trewavas 1983). When used in aquaculture it is necessary to control their breeding in order to prevent stunting of fish in ponds (Bruton et al 1982). This is often achieved through the rearing of infertile hybrids (George 1976). Some hybrids used in aquaculture are, however, fertile and *O. mossambicus* has been hybridised with nine alien tilapias many of which are fertile (Pike 1983b).

In 1981 "red tilapia" hybrids (*Oreochromis mossambicus* x *Oreochromis niloticus*) were imported from Taiwan to the Umgeni Hatchery. These fish have not been released into the wild but the intention is to develop the strain and make it available to fishfarmers at a later date. *O. mossambicus* is able to interbreed with this hybrid (Pike 1981, 1983a). The escape of these hybrids into natural waters could therefore genetically contaminate wild stocks of *O. mossambicus*. The consequences of this contamination are difficult to predict but they may reduce the fitness of wild stocks.

It is important that certain strains of *O. mossambicus* (such as the cold tolerant strain) should be protected throughout the world (Bruton and Safriel 1985; James and Bruton 1986).

REFERENCES

Anon (1944, 1945, 1950b); Ashton et al (1985, 1986); Begg (1976); Bowen (1978, 1979); Bowen and Allanson (1982); Bruton (1979e, 1980, 1986); Bruton and Allanson (1974); Bruton and Boltt (1975); Bruton and Kok (1980); Bruton and Safriel (1985); Bruton and Taylor (1979); Bruton et al (1982); Cochrane (1983); Crass (1964, 1969a); Deathe (1962); Dixon and Blom (1974); de Moor et al (1986); du Plessis and Groenewald (1953); Gaigher (1975b); Gaigher et al (1980); George (1976); Hamman and Gaigher (1979); Heemstra (1986); Jackson (1973a, 1982, in press); James and Bruton (1986); Jubb (1965, 1967, 1968b); Jubb and Gaigher (1971); Maciolek (1984); McVeigh (1980a); Philippart and Ruwet (1982); Pike (1980a, 1981, 1983a, 1983b); Potgieter (1974); Schrader (1985); Skelton (1981); Skelton and Cambray (1981); Skelton and Merron (1984); Skelton et al (1985); Trewavas (1983); van As and Basson (1984); van Rensberg (1963, 1966a); van Schoor (1969b); Welcomme (1981, 1984).

Personal communications: J A Cambray; R A Jubb; G S Merron; A Smith; P H Skelton.

SERRANOCHROMIS (SARGOCHROMIS) CODRINGTONI (Boulenger 1908)

green happy
groen happie

indigenous, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An indigenous species which occurs naturally in central Africa as far south as the Okavango and Zambezi Rivers. Translocated from the Okavango system to the Shashi dam on the Limpopo system (Botswana) in circa 1973/74 for the purpose of sport fishing.

Research: Fair. The taxonomy of this species is in a state of flux. A description of *Haplochromis codringtoni* and its general biology has been given by Bell-Cross (1975).

SPECIES DATA

Recent synonyms: *Paratilapia codringtonii, Sargochromis codringtoni, Haplochromis codringtoni, Tilapia woosnami* (Skelton et al 1985).

Distinguishing characteristics: Teeth slender and recurved, two rows on both jaws. Lower jaw protrudes beyond upper jaw. Snout and forehead light to olive green. Dorsal surface of body grey to olive green, belly off-white or light green. Cheek and operculum light green to light blue. Dorsal, caudal, pectoral and pelvic fins light greyish-green. Anal fin light grey-green with several rows of brown spots. Gold to red margin on dorsal fin of adults. Rust spot at base of scales on dorsal surface of body. Breeding males have yellow to golden ventral surface. Head, dorsal surface and caudal fins dark olive green to black. Dorsal and anal fins with red margins. Their maximum weight in upper Zambezi tributaries was 1,1 kg (Bell-Cross 1975).

Native range: Upper and middle Zambezi, Kafue and Okavango River systems (Bell-Cross 1975).

Date and purpose of introduction: *S. codringtoni* was recorded in the Shashi dam (Botswana) (Shashi River, Limpopo system) by Gilmore (1978) although this species was not recorded in this locality by Jubb (1967). Probably translocated from the Okavango system by the Botswana Ministry of Agriculture in 1973/74 (Gilmore 1978).

Present distribution: As for the native range and in the Shashi dam (Botswana).

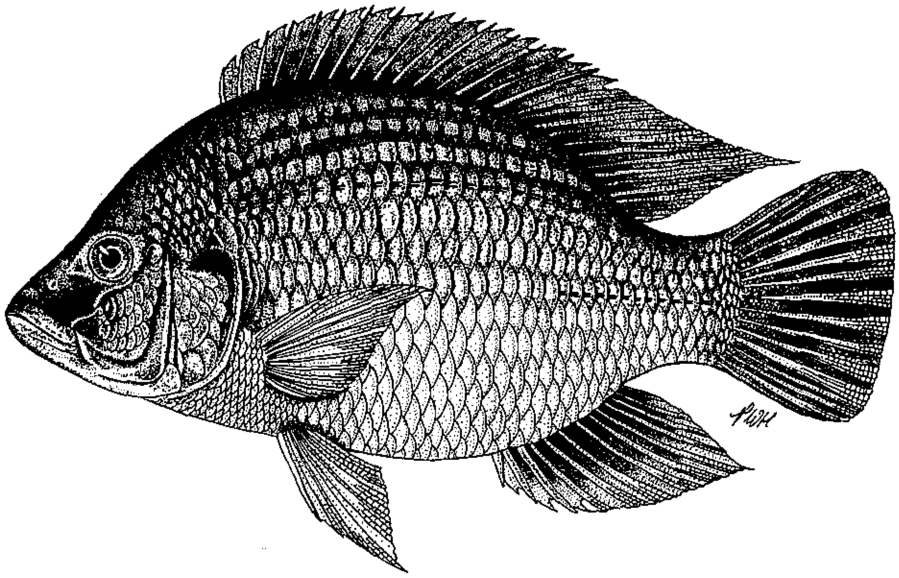
Habitat preferences: Found in shallow fringes of the Okavango Delta in heavily vegetated areas (Merron 1988).

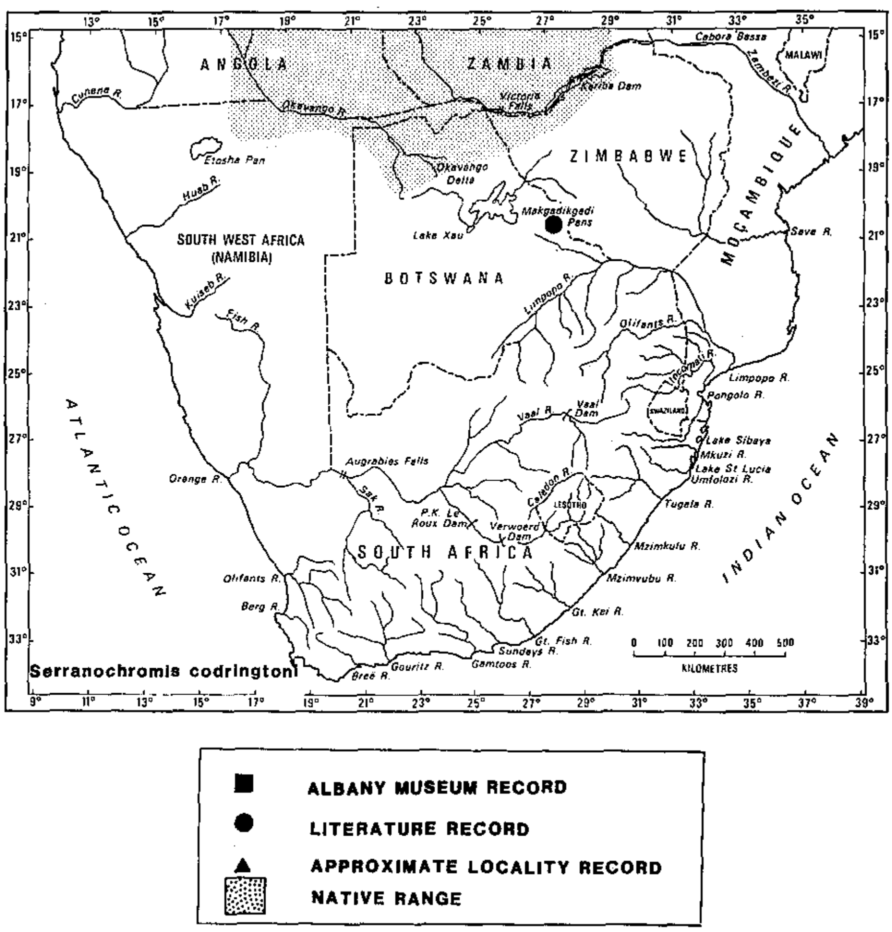
Breeding: The spawning season lasts from September to March in Lake Liambezi. A mouth-brooder which constructs simple oval or round nests. Green happies may spawn more than once per year (van der Waal 1985). In Zimbabwe breeding commences after the first rains in October/ November and a second spawning occurs in December/January. Ovarian egg counts vary from 300 to 850 (Bell-Cross 1975).

Feeding: In Lake Liambezi stomach content analyses revealed that this species feeds on *Nymphaea* seeds, water insects, molluscs and fish material (scales of large cichlids) (van der Waal 1985). Bell-Cross (1975) found that the main component of the diet was aquatic insect larvae and concluded that the presence of fish scales in the gut did not necessarily indicate that this species was a fish predator as the scales could be picked up

SERRANOCHROMIS CODRINGTONI (Boulenger 1908)

FIGURE 50. The green happy *Serranochromis codringtoni* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





accidentally during feeding.

Impact: The impact of *S. codringtoni* in the Shashi dam is unknown but it can be predicted that this predator could have a significant impact on feeding relationships in the Limpopo system if it becomes more widely established.

Control: Efforts should be made to prevent *S. codringtoni* from spreading further into the Limpopo system. The Shashi dam should be stocked with fish species which are indigenous to the Limpopo system.

Research recommendations: The record in the Shashi dam needs to be confirmed. Collections also need to be made to ascertain whether this species has spread further into the Limpopo system.

Remarks: *S. codringtoni* does not naturally occur in South Africa and it should be regarded as an alien species which should not be introduced into natural waters in this country.

REFERENCES

Bell-Cross (1975); Gilmore (1978); Jubb (1967); Merron (1988); Skelton et al (1985); van der Waal (1985).

SERRANOCHROMIS (SERRANOCHROMIS) ROBUSTUS JALLAE (Boulenger 1896)

nembwe
nembwe

alien, equivocal, potential impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An alien species which occurs naturally as far south as the Okavango and Zambezi systems. Translocated in the 1960's and 1970's to the Shashi dam (Botswana), Natal and the western Cape for sport fishing. *S. r. jallae* is an aggressive predator and could have a major detrimental impact on rare endemic species in western and southern Cape rivers should its range be extended to these areas. The nominotypical subspecies *S. r. robustus* has also been translocated from Lake Malawi to an impoundment in Swaziland.

Research: Good. The taxonomy and general biology have been reviewed by Trewavas (1983) and the populations in the western Cape were monitored by van Schoor (1969b). Merron (unpublished) has studied this species in the Okavango Delta, Botswana. Distribution records in southern Africa are, however, poorly documented.

SPECIES DATA

Recent synonyms: *Hemichromis jallae, Paratilapia robusta, Paratilapia thumbergi, Paratilapia zambesensis, Pelmatochromis ngamensis, Serranochromis thumbergi, Serranochromis robustus* (Skelton et al 1985).

Distinguishing characteristics: A robust and deep-bodied cichlid fish with two tooth rows in the jaws. Colour olive above, belly pale. Dorsal and caudal fins with light yellow or white margins, and orange-red spots on the soft rays. Anal fin with bright orange-red spots grouped on the dorsal part of the soft rays. Maximum size 3,3 kg, 400 mm SL, usually less than 2 kg (Bruton et al 1982). This subspecies (*S. r. jallae*) is distinguished by the chrome yellow colour on the throat and belly in breeding males. For a more detailed description of *S. r. jallae* and *S. robustus robustus* see Trewavas (1964). The description which follows is of *S. r. jallae*.

Native range: *S. r. jallae* is found in Mossamedes (Angola), Okavango, Upper Zambezi, Kafue, Luangwa system (Middle Zambezi) and in the Bangweulu region (Trewavas 1964).

Date and purpose of introduction: Introduced for angling purposes (Bourquin et al 1984). It was hoped that this species would augment or replace introductions of *Micropterus salmoides* in farm dams (van Schoor 1969b).

The following major introductions have been made:

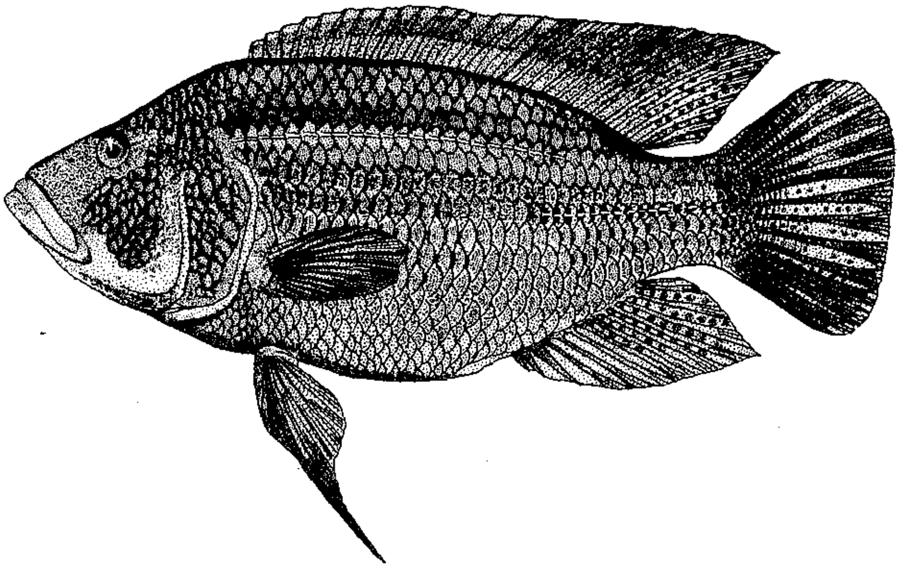
1. Reported by Gilmore (1978) to be present in the Shashi dam (Shashi River, Limpopo system, Botswana), although this species was not listed by Jubb (1967) as being present in this locality. They were probably introduced by the Fisheries Section of the Botswana Ministry of Agriculture in 1973/74 from the Okavango River system (Gilmore 1978).

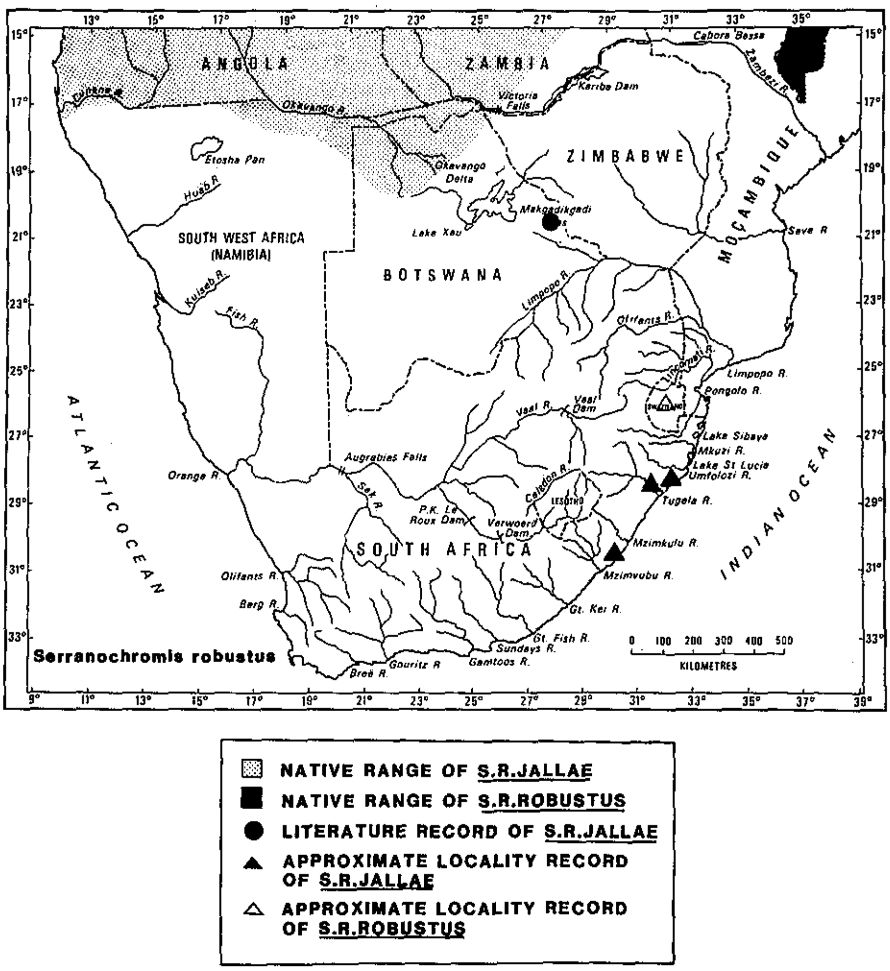
2. Introduced into Swaziland in 1975. Details of the localities were not given (Committee for Inland Fisheries of Africa, 1985).

3. Imported into Natal from Zimbabwe in the early 1960's (Bourquin et al 1984). Bred at the Umgeni Hatchery and later introduced into farm dams in the Eshowe, Empangeni and Port Edward districts (Pike 1980a, 1983a, Pike personal communication).

SERRANOCHROMIS ROBUSTUS JALLAE

FIGURE 51. The nembwe *Serranochromis robustus jallae* with the distribution of *S. r. jallae* and *S. r. robustus* in southern Africa (excluding Zimbabwe and Mozambique).





Pike personal communication).

4. In 1965 *S. robustus jallae* were sent from the Umgeni Hatchery to Jonkershoek (Stellenbosch) and were introduced into farm dams in the western Cape (van Schoor 1969b).

Details of introductions into specific localities are given in Appendix 15 .

Present distribution: A single specimen was caught in a farm dam in the Empangeni district in 1985 (Skelton personal communication). Sampling in 1968 in the Stellenbosch district indicated a survival rate of approximately 84 % in four farm dams (1966 stocking) and 12% from stocking on Rozendal farm (van Schoor 1969b). Therefore, it is likely that populations still exist in this area although there was apparently some winter mortality. Smith (personal communication) has no recent records of the presence of this species in the Stellenbosch district. Their present distribution outside their native range is probably as follows: Shashi dam (Botswana) and certain areas in Swaziland. Also present in Eshowe, Empangeni and Port Edward districts (Pike personal communication). Their presence in the Eerste River catchment in the western Cape needs further confirmation.

Habitat preferences: *S. robustus jallae* lives in well-vegetated areas or near submerged trees or rocks in the quieter reaches of rivers (Bruton et al 1982). Merron (1988) found, however, that *S. r. jallae* is found in faster-flowing rivers in the Okavango Delta than *S. thumbergi*. Although there was some winter mortality in populations in the Stellenbosch district, van Schoor (1969b) regards this species as being more tolerant of low temperatures than *Oreochromis mossambicus*. Their exact lower lethal temperature tolerances are not known.

This species is adversely affected by turbid conditions, probably because poor visibility interferes with its ability to see its prey (van Schoor 1969b).

Breeding: *S. r. jallae* is a female mouth-brooding species which breeds several times in a single season (van Schoor 1969b; Bell-Cross 1976; Bruton et al 1982). In Lake Liambezi ripe females were collected in January and March and ripe males from November to April. Their nests are simple saucer-shaped depressions approximately 30 cm across and are constructed amongst dense submerged vegetation on sandy substrates. Territorial males guard the nests (van der Waal 1985).

Feeding: A predator which feeds on small fish and invertebrates (Bruton et al 1982).

Behaviour: The nembwe normally conceals itself in vegetation and lunges out to more open areas to capture prey (Bruton et al 1982). Large specimens have also been observed to "patrol open waters of rivers and lakes", but do not move far from the shore-line (Trewavas 1964).

Large fish were found to be very pugnacious in captivity and could not be transported in small containers because of their aggressive behaviour (van Schoor 1969b).

Impact: Since there are no large indigenous predatory freshwater fish in western and southern Cape rivers, the impact of *S. robustus jallae* on smaller prey species would probably be more devastating in this area than in Natal and the Limpopo system where large indigenous predators such as *C. gariepinus* and (in some areas) *Hydrocynusforskahlii* occur.

Control: *S. r. jallae* is an aggressive predator which could potentially cause a great deal of harm to indigenous fish communities, and should therefore not be stocked beyond its native range.

Research recommendations: Distribution records need to be updated in the areas into which this species has been introduced.

Remarks: *S. r. jallae* is valued as an angling fish (Bruton et al 1982). Van Schoor (1969b) found that this species was more delicate than many other cichlids and does not survive rough handling.

There have been reports that the subspecies, *S. r. robustus*, which is endemic to Lake Malawi, has been introduced into the Sand River Dam in Swaziland (Welcomme 1981; Skelton personal communication), and it is now established in that locality (Jubb personal communication, Skelton personal communication). The native range of *S. r. robustus* and its distribution in Swaziland is indicated in Figure 51 by cross-hatching and open circles respectively.

REFERENCES

Bell-Cross (1976); Bourquin et al (1984); Bruton et al (1982); Committee for Inland Fisheries of Africa (1985); Gilmore (1978); Jubb (1967); Merron (1988); Pike (1980a, 1983a); Skelton et al (1985); Trewavas (1964); van der Waal (1985); van Schoor (1969b); Welcomme (1981).

Personal communications: M M Coke; R A Jubb; T Pike; P H Skelton; A Smith.

SERRANOCHROMIS ANGUSTICEPS (Boulenger 1907)

thinface largemouth
kleingesigte grootbek

indigenous, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An indigenous species which occurs naturally in central Africa as far south as the Cunene, Okavango and Zambezi Rivers. Translocated into the Shashi dam (Botswana) in circa 1973/74.

Research: Poor. Since the taxonomy of this species is in a state of flux there is confusion over their identification. The general biology has been poorly studied, but publications are in preparation by G S Merron on the biology of this species in the Okavango Delta.

SPECIES DATA

Distinguishing characteristics: A narrow-headed cichlid with a concave dorsal head profile and large, oblique mouth. Dorsal colour light olive to brown; belly pink to off-white. Mouth, cheek and gill covers with brown to red spots, especially in females. Breeding males with black ventral surface and pelvic fin. Maximum size 2,5 kg (Bruton et al 1982).

Date and purpose of introduction: Recorded by Gilmore (1978) as being present in the Shashi dam (Shashi River, Botswana, Limpopo system). These fish were probably introduced by the Botswana Ministry of Agriculture from the Okavango system in 1973/1974 (Gilmore 1978).

Native range: Zaire River in Zambia, upper Zambezi, Kafue and Cunene Rivers. Also in the Okavango Swamps (Bruton et al 1982; Skelton et al 1985).

Southern African distribution: As for native range and in the Shashi dam (Botswana). There have been no further records from the Limpopo system.

Habitat preferences: *S. angusticeps* prefers well-vegetated swamps and the edges of rivers. Also found in fast-flowing reaches over sand and rocks (Bruton et al 1982).

Breeding: A mouthbrooding species which breeds in spring (Jubb 1967).

Feeding: An active predator of small fish, shrimps and insects (Bruton et al 1982).

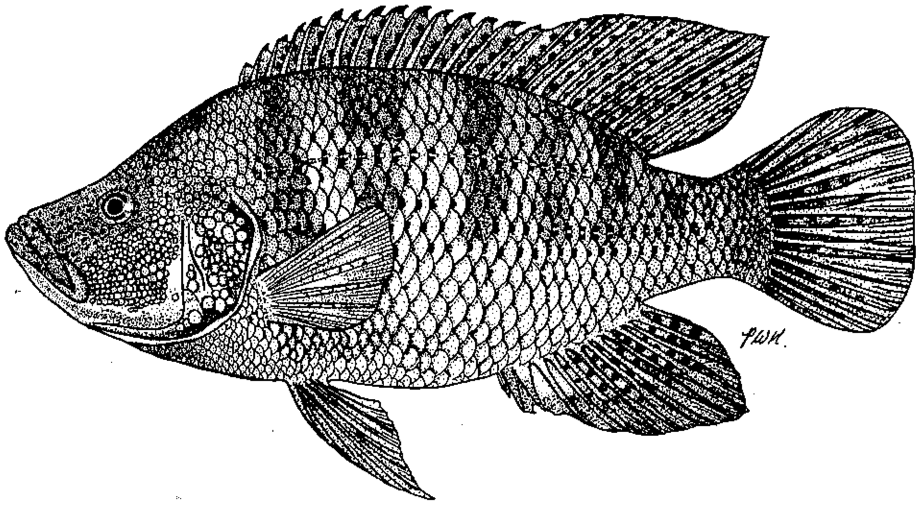
Behaviour: *S. angusticeps*, with its narrow body and large mouth, is perfectly adapted for hunting among dense aquatic plants for its prey. They are cryptic fish which may enter shallow water to feed.

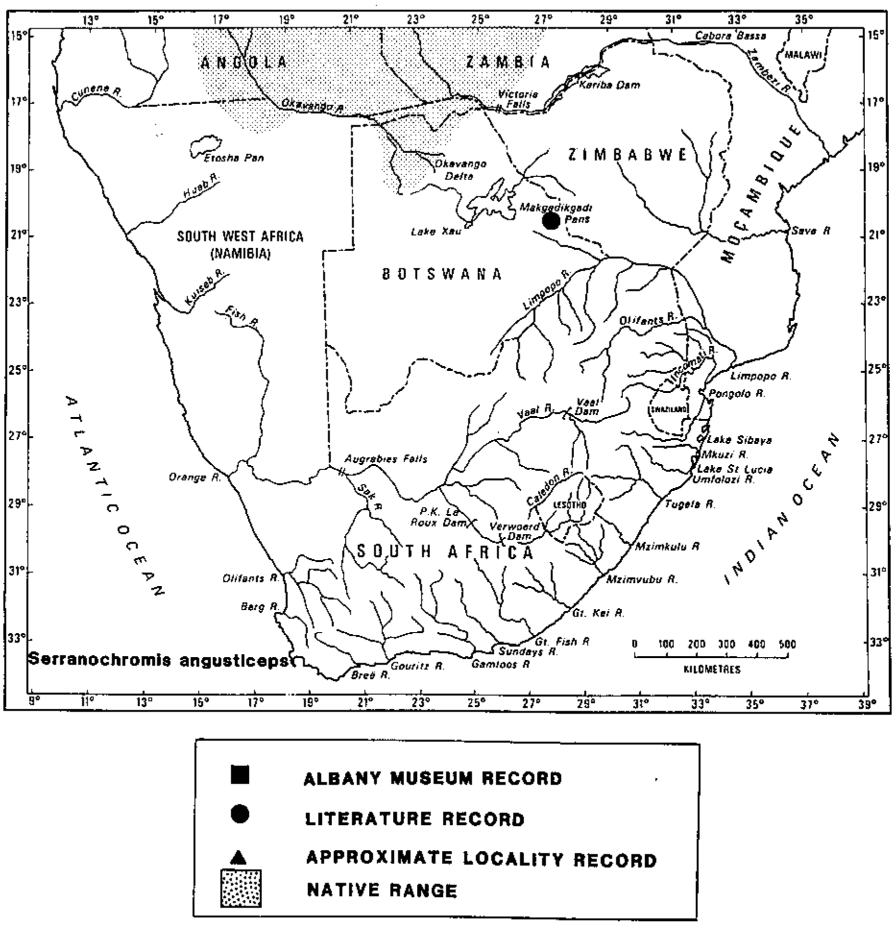
Impact: The impact of *S. angusticeps* in the Shashi dam is unknown but it can be predicted that this predator could have a significant impact on feeding relationships in the Limpopo system if it becomes more widely established.

Control: Efforts should be made to prevent *S. angusticeps* from spreading further into the Limpopo system. The Shashi dam should be stocked with fish species which are indigenous to the Limpopo system.

SERRANOCHROMIS ANGUSTICEPS (Boulenger 1907)

FIGURE 52. The thinface largemouth *Serranochromis angusticeps* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Research recommendations: Distribution records need to be updated to determine whether this species has spread further into the Limpopo system.

REFERENCES

Bruton et al (1982); Gilmore (1978); Jubb (1967); Skelton et al (1985).

SERRANOCHROMIS (SERRANOCHROMIS) THUMBERGI (Castelnau 1861)

brownspot largemouth
bruinkol-grootbek

indigenous, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An indigenous species which occurs naturally as far south as the Okavango-Zambezi system and was translocated in 1973/74 into the Shashi dam on the Limpopo system in Botswana. The impact of this translocation has not been assessed.

Research: Poor. Bell-Cross (1976), van der Waal (1985) and Merron (1988) have provided notes on the general biology of this species but there have been no detailed studies on its habitat preferences or its biology.

SPECIES DATA

Recent synonyms: *Chromys thumbergi, Paratilapia thumbergi, Paratilapia robusta, Serranochromis thumbergii* (Skelton et al 1985).

Distinguishing characteristics: A slender cichlid species. Large oblique mouth with two rows of small conical teeth on the side of the upper jaw and several rows in front. Generally olive-yellow on the flanks and belly with a dark olive-brown dorsal surface. In some specimens there is a dark lateral band. Anal fin with bright red spots; markings of a darker red occur in the dorsal and caudal fins, the former being edged with bright yellow. Breeding males have an overall yellow appearance and brighter colours (Jubb 1967).

Native range: Upper Zambezi, Kafue and Cunene Rivers (Jubb 1967). Although du Plessis and Groenewald (1953) reported that this species occurred in the western parts of the Limpopo system, there is some doubt about these records as *S. thumbergi* has not been collected there during extensive expeditions to the Limpopo (Hecht personal communication). It is now thought that the Limpopo system is not part of the native range of this species (Skelton personal communication).

Date and purpose of introduction: The presence of this species in the Shashi dam (Shashi River, Limpopo system) was reported by Gilmore (1978). There were later unconfirmed reports in the "Sunday Mail" (Zimbabwe) of this species being caught in the Shashi River (Jubb personal communication). It is possible that this species was included with the translocation (described by Gilmore 1978) of a number of species from the Okavango system to the Shashi dam in 1973/74 by the Botswana Ministry of Agriculture. Although the presence of *S. thumbergi* in the Shashi dam was noted by Gilmore (1978), it was not listed as being one of the newly translocated species, possibly because he thought that the western Limpopo system was part of the native range of this species.

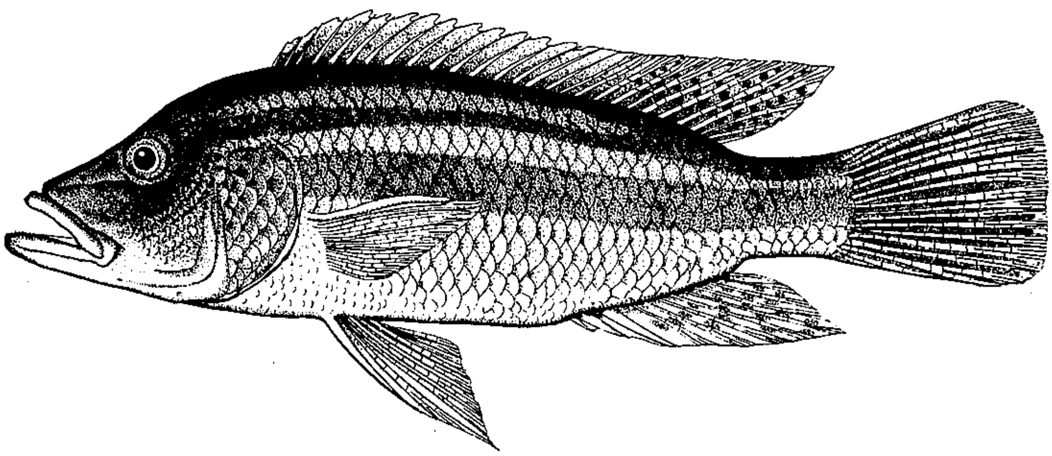
S. thumbergi is listed as being one of the species which was translocated from the Cunene River into South West Africa (van der Waal 1977). This translocation needs further confirmation.

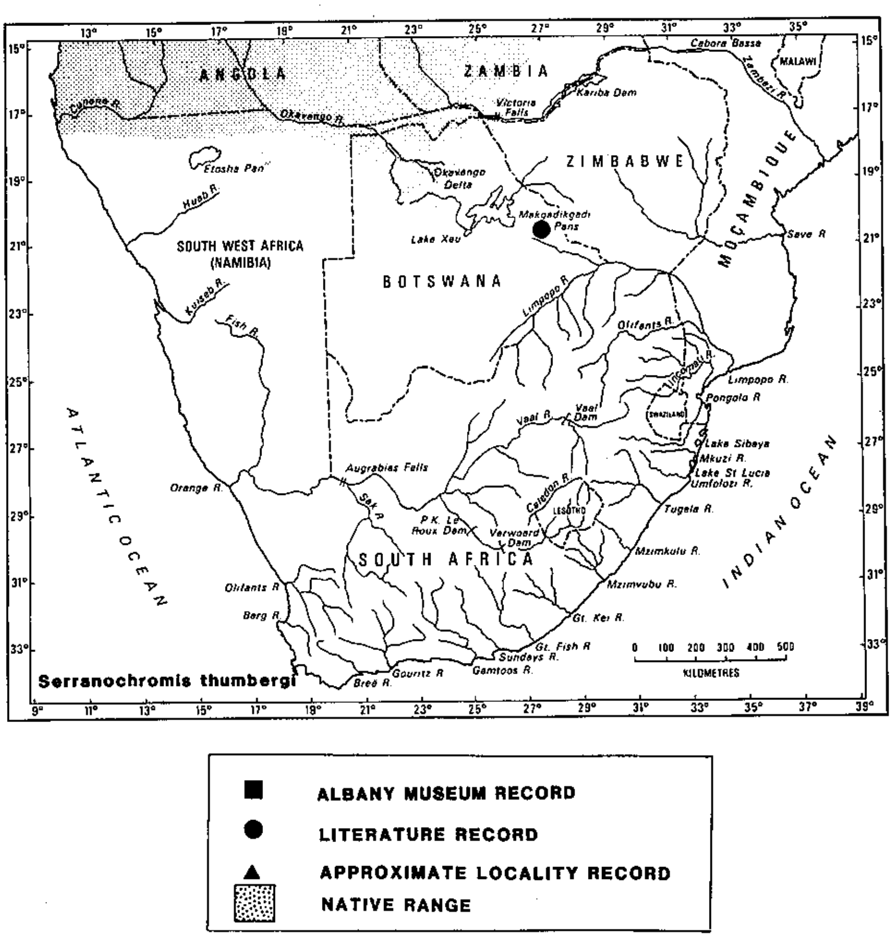
Present distribution: As for native range and in the Shashi dam and the Shashi River (Botswana). The latter record needs confirmation.

Habitat preferences: The habitat preferences of this species are strongly influenced by the presence or absence of tigerfish (*Hydrocynus forskahlii*). In areas where the latter species is absent *S. thumbergi* is found in open

SERRANOCHROMIS THUMBERGI (Castelnau 1861)

FIGURE 53. The brownspot largemouth *Serranochromis thumbergi* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





waters, and may occasionally be found in fast-flowing rocky habitats. In the upper Zambezi and Okavango systems where tigerfish occur *S. thumbergi* is relegated to lagoons, backwaters and marshy shallow areas (Bell-Cross 1976). These observations have been confirmed by Merron (1988) who notes that in the Okavango system the presence of both *H. forskahlii* and *S. robustus* may influence the habitat preferences of *S. thumbergi*. The fact that the latter species does not occur in the same habitat as *S. robustus* may be the result of avoidance of competition (rather than avoidance of predation) with this closely-related species.

Breeding: Described as a mouth-brooding species by du Plessis and Groenewald (1953) but Merron (personal communication) notes that, in five years of sampling fish in the Okavango system, he has never found mouth-brooding specimens of *S. thumbergi*, so he describes this species as a nest-guarder rather than a mouth-brooder.

In Lake Liambezi ripe females were collected from November to January and ripe males almost throughout the year. Nests are constructed in leks in sandy bays at a depth of 1 to 2 m. Approximately 20 to 50 nests spaced 50 to 150 cm apart were observed in single bays. The nests are simple saucer-shaped depressions about 20cm in diameter. A multiple spawner (van der Waal 1985).

Feeding: A predatory species which feeds on small fish, insects and snails (du Plessis and Groenewald 1953). Stomach content analyses on specimens from Lake Liambezi also revealed the presence of plant material and detritus (van der Waal 1985). In 52 specimens analysed, no prey fish longer than 50 mm were found and as many as 74 *Oreochromis macrochir* fry were collected from a single stomach. This species apparently favours young fry (van der Waal 1985).

Behaviour: A fighting angling fish in areas from which tigerfish are absent (Bell-Cross 1976).

Impact: This predatory species could have a deleterious impact on prey populations in the Limpopo River if it colonises this river system.

Control: *S. thumbergi* is alien to South Africa and efforts should be made to prevent its entry into the Limpopo system. The Shashi dam should be stocked with fish species indigenous to the Limpopo system.

Research recommendations: The record in the Shashi River needs confirmation.

REFERENCES

Bell-Cross (1976); du Plessis and Groenewald (1953); Gilmore (1978); Jubb (1967); Merron (1988); Skelton et al (1985); van der Waal (1977, 1985).

Personal communications: T Hecht; R A Jubb; G S Merron; P H Skelton.

TILAPIA GUINASANA Trewavas 1936

Otjikoto tilapia
Otjikoto-kurper

indigenous, equivocal, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An indigenous species, classified as endangered by Skelton (1987a), which was introduced from Lake Guinas to Lake Otjikoto in South West Africa.

Research: Good. Skelton (1987a) has reviewed the literature on this species. A study on populations in Lake Guinas and Lake Otjikoto is presently being carried out by Dr A J Ribbink.

SPECIES DATA

Distinguishing characteristics: A tilapiine cichlid reaching 140 mm TL. The colour and pigmentation of this species is extremely variable from a uniform dark greenish-black or olive-brown with darker vertical bars to specimens which are vividly particoloured in white, blue, yellow and black. There are one or two series of scales on the cheeks (Skelton 1987a).

Native range: Only occurs naturally in Lake Guinas (19 14S, 17 18E) in South West Africa (Skelton 1987a).

Date and purpose of introduction: This species has been introduced from Lake Guinas into Lake Otjikoto. The date and purpose of this introduction is unknown, but *T. guinasana* was not present in collections from Lake Otjikoto made in 1936 and was first collected in this locality in 1967 (Skelton 1987a, 1987b). *T. guinasana* has also been translocated into some farm dams and reservoirs in northern South West Africa (Skelton 1987a).

Present distribution: In Lake Guinas, Lake Otjikoto and may also be present in some farm dams in northern South West Africa.

Habitat preferences: Found in deep sinkhole lakes with moderately clear water. Water temperatures measured in these lakes range from 19 to 27°C (Skelton 1987a).

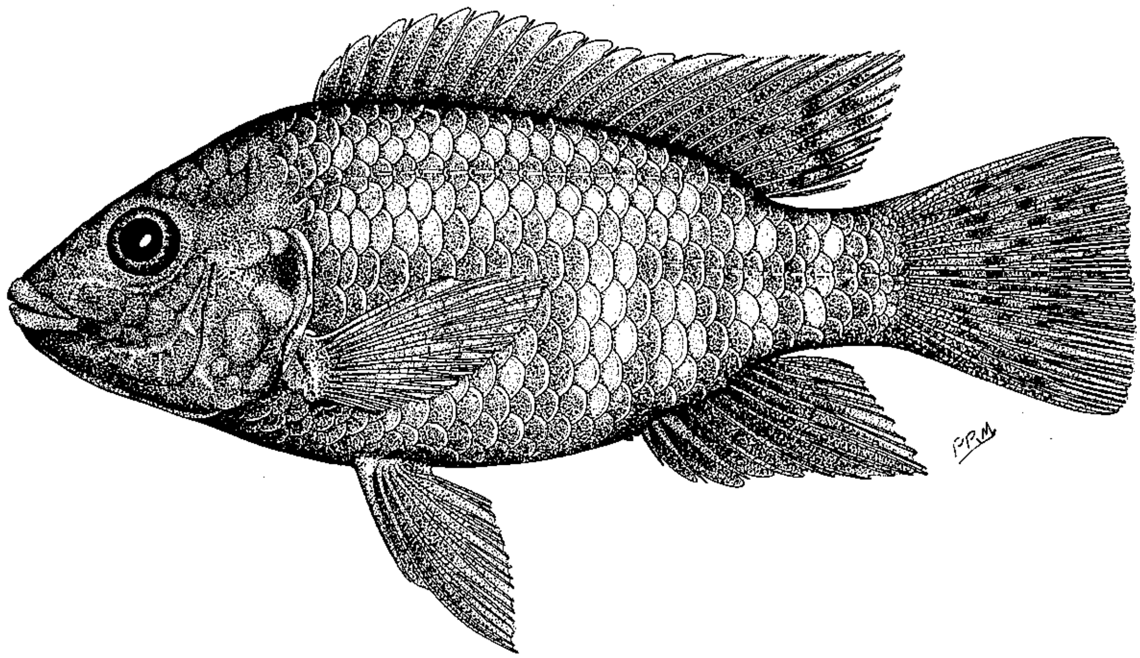
Breeding: *T. guinasana* is a substrate spawner and nest guarder. Nests are built on narrow rocky ledges and competition for these nest sites is intense. This species can hybridise with *T. sparrmanii* and fertile offspring are produced from these crosses (Skelton 1987a).

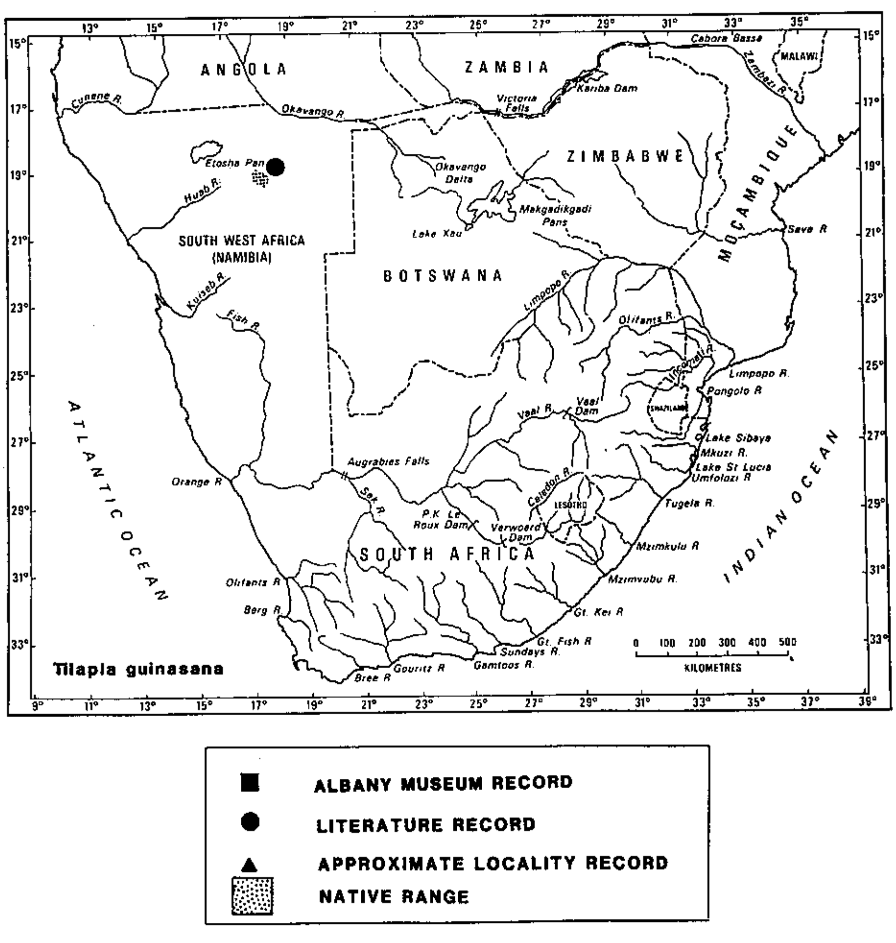
Feeding: Feeds mainly on algae and allochthonous material (Skelton 1987a).

Impact: Originally the only species present in Lake Otjikoto was *Pseudocrenilabrus philander* (Skelton 1987b). It is probable that the introduction of *T. guinasana* would have had some negative impact on this species due to competition. However since these two species have different nesting sites (*P. philander* makes nests in sand or mud) the competition is not very intense, and on a recent expedition to Lake Otjikoto *P. philander* was found to be present in reasonable numbers (Ribbink personal communication). The recent introduction of *O. mossambicus*, *Poecilia reticulata* and *Xiphophorus helleri* into Lake Otjikoto is likely to have a more serious negative impact on *P. philander* (Skelton 1987b; Ribbink personal communication).

TILAPIA GUINASANA

FIGURE 54. The Otjikoto tilapia *Tilapia guinasana* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Control: Since this species is classified as endangered in Skelton (1987a) it would not be desirable to attempt to control the population in Lake Otjikoto.

Research recommendations: Skelton (1987a) recommended that an investigation be undertaken into the biology and ecology of *T. guinasana* in Lake Guinas and Lake Otjikoto. This is presently been carried out by Dr A J Ribbink of the JLB Smith Institute of Ichthyology.

Remarks: Because this species is known to occur only in two sinkholes which are both subject to human interference, *T. guinasana* has been classified as endangered by Skelton (1987a).

REFERENCES

Skelton (1987a, 1987b).

Personal communication: A J Ribbink.

TILAPIA RENDALLI SWIERSTRAE Gilchrist and Thompson 1917

southern redbreast tilapia
rooibors-tilapia

indigenous, equivocal, major impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An indigenous cichlid species which occurs naturally as far south as the Limpopo, Mkuzi and Incomati systems. *T. r. swierstrae* has been translocated to areas in the Transvaal and Natal beyond its native range, where it has had a major detrimental impact due to its destruction of aquatic vegetation.

Research: Excellent. The general biology has been reviewed by Philippart and Ruwet (1982). Studies on the environmental degradation caused by excessive populations of this species have been performed by Junor (1969), Potgieter (1974) and Batchelor (1978).

SPECIES DATA

Recent synonyms: *Tilapia rendalli, Tilapia melanopleura, Tilapia melanopleura rendalli* (Skelton et al 1985).

Distinguishing characteristics: A deep-bodied tilapia with a red chest, upper half of caudal fin paler than lower half. Mouth small. Gill rakers 8 to 12 as in *Tilapia sparrmanii* but only 5 to 6 vertical bars on the flanks. Prominent "tilapia spot" usually present throughout life. Juveniles plain silvery, but throat and belly become red in larger fish. Adults olive above with scales outlined in light brown. Dorsal fin with greyish spots and thin red margin. Caudal fin green above, red or yellowish below. Maximum size 2 kg. Two subspecies occur, *T.r. rendalli* and *T. r. swierstrae*, the former being distinguished by the red colouration of the lower half of the caudal fin and the latter by the yellow colouration in the same area (Bruton et al 1982).

Native range: *T. rendalli* occurs from tropical Africa (Bruton et al 1982) as far south as the lower Phongolo River in the east (Batchelor 1978) and the Cunene River in the West (Safriel and Bruton 1984). The subspecies *T. rendalli swierstrae* occurs from the Limpopo system south to the Mkuzi (including Lake Sibaya) (Bruton et al 1982) and also in the Incomati system to altitudes of about 1000 m (Potgieter 1974).

Date and purpose of introduction: *T. r. swierstrae* has been used for the biological control of aquatic macrophytes (Pike 1986) and has also been introduced for mosquito control (Bourquin 1985). Stocks obtained from the Phongolo pans were bred in the Umgeni Hatchery (Natal) in 1952 and in 1955 these were distributed to various water bodies in Natal (Pike 1980a), especially in the warm coastal regions (Bruton and Kok 1980).

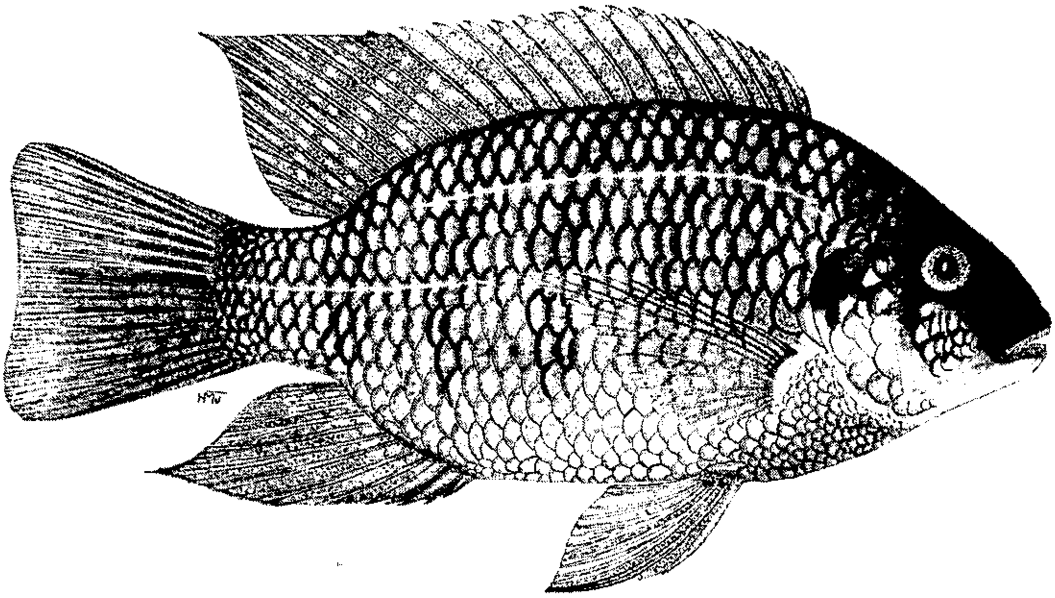
Tilapia r. swierstrae has been bred at the Lydenburg and Marble Hall hatcheries and stocked in various farm dams on the highveld (Potgieter 1974). Appendix 11 summarises localities into which this species has been introduced.

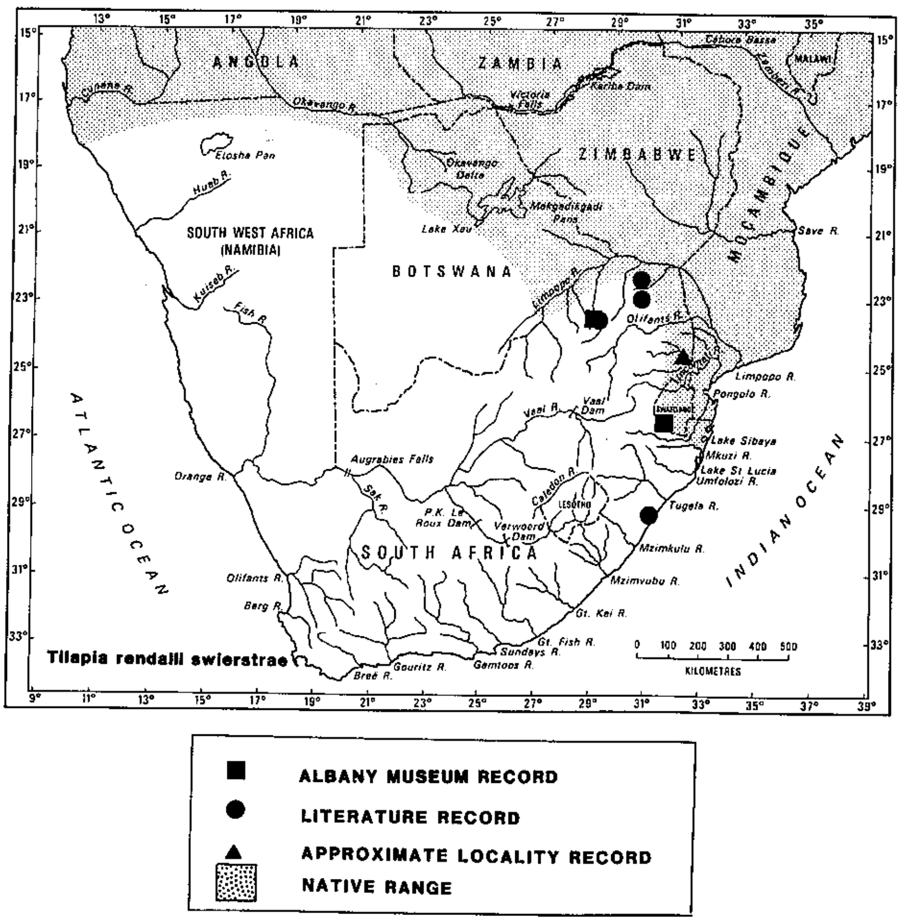
It is debatable whether or not the Klipkoppies, Longmere, Njelele and Hans Merensky dams (see Appendix 11) are within the native range of this species. Although there have undoubtedly been numerous other stockings in the Transvaal highveld and Natal, there are no definite records of these.

Present distribution: As for the native range and also in the Doorndraai dam (near Potgietersrus), the dams on the Witrivier mentioned above, the Hans Merensky dam, a small impoundment in Durban and on numerous farm dams in the Transvaal highveld and Natal.

TILAPIA RENDALLI SWIERSTRAE Gilchrist and Thompson 1917

FIGURE 55. The southern redbreast tilapia *Tilapia rendalli swierstrae* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Habitat preferences: A warm water species. Favours fresh water, but can survive in brackish conditions (Bruton et al 1982). *T. r. swierstrae* has been found in natural habitats in salinities up to 8 ‰. In laboratory conditions this species can tolerate salinities up to 19‰. They are not as tolerant of high salinities as *O. mossambicus* and would not be able to tolerate sea water. This intolerance prevented the colonisation of estuaries via the sea as is probably the case for *Oreochromis mossambicus*. Their salinity tolerance is related to temperature, the maximum tolerance being at 20 to 28°C (Whitfield and Blaber 1976; Philippart and Ruwet 1982).

Although Batchelor (1978) reported that temperatures as low as 12°C were tolerated, Philippart and Ruwet (1982) give the temperature range (in natural habitats) as 13,5 to 36,0°C but also state that temperatures from 11,0 to 40,5°C could be tolerated in some habitats and culture ponds.

Since larger water bodies tend to have a moderating influence on temperatures, the building of impoundments has led to the spread of *T. r. swierstrae* to new areas at higher latitudes and altitudes than would be expected from its intolerance of low temperatures (Batchelor 1978). This species favours lacustrine environments or the slower-moving reaches of rivers (Batchelor 1978).

Breeding: A monogamous species (Jackson in press). Breeding activity was only observed at temperatures above 21°C (Batchelor 1978). In Maputaland *T. r. swierstrae* breeds between October and March. The male digs a series of small pits as well as a central large pit. It is not known whether or not the female assists in nest building. The eggs are deposited in the pits and are guarded and fanned. The fry form independent shoals in underwater plant beds (Bruton and Kok 1980). The eggs and young are guarded by both parents (Bruton et al 1982). This species breeds 3 or 4 times a season with approximately 5000 to 6000 eggs being laid at each breeding session (McConnell 1955 in Batchelor 1978). After hatching the female moves the fry from one brood chamber to another (Potgieter 1974). In tropical and subtropical regions the breeding season starts before the rainy season (Philippart and Ruwet 1982).

Feeding: The juveniles feed on plankton and the adults feed mostly on macrophytes but also on algae, insects and crustaceans (Bruton et al 1982). Junor (1969) found in Lake Kyle (Zimbabwe) that *T. r. swierstrae* is predominantly herbivorous but also preyed on the fry of many fish species as well as on adults of smaller fishes such as *Barbus lineomaculatus, B. paludinosus, B. trimaculatus* and *Beirabarbus radiatus*.

Batchelor (1974) noted that severe food shortages (for this species) occurred when dam levels dropped sharply and marginal vegetation became unavailable. Potgieter (1974) found that *T. r. swierstrae* makes use of both aquatic and fringing vegetation and also occasionally consumes insects and fish fry, especially during October when many young fish are present in dams.

Impact: *T. r. swierstrae* has been known to rapidly denude dams of aquatic vegetation, which has a detrimental effect on populations of other fish and on aquatic birds which depend on floating vegetation for refuge and/or nest building (Junor 1969; Batchelor 1978). This species was accidentally introduced into Madagascar, and in three years had devastated nearly 3000 ha of *Ceratophyllum* and *Nymphaea* beds. This resulted in the almost total disappearance of a valuable indigenous fish, *Paretropus petiti* (Philippart and Ruwet 1982). Population levels of *Oreochromis mossambicus* in the Doorndraai dam (Sterk River, Limpopo system) declined after the introduction of this species (Batchelor 1978). Similar findings were reported by Junor (1969) who studied a number of impoundments in Zimbabwe and found that certain epiphytic algae growing on macrophytes formed a significant proportion of the diet of *O. mossambicus*. The decline in macrophytes after the introduction of *T. r. swierstrae* resulted in a simultaneous decline in the epiphytic algae and a subsequent decline and stunting of *O. mossambicus* populations.

In a study of impoundments in the Limpopo and Incomati systems Potgieter (1974) found that there was an overpopulation of *T. r swierstrae* in the Klipkoppies, Longmere and Primkop dams. In the Klipkoppies and Longmere dams fringing vegetation was entirely absent. This had a negative effect on *E. depressirostris* and *Labeo* species which require vegetation as refuge areas for their young. Fringing vegetation is also an important habitat for waterfowl. It was noted that African black duck, *Anas sparsa*, which had been abundant in the past, had disappeared from the Klipkoppies and Longmere dams. Denuding the vegetation in an impoundment adversely affects many different organisms in the ecosystem. Many of these changes are difficult to measure but turtles, frogs, insects and waterfowl are all negatively affected (Potgieter 1974). It was also noted that *T. r. sweirstrae* is a selective feeder and often ignores pest species of macrophytes. Therefore the introduction of *T. r. swierstrae* is not always an effective means of controlling invasive macrophytes (Potgieter 1974).

The impoundments mentioned by Potgieter (1974) which had excessively high densities of *T. r. swierstrae* were either on the edge of the native range of this species (eg the Longmere and Njelele dams) or within the native range (eg the Primkop dam). Therefore it appears that the excessive populations were probably the result of habitat alterations rather than the effect of the introduction of *T. r. swierstrae* into new areas. The building of dams is advantageous to this species and has a deleterious effect on some other species such as *Barbus polylepis* and *B. marequensis* (Potgieter 1974).

Potgieter (1974) surveyed 16 different localities in the Incomati and Limpopo systems and *T. r. swierstrae* was found to be a problem in three (or maybe four) dams. Predators such as *Micropterus salmoides, Eutropius depressirostris* as well as some piscivorous birds were present in these dams but were apparently unable to exert any control over the population levels of redbreast tilapia. *Crocodylus niloticus* was present in some of the localities in which the population levels of *T. r. swierstrae* were relatively low. The eradication of crocodiles from many areas may have been partly responsible for the build up of plague population levels of *T. r. swierstrae.*

The introduction of *T. r. swierstrae* into a small impoundment in Durban resulted in the destruction of all macrophytes except *Phragmites* species. Many aquatic invertebrates and vertebrates subsequently disappeared from the dam as a result of the destruction of the macrophytes (Bourquin 1985).

Eleven species of parasite have been found on *T. r. swierstrae* in southern Africa and of these one (*Trichodina acuta*) is alien (Basson et al 1983; van As and Basson 1984). The translocation of this indigenous fish may facilitate the spread of this alien parasite to new areas.

Control: Potgieter (1974) recommends that the following steps be taken to eradicate excessive populations of *T. r. swierstrae*:

1. Managers should attempt to maintain the correct ratio between predators (such as *E. depressirostris* and *M. salmoides*) and prey (*T. r. swierstrae*). This ratio could be determined using mark-recapture methods.

2. To maintain the correct ratio mentioned above it may be necessary to stock predatory species in certain dams. To ensure the successful stocking of these species it may be necessary to stock fish of over 10 cm total length and to provide some artificial plant cover such as floating mats of *Phragmites* or bundles of *Typha* species in the dams.

3. Anglers should refrain from returning any *T. r. swierstrae* to the water in "problem" dams and should also be allowed to use earthworms, plant material, spoons and lures as bait. Angling competitions could be held specifically to harvest *T. r. swierstrae* from overpopulated dams. The angling public should be made aware of the damage which this species can cause.

It may not be desirable to follow all of Potgieter's recommendations. Considering the adverse effect which the introduction of *M. salmoides* has had on indigenous species, it may be preferable to use an indigenous predator such as *Crocodylus niloticus* as a means of controlling *T. r. swierstrae.* This solution will not be practicable in some water bodies.

There is also some doubt about the effectiveness of using predators to control excessively high prey populations. Potgieter mentions that predators such as *M. salmoides, E. depressirostris* and piscivorous birds were apparently unable to control excessive populations of *T. r. swierstrae* and in Zimbabwe Junor (1969) noted that even the presence of a voracious predator such as the tigerfish, *Hydrocynus forskahlii*, had little effect on population levels of *T. r. swierstrae.*

Research recommendations: A detailed study of a relatively undisturbed ecosystem in which *T. r. swierstrae* exists at normal population levels may provide some answers concerning the factors which normally control excessive population levels of this species in its natural environment. This study may facilitate the formulation of a management plan to control population explosions of *T. r. swierstrae.*

Remarks: *T. r. swierstrae* is highly valued as an angling fish and is regarded as a favourable eating fish. This species is extensively used in aquaculture in tropical areas (Bruton et al 1982) and has been successfully hybridised with *Tilapia zillii* (Philippart and Ruwet 1982).

During droughts when water levels are low, large populations of stunted individuals of this herbivorous species are found in the Doorndraai dam (Sterk River) (Batchelor 1974).

REFERENCES

Basson et al (1983); Batchelor (1974, 1978); Bourquin (1985); Bruton and Kok (1980); Bruton et al (1982); Jackson (in press); Junor (1969); Philippart and Ruwet (1982); Pike (1980a, 1986); Potgieter (1974); Safriel and Bruton (1984); Skelton et al (1985); van As and Basson (1984); Whitfield and Blaber (1976).

TILAPIA SPARRMANII Smith 1840

banded tilapia
vlei tilapia

indigenous, equivocal, major impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An indigenous tilapia species which occurs naturally as far south as the Tugela and Orange-Vaal systems. *T. sparrmanii* was stocked as a forage fish for bass in eastern and southern Cape rivers and is widely distributed in these areas.

Research: Good. The habitat preferences and general biology have been reviewed by Philippart and Ruwet (1982). The distribution outside its native range in southern Africa is well documented.

SPECIES DATA

Distinguishing characteristics: A small widespread species of cichlid fish. *T. sparrmanii* has 8 to 9 vertical bars on the flanks. The "tilapia spot" on the soft part of the dorsal fin persists into adulthood. The juveniles and females are light green above with silvery sides. Breeding males are dark olive above with throat, chest and pelvic fins grey to black. The dorsal and caudal fins have red margins and brown spots. Maximum size about 200 mm TL (Bruton et al 1982).

Native range: Extends from the southern tributaries of the Zaire River system to the Orange River in the south. This range includes the entire Zambezi River system and the Okavango and Cunene Rivers as well as the east coast systems as far south as the Tugela (Crass 1964; Bell-Cross 1976). *T. sparrmanii* is absent from the following sections of the Orange River system: the Caledon River, the upper Orange River, some eastern lowland turbid reaches of the Orange River upstream of Lake le Roux, and the upper Fish River tributaries (Jubb 1972b; Skelton 1986b).

In South West Africa *T. sparrmanii* has been collected in the von Bach dam (Swakop system) (Skelton and Merron 1984) and in the Friedman dam (Kuiseb River system) (Albany Museum records). It is uncertain whether these localities are within the native range of this species but it is likely that they were stocked into these dams (Cambray personal communication).

Date and purpose of introduction: *T. sparrmanii* has been used as an alternative to bluegill as a forage fish for bass (Brand 1954). In 1941 specimens were sent by the Rand Piscatorial Association to Jonkershoek Hatchery (Harrison 1966c). These fish were used as a breeding stock and the offspring were then distributed to various farm dams in southern Africa (Anon 1945).

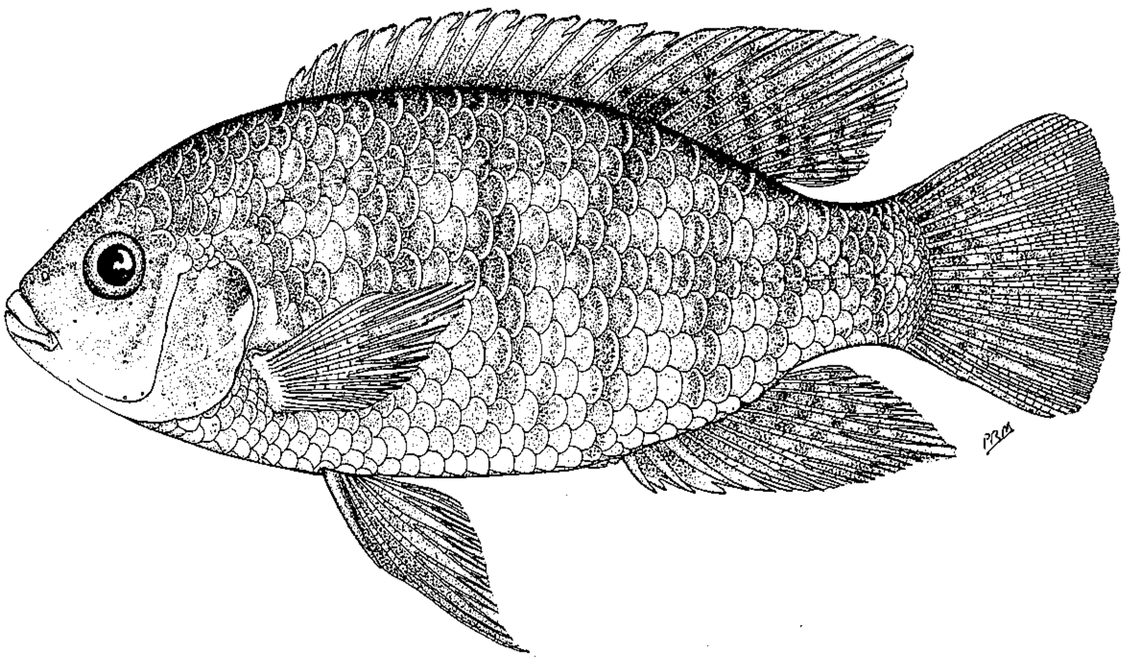
According to Schrader (1985) *T. sparrmanii* populations in farm dams in northern SWA may have been stocked from southern (Orange River) populations and these could pose a threat of genetic pollution to the northern SWA or Okavango populations.

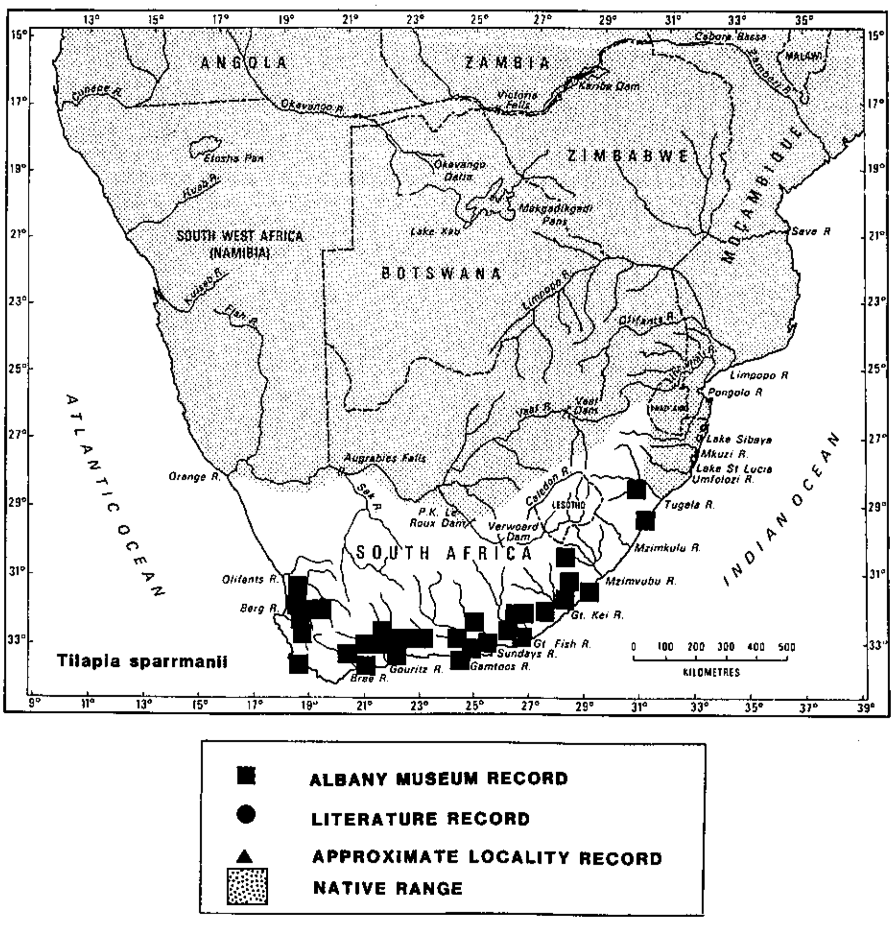
Tilapia sparrmanii appears on van der Waal's (1985) list of species translocated into South West Africa from the Cunene River. A detailed account of initial introductions and records in various localities is given in Appendix 12.

Present distribution: Outside its native range *T. sparrmanii* has been recorded in the following localities: van

TILAPIA SPARRMANII Smith 1840

FIGURE 56. The banded tilapia *Tilapia sparrmanii* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Staadens, Kariega and Buffalo Rivers (Jubb 1965), Breede River system (Braack 1981; Cambray and Stuart 1985), the lower reaches (below the last weir) of the Baakens River (Port Elizabeth) (Heard and King 1981), the Gourits River (Skelton 1987a) and the Tyume River (Keiskamma system) (Gaigher 1975a). In a survey of the south Olifants River (western Cape) conducted in 1963 and 1964 this species was found to be plentiful north of the Bulshoek dam wall and was also found between the Clanwilliam and Bulshoek dams but there have been no records in the mainstream south of the Clanwilliam dam. Also found in the Doornrivier tributary of the Olifants River and in farm dams adjacent to the Hex River, but not in the Hex River itself (van Rensburg 1966b).

Habitat preferences: The banded tilapia favours areas where plant cover exists along the edges of rivers, lakes or swamps (Bruton et al 1982). They have wide habitat preferences and are widespread in both river and swamp habitats in the Okavango system (Skelton et al 1985). *T. sparrmanii* prefers shallow sheltered waters and does not colonise the open water of large lakes. This species is a relatively stenohaline freshwater fish which cannot tolerate salinities above 20‰ but is able to survive in lakes with a very low mineral content. The temperature range in natural habitats ranges from 10 to 33°C but it can tolerate temperatures as low as 7°C in some habitats and in culture ponds (Philippart and Ruwet 1982). McVeigh (1980) gives the temperature tolerance range as 4 to 32°C. *T. sparrmanii* tolerates low oxygen concentrations. The lower lethal oxygen limit is 0,32 ppm dissolved oxygen (Chapman et al 1971).

Breeding: *T. sparrmanii* is a biparental guarding open-substrate spawning species. Courtship and mating take place close to a simple saucer-shaped nest which is constructed by the male. Three or more such nests may be constructed. The eggs are laid on stones and on the roots and stems of aquatic plants on the pond bottom. Both parents guard the eggs but the female is more active. After hatching the fry are picked up in the mouth and deposited in the nest. The young fry constantly vibrate their tails in order to circulate the water. The fry are also able to secure themselves at the bottom of the pit by means of an adhesive substance which is secreted from two cup-shaped glands on the head. The fry become free swimming after about 6 to 8 days and congregate in a shoal on the bottom of the nest. The adults, which assume an olive-green colouration with dark vertical bars when aggressive, guard the nest and chase away other predatory fish. The eggs, larvae and fry are guarded by both parents for 7 to 8 weeks. The parents may take fry into their mouths during the transfer to different nests but *T. sparrmanii* is not regarded as a "mouthbrooder" (Anon 1945; Jubb 1971a; Bruton 1979e; Bruton and Kok 1980; McVeigh 1981). In Lake Sibaya *T. sparrmanii* breeds from September to March (Bruton 1979e).

Feeding: *T. sparrmanii* is an omnivorous species which feeds on epiphytic and benthic algae as well as on macrophytes. They also prey on amphipods, insects and other invertebrates (Bruton 1979e). The diet of juveniles often includes small crustaceans and midge larvae (Pienaar 1978a).

Behaviour: *T. sparrmanii* is one of the few cichlids which attempts to jump over physical barriers during upstream migrations. It is sometimes successful in overcoming obstacles less than lm high (Bell-Cross 1976).

Impact: Gaigher (1981) considers that the presence of this species in the Olifants River has led to a decline in the numbers of indigenous species because of competition for available food resources and predation on juvenile indigenous fishes by *T. sparrmanii*.

The presence of *T. sparrmanii* in the Gourits River is considered by Skelton (1987a) to be a threat (under confined conditions) to *B. tenuis* which is classified as "rare". The major threat to the status of the latter species is probably a general degradation of the habitat.

Fourteen species of parasite have been found on *T. sparrmanii* in southern Africa. Of these parasites, the following are alien species which have recently been introduced into southern Africa: *Trichodina acuta* and *Argulus japonicus* (Basson et al 1983; van As and Basson 1984). The translocation of the banded tilapia to new localities may facilitate the spread of these parasites.

Control: *T. sparrmanii* has many properties of a successful invasive animal (wide habitat preferences and environmental tolerances, a flexible phenotype, broad dietary preferences), and would probably be capable of outcompeting local species in complex climax communities due to its precocial life style (Bruton 1986). Stockings of this species beyond its native range should therefore be undertaken with caution.

Research recommendations: Further research is needed on the present range of *T. sparrmanii* in southern Africa and on its impact as a predator of juvenile fishes.

Remarks: The banded tilapia is not favoured as an angling fish but can be an attractive aquarium species (Bruton et al 1982) and is regarded as a useful species to stock as forage for larger predators such as bass. Because of its small size (it seldom exceeds 300 g) *T. sparrmanii* is not considered to be suitable for aquaculture as a table fish but may be grown as a secondary farming product (to feed farm labourers) in existing farm dams in areas not suited for *Oreochromis mossambicus* (Lombard 1959).

REFERENCES

Anon (1945, 1949, 1950b, 1951b); Basson et al (1983); Bell-Cross (1976); Braack (1981); Brand (1954); Bruton (1979e, 1986); Bruton and Kok (1980); Bruton et al (1982); Cambray and Stuart (1985); Chapman et al (1971); Crass (1964); Gaigher C M (1981); Gaigher I G (1975a); Gaigher et al (1980); Harrison (1963a, 1966c); Heard and King (1981); Hyde (1956); Jubb (1965, 1971a, 1972b); Lombard (1959); McVeigh (1980, 1981); Philippart and Ruwet (1982); Pienaar (1978a); Schrader (1985); Skelton (1986b, 1987a); Skelton and Merron (1984); Skelton et al (1985); van As and Basson (1984); van der Waal (1985); van Rensburg (1963, 1966b); van Schoor (1966);

Personal communications: J A Cambray; P B N Jackson.

MUGIL CEPHALUS (Linnaeus 1758)

flathead mullet
platkop harder

indigenous, equivocal, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Mugilidae

SUMMARY

Status: An indigenous catadromous species with a cosmopolitan distribution in the ocean. Flathead mullet may spend part of their life cycle in rivers, but have been translocated for aquaculture purposes to some areas in the eastern Cape in which they did not previously occur. The impact of these translocations has not been assessed.

Research: Excellent. The taxonomy, general biology, life history and aquaculture potential have been studied by Blaber (1976), Blaber and Whitfield (1977), Bok (1980, 1983, 1984, 1985), Smith and Smith (1986) and Bruton et al (1987).

SPECIES DATA

Distinguishing characteristics: Head flat, with blunt, rounded snout. Adipose tissue overhangs the eyes to form "eyelids". Two dorsal fins. Reach 7 kg (Bok 1980).

Native range: Found throughout the world in warm temperate seas, estuaries and rivers. Enter rivers during certain stages of the life cycle and were previously found far upstream in many east and south coastal rivers in southern Africa (Bok 1985, Smith and Smith 1986).

Date and purpose of introduction: Translocated for the purpose of aquaculture. Fry were captured using seine nets on a number of occasions from the river mouths of the Kowie, Swartkops and Great Fish Rivers between 1975 and 1982. These fry were released into the following dams in the eastern Cape: Amanzi estates (33 43S 25 30 E), Morgenpracht (33 27S 25 07E), Strowan (33 18S 26 28E), Grasslands (33 08S 26 43E), Amalinda (32 59S 26 20E), Crossroads (33 26S 27 04E), Mountain view (33 29S 26 20E), Douglas reservoir (33 19S 26 32E), Avondale (33 28S 26 31E) (Bok 1984).

Present distribution: As for native range and in the localities mentioned above. The natural distribution has been restricted by the building of dams and weirs in rivers. In the Buffalo River *M cephalus* is now restricted to below the Bridle Drift dam (Jackson 1982).

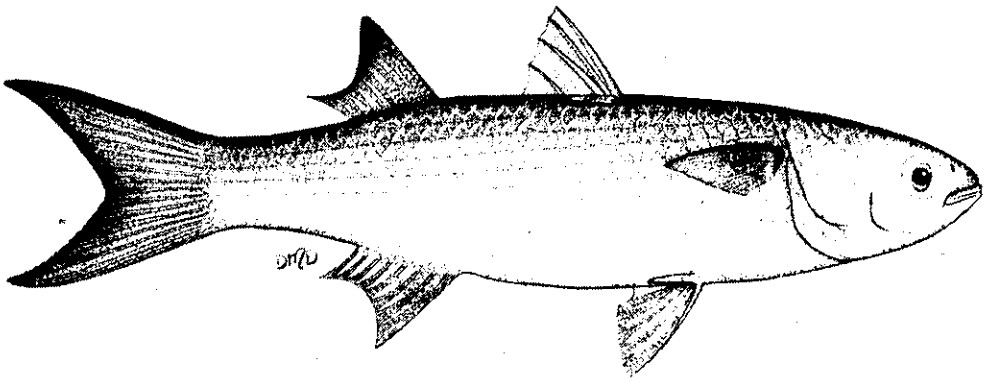
Habitat preferences: *M cephalus* feeds and grows in freshwater, estuaries and the sea and has been recorded 135 km upstream from the sea in the Gamtoos River (Bok 1980). Spawning takes place in the sea and juveniles move into estuaries (Bok 1985). The presence of suitable quiet shallow estuarine waters is essential for the successful transition from juvenile to adult feeding patterns (Blaber and Whitfield 1977).

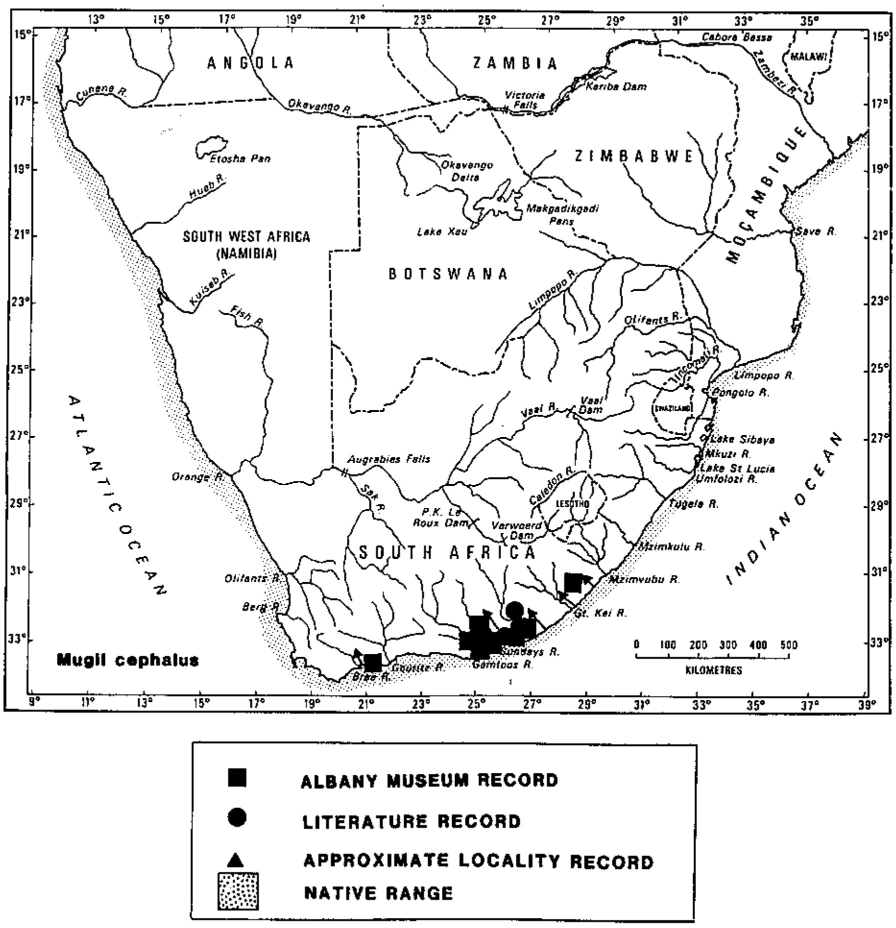
Breeding: Unlike *Myxus capensis*, this species reaches an advanced stage of sexual development while in freshwater (Bruton et al 1987). Spawning takes place in the sea and the greatest recruitment of fry into estuaries is from July to September (Bok 1985). This species is not however dependent on a completely freshwater phase in its life cycle (Bok 1983).

Feeding: Juveniles are carnivorous and adults feed on bottom detritus, algae and diatoms. The transition from being macrophagous carnivores to benthic microphagous omnivores takes place during the migration of the

MUGIL CEPHALUS (Linnaeus 1758)

FIGURE 57. The flathead mullet *Mugil cephalus* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





juveniles into shallow estuarine waters (Blaber 1976, Blaber and Whitfield 1977, Bok 1985). Adults may also eat soft-bodied insects if available (Bok 1980). Mullet tend to select the fraction of the sediments that is rich in microbial life (Jackson 1980c).

Behaviour: Flathead mullet are often seen leaping high out the water especially when disturbed by a strong light at night. Seldom caught on a hook and line (Bok 1980) but may be caught on a fly.

Impact: Since this species cannot reproduce in fresh water it is not expected to have a significant negative effect on the environment should it escape from farm dams into rivers (Bok 1985).

Control: The constant stocking of natural waters beyond its range and in which threatened indigenous fish species occur should be avoided.

Research recommendations: There is a need to study the impact of introduced mullet populations on indigenous freshwater communities.

Remarks: There have been a number of transfers from the lower sections of rivers to the upper reaches by the Cape Department of Nature Conservation. However this is not regarded as a translocation as the fish would normally occur in these areas had man-made obstacles such as weirs not impeded their normal migrations. King and Bok (1984) record such a transfer in the Baakens River from below the weirs at Settlers Park to a section of river above the weirs.

It has been recommended that fish ladders should be constructed at weirs to enable the mullet to carry out their normal upstream migrations. Work on this is being done at the Amalinda Fish Research Station, East London (King and Bok 1984).

The growth rate of this species is faster than that of *Myxus capensis* and *M. cephalus* also attains a larger maximum size. Considering its high yield from farm dams and the fact that it is not expected to cause a significant negative effect on the environment, this species would appear to be a favourable candidate for fish farming (Bok 1985).

REFERENCES

Blaber (1976); Blaber and Whitfield (1977); Bok (1980, 1983, 1984, 1985); Bruton et al (1987); Jackson (1980c, 1982); King and Bok (1984); Smith and Smith (1986).

MYXUS CAPENSIS (Valenciennes 1836)

freshwater mullet
varswater harder

indigenous, equivocal, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Mugilidae

SUMMARY

Status: An indigenous species which occurs naturally along the east coast of southern Africa and in associated rivers. The freshwater mullet has been translocated to new areas of the eastern Cape for the purpose of aquaculture.

Research: Excellent. The taxonomy, general biology, life history style and aquaculture potential have been reported in detail by Bok (1977, 1983, 1984, 1985), Smith and Smith (1986) and Bruton et al (1987).

SPECIES DATA

Recent synonyms: *Mugil capensis, Mugil euronotus, Trachystoma euronotus* (Smith and Smith 1986).

Distinguishing characteristics: A sharp-snouted mullet which frequents fresh water. Two dorsal fins present, second dorsal scaly. Caudal fin forked. Eyes large. Scales relatively small. Colour slaty grey above, dusky white below. Maximum size 480 mm FL (Bruton et al 1982).

Native range: From Kosi Bay along the east coast southwards to the Bree River mouth. Also on the west coast from the Cape peninsula up to (but not including) the Olifants River mouth (Skelton 1987a).

Date and purpose of introduction: Between 1975 and 1982 a number of fry were captured in the Kowie, Swartkops and Fish River estuaries and released in the following farm dams in the eastern Cape: Amazi estates, Morgenpracht, Strowan, Grasslands, Avondale, Hamilton dam, Amalinda, Douglas reservoir (Bok 1984). In February 1977, a number of juvenile fish were captured in the Kowie River (at "ebb and flow" downstream of a 3 m weir) and approximately 90 fish were then released into Seekoeivlei in the western Cape. The purpose of the introduction was to provide a nutritious indigenous fish for anglers (Bok 1977).

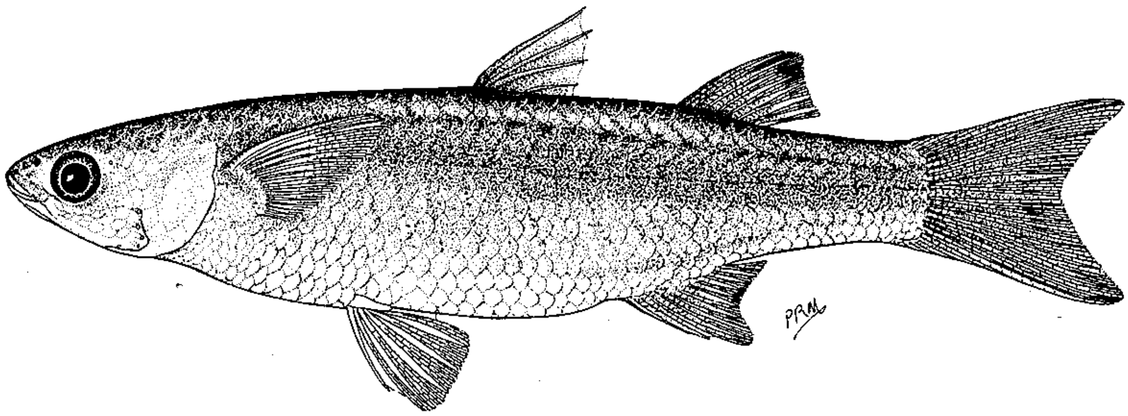
Southern African distribution: As for the native range and at localities mentioned above. Previously found far upstream (over 100 km from the sea) in many rivers. The building of dams and weirs has severely restricted the distribution of this species so that it has now virtually disappeared from the Buffalo and Kowie Rivers (Jackson 1982; Bruton et al 1987).

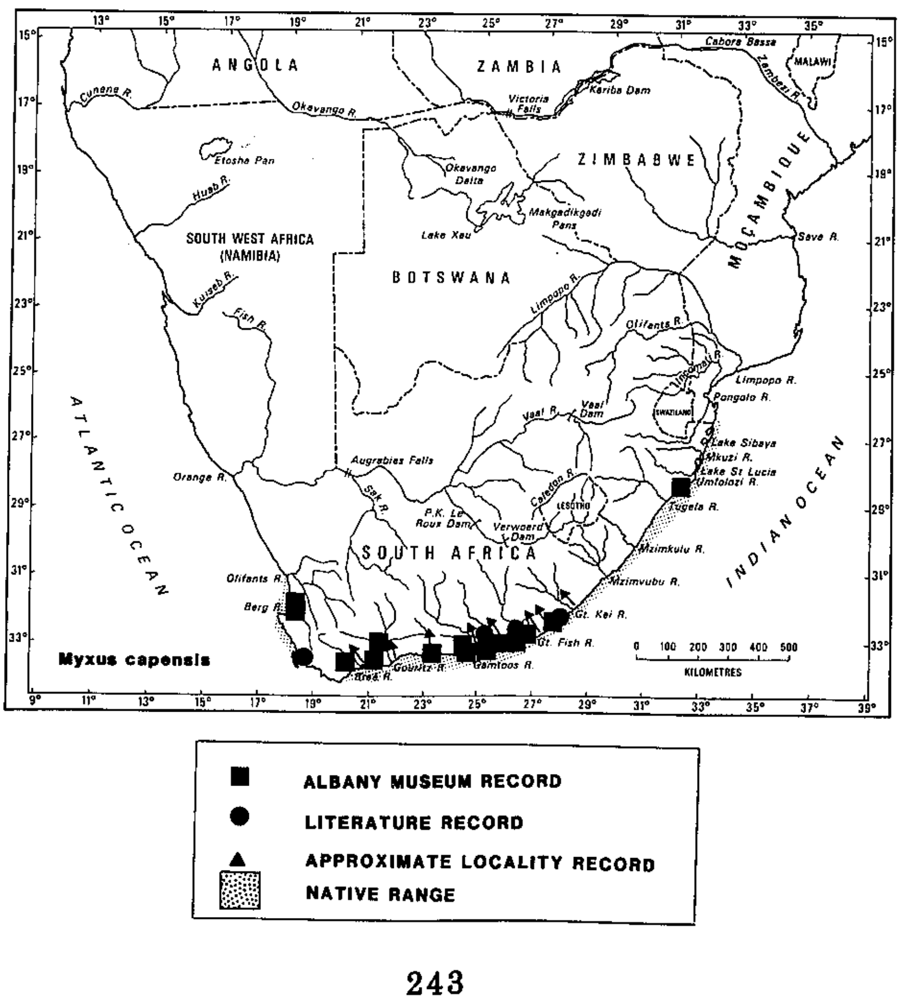
Habitat preferences: Feeds and grows in freshwater, but breeds in the sea (Bruton et al 1982). Prefers freshwater to estuarine conditions but is also found in the upper reaches of estuaries. Has been recorded 135 km upstream of the mouth of the Gamtoos River (Bok 1980).

Breeding: Catadromous life-cycle. The migration downstream to the sea begins between the ages of three and six years and the fish only become sexually mature after reaching estuarine waters (Bok 1980). Spawning occurs throughout the year and takes place in the sea close inshore near river mouths (Bok 1980). The migration of fry into estuaries occurs throughout the year with a peak between September and December. *M. capensis* is dependent on the freshwater phase of its life cycle (Bok 1983, 1985; Bruton et al 1987).

MYXUS CAPENSIS (Valenciennes 1836)

FIGURE 58. The freshwater mullet *Myxus capensis* with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





Feeding: Feeds on algae and small invertebrates in the bottom muds of rivers and estuaries (Bruton et al 1982). *M. capensis* tends to select the fraction of the sediment which is rich in microbial life (Jackson 1980c).

Impact: Since this species spawns in the sea it would not be expected to have a significant negative impact on the environment should it escape from farm dams into more natural habitats (Bok 1985).

Control: The constant stocking of natural waters beyond its range and in which threatened indigenous fish species occur, should be avoided.

Remarks: Population levels of this species have declined in the past 20 years. This is probably because the building of dams and weirs has restricted upstream movements, thus cutting off many stretches of river which would provide suitable habitats. Young fry moving upstream persistently try to overcome insurmountable obstacles such as weirs and thousands congregate below weirs, which makes them vulnerable to predators such as herons as well as to fishermen (Bok 1980). To overcome this problem the Cape Department of Nature Conservation has captured fry below weirs and transferred them upstream. Bok (1980) and Bruton et al (1987) recommend that "fish ladders" should be built past weirs. The simple construction of a line of small stones placed obliquely across a small measuring weir in the Great Fish River provided sufficient "resting places" for migrating fry to enable them to overcome this obstacle and migrate upstream (Jackson 1979).

Initial results of fish farming experiments indicate that the growth rate of this species in farm dams is not as high as that of the flathead mullet (*Mugil cephalus)*; therefore the latter species would be more favourable for extensive fish farming. However, unlike the flathead mullet, *Myxus capensis* can be caught with a hook and line. Therefore it may be used for both sport angling and food production in farm dams (Bok 1985).

REFERENCES

Bok (1977, 1980, 1983, 1984, 1985); Bruton et al (1982); Bruton et al (1987); Jackson (1979, 1980c, 1982); Smith and Smith (1986); Skelton (1987a).

SANDELIA CAPENSIS (Cuvier 1831)

Cape rocky
Kaapse kurper

indigenous, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Anabantidae

SUMMARY

Status: *S. capensis* is indigenous to the southern Cape and has been translocated to a tributary of the (Clanwilliam) Olifants River.

Research: Good. Numerous workers (Jubb 1971c; Braack 1981; Hamman et al 1984; King and Bok 1984; Cambray and Stuart 1985) have studied this species in the field. The impact of the translocation into the Olifants system has not been assessed.

SPECIES DATA

Distinguishing characteristics: A small perch-like fish endemic to South Africa. Dorsal and anal fins long with numerous spines and rays. Lateral line in two parts. Scales ctenoid. Gill cover margin weakly serrated. Colour variable and striking, generally yellowish-brown with intricate dark brown markings. Three dark bands radiate backwards from the eye. Belly and fins yellow with fin rays brown. Eyes yellow or rusty brown. Maximum size 220 mm TL (Bruton et al 1982).

Native range: From Verlorenvlei and the Berg River in the Western Cape to the Coega River in the eastern Cape. Absent from the Clanwilliam Olifants and the Orange River systems (Hamman et al 1984).

Date and purpose of introduction: Introduced into the Suurvlei River (Clanwilliam Olifants system) presumably for angling purposes. First recorded at this locality in 1982, and in 1983 it was confirmed that an established population existed in this river. Probably introduced by a farmer, Mr Smit, who transferred specimens from the Jansekraal River (which drains into Verlorenvlei) into a pond on his farm in the early 1950's. This pond overflowed into a tributary of the Suurvlei River (Hamman et al 1984).

Sandelia capensis has also been recorded in a pond in the Thomas Baines Reserve (Kariega system, near Grahamstown) (Skelton personal communication). The date and purpose of this introduction is not known.

Present distribution: As for the native range and in the Suurvlei River east of Citrusdal on the farm Buffelshoek (32 38 S, 19 10 E) (Hamman et al 1984). Also present in the Thomas Baines Reserve (Kariega system).

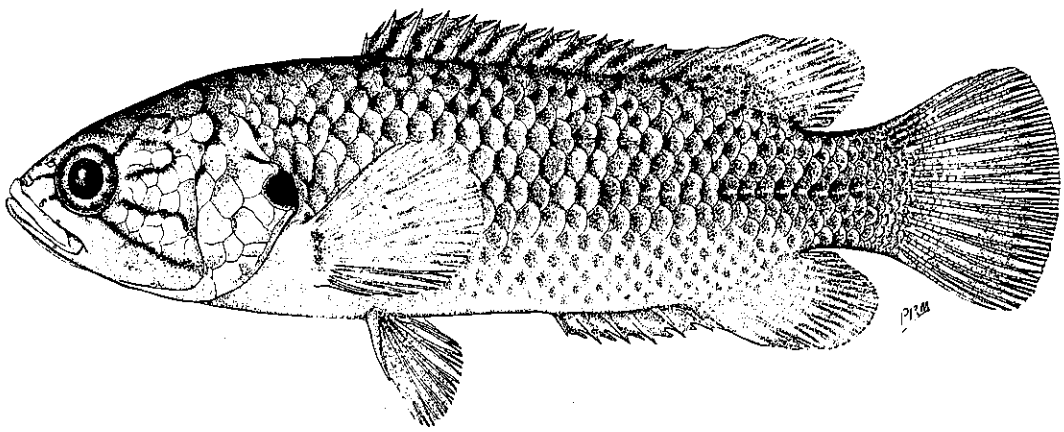
Habitat preferences: *S. capensis* is strictly a freshwater fish. The possession of a labyrinthine organ in the gill chamber enables this species to tolerate low oxygen concentrations and to survive for short periods out of water. *S. capensis* is also able to move from one isolated pool to another (Jubb 1971c). Survives extreme conditions of temperature and oxygen deprivation and has been reported to withstand almost complete desiccation (Jubb 1967).

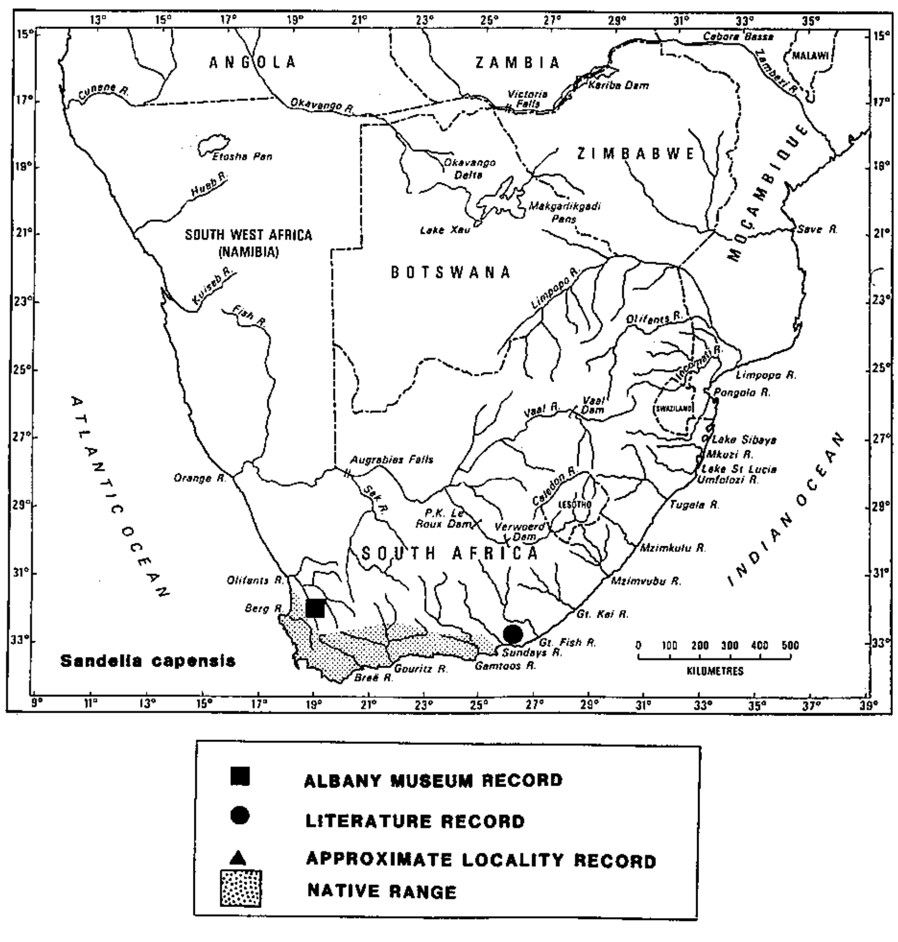
Breeding: Breeds in quiet shallow waters during early summer. During spawning the fish swim in a "whirling embrace" (Jubb 1967). The fertilised eggs sink and adhere to plants or rocks and are guarded by the male (Jubb 1967; Bruton et al 1982).

Feeding: Feed on aquatic insects and other invertebrates. Large specimens may take the young of other fish

SANDELIA CAPENSIS (Cuvier 1831)

FIGURE 59. The Cape rocky *Sandelia capensis*, with its distribution in southern Africa (excluding Zimbabwe and Mozambique)





(Hamman et al 1984).

Behaviour: A "lurking predator" which ambushes its prey (Bruton et al 1982).

Impact: The Cape rocky may have a detrimental effect on *Barbus erubescens* which is endemic to the Olifants River system and is only found in the Middeldeur and Suurvlei sections of the river. *S. capensis* may compete with this species for breeding space and food as well as prey on its young. Although *Sandelia capensis* does not pose an immediate threat to the existence of *B. erubescens*, the present situation may change. Future environmental modifications may create a situation in which *S. capensis*, together with *Micropterus dolomieui* (which in 1984 had not yet invaded this section of the Olifants system), could more effectively penetrate the few remaining habitats of *B. erubescens* and seriously threaten the survival of this species (Hamman et al 1984).

Van As and Basson (1984) have only recorded one species of parasite, *Argulus capensis* (an indigenous species) from *S. capensis*. It is therefore unlikely that the translocation of *S.capensis* has played a significant role in the spread of parasites to new areas.

Control: Future translocations of *S. capensis* into the habitats of vulnerable indigenous species should be avoided.

Research recommendations: The nature of the competition between *S. capensis* and *B. erubescens* should be examined in more detail.

Remarks: *S. capensis* has been ousted from some of the streams in its native range due to environmental degradation and the presence of alien predators (Braack 1981; Cambray and Stuart 1985). *S. capensis* has apparently disappeared from the Lower Baakens River (King and Bok 1984) and was completely eradicated from Paardevlei after the introduction of *Micropterus salmoides*. They appear to co-exist with aliens such as *M. salmoides* and *Parasalmo mykiss* in other rivers (Jubb 1967). Several Cape kurpers have been released into a dam in the Bontebok National Park (Breede River system) in order to re-establish the species in this area (Braack 1981).

REFERENCES

Braack (1981); Bruton et al (1982); Cambray and Stuart (1985); Hamman et al (1984); Jubb (1967, 1971c); King and Bok (1984); van As and Basson (1984).

Personal communication: P H Skelton.

PAULINIA ACUMINATA de Geer

Kariba weed grasshopper
Paulinia sprinkaan

alien, beneficial, little impact

Phylum: Arthropoda - arthropods
Class: Insecta - insects
Family: Acrididae

SUMMARY

Status: An alien grasshopper introduced from Lake Kariba and Trinidad to the Caprivi area in an attempt to control the aquatic weed, *Salvinia molesta*. *P. acuminata* has apparently become locally extinct in Botswana.

Research: Good. The general biology and impact on *S. molesta* in Kariba has been studied by Edwards and Thomas (1977) and Mitchell and Rose (1979).

SPECIES DATA

Distinguishing characteristics: A member of the acridid grasshopper group, which have the following characteristics: antennae with fewer than 30 annuli, usually shorter than the body, tympanum present, usually fully winged (de Villiers 1985). For a detailed description of this species see Thomas (1974).

Native range: South America (Room et al 1981).

Date and purpose of introduction: This grasshopper was introduced to control *Salvinia molesta* which had become a pest in the Botswana- Caprivi area. Stocks were obtained from Lake Kariba and later from Trinidad. The following releases were made:

1. 2700 were released at various points on the Chobe/Linyandi Rivers between 1972 and 1974 (van der Waal personal communication).

2. 550 were released at Pon Pon, Linyanti River, 10 km west of Shaile, Botswana, between 1975 and 1976 (Edwards and Thomas 1977).

Southern African distribution: No recoveries have been made from any of the initial (1972 to 1974) release sites. Although surveys in the Pon Pon district during 1976 confirmed that this species had become established in the area (Edwards and Thomas 1977), it now appears that the population has died out in Botswana (Thomas and Room 1986).

Habitat preferences: This grasshopper lives on floating aquatic vegetation, especially *Salvinia molesta*.

Breeding: Members of the Orthoptera are hemimetabolous insects which pass through a number of nymphal stages during development and lay elongate oval eggs in batches which are enclosed in "pods" held together by hardened secretions. Several pods are produced at regular intervals (de Villiers 1985). In this species the pods are attached to partially submerged parts of the plant (Mitchell and Rose 1979). Reproduction ceases at temperatures below 15°C (Edwards and Thomas 1977).

Feeding: *P. acuminata* feeds on the Kariba weed, *Salvinia molesta*. Older plants in thick interlocking mats and with strongly folded leaves are least favoured by this species (Edwards and Thomas 1977).

Behaviour: *P. acuminata* moves towards regions on the plant where new growth occurs (Edwards and Thomas 1977).

Impact: There are conflicting opinions about the effectiveness of this species in controlling *S. molesta*. After its release into Kariba in 1971 there was a decrease (from 15 to 5%) in the lake area covered by *S. molesta*. Mitchell and Rose (1979) concluded that this decline could be partly attributed to the presence of *P. acuminata* which had undergone a marked increase in population levels during this period.

Although no extensive assessment of the effectiveness of control of *S. molesta* by *P. acuminata* has been carried out in Botswana, it appears that this control programme was not successful. Initial surveys (in 1975/76) indicated that this species had established at Pon Pon. These preliminary studies suggested that although *P. acuminata* could survive and reproduce on *Salvinia molesta*, population densities were not sufficiently high to exert a significant negative influence on infestations of the weed (Edwards and Thomas 1977). It has now apparently disappeared from Botswana (Thomas and Room 1986).

Control: This species is apparently specific to *Salvinia molesta* and no negative impacts on indigenous plants are anticipated.

Research recommendations: Records of the distribution of this grasshopper must be maintained and specimens should be lodged in museums.

Remarks: *Salvinia molesta* has caused considerable problems in the eastern Caprivi area (refer to remarks in the account on *Cyrtobagous salviniae*) and it is imperative that attempts are made to control this weed. Although aerial spraying of herbicides has proved to be effective in removing dense mats of Kariba weed from large areas of open water, Edwards and Thomas (1977) list a number of problems arising from this method of control: it is not effective in areas where a canopy of trees or reeds covers the water surface and regrowth from these areas is very rapid; other more desirable indigenous plants may be eradicated by the herbicide, and eutrophication of the water is likely to result from the decay of dead mats of *Salvinia molesta*. Aerial spraying is extremely costly and would probably have to be repeated annually (Edwards and Thomas 1977).

Cyrtobagous salviniae has now been shown to be more effective in the control of *S. molesta* than *P. acuminata*. However the latter species can withstand a lower temperature than *C. salviniae* (it can breed at temperatures as low as 15°C whereas breeding of *C. salviniae* ceases at about 19 C). There is thus a possibility that *P. acuminata* could be used for the biological control of water weeds in areas where the weevil, *C. salviniae*, would not survive.

REFERENCES

de Villiers (1985); Edwards and Thomas (1977); Mitchell and Rose (1979); Room et al (1981); Thomas (1974); Thomas and Room (1986).

Personal communication: B C W van der Waal.

NEOCHETINA EICHHORNIAE Warner 1970

water weevil
waterkalander

alien, beneficial, little impact

Phylum: Arthropoda - arthropods
Class: Insecta - insects
Family: Curculionidae

SUMMARY

Status: An alien aquatic weevil imported in 1973 for the biological control of the water hyacinth, *Eichhornia crassipes*. This species has apparently become extinct in most of the areas into which it was introduced.

Research: Good. This species has been studied extensively in other countries, particularly by DeLoach and Cordo (1976). The releases and subsequent abundance of wild populations in southern Africa have however not been well documented and there are no published reports on the success of the introduction or their impact.

SPECIES DATA

Distinguishing characteristics: A small curculionid beetle, total length about 4,0 to 4,5 mm (Ferreira 1987). Head bright red. Found on water hyacinth *Eichhornia crassipes* (May and Sands 1986). A general description of curculionids is given in the account on *Cyrtobagous salviniae* and Warner (1970) provides a detailed description of this species.

Native range: South America (DeLoach and Cordo 1976).

Date and purpose of introduction: Introduced by the Plant Protection Research Institute for the biological control of *Eichhornia crassipes* (an aquatic macrophyte weed). In 1973 disease-free stocks were obtained from the USA and the following releases were made (Kluge personal communication):

1. November 1973 into Hartbeespoort dam (Crocodile River, Limpopo system).

2. September 1974 into Durban (Prospecton), the Vaal River and Hartbeespoort dam.

3. June 1975 into Bon Accord dam (Pienaars River, Limpopo system).

4. In December 1975 and 1976 more releases into Hartbeespoort dam and Bon Accord dam. 5 February 1978 into the Kuils River in the Cape.

A further importation of this species was made in late 1985 from the CSIRO, Brisbane, Australia, and a number of releases were made at sites in the Transvaal and Natal (Cilliers personal communication). In October 1987 60 specimens were released into the Swartkops River near Uitenhage (Ferreira 1987).

Southern African distribution: There are apparently no stable breeding populations in any of the initial (1974 to 1978) release localities due to chemical control programmes in Hartbeespoort dam and Bon Accord, reclamation of the site in Durban, and floods in the Vaal River (Kluge personal communication). The population at Kuils River also failed to establish (Kluge personal communication). There is however a recent record from the Bon Accord dam but this needs further confirmation (Bruwer personal communication). There have been no further reports on the releases into the Swartkops River.

Habitat preferences: *N. eichhorniae* lives on water hyacinth (Kluge and Annecke c. 1974). It has a high degree of host specificity and its association with *Eichhornia crassipes* is mentioned as a distinguishing characteristic of this species (May and Sands 1986). All stages of the life cycle are spent in the water in association with this plant (Ferreira 1987). *N. eichhorniae* survives at 10°C but is relatively inactive at this temperature. The egg-deposition and feeding rate increases with temperature and the optimum activity level is reached at 30°C. Thereafter there is a sharp decline in activity as the temperature rises above 30°C and egg deposition ceases at 35°C (DeLoach and Cordo 1976).

Breeding: A holometabolous insect which passes through the egg, caterpillar, pupa and imago stages. Eggs are laid in the leaf stalks of *E. crassipes* and develop in about 7 days. The young central leaves are the preferred site for oviposition. The larvae feed inside the leaf stalk and after approximately 30 days emerge from the leaf and spin a cocoon which is attached to the root hairs of the plant. It appears that the successful development of the pupa is dependent on a relationship between the pupa and the living root hairs of *E. crassipes*. Adults emerge after approximately 30 days and feed on the exterior of the leaf. Under optimum conditions the population size can double in 15 days (DeLoach and Cordo 1976, Ferreira 1987).

Feeding: The adults feed on the surface of the water hyacinth foliage. The eggs are embedded in leaf petioles and the larvae feed on the leaf stalk and crown of the plant (Kluge and Anneke c 1974).

Behaviour: *N. eichhorniae* is a nocturnal species, feeding actively at night. During the day the adults remain in the folded leaves between the ligules (DeLoach and Cordo 1976, Ferreira 1987).

Impact: Following larval tunnelling the stem and crown of the plant are destroyed (Kluge and Annecke c 1974). Although the adults of this species have a higher feeding rate than *N. bruchi*, the latter species was found to be more destructive to *E crassipes* because of its faster breeding rate (DeLoach and Cordo 1976).

Since *N. eichhorniae* is highly host specific, it is unlikely to have a significant negative impact on the environment (refer to the account of *Neohydronomus pulchellus* for the protocol adopted by the Plant Protection Research Institute on introductions of biocontrol agents). There is no reason to conclude that *N. eichhorniae* cannot establish in South Africa even though the first series of introductions was unsuccessful (Kluge personal communication).

Control: This species has been thoroughly tested by the Plant Protection Research Institute as to its likelihood of damaging indigenous water plants. No negative impact is anticipated. The potential benefits arising from the introduction of this biocontrol agent are, however, considerable as the water hyacinth poses a major problem in South Africa. *Eichhornia crassipes* is a plant native to South and Central America which has successfully invaded North America, Africa, Asia and Australia. It was first introduced into South Africa in 1884 (Stirton 1978). Water hyacinth have an enormous capacity for vegetative reproduction and large infestations may interfere seriously with recreational and industrial activities as well as ecological functions. *E. crassipes* is a declared noxious weed and it is essential that control methods on this species are applied.

Research recommendations: Records of distribution of the weevil should be kept up to date. When the weevil establishes breeding populations, impact assessment studies need to be done and published, so that the results are available for open scrutiny.

Remarks: A closely related species, *N. bruchi*, may also be considered as a suitable candidate for the control of water hyacinth in South Africa and it may be advisable to use the two species together in a biological control programme (DeLoach and Cordo 1976).

REFERENCES

DeLoach and Cordo (1976); Ferreira (1987); Kluge and Annecke (c. 1974); May and Sands (1986); Stirton (1978); Warner (1970).

Personal communications: C Bruwer; C Cilliers; A Ferreira; R Kluge.

SALMO SALAR Linnaeus 1758

Atlantic salmon — **alien, equivocal, little impact**
Atlantiese salm

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Salmonidae

SUMMARY

Status: An anadromous species indigenous to the North Atlantic Ocean and associated rivers in the USA and Europe. This species was first imported into South Africa for angling purposes from Scotland in 1896 and 1897 and stocked in numerous rivers in the western and eastern Cape, but failed to establish viable populations and is now locally extinct.

Research: Good. Numerous studies have been performed on this species in Europe and North America. Newdick (1979) has described the general biology.

SPECIES DATA

Distinguishing characteristics: A large anadromous salmonid fish. In the sea both sexes have a bluish green back, silvery sides spotted with black, and a white belly. In freshwater males are greenish brown on the dorsal side, with the flanks brownish or pink with black spots edged with pink or orange. The fins are dark bluish grey or brown, and the lower jaw is often hooked. The female is similar but lacks the pink tint and hooked jaw. Length between 40 and 90 cm TL (Newdick 1979).

Native range: Northern Atlantic Ocean, north western seaboard of Europe and north eastern seaboard of the USA and Canada (Welcomme 1981).

Date and purpose of introduction: The Atlantic salmon was introduced into southern Africa for angling purposes. Ova were imported from Scotland in 1896 and 1897 and hatched at the Jonkershoek Hatchery. This stock was presumably used to supply the Pirie Hatchery, because Harrison (1965/66b) reports that certain rivers in the eastern Cape were stocked from the Pirie Hatchery in 1898. In 1899 new stock was imported from Dumfries, Scotland, to the Pirie Hatchery. Details of releases into specific localities in southern Africa are given in Appendix 13.

Southern African distribution: There are no recent records of this species in natural waters in southern Africa. The young fish could have migrated to sea, but none have made the return migration into inland waters (Anon 1944)

Habitat preferences: The Atlantic salmon spends most of its life at sea and enters rivers to spawn. It requires clean, clear rivers and is usually found in fast-flowing rivers. This species is also found in some lakes in Europe (Newdick 1979).

Breeding: An anadromous species. In Europe salmon spawn between October and January when the fish move into the upper reaches of rivers. Large orange eggs measuring about 6 mm in diameter are shed in gravel nests (redds) which are constructed by the female in running waters. After each batch of eggs is laid the female uses her tail to scoop out gravel from an area upstream of the nest in order to cover the eggs. In so doing she constructs the next nest. Males may mate with more than one female before moving downstream. Mortality is high after spawning (especially for males), but if the fish reaches the sea recovery is rapid and a return migration to the spawning grounds is made after about 18 months (not necessarily to the same river). The eggs usually hatch during April or May. The larvae live off their yolk sacs for about 6 weeks and mature after two to four years. Salmon usually migrate to sea in their fifth year (Newdick 1979).

Feeding: The young fish eat a wide variety of invertebrates whereas adults feed on fish and crustaceans (Newdick 1979).

Behaviour: Salmon display a spectacular ability to surmount obstacles such as waterfalls in their upstream migration to the spawning grounds. During this period feeding ceases although they will still take an angler's fly (Scott and Crossman 1973).

Impact: Bruton et al (1987) have expressed surprise that no anadromous salmonid fishes have established breeding populations on the west and south-west coast of the Cape as conditions there appear to be adequate both in the sea and in influent rivers for their survival. It would, however, be undesirable to stock *S. salar*, despite its angling potential, because of the negative impact it is likely to have on the rare and endangered indigenous fishes of the western Cape, especially the indigenous species flock in the Olifants River.

Control: No control measures are presently necessary as salmon have apparently not established breeding populations in southern Africa. Their re-introduction into southern Africa is not recommended.

Research recommendations: Any records of salmon in South Africa (either current or historical) would be of value to the authors.

Remarks: Even though the salmon did not establish populations in the rivers into which they were released, this cannot be regarded as conclusive evidence that these waters are unsuitable for them. Post-breeding mortalities are normally very high in this species and only a small percentage can be expected to survive to breed (Anon 1944). It is however possible that the southern Cape rivers are too warm for this temperate species.

REFERENCES

Anon (1944); Bruton et al (1987); Harrison (1953c, 1965/66b); Newdick (1979); Scott and Crossman (1973); Welcomme (1981).

SALVELINUS FONTINALIS (Mitchill 1815)

brook trout **alien, equivocal, little impact**
beek forel

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Salmonidae

SUMMARY

Status: An alien species indigenous to North America. *S. fontinalis* was imported from Scotland in 1890 for angling purposes and was widely stocked in Natal and southern Cape rivers. This species has now apparently become extinct in southern Africa as there have been no recent records in natural waters.

Research: Excellent. *S. fontinalis* is a popular angling fish which has been introduced into many countries in the world. The general biology of this species has been described by Scott and Crossman (1973) and the impact on natural ecosystems has been reviewed by Welcomme (1981, 1984) and other authors in Courtenay and Stauffer (1984).

SPECIES DATA

Recent synonyms: *Salmo fontinalis* (Scott and Crossman 1973).

Native range: North-eastern North America (Welcomme 1981).

Distinguishing characteristics: Colouration variable. Dorsal surface usually deep olive mottled with paler spots and bars. Sides brownish green or pink with yellow and red spots, belly pink or white (Newdick 1979). Compared to *S. trutta* the body is flattened and the head large and elongated with a deeply cleft mouth. The eyes are large and set above the central line of the body. Males are distinguished from females by their more vivid colouration and the presence of a hooked curvature in the lower maxillary bone (Holcik and Mihalik 1968).

Date and purpose of introduction: Pike (1980a) reports that 3200 "brown and brook trout" ova were imported to the Boschfontein Hatchery (Balgowan, Natal) in 1890 from Scotland and later in the same year some fingerlings were successfully introduced into the Bushmans and Umgeni Rivers in Natal. Other authors (Jackson 1973a; Jubb personal communication) report that brook trout were first introduced into southern Africa in 1950. In January 1950 a consignment of ova was received by the Jonkershoek Hatchery from New York (Geddes-Page 1950; Anon 1951a) and distribution to various localities in southern Africa began in 1951. Details of specific introductions are given in Appendix 14.

In 1961 another batch of ova were imported from Georgia, USA, to the Jonkershoek Hatchery. These were successfully hatched. The purpose of this importation was to replenish stocks for the breeding of a "tiger trout" (*Salmo trutta* x *S. fontinalis*) cross which had proved to be successful in the Steenbras reservoir (Louw 1962).

Southern African distribution: Listed by Bowmaker et al (1978) as being present in the south and east coastal drainage basins in southern Africa, but there is no definite proof that it has become established anywhere in the Cape Province (Jubb 1965). Brook trout were recorded in the headwaters of the Blyde River (Limpopo system) in the past but no specimens were found during a survey of this river in 1984. It is possible that this species still occurs in this area in low numbers (Kleynhans personal communication). There is one Albany Museum record from the Toise River (Stutterheim), but this was collected in 1958 (Cambray personal communication), soon after it was stocked. It is unlikely that this species still occurs in this river. There have been no records of brook trout catches from the Cape angling fraternity in the last ten years (Davies personal communication). It appears therefore that this species has become locally extinct in southern Africa.

Habitat preferences: In Canada brook trout occur in cool, well-oxygenated streams and lakes. They seek temperatures below 20°C (Scott and Crossman 1973). There was a very low survival rate in the Steenbras reservoir and fish were unable to breed in this acid, peat-stained water (pH between 4,2 and 6,4) (Harrison 1964).

Breeding: In North America brook trout breed in late summer or autumn. They usually spawn over gravel beds in the shallows of headwaters of streams, but can also spawn in gravelly lakes if there is a spring upwelling and a moderate current. Mature fish may travel long distances to reach the spawning grounds. The males are territorial. The female clears away debris and silt from the nesting area by a series of rapid fanning movements of the caudal fin. Spawning occurs during the daytime. The eggs are adhesive for a short period after extrusion. After spawning the female covers the eggs with gravel. The number of eggs deposited varies from 100 to 5000 depending on the size of the female. The incubation time is dependent on water temperature and oxygen concentration (at 10°C hatching occurs after 50 days). The upper lethal temperature limit for developing eggs is 11,7°C. After hatching the fry remain in the gravel until the yolk is absorbed. Brook trout have a longevity of about 5 years (Scott and Crossman 1973).

Feeding: Carnivorous. Feed on a wide range of organisms including worms, leeches, crustaceans, aquatic and terrestrial insects, spiders, molluscs and several different species of fish. They may occasionally also eat their own young (Scott and Crossman 1973).

Impact: Since it appears that this species has become locally extinct it is unlikely to have exerted any significant impact on indigenous freshwater communities.

Salvelinus fontinalis is listed by Welcomme (1984) as a species viewed internationally with "mixed feelings", ie it may be desirable for certain objectives, but has posed serious problems in certain areas into which it has been introduced. The brook trout is a less successful invader than rainbow and brown trout, but has established alien populations in many countries in Asia, Europe, South America, Australia and New Zealand (Welcomme 1981, 1984; Bruton 1986). Considering the international reputation of this species, it would be undesirable to introduce it into southern Africa again.

Control: Control measures would be unnecessary since it appears that the local populations have become extinct.

Research recommendations: The presence or absence of brook trout in natural waters in South Africa needs to be confirmed. The competitive abilities of this species also need to be determined. It would be of interest to determine the reasons why this species has failed to establish viable populations in southern Africa, despite extensive stockings.

Remarks: The few specimens of *S. fontinalis* which were caught in the Steenbras reservoir proved to have poor angling potential (they were too weak to "fight"). The "tiger trout" hybrid (female *S. trutta* and male *S. fontinalis*) is, on the other hand, considered to be an excellent "fighting" angling fish. This cross was produced at the Jonkershoek Hatchery in 1960, and 1050 fingerlings were released into the Steenbras reservoir later in the same year. These fish proved to be very successful. This is however an infertile hybrid and, since no further introductions were made, the stock died out (Harrison 1964) (see also the section on *S. trutta*).

REFERENCES

Anon (1950a, 1951a, 1951b); Atkinson (1952); Bowmaker et al (1978); Bruton (1986); Courtenay and Stauffer (1984); Geddes-Page (1950); Harrison (1949, 1964, 1970/71); Holcik and Mihalik (1968); Jackson (1973a); Jubb (1965); Louw (1962); Newdick (1979); Pike (1980a); Scott and Crossman (1973); Welcomme (1981, 1984).

Personal communications: J A Cambray; M T T Davies; R A Jubb; C J Kleynhans.

BARBUS GURNEYI Gunther 1868

redtailbarb
rooistert ghieliemientjie

indigenous, detrimental, little impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cyprinidae

SUMMARY

Status: An indigenous species which occurs in Natal as far north as the Tugela River. Translocated into Lake Nhlange in Maputaland as a forage fish for bass. The redtail barb has apparently now become extinct in this locality.

Research: Fair. The general biology is described by Crass (1964).

SPECIES DATA

Distinguishing characteristics: Lateral line complete or incomplete, dorsal fin with 7 branched rays. Two long pairs of barbels present, snout tapering but rounded at the end and dorsal profile of head flattened with nape rising sharply. Adults have numerous small tubercles on the head, particularly on the snout. The species is easily recognisable when in breeding colouration as the whitish tubercles on the head stand out against the brownish olive dorsal surface. Iris pale golden, gill covers bright golden, flanks bronze with dark markings along the lateral line posteriorly. Belly dull pinkish white. Caudal fin bright red with a narrow white border, and other fins a pale rust colour except the distal portion of each which is dull white. Maximum length about 10 cm (Crass 1964).

Native range: Found in Natal from the Umtamvuna River northwards to the Tugela basin, up to an altitude of 1200 m and in streams in the hills of central Zululand. Originally absent from northern Natal rivers (Skelton 1986a). In 1967 the distribution was described as being between (and including) the Umtamvuna and Tugela Rivers between altitudes of 300 to 1000 m (Jubb 1967) but Bourquin and Morty (1979) also recorded this species in the Ngoje River (Amatikulu River catchment) at an altitude of 460m. This river is immediately to the north of the Tugela catchment.

Date and purpose of introduction: Introduced as a forage fish for bass. Forty specimens were translocated from central Natal to a small pan west of Lake Nhlange in Maputaland by the Natal Parks Board in 1970 (Bruton and Kok 1980).

B. gurneyi has also been recorded in a tributary of the Sabie River in the eastern Transvaal (Crass 1964). Since this species has not been recorded again in this area despite numerous surveys, it appears that the fish was either misidentified or some specimens were released into the river which were subsequently collected by Crass. It is probable that no population has become established in the Sabie River (Skelton personal communication).

Present distribution: As for native range. Until recently this species was also established in a small pan west of Lake Nhlange (Kosi system) in Maputaland. No fish of this species were captured in this locality during more recent sampling (Bruton personal observation 1985).

Habitat preferences: This species is found in small streams and has a preference for small pools fringed with *Juncus*. *B. gurneyi* is often the commonest species in small tributaries in Natal at altitudes between 300 to 1000 m that are too shallow for *Barbus natalensis* (Crass 1964).

Breeding: Breeds throughout the summer. Sexual maturity is reached at about 5 cm (Crass 1964).

Feeding: *B. gurneyi* feeds on small insects and other small organisms including tadpoles (Crass 1964).

Impact: If the *B. gurneyi* population has survived in the pan near Lake Nhlange it is likely to compete with *Barbus paludinosus* and *Barbus viviparus*, the common minnows in eastern Maputaland.

Research recommendations: The presence or absence of *B. gurneyi* in Maputaland and in the eastern Transvaal needs to be established.

Remarks: The striking colouration of *B. gurneyi*, and especially its bright red caudal fin, is likely to result in this species becoming popular in the aquarium trade.

REFERENCES

Bourquin and Morty (1979); Bruton and Kok (1980); Crass (1964); Jubb (1967); Skelton (1986a).

Personal communication: P H Skelton.

SAROTHERODON GALILAEUS (Linnaeus 1758)

Israeli tilapia
Israeliese tilapia

alien, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An alien species indigenous to north Africa and the Middle East. Imported from Israel in 1959 for aquaculture and experimental purposes. Specimens were released in the Stellenbosch area but these may now have become locally extinct.

Research: Excellent. *S. galilaeus* is widely used for aquaculture and the general biology has been studied by many workers (reviewed by Trewavas 1983).

SPECIES DATA

Recent synonyms: *Tilapia galilaea* (Trewavas 1983). This biparental mouthbrooder was retained in the genus *Sarotherodon* by Trewavas (1983) who transferred the maternal mouthbrooders to the genus *Oreochromis*. This species has been divided into a number of subspecies. *S. galilaeus galilaeus* occurs in Israel and since the specimens from Jonkershoek were imported from Israel the description that follows is of this subspecies.

Distinguishing characteristics: A large tilapiine fish. Silvery grey to green in colour with black spots on the body which form incomplete bars on the flanks. The edge of the caudal fin is tinged with pink. In the breeding season the throat may be slightly pink. Maximum size about 330 mm TL (Holden and Reed 1972).

Native range: Lake Huleh, Lake Kinneret, River Jordan, Mediterranean rivers of Israel, Nile, Blue Nile, Lake Albert, Aswa River, Lake Rudolf, Jebel Marra, Lake Chad basin, Ubangui and Uelle Rivers, Draa River, Morocco, Adrar, Mauritania, West Africa from Senegal to Guinea, Volta and Niger basins and the catchments in between, Cross River and Lake Barombi Kotto, Meme system (Trewevas 1983).

Date and purpose of introduction: In 1959 "*Tilapia galilaea*" (presumably this species) together with *Tilapia zillii* and *Tilapia nilotica* were imported from Israel to the Jonkershoek Hatchery. These fish were bred in the hatchery and later some fry were stocked in farm dams in the Stellenbosch district (van Schoor 1966).

'*Tilapia aureus*' and '*T. galilaea*' were stocked in experimental ponds at Jonkershoek Hatchery in 1965 (van Schoor 1969a). As far as is known neither of these two *Tilapia* species were released into natural waters at the termination of this experiment.

Southern African distribution: Although there have been no recent records of Israeli tilapia in the Stellenbosch district (Smith personal communication), a small number may still be present in farm dams in the area.

Habitat preferences: This species has a preference for sandy bottomed pools, but is also found in other habitats (Holden and Reed 1972). They are probably more tolerant of cold water temperatures than *O. mossambicus* as they are able to tolerate the winter temperatures of Egypt and the Mediterranean rivers of Israel. Heavy mortalities have however been recorded in these areas after the water temperatures dropped to 9 C due to an influx of melting snow into the rivers (Trewavas 1983). Van Schoor (1966) records that '*T. galilaea*' failed to survive outdoor temperatures at the Jonkershoek Hatchery.

In the Middle Niger River this species is found on the edge of sandbanks and over sandy bottomed sections of the river. Unlike *O. niloticus*, *S. galilaeus* does not move into flooded swamps, generally preferring slow-flowing or stagnant sections of streams. This species usually thrives in impoundments where the adults are found offshore feeding on phytoplankton (Trewavas 1983).

S. galilaeus tolerates temperatures from 10,5 to 32 C in its native range, but can tolerate extreme temperatures as low as 6,5 C in some habitats and in culture ponds (Philippart and Ruwet 1982).

Breeding: *S. galilaeus* is a biparental mouthbrooder. No obvious sexual dimorphism has been observed, but after the second year males grow faster and have longer soft dorsal and anal fin-rays than the female. In Lake Kinneret (Israel) the breeding season begins at the end of March and extends until August. The females usually produce two broods per season. Sexual maturity is reached at the end of the second year. The initiative for courting and mating is taken predominantly by the female which is also responsible for excavating the nest, a depression made in the shallows near the shore. The female also defends the mating territory. The eggs are laid in batches of 20 to 40 and each bundle is fertilised by the male as it is laid. The eggs adhere to each other in the pit and after the whole clutch has been laid the parent (either the male or the female) takes them into the mouth. Both parents participate in parental care. Normally the male and the female form a strong pair-bond which remains for several days and sometimes as long as two weeks. The developing larvae remain in the mouth until the yolk is absorbed after about 14 days. There is no evidence of any further contact with the parents after this period (Trewavas 1983).

Feeding: Phytoplankton, zooplankton and epiphytic plants growing on other plants form the basis of their diet (Holden and Reed 1972). The diet varies with age, the young fry feeding more on zooplankton than older fish. Some populations also feed predominantly on phytoplankton while in other populations the predominant food type is epiphytic algae and bottom detritus. Within the same population the diet may vary during different seasons of the year (Trewavas 1983).

Behaviour: This species forms large schools in Lake Kinneret. These schools disperse prior to the breeding season in March (Trewavas 1983).

Impact: Israeli tilapia have had no known impact in South Africa. If this species becomes established in the wild, it is likely to compete for food and space with other detritivorous cichlids such as *Oreochromis mossambicus* and *O. andersonii*

Control: It would be advisable to eliminate any remaining populations of this species in natural waters.

Research recommendations: The presence of this species in natural waters in South Africa needs to be confirmed.

Remarks: From the behavioural point of view this is a very interesting species as it is one of the few biparental brooding tilapiines.

REFERENCES

Holden and Reed (1972); Philippart and Ruwet (1982); Trewavas (1983); van Schoor (1966, 1969a).

Personal communication: A Smith

TILAPIA ZILLII (Gervais 1848)

Jordan's St Peter's fish
Jordaniese St Petrusvis

alien, detrimental, unknown impact

Phylum: Chordata - chordates
Class: Osteichthyes - bony fishes
Family: Cichlidae

SUMMARY

Status: An alien cichlid fish imported from Israel in 1959 for experimental and aquaculture purposes. A number of fish were stocked into dams in the Jonkershoek valley, but these may have died out.

Research: Excellent. The aquaculture potential of this species as well as its impact in natural waters into which it has been introduced in other parts of the world has been extensively studied. This research has been reviewed by Lowe-McConnell (1982), Philippart and Ruwet (1982) and Trewavas (1983).

SPECIES DATA

Distinguishing characteristics: A moderately sized tilapia with prominent vertical bars. Body olive green with a blue sheen, marked with 6 to 7 dark vertical bars. Throat red; during breeding this colour intensifies. Dorsal, anal and ventral fins marked with yellow spots. The edges of both the dorsal and anal fins are usually outlined with orange. Maximum length 270 mm TL (Holden and Reed 1972). This species is similar to *T. rendalli* in appearance but the latter is generally more deep-bodied and has dark vertical bars on the body, whereas *T. zillii* usually has two horizontal stripes, one mid-lateral, the other nearer the dorsal outline. These stripes are crossed by vertical bars and the darkest marks are the blotches at the intersections (Trewavas 1983).

Native range: *T. zillii* extends from West Africa through the Chad basin to the Nile, Lake Albert and Lake Turkana into Israel and the Jordan valley (Trewavas 1982).

Date and purpose of introduction: Imported for aquaculture purposes. The following introductions have been made:

1. Imported from Israel to Jonkershoek Hatchery in 1959 for experimental purposes. It was hoped that *T. zillii* would be a suitable species for aquatic weed control. In about 1960 fish were stocked into 15 farm dams in the Eerste and Lourens River basins (van Schoor 1966).

2. *T. zillii* were introduced together with the "Taiwan red tilapia" (species not given) into Natal for experimental purposes (Bourquin et al 1984). There was no mention of this species being stocked into natural waters, so it is probable that they were only kept in hatcheries.

Southern African distribution: In 1964 13 of the original dams which were stocked in the Jonkershoek area were investigated. Only one was considered to have been "successfully" stocked with *T. zillii* although this species was present (but not thriving) in seven other dams (van Schoor 1966). There have been no further records (Smith personal communication) but populations of this species may still exist in some farm dams in the area.

Habitat preferences: Usually found in shallow water among dense aquatic macrophytes (Holden and Reed 1972, Bruton personal observation). In natural habitats this species is found at temperatures ranging from 10,5 to 36°C but they can tolerate extremes from 7 to 39°C in some habitats and in culture ponds (Philippart and Ruwet 1982). In its native range *T. zillii* usually occurs together with large predators such as *Lates niloticus* and

Hydrocynus forskahlii and is restricted to pools, lagoons and the edges of rivers and floodplains where aquatic vegetation provides adequate cover. They have fairly generalised habitat requirements, and occur over rock, sand or muddy substrates, in still or running water (Lowe-McConnell 1982).

Breeding: A non-guarding open substrate spawner. Males first move to the shoreline where territories are delimited and defended. They are then joined by the females. Both males and females prepare the nests which consist of holes of varying depth. The territories may adjoin those of other "couples". The fertilised eggs stick to the bottom and both partners guard and ventilate the eggs. After hatching the alevins are frequently moved from one hole to another. Soon after learning to swim the alevins form a shoal which stays near the nest and retreats into a hole in times of danger (Philippart and Ruwet 1982). In equatorial and sub-tropical waters this species may breed continuously throughout the year but breeding intensity may vary seasonally. In higher latitudes *T. zillii* tends to breed during the hottest times of the year. This species prefers substrates of pebbles or sand with abundant vegetation for breeding (Philippart and Ruwet 1982).

Feeding: *T. zillii* is a herbivore. The adults feed preferentially on filamentous algae, aquatic macrophytes and vegetable matter of terrestrial origin. Occasionally when the plant food supply is low, they will also take animal food and in Lake Kinneret they feed on blue-green algae (Lowe-McConnell 1982, Philippart and Ruwet 1982).

Behaviour: This is a ubiquitous and fecund species which forms dense populations in its preferred habitat.

Impact: *T. zillii* had a detrimental effect on other cichlids in Lake Victoria into which it was introduced (see "Remarks" below). There are no indigenous cichlids in the Jonkershoek area with which it could compete in a similar way. The effect which this species may have on indigenous *Barbus* species in the western Cape is difficult to predict. If *T. zillii* is released into natural watercourses in Natal there is a danger that it would interbreed and / or compete with indigenous cichlids such as *Tilapia rendalli* and *T. sparrmanii.*

Control: *T. zillii* has many of the properties of a successful invader and care should be taken to prevent its escape into natural waters in southern Africa.

Research recommendations: It is recommended that collections should be made in the Stellenbosch area in order to ascertain whether any populations have survived.

Remarks: *T. zillii* was introduced into Lake Victoria from Lake Albert in 1954. It spread rapidly in the northern end of the lake, appeared in the southern and eastern parts in 1960 and was abundant by 1964. *T. zillii* later became the dominant species in areas where *Oreochromis variabilis* had previously been dominant (in shallow marginal waters) with the fry and juveniles found predominantly on the sandy, shelving shores in sheltered places. There appeared to be little competition for food between adults of alien species and the indigenous species that they replaced. The strongest competition was apparently for breeding grounds. Both *T. zillii* and *O. variabilis* require clean, firm substrates for spawning and *T. zillii* outcompeted the smaller *O. variabilis* for these areas (Lowe-McConnell 1982)

REFERENCES:

Bourquin et al (1984); Holden and Reed (1972); Lowe-McConnell (1982); Philippart and Ruwet (1982); Trewavas (1982, 1983); van Schoor (1966).

Personal communication: A Smith

ANAS PLATYRHYNCHOS Linnaeus 1758

mallard duck **alien, detrimental, potential impact**
mallardse eend

Phylum: Chordata - chordates
Class: Aves - birds
Family: Anatidae

SUMMARY

Status: The mallard duck is an alien waterbird which is found in many semi-natural and natural waters but has been unable to establish feral populations in southern Africa. Because of its ability to produce fertile offspring with closely related species, mallards pose a threat of genetic contamination of indigenous duck populations.

Research: Excellent. The impact of introductions in other parts of the world has been reviewed by Long (1981). In southern Africa the distribution of this species and its potential impact on indigenous populations has been studied by Siegfried (1979) and Liversidge (1979).

SPECIES DATA

Distinguishing characteristics: Male: head and neck iridescent green; white collar at base of neck. Breast purplish chestnut, underparts whitish with dark bars, rump black, wings brownish grey with purplish blue speculum and bordered at sides with black and white bars. Bill yellowish or greenish. Female: head and neck buff, streaked brown. Body mottled and streaked chestnut-brown (Long 1981).

Native range: Eurasia to North America. Iceland, The Faeroes, across Europe and Asia from south of the Arctic Circle to the Mediterranean, Turkestan, Mongolia and Japan; the Aleutian and Pribilof Islands and North America from north-western Alaska, north-western and south-eastern Canada to central Mexico (Long 1981; Brooke personal communication).

Date and purpose of introduction: The mallard is known to have been introduced into South Africa during the 1940's (Liversidge 1985). A number of separate introductions have been made by bird fanciers and during the early 1960's mallard were freely offered for sale by dealers (Siegfried 1962).

Southern African distribution: Although Siegfried (1979) reports that there were frequent sightings in wild situations and the mallard is widespread as a domestic animal in parks and on farms, it has failed to establish viable feral populations in South Africa (Liversidge 1985).

Habitat preferences: Mallards have a preference for still shallow waters, but are also found on salty coastal lagoons. They live in both fresh and brackish waters and are also found in grain fields and other agricultural lands (Long 1981).

Breeding: The breeding season varies in different latitudes. In its native range the mallard breed from March to October and they may have two broods per year in some areas. The nests of grasses, reeds and leaves are lined with down. They are usually found on the ground and rarely in trees. The clutch size varies between 5 and 15 eggs (Long 1981).

Feeding: The mallard is an omnivore which feeds on aquatic vegetation as well as insects, snails, worms, fish fry, seaweed, molluscs and grain (Long 1981).

Behaviour: Mallard are usually sedentary but sometimes undertake irregular migrations. They are found in pairs for part of the year. They may also form small flocks with other species. Large flocks may form during the non-breeding season (Long 1981).

Impact: *Anas platyrhynchos* is very widespread and is capable of hybridising (in captivity) with three indigenous species of anatids (*Alophen aegyptiaca, Anas undulata* and *A. erythrorhyncha*) (Liversidge 1985, Brooke personal communication). The *A. platyrhynchos* x *A. undulata* cross is the only cross which results in fertile offspring (Liversidge 1985). There are fears that indigenous species may become genetically contaminated with mallard hybrids (Zaloumis and Milstein 1975; Stevenson personal communication). This problem has already been encountered in New Zealand where the mallard breeds with the indigenous grey duck, *A. superciliosa*, to produce fertile hybrids in which the mallard strain dominates. This has resulted in the gradual loss of characters in the native bird (Siegfried 1979). In Australia there have been recent reports of mallard breeding with the black duck (also *A. superciliosa*) and producing offspring which are considered to be inferior game birds (Long 1981).

Liversidge (1979) points out that wild mallard hybrid populations have all died out in southern Africa and he regards the danger of hybridisation as having been exaggerated. Mr R Brooke of the Percy Fitzpatrick Institute of African Ornithology also supports this view. He points out that most domestic ducks kept in captivity are also derived from European *A. platyrhynchos*. The domestic duck would also then be expected to hybridise with *A. undulata*. It therefore seems pointless to exert strict controls over wild mallards without having similar controls over domestic ducks (Brooke personal communication).

A Stevenson of the Cape Department of Nature Conservation disagrees with Liversidge and emphasises that even though hybrid populations have not survived for any length of time in the past, there is still a danger of a "super-hybrid" being bred which would be better adapted to survive in the wild. He therefore regards mallards as a serious threat to a number of indigenous waterbirds.

Control: The keeping of mallards in captivity has been forbidden by the Cape Department of Nature Conservation except under special circumstances (such as in zoos) and wild birds or their hybrids are shot on sight (Stevenson personal communication). The law concerning this species is not as stringent in other parts of southern Africa where mallards are still widespread in parks.

Taking the comments of Brooke (1986) into account (see Remarks) it is important to emphasise that, should the importation of this species be allowed, stringent controls should be applied to ensure that only domesticated or ornamental stocks are permitted, and not the wild strains used in hunting.

Research recommendations: Further research needs to be conducted on the ability or otherwise of mallard to interbreed with indigenous duck species.

Remarks: In view of the opposing ideas amongst South African ornithologists regarding the potential threat of mallard to indigenous waterbirds, it is worthwhile to examine the history of the New Zealand experience. Small numbers of mallard were intermittently introduced into that country from 1867 onwards and a number of releases were made between 1910 and 1918. In 1930 it was reported that in nearly all cases the species had failed to establish. After 1939 interest in introducing mallard was revived and for several years approximately 300 birds were released annually mainly in the Manawatu and Rangtikei districts. Feral populations were only established after many years of repeated releases of large numbers of birds. By 1947 mallard were well established in many areas and they are now widespread and common in the North and South Islands. They hybridise with the indigenous grey duck (*A. superciliosa*) and in some areas hybrids are becoming numerous. They also compete with native duck and in some areas appear to be replacing the native species (Long 1981). Brooke (1986) however points out that conditions prevailing in New Zealand are not paralleled in southern Africa. The African continent harbours a number of predators and pathogens which naturally control populations of alien birds. This is not the case in New Zealand where these natural controls are largely absent. It is also of interest to note that in New Zealand wild-stock mallards were imported for the purpose of game-shooting. This is not the case in southern Africa where only ornamental and domestic varieties have been imported (Brooke 1986).

Taking the above arguments into consideration, we nevertheless feel that management decisions on the control of the mallard should err on the side of caution in order to ensure that indigenous anatids are protected from competition and/or genetic contamination. Mallards have been in New Zealand for at least 30 years longer than in South Africa, and the possibility still exists that in future feral populations of pure strains and hybrids will become established here.

REFERENCES

Brooke (1986); Liversidge (1979, 1985); Long (1981); Siegfried (1962, 1979); Zaloumis and Milstein (1975).

Personal communications: R Brooke; A Stevenson.

CYGNUS OLOR (Gmelin 1789)

mute swan
swaan

alien, detrimental, little impact

Phylum: Chordata - chordates
Class: Aves - birds
Family: Anatidae

SUMMARY

Status: An alien species imported from Europe for ornamental purposes. Feral populations existed in some eastern Cape estuaries for many years, but have since become extinct.

Research: Fair. Information on southern African populations has been summarised by Siegfried (1962) and Maclean (1985).

SPECIES DATA

Distinguishing characteristics: A large white bird with a long gracefully curved neck. Bill black and orange (Maclean 1985).

Native range: Central Europe and central Asia (Maclean 1985).

Date and purpose of introduction: The mute swan was introduced into South Africa for ornamental and sentimental purposes. Numerous introductions have been made into parks and other semi-natural habitats. A breeding pair was reportedly introduced into the Humansdorp district before 1920 (Siegfried 1962).

Southern African distribution: Widely distributed in parks around southern Africa. A colony of 40 feral birds was present at the Kromme River mouth (Humansdorp) (Siegfried 1962). Feral populations were also present at the Gamtoos, Bitou and Seekoei River mouths and at Groenvlei Lake, Knysna. All these populations are now extinct (Maclean 1985, Brooke personal communication).

Habitat preferences: In their native range mute swans occur in standing or slow-flowing waters, river mouths and in sheltered areas along the coast (Anon 1961).

Breeding: Mute swans have the same mate for life. Breeding commences in the third or fourth year and they may live to 30 years. They aggressively guard their nests and young during the mating season and will attack any bird or small mammal approaching the nest (Siegfried 1962). In South Africa mute swans breed in September and October. The nest is a large mound of plant material on a small island, on a shoreline or among reeds. The clutch usually consists of 5 to 8 eggs. The incubation time varies from 35 to 41 days. Both parents guard the young fledglings (Maclean 1985).

Feeding: Mute swans feed on watergrass, roots, flowers and the shoots of water plants. They continually forage underwater to a depth of 1 m for food but also occasionally feed alongside shallow rivers and may undermine river banks when grubbing for roots in the bank (Anon 1961). They also feed on frogs, tadpoles, molluscs, worms and insects (Maclean 1985).

Behaviour: Mute swans are known to undertake migrations to more favourable areas. If they are established in a mild climate these migrations do not occur (Anon 1961). They may form flocks of up to 60 birds when not breeding (Maclean 1985).

Impact: Their impact has not been fully assessed, but they would be expected to compete with indigenous waterbirds for nesting sites and food. They also cause damage to river banks. Winterbottom (1966) noted that this species had limited success in southern Africa as it showed no sign of spreading from the Kromme River mouth. Their recent extinction may have been due to high poaching pressure from humans as Siegfried (1979) reported that these birds have a high black market value.

Control: Mute swans do not appear to be capable of establishing feral populations in South Africa. Control measures are not necessary at present.

Research recommendations: It would be useful to determine why this species was not a successful coloniser in South Africa.

REFERENCES

Anon (1961); Clancey (1965); MacLean (1985); Siegfried (1962, 1979); Winterbottom (1966).

Personal communication: R Brooke

APPENDICES

Appendix 1. Dates of initial stocking and initial records of Parasalmo mykiss in various localities in southern Africa

Date	Locality	Remarks	Reference
Cape			
1901 to 1902	Berg, Eerste and Lourens Rs		Anon (1944)
1899 to 1900	Zeekoeivlei		Harrison (1972/73)
1899	Princess Vlei		Harrison (1972/73)
1899 to 1900	Rondevlei		Harrison (1972/73)
1931	Bethel reservoir (Paarl)	The reservoir was drained in 1931 and 40 fish were restocked	Harrison (1976a)
Early part of the century	Wemmer R (Berg R system)		Harrison (1966/67)
1958 to 1959	Wemmershoek reservoir		Harrison (1966/67)
1925	Kaffirskuil R (Vette R system)	Unsuccessful	Harrison (1938)
1924 and 1929	Buffelsjacht R (Breede R system)	Unsuccessful	Harrison (1938)
1897	Bokkeveld R (Olifants system)	Species not given	Harrison (1963)
1906	Hex R (Olifants system)		Harrison (1963)
1951	24 rivers (Porterville)		Anon (1951b)
1961	Kleinkliphuis R (tributary of "24 rivers")	In upper section of river cut off by waterfalls	Bell (1961/62)
1948	Ratel R (Olifants system)		Harrison (1948b)
1962	Upper and lower sections of Ratel R	In areas that were not previously stocked	Bell (1961/62)
Prior to 1909 and 1911 and 1931	Muizenberg reservoir	Species of trout not given. Peat-stained, acid water. Trout left water with first overflow of spillway	Harrison (1962/63b) Harrison (1975)
1916	Steenbras River	Peat-stained, acid waters	Harrison (1964)
1952 to 1964	Steenbras reservoir	Regular stocking. Fish survived but did not breed	Harrison (1948a, 1964)
1946	Liesbeeck lake	Catches in 1949 indicated it had established	Harrison and Lewis (1968/69)

Appendix 1 (continued)

Date	Locality	Remarks	Reference
1927	Bushmans R (Little Brak system)	Unsuccessful	Atkinson (1952)
1952	Paardeberg R (Little Brak system)		Atkinson (1952)
Prior to 1928	Paardevlei	Unsuccessful	Harrison (1954a)
1947	Diepgat Kloof (Lourens R)	Fish survived but did not breed	Ackerman (1951)
1899	Gxulu R	Species of trout not given	Harrison (1954c)
1948	de Hoop Vlei (Bredasdorp)	Had disappeared by 1962	Harrison (1948b) Deathe (1962)
1958	Upper and middle Elandspad R		Anon (1961/62)
Eastern Cape			
1901	Buffalo R	Species of trout not given	Harrison (1954c)
1901	Kubusie R	Species of trout not given	Harrison (1954c)
1902	van Staadens and Baakens R	Species of trout not given	Harrison (1954c)
1903	Sections of Buffalo R	Species of trout not given. Trout caught in 1904	Harrison (1955)
Late 1903 onwards	Buffalo, Tyumie and Keiskamma R	Species of trout not given	Harrison (1955)
1951	Klipplaat R		Anon (1951b)
1951	Rivers in Egcobo area	Species of trout not given	Anon (1951e)
1951	Franklin district		Anon (1951b)
1951	Knysna area		Anon (1951a)
1951	Maden dam (Buffalo R)		Anon (1951b)
1951	Rooikrantz dam (Buffalo R)	Species of trout not given	Anon (1951b)
1958	Berg R (Loerie Mountains near Port Elizabeth)		Bickell (1959)
1958	Honeyclough and Oubos Rs		Bickell (1959)
1899 onwards	Rivers in P E district	Failed. Species of trout not given	Donnelly (1965) Barrow (1971)
1963 and 1964	Bulk R dam (Swartkops system)	Species of trout not given	Donnelly (1965) Barrow (1971)

Appendix 1 (continued)

Date	Locality	Remarks	Reference
Unknown	Dorps R (Gouritz system)	Successful	Donnelly (1965)
Transkei			
About 1902	Wildebeeste R (Tsitsa R system, Maclear district)	Successful. Ova used for re-stocking. Gatberg and Ntombi-si-Nintshi tributaries invaded	Hey (1926)
1909	Mooi R (Tsitsa	Successful	Hey (1926)
1911 to 1912	Umzimhlava R	Successful	Hey (1926)
1926	Ncome R Kenegha system Mount Frere district)		Hey (1926)
1920	Cancele R (Tina R system)	Successful	Hey (1926)
1910	Xokonxa R (Tsitsa system, Tsolo district)	'Disappeared by 1926. Probably washed away in floods	Hey (1926)
1906 to 1912	Umtata R	Present in 1926. Later washed away in floods	Hey (1926)
About 1915	Gora and Manina Rs (Bashee R system, Engcobo district)	Present in 1926	Hey (1926)
1916 to 1920	Engcobo R (Engwali system, Engcobo district)	Present in 1926	Hey (1926)
1925	Qutyeni R (Emgwali system)		Hey (1926)
1908	Tsomo R (Kei system)	Disappeared by 1926	Hey (1926)
1911	Mtakatyi R (Libode district)		Hey (1926)
About 1912	Big Umgazi R		Hey (1926)
1903 to 1955	Upper tributary of Umtata R	Many introductions. Initially unsuccess-ful but established by 1956	Anon (1956b)
1908	Little Pot R (Maclear district)	Invaded Big Pot R by 1926	Hey (1926)
About 1918	Tsitsa R (Umzimvubu system, Mount Fletcher district)	Successful	Hey (1926)
1924	Luzi R (Tina R system, Mount Fletcher dist-rict)		Hey (1926)
1908	Tina R (Umzimvubu system, Mount Fletcher district)	Invaded Tinana tributary by 1926	Hey (1926)

Appendix 1 (continued)

Date	Locality	Remarks	Reference
About 1908	Kenegha R (Umzimvubu system)	Unsuccessful. Presence of carp probably detrimental to colonisation	Hey (1926)
1916	Matatiele municipal res-ervoir	Unsuccessful	Hey (1926)
About 1910	Little Umzimvubu R (Umzimvubu system)	Successful	Hey (1926)
1923	Mvenyani R Umzimvubu system (Mount Frere district)	Successful	Hey (1926)
1911	Umzimvubu R	Present in 1926. Threatened by carp	Hey (1926)
1903	Umzimhlava R (Umzimvubu system)	Successful	Hey (1926)
1905	Gingqiskodo R (Ngwangwana system, Umzim-kulu district)	Successful	Hey (1926)
Before 1926	Ibisi R (Umzimkulu system)	Successful	Hey (1926)
1910	Ncweleni R (Umzimhlava system)	Successful	Hey (1926)
1910	Mnceba R (Umzimhlava R system)	Present above 1st waterfall in river	Hey (1926)
Natal			
1903	Merthley Lake (Greytown)		Pike (1980b)
Before 1932	Henley Lake (Umzindusana R)		Day (1932a)
1904	Natal streams		Pike (1980b) Day (1932a)
1927	Upper Tugela R	Survived but did not breed. <u>Barbus</u> spp. preyed on young	Day (1932a)
1918	Bushmans R (Estcourt district)		Crass (1969b)
1966	Downing's dam Little Mooi R (Kamberg district)	Kamloops strain. Survived. No evidence of breeding	Crass (1968)
1967	Dam on Furth R (Dargle district.	Kamloops strain	Crass (1968)
About 1968	Impendhle and Underberg districts (farm dams)	Successful. Danish strain	Crass (1970)

Appendix 1 (continued)

Date	Locality	Remarks	Reference
??	Highmoor dam	Regular stocking	Pike and Wright (1972)
Prior to 1948	Umzimvubu and Umzimhlava R	Deterioration in trout fishery after introduction of carp	Harrison (1948b)
Transvaal			
Prior to 1955	Upper Mutale R (above Lake Fundudzi)		Hewitt Ivy (1955)
Before 1955	Mutshindudzi R above Phiphidi Falls		Hewitt Ivy (1955)
Before 1968	Longmeadow farm on tributary of Crocodile R (near Dullstroom)		le Roux (1968)
1910 1922	Sterkspruit and Dorpsrivier (near Lydenberg)	Species of trout not given. Established in Sterkspruit by 1924	du Plessis (1961)
1916	Potspruit at Kraaiberg (Lydenberg district)	Established by 1922. Species of trout not given	du Plessis (1961)
1924	Rivers in Lydenberg district	Species of trout not given	du Plessis (1961)
1957 to 1967	Treur River		Pott (1981)
1976 to 1977	Wilgekraalspruit (tributary of Crocodile R, Incomati system)	Illegal introduction	Kleynhans personal communication
Orange Free State			
1981 1982	Sterkfontein dam (Wilge R, Vaal system)		O F S Nature Conservation (1983)
Swaziland			
1908	Swaziland		Welcomme (1981)
1910	Lake Adelaide		Clay (1972)
1908 to 1930	Various parts of Swaziland	Failed to establish	Clay (1972)
1952 to 1954	Popoyani R (Pigg's Peak plantations)	Unsuccessful	Clay (1972)
1954	Komozane R (Komati system)	Successful. Species of trout not given	Clay (1972)
1955 1968	12 dams on property of Usutu Pulp Company	Species of trout not given. Successful	Clay (1972)
Lesotho			
1943	Tsoelikana R		Pike and Tedder (1973b)

Appendix 1 (continued)

Date	Locality	Remarks	Reference
1967	Khubelu R (Orange system)	Transferred from Tlolohatse R (Oxbow, Orange system	Liebenberg (1967/68)

Appendix 2. Dates of initial stocking of <u>Salmo trutta</u> in various localities in southern Africa

Date	Locality	Remarks	References
Western Cape			
About 1892	Cape flats, Newlands and Lourens R		Anon (1944, 1945)
1900	Zeekoeivlei (western Cape)		Harrison (1972/73)
1890's	White R	Established by 1934	Harrison (1975)
1931	Bethel	"Trout" stocked. Unsuccessful	Harrison (1976a)
1909	Gwaayang R (Witfontein tributary, George)		Harrison (1966a)
1910	Gwaayang R (mainstream)		Harrison (1966a)
1916	Steenbras R (above reservoir)	Peat-stained acid water. Survived, did not breed	Harrison (1964)
1928, 1947 and 1957 to 1969	Steenbras reservoir	Survived, did not breed	Harrison (1948a, 1970/71a)
1931 to 1935	Muizenberg reservoir	Peat-stained water. Survived, did not breed	Harrison (1962/63b)
1935	Kromme R (Berg R system)		Harrison (1975)
1961	Upper Elandspad river		Anon (1961/62)
About 1936	Wemmer R		Harrison (1977/78)
1895 and 1906	Upper Olifants R	Well established by 1916	Harrison (1971)
1899 to 1905 and 1918	Cedarberg streams east of Uitkyk pass (Olifants system)	Initially failed because of high temperatures. Present in 1917. Disappeared by 1938	Harrison (1963a)
1897	Bokkeveld streams (Olifants system)	Trout species not given	Harrison (1963a)
1906	Hex R (Olifants system)		Harrison (1963a)
1961	Kleinkliphuis R (24 Rivers, Die Hel)	Released in upper reaches cut off from mainstream	Bell (1961/62)

Appendix 2 (continued)

Date	Locality	Remarks	References
1962	Upper and lower Ratel R (Olifants system)		Bell (1962/63)
Eastern Cape			
About 1895	Upper Buffalo R	Escaped from Pirie Hatchery	Anon (1952b)
About 1895	Farm dam, Hazelton district		Anon (1952b)
1903	Buffalo R		Harrison (1955)
1903	Buffalo, Keiskamma and Tyume Rs	Successful	Harrison (1955)
1912	Mooi R (Tsitsa R, Maclear district)	Disappeared by 1917	Hey (1926)
1908	Little Pot R, Maclear district	Disappeared by 1921	Hey (1926)
Transkei			
1908	Tina R (Umzimvubu syst) Mount Fletcher district		Hey (1926)
About 1910	Little Umzimvubu R (Umzimvubu system)	Unsuccessful	Hey (1926)
1911	Umzimvubu R	Not found in 1926 samples	Hey (1926)
1903	Umzimhlava R (Umzimvubu system)	Disappeared by 1926	Hey (1926)
1905	Gingqiskodo R (Ngwangwana system, Umzimkulu district)	Successful	Hey (1926)
1910	Ncweleni R Umzimhlava system)	In 1926 present below second waterfall	Hey (1926)
1911 1912	Umzimhlava R	Present in 1926	Hey (1926)
1910	Xokonxa R (Tsitsa system, Tsolo district)	Washed away in floods	Hey (1926)
1906 to 1912	Umtata R	Washed away in floods	Hey (1926)
About 1915	Gora and Manina Rs (Bashee system, Engcobo district)	Disappeared by 1926	Hey (1926)
1916 to 1920	Engcobo R (Engwali system, Engcobo district)	Unsuccessful	Hey (1926)
1925	Qutyeni R (Engwali system, Engcobo district)		Hey (1926)
1908	Tsomo R (Kei system)	Unsuccessful	Hey (1926)

Appendix 2 (continued)

Date	Locality	Remarks	References
About 1912	Big Umgazi R	Probably unsuccessful	Hey (1926)
Natal			
1890	Bushmans and Umgeni Rs		Pike (1980b)
1891	Mooi R Little Mooi R Little Tugela R Klip R Umgeni R Umlaas R Yarrow R Inyamvuba R Illovo R	_S. trutta_ and _S. salar_ stocked	Day (1932a)
1891 to 1892	Natal streams		Pike (1980b)
1910 to 1920 and 1926	Upper Umkomazana R		Greenwood and Jubb (1967)
Regular stocking	Highmoor dam	Survive, do not breed	Pike and Wright (1972)
Lesotho			
?	Various localities		Welcomme (1981)
Swaziland			
1908 to 1930	Various localities	Apparently unsuccessful. Species of trout not given	Clay (1972)
Orange Free State			
1951	Hawkins dam (Harrismith district)		Anon (1956a)

Appendix 3. Dates of initial introductions and initial records of _Cyprinus carpio_ in various localities in southern Africa

Date	Locality	Remarks	Reference
Cape			
Late 1910 to 1920's	Colesberg farm dams		Bennion (1923)
1923	Little Princess vlei		Bennion (1923)
1936	Sandvlei (Sand R, w Cape)		Harrison (1936)
1935	Van Ryneveld irrigation scheme (Graaf-Reinet)		Harr[illegible] (1936)
1934	Kamanassie (Oudtshoorn)		Harrison (1936)
1933	Benfontein dam (near Kimberley)		Harrison (1936)
1934	Rietfontein farm dam (Somerset East)		Harrison (1936)
1934	Seekoeivlei (w Cape)		Harrison (1936)

Appendix 3 (continued)

Date	Locality	Remarks	Reference
1938	Gouritz R system		Harrison (1938)
1948	Rondevlei		Harrison (1948b)
Transkei			
1908	Kanegha R (Umzimvubu system)		Hey (1926)
1922	Mount Frere Municipal reservoir	Pest by 1926	Hey (1926)
Natal			
1915	Matatiele Municipal reservoir	Pest by 1926	Hey (1926)
1926	Mvenyane R (Umzimvubu R)	Introduction failed	Hey (1926)
1911 to 1926	Main Umzimvubu R	Dam burst in upper catchment	Hey (1926)
1935	Buffalo R and farm dams near Newcastle		Coke personal communication
1966	Midmar dam	Illegal introduction. From here spread to Umgeni R, Albert Falls and Nagle dams.	Pike personal communication
1970	Chelmsford dam	Stocked by Natal Parks Board	Coke personal communication
1984	Pongolapoort dam	Escape from dams in catchment during cyclone	la Hausse de Lalouviere (1986)
Transvaal			
1904	Homestead dam (Benoni)		Bennion (1923)
1905 1910	Farm dams in Standerton district		Bennion (1923)
1915	Balfour district		Bennion (1923)
1923	Kleinfontein dam (Benoni)		Bennion (1923)
1978	Olifants R (Kruger National Park)	Mirror carp	Pienaar (1978c)
South West Africa			
?	Kuiseb R (Kuiseb canyon)		Dixon and Blom (1974)
?	Hardap dam (Fish R, S W A)	Probably introduced by early German settlers	Gaigher (1975b)

Appendix 4. Dates of initial introductions of tench Tinca tinca into various localities in southern Africa.

Date	Locality	Remarks	Reference
Cape			
1933	Paardevlei (western Cape)		Anon (1975/76) Harrison (1968)
1936	Little Princess Vlei (Heathfield)		Harrison (1976a)
Before 1936	Breeland farm dam (Slanghoek, Rawsonville)		Harrison (1936)
Before 1935	Brandvlei Lake (Breede R system)		Harrison (1936)
1928	Cradock Municipal Reservoir	Sucessful Used to stock farm dams	Harrison 1936
1934	Great Fish R	Escapees from Cradock Municipal Reservoir	Harrison (1936)
?	Cranmere farm dam (Pearston)		Harrison (1936)
?	Oak valley farm (Elgin R)	Unsucessful	Harrison (1936)
Natal			
?	Zwartberg-Franklin district		Coke (personal communication)
Transvaal			
Before 1923	Florida Lake Boksburg Lake Nancefield dam Star dam (Newclare) Benoni dams.		Bennion (1923)
South West Africa			
1908	Lake Otjikoto sinkhole (20 km west of Tsumeb)		Ribbink personal communication

Appendix 5. Dates of initial introductions of Gambusia affinis into southern Africa

Date	Locality	Remarks	Reference
1931	Silvermine reservoir (Muizenburg)	Failed to establish	Harrison (1939b)
?	Groenvlei (Knysna)		Harrison (1977a)
Before 1955	Palmaryville dam (Sibasa-(Transvaal)		Hewitt Ivy (1955)

Appendix 5 (continued)

Date	Locality	Remarks	Reference
1950	Slaaikraal dam and van der Riet's farm (Albany district)		Coetzee (1977)

Appendix 6. The first introductions of Lepomis macrochirus into various localities in southern Africa

Date	Locality	Remarks	Reference
Cape			
1939	Blougat pool (Berg R)		Harrison (1962/63a)
1940	Paardevlei		Harrison (1954d)
1940	Little Princess Vlei		Harrison (1977/78)
1950	Tygerberg conservation scheme- dam 2 dam 4		Anon (1950d)
1939	Farm dams in Elgin district		Harrison (1977/78)
1947-1948	de Hoopvlei	Disappeared by 1962	Deathe (1962)
1940	Groenvlei (Knysna)	Intended to replace Gilchristella aestaurius as forage for bass	Harrison (1977a)
1944	Silvermine Reservoir (Muizenberg)	Apparently unsuccessful	Harrison (1962/63b)
Before 1961	Olifants R	Probably accidental escapees from farm dams	Harrison (1963a)
NATAL			
Early 1960's	Dams in Kwa-Monamulu district and between Tugela R and Mozambique border	Stocked by Forestry Department	Dekker (personal communication)
Orange Free State			
Before 1983	Sterkfontein dam (Wilge R, Vaal system)		OFS Nature Conservation (1983)
TRANSVAAL			
1942	Longmere dam (Witrivier)	Population had spread to Crocodile R by 1944	Potgieter (1974)
Swaziland			
1940 and 1942	Black Umbeluzi R above Hawane Falls		Clay (1972)
1941	Poponyani R (Pigg's Peak)		Clay (1972)

Appendix 6 (continued)

Date	Locality	Remarks	Reference
1941	Mtitshane R (tributary of Motshane R)		Clay (1972)
1950	Dams on tributaries of Komati R (at Hereford's farm)		Clay (1972)

Appendix 7. Dates of introductions of Micropterus dolomieui into southern Africa.

Date	Locality	Remarks	References
Cape			
1938-1939	Muizenberg reservoir	Reservoir emptied in 1941	Harrison (1962/63b)
1938 and 1939	Berg R	Rapidly established. The only known stocking of this river	Harrison (1953b, 1962/63a)
1949	Klein R		Anon (1949)
1949	Grobbelaar's R at Schoemanshoek		Anon (1949)
1943	Jan Diesels R (Olifants system)	Established by 1945. Stocking affected river below Clanwilliam dam	Harrison (1963a) Gaigher (1973)
1945	Keerom (Olifants R above Clanwilliam dam).	Entire river established from Clanwilliam barrage to below cascades at Bulshoek by 1948	Harrison (1963a)
1950	Tygerberg conservation scheme- dam 2		Anon (1950d)
1950	Paarl municipal reservoir		Anon (1950d)
1939 to 1940	Breede R		Harrison (1953b)
1946 to 1948	Rondevlei	To control carp	Anon (1948a)
1950	Vleis on Hangklip estates		Anon (1950d)
1946	Paardevlei	Established by 1950	Harrison (1954d) Anon (1950b)
1947 and 1948	de Hoop vlei (Bredasdorp)	Disappeared by 1962	Harrison (1948b) Deathe (1962)
1946 to 1948	Pearly Beach estate lake, Bredasdorp		Harrison (1948b)

Appendix 7 (continued)

Date	Locality	Remarks	References
1948	Uitenhage district: Swartkops R, dams in Elands R catchment, Bulk R, dam, Sand R dam and reservoir in Coega district		Harrison (1948b)
Prior to 1951	Tsitsikama from Mossel Bay northwards	Peat-stained rivers. Many unsucessful introductions	Harrison (1951)
1939/40	Steenbras Reservoir	Peat-stained water. An established breeding population, with a slow growth rate	Harrison (1949)
Transkei			
1947 to 1949	Umtata R	Plentiful in river by 1951	Anon (1952a)
1948	Umtata district: Xora R, Mtakatyi R, Bunga dams (Umtata R system)		Anon (1948)
1949	Umtata district: Maagondo R, Xora R, Pafona R Umtata R		Anon (1949)
1948	Butterworth district: Nxaxo R, Gcuwa R, Ceguana R, (Gcuwa R system)		Anon (1948)
1948	Idutywa district: Ncingwane R, (Nqabara system), Nqabara dam, 2 farm dams		Anon (1948)
1949	Umgazi R (Port St John's) Umgazana R		Anon (1949)
Natal			
1938	Waters in Natal	Limited success	Crass (1964)
Before 1946	Karkloof, Mooi, Umgeni and Lions Rs.	Established by 1946. Not as successful as in the Cape, probably because of floods	Crass (1955)
Transvaal			
Between 1957 and 1981	Blyde and Treur Rs (Limpopo system)		Pott (1981)
1969 to 1977	Boskop dam (Mooi R, Vaal system)	20 000 introduced	Koch and Schoonbee (1980)

Appendix 7 (continued)

Date	Locality	Remarks	References
Before 1974	Longmere and Primkop dams (Witrivier, Incomati system)		Potgieter (1974)
1960	Rietvlei dam (Limpopo system, Pretoria)	Successful	Smith (1983)
Swaziland			
1940 and 1941 to 1947	Moutjane R, (Little Usutu system)	Regular stocking. Unsuccessful	Clay (1972)
1940 and 1942	Black Umbeluzi River above Hawane Falls		Clay (1972)
1949	Forbes Reef dam		Clay (1972)

Appendix 8. Initial introductions of M. punctulatus into various localities in southern Africa.

Date	Locality	Remarks	Reference
Cape			
1940	Berg R (Groot Drakenstein)		Harrison (1977b)
1940	Nuwejaars R (Elim)		Harrison (1977b).
1941	Palmiet R (Elgin road bridge)		Harrison (1977b)
1941	Dam on Palmiet R		Harrison (1977b)
1941	Bot R		Harrison (1977b)
1944	Klein R (Caledon)	Fingerling found in 1948 Apparently successful	Harrison (1948)
1945	Keerom (Olifants R)		Harrison (1963a)
1945	Olifants River upstream of Citrusdal		van Rensburg (1963)
1946	Paardevlei		Harrison (1954d)
1946 to 1948	Paardevlei		Anon (1948)
1947	de Hoop vlei		Harrison (1948b)
1949	Dam on Lipp's farm (Stellenbosch area)		Anon (1949)
1949	Paarl municipal Reservoir		Anon (1949)
1946 to 1948	Rondevlei		Anon (1948)
1947 to 1948	de Hoop vlei	Disappeared by 1962	Anon (1948b) Deathe (1962)
1950	Vleis at Hangklip estates		Acidic waters	Anon (1950b)

Appendix 8 (continued)

Date	Locality	Remarks	References
1950	Tygerberg conservation scheme (dam 3)		Anon (1950b)
	dam 4		Anon (1950b)
Before 1951	Tsitsikama coastal rivers	Numerous unsuccessful attempts in peat-stained rivers	Harrison (1951)
Eastern Cape			
1947	Buffalo R below Maden dam		Harrison (1954b)
Before 1948	Lower Swartkop R, dams of the Elands R and Sand R and Coega R reservoirs		Harrison (1948b)
Natal			
1946 to 1948	Umzimhlava R (Kokstad)		Harrison (1948b) Anon (1948b)
1947	Karkloof River	Unsuccessful	Crass (1955)
Swaziland			
1940	Many localities	Unsuccessful	Welcomme (1981)
1949	Hlambanyati R (Little Usutu system)		Clay (1972)

Appendix 9. First recorded introductions of M. salmoides into various natural waters in southern Africa.

Date	Locality	Remarks	Reference
Southern Cape			
1930	Paardevlei, Brandvlei Lake Oukloof dam		Harrison (1977a) Anon (1944)
1930	Berg R		Harrison (1940b, 1953b)
1933	Porterville dam (Berg R)		Harrison (1936)
1930 and 1932	Oukloof Irrigation dam (Prince Albert)	Successful	Harrison (1936)
1933	Farm dam in Bedford district		Harrison (1936)
1932	Vlei near Caledon Railway Station		Harrison (1936)
1930	Irrigation dam near Caledon		Harrison (1936)
1935	Hout Bay River		Harrison (1936)
1932	Marais' farm vlei (Breede R System)		Harrison (1936)
1938	Weiders R catchment, Gouritz system		Harrison (1938)

Appendix 9 (continued).

Date	Locality	Remarks	Reference
1934	Kuilkietjieskraal reserve dam (Breede R catchment)	Established in Breede R system by 1938	Harrison (1938)
1930 and 1932	Brandvlei lake (Breede R system)	Migrated from lake to Breede R. Present in river by 1935	Harrison (1936)
1935	Klein R (Hermanus)		Harrison (1936)
1934	Rosslands farm dam (Steynberg)		Harrison (1936)
1932	Flitwick Grange reservoir, Swartberg		Harrison (1936)
1934	Groenvlei lake, Knysna		Anon (1944) Jubb (1973a) Harrison (1977a)
1934	Large Princess vlei	Successful	Harrison (1936)
1932	Little Princess vlei (Heathfield)	Breeding successfully by 1936. Transferred from Paardevlei	Harrison (1975, 1976a)
Prior to 1930	Sandvlei (Lakeside)	Not very successful	Harrison (1976b)
1937	Zoetendals vlei, Elandskloof R (near Agulhas)	No records of survival	Harrison (1964/65a)
1934	Rondevlei		Harrison (1975)
1946-1948	Rondevlei		Anon (1948)
1950	Elsenberg dams (Muldersvlei)		Anon (1950)
1950	Tygerberg conservation scheme		Anon (1950)
1951	Conservation dams in western Cape		Anon (1951b)
1934	Olieblom vlei (Cape flats)		Harrison (1975)
1934	Zeekoeivlei	Apparently unsuccessful	Harrison (1975, 1976b)
1933	Palmiet R (Elgin)		Harrison (1975)
1937	Hout bay R estuary	Transferred from Paardevlei	Harrison (1976a)
1937	Farm dam at Noordhoek		Harrison (1976a)
1935	Klein R (Sandford)	Present in many pools in river by 1948	Anon (1948) Harrison (1976a)

Appendix 9 (continued).

Date	Locality	Remarks	Reference
1936	Upper Bot R lagoon	Peat-stained river	Harrison (1976a)
1933	Bethel reservoir	By 1937 was the dominant species in reservoir	Harrison (1976a)
1949	Elsenburg College dam (Stellenbosch)		Anon (1949)
Prior to 1940	Irrigation reservoirs in George and Knysna districts		Harrison (1940a)
Prior to 1951	Tsitsikama rivers from Mossel Bay northwards	Numerous unsuccessful attempts. Peat-stained rivers	Harrison (1951)
1933 to 1951	Groenvlei		Harrison (1951)
1931 and 1934	Highlands Farm dam (Malmesbury)		Harrison (1936)
1934	Kamanassie dam and river (Oudtshoorn)		Harrison (1936)
1933	Paarl Municipal reservoir	Successful	Harrison (1936)
1947-48 and 1950	de Hoopvlei	Disappeared by 1962	Deathe (1962)
1933	Bulshoek dam (Olifants R)	Successfully established by 1937. Whole of lower Olifants colonised from this stocking.	Harrison (1936, 1963) Gaigher (1973)
1936 and 1937	Clanwilliam dam (transported from Bulshoek dam)	1 breeding pair + 5 adults. Dam had previously been a barrier to colonisation of upper Olifants River	Harrison (1963a)
1934	Forestry School dam (George)	Successful	Harrison (1936)
1932	Modder R vlei (George)		Harrison (1936)
1930 to 1934	Farm dams in Groot Drakenstein area (Berg R catchment) (Bakers pool, Meerlust pool, Nuwehoop pool, Langerust, Sondernaam)	Mostly successful	Harrison (1936)
1934 and 1935	"Bien Donne" (Upper Berg R)	Probably unsuccessful	Harrison (1936)
1932	Bethlehem farm dam Dwars R catchment)		Harrison (1936)

Appendix 9 (continued).

Date	Locality	Remarks	Reference
1933	Vette R (Riversdale) (tributary of Kafferskuil R)	First placed in Novo dam. Later escaped. Initially indigenous fish plentiful. No indigenous fish in dam in 1938 and bass stunted.	Harrison (1936, 1938) Harrison (1938)
Northern Cape			
1933	Benfontein farm dam (Kimberley)		Harrison (1936)
Eastern Cape			
1935	Buffalo R (Kingwilliamstown)		Harrison (1936)
1933	Queenstown municipal reservoir		Harrison (1936)
1933	Breeland farm dam (Slanghoek, Rawsonville)		Harrison (1936)
1933 and 1934	Farm dams in Somerset East (Naude's R catchment)		Harrison (1936)
1933	Bain's farm dam (Kei R)	Escaped from dam to river	Harrison (1936)
Unknown	Swartkops R	Colonised river from Despatch to upper reaches	Barrow (1971)
1980	Farm dam near Franklin (East Griqualand)	Florida bass stocked	Anon (1980)
1935	Grassridge dam (Cradock) (Fish River)	Not present in 1976 collections	Harrison (1936); Cambray and Jubb (1977a, 1977b)
1934	Golonge River		Harrison (1936)
1932	3 dams on "Vogelvlei", Dordrecht	Probably died because of low temperatures	Harrison (1936)
1930	Matatiele municipal reservoir	Successful	Harrison (1936)
1932 to 1935	Farm dams in Elgin district (Palmiet R catchment). ("Eikenhof, Oakvalley, Glen Fruin" and "Catleigh")	Mostly successful	Harrison (1936)
1933 to 1935	Palmiet R	Escapees from farm dams + 2400 fry released. Successful.	Harrison (1936)

Appendix 9 (continued).

Date	Locality	Remarks	Reference
1933	Water furrow, Zonderend R. system (Elgin district)	Successful. Present in Zonderend R by 1935	Harrison (1936)
1934	Farm dams in Graaff-Reinet	Supplied from municipal reservoir	Harrison (1936)
1935	van Ryneveld Pass irrigation dam (Sundays R)		Harrison (1936)
1934	Cranemere farm dam (Pearston)		Harrison (1936)
1933	Kragge Kama Lake (P E)		Harrison (1936)
1933	Amanzi estate dam (Uitenhage)		Harrison (1936)
1935	Groendal dam (Uitenhage)		Harrison (1936)
1933	Slaaikraal reservoir (Grahamstown)	None found in 1939 survey	Harrison (1936)
Prior to 1939	Howiesons Poort dam (Grahamstown) (Kariega system)	Successful. In 1929 200 fry distributed to farm dams in the district.	Coetzee (1977)
1933	Kowie R		Harrison (1936)
Transkei			
1946 to 1948	Ibeka dam		Anon (1948a)
1954	Tsolo Agricultural School dam	Successful	Hyde (1956)
Natal			
1938	Black Umbeluzi R below Hawane falls	Sent from Swaziland to Zululand	Clay (1972)
1948	Black Umbeluzi R above Hawane falls		Clay (1972)
1935	Lake Sibaya	Did not survive (1980 report)	Harrison (1936) Bruton (1980)
1931 to 1935	Prospect farm dams (Karkloof, Howick)	Original stock used for breeding and restocking	Harrison (1936)
1934 and 1935	Karkloof R (Howick)		Harrison (1936)
1933 and 1935	Taynton stream (Karkloof R system)		Harrison (1936)
Early 1960's	Dams between Tugela R and Mozambique		Dekkker personal communication
1970	Maputaland, pan west of Nhlange Lake (Kosi system)		Bruton (1979e)

Appendix 9 (continued).

Date	Locality	Remarks	Reference
Transvaal			
c. 1938	Palmaryville farm fishery (Sibasa)	Also distributed to rivers and dams in the district	Hewitt Ivy (1955)
1953	Doorndraai dam (Sterk R, Limpopo system) near Potgietersrus		Batchelor (1974)
Before 1982	Steelpoort R (Olifants, Limpopo system)		Hecht and Scholtz (1983)
c. 1938	Lake Fundudzi (22S, 30E CD) (Sibasa district, northern Transvaal)		Hewitt Ivy (1955)
1961	Klipkoppies dam (Witrivier, Incomati system)	Regular stocking after 1961	Potgieter (1974)
1930's	Longmere dam, Witrivier. Restocked in 1961	Regular stocking since 1930's Initial success. Later decline after introduction of *L. macrochirus*	Potgieter (1974)
Before 1974	Primkop dam on Witrivier		Potgieter (1974)
Before 1983 and in 1983	Rietvlei dam (south east of Pretoria, Limpopo system)		Smith (1983)
Swaziland			
1933	Dam in Mbabane district (Mbuluzi catchment)	Successful. Distributed from here to other dams in Swaziland	Harrison (1936)
1935	Hlatikulu pool (southern Swaziland)	Successful	Harrison (1936)
1933	Lake Adelaide	Established by 1934	Clay (1972)
1935	Various dams and streams including Sidokodo R (tributary of Little Usutu) and Tubungu R (tributary of Usutu R)		Clay (1972)
1950	Hlambanyanti R (tributary of Little Usutu R)		Clay (1972)
1950	Dams at Herefords farm (tributary of Komati R)		Clay (1972)
1950	Dammed tributaries of White Umbeluzi R		Clay (1972)
1928, 1936, 1937 and 1949	Forbes Reef dam		Clay (1972)

Appendix 9 (continued).

Date	Locality	Remarks	References
South West Africa			
1934	Windhoek municipal dam	Farm dams in SWA stocked from 1944 to 1949	Harrison (1936); Skelton and Merron (1984)
1932	Municipal pools in Narubis		Schrader (1985)
Lesotho			
1937	Localities not given		Committee for Inland Fisheries of Africa (1985)

Appendix 10. Dates of first introductions of O. mossambicus into various localities in southern Africa

Date	Locality	Remarks	Reference
Western Cape			
1959	Seekoeivlei	Established by 1960	van Rensburg (1966a) Anon (1960)
1950	Lakeside (Muizenberg)	Water sometimes saline	Anon (1950b)
1958	de Hoop vlei	Established by 1962 and had colonised some inflowing streams	van Rensburg (1966a) Deathe (1962)
1973	Sandvlei	Introduced for macrophyte control but failed in this task	Begg (1976)
1975 and 1976	Marina canals. (connected to Sandvlei)	Introduced to control algae and and chironomids and for angling	Begg (1976)
1969	Jan Diesels R (Olifants system)	Probably escaped from farm dams in the catchment	Crass (1969a)
		Not present in the system in 1963	Van Rensburg (1963)
Eastern Cape			
1961	North End lake (Port Elizabeth)	Lake receives warm effluent. Introduced to control chironomids.	Jubb (1968b)
1982	Laing dam (Buffalo R)		Jackson (1982)
Unknown	Lake Mentz (Sundays R)	There may be a cold-resistant strain in this locality	Jackson (in press)
North western Cape			
Unknown	Lower Orange R	Probably introduced via the Fish River (Hardap dam)	Skelton and Cambray (1981)

Appendix 10 (continued)

Date	Locality	Remarks	Reference
Natal			
Unknown	Paulpietersberg (Phongolo system, altitude 1700m)	Isolated high altitude record	Crass (1964)
South West Africa			
Unknown	Namib Desert Rivers (Kuiseb, Omaruru and Ugab). In perennial pools fed by underground waters	Probably placed in pools. Rare storms link the pools and spread the fish	Dixon and Blom (1974)
Unknown	Hardap dam (Fish River, S W A)	First record in 1973. Probably introduced by early settlers	Gaigher (1975b)

Appendix 11. Dates of initial introductions of Tilapia rendalli swierstrae into various localities in southern Africa

Date	Locality	Remarks	Reference
?	Small impoundment in Durban	For mosquito control	Bourquin (1985)
Before 1967	Doorndraai dam (Sterkrivier, Limpopo system)		Batchelor (1978)
1961	Klipkoppies dam (Witrivier, Incomati system altitude 1090 m)	Presumably at this high altitude this dam is not in the native range of T. r. swierstrae	Potgieter (1974)
1961	Longmere dam (Witrivier) (altitude 1000m)	Altitude beyond the native range of this species	Potgieter (1974)
1951	Njelele dam (south east of Tshipise, Limpopo system)	Altitude beyond the native range of this species	Potgieter (1974)
Circa 1950	Hans Merensky dam (Letaba-Limpopo system)		Potgieter (1974)

Appendix 12. Dates of initial introductions of T.sparrmanii into various localities in southern Africa

Date	Locality	Remarks	Reference
1949 to 1950	Elsenberg College dam (Stellenbosch)		Anon (1949) Anon (1950b)
1950	Lakeside dam (Muizenberg)		Anon (1950b)
1951	Conservation dams (western Cape)		Anon (1951b)
1954	Tsolo Agricultural School (Transkei)	Used as breeding stock for other introductions in the district	Hyde (1956)

Appendix 12 (continued)

Date	Locality	Remarks	Reference
About 1956	Tsolo municipal reservoir		Hyde (1956)
1964	Caledon R (Orange system)	Originally absent from this section of the Orange R	Jubb (1972b)
Before 1961	Olifants R (Clanwilliam)	Probably escaped from farm dams	Harrison (1963a) van Rensburg (1963)

Appendix 13. Dates of initial stocking of Salmo salar in various localities in southern Africa

Date	Locality	Remarks	Reference
About 1897	Eerste R	Accidental release	Harrison (1965/66b)
1898	Dwars R (Berg R system)	5000 released	Harrison (1965/66b)
1898	Keiskamma R	8000 fingerlings	Harrison (1965/66b)
1899	Rabula Stream (Keiskamma tributary)	7000 fry released	Harrison (1953c)

Appendix 14. Dates of initial introductions of Salvelinus fontinalis into various localities in southern Africa

Date	Locality	Remarks	Reference
1951	Upper Lourens R, Dwars R (Banhoek), Upper Berg R (Assegaaibos), Liesbeeck R (Bishopscourt), Orange-Kloof stream (Hout Bay), Hex R (above Kanetvlei causeway), Ceres stream, Witte R (Bain's Kloof) Steenbras reservoir, Groot Drakenstein reservoir		Anon (1950a)
1952-1958	Steenbras reservoir	42000 fingerlings released. 45 recoveries were made between 1955 to 1960	Harrison (1964) Harrison (1970 / 1971)
	Upper Breede R system, Berg R, Dwars R		Anon (1951b)
1952	Bushmans and Paardeberg Rs (Little Brak R system)		Atkinson (1952)
Before 1949	Smalblaar R (Breede R system)		Harrison (1949)

Appendix 15. Dates of initial records and first introductions of S. robustus jallae into various localities in southern Africa.

Date	Locality	Remarks	References
Western Cape			
1966	4 farms dams in Eerste R basin (farms Uitkyk, Warwick and Woodlands)	From stock that survived the winter in outdoor ponds	van Schoor (1969b)
1967	Rozendal farm dam (Stellenbosch district)		van Schoor (1969b)
1968	Dam at Plant Quarantine Station (Stellenbosch)		van Schoor (1969b)
Natal			
1965/ 1966	Uvongo above falls	Probably died out during floods	Coke (personal communication)
1968	Uvongo R at Margate quarries	Probably died out during floods	Coke (personal communication)
1968	Cornhill farm dam (Port Edward)		Coke (personal communication)
1968	Seldon Park farm dam (Margate)		Coke (personal communication)
?	"Dreadnought" Hatchery (Eshowe)		Coke (personal communication)

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