The zooplankton of Zeekoevlei and Princess Vlei (Western Cape) - A preliminary assessment

S Combrink

Scientific Services Branch, City Engineer's Department, PO Box 1694, Cape Town 8000, South Africa

Abstract

This paper provides a 3-year record of the zooplankton composition and seasonality in Zeekoevlei and Princess Vlei, 2 coastal lakes situated on the Cape Flats of the Cape Peninsula, South Africa. Zeekoevlei (256 ha) is a poorly flushed, shallow hyper-eutrophic lake dominated year-round by cyanophyte algal species with underlying diatom and chlorophyte assemblages. Princess Vlei is smaller (35 ha), shallow and eutrophic with significant hydraulic flushing during winter resulting in a clear water phase. The zooplankton composition and relative abundance in Zeekoevlei and Princess Vlei were similar. In both lakes copepods contributed most to the total zooplankton standing stock. In Princess Vlei this was enhanced by the presence of the calanoid copepods *Metadiaptomus purcelli* and *Lovenula simplex* during the winter clear water phase. Cladocerans were poorly represented and present in low numbers in both lakes. It appears that the abundance of zooplankton in Zeekoevlei is controlled by factors other than phytoplankton resource availability. In Princess Vlei low algal densities during the winter clear water phase appear to be advantageous to filter-feeders such as *Daphnia* spp. as well as calanoid copepods.

Introduction

Very few South African coastal lakes have been studied extensively with special reference to zooplankton. Investigations have been conducted in Natal in the estuarine or semi-estuarine systems of Lake Sibaya (Hart, 1981) and Lake Mzingazi (Fowles and Archibald, 1987), in the southern Cape on the Wilderness Lakes complex (Coetzee, 1980; 1981 and 1983) and recently, Lake Cubhu in Zululand (Martin and Cyrus, 1994). Sparse data exist on the zooplankton of the principal coastal lakes of the Cape Peninsula Zeekoevlei, Princess Vlei and Zandvlei (Hutchinson et al., 1932; Harrison, 1962 and Van Wyk, 1970).

This report describes the zooplankton composition and relative abundance during the period October 1989 to December 1992 of Zeekoevlei and Princess Vlei with the aim of establishing baseline data for comparison with future changes in the zooplankton community structure in these 2 lakes.

Study area

Zeekoevlei (34°S 18°30'E) is a 256 ha, shallow (mean depth 1.9 m) perennial, freshwater coastal lake situated 20 km south of Cape Town on the Cape Flats of the Cape Peninsula (Fig. 1). The lake is hyper-eutrophic as a result of high concentrations of nitrogen and phosphorus (Table 1) introduced via catchment runoff, and internal phosphorus loading from the considerable sediment accumulations (Harding, 1992b). Zeekoevlei exhibits the effects of excessive nutrient enrichment and is dominated year-round by the cyanophyte alga *Microcystis aeruginosa* (Harding, 1992b).

Princess Vlei (34°S 18°30'E) is a small (35 ha), shallow (mean depth 2.4 m), permanent freshwater coastal lake (as defined by Davies and Day, 1986) situated approximately 2 km NW of Zeekoevlei (Fig. 1). Princess Vlei is fed by the Southfield Canal and drains an urban catchment of approximately 800 ha and has been described as eutrophic (Table 2) (Harding, 1992a).

Received 23 November 1993; accepted in revised form 19 July 1994.

Materials and methods

Physical and chemical water sampling was previously conducted on a fortnightly basis at each lake. These results, including the phytoplankton composition and periodicity of Zeekoevlei and Princess Vlei, have been described in detail by Harding (1992a; 1992b).

Zooplankton samples were collected fortnightly from October 1989 from Station 3 of both lakes (Fig. 1). A 3 *ℓ* Van Dorn sampler was lowered vertically into the water to collect subsurface samples which were then filtered through a 60 µm Nitex screen to retain small crustacean as well as rotifer species. The samples were preserved following the method of Haney and Hall (1973) for later taxonomic identification and enumeration (sub-sampled using the method of Allanson and Kerrich, 1961) using a Zeiss low-power binocular microscope. No distinction was made between copepod larval stages and larval stages were simply counted as nauplii. The results were reported as number of individuals·ℓ^{-1}.

Three additional zooplankton samples were collected from the same site between May 1990 and July 1991 in order to estimate the total zooplankton community biomass. These samples were preserved in 4% formalin and stored overnight at 4°C. This allowed the buoyant algal species to float to the surface of the sample where they could be removed without disturbing the settled zooplankton. Each of the zooplankton samples was then filtered onto a preweighed 60 µm Nitex filter and dried at 105°C for 24 h. A mean value was calculated in order to obtain the zooplankton community biomass as mg·ℓ^{-1} dry mass.

Between July 1991 and August 1992 the Van Dorn sampler was replaced with a zooplankton collecting net with a mouth opening of 300 mm and mesh aperture of 74 µm, with the intention of collecting a series of qualitative samples ensuring that no zooplankton species were missed due to the small sample volume (3 *ℓ*) of the Van Dorn Bottle. The net was towed horizontally alongside the boat for a distance of 4.2 m, and the samples treated in the same manner as described previously. These results, calculated as per m^{-3}, were converted to number of individuals·ℓ^{-1} and biomass to mg·ℓ^{-1} dry mass. The dense cyanobacterial populations in both lakes, however, caused clogging of the sampling net and consequently the Van Dorn sampling bottle technique was resumed

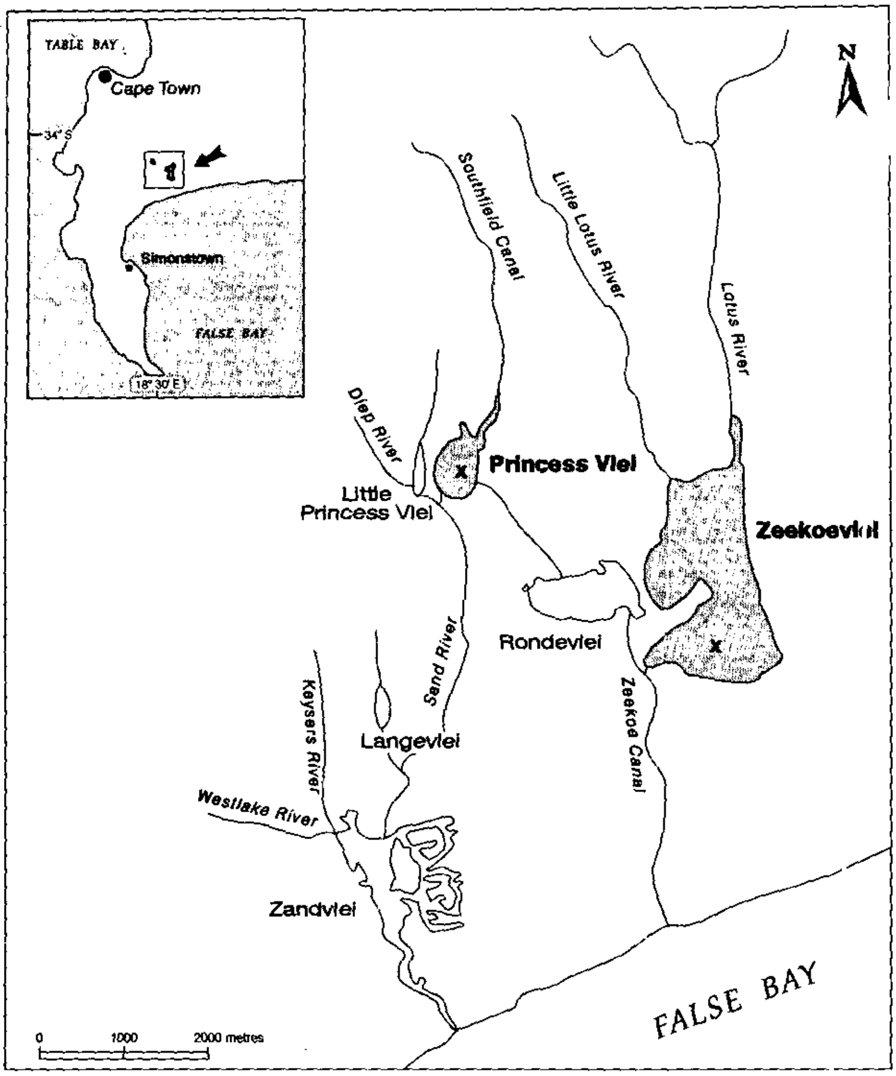

Figure 1
Map showing position of Zeekoevlei and Princess Vlei in relation to the Cape Peninsula (insert) and to other SW Cape coastal lakes. Station 3 at Zeekoevlei and Princess Vlei is marked with a cross (x).

TABLE 1
SUMMARY OF PHYSICAL AND CHEMICAL DATA FOR ZEEKOEVLEI, OCTOBER 1989 TO DECEMBER 1992

Determinant		**Min**	**Max**	**Mean**	***S***	**N**
Temperature	°C	10.9	23.9	18.4	3.7	81
Dissolved oxygen	$mg \cdot \ell^{-1}$	5.1	20.5	9.6	2.3	77
Oxygen saturation	%	58	162	100	19	76
Secchi transparency	cm	14	58	28	8	82
pH		8.2	10.8	9.5	0.5	82
Conductivity	$mS \cdot m^{-1}$	57	200	127	31	82
Total suspended solids	$mg \cdot \ell^{-1}$	26	136	59	21	44
Total Kjehldahl nitrogen	$mg \cdot \ell^{-1}$	0.6	6.6	3.3	1.4	44
Ammonia as N	$mg \cdot \ell^{-1}$	0	0.98	0.09	0.15	48
Nitrate + nitrite N	$mg \cdot \ell^{-1}$	0	3.55	0.60	0.84	48
Total phosphorus	$mg \cdot \ell^{-1}$	0.27	1.18	0.59	0.23	49
Total dissolved P	$mg \cdot \ell^{-1}$	0.02	0.82	0.31	0.24	46
Soluble reactive P	$mg \cdot \ell^{-1}$	0.01	0.76	0.27	0.23	51
Reactive silicon	$mg \cdot \ell^{-1}$	0.06	2.88	0.64	0.52	44
Total alkalinity	$mg \cdot \ell^{-1}$	92	212	156	33	45
Chlorophyll *a*	$\mu g \cdot \ell^{-1}$	78	434	221	76	74
Phaeophytin	$\mu g \cdot \ell^{-1}$	0	133	46	30	71

KEY: *S* : Standard deviation; N : number of values

TABLE 2
SUMMARY OF PHYSICAL AND CHEMICAL DATA FOR PRINCESS VLEI, OCTOBER 1989 TO DECEMBER 1992

Determinant		Min	Max	Mean	*S*	N
Temperature	°C	11.6	24.5	18.6	3.9	61
Dissolved oxygen	mg·ℓ⁻¹	5.1	15.0	8.3	1.5	61
Oxygen saturation	%	60	180	89	19	59
Secchi transparency	cm	18	137	60	30	61
pH		7.1	9.6	8.5	0.7	60
Conductivity	mS/m	28	72	55	10	61
Total suspendid solids	mg·ℓ⁻¹	3	96	29	25	27
Total Kjehldahl nitrogen	mg·ℓ⁻¹	0.80	3.30	1.82	0.57	27
Ammonia as N	mg·ℓ⁻¹	0	0.74	0.19	0.20	28
Nitrate + nitrite N	mg·ℓ⁻¹	0.01	1.61	0.36	40	25
Total phosphorus	mg·ℓ⁻¹	0.04	0.23	0.14	0.06	28
Total dissolved P	mg·ℓ⁻¹	0.01	0.10	0.04	0.03	28
Soluble reactive P	mg·ℓ⁻¹	0	0.09	0.03	0.03	30
Reactive silicon	mg·ℓ⁻¹	0	2.69	0.84	0.82	14
Total alkalinity	mg·ℓ⁻¹	62	184	110	28	14
Chlorophyll *a*	μg·ℓ⁻¹	2	150	52	35	41
Phaeophytin	μg·ℓ⁻¹	0	57	15	12	41

KEY: *S* : Standard deviation; N : number of values

from September 1992 onwards. As a result of the larger mesh size of the collecting net (74 μm), smaller zooplankton specimens, especially the rotifer *Keratella* sp., were not retained and therefore not recorded during the period of zooplankton collection by net.

Correlation coefficients between various abiotic and biotic components in both Zeekoevlei and Princess Vlei were determined by using Spearman Rank correlation analysis (Statgraphics Version 5).

Results

Zeekoevlei

The zooplankton community of Zeekoevlei comprised primarily rotifers, cladocerans and copepods (Table 3). The predominant copepod species present throughout the 3-year study period was *Thermocyclops schuurmanae*. Occasionally the calanoid copepod *Metadiaptomus purcelli* occurred. The rotifer population was dominated by species of *Brachionus*, together with other typical freshwater species (Table 3). Cladoceran numbers were always fewer than 400 individuals·ℓ⁻¹. Both *Daphnia pulex* and *Daphnia longispina* were identified. *Daphnia* spp. reached maxima (always fewer than 80 individuals·ℓ⁻¹) in spring. Species of *Moina* and *Ceriodaphnia* co-existed from November to June for each of the 3 years of the study period. A graphical presentation of the relative abundance of the species recorded in Zeekoevlei during this study period is given in Fig. 2.

Total zooplankton community biomass between May 1990 and July 1991 averaged 2.04 mg·ℓ⁻¹ dry mass (standard deviation = 1.05, n = 31). Of the 3 groups of zooplankton present in Zeekoevlei, copepods, which were present throughout the year, contributed most to the total standing stock. Rotifers, although often numerically abundant, did not significantly influence the total standing stock as a consequence of their small size.

TABLE 3
DIVERSITY OF ZOOPLANKTON SPECIES IN ZEEKOEVLEI AND PRINCESS VLEI, OCTOBER 1989 TO DECEMBER 1992

Rotifera	*Brachionus calyciflorus* Pallas[1,2]
	Brachionus plicatilis Müller[2]
	Keratella sp.[1,2]
	Hexarthra sp.[1,2]
	Polyarthra sp.[1,2]
	Asplanchna sp.[1,2]
	Filinia sp.[1,2]
	Lecane sp.[1,2]
Copepoda	*Thermocyclops schuurmanae* Kiefer[1,2]
	Metadiaptomus purcelli (Sars)[1,2]
	Lovenula simplex Kiefer[2]
	Copepod nauplii[1,2]
Cladocera	*Daphnia pulex* Leydig[1,2]
	Daphnia longispina Müller[1,2]
	Ceriodaphnia rigaudi [1,2]
	Moina micrura Kurz[1,2]
	Bosmina sp.[1,2]
	Alona sp.[1,2]
Ostracoda	

KEY:
1 = Zeekoevlei
2 = Princess Vlei

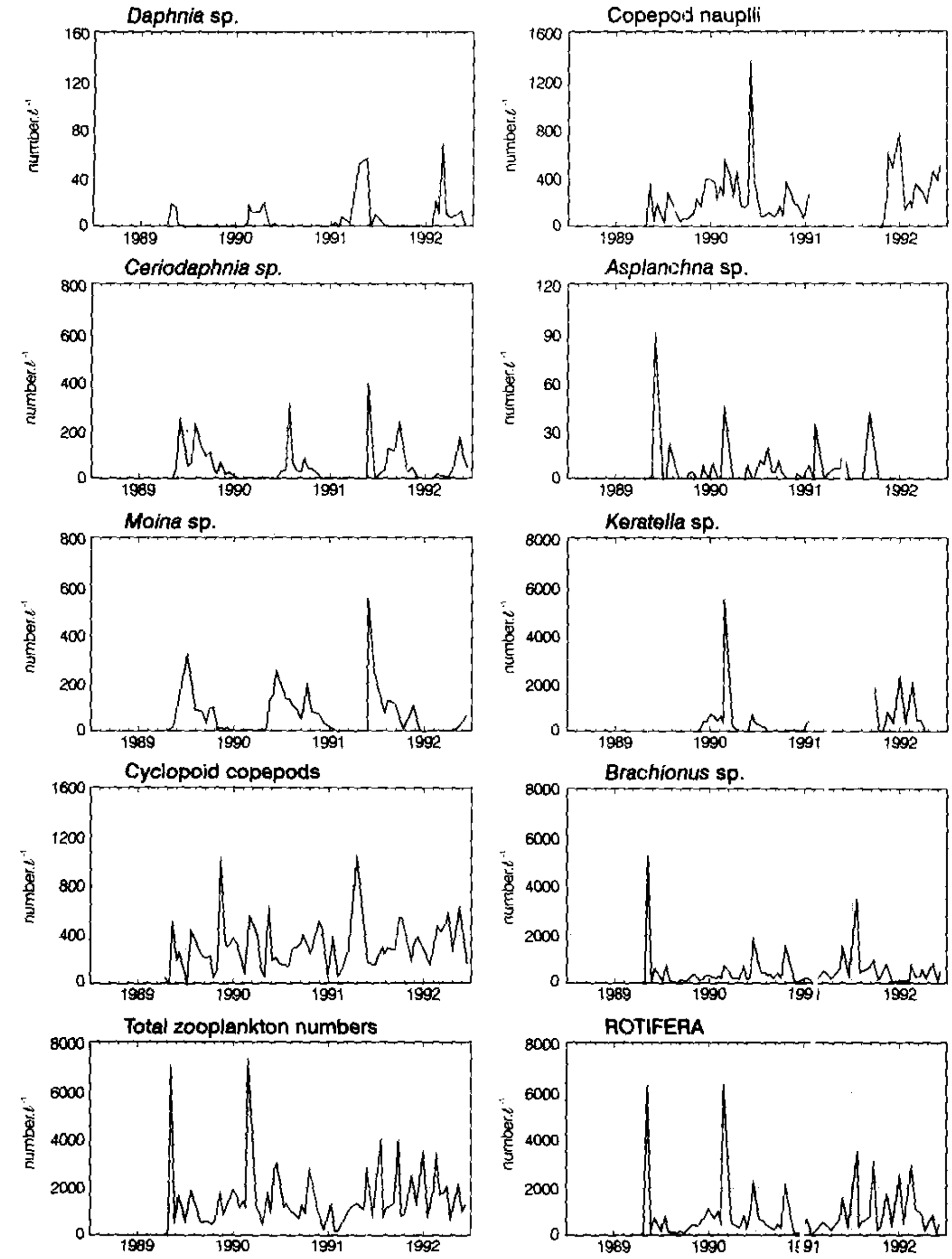

Figure 2
Graphical presentation of zooplankton abundance in Zeekoevlei, October 1989 to December 1992

Princess Vlei

The zooplankton community of Princess Vlei was composed of the cyclopoid copepod *Thermocyclops schuurmanae* and the calanoid copepods *Metadiaptomus purcelli* and *Lovenula simplex*, together with some cladoceran and rotifer species similar to those recorded in Zeekoevlei during this study (Table 3). The cladocerans *Daphnia pulex* and *Daphnia longispina* reached their maximum during the period of low cyclopoid copepod abundance. *Ceriodaphnia rigaudi* was recorded on 2 occasions only, i.e. 15 January 1990 (8 individuals$\cdot \ell^{-1}$) and 7 January 1992 (34 individuals$\cdot \ell^{-1}$), during this study. Figure 3 presents a graphical account of the relative abundance of zooplankton species in Princess Vlei during this study.

In Princess Vlei copepods contributed most to the total standing stock, estimated at an average of 1.80 mg$\cdot \ell^{-1}$ dry mass (standard deviation = 0.72, n = 29) for the period of May 1991 to July 1992. As was the case in Zeekoevlei, rotifers had little effect on biomass due to their small size.

Discussion

The zooplankton species encountered in both Zeekoevlei and Princess Vlei from October 1989 to December 1992 were typically freshwater forms. Zeekoevlei, although probably a lake of estuarine origin, contains no zooplankton to suggest a historical link with the marine environment. Similar zooplankton assemblages have been recorded in Hartbeespoort Dam (NIWR, 1985) and Rhenosterkop Dam (Heath et al., 1988; Robarts et al., 1992), 2 man-made lakes in the Transvaal. The zooplankton compositions of these 2 lakes are consistent with the trophic states of Zeekoevlei and Princess Vlei. Seaman et al. (1981) proposed a mean zooplankton dry mass

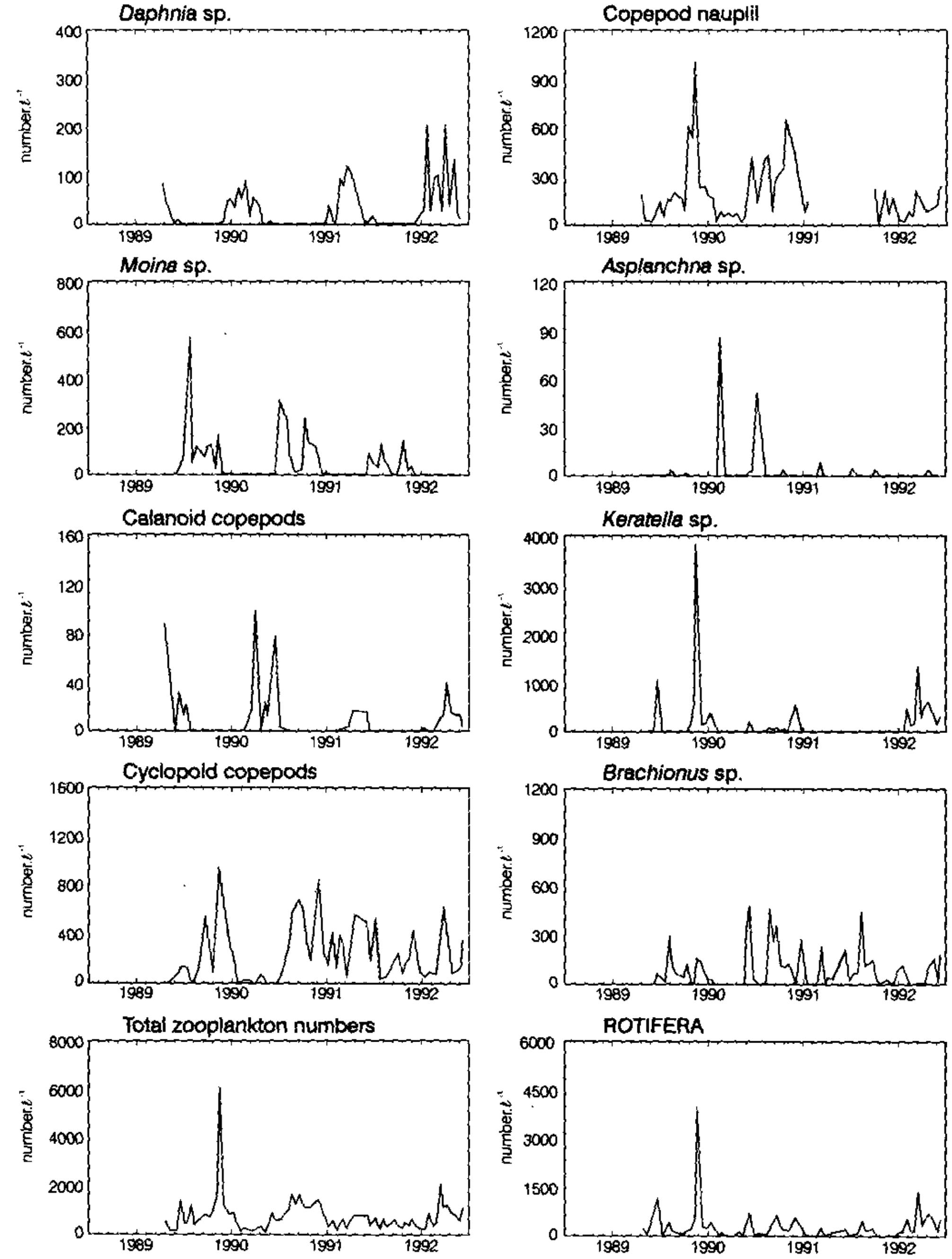

Figure 3
Graphical presentation of zooplankton abundance in Princess Vlei, October 1989 to December 1992

of greater than 0.6 g·m^{-3} for a eutrophic system. The estimated zooplankton biomass of this study on Zeekoevlei and Princess Vlei zooplankton, fell well within this eutrophic category (2.04 and 1.80 g·m^{-3} respectively).

An early account of zooplankton identified in Zeekoevlei and Princess Vlei is summarised in Table 4 (Hutchinson et al., 1932; Harrison, 1962 and Van Wyk 1970). The harpacticoid copepod *Cletocamptus trichotus*, identified by Hutchinson et al. (1932) from Zeekoevlei, was not recorded during this study (October 1989 to December 1992). Harrison(1962) also investigated a zooplankton sample taken from Zeekoevlei in the summer of 1948 and reported a similar assemblage (Table 4) to that of this survey (October 1989 to December 1992).

In Princess Vlei Hutchinson et al. (1932), reported one cladoceran species that no longer seems to be present in this lake, namely *Graptoleberis testudinaria*. This species is not a true component of the open water plankton and probably occurred in the weed beds or bottom. Harrison (1962) reported only 2 species of zooplankton found in a sample collected in 1948. They were the cladoceran *Moina dubia* and the ostracod *Cypridopsis* sp. *Moina* spp. as well as unidentified Ostracoda were encountered during this study.

Zeekoevlei

The zooplankton of Zeekoevlei was characterized by an annual shift from the large-bodied cladoceran *Daphnia* species during spring, to the smaller-bodied cladocerans *Moina* sp. and *Ceriodaphnia* sp. during summer (Fig. 2). This shift in size-structure towards smaller zooplankton in eutrophic waters was also recognized by Paloheimo and Fulthorpe (1987). The annual change in zooplankton composition may indicate a combination of fish

TABLE 4
COMPOSITION OF ZOOPLANKTON OF ZEEKOEVLEI AND PRINCESS VLEI
FROM HUTCHINSON ET AL., 1932 AND HARRISON, 1962

	Zeekoevlei		**Princess Vlei**
	Hutchinson et al. (1932)	**Harrison (1962)**	**Hutchinson et al. (1932)**
Rotifera	*Brachionus plicatilis* *Brachionus calyciflorus pala* *Pedalia fennica* (currently *Hexarthra*)	*Br. calyciflorus* var. *dorcas* *Br. calyciflorus* var. *dorcas forma spinosa* *Asplanchna sieboldii*	*Brachionus angularis* *Brachionus calyciflorus* *Keratella quadrata*
Copepoda	*Cletocamptus trichotus*	*Mesocyclops oblongatus* *Cyclops* cf. *tenuisaccus* *Diaptomus capensis*	*Mesocyclops schuurmanae*
Cladocera		*Moina dubia*	*Ceriodaphnia rigaudi* *Moina brachiata* *Graptoleberis testudinaria* *Alona quadrangularis* *Alona affinis*

predation pressure (Brooks and Dodson, 1965), food availability (Porter and Orcutt, 1980; Vanni, 1987) and competition among Cladocera (Smith and Cooper 1982). These factors together probably have a strong influence on the relative abundance of the Zeekoevlei zooplankton.

The abundance of *Ceriodaphnia* sp., *Moina* sp. and *Brachionus* sp. was positively related to surface temperature whilst the cyclopoid copepods correlated significantly with chlorophyll *a* and phaeophytin content (Table 5). This may be an indication of a possible food source, namely phytoplankton and dead organic matter, to cyclopoid copepods.

According to Harding (1992b) the phytoplankton periodicity in Zeekoevlei was atypical for this study period in a sense that in this lake *Microcystis* sp. blooms and reaches its maximum in spring whereas classically *Microcystis* sp. usually becomes dominant during summer to late summer. In Zeekoevlei the *Daphnia* spp. spring bloom coincided with the peak cyanophyte algal bloom. McNaught (1975) found that *Daphnia* has a high filtration rate and can consume large and small algae (as reviewed by Ravera, 1980) and also cyanophyte colonies up to 100 µm diameter (Jarvis et al., 1987). As a consequence of the low nutritional quality of cyanophyte algae, together with a possibility of toxicity to *Daphnia* spp., the population may remain small because the energy production will not be sufficient for successful reproduction (Porter and Orcutt, 1980). Data collected by Smith and Cooper (1982) suggest that the degree of competition amongst *Daphnia* spp., *Ceriodaphnia* spp. and *Moina* spp., is dependent on food availability and the age of the competitors. The shift from *Daphnia* spp. to *Ceriodaphnia* sp. and *Moina* sp. in Zeekoevlei, supports the above-mentioned finding.

Both herbivorous and carnivorous zooplankton are important in the diet of planktivorous fish such as *Oreochromis mossambicus* and *Cyprinus carpio* (NIWR, 1985). According to Hamman et al. (1977) both these species occur in Zeekoevlei, with *Oreochromis mossambicus* contributing only 91 $kg \cdot ha^{-1}$ of the total biomass of 774 $kg \cdot ha^{-1}$ compared to 683 $kg \cdot ha^{-1}$ by *Cyprinus carpio*. This high biomass value is indicative of the advanced state of eutrophication of this lake. Under zooplanktivorous fish predation pressure the larger or slower moving zooplankton will be more easily eliminated resulting in the dominance of smaller-bodied and faster moving species (Hall and Threlkeld, 1976), which is in accordance with the findings of Rudstam et al. (1993). Christofferson et al. (1993) agree that rotifers tend to increase and cladocerans decrease in numbers in the presence of planktivorous fish. This phenomenon appears to be true in Zeekoevlei as this lake has a predominantly *Thermocyclops schuurmanae* population together with the dominant rotifer *Brachionus sp.*, both these species being present throughout the year.

Brandl and Fernando (1981) showed that cyclopoid copepods could consume an average of 10% of the total zooplankton standing stock at natural densities in epilimnetic water during summer. The prey included rotifers, Cladocera and naupliar stages of copepods. This raptorial behaviour of copepods can result in a scenario where the estimated mortality caused by invertebrate predators may be equal to or even exceed the possible reproductive rate of a prey population. This factor could help to explain why Zeekoevlei has so few and mostly small-bodied cladocerans.

The nutrient status of a lake ecosystem affects the importance of each functional group of the system. A nutrient-poor (oligotrophic) lake will have a foodweb dominated by the phytoplankton-zooplankton-fish-chain. In contrast a nutrient-rich (eutrophic) system becomes dominated by algal species of low palatability to zooplankton. This decreases the importance of the direct link from phytoplankton to zooplankton (NIWR, 1985). The presence of so few filter-feeding zooplankton in Zeekoevlei may be attributed to the poor palatability and/or nutritional value of *Microcystis* sp. the dominant phytoplankter of Zeekoevlei. It would then appear that the dominant pathways between phytoplankton and fish become phytoplankton-detritus-fish, or even phytoplankton-fish, and a reduced population of zooplankton fulfilling a less important function. The reduction of the mean size of the zooplankton community reduces their grazing impact on larger phytoplankton forms (Jarvis, 1988).

TABLE 5
RESULTS OF SPEARMAN RANK CORRELATION ANALYSIS BETWEEN VARIOUS BIOTIC AND ABIOTIC FACTORS IN ZEEKOEVLEI AND PRINCESS VLEI, OCTOBER 1989 TO DECEMBER 1992

Zeekoevlei

		Daphnia sp.	*Cerio-daphnia* sp.	*Moina* sp.	Cyclopoid copepods	Copepod nauplii	Copepod sp.	*Keratella* sp.	*Asplanchna* sp.
Ceriodaphnia sp.		-0.59*							
Moina sp.		-0.49*	0.49*						
Cyclopoid copepods		-0.11		-0.10					
Copepod nauplii		0.27	-0.43*	-0.20	-0.13				
Brachionus sp.		-0.16	0.37*	0.33					
Keratella sp.		0.12	-0.19	-0.14		0.65*	0.31		
Asplanchna sp.			0.23		0.25	-0.18	0.12	0.11	
Chlorophyll *a*	$\mu g \cdot \ell^{-1}$	0.21	-0.15		0.45*	0.16		0.19	
Phaeophytin	$\mu g \cdot \ell^{-1}$				0.53*		-0.16	-0.18	
Temperature	°C	-0.22	0.54*	0.66*	-0.16	-0.37*	0.35*	-0.31	
Dissolved oxygen	$mg \cdot \ell^{-1}$	0.21	-0.18	-0.43*	-0.10		-0.30		-0.26
Secchi	cm	-0.20	0.14		-0.20	-0.12	0.12		-0.14

Princess Vlei

		Daphnia sp.	*Moina* sp.	Cyclopoid copepods	Calanoid copepods	Copepod nauplii	*Brachionus* sp.	*Keratella* sp.	*Asplanchna* sp.
Moina sp.		-0.72*							
Cyclopoid copepods		-0.47*	0.54*						
Calanoid copepods		0.28	-0.35	-0.66*					
Copepod nauplii		-0.32	0.48*	0.42*	-0.12				
Brachionus sp.		-0.37*	0.25	0.44*	-0.22	0.52*			
Keratella sp.		0.30		0.14		0.18	0.11		
Asplanchna sp.				-0.30	0.34				
Chlorophyll *a*	$\mu g \cdot \ell^{-1}$	-0.77*	0.77*	0.65*	-0.30	0.64*	0.58*		
Phaeophytin	$\mu g \cdot \ell^{-1}$	-0.50*	0.31	0.56*	-0.30	0.38*	0.46*	0.15	-0.39
Temperature	°C	-0.44*	0.20		0.30	0.20	0.35	-0.29	0.38
Dissolved oxygen	$mg \cdot \ell^{-1}$	-0.12	0.34	0.38*	-0.39*	0.37*		0.38*	-0.38
Secchi	cm	0.79*	-0.70*	-0.45*	0.25	-0.32	-0.42*	0.39*	

KEY: *: level of significance $p < 0.05$; Copepod nauplii: cyclopoid and calanoid nauplii; Chlorophyll *a*: corrected for phaeophytin;

Princess Vlei

The presence of the calanoid copepod *Metadiaptomus purcelli* and *Lovenula simplex* in Princess Vlei during spring could be attributed to a coincident clear water phase during winter-early spring (September to November) each year, favouring the good food collection ability and high ingestion rates of calanoid copepods at low algal densities of small cell size (McNaught, 1975). The calanoid copepod population reached its maximum in winter when cyclopoid copepod and cyanophyte algal numbers were low (no detectible algal biomass (Harding, 1992a and personal communication)) and water clarity was high.

In Princess Vlei dissolved oxygen rather than temperature seems to be the more important influencing factor judging from positive correlations (Table 5). *Daphnia* spp. preferred the clear water phase (r ≈ 0.79 between *Daphnia* spp. and Secchi transparency). Cyclopoid copepods and copepod nauplii were positively influenced by chlorophyll *a* and phaeophytin content (Table 5), phytoplankton and dead organic matter, as in Zeekoevlei, being a possible food source for these organisms.

Conclusion

The standing stocks of zooplankton in Zeekoevlei and Princess Vlei are high compared to other lakes in general but low compared to the high rates of primary production (Harding, in prep.) and high chlorophyll values (Harding, 1992a; b). The relative abundance of zooplankton in Zeekoevlei and Princess Vlei was similar in seasonal events even though Zeekoevlei has an atypical algal periodicity. This, together with the lack of significant positive correlations between some crustaceans and chlorophyll content, indicates that the zooplankton of Zeekoevlei is controlled by factors other than phytoplankton resource availability. Princess Vlei, in contrast with Zeekoevlei, is subjected to annual hydraulic flushing during winter which prevents dense populations of nuisance algae from becoming dominant (Harding, 1992a) resulting in an environment with periodic low algal densities more suitable for organisms with high food collection ability such as calanoid copepods. In both lakes cyclopoid and calanoid copepod predation on rotifers may have occurred during this study, but the lack of significant negative correlations between these species and some rotifer species respectively, indicate that copepods do not consistently affect the rotifer populations.

The ecological problems pertaining to disturbed ecosystems such as Zeekoevlei, are likely to become more common in Southern Africa as a result of increased population growth together with increased pollution.

Acknowledgements

This paper is published with the permission of the Cape Town City Engineer. The opinions expressed are those of the author and do not necessarily reflect the opinions of the City Engineer or the Cape Town City Council. The author wishes to thank Dr. AD Harrison, Dr. AC Jarvis and especially Mr. WR Harding for reading and commenting on the manuscript.

References

ALLANSON, BR and KERRICH, E (1961) A statistical method for estimating the number of animals found in field samples drawn from polluted rivers. *Verh. Int. Verein. Limnol.* **14** 491-494.

BRANDL, Z and FERNANDO, CH (1981) The impact of predation by cyclopoid copepods on zooplankton. *Verh. Int. Verein. Limnol.* **21** 1573-1577.

BROOKS, JL and DODSON, SI (1965) Predation, Body Size, and Composition of Plankton. *Science* **150** 28-35.

CHRISTOFFERSON, K, RIEMANN, B, KLYSNER, A and SONDERGAARD, M (1993) Potential role of fish predation and natural populations of zooplankton in structuring a plankton community in eutrophic lake water. *Limnol. Oceanogr.* **38**(3) 561-573.

COETZEE, DJ (1980) Zooplankton and environmental conditions in Groenvlei, Southern Cape, during 1976. *J. Limnol. Soc. South. Afr.* **6**(1) 5-11.

COETZEE, DJ (1981) Zooplankton distribution in relation to environmental conditions in the Swartvlei system, southern Cape. *J. Limnol. Soc. South. Afr.* **7**(1) 5-12.

COETZEE, DJ (1983) Zooplankton and environmental conditions in a southern Cape coastal lake system. *J. Limnol. Soc. South. Afr.* **9**(1) 1-11.

DAVIES, BR and DAY, JA (1986) *The Biology and Conservation of South Africa's Vanishing Waters*. Centre for Extra-Mural Studies, University of Cape Town. 186 pp.

FOWLES, BK and ARCHIBALD, CGM (1987) Zooplankton and estuarine relict (benthic) fauna in Lake Mzingazi, a freshwater coastal lake of Natal. *J. Limnol. Soc. South. Afr.* **13**(2) 66-74.

HALL, DJ and THRELKELD, ST (1976) The size-efficiency hypothesis and the size structure of zooplankton communities. *Ann. Rev. Ecol. Syst.* **7** 177-208.

HAMMAN, KCD, HEARD, HE and THORNE, SC (1977) Fish Population Structures as Determined by Seine and Gill Nets. Department of Nature and Environmental Conservation. Provincial Administration. Cape of Good Hope. *Freshwaters* 5-23.

HANEY, JF and HALL, DJ (1973) Sugar Coated *Daphnia*: A Preservation Technique for Cladocera. *Limnol. Oceanogr.* **18** 971.

HARDING, WR (1992a) A contribution to the knowledge of South African coastal vleis: The limnology and phytoplankton periodicity of Princess Vlei, Cape Peninsula. *Water SA* **18**(2) 121-129.

HARDING, WR (1992b) Zeekoevlei - Water chemistry and phytoplankton periodicity. *Water SA* **18**(4) 237-246.

HARRISON, AD (1962) Hydrobiological Studies on alkaline and acid still waters in the Western Cape Province. *Trans. R. Soc. S. Afr.* **36**(4) 213-243.

HART, RC (1981) Population dynamics and demography of an estuarine copepod (*Pseudodiaptomus hessei*) in Lake Sibaya, a subtropical freshwater lake. *J. Limnol. Soc. South. Afr.* **7**(1) 13-23.

HEATH, RGM, JARVIS, AC, ZOHARY, T and ROBARTS, RD (1988) The Potential Yield and Management of the Fish Community of Rhenosterkop Dam, KwaNdebele. A Report for the Department of Development Aid. Project No 620/9104/6. Division of Water Technology, CSIR, Pretoria. 97 pp.

HUTCHINSON, GE, PICKFORD, GE and SCHUURMAN, FM (1932) A contribution to the hydrology of pans and other inland waters of South Africa. *Arch. Hydrobiol.* **XXIV** 1-154.

JARVIS, AC, HART, RC and COMBRINK, S (1987) Zooplankton feeding on size fractionated *Microcystis* colonies and *Chlorella* in a hypertrophic lake (Hartbeespoort Dam, South Africa): implications to resource utilization and zooplankton succession. *J. Plankton Res.* **9**(6) 1231-1249.

JARVIS, AC (1988) Ecological problems in Hartbeespoort Dam. *J. Limnol. Soc. South. Afr.* **14**(2) 82-86.

MARTIN, TJ and CYRUS, DP (1994) Zooplankton in the open water areas of Lake Cubhu, a freshwater coastal lake in Zululand, South Africa. *Water SA* **20**(2) 107-112.

McNAUGHT, DC (1975) A hypothesis to explain the succession from calanoids to cladocerans during eutrophication. *Verh. Int. Verein. Limnol.* **19** 724-731.

NIWR (NATIONAL INSTITUTE FOR WATER RESEARCH, CSIR) (1985) The Limnology of Hartbeespoort Dam. South African National Scientific Programmes. Report 110. CSIR, Pretoria. 269 pp.

PALOHEIMO, JE and FULTHORPE, RR (1987) Factors influencing plankton community structure and production in freshwater lakes. *Can. J. Fish. Aquat. Sci.* **44** 650-657.

PORTER, KG and ORCUTT, JD (1980) Nutritional adequacy, manageability, and toxicity as factors that determine the food quality of green and blue-green algae for *Daphnia*. In: *Evolution and Ecology of Zooplankton Communities*. Special Symposium. *Am. Soc. Limnol. Oceanogr.* **3** 268-281.

RAVERA, O (1980) Effects of eutrophication on zooplankton. *Prog. Water Technol.* **12** 141-159.

ROBARTS, RD, ZOHARY, T, JARVIS, AC, PAIS-MADEIRA, CM, SEPHTON, LM and COMBRINK, S (1992) Phytoplankton and zooplankton population dynamics and production of a recently formed African reservoir. *Hydrobiol.* **237** 47-60.

RUDSTAM, LG, LATHROP, RC and CARPENTER, SR (1993) The rise and fall of a dominant planktivore: Direct and indirect effects on zooplankton. *Ecol.* **74**(2) 303-319.

SEAMAN, MT, WALMSLEY, RD and ALEXANDER, CJ (1981) Zooplankton biomass of some Transvaal impoundments and its relationship to trophic status. *J. Limnol. Soc. South. Afr.* **7**(1) 1-4.

SMITH, DW and COOPER, SD (1982) Competition among Cladocera. *Ecol.* **63**(4) 1004-1015.

VANNI, MJ (1987) Effects of food availability and fish predation on a zooplankton community. *Ecol. Monogr.* **57**(1) 61-88.

VAN WYK, J (1970) An Introduction to the Ecology of Seekoevlei, Cape Peninsula. Report to the Department of Nature Conservation, Division of Inland Fisheries. 18 pp.