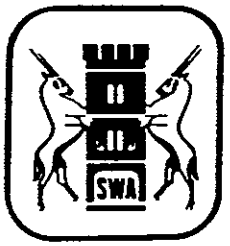


Invasive alien organisms in South West Africa/Namibia

Edited by C J Brown, I A W Macdonald and S E Brown

This report results from a workshop organized by the Directorate of Nature Conservation and Recreation Resorts in Windhoek, and is produced in conjunction with the Council for Scientific and Industrial Research

A report of the National Programme for Environmental Sciences

Produced as part of the South African contribution to the international SCOPE project on the Ecology of Biological Invasions

SOUTH AFRICAN NATIONAL SCIENTIFIC PROGRAMMES REPORT NO

119

Issued by
Foundation for Research Development*
Council for Scientific and Industrial Research
P O Box 395
PRETORIA
0001
from whom copies of reports in this series are available on request

Printed in 1985 in the Republic of South Africa

ISBN 0 7988 3800 0

Editors' addresses:

Mr C J Brown
Directorate of Nature Conservation and Recreation Resorts
Private Bag 13306
WINDHOEK
9000

Mr I A W Macdonald
Percy FitzPatrick Institute of African Ornithology
University of Cape Town
RONDEBOSCH
7700

Mrs S E Brown
South West Africa Herbarium
Directorate of Agriculture and Forestry
Private Bag 13184
WINDHOEK
9000

*previously Cooperative Scientific Programmes

PREFACE

Workshop sessions were held during the annual Professional Officer's Research Meeting of the Directorate of Nature Conservation, on the afternoons of 27-29 November 1984. The objectives of these workshops were to determine the extent of invasion of SWA/Namibia by alien species of plants and animals, and to assess as far as possible the potential for further invasion so that preventative measures can be implemented before the problems get out of hand.

Expertise was drawn from many sources: Mr Ian Macdonald, currently with the CSIR and working on invasive aliens throughout southern Africa (and coordinator of southern Africa's participation in the SCOPE project) came up from Cape Town for the workshops. Research and management staff of the Directorate of Nature Conservation and Recreational Resorts actively participated, as did members of staff of the SWA Herbarium (Directorate of Agriculture), Directorate of Veterinary Services and Department of Water Affairs. Other participants included Dr N Fairall of the Mammal Research Institute at the University of Pretoria, and Dr J Ferreira of the Rand Afrikaans University.

It emerged from the workshops that while large parts of SWA/Namibia are reasonably free from invasion by alien organisms other parts are already seriously infested or are high risk areas.

SWA/Namibia, while generally considered an arid country, can be seen to be composed of several distinct vegetation types. Mean annual rainfall increases from west to east and from south to north, and this is reflected in the distribution of vegetation types, with desert extending down the west coast, savanna occupying most of the central areas, dry woodland in the north-eastern sections of the country, and the Kalahari semidesert in the south-eastern area (Giess 1971) (Map 1).

There are no perennial rivers within the country, but five river systems form common borders with adjacent countries. These include the Orange River in the south which forms the border with South Africa, and the Cunene and Okavango Rivers in the north which form the boundary with Angola. The Kwando-Linyanti-Chobe system flows across eastern Caprivi, forming the southern border of this region with Botswana, while the Zambezi River forms the short northern border with Zambia. A general bioclimatic map of SWA/Namibia has been produced, which divides the area into 11 bioclimatic regions (Map 2). This map also shows (i) the quarter degree square grid, the mapping system used throughout the invasive alien workshops; (ii) the major river systems and (iii) the larger towns. The distributions of the invasive alien species for which sufficient information is available to warrant it, have been plotted onto this standard map. No more than one map has been drawn per species; in some cases this represents a synthesis of information from several chapters. In addition, all records of specimens held in the SWA Herbarium have been included. In the case of species for which only a few localities are known, these are mentioned in the text. Distribution maps have been placed at the end of the publication.

An index of scientific names is provided on page 69 which includes, in addition to the alien species discussed in the following chapters, all alien plant species mentioned in Merxmüller (1966-1972). Common names (where available) are given after the scientific name followed by the page numbers. The map page number is printed in bold.

The first seven chapters of this publication deal with invasive alien plants. The country has been divided into several geographic regions for this purpose (Map 3). The remaining four chapters deal with invasive animals. As the number of species involved in these cases are considerably fewer, each chapter deals with the country as a whole.

ACKNOWLEDGEMENTS

Isgard Henrichsen and Ben Riekert are acknowledged for assistance with the workshop organization and production of workshop documents. Herta Kolberg is thanked for assistance in checking herbarium specimens and Ingrid Bieker and Almuth Henrichsen for extracting information from the German literature. We are grateful to Patricia Craven for supplying a list of alien plants based on her experience and information extracted from the literature. Officials of the Teachers Training College, Windhoek, are thanked for making facilities available for the workshops.

Fiona Powrie is thanked for preparing the final copies of the figures and species maps.

SUMMARY

The greatest threat of invasion of alien species of plants and animals is posed by species which originate from similar arid habitats in other parts of the world. In general the smaller the number of individuals of an alien species introduced into the country, the smaller are its chances of becoming established as an invasive problem species. For this reason all efforts at reducing the numbers of alien species should be regarded as worthwhile, even if total eradication of the species seems impossible.

Approximately 40 species of invasive alien plants have been identified in SWA/Namibia. The species of greatest concern in order of priority are Salvinia molesta, Prosopis spp, Nicotiana glauca, Datura spp and Opuntia spp, although priorities differ from place to place. The areas most prone to invasion are the river washes, particularly those rising on or running through farmlands. Seed dispersal in these areas is mainly waterborne. Other invasion-prone ecosystems are those associated with perennial river systems (eg the Kavango and Caprivi areas). Although reasonably isolated in the past, these regions are developing fast, with the resultant dangers of invasion by many species which tend to spread with the spread of human habitation. The perennial availability of water allows many more species of alien plants to become established in these areas than in other parts of the country.

The loss of the genetic integrity of the African wild cat because of interbreeding with the domestic cat appears to be of major concern. A number of feral populations of alien mammals are identified, and some alien rodent species have set up free-living populations around areas of human habitation, but none of these are seen to pose serious threats of invasion.

Three alien species of birds sustain free-living populations in SWA/Namibia, but as these are all commensal with man, being found only around areas of human habitation, they are not considered to pose any great threat to endemic species.

Potentially invasive fish species (three species currently falling into this category) will in future not be permitted to be introduced north of Windhoek, in order to safeguard the river systems in the north,

particularly the Okavango. This is necessary because in years of high rainfall it is possible that seasonal river systems such as the Omatako Omuramba could flow, allowing the spread of fish from farm dams into these river systems. This could have long-term effects on the ecology of these river systems and pollute the gene pools of indigenous species.

OPSOMMING

Die grootste bedreiging van indringing deur uitheemse plant- en dierspesies is deur die spesie wat voorkom in dieselfde tipe droë habitat in ander dele van die wêreld. Hoe kleiner die aantal individue van 'n uitheemse spesie wat gevestig word, hoe kleiner die kans dat dit gevestig kan word as 'n indringer probleemspesie. Om hierdie rede moet alle pogings om die getal uitheemse spesies te verminder as waardevol beskou word, al lyk die totale uitwissing van die spesies onmoontlik.

Ongeveer 40 verskillende spesies van indringer uitheemse plante is alreeds in SWA/Namibia geïdentifiseer. Die spesies wat die grootste kommer wek is in volgorde van prioriteit: Salvinia molesta, Prosopis spp, Nicotiana glauca, Datura spp en Opuntia spp, alhoewel prioriteite van plek tot plek verskil. Die gebiede wat meer gevoelig is vir indringing is rivierlope, veral die wat ontspring op, of wat deur plase vloei. Verspreiding van saad in hierdie gebiede vind is gewoonlik deur middel van water plaas. Ander indringergevoelige ekosisteme is die wat geassosieer word met standhoudende riviersisteme (bv die Kavango en Caprivi gebiede). Alhoewel redelik geïsoleer in die verlede, ontwikkel hierdie streke nou vinnig, met die gevolglike gevaar van indringing deur baie spesies wat met die verspreiding van mense gepaardgaan. Die standhoudende water in hierdie gebiede veroorsaak dat baie meer uitheemse plantspesies hier gevestig raak as in ander dele van die land.

Die verlies van die genetiese integriteit van die vaalboskat as gevolg van inteling met die huiskat wek groot kommer. 'n Aantal wilde bevolkings van uitheemse soogdiere is geïdentifiseer, en sommige uitheemse knaagdierspesies het vrylewende bevolkings rondom bewoonde gebiede gevestig, maar nie een van hierdie word as 'n ernstige bedreiging van indringing beskou nie.

Drie uitheemse voëlspesies ondersteun vrylewende bevolkings in SWA/Namibia, maar aangesien hulle in onafhanklike assosiasie met die mens leef, word hulle nie as 'n groot bedreiging vir endemiese spesies beskou nie.

Potensiële indringer visspesies (drie spesies val huidiglik in hierdie kategorie) sal in die toekoms nie toegelaat word om noord van Windhoek gevestig te word nie, om die riviersisteme in die noorde te beskerm, veral die Okavango. Hierdie stap is nodig omdat dit in hoë reënvaljare moontlik is dat seisoenale riviersisteme soos die Omatako Omuramba kan vloei en verspreiding van vis uit plaasdamme in hierdie riviersisteme kan veroorsaak. Dit kan langtermyn effekte op die ekologie van hierdie riviersisteme hê en sodoende die genepoel van inheemse spesies besoedel.

TABLE OF CONTENTS

CHAPTER 1 INVASIVE ALIEN PLANTS IN THE COMMERCIAL GRAZING AREAS, URBAN AREAS, DIAMOND AREAS AND HERERO LAND

M A N Muller

INTRODUCTION

This chapter covers a vast area of SWA/Namibia (Map 3). For this reason it has not been possible to record all infestations of all alien plant species, instead the most important infestations of the most important invasive species have been located and recorded, and all known infestations are mentioned. These records are not exhaustive, and minor infestations of invasive alien plants certainly occur in areas other than those mentioned.

The most important invasive alien plants recorded in these areas are Argemone ochroleuca, Chenopodium ambrosioides, Datura ferox, Datura stramonium, Dodonaea viscosa, Flaveria bidentis, Lantana camara, Melia azedarach, Nicotiana glauca, Opuntia aurantiaca, Opuntia engelmannii, Opuntia ficus-indica, Opuntia stricta, Pennisetum setaceum, Prosopis spp, Sesbania punicea, Tagetes minuta and Xanthium spinosum.

SPECIES ACCOUNTS

Argemone ochroleuca (Map 4). The time and means of introduction of this species are unknown. It is currently widespread over most of the country and dense infestations are to be found in riverbeds and disturbed areas close to most towns. The most densely infested areas known are the Omaruru River, 25 km up- and downstream from Omaruru; the Oanib and Usib Rivers near Rehoboth and the Avis Dam near Windhoek.

All river courses and disturbed areas are potential habitat. Seeds are water dispersed and they may also be dispersed by birds.

This species is not thought to compete with indigenous plants to any great extent as it occurs in rivers and disturbed areas where very little else grows. No attempt has been made to clear any Argemone infestations. Young plants of this species are eaten by goats, sheep and springbok.

Chenopodium ambrosioides (Map 6). This species is fairly widespread, especially in the central and western regions of the country. It is found mainly in river courses and around dams. No control has been attempted.

Datura ferox (Map 7) and Datura stramonium (Map 9). Infestations of these species are widespread over the whole country, but are most dense in urban areas, in rivers and in disturbed areas. All rivers and disturbed areas are potential habitat.

Seeds are distributed by birds and by water flow along the rivers. Competition with the indigenous vegetation is minimal, although Datura may threaten the herbaceous plants of the river banks. No control of these species has been attempted.

Dodonaea viscosa. This species was introduced as a garden ornamental. Light to moderate infestations occur in the Grootfontein townlands and on adjacent farms (locus 1918CA).

This species grows in disturbed areas and occurs interspersed with the indigenous vegetation, thus making control by chemicals very difficult.

Flaveria bidentis (Map 10). This species is fairly widespread along road verges, in townlands and in drainage areas. It is not considered a particularly aggressive invader and no control has been attemped.

Lantana camara (Map 11). These plants were, and still are, planted as ornamentals in gardens from whence they escape.

Light infestations occur in the Grootfontein district, viz the townlands of Grootfontein and on farms GR 777 and Berg Aukas. The plants are scattered and at present do not pose a threat to the indigenous vegetation. Experience from South Africa and elsewhere, however, has shown that Lantana can become a serious problem.

Seeds are distributed by birds and kudu Tragelaphus strepsiceros which makes the whole of the mountain savanna region in this area a potential habitat.

Control has not been attempted. When it does become necessary, biological control methods should be applied, since such methods are available. To limit the further spread of this species, no Lantana should be sold at nurseries.

Melia azedarach (Map 12). Light to moderate infestations of this species occur on the farms Annenhof and Omombonde East in the Grootfontein district, along a seven kilometre length of a tributary of the Omuramba Omatako. This species is considered to pose a threat to the indigenous vegetation of this area. Invasion of the extensive Omuramba Omatako is a definite possibility. Seeds are washed down the river and germinate in large numbers. Seed-eating birds, especially grey loeries Corythaixooides concolor, also disperse the seeds.

The farmer on whose farm the infestation occurs claims that his livestock feed on the plants all year round. Steyn (1934) states, however, that the leaves and seeds can be poisonous to animals at certain times of the year but that toxicity varies seasonally and from year to year.

No control measures have as yet been applied, as the infestation was only recently discovered.

Nicotiana glauca (Map 13). This species is widespread in the western, low rainfall areas of SWA/Namibia. Moderate infestations occur along main roads and rivers. It very easily infests cultivated lands. All main roads and river courses are potential habitats. This species is not known to threaten the indigenous flora and no control has been attempted.

Opuntia aurantiaca. This species is cultivated as an ornamental in gardens. Parts of the plant are often dumped outside towns and single plants occur near most towns. This species has the potential to become a serious problem and control should be attempted while it is still fairly easy.

Opuntia engelmannii. This species was introduced as a garden ornamental species in 1922 by Mr Rusch of the farm Lichtenstein in the Windhoek district. The species escaped and infested the farm. It has been recorded from the following loci: 2217AC, CA and CC.

Currently a large area along a river is very densely infested. Baboons and the seasonal flow of water seem to be the main causes of the spread of this species. In their attempts to reach the fruit, baboons tear off cladodes and scatter them, and new plants grow from these fallen cladodes. The baboons eat the fruit and are thought to disperse viable seeds in this way. The species out-competes indigenous plants in this area.

In November 1983 a small area of plants was infested with eggs of the insect Cactoblastis cactorum. The results were disappointing. Control is hampered by the fact that the plant occurs on cliffs. As O engelmannii does not create serious problems in South Africa, no specific research has been done on its biological control. Nevertheless, experiments are now underway at the Uitenhage Weed Laboratory to try to find a suitable biocontrol agent.

Opuntia ficus-indica (Map 14). This species was originally introduced as a drought fodder plant, as well as for its edible fruit. It competes aggressively with the indigenous vegetation.

The areas presently infested are in the Omaruru and Grootfontein districts. Moderately dense infestations occurs in the Omaruru River, about 25 km up- and downstream of Omaruru township. A few farms near Grootfontein are infested, with the farm Hoba West being densely infested.

The species spreads fairly rapidly since it can propagate vegetatively as well as by seed. Potential habitat includes the length of the Omaruru River, and (in the Grootfontein district), the farms bordering on the infested areas.

Biological control using cochineal Dactylopius opuntiae has been attempted in both these areas. At Hoba West where cochineal was introduced in 1983, half of the plants were infested by the insect after about a year. At Omaruru the introduction of cochineal has been less successful. As biological control techniques have been developed for Opuntia spp, these methods should be employed in preference to chemical control methods wherever possible.

In order to prevent Opuntia being planted as drought fodder, research should be undertaken to find a suitable alternative.

Opuntia stricta. This species was originally introduced for its fruit.

Light infestations occur on the farms Rietfontein and Berg Aukas in the Grootfontein district. It has been recorded from the following loci: 1917DD, 1918AC and CA. The species out-competes indigenous plants of this area.

O stricta is difficult to control locally as it occurs in mountainous terrain. In 1975, however, cochineal was introduced on the farm Rietfontein and by 1984 almost the entire infestation had been destroyed.

Pennisetum setaceum. This species was introduced as a garden ornamental from whence it escaped.

Dense infestations occur along roads and in disturbed areas at the entrance routes to Grootfontein, Tsumeb and Kombat for up to 20 km from the towns. Light infestations occur on the entrance routes to Windhoek. It has been recorded from the following loci: 1917BC, DA, DB, 1918CA, 2016BC, 2216DB and 2217CA.

At present the species is no threat to indigenous vegetation, as it only occurs along roads where the vegetation has been disturbed or cleared anyway.

All roadsides are potential habitat. Seeds are distributed by wind and water and germinate readily.

No attempt has been made to clear these infestations.

Prosopis spp (Map 15). This plant was introduced in 1912 by Prof K Dinter, to be planted as a fodder tree. Since this time it has spread over almost the entire country. This extremely drought-resistant plant competes with indigenous vegetation. Avian diversity is also influenced, particularly where Prosopis often forms almost monospecific stands.

At present most townlands are infested to some extent, the areas around Windhoek, Okahandja and Rehoboth having the densest infestations. The townlands of Gibeon, Tses, Kalkrand, Mariental, Keetmanshoop and Usakos are less heavily infested. Dense infestations also occur in the White and Black Nossob Rivers. As the seeds of Prosopis are dispersed by water, most of the major seasonal drainage lines arising on or passing through farmlands or townlands are infested. Rivers owned by the state and/or municipalities, especially those entering conservation areas, should be cleared of this species, for example the Khan River should be cleared by the Usakos municipality.

Seeds are also dispersed by animals which eat the very nutritious pods. Germination of ingested, undamaged seed occurs readily and the spread of this species is therefore not limited to river courses. Research should be initiated to find an indigenous plant species which could replace Prosopis as a fodder plant. Acacia albida might be a possibility.

At present the Windhoek minicipality attempts to control Prosopis with chemicals such as Tordon 125 and Tordon 225. These successfully kill Prosopis but the environmental side effects of the chemicals are not yet known.

Sesbania punicea. This species is cultivated in gardens in most towns. It could escape and infest areas of natural vegetation, particularly river courses. This species should not be sold at nurseries.

Tagetes minuta. Light infestations of this species are widespread in the central and central-northern areas of SWA/Namibia. This species occurs mainly in rivers and disturbed areas. It is not thought to compete with the indigenous vegetation. No control has been attempted.

Xanthium spinosum (Map 18). Light to moderate infestations of this species are found in river courses, urban areas and heavily utilized agricultural areas such as cattle pens and near drinking troughs, mainly in the central and eastern regions of the country. The effect of X spinosum on the indigenous vegetation is not known and no control has been attempted.

DISCUSSION

SWA/Namibia is fortunate in that, at present, it has relatively few serious problems with invasive alien plants. All possible efforts should be made to monitor and control those plant species which pose a threat of invasion.

At present several species of alien plants with high invasive potential are sold at nurseries in SWA/Namibia. This practice should be halted immediately, and a ban should be placed on the sale of the following species: Lantana camara, Melia azedarach, Opuntia spp, Pennisetum setaceum, Prosopis spp and Sesbania punicea.

CHAPTER 2 INVASIVE ALIEN PLANTS IN BUSHMANLAND, OWAMBO, KAVANGO AND CAPRIVI

C J H Hines, C H G Schlettwein and W Kruger

INTRODUCTION

This chapter covers the extreme northern and eastern regions of SWA/Namibia (Map 3). These consist mainly of northern Kalahari sandveld and contain the only area of tree savanna or woodland in the country (Bioclimatic region 11, cf Map 2). Dominant tree species in the north include Baikiaea plurijuga and Pterocarpus angolensis while further to the south (near Tsumkwe) the woodland merges into open savanna with Combretum imberbe and Acacia species being dominant (Giess 1971). The western part of Owambo falls outside of the woodland vegetation type and into the mopani savanna (Bioclimatic region 9). Rainfall increases towards the east and north and covers the range of 400 to 700 mm per annum. Four perennial rivers occur in these regions; the Cunene on the extreme north-western corner of Owambo, the Okavango which runs along the northern border of Kavango and then cuts across into Botswana, and the Kwando-Linyanti-Chobe and Zambezi in eastern Caprivi. Two other systems, both episodic in character, are of importance. They are the Omatako system which rises on farmlands in north-eastern SWA/Namibia and crosses central Kavango to the Okavango River, and the Cuvelai system which rises some 300 km inside Angola, drains through central Owambo and ends in the Etosha Pan. The human population is very unevenly distributed in these regions with 44% of the total SWA/Namibia population of some 1 025 000 people living in Owambo. High population densities are also to be found in Kavango but confined to the edge of the Okavango River, and moderate (1-4 persons per km^2) human densities occur in eastern Caprivi. In the remainder of the area population densities are lower than one person per 4 km (van der Merwe 1983).

BUSHMANLAND

There are no alien plants in Bushmanland which are at present invasive. The following species are at present centred on human habitation, but pose a threat of potential invasion: 'Baster tsamma', Melia azedarach, and Xanthium spinosum.

SPECIES ACCOUNT

'Baster tsamma'. This melon is a cross between the indigenous tsamma (Citrullus lanatus) and another, non-indigenous species. The plant is

extensively cultivated by the Bushman in villages outside Tsumkwe, and is likely to be sought after by elephants Loxodonta africana and other game. Concern over this species is centred largely on contamination of the gene pool of the naturally occurring species.

Melia azedarach (Map 12). A number of trees have been planted in Tsumkwe and these could provide a potential source of infestation into surrounding areas.

Xanthium spinosum (Map 18). This species has recently been introduced into the area, with the establishment of an experimental farm, where about 300 cattle are kept. It was first found at a waterhole used by cattle when thousands of these animals were recently brought into Bushmanland by Hereros from Botswana. The recent occurrence of X spinosum in this area appears to be closely linked to the initiation of modern agricultural practices here.

Until recently Bushmanland has been relatively isolated from the activities of 'non-indigenous' man. This situation is changing rapidly, however, and a number of potential source points from which invasion of aliens could occur now exist. These are:

(1) The army camps now situated in Bushmanland. Gardens are a potential source of aliens such as Bidens formosa, Lantana camara, and others.

(2) Homesteads of Europeans in the Tsumkwe district, from which invasive species could also escape.

(3) Development projects, eg roads, experimental farms etc. Man-made disturbances in an area offer potential sites for invasion by aliens.

(4) Bushman villages. These are not considered a serious problem at present.

OWAMBO

No information is available on terrestrial alien plants in this area. The presence of a very dense human population, the large concentration of army camps and the extensive military movement in the area indicate the likelihood that invasive aliens probably do occur. This same military presence, however, makes assessing the situation almost impossible.

Two species of aquatic aliens have been recorded from the area. Myriophyllum aquaticum has been found in a man-made canal in Owambo (loci: 1714AD, BC and BD) and Pistia stratiotes has been recorded at Calueque (locus: 1714AD)

KAVANGO

The alien plants of Kavango are highly restricted in their distribution, and, at present, infestations can be regarded as light in all areas where these plants do occur. Species which have been recorded for this region

are Bidens pilosa, Lantana camara, Opuntia ficus-indica and Ricinus communis. The distribution of these species is restricted to areas of human habitation and to areas along the Okavango River.

Bidens pilosa. This species is at present limited to old agricultural lands, roadsides and other areas of disturbance.

Lantana camara (Map 11). This species has not yet been found along the river, but is very common in the town of Rundu, largely because it is sold by the Forestry nursery in the town. It has the potential to become a dangerous invader in this area.

Opuntia ficus-indica (Map 14). This species is restricted to old villages and areas of human habitation. It is not regarded as a potentially dangerous invader in this area as the habitat is not suitable for its spread. Present known distribution includes Mukwe, Andara area, the Fountain Omuramba and the Rundu area.

Ricinus communis (Map 16). The present distribution of this species is similar to that of Bidens pilosa, but also includes stretches of the river bank. Control measures should be initiated in the near future as this plant is potentially a very aggressive invader.

The potential source areas and routes for invasive alien entry into the Kavango are much the same as for Bushmanland. No aquatic aliens are known from Kavango.

CAPRIVI

The Caprivi has a number of invasive and potentially invasive aliens. Aquatic alien plants include Pistia stratiotes and Salvinia molesta.

SPECIES ACCOUNTS

Pistia stratiotes. One incidence of local infestation near Nkasa Island (locus: 1823BC) has been recorded. This infestation is light and currently is not considered to pose a threat. This species would probably be out-competed by Salvinia.

Salvinia molesta (Map 17B). This plant was first collected from the Zambezi River at Kazangula Island in 1948 (Mitchell 1967). It entered the Chobe River (a tributary of the Zambezi) in the early 1950's and by 1959 was considered to be abundant (Edwards and Thomas 1977). In 1965 S molesta was discovered in Lake Liambezi (Edwards et al 1972) and by 1967 it was found in the Linyanti River at Shaile, 43 km west of Lake Liambezi (Smith 1969). By 1972 it occurred continuously along the length of the Zambezi and Chobe Rivers in SWA/Namibia and had formed extensive mats on Lake Liambezi and the Linyanti River. By 1974 the upper Kwando River was infested (Edwards 1977). The infestation reached a peak in 1975 when 26% of the water surface of Lake Liambezi was covered (Seaman et al 1978).

Since 1975 the distribution of S molesta has not changed, but the density has fluctuated considerably.

During early stages of infestation this species has little influence on the aquatic habitat, but because of its exponential rate of proliferation it rapidly establishes an almost mono-specific dominance and displaces indigenous free-floating plants. The natural succession from aquatic to semi-aquatic and ultimately to a terrestrial ecosystem is considerably accelerated, particularly in areas such as Caprivi where the river gradients are small and where mats of Salvinia molesta hamper water flow and create permanent blockages that effect flood levels. Dense mats also effect water quality by excluding light, and the large accumulation of organic material results in anaerobic conditions and a change in the water pH (Schlettwein 1984).

Control methods were implemented in 1969. Two pools near Shaile and their surrounding areas were treated with Paraquat mixed with a wetting agent. After 24 days the pools were clear with only a few plants surviving near the edges (Smith 1969). In 1975 aerial spraying with Paraquat was attempted at Shaile, near Quega Island and a large reed-enclosed area at Kamantaudo on Lake Liambezi. Eight days after the first spraying, areas that had been missed were resprayed. Eight weeks later the whole area was resprayed to control regrowth. Four months after the treatment the water surface was open, but 16 months later abundant regrowth had occurred (Edwards and Thomas 1977). Between 1975 and 1979 an area of about 125 km^2 between Kongola Bridge and Lizuali Village was sprayed with Gramoxone and Paraquat. Good control was achieved, but abundant regrowth occurred (van der Waal 1979).

Biological control was initiated between 1972 and 1974 on the Chobe and Linyanti Rivers with the release of about 2 700 Paulinia acumniata and 1 300 Cyrtobagous singularis insects (Edwards and Thomas 1977). A second introduction of these two insect species was attempted by the Botswana Government, but attempts at recapture proved unsuccessful and it was assumed that neither species had become established. In 1981 C singularis were found on S molesta, but were not providing an adequate control; their natural host appears to be S anugularis (Schlettwein 1984). In 1982 the Department of Water Affairs, SWA/Namibia, imported 144 C salviniae insects, a species which has proved to be a successful control agent of S molesta in Australia. The breeding programme was unsuccessful, but in 1983 a further 500 insects were obtained. These bred successfully and by late 1984 some 7 000 individuals had been released at various localities in eastern Caprivi. They have become well established and it is hoped that by late 1985 the required control will have been achieved.

S molesta is a nutrient scavenger, capable of achieving high growth rates (3-8% per day), even in waters of low nutrient concentrations. It has no natural enemies and because of its floating nature, dispersal can be very rapid. For these reasons, every care should be taken to prevent its introduction to other water systems in SWA/Namibia, eg the Okavango River.

At present infestations of terrestrial alien plants are highly localized in the Caprivi. It should be noted, however, that a number of the species recorded are considered to have the potential to become extremely aggressive invaders. The reason for the present low incidence of alien infestation is that the Caprivi, like the Kavango and Bushmanland areas, has only

recently become affected by developments associated with the advance of western civilization. At present the most important potentially invasive plants are those associated with human habitation along the rivers. These include Argemone ochroleuca, Bambusa balcooa, Cannabis sativa, Erythrina spp, Ipomoea purpurea, Lantana camara, Mangifera indica, Melia azedarach, Opuntia spp, Psidium guajava, Ricinus communis, Sacchurum sacher, Solanum mauritianum and S seaforthianum.

SPECIES ACCOUNTS

Argemone ochroleuca (Map 4). This species has been recorded from isolated localities throughout the area where it invades disturbed areas such as old agricultural lands and roadsides. It is a potential threat, although it is not known how competitive this species is in areas where indigenous species are well established.

Bambusa balcooa (Map 17A). Two isolated populations are known to occur in the Zambezi River near Katima Mulilo. The potential threat of the species is difficult to assess.

Cannabis sativa. This species has been planted in some areas and can escape, but is unlikely to cause problems as escapees will probably always be utilized.

Erythrina spp. This genus does not occur naturally in the Caprivi, but has been planted around kraals and villages and has been noted to be growing 'wild' near some villages.

Ipomoea purpurea. There are widespread infestations of this species in the swampy areas.

Lantana camara (Map 11) and Melia azedarach (Map 12). These species are common in the gardens in the towns. So far no known infestations occur outside the towns, but the potential for invasion is high.

Mangifera indica. The present status of this species and its potential for invasion are closely linked to those of Psidium guajava. This species may be regarded as a particular threat along the river courses.

Opuntia ficus-indica (Map 14). Some localized infestations occur around human habitation. As in the Kavango, the potential threat is low due to the general lack of suitable habitat.

Psidium guajava. This species is restricted at present to areas of human habitation. The potential rate of spread of this species is extremely high. Once P guajava becomes successfully established it is extremely difficult to control as it is attractive to a wide variety of frugivorous

birds and other animals. P guajava can be a highly aggressive competitor. In Natal it has been known to take over large tracts of riverine bush, in association with Mangifera indica. There is considerable cause for concern with regard to this species.

Ricinus communis (Map 16). Small isolated populations occur througout the area. This species has spread with the advance of civilization in the area, being found along roads and in old agricultural lands as well as on the floodplains of the Zambezi, Chobe and Kwando Rivers. This species poses a serious threat because of the large areas which may potentially be infested, and because its control is difficult.

Sacchurum sacher. This species was planted by the local inhabitants along the banks of the malopos (isolated 'fingers' of fresh water), from whence it has been observed to spread along the shoreline. The potential for infestation of other areas is likely to be low, but the ecological threat to the malopos is considerable. This species is likely to be difficult to control.

Solanum mauritianum (Map 17C). This species is known from some gardens, and a population occurs within Katima Mulilo. Its invasive potential is high as its berries are a highly sought after food source for frugivorous birds.

Solanum seaforthianum. Commonly cultivated in gardens in the town. This species can be a real problem in riverine fringing vegetation. Its invasive potential is considerable.

DISCUSSION

One feature of all these areas is that there are few, if any, invasive species, and where these species do occur their incidence of occurrence is low. This situation exists for a number of reasons.

All these areas have been relatively isolated from the influences of urbanization, infrastructural development and expanding white populations for a long time. The areas have been relatively inaccessible and because of this alien plants have only relatively recently been introduced. Exceptions are the aquatic species, which have been transported by river rather than by man. These areas can therefore be said to be years behind the rest of the country as regards the introduction and spread of invasive aliens.

These areas are subject to high frequency fires. Up to 60% of their area burns every year and fires are of a random nature and probably of high intensity as ground cover is usually good. This fire regime has existed for hundreds if not thousands of years and the indigenous vegetation can therefore be expected to be highly fire-adapted. The competitive advantage usually afforded an invasive alien because of the absence of natural predators/pathogens can be considered to be negated by this fire regime. Fire can therefore be regarded as a major factor in the control of invasive plants in these areas.

Bushmanland and the southern Kavango have always been extremely sparsely populated and because of this have never been subject to any intensive agriculture. These areas are isolated on a veterinary basis and there has therefore been no migration of potential alien invasives from the farming areas into Bushmanland/Kavango. This situation has recently changed in Bushmanland with the establishment of the experimental farm. Special attention is required to make sure that invasive alien plants are not introduced into the area in stock feeds.

Bushmanland and southern Kavango are unique in that there are no rivers or drainage systems in the area. Precipitation tends to be locally dispersed (into pans and omiramba) and there is no inflow and outflow of water in these systems.

CONCLUSION

It is the conclusion of the authors that the situation which exists at present in Bushmanland, Kavango and Caprivi is unique. Large areas have no invasive aliens at present and other areas have extremely low levels of infestation. Special attention should be given to this situation in so far as the control of the importation of species, plant eradication and the sale of invasive aliens are concerned. It is a matter for concern that in both Kavango and Caprivi potential invasive aliens are sold by the Forestry departments. In the opinions of the authors this practice should be suspended immediately. It is also felt that the planting of alien species along river banks should be strictly controlled. An ordinance covering invasive alien plants is urgently required if this desirable situation is to be perpetuated. The situation in the more densely populated Owambo is uncertain and warrants more detailed investigation.

CHAPTER 3 INVASIVE ALIEN PLANTS IN THE ETOSHA NATIONAL PARK

K Nott

INTRODUCTION

The Etosha National Park (22 270 km^2) is situated in the north of SWA/ Namibia, bordering on Owambo (Map 3). The saline Etosha Pan (6 133 km^2) occupies the central and north-western sector of the Park (Berry 1972) and is surrounded by dwarf shrub savanna fringe, while the rest of the Park falls within the mopane savanna region (Giess 1971) (Bioclimatic regions 9 and 10, cf Map 2). The Park receives between 300 and 500 mm of rain per annum, the western parts being more arid than the east. Only two climatic seasons are recognised; a dry (April to October) and a wet (November to March) season. Three large tourist camps have been constructed within the Park; Okaukuejo, Halali and Namutoni. These are served by a network of gravel roads which are confined mainly to the south and western regions bordering the Etosha Pan.

Several alien invasive plant species were recorded by le Roux (1980) in his vegetation classification studies in Etosha National Park. The control of alien invasive plants began in 1980 in the Namutoni area.

The following invasive aliens have been recorded in the Park, outside tourist camps and residential areas: Bidens biternata, Datura innoxia, Nicotiana glauca and Opuntia ficus-indica. In addition the following aliens occur within tourist camps and residential areas within the Park: Agave spp, Argemone ochroleuca, Datura spp, Lantana camara, Melia azedarach, Nicotiana glauca, Opuntia spp, Prosopis spp, Ricinus communis and other aliens which could cause a threat of invasion.

SPECIES ACCOUNTS

Bidens biternata (Map 5). This species is recorded as occurring in isolated horse camps, waterholes, rubbish dumps and probably occurs throughout the Park. It was recorded by le Roux (1980). The known infestations are localized and, as yet, no control has been undertaken. The potential rate of spread and the ecological impact of this species are unknown. It is thought to have spread into the Park from adjoining farmlands.

Datura innoxia (Map 8). This species occurs in localized areas near Okaukeujo, at Gemsbokvlakte and Eindpaal. Localized areas which can become waterlogged and drainage lines throughout the Park provide potential habitat for these plants. As yet, no control measures have been taken.

Nicotiana glauca (Map 13). This species has not yet been recorded within the Park itself, but it has been necessary to control plants found growing within 100 m of Anderson Gate in a disturbed area resulting from road building activities. These plants were growing on the piles of soil dumped along the new road. In the near future the road building activities will be extended into the Park. The potential habitat of this species extends throughout the Park. Approximately 47 plants < one metre in height and 35 plants > one metre in height, occurring within a 12 m X 30 m area were removed. Plants were chopped out and their roots removed. The plant material was then burned.

Opuntia ficus-indica (Map 14). This species occurs in the vicinity of the Okaukeujo camp, the Aroe area near Namutoni and the Halali rubbish dump. This species was probably introduced into the Park by police during the early occupation of Namutoni, as well as by the staff living in the camps. It may also have spread from the neighbouring farms. The exact time of introduction is unknown. These infestations have been restricted to relatively small areas (60 plants near Okaukeujo and 90 plants near Namutoni). The potential habitat of these plants extends throughout the Park.

Control measures were initiated in 1980 but unfortunately no detailed information is available. Any O ficus-indica plants found in the Park are immediately chopped out and burned. Roots of the smaller plants are removed, but this is often difficult with the larger individuals. Since areas of infestation are small and all known plants have been removed, this species does not appear to present a threat to indigenous species, provided control operations are continued. Many of these plants still exist in the camps, and these should be removed and destroyed to remove the remaining sources of seed and prevent further infestation.

ALIEN PLANTS IN CULTIVATED AREAS

Agave spp, Argemone ochroleuca, Datura spp, Lantana camara, Melia azedarach, Nicotiana glauca, Opuntia spp, Prosopis spp, Ricinus communis and other aliens occur in tourist camps and residential areas. These species have either been planted for shade, fruit or as ornamentals in gardens, or have become established on areas which have been disturbed due to construction operations within the camps. Their eradication is discussed below.

CONCLUSION

The following policy is proposed for the control and monitoring of invasive alien plants in the Etosha National Park:

Within the Park excluding tourist camps and residential areas:

(a) A form has been compiled which enables nature conservators to record all alien invasive plants in their areas.

(b) All recorded observations of alien plants are reported to the park's botanist. Control measures are then selected and implemented.

(c) All imported fodder must be investigated for the presence of seeds of invasive alien plants.

Within tourist camps and residential areas:
All the species listed above must be removed. A close watch should be kept on other alien species planted in gardens so that any of these exibiting invasive tendencies can be checked before any major problems arise. Cryptostegia grandiflorus must be assessed and evaluated as a possibly invasive species. When aliens are removed from gardens a suitable replacement should be supplied.

CHAPTER 4 INVASIVE ALIEN PLANTS IN THE WATERBERG PLATEAU PARK

R W Jones and W Jankowitz

INTRODUCTION

The Waterberg Plateau Park (40 549 ha) is situated approximately 65 km east of Otjiwarongo. The Park (previously farmland) was proclaimed in 1972, and since then a close watch has been kept on any invasive plants occurring within its boundaries. The Waterberg mountain plateau rises about 420 m above the surrounding plains at its south-western and northern sides, and slopes gently down into the surrounding area to the north-east. The plateau is circumscribed by sandstone cliffs of varying height. The plateau has a deep, continuous reddish sand layer. Below the cliffs is a fairly even slope to the base of the mountain, covered by sandstone rocks weathered from the summit. The vegetation on the summit is an extension of the woodland flora while the surrounding plains are mainly Acacia savanna. The annual rainfall is about 460 mm. The bioclimatic characteristics of the region are described in detail by Jankowitz (1983).

Invasive alien plants occurring in this region are Datura ferox, Lantana camara, Melia azedarach, Opuntia ficus-indica and Ricinus communis.

SPECIES ACCOUNTS

Datura ferox (Map 7). This is the only invasive alien plant which has to date been located on the plateau. Little is known about the history of this plant in the area, but it is thought to have been introduced during the farming era. At present it is found in a few disturbed places over a total area of about 75 m^2. Potential habitat of this species is confined to the disturbed areas, eg along firebreaks and around water points. Its rate of spread over these areas is rapid after any period of high rainfall. Until now its ecological impact appears to have been slight, largely due to the fact that the plant is confined to bare, sandy areas which have already been ecologically disturbed, but it probably competes with indigenous pioneer species.

D ferox is relatively easy to control manually although the process is time consuming. At present plants are removed whenever they are encountered, and normally prior to seeding.

Lantana camara (Map 11). This species has only been recorded to date in the Okatjikona region of the Park. This is a small section of old farmland

at the base of the plateau, which was overutilized in the past. L camara was planted in the garden of the farm Okatjikona during the first half of the century. It subsequently spread, mainly through the agency of frugivorous birds, beyond the garden. The area infested is at present about four hectares in extent. The current rate of spread is slow, but under more favourable climatic conditions this could accelerate. The potential habitat of this species in the area is estimated at 15 ha.

This species competes aggressively with indigenous plants, particularly for moisture. Various methods of control have been attempted in the past, but this has proved to be extremely difficult.

Melia azedarach (Map 12). This species was originally introduced to the area by farmers during the first half of the century. At present it occurs over an area of about 600 m^2 at Rodenstein (at the base of the plateau). The area suitable for potential infestation extends over about 2,25 km^2.

This species is thought to compete for moisture with indigenous species such as Ficus sycomorus, Rhus lancea and others. At present the ecological impact of this invader is minimized as it is removed wherever possible. The rate of spread is slow but under more favourable climatic conditions it could be expected to accelerate. Eradication of this species is difficult and only chemical or mechanical means offer possibilities at this stage. Manual removal is difficult as the roots penetrate rocky areas and may grow through cracks in rocks.

Opuntia ficus-indica (Map 14). This species is located mainly along the scree at Rodenstein. It was originally planted in the area by farmers who moved into the region around 1907. The species was planted for its fruit and for the cold drink syrup which can be made from it. This species spread dramatically over large areas until 1980, when biological control measures, employing cochineal Dactylopius opuntiae, were initiated. The cochineal has spread fairly effectively and has both checked the spread of the cactus and killed off several hectares of existing stands of the invader. The area currently infested is about 10 ha in extent, but is at present decreasing.

It is of vital importance that a close check be kept on this species as the possible extent of infestation is great. The area of potential habitat (rocky areas along the scree) totals approximately 15 000 ha. This plant encroaches aggressively on indigenous vegetation and competes for water and nutrients. The impact on the ecosystem were this species allowed to get out of control would be extensive.

Ricinus communis (Map 16). This species is found at Rodenstein, mainly along the scree and in the vicinity of the fountains which occur in the area. It is not known when and by whom this species was originally brought into the area, but it was possibly introduced in cattle feed. The area at present infested is about 150 m^2 in extent. The spread of this species in this area is restricted as it is confined to areas of high moisture and shade. The plant can be removed manually with relative ease, although this process is time consuming. Whenever encountered in the park it is immediately removed. Its invasive potential in this area is not high.

DISCUSSION AND SUMMARY

At present there are no major problems with invasive alien plant species within the park. Those species which do occur are under satisfactory control. Effective control of Opuntia species is possible using cochineal. The Lantana camara infested area will be controlled chemically at the earliest opportunity when climatic conditions are favourable, as will the Melia azedarach infestations. Mechanical methods (largely manual), although time consuming, will need to be continually implemented to prevent any of the other invasive species in the area from getting out of control.

The long history of occupation of some of the old homesteads in the park, together with the large variety of alien plant species that were introduced has led to a situation where park managers will have to be on the look out for new alien plant problems. Recently a hitherto unrecorded invasive alien plant for SWA/Namibia, Cardiospermum grandiflorum, was recorded from the park (Macdonald and Nott in press). This species was found growing over a few trees at Rodenstein. It has since been removed and destroyed. Little is known about the invasive potential of this plant in an area such as Waterberg, but it has caused considerable ecological damage in Natal, and efforts will be made to ensure that it does not become established in this area.

It is apparent that the occurrence of the various invasive species in the area can be attributed to farmers in the early half of the century, who were certainly unaware of the potential problems that these plants can cause.

CHAPTER 5 INVASIVE ALIEN PLANTS IN THE SKELETON COAST PARK, WESTERN DAMARALAND AND WESTERN KAOKOLAND

P W Tarr and R Loutit

INTRODUCTION

This chapter covers the northern coastal region of SWA/Namibia, from the Ugab River in the south to the Cunene River in the north, and extends westwards to the mountainous escarpment in Damaraland and Kaokoland, about 80 km from the coast (Map 3). The region is carved by numerous episodic rivers (only the Cunene River is perennial), many of which rise on farmlands in the central parts of the country, and which run through deep valleys in the escarpment and open into broad floodplains over the narrow coastal plain. The rainfall is low (<100 mm per annum) although the regular occurrence of coastal fog considerably increases precipitation. The vegetation of the Northern Namib (Bioclimatic region 1, cf Map 2) is discussed by Giess (1971).

The alien flora of north-western SWA/Namibia was quantitatively mapped in order to assess the distribution and degree of infestation of each species. Alien plants were found to be confined to the major, periodically flowing river courses within the area. The following species were encountered: Argemone ochroleuca, Datura innoxia, D stramonium, Nicotianaglauca, Opuntia ficus-indica, Prosopis spp and Ricinus communis.

Wherever possible these species have been discussed with respect to: the current area infested; the degree of infestation; potential habitats; their ease of control and their impact on invaded ecosystems.

METHODS

Each of the river systems were surveyed from a vehicle during 1984. The density of each alien species was estimated for each five kilometre stretch of riverbed traversed (Table 5.1). The density of infestation has been quantitatively defined as follows:

Nicotiana glauca:
- Dense infestation: more than 2 000 plants/km
- Moderate infestation: 500-2 000
- Light infestation: 1-500.

All other alien species:
- Dense infestation: more than 250 plants/km
- Moderate infestation: 100-250
- Light infestation: 1-100.

TABLE 5.1. The percentage of five kilometre-long blocks supporting varying degrees of alien infestations for the river beds of the Skeleton Coast Park and adjacent areas

Species	River System	% of densely infested blocks	% of moderately infested blocks	% of lightly infested blocks	% of uninfested blocks	No of blocks surveyed
Argemone ochroleuca	Ugab	0	0	87,5	12,5	16
	Huab	0	22,2	55,6	22,2	18
	Hoanib	0	0	6,3	93,8	16
Datura innoxia	Ugab	12,5	6,3	75,0	6,3	16
	Huab	11,1	27,8	38,9	22,2	18
	Hoanib	50,0	18,8	31,3	0	16
	Hoarusib	37,5	37,5	25,0	0	8
	Cunene	0	0	100	0	1
Datura stramonium	Ugab	0	0	50,0	50,0	16
	Huab	0	0	50,0	50,0	18
	Hoanib	0	0	6,3	93,8	16
Nicotiana glauca	Ugab	25,0	6,3	68,8	0	16
	Huab	0	11,1	77,8	11,1	18
Prosopis sp	Ugab	0	0	37,5	62,5	16
Ricinus communis	Ugab	6,3	0	56,3	37,5	16
	Huab	0	22,2	44,4	33,2	18
	Uniab	0	0	21,4	78,6	14
	Koichab	0	6,3	31,3	62,5	16
	Hoanib	25,0	0	43,8	31,3	16
	Hoarusib	0	0	62,5	37,5	8
	Khumib	4,8	0	81,0	14,3	21
	Sechomib	0	0	25,0	75,0	12
	Nadaf	25,0	0	50,0	25,0	4
	Engo	8,3	0	8,3	83,3	12
	Cunene	0	0	100	0	1

SPECIES ACCOUNTS

Argemone ochroleuca (Map 4). This is a recent invader of this area, appearing in the Ugab, Huab and Hoanib Rivers after the 1984 floods. In all three rivers, light infestations currently occur. Open sandy riverbeds and floodplains appear to be the favoured habitat of this species.

The impact of A ochroleuca on the ecosystem is unknown. It could, however, be highly invasive. The removal of the existing population is planned.

Datura innoxia (Map 8). This species currently infests five of the 12 rivers surveyed in this region. In the Cunene, Hoarusib, Huab and Ugab Rivers infestation occurs along the entire riverbed almost to the coast. In the Hoanib River infestation occurs as far west as the Hoanib floodplain. D innoxia is believed to have entered the northern areas of this region in the same manner and at the same time as Nicotiana glauca. In the south it was first observed in the Huab and Ugab Rivers after the 1982 floods. At present the degree of infestation varies from light in the Cunene, to moderate in the Hoarusib, upper Hoanib, Huab and Ugab Rivers, to dense in the Hoanib floodplain where virtually continuous stands occur.

The potential habitat of this species includes all riverbeds where waterborne seed dispersal can occur. D innoxia tends to favour the banks of rivers and the high ground in riverbeds. Dense infestations are likely where floodplain conditions occur, or on the up-river sides of dense reed beds.

D innoxia will be difficult to control because of the high reinvasion potential caused by the periodic westward flow of the rivers. Test plots in the Hoanib floodplain have shown that reinvasion of 100% or more may occur after flooding. Furthermore, a single Datura plant in this area can produce an average of 15 pods at any one time. Each pod contains an average of 650 seeds of which, according to Landsdell (1927), at least 87% germinate. He mentions that the seeds are viable for up to 20 years.

Birds and mammals ingesting the seeds and leaves of this alien could be affected by various poisonous alkaloids such as Daturine, Hyosayamine and Atropine which are found in all Datura species (Landsdell 1927). This author mentions that in South Africa the seeds are fatal to young ostriches Struthio camelus, but that farmers in the Karoo and Highveld districts have observed cattle and goats eating the leaves with impunity. Over 1 000 seeds were found in the crop and stomach of a doublebanded sandgrouse Pterocles bicinctus (Brown et al 1984) and Cape turtle doves Streptopelia capicola and laughing doves Streptopelia senegalensis have been observed feeding on these seeds.

Hand removal of small plants is relatively simple and an intense eradication campaign, using manual methods and starting at the source of the rivers is advocated. However, because the middle and lower reaches of the Hoanib River support relatively high game numbers, including the desert dwelling elephants which are sensitive to human disturbance, it is strongly recommended that, before a full-scale eradication programme is undertaken west of Sesfontein, an in-depth monitoring programme should be completed. This programme would include investigation of the extent to which the

aliens in the Hoanib are increasing and the extent to which the natural vegetation and ecology of this area are being threatened.

It is believed that this species is likely to constitute an ecological threat in the future especially where it occurs in dense stands. Areas of dense indigenous vegetation appear not to be susceptible to invasion, but fast flooding creates channels through such areas which soon become invaded, thereby reducing the indigenous floral component.

Datura stramonium (Map 9). This species lightly infests the Hoanib, Huab and Ugab Rivers. It occurs within four kilometres of the coast in the Ugab River and as far west as the floodplain in the Hoanib River. It is uncertain when and how it was introduced into these areas.

D stramonium is relatively easy to remove by hand, and low densities favour manual methods. However, no control has been exercised to date.

Nicotiana glauca (Map 13). This species currently occurs in the Ugab and Huab Rivers, both in western Damaraland and the Skeleton Coast Park. It is believed to have been introduced to this area in horse fodder, which was imported from South America at the turn of the century during the German occupation of SWA/Namibia. At present dense infestations occur in the lower reaches of the Ugab River from the coast to 20 km inland. Light infestation occurs along the remainder of the Ugab River and along the Huab River.

The potential habitat for this species includes sparsely vegetated riverbeds where nonsaline, sandy soils are present. Investigations have shown that this species is susceptible to drowning when exposed to standing water for any length of time.

N glauca is difficult to control since reinfestation occurs with seasonal river flow from farming areas inland. Natural control of this species does occur, specifically where dense beds of Phragmites australis are found, and where standing water causes drowning. Nevertheless, large scale reinfestations of N glauca after river flow far outweigh the natural removal by flood erosion and other factors.

The potential rate of spread of this species appears to be fairly rapid. A 100 m^2 plot in the Ugab River mouth area showed an increase of 6,22% after flooding despite clearing operations to the east of the site and the presence of dense stands of natural vegetation in the surrounding areas.

Seedlings and immature plants are easily removed by hand provided they do not occur in compact soils or dried silts. No large-scale control has been attempted, and it is felt that the Directorate of Agriculture should identify and monitor inland farming areas from which reinvasion occurs. Efforts should be made to initiate a national eradication campaign, starting in the east and moving westwards, using manual labour methods.

Reinvasion after flooding ensures that this species colonizes the majority of the open riverbed, thus competing with indigenous plants for available ground water. It is possible that these plants are able to absorb moisture

from fog since isolated specimens have been encountered far away from river beds. The longevity and apparent ability of Nicotiana glauca to thrive under arid conditions makes this species a formidable alien invader in this area.

Opuntia ficus-indica (Map 14). Currently this species is confined to the farm 'Eerste Begin', in western Damaraland. The potential rate of spread of this species is unknown as is the year of its introduction into the area.

Since its distribution is localized, control of this species should be simple and all efforts should be made to prevent a westward spread down the Huab River.

Prosopis sp (Map 15). This plan is confined to the Ugab River and is found both within the Skeleton Coast Park and western Damaraland. Less than 20 trees occur and a removal programme is under way.

No further infestation has occurred during the period 1978-1984 and no trees have produced seeds during this period.

Ricinus communis (Map 16). This species currently infests all 12 rivers surveyed in this region. In the south it was first observed in the Koichab, Huab and Ugab Rivers following the 1982 floods, but could have been present in the Uniab River from as early as 1964.

Light infestations occur in the Cunene, Engo, Nadas, Munutum, Sechomib, Khumib, Hoarusib, upper Hoanib, Uniab, Koichab, Huab and Ugab Rivers. The western extremes of the last three rivers are currently uninfested. Isolated areas of the Springbok River in western Damaraland are also lightly infested while moderate infestation occurs in the middle Ugab area (in the vicinity of the Skeleton Coast Park boundary) and in the western floodplains of the Engo and Hoanib Rivers.

The open stretches of all riverbeds provide an ideal habitat for this species particularly where loose sandy soils predominate. This species favours the banks of rivers and high ground in riverbeds.

R communis is not as aggressive as N glauca or D innoxia and westward infestation in the south appears to be limited by dense stands of indigenous vegetation, mainly Phragmites australis and Suaeda plumosa. Periodic flooding has also helped to keep this species under control as it is susceptible to drowning when subjected to standing water for any length of time.

Plants less than one year old are very easy to pull out by hand, but reinvasion of cleared areas occurs after river-flow.

The ecological impact of R communis has not been established but it is thought to be less than that of the previous two species. Elephants Loxodonta africana periodically browse this species in the Hoanib floodplain, while birds are thought to utilize the seeds.

CHAPTER 6 INVASIVE ALIEN PLANTS IN THE NAMIB-NAUKLUFT PARK

R D Vinjevold, P Bridgeford and D Yeaton

INTRODUCTION

The Namib-Naukluft Park (23 400 km^2) is situated in the central western region of SWA/Namibia and extends from the escarpment to the coast (Map 3). The park incorporates parts of the mountainous Pro-Namib at Naukluft (Bioclimatic region 3, cf Map 2) and covers the central portion of the Namib Desert (Bioclimatic region 1). The ecology of the extensive dune system south of the Kuiseb River which bisects the park has been extensively studied (eg Seely 1978; Holm and Schaltz 1980). The gravel plains that occur north of the Kuiseb River are less well known (Watson 1980). Most of the invasive alien plants in the park are located in the Kuiseb River (cf Seely et al (1979) and Theron et al (1980) for an account of the riverine fringing vegetation) and in the Swakop River which flows further north. The vegetation of the Swakop River has been extensively modified by livestock ranching up to 1977, when the small-holders were bought out. The Kuiseb River within the park is still occupied by numerous subsistence farmers (Topenaars) who hold large flocks of goats, cattle and donkeys which have extensively modified the vegetation around their well-points.

The following invasive alien species have been recorded for the Namib-Naukluft Park: Argemone ochroleuca, Datura innoxia, D stramonium, Melia azedarach, Nicotiana glauca, Opuntia aurantiaca, Prosopis sp and Ricinus communis.

SPECIES ACCOUNTS

Argemone ochroleuca (Map 4). Light infestations of this species have been found in the upper Kuiseb and Swakop Rivers, and possibly on the Naukluft plateau. No control measures have been implemented as yet.

Datura innoxia (Map 8). This species is present in all the major water courses in the Park, but heavy infestations have been recorded only along the Kuiseb River. Recently drought has limited infestations in most areas of the Park, but following floods infestation levels increase rapidly. Light infestations also occur throughout the Naukluft mountains, along streams and around old farmsteads and, after rain, along roads. In the Kuiseb River the only areas where D innoxia is absent, apart from the areas where the river has not recently flowed, are around well-points. There is no evidence to indicate that livestock browse this species, so its absence is probably due to the effects of trampling by animals.

To test this point the following experiment was set up: 10 x 1 m^2 plots were randomly chosen at 100 m, 200 m, 400 m, 800 m, 1 600 m, 3 200 m and 6 400 m away from a well. A total of 1 750 pegs, 25 pegs per plot, were placed out. The plots were monitored over a period of one month, in order to determine the intensity of trampling. The results are evident from Figure 6.1.

A monitoring programme for the spread of this species in the Kuiseb is being set up, using transects which have already been sited. Populations will be removed and the rate of reinfestation measured.

Attempts will be made to remove D innoxia from all areas of high public visibility, viz hiking trails in Naukluft, campsites at Homeb on the Kuiseb river, Gobabeb etc. This is purely for aesthetic reasons. The only realistic control or eradication measure which can be envisaged at present would be some form of biological control.

Datura stramonium (Map 9). This species is only known to occur in the Kuiseb River and infestation is medium to dense. It coexists with D innoxia, but appears to prefer the river bank habitat to the riverbed. Monitoring and control will be identical to that described for D innoxia.

Melia azedarach (Map 12) and Opuntia aurantiaca. Both these species occurred historically around farmsteads in the Naukluft region. All Opuntia and most Melia plants have been removed, but it is suspected that rainfall will initiate reinfestation in these areas.

Nicotiana glauca (Map 13). This species has been recorded at low densities in the Kuiseb and Swakop Rivers. It is being removed as it is encountered.

Prosopis sp (Map 15). Dense infestations of this species are found along the entire length of the Swakop River. It also occurs around old farmsteads in the Naukluft region. This species was apparently introduced by early settlers in the German era (the beginning of the century) for shade and fodder. Figure 6.2 indicates how its occurrence in the Swakop River is closely related to early dwellings and well-points, most of which were only recently abandoned by man. This species has the potential to invade all the major rivers and water courses in the Park. Its occurrence has been noted in the headwaters of the Kuiseb, although it has not yet infested the lower reaches of this river, in the Park.

In an experiment to assess the ecological impact of this species a pressure chamber was used to determine the water potential of a Prosopis tree and an indigenous Acacia erioloba of similar size some 10 m away. Readings were taken over a 24 hour period, and results indicate a definite and constant difference, indicating that the Prosopis has access to more water than the A erioloba (Figure 6.3).

The potential rate of spread of this species is not known, but it is probably high during years when the rivers flood. The recent removal of livestock from the infested area may help to check the rate of spread.

Control around the old farmsteads is reasonably feasible, but in the Swakop River control is proving both difficult and time consuming. Tests were carried out with a herbicide, Tordon 155 (2,4,5-T/picloram), and the mortality rate for trees over three metres in height was 60%, while for trees of less than two metres it was 90%. It was found, however, that the herbicide also affected indigenous vegetation, insects and other wildlife. Since the use of such chemicals in a conservation area is not desirable, this form of control has been stopped.

At present mechanical control seems to be the only solution. The situation is complicated by the multistemmed growth form of the trees, particularly in the Swakop River, which makes it difficult to get to the stems and saw them off. The stems show a high potential for regrowth, but are fortunately killed by fire. In December 1984, 105 Prosopis trees were burnt in the Swakop River. By the end of February 1985, after rain and considerable river flooding, no signs of regrowth were evident. At this stage 54 man-days, using chain saws, have been spent on mechanical control operations, with 105 trees burnt (successfully) and another 250 prepared for burning (6,6 trees per man-day).

Prosopis sp is the invasive alien plant which causes the most concern in this Park at present, and will therefore receive the most attention.

Ricinus communis (Map 16). This species has only been recorded in the Naukluft watershed, and the Swakop and Kuiseb Rivers, but it is possible that it also occurs in other rivers in the park. Infestations are light and this species is being, and will continue to be, removed whenever encountered.

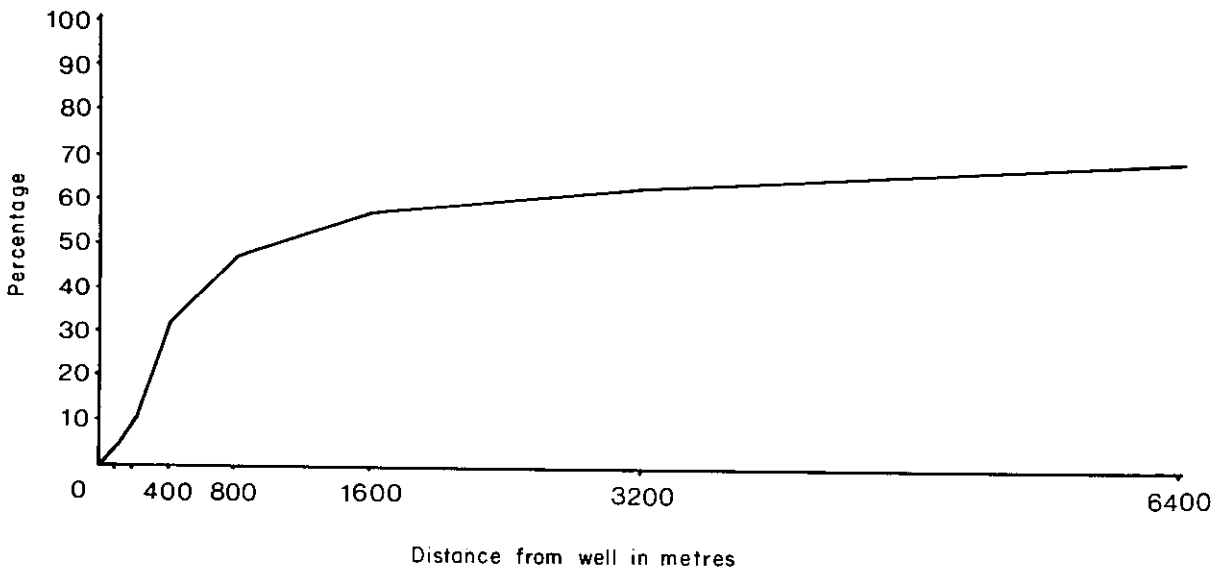


FIGURE 6.1. Percentage of pegs not knocked over by ungulates over one month at different distances from a well in the Kuiseb River.

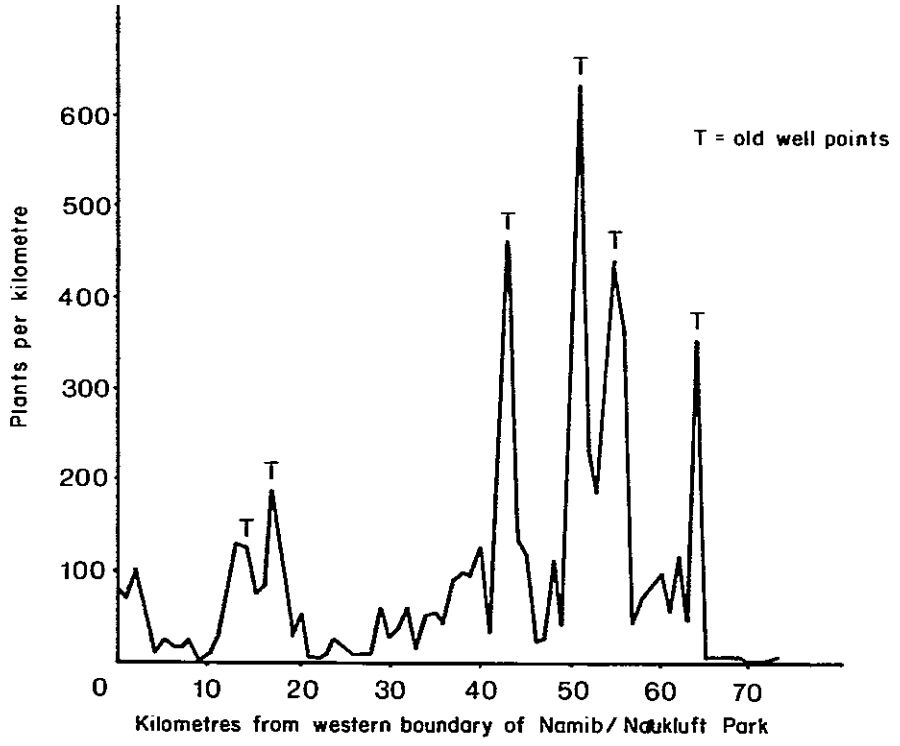


FIGURE 6.2. Density of Prosopis sp in the Swakop River related to the occurrence of old well-points.

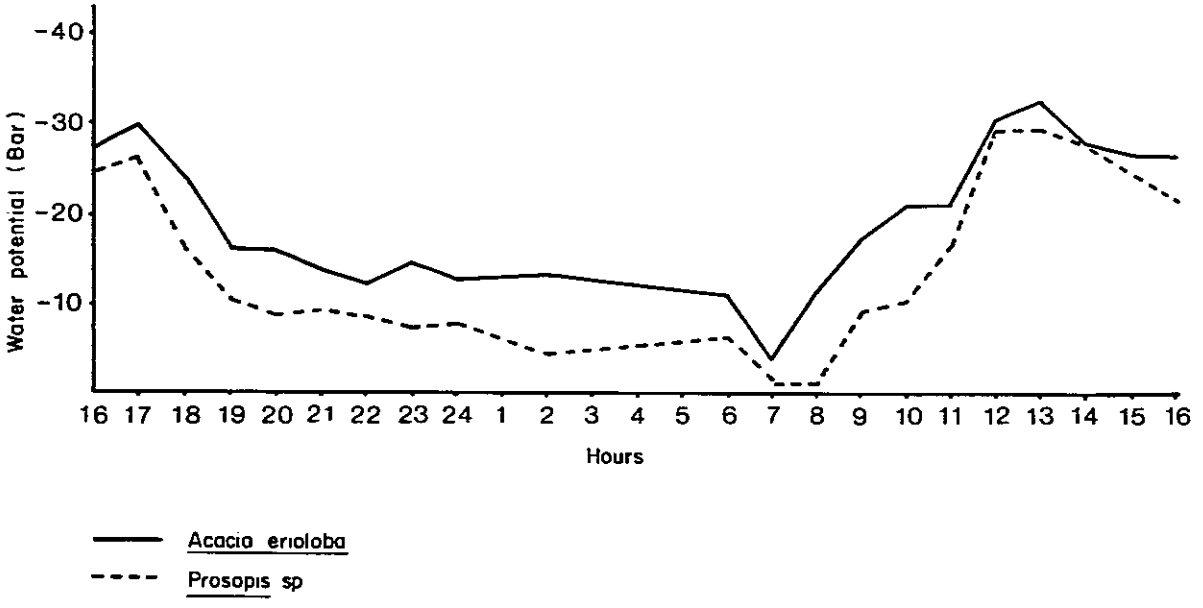


FIGURE 6.3. Water potential of a Prosopis tree and an adjacent Acacia erioloba tree over 24 hours.

CHAPTER 7 A STRATEGY FOR THE CONTROL OF ALIEN PLANTS IN SOUTH WEST AFRICA/NAMIBIA

L Scheepers

INTRODUCTION

This chapter is intended to provide an overview of the situation regarding alien plants in SWA/Namibia as a whole. It is based on a discussion involving all the participants in each workshop group, and encompasses all the areas discussed in the preceding six chapters.

A PRIORITY LISTING OF ALIEN PLANT SPECIES

Arising from the group discussion, a table has been drawn up in which invasive species of alien plants have been arranged in a priority list according to each species' importance (Table 7.1). Possible control measures are recommended.

TABLE 7.1. IDENTIFICATION OF THE MOST IMPORTANT INVASIVE SPECIES AND PROPOSED CONTROL MEASURES

	Species	Mechanical	Chemical	Biological	Combined
1.	Salvinia molesta	0	2	3	-
2.	Prosopis spp	1	3	0	-
3.	Nicotiana glauca	1	3	0	-
4.	Datura innoxia	2	3	?	-
5.	Opuntia ficus-indica	0	2	3	3
6.	Melia azedarach	0	3	0	-
7.	Lantana camara	1	3	3	3
8.	Ricinus communis	1	2	?	-
9.	Argemone ochroleuca	1	2	?	-
10.	Dodonea viscosa	1	3	?	-

KEY: 0 = no known control measures available - > 3 = excellent control measures available.

DISCUSSION

In accordance with the basic principles of nature conservation, preference should always be given to biological control methods over chemical methods, providing these have been thoroughly tested to ensure that they are specific to the alien plants involved and will not affect the indigenous flora or fauna. Satisfactory methods of biological control are not always available, however. Integrated mechanical or biological and chemical methods of control can sometimes be used effectively. In these cases mature plants should first be controlled by chemical methods and regrowth then controlled mechanically or biologically.

Legislation concerning the import and control of potentially invasive plant species is considered to be inadequate at present. SWA/Namibia has no customs system with South Africa and consequently there is no restriction on the movement of plants and plant products over this border. As a result of this lack of customs control we are 'obliged' to maintain the same standards as South Africa as regards control over plant products. Current legislation in South Africa is in itself considered inadequate to effect the necessary control, and as a result of a shortage of personnel enforcing the existing legislation at control points such as airports, harbours and border posts, existing legislation cannot be effectively applied. Nevertheless some laws regarding plants which are effective in South Africa are not at present applicable to SWA/Namibia and adoption of these is discussed under 'recommendations' below.

It is generally considered that the public of SWA/Namibia is unaware of the dangers of declared weeds and of invasive aliens in general. In addition few people are conscious of the potential ecological disasters which can be initiated by the misuse of herbicides. It is also worth noting that many of the invader plants discussed above are not yet mentioned on the labels of chemical weed killers.

POLICY RECOMMENDATIONS

In the light of the information presented above, the following recommendations are made:

(1) The Department of Agriculture and Nature Conservation should investigate control measures for invasive alien plants on an experimental basis. The degree of infestation of agricultural land should also be monitored by this Department.

(2) The following South African legislation should be made applicable in SWA/Namibia:

- law on the conservation of agricultural resources (weeds) (Act 43 of 1983).
- law on agricultural pests (Act 36 of 1983).
- plant improvement law (conditions pertaining to import and export of plants and plant products, nursery registration, etc) (Act 53 of 1976).

Authorization should be given to current law enforcement personnel of the Directorate of Nature Conservation to ensure this legislation is obeyed.

(3) A campaign should be launched through the media, to inform the public as to the potential damage to ecosystems that could be caused by invasive alien plants, and to set out the correct methods of control of these plants. Advantages and limitations or disadvantages of each method should be very clearly emphasised and the need for care in the use of herbicides should be stressed.

(4) Wherever infestations of water-dispersed alien plant species are to be controlled the possibility of reinfestation from headwater regions must be considered. In some cases reinfestation is such an important consideration that control operations should only be initiated where the upper reaches of the catchments can be included in the control programme. The cooperation of all the landuse authorities involved in a catchment is thus essential to the success of such a programme. The Department of Agriculture and Nature Conservation should define a priority catchment and/or an invasive alien plant problem and attempt to solve it with the cooperation of all the relevant authorities and landowners.

PRACTICAL RECOMMENDATIONS

In addition the following steps should be taken:

(1) Nurseries should be provided with a list of plants which may not be propagated or sold.

(2) Horticultural sections of all government departments and municipalities should be fully informed of invasive aliens, and should be provided with a list of 'safe' flowers, shrubs and trees. They should be encouraged to plant indigenous species, and to avoid and to actively remove species proven to be invasive.

(3) Plants planted in the public areas of nature conservation rest camps should be limited to indigenous species. Plants grown in the gardens of resident staff in these camps should be carefully screened for invasive potential.

(4) A section regarding invasive aliens should be included in the master management plan of each nature conservation area, and a policy of active removal of all invasive aliens in these areas should be undertaken wherever feasible. In cases where the control of an alien species is at present impossible, research should be undertaken to seek a solution.

Implementation of these recommendations will provide a sound foundation on which control programmes can be based.

CHAPTER 8 SOME INVASIVE ALIEN PARASITES IN SOUTH WEST AFRICA/NAMIBIA

H C Biggs and I G Horak

INTRODUCTION

Some parasites currently well established in SWA/Namibia have clearly originated outside the territory. Because certainty can be attached to the origin of parasites which are largely or totally restricted to alien hosts, and because parasites have been more intensively studied in such animals, this report deals with parasites of domestic mammals and man. Certain parasites which may have been expected, but have failed, to establish locally are also discussed.

The following parasites which occur in SWA/Namibia but are definitely alien, are dealt with:

(1) Oestrus ovis, the nasal bot fly of sheep, goats and closely related species.

(2) Biting lice of the genus Damalinia and sucking lice of the genera Linognathus and Haematopinus, which infect domestic ruminants.

(3) Taenia saginata, a tapeworm of man with its cystic larval stage (measle) Cysticercus bovis occurring in cattle.

Other parasites which fall into this category but are not dealt with here due to paucity of information with regard to their status in this country, are:

(4) Taenia solium, a tapeworm of man with its cystic larval stage (measle) Cysticercus cellulosae occurring in pigs.

(5) Gasterophilus intestinalis, one of the bot flies of horses.

CURRENT AREA INFESTED AND DENSITY OF INFESTATION.

(1) Oestrus ovis is found wherever sheep and goats occur. As might be expected, dense infestations (10's of larvae/head in season) occur in the sheep farming areas in the south of the country.

(2) The lice that infest domestic ruminants are found wherever their respective hosts (sheep, goats, cattle) are farmed. Louse infestations in late winter can be high (100's per animal) if hosts are nutritionally stressed; this stress usually results from overgrazing.

(3) Taenia saginata may be present wherever man and cattle are found. The prevalence of man-cattle measles is light (abattoir incidence < 3%) throughout most of the territory, except in Owambo where it is slightly higher as would be expected considering the higher human and cattle densities there. The low prevalence generally of C bovis cysts in SWA/Namibia can possibly be attributed to the low human density and the effect of the hot climate on the egg stage on the veld.

RELATIVE EASE OF CONTROL

Although these three groups of parasites are all reasonably easy to control, it is doubtful whether any of them could be entirely eradicated.

(1) O ovis. Sheep and goats introduced from surrounding countries are almost certain to be infested. In addition the adult fly can probably travel several kilometres or more in search of a host, and in this way can cross national and farm boundaries. This species can be controlled fairly easily, however, if sheep and goats are treated with the correct larvicidal drugs during the major larval peak, although this may be a relatively short and changeable period.

(2) Cattle, sheep and goats purchased from neighbouring countries can introduce lice. Ruminant lice are probably easiest to control as these are host-specific, permanent parasites, unable to survive away from their host for any length of time. Dipping the entire host population on a farm or in a region at the same time during autumn, winter or spring is probably the most effective method of control.

(3) The tapeworm T saginata has a final host (man) and an intermediate host (cattle). Humans can be dewormed with an anthelminthic but only the permanent cessation of eating raw or poorly cooked meat of bovine origin by the whole population would halt transmission. Continual reintroduction of tapeworms by visiting or immigrating humans would be almost impossible to control.

POTENTIAL HABITAT AND RATE OF SPREAD

The sheep nasal bot fly, ruminant lice and the tapeworm of man all depend entirely on the distribution and spread of their host animals.

IMPACT ON THE ECOSYSTEM

Sheep nasal bot fly and louse infestations could be favourable from an ecological point of view in that they place a brake on overpopulation by domestic livestock. O ovis does this by reducing the breeding success as the larvae in the nasal passages and sinuses interfere with the ram's ability to find ewes in season. Heavy louse burdens during winter could result in the death of domestic stock which is already nutritionally stressed. None of the parasites mentioned have been recovered from indigenous hosts in SWA/Namibia and presumably do not threaten these hosts locally.

PARASITES WHICH HAVE NOT ESTABLISHED IN SWA/NAMIBIA

Several alien parasites have not established with their hosts in SWA/Namibia, presumaby for environmental reasons. These include:

(1) Osterstagia spp (the brown stomach worms of ruminants); and Boophilus microplus (the pantropical blue tick) with its associated protozoan Babesia bovis (which causes Asian redwater). It seems probable that neither this tick nor the worms can survive in this country due to the sensitivity of free-living stages of the life-cycle to dessication.

(2) Hyalomma marginatum turanicum (a Russian tick which has become established in the cold arid karoo). It is thought that this species has not become estabished in this country as the winters are not sufficiently cold.

(3) Fasciola hepatica (the non-African liver fluke of ruminants). It would appear that the lack of suitable habitat (semi-aquatic, montane, cool) for its intermediate snail host Lymnea trunculata has prevented the establishment of this host, which has in turn prevented the fluke from becoming established in this country.

DISCUSSION

Several ecological principles can be seen to emerge from this study. It would appear that the harsh climate of SWA/Namibia makes this country relatively immune to invasion by alien parasites. Only those closely associated with the host for their whole life cycle (eg lice), those relatively environmentally resistant during their free-living stages (eg tapeworms), and those whose life cycle is synchronized to coincide with advantageous environmental conditions (ie versatile gaiting ploys, eg Oestrus ovis) seem able to survive. In general, if the effect of the indigenous parasites on exotic hosts (well known, but not discussed here) is considered, it is clear that this is often far more dramatic than the effect of exotic parasites on indigenous hosts.

An alien parasite in its new environment is often able to continue fulfilling the same ecological role (with respect to its introduced host) as in its native habitat.

CONCLUSIONS

As a result of discussion during the workshop session (and subsequent plenary session) on alien parasites in SWA/Namibia, the following conclusions were reached:

(1) Control of alien parasites entering SWA/Namibia with game is recommended as a safety measure to reduce the (small) chance of such parasites causing undesirable ecological damage, for instance by infesting other species. Current legislation is sufficient to allow for this, but it is becoming apparent that game smuggling on a small scale is taking place and this could negate all control efforts. It was generally felt that adequate control would only be possible if there was control at the border posts with South Africa.

(2) It should be clearly emphasized that parasite treatment is for various reasons not infallible in preventing the establishment of a parasite which is particularly suited to a new habitat, but can reduce the risk considerably.

(3) The risk incurred in the importation of alien host species should therefore be considered to include the risk of introducing alien parasites.

(4) While treatment of game moving from area to area within the country might be desirable, it would be impractical as control would be very difficult to implement. It should also be remembered that in the past natural migrations took place over large areas of the country, presumably disseminating parasites.

(5) More attention should be paid to monitoring the possible introduction of alien parasites with game in situations where such parasites may have become established.

(6) The grazing of game with domestic stock is a procedure which potentially enhances disease and parasite transmission and should be discouraged.

(7) Although every veterinary authority has lists of countries from which animals should not be accepted for reasons of disease risk, control of this is almost impossible as importers find ways of overcoming the rules, for example, by importing via a 'neutral' country.

(8) Tick-susceptible species such as eland Taurotragus oryx can be introduced into habitats to which they are poorly adapted, and if not eliminated by parasites can act as amplifiers of tick populations.

(9) Parasites do play a role in population regulation and introduced host-specific types such as lice may be considered as neutral or even desirable in years to come.

ACKNOWLEDGEMENTS

For discussion: Anna Verster, Tammi Scialdo-Krecek and Fred Potgieter.

CHAPTER 9 INVASIVE ALIEN FISHES IN SOUTH WEST AFRICA/NAMIBIA

H J Schrader

INTRODUCTION

This chapter has been based on information drawn from a variety of sources. For the white farming areas of SWA/Namibia data were obtained from questionnaires and from surveys conducted on a seasonal basis in state dams. In addition information was drawn from surveys conducted in the northern communal areas by various researchers (eg Barnard 1948; Schrader 1983; Merron et al 1984; Skelton and Merron 1984; van der Waal and Skelton 1984), but as no mention was made of alien species in any of these publications, discussion focusses mainly on the situation in the white farming areas.

IMPORTANT RIVER SYSTEMS IN SOUTH WEST AFRICA/NAMIBIA

The Cunene, Okavango and Orange are the only permanent rivers in SWA/Namibia, excluding those in the eastern Caprivi. The Cunene forms the natural boundary between north-western SWA/Namibia and Angola, and flows into the Atlantic ocean. In the north-east the Okavango River forms the boundary between the same two countries, before flowing into Botswana, where it ends in the Okavango Swamps. The Orange River forms the boundary between southern SWA/Namibia and South Africa.

The Omatako drainage system from the central to the north-eastern parts of the country flows into the Okavango River. A considerable amount of discussion focuses around this system as the possibility exists that invasive fish species, already occurring in farm dams in the vicinity of this system, could spread into the Okavango River. The Cuvelai system drains from southern Angola through Owambo and into the Etosha Pan. Since the mid-1970's, however, this has been artificially linked to the Cunene by means of the Ombalanta canal. This therefore presents a potential means of pollution of the Cunene with alien species.

Most of the rivers which flow towards the west run through the Namib desert and during a good rainy season flow into the Atlantic ocean. Invasive alien species do not pose any ecological threat in these seasonal rivers. Other seasonal rivers of note are the Olifants and Nossob drainage sytems in the south-eastern parts of the country, which end in thick Kalahari sand (which limits further distribution of any alien species), and the Fish River which drains the central and southern parts of the country and flows

into the Orange River. The threat of invasion of alien species into any of these seasonal rivers is minimal.

The following species of fish can be considered as invasive aliens in SWA/Namibia: Cyprinus carpio, Micropterus salmoides and Oreochromis mossambicus.

SPECIES ACCOUNTS

Cyprinus carpio (Map 19). It is thought that this species was probably introduced to this country by early German settlers. It was supplied to farmers by the Freshwater Fish Institute at Hardap Dam between 1974 and 1983. Since 1983 it has neither been supplied to farmers within SWA/Namibia, nor have any permits been issued for its importation from elsewhere. It is, however, already widely distributed throughout the farming areas and state impoundments, and its potential rate of spread is believed to be very high as farmers show a preference for this species. This preference is probably at least partly due to ignorance of other options, a situation which is rapidly changing since the establishment of the hatchery at Hardap, and the subsequent availability of fingerlings of indigenous fish.

This species is already widely distributed in the catchment area of the critical Omuramba Omatako drainage system, and thus poses a threat of invasion of the Okavango system. No threat of genetic pollution by this species exists, but it would compete with indigenous species for food and breeding grounds, and because of its feeding habits it stirs up mud which increases the turbidity of the water which can have a detrimental effect on predatory species.

No feasible method for the removal of this species from the sensitive catchment areas has as yet been suggested. Its distribution is so extensive as to render such efforts as have been proposed overwhelmingly costly and time consuming.

Micropterus salmoides (Map 20). This species was imported from the Jonkershoek hatchery to municipal pools in Narubis in 1932, and to Windhoek in 1934. Further introductions occurred between 1944 and 1949 (Harrison 1936; Inland Fisheries Departmental Reports 1944-1949). As with the previous species it was supplied by the Freshwater Fish Institute at Hardap between 1974 and 1983. Since 1983 it has not been supplied to farmers within SWA/Namibia, and no permits have been issued for its importation. It is already, however, widely distributed throughout the country, including within the sensitive catchment area of the Omatako system, and therefore poses a threat of invasion to the northern water systems. The high turbidity of seasonal rivers, however, does appear to have an effect on the distribution of this species, and in addition it has very specialized breeding requirements, needing a gravel substrate on which to spawn. It can therefore be regarded as less of a potential hazard than the other two species. No threat of genetic pollution exists. If it were to become established it would compete with indigenous species for food, and possibly also for spawning grounds if it were successful at utilizing shallow sandy beds as a spawning substrate. This, however, seems unlikely.

No feasible method of eliminating M salmoides from this country can be envisaged at present. Its spread within the country can be controlled to some degree by the fact that it is no longer available from the Hardap Dam hatchery, and no permits are issued for its import under any circumstances.

Oreochromis mossambicus (Map 21). This species was introduced to SWA/Namibia from Jonkershoek in the Cape in 1947 and 1949. From 1974 until 1983 this species was supplied to farmers by the Freshwater Fish Institute at Hardap Dam. Since 1983 tnis supply has been limited to farms south of Windhoek, but it is now considered to be fairly widely distributed throughout the country. It already occurs in the critical Omatako Omuramba catchment and there is a possibility that it could have spread to Owambo. It should therefore be regarded as a potential threat to the Okavango, Cuvelai and Cunene systems. The potential rate of spread is difficult to assess as it is dependent on a wide variety of factors, including human activity, annual rainfall, periodic droughts and the general hydrology of the systems involved.

O mossambicus is mainly popular with farmers due to its capacity for keeping dams and reservoirs clear of algae. It is not farmed commercially in this country, and few farmers make use of this species either as rations for their labourers or for sporting and recreational purposes.

The impact of an invasion of the northern river ecosystems by this species would be considerable as there is a strong possibility that genetic pollution of indigenous species would occur. The potential for interbreeding between O mossambicus and the indigenous O machrochir and O andersonii would appear to be great. In addition O mossambicus would probably compete aggressively with indigenous cichlids for spawning grounds as well as for food.

The only presently envisaged means of controlling the spread of this species is by killing off all the O mossambicus in the Omatako catchment area with the fish poison, rotenone. The disadvantages of such a method are fairly extensive. All fish in the dams would be affected, and the cooperation of farmers would have to be attained. Farmers would have to be persuaded to accept losing all their fish stocks on condition that the fish were replaced by indigenous species which could be supplied by the Freshwater Fish Institute at Hardap Dam. In addition the costs of the chemicals and the extent of the manpower which would be necessary for this project to be successfully undertaken render it rather a daunting proposition.

Further distribution of this species to farm dams and other water bodies is under the control of the Department of Agriculture and Nature Conservation. Since 1983 this has been restricted to areas south of Windhoek, while indigenous species such as O macrochir, O andersonii and Tilapia rendalli rendalli, which are bred in the hatchery at Hardap Dam, are available for distribution to the northern parts of the country.

POTENTIAL TRANSLOCATION OF INDIGENOUS SPECIES VIA ARTIFICIAL DRAINAGE LINKS

In addition to the potential invasion of alien species into SWA/Namibia water systems, there is also a problem in this country of translocation of

indigenous fish species from one system to another by means of artificial drainage links. This may result either in species which were previously absent entering a water system or in the genetic mixing of strains of the species which have been genetically isolated for a very long time and might prove to be taxonomically distinct. The Cuvelai and Cunene systems have been linked artificially by the Ombalanta Canal since the mid-1970's. Fish species indigenous to the Cuvelai system which could spread to the Cunene, and species indigenous to the Cunene that could spread to the Cuvelai system, are listed in Table 9.1.

As part of a National Master Water Plan, the Department of Water Affairs is constructing a long-distance water carrier known as the Eastern National Water Carrier (ENWC). This is to be an integrated water supply project which will eventually supply water from such sources as the Okavango River, the Karstveld boreholes and other surface sources via a series of pipelines, open canals, inverted syphons and storage impoundments to meet the water demands in the interior of SWA/Namibia. This system is not yet linked with the Okavango River, but this should be the case by the 1990's. Species which have the potential of invasion via the ENWC are listed in Table 9.2.

TRANSLOCATED INDIGENOUS SPECIES

Although not confirmed, it is believed that the sharptooth catfish, Clarias gariepinus, and the banded tilapia Tilapia sparrmanii, in farm dams in the northern area impoundments could be of the southern (Orange River) strain, and could pose a threat of genetic pollution to the northern or Okavango River strains of these species.

RECOMMENDATIONS

(1) Some form of control is necessary to prevent fish entrainment at the draw-off points of artificial water carriers. It is recommended that research should be undertaken to investigate feasible methods of control. The existing canal between the Cunene and Ombalanta could be used as a case study example.

(2) No tropical fish popular in the aquarium trade should be imported into the northern areas.

(3) Export of live fish from SWA/Namibia to other countries should only be permitted in cases where valid import permits have been obtained. Exportation of fish should be under the control of the nature conservation body of the country of import.

(4) If a case should arise where an aquatic problem would appear to require biological control, this should not even be considered until a careful investigation of both the problem itself and the effects on the ecosystem of the proposed control species has been undertaken.

TABLE 9.1. Fish species indigenous to the Cuvelai system which could spread to the Cunene River (column A), and fish species indigenous to the Cunene River which could spread to the Cuvelai system (column B) via the artificial Ombalanta Canal. Some species occur in both systems but the two strains are thought to have been genetically isolated for a great many years.

SPECIES	A	B
Alestes lateralis	*	
Aplocheilichthys johnstonii		*
Barbus afrovernay		*
B barnardi	*	
B bifrenatus	*	
B codringtoni		*
B eutaenia		*
B fasciolatus		*
B lineomaculatus		*
B mattozi	*	
B paludinosus	*	
B puellus		*
B radiatus	*	
B tangandensis	*	
B cf trimaculatus	*	
B unitaeniatus		*
Clarias gariepinus	*	
C ngamensis	*	
C stappersi		*
C theodorae		*
Coptostomabarbus witlei	*	
Haplochromis cf mellandi	*	
H cf steindachneri	*	
Haplochromis sp		*
Hemigrammocharax machadoi	*	
Hippopotamyrus ansorgi	*	
Labeo cylindricus	*	
L molybdinus	*	*
Mormyrus lacerda		*
Neobola brevianalis	*	
Oreochromis andersonii	*	
O macrochir		*
O mossambicus (exotic)	*	
Orthochromis machadoi		*
Pharyngochromis cf darlingi	*	
Pollimyrus castelnaui		*
Pseudocrenilabrus philander	*	
Rhabdalestes maunensis	*	
Schilbe mystus	*	
Serranochromis (Sargochromis) angusticeps		*
S (Sargochromis) codringtonii	*	*
S (Sargochromis) giardi	*	*
S (Serranochromis) macrocephalus	*	
S robusta jallae		*
Serranochromis sp		*
Synodontis macrostigma	*	
S leopardinus	*	
S woosnami	*	
Synodontis sp		*
Tilapia rendalli	*	*
T sparrmanii	*	*

TABLE 9.2. Potential invaders of the Okavango system via the Eastern National Water Carrier.

SPECIES
Alestes lateralis
Amphilius uranoscopus
Aplocheilichthys johnstonii
Barbus barnadi
B barotseensis
B bifrenatus
B palludinosus
B poechii
B radiatus
B unitaeniatus
Chiloglanis fasciatus
Clarias gariepinus
C ngamensis
Labeo cylindricus
L lunatus
Mastacembelus frenatus
M van derwaali
Oreochromis andersonii
Pharyngochromis darlingi
Pollimyrus castelnaui
Pseudocrenilabrus philander
Schilbe mystus
Synodontis leopardinus
S microstigma
Tilapia rendalli
T sparrmanii

CHAPTER 10 INVASIVE ALIEN BIRDS IN SOUTH WEST AFRICA/NAMIBIA

C J Brown

INTRODUCTION

There are three species of invasive alien birds which have established wild, self-sustaining populations in SWA/Namibia. These are Columba livia, Passer domesticus and Sturnus vulgaris.

SPECIES ACCOUNTS

Columba livia. Feral pigeons are derived from domestic pigeons which have escaped and established wild, self-sustaining populations. The ancestor of these domestic pigeons is the wild rock pigeon of Europe, India, west Asia and north Africa. Nearly a century ago, Darwin estimated that there were about 150 different domestic varieties sustained by fanciers for pleasure and sport. Rowan (1983) estimates that there are more than 5 000 pigeon fanciers in southern Africa, with more than 150 000 birds. Domestic pigeons were probably introduced into southern Africa at the time of the earliest European settlers. Since then, birds have been, and still are, frequently imported.

In SWA/Namibia at present domestic pigeons occur in all towns and villages, and on many farms. The distribution of self-sustaining feral populations, however, is probably restricted to the urban areas of Windhoek (2217CA), Walvis Bay (2214 DC) (Sinclair 1984) and Luderitz (2615CA). Because these birds are allowed to fly freely from their lofts it is often difficult to distinguish feral from domestic birds. Control of feral populations has not been attempted but would probably be reasonably easy, although continuous recruitment from domestic stock would be likely to occur. Populations are apparently self-limiting, however, as only three small, urban areas have become infested after many years of exposure to domestic pigeons. Potential habitat for this species would appear to be restricted to cities, towns and possibly villages, as these birds usually feed in streets and other public places. They probably compete most closely with rock pigeons Columba guinea, but these usually fly out of towns to forage. Both species use similar nesting sites in cities, but there would appear to be a superabundance of these sites, and it is likely that food is a more important factor limiting feral pigeon numbers. There are no records to date from SWA/Namibia of raptors such as lanner falcons Falco biarmicus moving into towns to feed on feral pigeons.

Hybridizations between feral and rock pigeons have been achieved in captivity, but the fertility rate and the subsequent survival rate of the nestlings are extremely low. In addition the behavioural characteristics of the two species in the wild state are too different for successful interbreeding to be likely. Although hybrids were once popular amongst pigeon-fanciers these have now gone out of fashion as they have a weakened homing instinct, which persists even into the second and subsequent generations.

Feral pigeons are not considered a threat to indigenous birds in SWA/Namibia, and management of this species is not considered important at this stage.

Passer domesticus (Map 22). Birds of this species were introduced to Durban at the end of the nineteenth century, probably by Indians imported for work in the sugar belt, as this subspecies P d indicus is native to Asia. Although the European race P d domesticus was introduced in a number of places (eg East London, Cape Town) in 1930, the influence of this subspecies is now barely detectable in southern African samples.

The spread of P domesticus through SWA/Namibia has been extremely rapid. The earliest records of this species date from the late 1950's and early 1960's. Vierke (1970) shows them at Ariamsvlei and Aroab, in the extreme south-west of the country, between 1957 and 1960, and Winterbottom (1969) mentions a record on the SWA/Namibia - Cape Province border just south of Warmbad from 1959. Uys (1962) recorded P domesticus at Grünau in June 1961. Von Schwind (1963) discusses this record and remarks on earlier sitings in the same district. An editorial footnote to his article mentions records of this species from Windhoek in 1962, although Winterbottom (1965) records P domesticus at Mariental in 1964 and states that this is the northernmost limit recorded. It is interesting to note that Harwin and Irwin (1966) describe the spread of P domesticus in south-central Africa as consisting not of regular point to point progressions, but rather as a series of irregular jumps. This is confirmed by Vierke (1970) who plotted the spread of this species in southern Africa up to 1969, and suggested possible routes of invasion. Other records from the 1960's show that these birds were present in Swakopmund by 1964 (Bierberg 1965), Luderitz by 1965 (Becker 1965) and north of Omaruru (farm Etembe) by 1967 (Immelman 1967). By 1969 P domesticus had reached the farm Heliodor on the eastern border of the Etosha National Park and was recorded at the eastern entrance gate in 1972 (Becker 1972). By 1975 it had firmly established itself at Namutoni (Clinning and Jensen 1977) and in 1976 was first recorded at Okaukuejo (H H Berry pers comms). Maclean (1985) indicates that this species is distributed throughout SWA/Namibia with the exception of the extreme north-west of the Skeleton Coast Park and Kaokoland and the Caprivi. It would appear that even these areas are rapidly becoming colonized. It is reported to have been resident at Springbokwater since 1980, to have been seen occasionally at Ugab Mouth, although not having settled there as yet, and one male and one female to have arrived at Möwe Bay in 1984 (Macdonald and Nott in press). It would also appear to be spreading into the Caprivi, having been sited at Chinchimane in March 1985, although colonization of this area could have originated from Botswana or Zimbabwe.

P domesticus is a commensal of man, occurring in built-up areas, around farmyards and in gardens. Potential habitat includes all farms, villages and kraals which have not yet been colonized. It would be almost

impossible to eliminate the species from SWA/Namibia, as recolonization from adjacent areas would probably take place as quickly as areas could be cleared. No control of this species has been attempted, and none is recommended. As it is so reliant on human habitation this bird is not considered to be a threat to indigenous species.

Sturnus vulgaris. This species was originally introduced to southern Africa by Cecil Rhodes, who imported these birds to Cape Town in 1899. They subsequently spread rapidly along the south and east coasts, reaching Port Elizabeth in 1955, East London in 1966 and the southern Natal border in 1983. The distribution of this bird in SWA/Namibia has not changed over the past 15 years. It is only found at Oranjemund, where it has been recorded since 1970. It appears to be restricted to the urban areas and fruit orchards of this region (loci: 2816 CB and DA). It has been suggested that the arid conditions (lack of fruit and hard compacted ground which prevents probing with the bill for insects) and large distances between Oranjemund and other towns/villages have prevented it from spreading further. If it were to establish a population further north (eg in Windhoek) it could be expected to spread quite rapidly. Potential habitat consists mainly of cities, towns and villages, but farms in the higher rainfall areas of the country (north-east) could perhaps also be suitable. Insects and soft fruits form the main food items of this species.

The present population would probably be fairly easy to control, but recolonization from the south would continually take place. No control has so far been attempted, and none is recommended at this stage, as the ecological impact of this species in this country can be considered to be minimal. It is, however, recommended that any populations establishing at centres north of Oranjemund be systematically eradicated.

DISCUSSION

The Department of Agriculture and Nature Conservation has taken the following precautionary measures in order to guard against other alien species of birds, which could establish feral populations, being introduced into the country:

(1) At present, no individual is allowed to keep more than 10 birds of any species.

(2) It is recommended (though not yet law) that aviculturalists who require more than 10 individuals of each species keep no more than 10 birds per cage.

(3) Certain notoriously invasive species (eg Acridotheres tristis) are not allowed into the country.

(4) Applications for import permits for species not known to the staff in the permit office are referred to the Department's ornithologists.

CHAPTER 11 INVASIVE ALIEN MAMMALS, REPTILES AND AMPHIBIANS IN SOUTH WEST AFRICA/NAMIBIA

M Griffin and K Panagis

INTRODUCTION

The animals discussed in this chapter have been divided into several categories, ie reptiles, amphibians, murid rodents, small carnivores and large mammals.

Murid rodents can be said to be well suited to an invasive life style. They have invaded the globe to such an extent that their places of origin are often open to controversy.

Invasive alien small carnivores are an international problem, although in SWA/Namibia only the domestic cat is giving cause for concern at present. This concern focuses largely around the contamination of the gene pool of indigenous cat species.

Large mammals are sometimes introduced into an area by game farmers, and can become free-ranging. In SWA/Namibia at present there seems to be little threat of any of these species becoming invasive. Contamination of the gene pools of indigenous species is a possibility which should not be overlooked, however, and for this reason the common practice of game transfer in this country should come under review.

Reptiles and amphibians rarely become established in alien habitats, and even more rarely become invasive. At present there are no problems with these animals in southern Africa, with the possible exception of the red-eared terrapin Chrysemys scripta elegans (N H G Jacobsen pers comm).

The following members of these categories can be regarded as invasive aliens in SWA/Namibia at present: Oryctelagus cuniculus, Mus musculus, Rattus rattus, Rattus norvegicus and Felis catus. In addition feral populations of the following exist, although they do not at present appear to be invasive: Equus asinus, Equus caballus and Capra hircus. The following species have been imported into the country at some stage, but are not at present considered invasive: Capra ibex, deer (unspecified), Dama dama, Bubalus bubalus, Connochaetes gnou, Damaliscus dorcas and Tragelaphus angasii.

AMPHIBIANS

No alien amphibians are known to occur in SWA/Namibia.

REPTILES

No invasive alien reptiles are known to occur in SWA/Namibia. It is probable, however, that tortoises of the genera Chersina, Homopus and Psammobates are occasionally transported from South Africa to gardens in this country, from whence they later escape into the wild. It is unlikely that viable populations will be established in this way.

MAMMALS

Species accounts

Oryctelagus cuniculus. Domestic rabbits were deliberately introduced to Possession Island (2715 AA) by guano gatherers, but little is known about the present status of this population. In similar situations elsewhere O cuniculus have been known to use the burrows of nesting birds for shelter, which results in high chick mortality due to suffocation. It is possible that this situation also occurs here, but no information is at present available.

Mus musculus (Map 23). This species was originally brought in to SWA/Namibia by ship and has since spread over the country by road and rail transportation. It is at present found in many urban areas and farmsteads, and at least one feral population exists, at Sandwich Harbour salt marsh (2314 AD).

M musculus is a potential problem in grain storage facilities, but serious damage has not yet been reported in SWA/Namibia. The species has invaded many urban households, but it can usually be controlled in these situations. Little is known about the population at Sandwich Harbour. The presence of M musculus here might be explained by the absence of its successful competitor Mastomys natalensis.

Rattus rattus (Map 24). This species originally arrived in SWA/Namibia off the early sailing ships and subsequently became distributed around the country by transport on wagons, trucks and railways. It is now established in many urban areas and feral populations are known to exist at Sandwich Harbour and at Hardap Dam.

R rattus is a potential pest in grain storage areas, but this situation has not yet been reported in SWA/Namibia. R rattus is a very aggressive species and could cause considerable harm to ground-nesting birds at Sandwich Harbour. Information on this aspect, however, is at present inadequate, and the situation requires investigation.

Rattus norvegicus. Like R rattus, this species was introduced to SWA/Namibia off early sailing ships, but its distribution appears to have remained restricted to the sea ports of Luderitz (2615CA) and Walvis Bay (2214CD and DC).

Population numbers appear to be in a continual state of flux. When they increase dramatically this species becomes a serious pest, and it has periodically plagued the fishing industry in these areas. This species is also a potential threat to ground-nesting birds in Luderitz. No feral populations are known in SWA/Namibia.

Felis catus. Cats have been introduced to most towns and farmsteads and many prospecting and nature conservation camps in SWA/Namibia. Feral populations as such have not become established but another, and perhaps a more serious, problem has become apparent. Felis catus interbreeds freely with the indigenous African wild cat Felis lybica, which has resulted in the loss of genetic integrity in the indigenous species. As F catus is now extremely widespread it can be assumed that all F lybica stock in SWA/Namibia has been polluted to some extent. The argument is sometimes advanced that because these two species interbreed successfully their specific status should come under review. Nevertheless the importance of genetic conservation should not be underemphasised.

Equus asinus. A small feral population of donkeys exists in the Grootberg area of Damaraland (2014DA). These are said to interbreed with the indigenous Hartmann's zebra Equus zebra, a species which is specially protected. The fact that interbreeding between these species can take place was recently confirmed (Brown and Jenkins in press) when a hybrid foal was photographed near Hotsas, Namib-Naukluft Park (2215CD) suckling from a pure E zebra. The E asinus sire was not with the group, and was thought to originate from farmlands to the east of the park. No further information on the extent of hybridization and its viability is available.

Equus caballus. Approximately 175 wild horses live in the vicinity of Garub, near Aus (2615BD, DB, 2616AC and CA). These are descendants of military horses abandoned in 1915 and they are restricted to the area around this water source. They are regarded as being of historical significance and there is no indication that they are, or are likely to become, invasive.

Capra hircus (Map 25). Small populations of feral goats have been reported from the Brukkaros (Namaland) and Tsoabis (Damaraland) areas. In addition feral populations have been known to occur in some of the west flowing river courses in the Namib Desert and on its fringe. No detailed information is available.

Other alien species present but not thought to be invasive Capra ibex, deer (unspecified), Dama dama, Bubalus bubalus, Connochaetes gnou, Damaliscus dorcas and Tragelaphus angasii are all alien to SWA/Namibia, but have been imported to this country for various reasons in the past. They are now free-ranging, but are not at present considered to be invasive.

In addition to the alien mammals discussed above, there are also a number of species of mammals which occurred historically in SWA/Namibia, or which occur at present in this country, but have a very limited natural range. Some of these species have recently been re-established, or been

established in areas outside their natural range. These species include: Ceratotherium simum, Kobus ellipsiprymnus, Syncerus caffer, Aepyceros melampus, Redunca arundinum and Connochaetes taurinus. None of these species are at present considered to be potentially invasive.

RECOMMENDATIONS

It is recommended that the following steps should be taken by the Department of Agriculture and Nature Conservation and/or other conservation bodies in SWA/Namibia:

(1) Investigations into the following situations should be conducted as soon as possible:
- the relationships between Rattus spp and ground-nesting birds at Sandwich Harbour and Luderitz.
- the relationship between Oryctelagus cuniculus and ground-nesting birds on Possession Island.
- the cross-breeding of Equus asinus and Equus zebra in Damaraland.
- the status of feral populations of Capra hircus in Damaraland and Namaland.

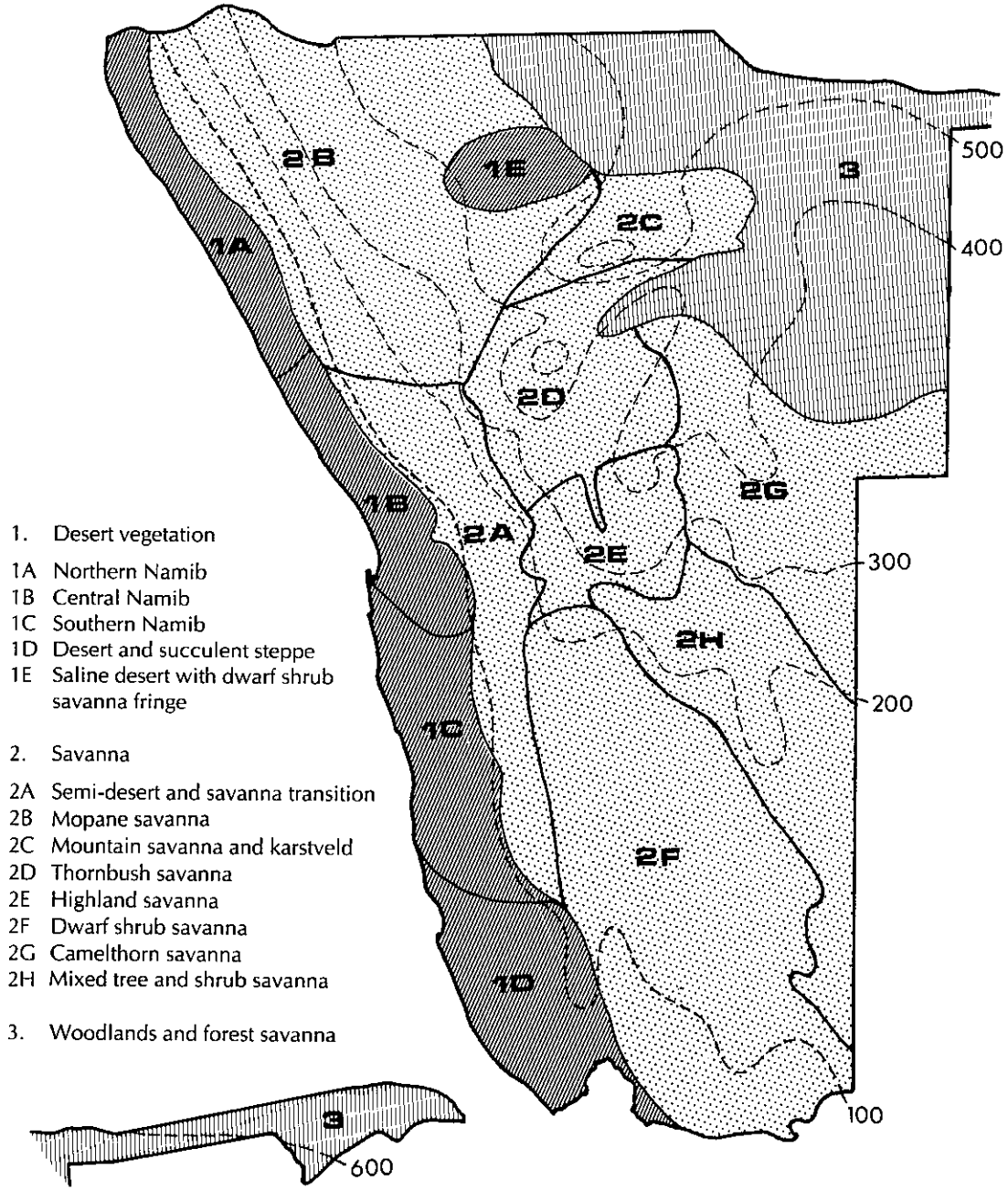
(2) Felis catus should be eliminated from feral situations whenever opportunities arise. A particular effort in this respect should be made in nature reserves.

(3) Ownership of alien game species should be considered to cease when the game leaves the registered owner's property.

(4) A committee should be appointed to handle all new applications to import alien species. The prospective importer should be required to prove to the committee that no problems are likely to arise as a result of the importation.

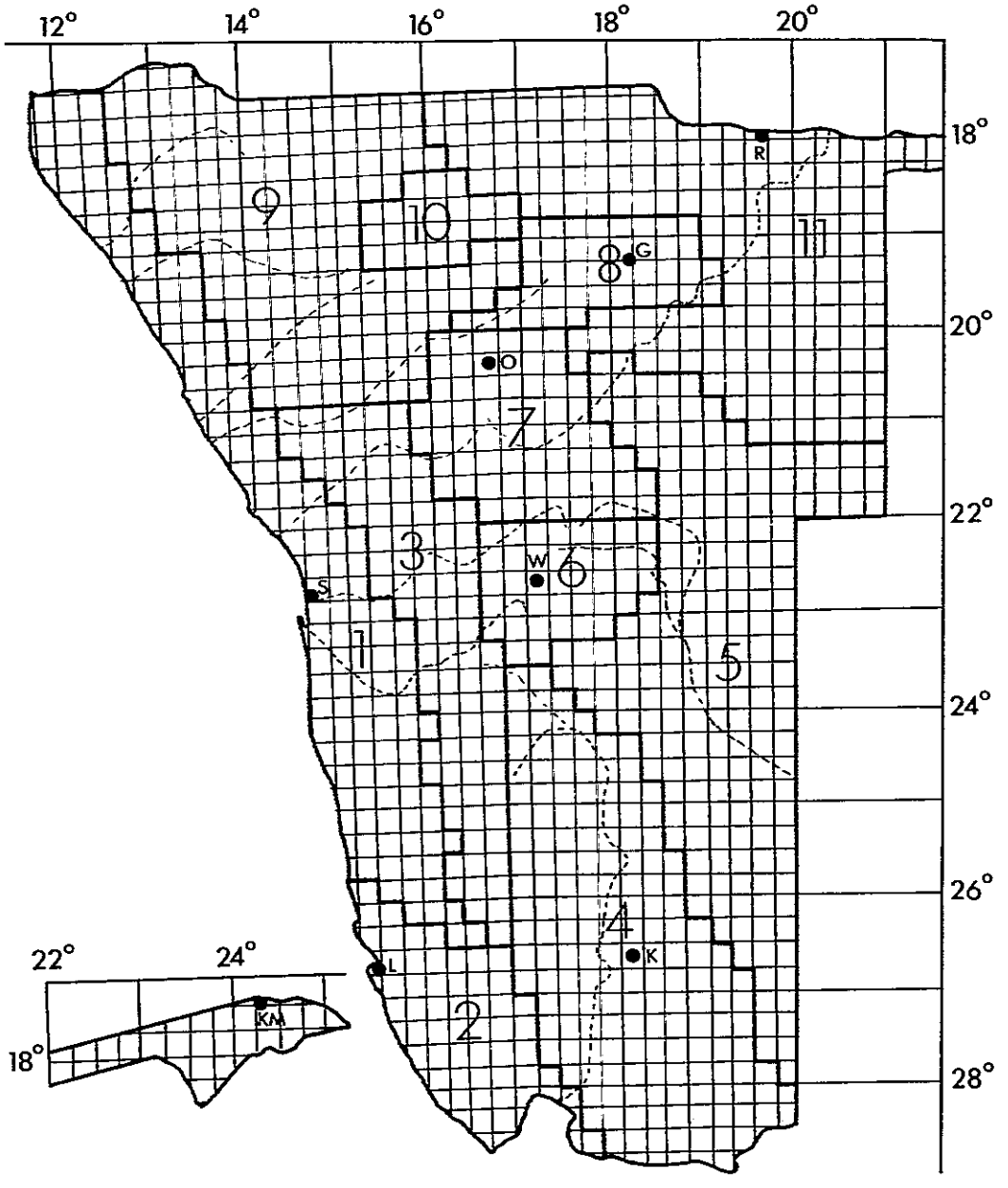
(5) An unconditional ban should be placed on all nondomestic breeds of goats and sheep (Caprinae), and also on Mongolian gerbils (Meriones spp), in order to prevent these notoriously invasive animals from ever becoming established in SWA/Namibia.

MAP 1. The vegetation zones (after Giess 1971) and the mean annual rainfall isohyets in South West Africa/Namibia.

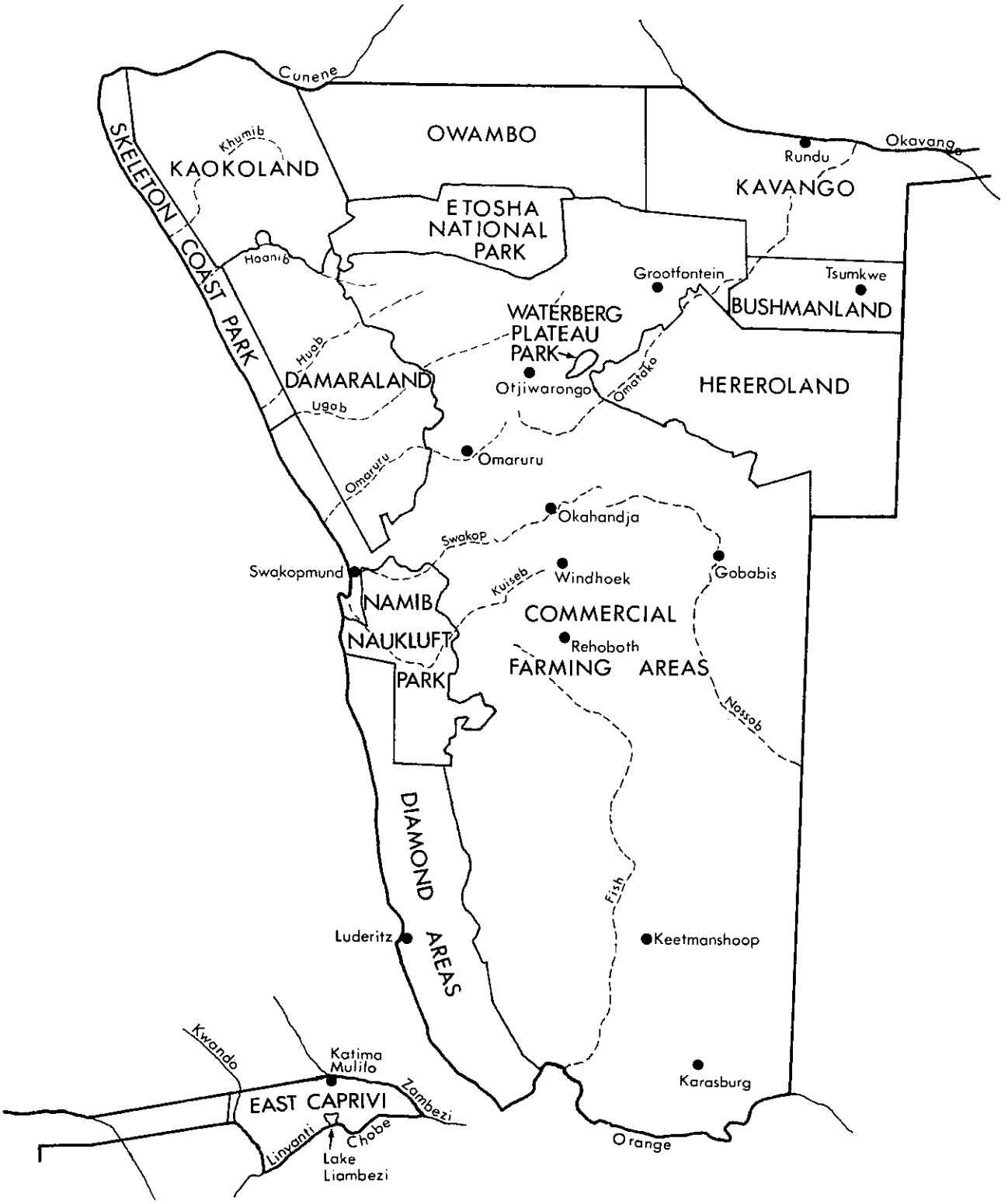


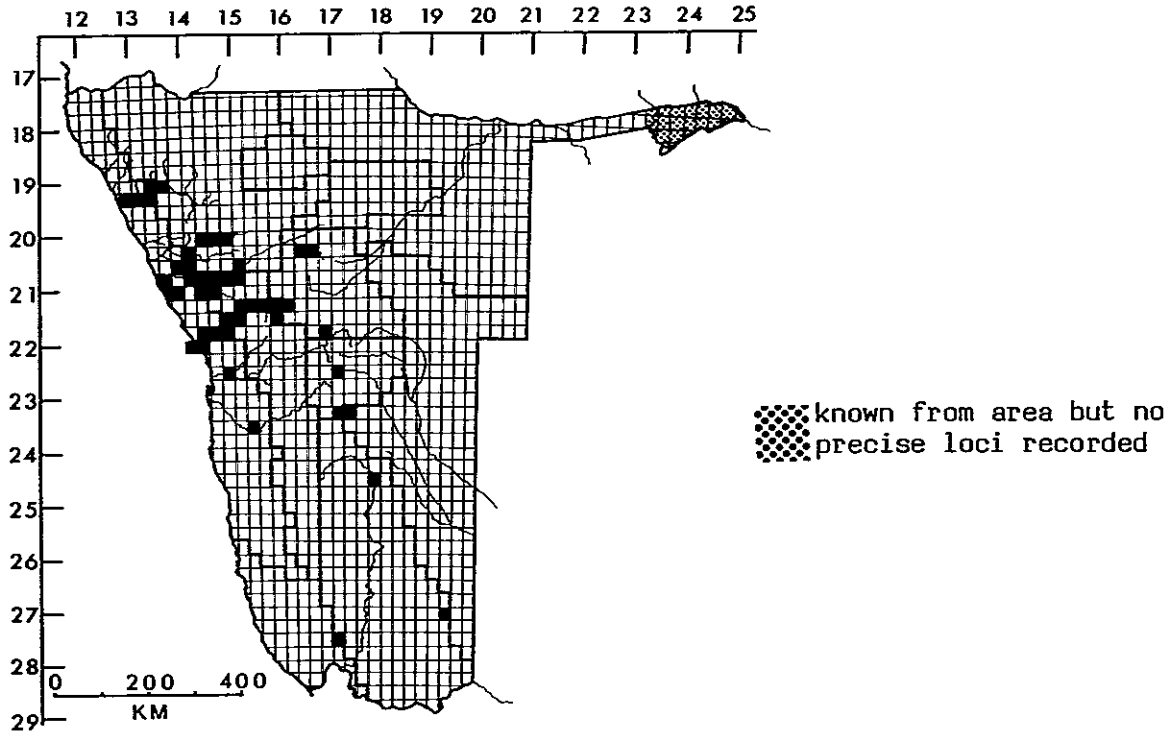
MAP 2. Bioclimatic map showing regions, quarter-degree squares, major rivers and major towns.

Region 1 Namib Desert, summer rainfall; 50 mm
2 Namib Desert, winter rainfall; 50 mm
3 Semi-desert and savanna transition; 50-150 mm
4 Dwarf shrub savanna; 50-200 mm
5 Kalahari Acacia savanna; 150-400 mm
6 Highland savanna; 250-400 mm
7 Thornbush savanna; 350-450 mm
8 Mountain savanna; 450-600 mm
9 Mopane savanna; 100-400 mm
10 Saline pans with dwarf shrub fringe
11 Forest savanna and woodland; 400-700 mm

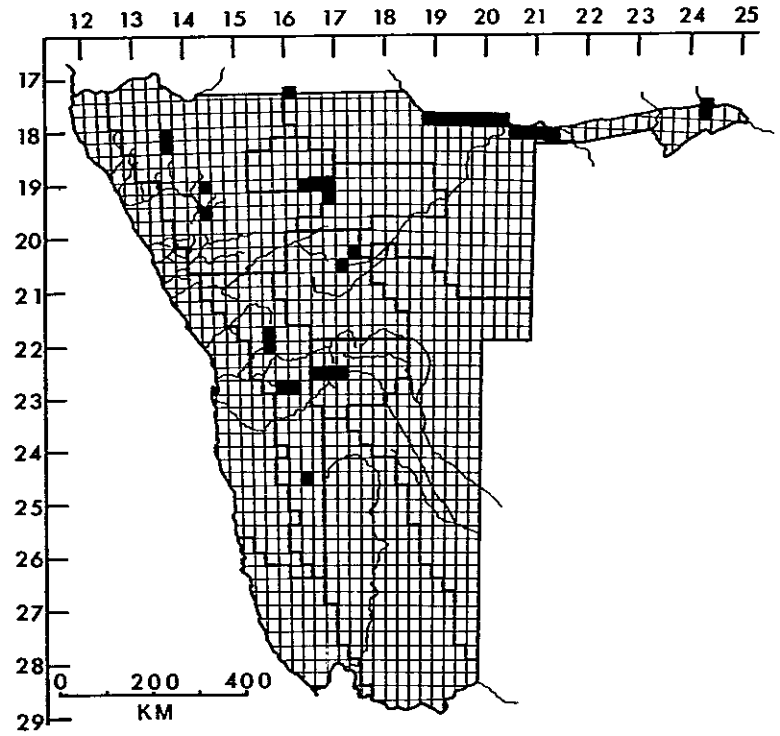


MAP 3. South West Africa/Namibia showing main place names mentioned in text.

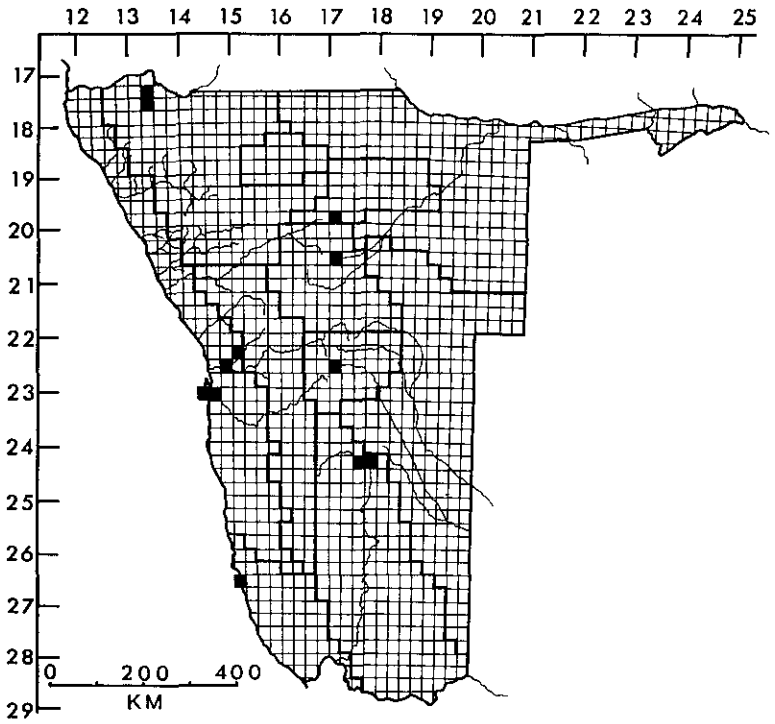




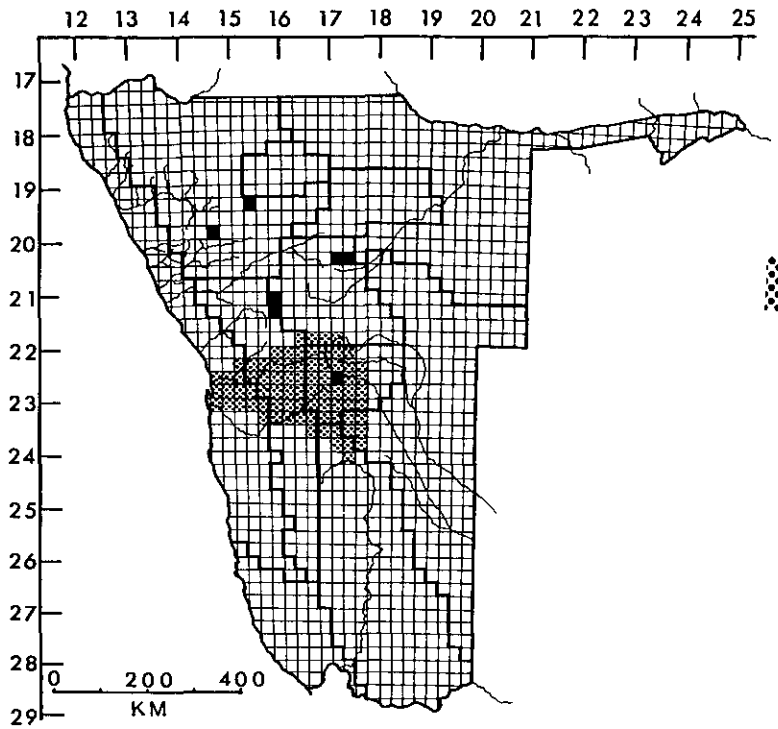
MAP 4. Distribution map of Argemone ochroleuca.



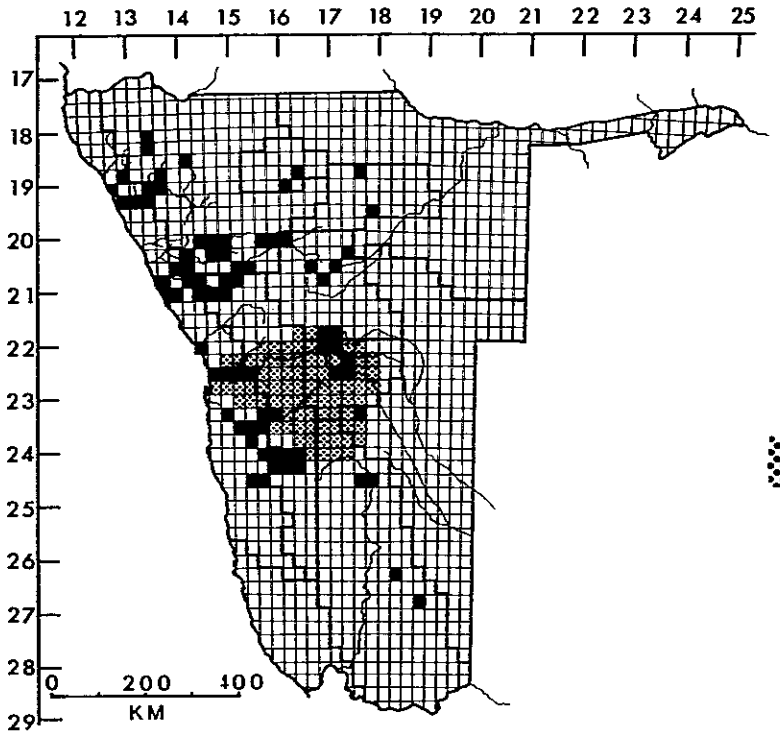
MAP 5. Distribution map of Bidens biternata.



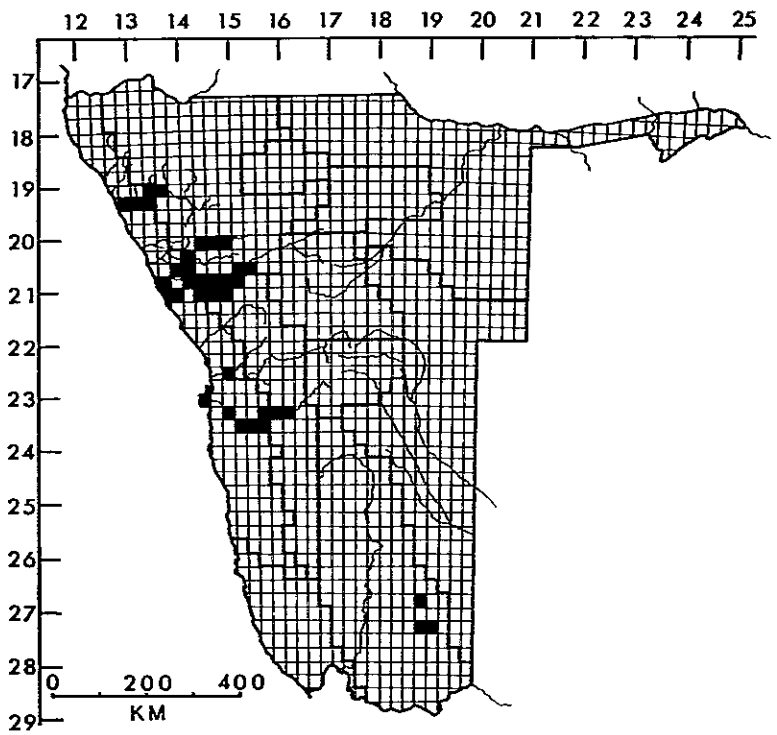
MAP 6. Distribution map of Chenopodium ambrosioides.



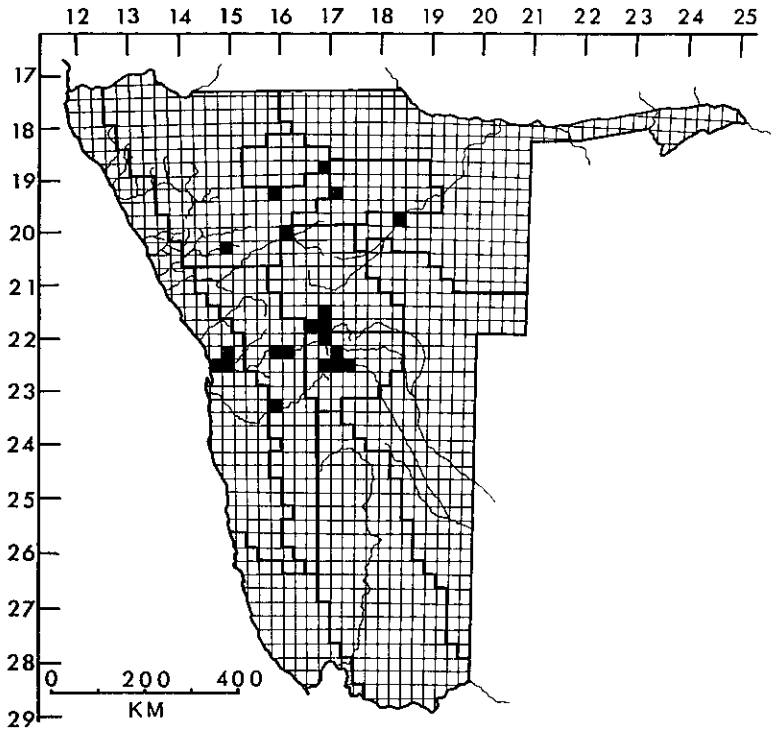
MAP 7. Distribution map of Datura ferox.



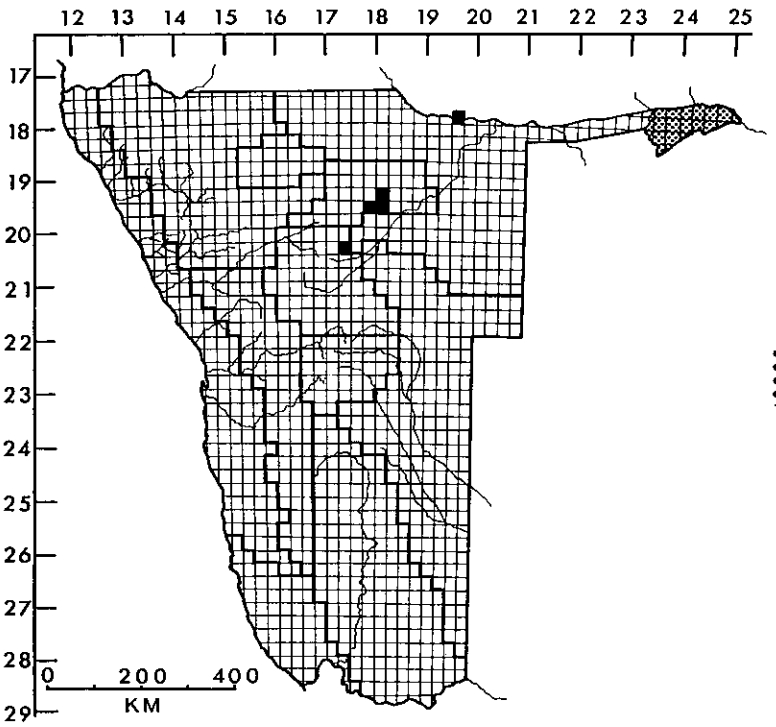
MAP 8. Distribution map of Datura innoxia.



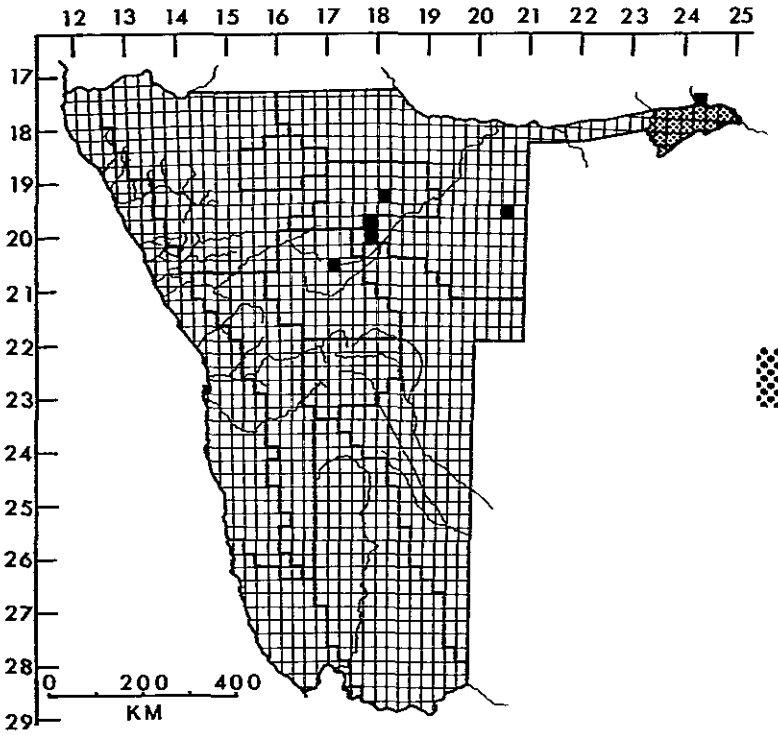
MAP 9. Distribution map of Datura stramonium.



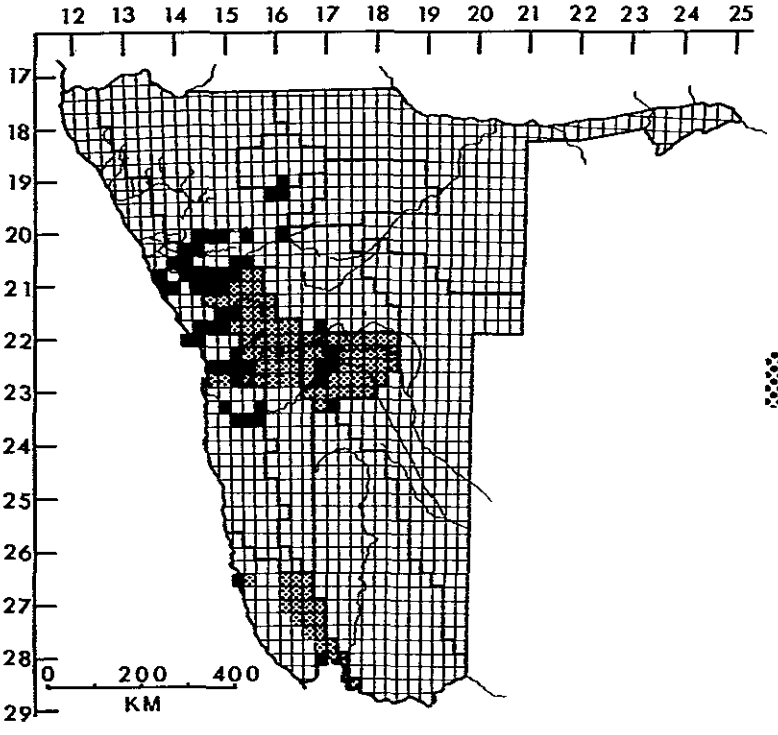
MAP 10. Distribution map of Flaveria bidentis.



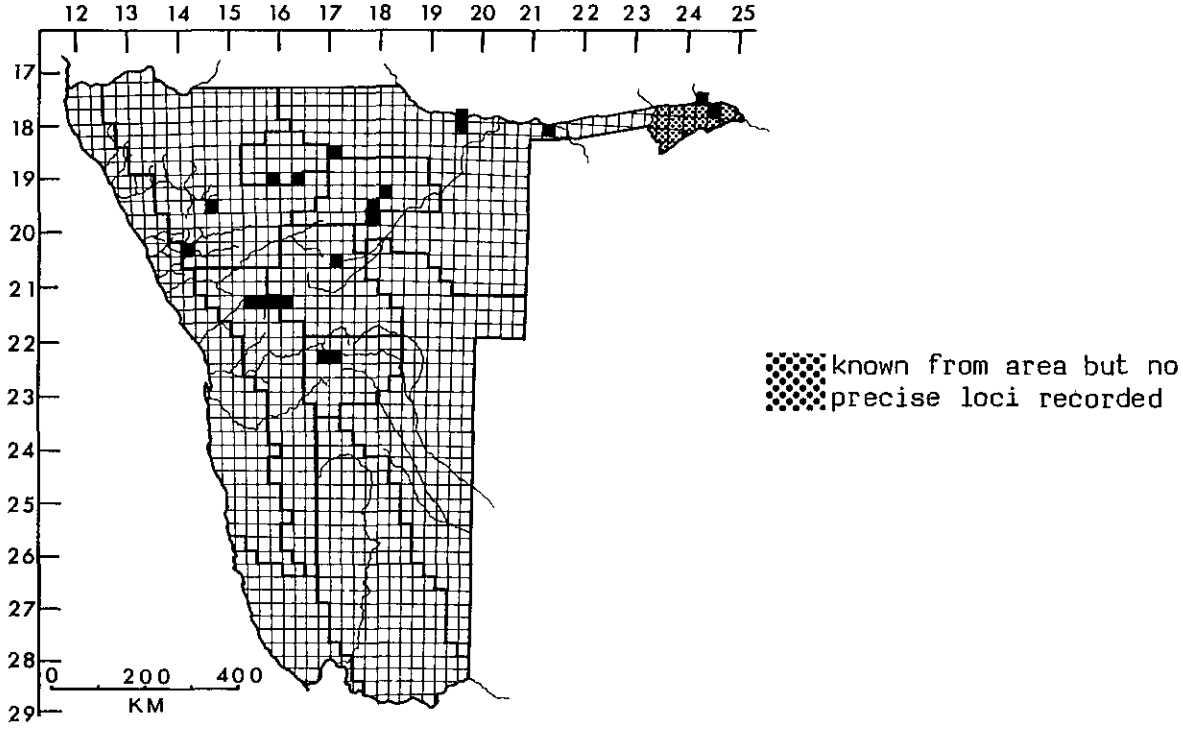
MAP 11. Distribution map of Lantana camara.



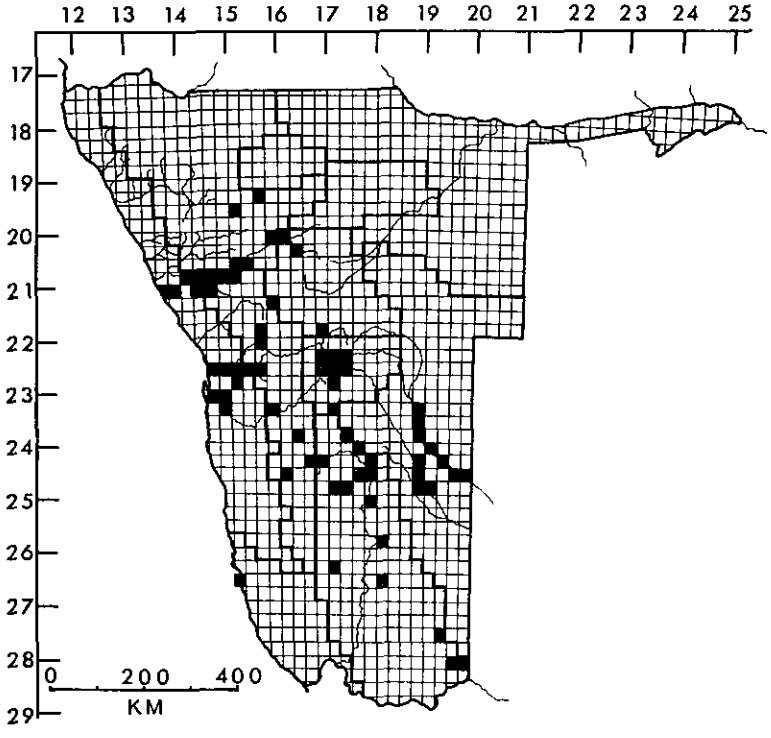
MAP 12. Distribution map of Melia azedarach.



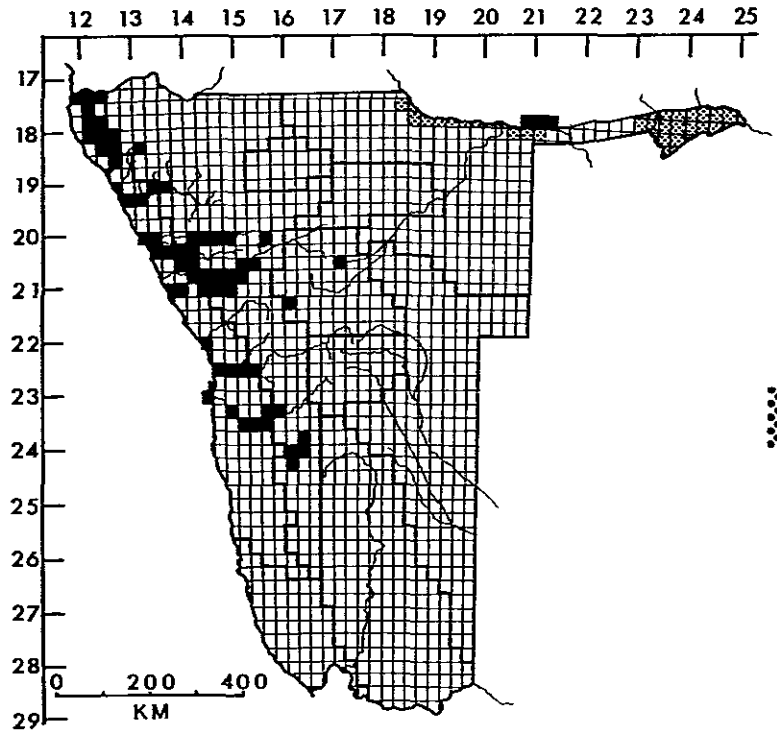
MAP 13. Distribution map of Nicotiana glauca.



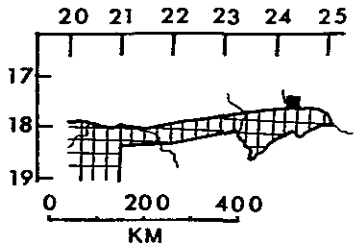
MAP 14. Distribution map of Opuntia ficus-indica.



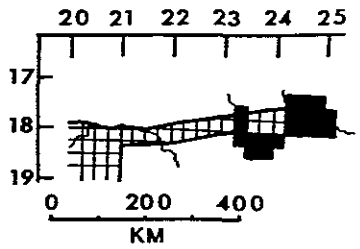
MAP 15. Distribution map of Prosopis spp.



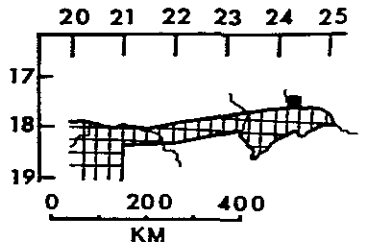
MAP 16. Distribution map of Ricinus communis.



Bambusa balcooa

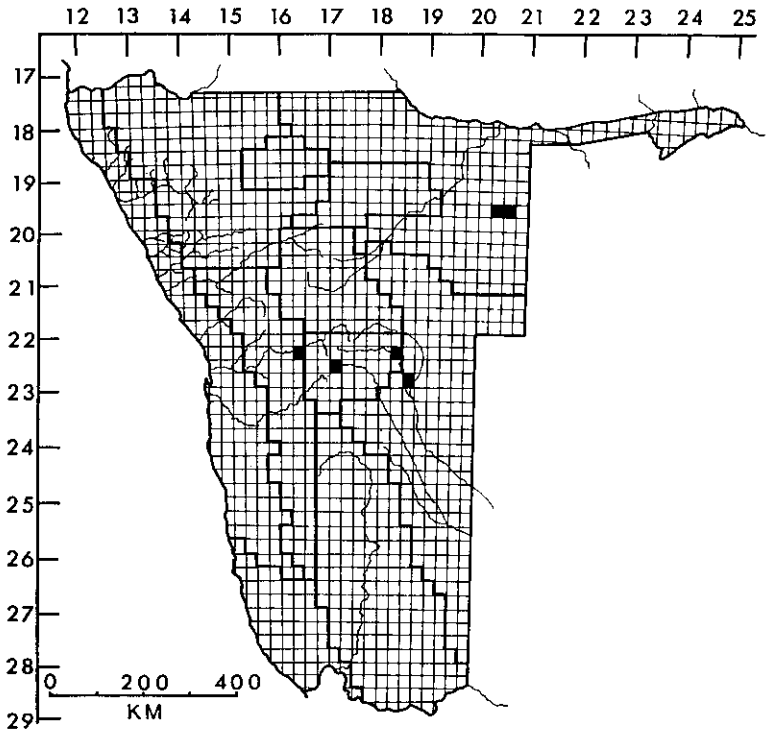


Salvinia molesta

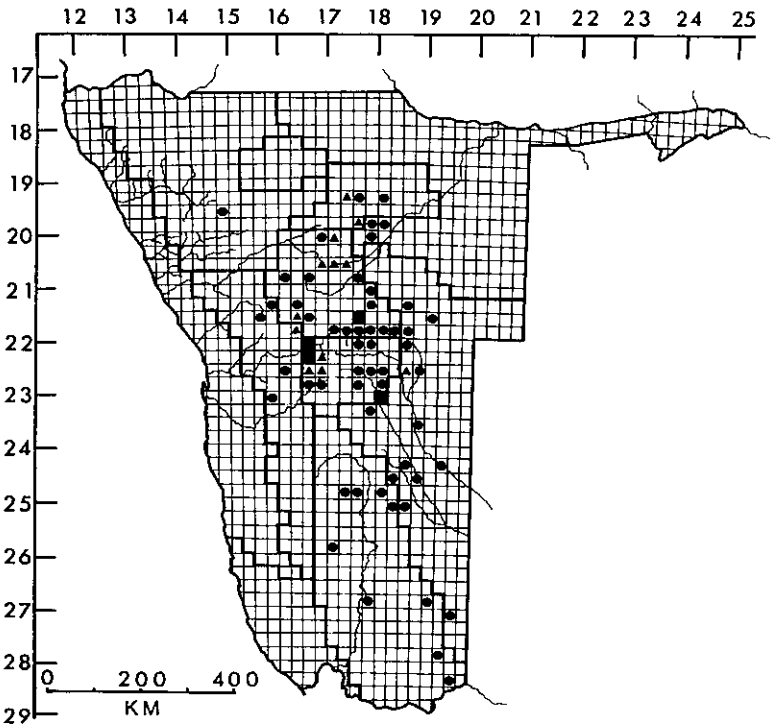


Solanum mauritianum

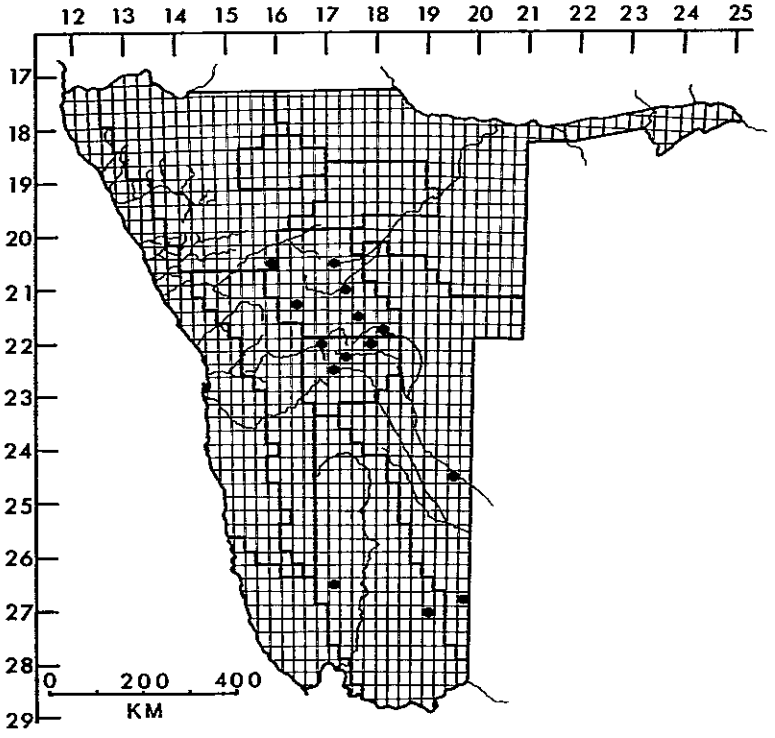
MAP 17. Distributions of three alien plant species known only from the Caprivi Strip.



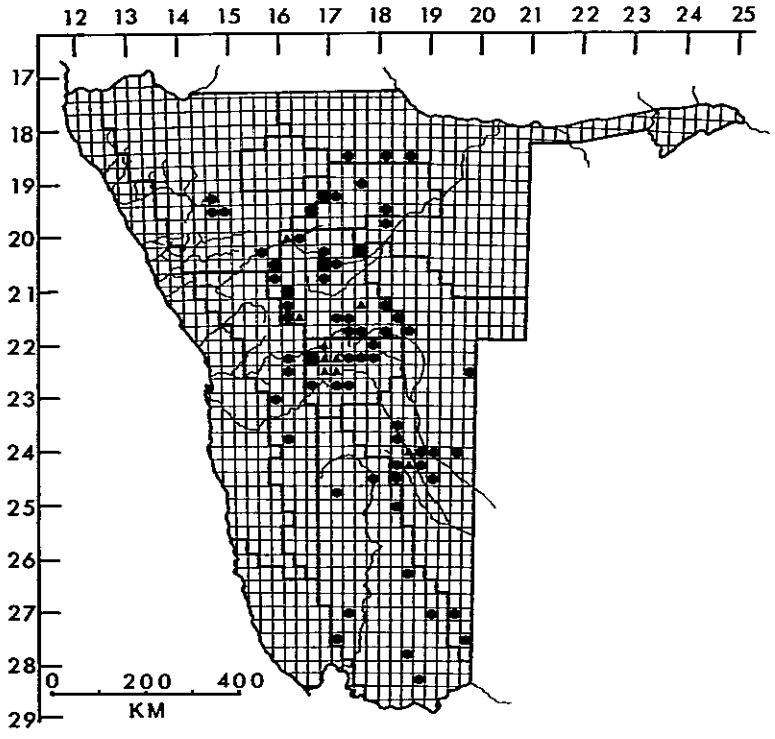
MAP 18. Distribution map of Xanthium spinosum.



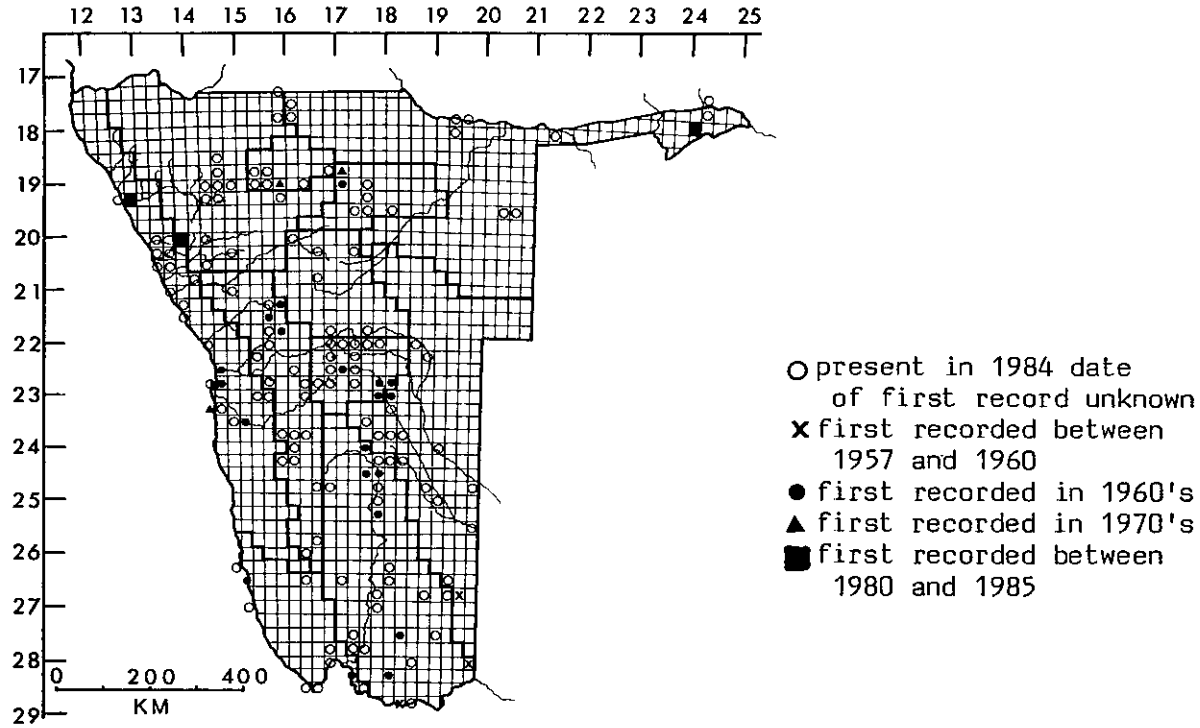
MAP 19. Distribution map of Cyprinus carpio.



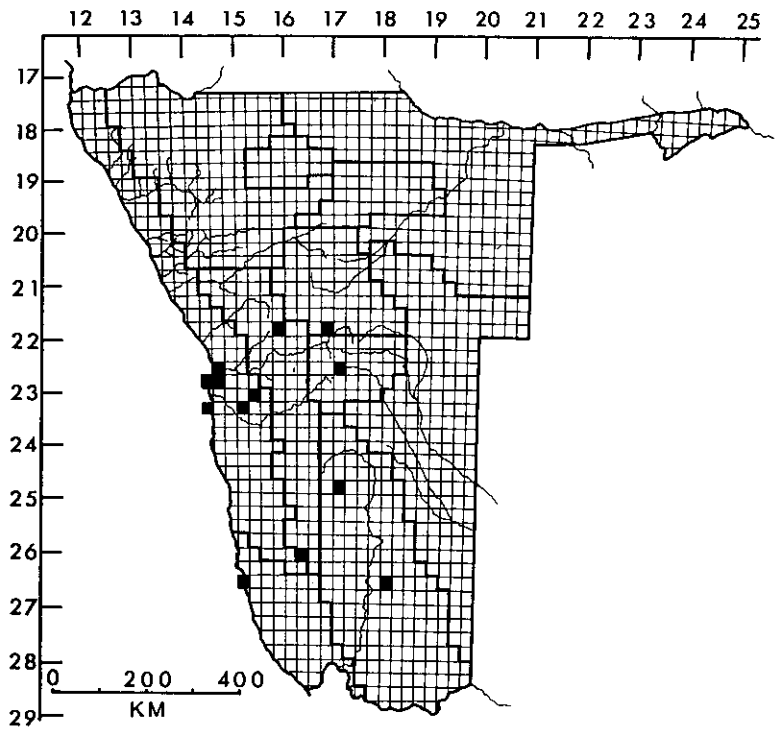
MAP 20. Distribution map of Micropterus salmoides.



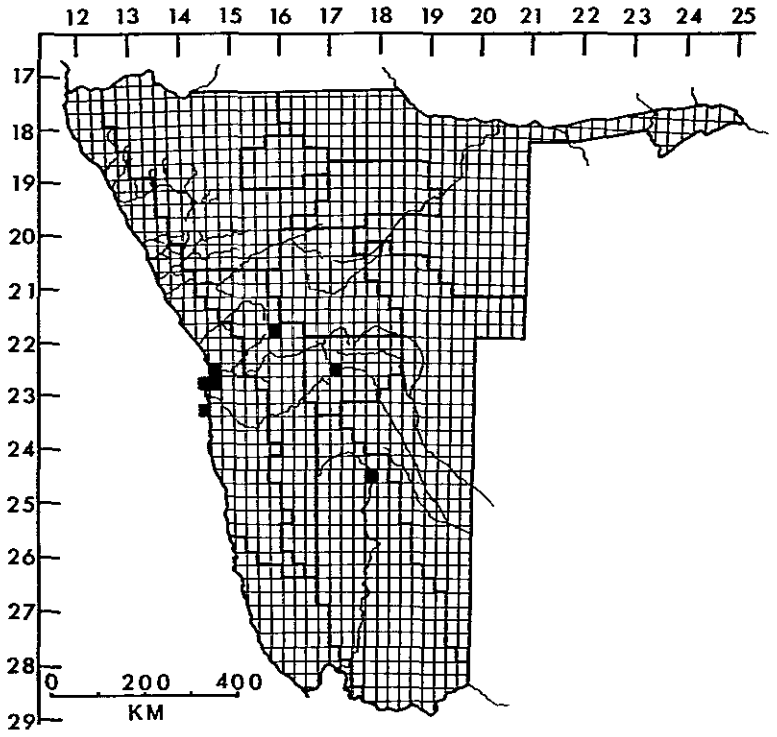
MAP 21. Distribution map of Oreochromis mossambicus.



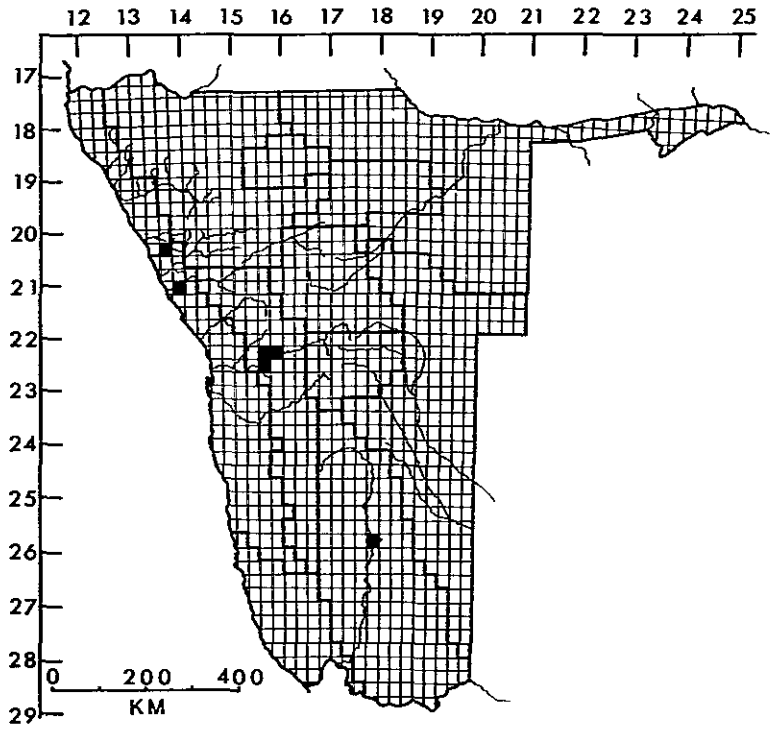
MAP 22. Distribution map of Passer domesticus.



MAP 23. Distribution map of Mus musculus.



MAP 24. Distribution map of Rattus rattus.



MAP 25. Distribution map of known feral population Capra hircus.

REFERENCES

ANON 1966. Beringungen durch die OA im Jahre 1965. Mitteilungen der Ornithologischen Arbeitsgruppe, SWA. Wissenschaftliche Gesellschaft 3-5: 1-3.

BARNARD K H 1948. Report on the collection of fishes from the Okavango River, with notes on the Zambezi Fishes. Ann S Afr Mus 36 (5): 407-458.

BECKER P 1965. Ornithologische Beobachtungen in Luderitzbucht taucht Hausspserling auf. Mitteilungen der Ornithologischen Arbeitsgruppe, SWA. Wissenschaftliche Gesellschaft 7-9: 2-5.

BECKER P 1972. Ornithologische Beobachtungen waehrend eines Busuches in der Etosch-Pfanne vom 30.7. - 9.8.1972. Mitteilungen der Ornithologischen Arbeitsgruppe, SWA. Wissensschaftliche Gesellschaft 6-7: 4-12.

BELL-CROSS G 1965. The distribution of fishes in Central Africa. Fish Res Bull Zambia 4: 3-20.

BENSELER A 1968. Gelegenheitsbeobachtungen in verschudenen gebieten Suedwests. Mitteilungen der Ornithologischen Arbeitsgruppe, SWA. Wissensschaftliche Gesellschaft 1-3: 6-8.

BERRY H H 1972. Flamingo breeding on the Etosha Pan, South West Africa, during 1971. Madoqua, Series I, No 5: 5-31.

BIERBERG J 1965. Das Vorkommen des Haussperlings in Swakopmund 16-20 Okt 1964. Mitteilungen der Ornithologischen Arbeitsgruppe, SWA. Wissenschaftliche Gesellschaft 1965, No V 13-14, S.4.

BROWN C J and JENKINS A R (in press). Hybridization between a Hartmann's mountain zebra and a donkey. Madoqua.

BROWN C J, RIEKERT B R and VINJEVOLD R 1984. Datura innoxia seeds eaten by doublebanded sandgrouse. Lanioturdus 20 (11): 1.

CLINNING C F and JENSEN R A C 1977. Additions to the bird checklist of Etosha National Park. Madoqua 10 (2): 143-148.

DIXON J E W and BLOM M J 1974. Some aquatic vertebrates from the Namib Desert, South West Africa. Madoqua 2 (3): 69-73.

EDWARDS D and THOMAS P A 1977. The Salvinia molesta problem in the northern Botswana and eastern Caprivi area. In: Proceedings of the second national weeds conference of South Africa, Stellenbosch, 4-7 February. A A Balkema, Cape Town.

EDWARDS D, MUSIL C J, VAN ROBBROECK T C P, VAN DER MERWE W, WAUGH W F, BENNISON O H, URBAN N S, SMITH P A, WILSON P H and RAFFLE J A 1972. Report by November 1972 on a joint Botswana - South Africa survey of the extent and degree of occurrence of Salvinia molesta (Kariba weed) in the Chobe-Linyanti-Kwando River system. Unpublished report to Botswana and South African Governments.

FARQUHARSON F L 1962. The distribution of cyprinids in South Africa Ann Cape Prov Mus 11: 233-251.

GABIE V 1965. Problems associated with the distribution of freshwater fishes in southern Africa. S Afr J Sc 11: 383-391.

GAIGHER I G 1973. Distribution of fishes in southern Africa. S Afr J Sc 69: 25-27.

GAIGHER I G 1975. The Hardap Dam: an angler's paradise in South West Africa. Piscator 93: 4-8.

GIESS W 1971. A preliminary vegetation map of South West Africa. Dinteria 4: 114 pp.

HARRISON A C 1936. Black bass in the Cape Province. Second report on the progress of American largemouth black bass Micropterus salmoides, lacepede. Department of Commerce and Industries, Fisheries and Marine Biology Survey Division. Investigational Report No 7, 119 pp.

HARWIN R M and IRWIN M P S 1966. The spread of the house sparrow, Passer domesticus, in south-central Africa. Arnoldia 2 (24), 1-17.

HENDERSON M and ANDERSON J G 1966. Common weeds in South Africa. Department of Agricultural Technical Services. Botanical Survey, Memoir No 37. The Government printers, Pretoria.

HOLM E and SCHALTZ C H 1980. Structure and pattern of the Namib Desert dune ecosystem at Gobabeb. Madoqua 12 (1): 3-39.

IMMELMAN K 1967. Reisegruppe der Deutschen Ornithologen Gesellschaft in Suedwest. Beobachtungsliste auf Farm Etemba und Umgebung. Mitteilungen derOrnithologischen Arbeitsgruppe, SWA. Wissenschaftliche Gesellschaft 8: 1-2.

Inland Fisheries Department, Cape Province, Cape Provincial Administration 1944 - 1949.
Report No 1 (1944): 47 pp.
Report No 2 (1945): 28 pp.
Report No 3 (1946): 49 pp.
Report No 4 (1947): 46 pp.
Report No 5 (1948): 61 pp.
Report No 6 (1949): 23 pp.

JANKOWITZ W J 1983. Die plantekologie van die Waterberg Platopark. PhD thesis. Bloemfontein University.

JUBB R A and FARQUHARSON F L 1965. The freshwater fishes of the Orange River drainage basin. S Afr J Sc 61: 118-125.

JUBB R A 1976. Unintentional introductions of fishes via hydro electric power stations and centrifugal pumps. J Limnol Soc sthn Afr 2 (1): 29-30.

JURGENS J D 1979. The Anura of the Etosha National Park. Madoqua Vol II, No 3: 185-208.

LANDSDELL K A 1927. Weeds of South Africa. Department of Agriculture, Pretoria. Bulletin No 18.

LE ROUX C J G 1980. Vegetation classification and related studies in the Etosha National Park. PhD thesis. University of Pretoria.

MACDONALD I A W and NOTT T (in press). Invasive alien organisms in central South West Africa/Namibia: results of a reconnaisance survey conducted in November 1984. Madoqua.

MACLEAN G L 1985. Roberts' birds of southern Africa. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

MATHUR D and HEISERY P G 1980. Monitoring of fish in pumped storage systems. In Biological Monitoring of Fish. Eds. HOCUTT C H and STAUFFER J R Lexington Books, Lexington, Toronto.

MERRON G S, BRUTON M N and SKELTON P H 1984. Report on the March 1984 Okavango expedition. JLB Smith Institute of Ichthyology Investigational Report No 10.

MERXMÜLLER H 1966-1972. Prodromus einer Flora von Sudwestafrika 35. Lieferung. 3301 Lehre: Cramer.

MICHELL D S 1967. A survey of Salvinia auriculata in the Chobe River system - March 1967. Unpublished Report to Botswana Government.

MICHELL D S 1972. Salvinia molesta. Brit Fern Gaz 10: 251-252.

ROWAN M K 1983. The doves, parrots, louries and cuckoos of southern Africa. David Philip, Cape Town.

SCHLETTWEIN C H G 1984. Salvinia molesta, an invasive alien plant in the eastern Caprivi Zipfel. Internal Report, Department of Water Affairs, SWA.

SCHRADER H J 1983. Verslag Visseryondersoek Kavango en Oos-Caprivi. Internal Report, Department of Agriculture and Nature Conservation, SWA.

SEAMAN M T, SCOTT W D, WALMSLEY R D, VAN DER WAAL B C W and TOERIEN D F 1978. A limnological investigation of Lake Liambezi, Caprivi. J Limnol Soc Sthn Afr 4 (2): 129-144.

SEELY M K 1978. The Namib Dune Desert: an unusual ecosystem. J Arid Environ 1 (2): 117-128.

SEELY M K, BUSKIRK W H, HAMILTON W J and DIXON J E W 1979. Lower Kuiseb River perennial vegetation survey. J SWA Scientific Society 34: 57-86.

SINCLAIR J C 1984. Ian Sinclair's field guide to the birds of southern Africa. C Struik, Cape Town.

SKELTON P H and MERRON G S 1984. The fishes of the Okavango River in South West Africa. With reference to the possible impact of the Eastern National Water Carrier on fish distribution. JLB Smith Institute of Ichthyology Investigational Report No 9.

SMITH P A 1966. Common names of South African plants. Department of Agricultural Technical Services, Botanical Survey, Memoir No 35. The Government printers, Pretoria.

SMITH P A 1969. Report on: (i) a search for the aquatic weed Salvinia auriculata Auba, in the Kwando, Linyanti and Savuti Rivers and the Selinda Spillway, and (ii) a herbicide spraying experiment and other measures to control the Salvinia infestation at Shaile on the Linyanti River in northern Botswana, January-May 1968. Unpublished Report to the Botswana Government.

SMITHERS R H N 1983. The mammals of the southern African subregion. University of Pretoria, Pretoria.

STEYN D G 1934. The toxicology of plants in South Africa. Central News Agency, Cape Town.

THERON G K, VAN ROOYEN G and VAN ROOYEN M W 1980. Vegetation of the lower Kuiseb River. Madoqua 11 (4): 327-339.

UYS C J 1962. House Sparrow Passer domesticus at Grünau South West Africa. Ostrich 33 (4), 39.

VAN DER MERWE J H (Ed) 1983. National Atlas of South West Africa. National Book Printers, Goodwood, Cape.

VAN DER WAAL B C W 1979. Report on occurrence of Salvinia molesta in Caprivi: 1-2 November 1979. Unpublished Report.

VAN DER WAAL B C W 1979. Salvinia control, Caprivi (Afri). Unpublished Report to Secretary of Agriculture and Forestry, Katima Mulilo.

VAN DER WAAL B C W and SKELTON P H 1984. Checklist of the fishes of Caprivi. Madoqua 13 (4): 303-321.

VAN DER WAAL B C W (in press). Notes on the fish life of the Cuvelai River, Owambo, and invasion of Cunene fish species. Madoqua.

VIERECK A 1967/68. Meine Nachbarn: Die Mahalis. Mitteilungen der Ornithologischen Arbeitsgruppe, SWA. Wissensschaftliche Gesellschaft 9-10: 3-4.

VIERECK A 1969. Noch eine Vogelbeobachtung auf Neuhof-Kowas. Mitteilungen der Ornithologischen Arbeitsgruppe, SWA. Wissensschaftliche Gesellschaft 6-7: 1.

VIERKE J 1970. Die Besiedlung Sudafrikas durch den Haussperling (Passer domesticus). J Orn 111: 94-103.

VON SCHWIND H 1963. Ausspreitung des Haussperlings (Passer domesticus L). Mitteilungen der Ornithologischen Arbeitsgruppe, SWA. Wissensschaftliche Gesellschaft IV/3: 5.

WATSON A 1980. Vegetation polygons in the central Namib Desert near Gobabeb. Madoqua 11 (4): 315-325.

WEHRHAHN C 1970. Wochenendfahrt nach Sandwich Harbour. Mitteilungen der Ornithologischen Arbeitsgruppe, SWA. Wissensschaftliche Gesellschaft 7: 2-5.

WINTERBOTTOM J M 1965. House Sparrow at Kalkrand. Ostrich 36 (2), 91.

WINTERBOTTOM J M 1966. Notes on a journey from Windhoek to Cape Town, October-November 1965. Ostrich 37: 137.

WINTERBOTTOM J M 1969. On the birds of the sandveld Kalahari of South West Africa. Ostrich 40 (4): 182-204.

WINTERBOTTOM J M 1972. Birds of the Maltahöhe District, South West Africa. Ostrich 43: 217-227.

CONTRIBUTORS

All the information presented in these chapters was discussed during workshop sessions, which involved not only the authors (listed first), but also several other participants. In some cases additional information was obtained from people who were not present at the workshops. Contributors of information for the various chapters are listed below.

Chapter 1: M A N Muller, SWA Herbarium, Directorate of Agriculture and Forestry, Private Bag 13184, WINDHOEK, 9000.
P Craven, V du Plessis, E Irish, H Kolberg, R Grant, G Jordaan, K Kellner, A Macdonald, I Macdonald, P van der Walt.

Chapter 2: C J H Hines, Biologist, Bushmanland and Kavango, Directorate of Nature Conservation and Recreation Resorts, Private Bag 2044, GROOTFONTEIN, 9000.
C H G Schlettwein, Department of Water Affairs, Private Bag 13195, WINDHOEK 9000.
W Kruger, ENOK, P O Box 12, RUNDU, 9000.
B Beytell, C Grobler, M Grobler, I Macdonald, W Raats, C van Niekerk.

Chapter 3: K Nott, Okaukuejo, Etosha National Park, via OUTJO, 9000.
T Archibald, H Berry, T Cooper, B Holton, M Lindeque, T Nott, M Paxton, P Stander, J Steyn, H Theron, P van der Westhuizen.

Chapter 4: R W Jones, Waterberg Plateau Park, Private Bag 2506, OTJIWARONGO, 9000.
W Jankowitz, Teachers Training College, Private Bag 13285, WINDHOEK, 9000.
A Cilliers, T Cooper.

Chapter 5: P W Tarr, Mowe Bay, Skeleton Coast Park, Private Bag 5001, SWAKOPMUND, 9000.
R Loutit, Ugab River Mouth, Skeleton Coast Park, Private Bag 5001, SWAKOPMUND, 9000.
R Braby, C Eyre, B Loutit, I Macdonald, J Paterson, J Tarr.

Chapter 6: R D Vinjevold, Ganab, Namib-Naukluft Park, P O Box 1085, SWAKOPMUND, 9000.
P Bridgeford, Zais, Namib-Naukluft Park, Private Bag 5021, WALVIS BAY, 9190.
D Yeaton, Department of Botany, University of the Witwatersrand, 1 Jan Smuts Avenue, JOHANNESBURG, 2001.
D Boyer, V du Plessis, J Lensen.

Chapter 7: L Scheepers, Directorate of Nature Conservation and Recreation Resorts, Private Bag 13306, WINDHOEK, 9000.
C Brown, E Irish, R Jessnitz, I Macdonald and others from all chapters.

Chapter 8: H C Biggs, Central Veterinary Laboratory, Directorate of Veterinary Services, Private Bag 13187, WINDHOEK, 9000.
I G Horak, Tick Research Unit, Rhodes University, P O Box 94, GRAHAMSTOWN, 6140.
G Gandini, A Malan, J Nowers, T van Wyk.

Chapter 9: H J Schrader, Freshwater Fish Institute, Hardap, P O Box 127, MARIENTAL, 9000.
S Bethune, J Ferreira, P Richards, I Stutterheim, B van der Waal.

Chapter 10: C J Brown, Ornithology Section, Directorate of Nature Conservation and Recreation Resorts, Private Bag 13306, WINDHOEK, 9000.
I Macdonald, B Riekert, K Roberts, A Williams.

Chapter 11: M Griffin, Directorate of Nature Conservation and Recreation Resorts, Private Bag 13306, WINDHOEK, 9000.
K Panagis, Directorate of Nature Conservation and Recreation Resorts, Private Bag 13306, WINDHOEK, 9000.
D Boyer, N Fairall, E Joubert, M Lindeque, D Morsbach, P Rankin, K Roberts, I Stutterheim.

SPECIES INDEX

PLANTS

Species names not followed by page numbers are alien plants which have been recorded in SWA/Namibia but are not considered to pose a serious threat of invasion and as such have not been mentioned in the chapter accounts. Common names are from Smith (1966) and Henderson and Anderson (1966).

ANIMALS

TITLES IN THIS SERIES

90. Pipeline discharges of effluents to sea. D A Lord, F P Anderson and J K Basson (editors). October 1984. 108 pp.

91. Monitoring in South African grasslands. M T Mentis. September 1984. 55 pp.

92. Conservation of threatened natural habitats. A V Hall (editor). November 1984. 185 pp.

93. Limnological criteria for management of water quality in the Southern Hemisphere. R C Hart and B R Allanson (editors). December 1984. 181 pp.

94. Water quality criteria for the South African coastal zone. J A Luscher (editor). December 1984. 42 pp.

95. National Programme for Weather, Climate and Atmosphere Research Annual Report 1984/85. C W Louw (compiler). December 1984. 28 pp.

96. A guide to the literature on research in the grassland biome of South Africa. N M Tainton. December 1984. 77 pp.

97. South African Red Data Book - Birds. R K Brooke. December 1984. 213 pp.

98. Directory of southern African conservation areas. T Greyling and B J Huntley (editors). December 1984. 311 pp.

99. *The effects of crude oil pollution on marine organisms. A C Brown. February 1985. 33 pp.

100. *SANKON: Opsommingsverslag oor mariene navorsing 1984. SANKON. Februarie 1985. 53 pp.

101A Verslag van die Hoofprogram vir Navorsingsondersteuning. Februarie 1985. 30 pp.

101E Report of the Main Research Support Programme. February 1985. 30 pp.

102. National Programme for Remote Sensing. Report: 1984. P J van der Westhuizen. February 1985. 50 pp.

103. Bibliography of marine biology in South Africa. A supplement to the 1980 edition. A C Brown. March 1985. 83 pp.

104. The plant communities of Swartboschkloof, Jonkershoek. D J McDonald. March 1985. 54 pp.

105. Simulation modelling of fynbos ecosystems: systems analysis and conceptual models. F J Kruger, P M Miller, J Miller and W C Oechel (editors). March 1985. 101 pp.

106. The Kuiseb environment: the development of a monitoring base line. B J Huntley (editor). March 1985. 138 pp.

107. Annotated bibliography of South African indigenous evergreen forest ecology. C J Geldenhuys. May 1985. 125 pp.

108. Review of metal concentrations in southern African coastal waters, sediments and organisms. H F-KO Hennig. August 1985. 140 pp.

109. Coastal dunes of South Africa. K L Tinley. September 1985. 293 pp.

110. The limnology of Hartbeespoort Dam. NIWR. September 1985. 269 pp.

111. Management of invasive alien plants in the fynbos biome. I A W Macdonald, M L Jarman and P Beeston (editors). October 1985. 140 pp.

112. The SANCOR Marine Pollution Research Programme 1986-1990. October 1985. 16 pp.

113. Alien and translocated aquatic animals in southern Africa: a general introduction, checklist and bibliography. M N Bruton and S V Merron. October 1985. 59 pp.

114. A synthesis of field experiments concerning the grasslayer in the savanna regions of southern Africa. T G O'Connor. October 1985. 126 pp.

115. South African marine pollution survey report 1979-1982. B D Gardner, A D Connell, G A Eagle, A G S Moldan, R J Watling. December 1985. 81 pp.

116. Basic needs in rural areas. A report on a seminar held in Cape Town on 19 February 1985. December 1985. 103 pp.

117. South African Red Data Book: Plants - fynbos and karoo biomes. A V Hall and H A Veldhuis. 144 pp.

118. Invasive alien plants in the terrestrial ecosystems of Natal, South Africa. I A W Macdonald and M L Jarman (editors). 88 pp.

119. Invasive alien organisms in South West Africa/Namibia. C J Brown, I A W Macdonald and S E Brown. 74 pp.

*Out of print.