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Hydrobiological Studies in the Catchment of Vaal Dam, South Africa

Part 3. Notes on the Cladocera and Copepoda of Stones-in-current, Marginal Vegetation and Stony Backwater Biotopes

Contents

1. *Introduction*

A general description of the study area may be found in Part 1 (Chutter, 1970), where the fauna other than Cladocera and Copepoda of stones-in-current, marginal vegetation and stony backwaters has been described. It was found that the streams and rivers could be divided into a number of zones and that the fauna was related to the river zonation. The river zones were, in order downstream, the Source Zone, the Eroding Zone, the Stable Depositing Zone and the Unstable Depositing Zone. The Source Zone was made up of open pools below marshes at the very headwaters of the streams. The Eroding Zone was where the streams were falling rapidly so that stream beds were stony, there was little deposition of silt and there were few emergent or fully submerged macrophytes. In the Stable Depositing Zone there was deposition of silt in small amounts and profuse growths of macrophytes were found. However, as its name implies, the river beds in this zone were stable, which was in marked contrast to the Unstable Depositing Zone. Here there were large amounts of shifting silt and sand in the river beds, the water was turbid for prolonged periods and water levels fluctuated considerably. There were consequently few aquatic macrophytes. The beds of some streams were typical of the Unstable Depositing Zone at places where from their size, profile and altitude the streams should have been in the Eroding or Stable Depositing Zones. These were called the High-lying Unstable Depositing Zone streams and they were, according to the nature of their beds, divided into two categories, Sandy and Muddy. The composition of the fauna varied with these zones, and it was concluded that the amount of silt and sand in the river beds was an important factor governing the type of fauna likely to be recorded. Finally there was a number of sampling points situated where sewage works and other effluents reached the rivers. All these sampling points were in the Unstable Depositing Zone and have been treated separately both here with respect to the Cladocera and Copepoda and previously (CHUTTER, part 2, 1971).

It was found that the year could be divided into three biological seasons, called the Summer, the Winter and the Dry Early Summer. The Summer was the rainy season when flows fluctuated and conditions were most unstable in the Unstable Depositing Zones. During the Winter flows were low and the water was cold. The amount of algae in the rivers gradually increased. In the Dry Early Summer flows and turbidities were lowest, the water was warmer than in Winter and growths of diatoms and other algae were greatest. The beginning of the Summer was taken from the first widespread and heavy summer rains, which washed away the algae and the animals associated with them.

The above systems of classification of the streams and rivers and of the seasons has been followed in this paper.

2. *Methods*

Sampling methods have been described in detail in Part 1. The stones-in-current biotope was sampled using a square foot Surber sampler (SURBER 1936) or a circular hand net. Most of the Cladocera and Copepoda collected from this biotope were drifting downstream with the current when collected. The numbers found were consequently partly dependent on the time the sampling net was in the water. The fauna of the marginal vegetation was collected by sweeping the hand net back and forth through the vegetation. Stony backwaters were also sampled with the hand net.

Where the Surber sampler was used in the stones-incurrent it has been possible to arrive at numbers of Cladocera and Copepoda per 0.1 sq m of stream bottom. Taken literally this is meaningless, since the numbers collected in the biotope were a function of the volume of water filtered by the sampler and not of the area of bottom sampled. However, since current speeds were reasonably uniform at the sampling points (Part 1) it is reasonable to use the numbers per 0.1 sq m as a guide to the relative abundance of the Cladocera and Copepoda from zone to zone. The comparison of numbers of individuals collected from the marginal vegetation is straightforward where the amount of vegetation sampled was estimated. The densities are given as numbers per 0.3 m of vegetation, but it should be borne in mind that the hand net was swept back and forth through the vegetation. Data presented in Part 1 show that large numbers of animals were collected by the return sweep. The numbers per 0.1 sq m of stones in current are of course in no way comparable to the numbers per 0.3 m of marginal vegetation.

There were many stones-in-current samples collected with the hand net and many samples from unknown lengths of marginal vegetation. Moreover none of the stony backwater samples were collected from areas of known dimensions. In order to make use of these 'non-quantitative' data it has been found best to relate the numbers of Cladocera and Copepoda to the numbers of the other animals found with them. This has been done by expressing the numbers of Cladocera and Copepoda in each sample as percentages of the total numbers of all kinds of animals collected with them.

3. *The Cladocera and Copepoda*

a) General remarks

HARDING (1961) and HARDING and SMITH (1967) have recently published papers on the South African Cladocera and Copepoda. Some of the material they worked on was collected from the Vaal Barrage which is further down the Vaal River than the Vaal Dam catchment. These publications probably give a fair indication of the species present in the Vaal Dam catchment. However, when the field samples, on which this account of the Cladocera and Copepoda has been based, were analysed, there was no modern guide to the forms likely to be encountered in South Africa. Except in the genus *Simocephalus* identifications have therefore been taken only as far as genus. A large amount of material has, however, been catalogued and preserved. It is hoped that one day someone will have the time, interest and persevercnce to work through it.

b) Zonation and seasonal variation

In both the biotopes for which there are 'quantitative' data, that is the stones-in-current and the marginal vegetation, the greatest densities of Cladocera and Copepoda were usually recorded in the Dry Early Summer (Table 1). There were two exceptions to this. In the marginal vegetation of the Source Zone, where physical conditions were very stable throughout the year, the lowest density was recorded in the Dry Early Summer. In the stones-in-current where the water was contaminated by effluents the largest numbers of Cladocera and Copepoda were recorded in the Summer.

The highest densities of Cladocera and Copepoda in both the stones-in-current and the marginal vegetation occurred where the rivers were contaminated by effluents (Table 1). Density differences between the other zones were related to the general stability of the aquatic environment. Summer spates carried away most of the Cladocera and Copepoda. Consequently the Summer density of these animals was far higher in the Source Zone, where there were no spates, than it was in the other zones where there were spates. Then again bed instability and lack of shelter from the current were greatest in the Sandy High-lying Unstable Depositing Zone and here the density of the Cladocera and Copepoda was lowest. On the other hand densities of Cladocera and Copepoda were low in the Muddy High-lying Unstable Depositing Zone only in the Summer, as conditions were sheltered in this zone in other seasons. The stable conditions of the Stable Depositing Zone are shown by the rather large numbers of Cladocera and Copepoda collected from both the stones-in-current and the marginal vegetation.

Comparison of the density data given in Table 1 with the percentage data (see Methods) given in the same table shows that the percentages usually followed the densities. However, at the sampling points where there was stream contamination there were increases in the densities of other animals as well as of Cladocera and Copepoda. Consequently Cladocera and Copepoda percentages rose by only a relatively small amount (stones-in-current) or not at all (marginal vegetation). Provided that data from contaminated sampling points are treated with some caution, it is reasonable to assume that in the stony backwaters, where there were no density data, percentage changes give a fair indication of changes in the abundance of these animals. They were least abundant in the Eroding Zone backwaters and most abundant in the backwater of the Stable Depositing Zone and where the rivers were enriched.

Table 1. The mean numbers and percentages of all the Cladocera and Copepoda, zone by zone, season by season and biotope by biotope

	Mean numbers per 0.1 sq. m stones -in-current			Mean numbers per 0.3 m marginal vegetation			Mean percentage of whole fauna: Stones-in-current			Mean percentage of whole fauna: Marginal vegetation			Mean percentage of whole fauna: Stony backwaters		
Season	W	D	S	W	D	S	W	D	S	W	D	S	W	D	S
							%	%	%	%	%	%	%	%	%
Zones:															
Source	—	—	—	1132	668	725	—	—	—	84	85	70	—	—	—
Eroding	4	456	23	34	264	12	P	15	3	10	42	12	3	15	1
Stable Depositing	99	1634	192	586	1659	113	3	22	10	60	77	35	36	56	14
Unstable Depositing	31	1398	44	138	402	268	2	32	6	18	67	10	9	23	6
Sandy High-lying Unstable Depositing	13	18	3	23	146	P	1	13	1	1	25	P	—	—	—
Muddy High-lying Unstable Depositing	354	—	9	422	973	77	19	28	15	62	74	44	10	24	11
Enriched Water	3405	3362	5543	3437	4630	231	24	48	55	68	70	42	9	66	16

Notes 1. W — winter, D — dry summer, S — summer
2. — — no samples collected or no quantitative samples collected
3. P — present but less than 1 individual or 1 per cent

c) The biotopes in which the various genera were found

Comparison of data from several sampling points where stones-in-current, marginal vegetation and stony backwater biotopes were all sampled showed that some genera were to be found mainly in the stones in current, others mainly in the other two biotopes, while in others there was no apparent preferred biotope. The genera found mainly in the stones-in-current samples were *Daphnia*, *Moina*, *Bosmina* and *Diaptomus* (s. l.). These are all planktonic forms and were being carried through the biotope by the current. *Simocephalus* spp., *Alona*, *Pleuroxus*, *Chydorus*, *Mesocyclops*, *Tropocyclops* and Harpacticidae were found mainly in the marginal vegetation. However, at some stations there was a current through the vegetation and here *Daphnia*, *Moina*, *Bosmina* and *Diaptomus* were found in large numbers in the marginal vegetation samples. These four genera include open water species. Their occurrence in marginal vegetation samples suggests that just as pelagic Crustacea avoid the margins of lakes (SIEBECK 1968) so these four genera were avoiding the marginal vegetation. They were obviously not able to avoid currents and were consequently found in biotopes with a current through them, the stones-in-current and the marginal vegetation at certain stations. On the other hand the marginal vegetation forms avoided being caught up in currents and transported downstream.

d) Notes on the distribution of the genera encountered

The following notes are based on data given in Table 2.

Daphnia: An open water form recorded mainly in Unstable Depositing Zone and most abundant where the water was enriched by effluents containing organic matter. Highest percentages were recorded in the Dry Early Summer. It was found at only one sampling point in the Unstable Depositing Zone in the Summer. This station (Station 41) was atypical of the zone in that it was on a very small lowland stream which had not flooded for a long time before sampling. CHUTTER (1963) recorded large numbers of *Daphnia* spp. in the Dry Early Summer in the water flowing out of the Vaal Barrage.

Simocephalus spp.: The three species encountered were all marginal vegetation forms, but they had rather different distributions.

S. exspinosus was found mainly in the Source Zone, *S. serrulatus* in the Source and Stable Depositing Zones, while *S. vetulus* was rare in the Source, Eroding and Sandy High-lying Unstable Depositing Zones, but was fairly common elsewhere. This pattern of distribution of the three species is very similar to the distribution recorded by SCOURFIELD and HARDING (1958) in Britain. They give the following habitats: *S. exspinosus*, generally in ponds — *S. serrulatus*, in small weedy waters — *S. vetulus*, common among vegetation in all kinds of waters.

Ceriodaphnia: Recorded mainly from the Stable Depositing Zone and where effluents entered the rivers.

Ilyocryptus: Recorded everywhere except in the Sandy High-lying Unstable Depositing Zone. *Ilyocryptus* is a bottom form and larger percentages of it were recorded in the stony backwaters than in the other biotopes.

Macrothrix: Widely distributed but found mainly in the marginal vegetation and backwaters of the Unstable Depositing Zone and where effluents entered the rivers.

Table 2. The mean percentages of the Cladocera and Copepoda recorded in stones-in-current, marginal vegetation and stony backwater biotopes in the Vaal Dam catchment, season by season and zone by zone

		Source Zone			Eroding Zone			Stable Depositing Zone			Unstable Depositing Zone			Sandy High-lying Unstable Depositing Zone			Muddy High-lying Unstable Depositing Zone			Enriched Waters		
		W*	D	SU	W	D	SU	W	D	SU	W	D	SU	W	D	SU	W	D	SU	W	D	SU
Daphnia	ST**	–	–	–	0	P	P	P	3	0	P	3	3	0	P	P	0	1	0	7	11	1
	M	P	P	0	0	0	0	P	P	0	0	12	0	0	0	0	0	0	0	3	5	P
	B	–	–	–	0	0	0	P	P	0	P	0	0	–	–	–	0	0	0	2	5	P
Simocephalus expinosus (Koch)	ST	–	–	–	0	0	0	0	0	0	0	0	0	0	0	P	0	0	0	P	P	P
	M	1	6	0	0	1	0	P	P	P	P	1	P	0	0	0	0	P	0	P	P	P
	B	–	–	–	0	0	0	P	0	0	0	0	0	–	–	–	0	0	0	P	0	0
Simocephalus serrulatus (Koch)	ST	–	–	–	0	P	0	P	P	P	0	0	0	0	0	0	0	0	0	0	P	0
	M	5	3	3	0	P	0	4	2	2	P	1	P	0	0	0	0	P	0	1	P	P
	B	–	–	–	0	0	0	3	0	P	0	0	0	–	–	–	0	0	0	0	0	0
Simocephalus vetulus (O. F. Müller)	ST	–	–	–	0	1	0	P	P	P	P	1	P	0	0	0	0	1	0	2	1	0
	M	0	0	1	0	2	0	8	6	5	P	3	0	0	0	0	5	9	P	3	4	P
	B	–	–	–	0	0	0	P	P	P	0	P	0	–	–	–	0	0	0	P	P	0
Simocephalus juveniles	ST	–	–	–	P	P	P	P	P	1	P	1	P	0	0	0	0	P	0	P	P	0
	M	6	0	0	3	1	1	2	1	2	P	6	P	0	P	0	1	14	0	4	1	P
	B	–	–	–	0	0	0	P	P	P	P	P	0	–	–	–	0	1	0	0	4	0
Ceriodaphnia	ST	–	–	–	0	0	P	P	3	1	P	1	P	0	0	0	0	P	0	0	2	1
	M	P	0	P	0	P	0	P	6	1	0	P	0	0	0	0	P	1	0	P	3	1
	B	–	–	–	0	0	0	0	P	P	0	P	0	–	–	–	0	0	0	0	3	0
Ilyocryptus	ST	–	–	–	0	P	0	0	P	P	P	P	P	0	0	0	0	0	0	P	P	0
	M	P	P	P	P	P	0	P	P	2	0	P	0	0	0	0	P	P	P	1	P	P
	B	–	–	–	P	2	0	P	P	1	0	7	0	–	–	–	P	0	0	0	3	0
Macrothrix	ST	–	–	–	0	P	0	0	0	0	P	2	1	1	1	0	P	1	0	1	1	P
	M	P	P	1	0	P	0	P	P	P	P	10	P	1	P	0	1	P	0	1	3	P
	B	–	–	–	P	1	0	0	0	0	2	5	1	–	–	–	P	0	0	3	5	0

	ST	–	–	–	P	0	0	0	P	1	P	1	P	0	0	0	0	0	1	P	2	42
Moina	M	0	0	11	0	0	0	P	0	P	0	0	1	0	0	0	0	P	P	P	1	13
	B	–	–	–	0	0	0	0	P	P	0	0	1	–	–	–	0	0	2	P	0	10
	ST	–	–	–	0	0	0	P	3	2	P	5	P	0	1	0	0	0	0	4	4	P
Bosmina	M	P	0	0	0	0	0	0	1	0	0	5	0	0	P	0	0	0	0	1	1	0
	B	–	–	–	0	0	0	P	P	0	0	P	0	–	–	–	0	1	0	0	2	0
	ST	–	–	–	0	0	0	0	P	0	0	0	0	0	0	0	0	0	0	0	0	0
Acroperus	M	0	0	0	0	0	0	P	2	P	0	0	0	0	0	0	0	0	0	0	0	0
	B	–	–	–	P	0	0	P	0	P	0	0	0	–	–	–	0	0	0	0	0	0
	ST	–	–	–	0	3	0	1	6	P	0	P	0	0	P	0	P	3	2	P	P	0
Alona	M	1	12	4	1	1	P	4	4	1	0	P	P	0	0	0	2	1	0	6	1	P
	B	–	–	–	P	2	0	3	1	P	P	0	0	–	–	–	1	11	0	P	0	0
	ST	–	–	–	0	P	0	0	P	P	0	0	0	0	0	0	0	0	0	0	0	0
Camptocercus	M	P	0	0	P	0	0	0	1	P	0	0	0	0	0	0	0	0	0	0	0	0
	B	–	–	–	0	0	0	0	1	0	0	0	0	–	–	–	0	0	0	0	0	0
	ST	–	–	–	0	1	1	0	P	0	0	1	0	0	0	0	1	1	0	P	P	0
Leydigia	M	0	0	0	P	P	P	P	1	P	P	P	P	0	0	0	P	3	P	P	P	P
	B	–	–	–	P	3	0	0	12	0	0	1	0	–	–	–	P	3	0	0	7	0
	ST	–	–	–	0	3	P	P	1	0	P	4	0	0	1	0	0	15	0	P	2	0
Pleuroxus	M	P	7	0	P	7	1	7	6	P	1	8	P	0	3	0	10	26	0	4	27	1
	B	–	–	–	1	4	P	3	P	P	1	6	0	–	–	–	P	2	0	P	18	0
	ST	–	–	–	0	2	P	P	4	0	0	1	0	0	P	0	0	4	0	0	1	0
Chydorus	M	26	20	2	0	1	P	13	20	1	P	1	P	0	1	0	1	10	1	10	4	P
	B	–	–	–	P	0	P	10	38	1	P	P	0	–	–	–	P	1	0	P	P	P
	ST	–	–	–	0	P	P	P	1	2	1	1	1	0	0	P	0	P	0	7	6	3
Diaptomus	M	0	0	2	P	P	P	0	P	P	P	P	P	0	0	P	0	0	P	P	P	3
	B	–	–	–	0	0	0	0	0	P	P	0	2	–	–	–	P	0	0	P	8	2
	ST	–	–	–	0	P	P	0	P	0	P	P	0	0	0	0	P	0	0	P	P	0
Mesocyclops	M	2	2	1	2	P	0	1	2	P	P	P	P	0	P	0	P	0	0	P	P	P
	B	–	–	–	P	0	0	P	0	0	P	0	0	–	–	–	0	0	0	P	0	0
	ST	–	–	–	0	0	0	P	P	0	P	P	0	P	P	0	16	1	4	P	1	0
Paracyclops	M	4	3	1	2	1	1	P	2	P	P	P	P	P	2	0	1	P	3	1	P	2
	B	–	–	–	1	0	0	5	P	0	P	1	P	–	–	–	5	5	2	P	1	0

		Source Zone			Eroding Zone			Stable Depositing Zone			Unstable Depositing Zone			Sandy High-lying Unstable Depositing Zone			Muddy High-lying Unstable Depositing Zone			Enriched Waters		
		W*	D	SU	W	D	SU	W	D	SU	W	D	SU	W	D	SU	W	D	SU	W	D	SU
Tropocyclops	ST	–	–	–	0	0	0	P	0	0	P	P	0	0	0	0	0	0	0	0	0	0
	M	1	2	0	P	1	1	2	1	P	P	P	P	0	0	0	5	1	1	P	1	0
	B	–	–	–	0	0	0	P	0	0	P	0	0	–	–	–	0	0	0	P	0	0
other Cyclopoid Copepods	ST	–	–	–	P	5	2	2	1	5	1	12	2	P	10	1	2	1	8	3	17	9
	M	30	28	42	2	27	8	19	21	21	17	20	9	P	19	P	36	9	39	31	18	22
	B	–	–	–	1	3	1	12	4	12	6	4	3	–	–	–	4	P	5	4	10	4
Harpacticidae	ST	–	–	–	0	P	0	P	P	P	0	0	0	0	0	0	0	0	0	P	P	0
	M	8	2	2	P	P	P	P	1	P	0	0	0	0	0	0	0	0	0	P	P	0
	B	–	–	–	P	P	0	0	1	P	P	0	0	–	–	–	0	0	2	0	0	0

Other genera found were *Scapholeberis*, *Tretocephala* and *Lovenula*. They were very rare.
W* — Winter, D — Dry Early Summer, SU — Summer. — ST** — Stones in current, M — marginal vegetation, B — backwaters. — A dash (–) means no samples collected. — 0 means none found

Moina: This genus stands out among the Cladocera and Copepoda as the only one which was more abundant in the Summer than in the Winter or Dry Early Summer. This animal is an open water form and was particularly abundant where the water was enriched by effluents. CHUTTER (1963) found large numbers of *Moina* in the summer both in the fringing vegetation of the Vaal Barrage and in the plankton carried out of the Barrage.

Bosmina: An open water form found mainly in the larger streams and rivers. Not common in Summer.

Acroperus: Almost entirely restricted to the Stable Depositing Zone which suggests that it favours riverine conditions where there are not large amounts of silt and sand and where there is shelter from the current.

Alona: The distribution of this genus suggests that it is an upper river form. Only once did it form a large part of the fauna where effluents entered the rivers. This was in the winter at Station 11a which was a sampling point close to the Stable Depositing Zone (Part 1). The highest percentages were recorded in the marginal vegetation of the Source and Stable Depositing Zones, where there was more shelter from the current than in other zones. The South African literature contains conflicting reports on the response of *Alona* to pollution, due probably to different species being involved. ALLANSON (1961) and OLIFF (1960) found large increases in the number of *Alona* at severely polluted sampling points, while CHUTTER (1963) found that *Alona* was the only Cladoceran whose numbers did not increase at a sampling point where there was organic enrichment of the water.

Camptocercus: Rare and only recorded from the upper zones, most often from the Stable Depositing Zone.

Leydigia: The largest percentages of *Leydigia* were recorded in the Dry Early Summer from the stony backwaters. SCOURFIELD and HARDING (1958) reported that one species of *Leydigia* is a bottom form and it is likely that the Vaal Dam catchment species also live on the bottom. *Leydigia* was not recorded in the Source and Sandy High-lying Unstable Depositing Zones.

Pleuroxus: Widespread, found mainly in the marginal vegetation and much rarer in the Summer than in the other seasons, even in the Source Zone. This suggests that its tendency to disappear in the Summer was not due only to the silt and floods of Summer, but that the animal may have been affected by a seasonal change, such as an increase in temperature, which would affect all zones. The highest percentages of *Pleuroxus* were recorded from the Muddy High-lying Unstable Depositing Zone (where there was shelter from the current in the Winter and the Dry Early Summer) and from places where effluents entered the rivers. OLIFF (1960), ALLANSON (1961) and CHUTTER (1963) all found very large numbers of *Pleuroxus* where there was an increase in the amount of organic matter in the rivers they studied.

Chydorus: This genus made up a large part of the marginal vegetation fauna wherever there was shelter from the current, that is in the Source, Stable Depositing and Muddy High-lying Unstable Depositing Zones. Like *Pleuroxus*, *Chydorus* tended to disappear in the Summer, even in the Source Zone. Unlike *Pleuroxus* there was not a large increase in *Chydorus* where the water was enriched by effluents. This was unusual for ALLANSON (1961), OLIFF (1960) and CHUTTER (1963) all recorded increases in the numbers of *Chydorus* where there was organic enrichment. ALLANSON and GIESKES (1961) found that while *Chydorus* was very abundant in the winter and spring in the marginal vegetation at Meerhof on the Hartbeespoort Dam, it was not abundant in summer confirming that this animal may disappear in the summer for reasons other than floods.

Diaptomus (s. l): Open water forms found in all zones, but increasing greatly in numbers where the water was enriched by effluents. CHUTTER (1963) found large numbers of *Diaptomus* in waters leaving the Vaal Barrage in the summer.

Mesocyclops: An upper river, marginal vegetation form, found mainly in the Source Zone.

Paracyclops: This genus was widespread, found in all three biotopes and was less abundant in the Summer than in other seasons. *Paracyclops* has often been recorded in very large numbers in other South African rivers in places where there is severe organic pollution (ALLANSON 1961, HARRISON 1958, HARRISON et al 1960, CHUTTER 1963, OLIFF 1960). *Paracyclops* was not recorded in unusually large numbers where that water was enriched in the catchment of Vaal Dam, indicating that the amounts of organic matter reaching the rivers were not particularly great. It did thrive in the very silty conditions in the Muddy High-lying Unstable Depositing Zone.

Tropocyclops: Found mainly in the marginal vegetation biotopes where there was shelter from the current. Did not increase where the water was enriched by effluents.

Other Cyclopoid Copepods: Found in all biotopes. Percentages were highest in the marginal vegetation but there was no clear trend of percentage change from zone to zone. Few of these animals were found in the Sandy High-lying Unstable Depositing Zone in the Winter and the Summer.

Harpacticidae: Recorded mainly from the marginal vegetation in the Source Zone.

4. Discussion

Changes in the size and composition of the Cladoceran and Copepod populations were closely related to the zonation of the rivers. From this it may be concluded that the major factors governing the distribution of the Cladocera and Copepoda were the nature and stability of the river beds from which the zonation was originally recognised. The Sandy High-lying Unstable Depositing Zone, where streams and rivers were choked with easily transported sand, was particularly unfavourable for these animals. There were seasonal changes in the occurrence of the Cladocera and Copepoda. The most pronounced of these were associated with spates which only occurred in the summer. However, Summer is naturally also the season when temperatures are highest. There were indications that some of the Chydorinae which disappeared in the Summer may have done so because of unfavourable temperatures, though they would not in any case be likely to thrive in the floods and very silty conditions of summer.

There have been few detailed studies of the fauna of rivers in which the netting used has been fine enough to sample the Cladocera and Copepoda adequately. In South Africa OLIFF (1960) and ALLANSON (1961) worked with fine meshed nets, but the streams they studied were small and rather heavily polluted. They found few individuals of *Daphnia*, *Moina*, *Bosmina* and *Diaptomus*, the open water genera of the streams and rivers in the Vaal Dam Catchment. Three of these genera were abundant in the water leaving Loch Vaal (CHUTTER 1963) where they were assumed to be leading a truly planktonic life. BERG (1948) records *Daphnia*, *Bosmina*, *Chydorus sphaericus* O. F. M., *Diaptomus* and some *Cyclops* spp. as plankton in a very slow flowing part of the Susaa River. The open water forms in the Vaal system appear to avoid the fringing vegetation in still water, though they are unable to avoid being caught up in the faster flowing water and transported downstream. In that they are open water forms apparently at the mercy of water currents they may be regarded as a river plankton.

The very pronounced increase in the abundance of the Cladocera and Copepoda where the water was enriched was one of the most obvious responses to the changed conditions in the fauna as a whole (that is including the animals described in Parts 1 and 2). In all cases where effluents entered the rivers the organic matter in them was finely divided as the effluents had been treated. The changes in the fauna associated with these effluents may be regarded as based on the exploitation of finely-divided, suspended particles of organic matter, particularly by the filter-feeding open water forms of Cladocera and Copepoda. The unusually large filter-feeder populations were themselves exploited by the netspinning Hydropsychid Trichoptera in the stones-in-current biotopes. It seems reasonable to predict that as more and more sewage works and industrial effluents are successfully treated prior to their release into rivers, changes in the abundance of filter-feeding component of the river biota will come to be regarded as the most easily recognised faunal change associated with effluents.

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6. *Summary*

The occurrence of Cladocera and Copepoda in the catchment of Vaal Dam was related to the biotopes sampled, the seasons and the zonation of the rivers. There were open water forms, marginal vegetation forms and bottom forms. Generally Cladocera and Copepoda were least abundant in the Summer, rainy, season when river conditions were most unsettled due to silt-laden floods. Populations built up over Winter and were highest in the early Summer before the rains. However, the greatest populations of *Moina* were recorded in the Summer. The Cladocera and Copepoda were least abundant in river zones where conditions were most unstable through the deposition and transport of sediments.

There were very large increases in the density of the Cladocera and Copepoda, particularly of the open water forms *Daphnia*, *Bosmina*, *Moina* and *Diaptomus* (s. l.), where treated sewage and industrial effluents entered the rivers. It is suggested that with increasing effluent treatment, increases in the filterfeeding component of the river fauna will become the most obvious faunal change associated with organic enrichment.

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