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Zooplankton Distribution and Species Diversity in Myponga Reservoir, South Australia

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ABSTRACT

Myponga Reservoir is a water storage that supplies drinking water to the southern metropolitan area. It is a highly managed water body with prolonged artificial mixing and regular algicide dosing ($CuSO_4$) to manage water quality problem. The total number of taxa in Myponga was 16 and Cladocera was the dominant taxonomic group in relation to the total number of taxa. In terms of total density, Copepoda were the numerically dominant group in both reservoirs. The most frequently occurring Cladocera were *Ceriodaphnia* cf. *quadrangula*, *Ceriodaphnia cornuta* and *Bosmina meridionalis* while *Asplanchna priodonta* was the predominant Rotifera throughout the study. Copepoda were dominated by *Calamoecia ampulla* and *Microcyclops* sp., making up the largest portion of total zooplankton density. Observations showed relatively consistent species diversity and density throughout the study in Myponga Reservoir except for low densities during summer for Cladocera and Copepoda groups. Shallow locations have greater zooplankton densities compared to deep locations in the reservoir. Biological factors including the occurrence of green algae and cyanobacteria may influence zooplankton abundance and the dynamics of the community.

Keywords: zooplankton, Myponga Reservoir, Cladocera, Copepoda, Rotifera

1. INTRODUCTION

Little is known of the plankton community in Myponga Reservoir water as most of the study only focus on cyanobacteria in order to control the algae bloom problem. For example, Brookes *et al.* (2002) described the physical and chemical conditions which supported cyanobacterial growth, Hayes & Burch (1989) reported on odorous compounds isolated from samples of cyanobacteria in order to facilitate the development of methods for their control or removal and Baker *et al.* (2001) examined the toxicity of benthic cyanobacterium

Phormidium. Other studies proposed some techniques to improve water quality problem including Suter & Kilmore (1990) who suggested the mixers technique, Kirke (2001) recommended the pumping technique to prevent cyanobacterial bloom, and Brookes *et al.* (2008) also evaluated some techniques and strategies to reduce cyanobacteria in Myponga Reservoir. Furthermore, Regel *et al.* (2004) investigated the implication of small-scale turbulence in the physiology of the freshwater cyanobacterium, *Microcystis aeruginosa*.

Unlike northern hemisphere countries where zooplankton have been studied intensively over a long time, species distribution and composition in Australia particularly South Australia is far less investigated. In fact, no study has been undertaken in relation to zooplankton community dynamics in this unmanaged drinking water reservoir. The scarcity of research on biological elements mirrors a similar scarcity of such studies particularly in South Australian reservoirs. Therefore, research on zooplankton distribution in Myponga Reservoir has been undertaken in the present study in order to provide the earliest information on zooplankton community.The objectives of the investigation in particular are: i)To determine the diversity and densities of the zooplankton community in the reservoir; ii)To determine the seasonal and spatial distribution and variation of the dominant zooplankton species in the reservoir; iii)To determine relationships between environmental and biological attributes to seasonal patterns of the zooplankton community, particularly in relation to the lack of stratification in the summer due to aeration in Myponga Reservoir.

2. MATERIALS AND METHODS

Zooplankton samples have been collected from the managed Myponga Reservoir which is situated on the Fleurieu Peninsula approximately 70 km south of Adelaide in SouthAustralia. As the reservoir is a water storage that supplies drinking water to the southern metropolitan area, the present study was carried out to understand the functional roles of herbivorous zooplankton on the phytoplankton community in the reservoir.

The sampling gears used throughout the study were the 4 litre plankton trap and a plankton net.Samples has been preserved with 70% ethanol.Triplicate vertical hauls with the trap were taken at three localities. The locations consisted of a deep location (30 m – Location A) near the dam wall and two shallow locations (approx. 14 m - Location B and approx. 10 m – Location C) for both reservoirs (Figure 2.1).Zooplankton sampling was carried out at monthly intervals over the month of January 2008 to June 2009 between 1000 and 1200 h. Unfortunately, on June 2008, zooplankton sampling could not be conducted in Myponga Reservoir due to unavailability of vehicle facilities and some technical problems.

The samples were thoroughly shaken to achieve uniform distribution of the organisms and subsamples of 1 ml were placed in Sedgewick–Rafter chambers (APHA, 1998). The subsamples were identified to species level wherever possible and counted under a dissecting and an inverted microscope at various magnifications. All counts were converted to number of animals L^{-1} prior to analysis. Taxonomic identification for zooplankton followed Bayly (1964, 1992), Shiel & Koste (1979, 1983), Benzie (1988), Shiel (1995)and Holynska & Brown (2003). The analyses of variance (ANOVA) were carried out using the SPSS statistical analysis 17.0 to determine the significant effects of sampling station, depth and temporal effects at the study site.

3. RESULTS

A total of six cladoceran, four copepod and six rotifer taxa were identified from collections made between January 2008 and June 2009 (Figure 3.1). Their taxonomic richness and relative contribution varied temporarily (Figure 3.2). Cladocera was the dominant group in relation to number of taxa on all sampling occasions except March 2008, and May and June 2009 when Copepoda was dominant. However, in terms of total zooplankton density, Copepoda was the dominant group, followed by Cladocera and Rotifera on all sampling occasions except February 2009 when Rotifera was the dominant group (Figure 3.3). Table 3.1 lists the percentage of zooplankton species during the study period. *Calamoecia ampulla* was the most dominant copepod (6.92%) followed by *Microcyclops* sp. (3.10%). *Ceriodaphnia* cf. *quadrangula* was the predominant cladoceran throughout the sampling period (11.07% of the total zooplankton), followed by *Ceriodaphnia cornuta* (5.31%) and *Bosmina meridionalis* (5.09%). The rotifer population was dominated by *Asplanchna priodonta,* which accounted for 13.60% of the total zooplankton. The rest of the rotifer community comprised of *Trichocerca similis* (2.01%) and *Hexarthra intermedia* (1.36%) while the remaining three species each comprising <0.2% of the total zooplankton.

On the other hand, a comparable temporal change of zooplanktonic community was observed among three stations: station A which was located in the deep area (maximum 30 m depth), station B and C which represented shallow area (maximum 12 and 10 m respectively). In terms of density, zooplankton showed the highest number at shallow locations, Location B which accounted for 77.28 indi L^{-1} (Feb 08) to 1228.07 indi L^{-1} (Feb 09) followed by Location C (Figure 3.4).

On the whole, total zooplankton density occurred at the highest number in February 2009 due to the presence of rotifers *Asplanchna priodonta* whereas the lowest number was recorded in February 2008 because of the occurrence of blue-green algae *Anabaena circinalis* in January 2008 which is potentially toxic to zooplankton species.

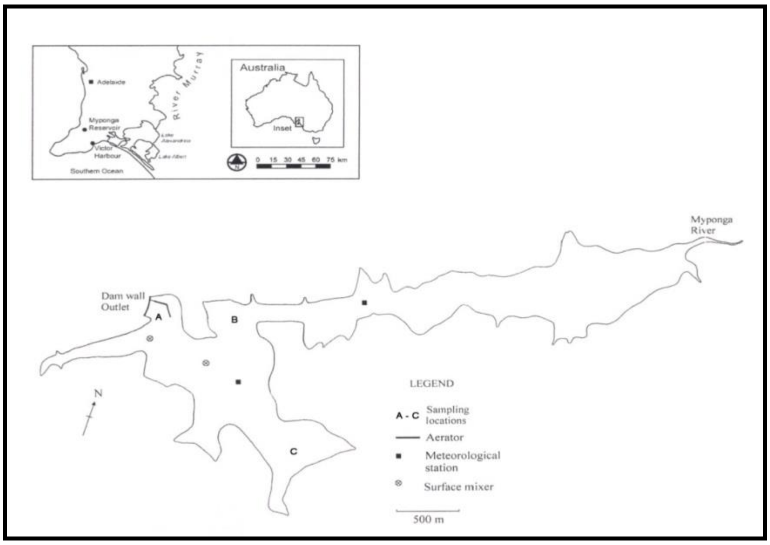

Figure 2.1. Map of Myponga Reservoir showing the locations of sampling, aerator, mixer and meteorological stations (Modified from Brookes *et al.*, 2008)

3.1 Statistical Analyses

Table 3.2 yielded ANOVA results of zooplankton density according to independent factors (month, zooplankton group, location and depth). Based on the fact that P is considerably less than 0.05, all independent factors significantly varied between each other except for location and depth which their interaction did not show significant difference ($p = 0.337 > 0.05$), thus fail to reject the null hypothesis.

4. DISCUSSION

The dominant species found in Myponga Reservoir corresponded to those recorded by Shiel (1981) in Burrinjuck Dam, Australia including *Calamoecia ampulla*, *Daphnia carinata*, *Diaphanosoma unguiculatum*, *Ceriodaphnia* cf. *quadrangula* and *Bosmina meridionalis*. The total number of Cladoceran species recorded in the present study (6 species) was comparable with the finding of Saunders & Lewis (1988) in Lake Valencia, Vanezuela (6 species) and higher than that found by Isumbisho *et al.* (2006) in Lake Kive, eastern Africa (4 species). Meanwhile, Ferrara *et al.* (2002) observed four species of Cladocera in the pelagic zone of Lake Bracciano, Italy. The differences in species richness between reservoirs are probably due to the differences in sampling methods such as sample volume and sampling location of littoral areas in comparison to the limnetic zone. Therefore, comparison on zooplankton abundances is somewhat difficult.

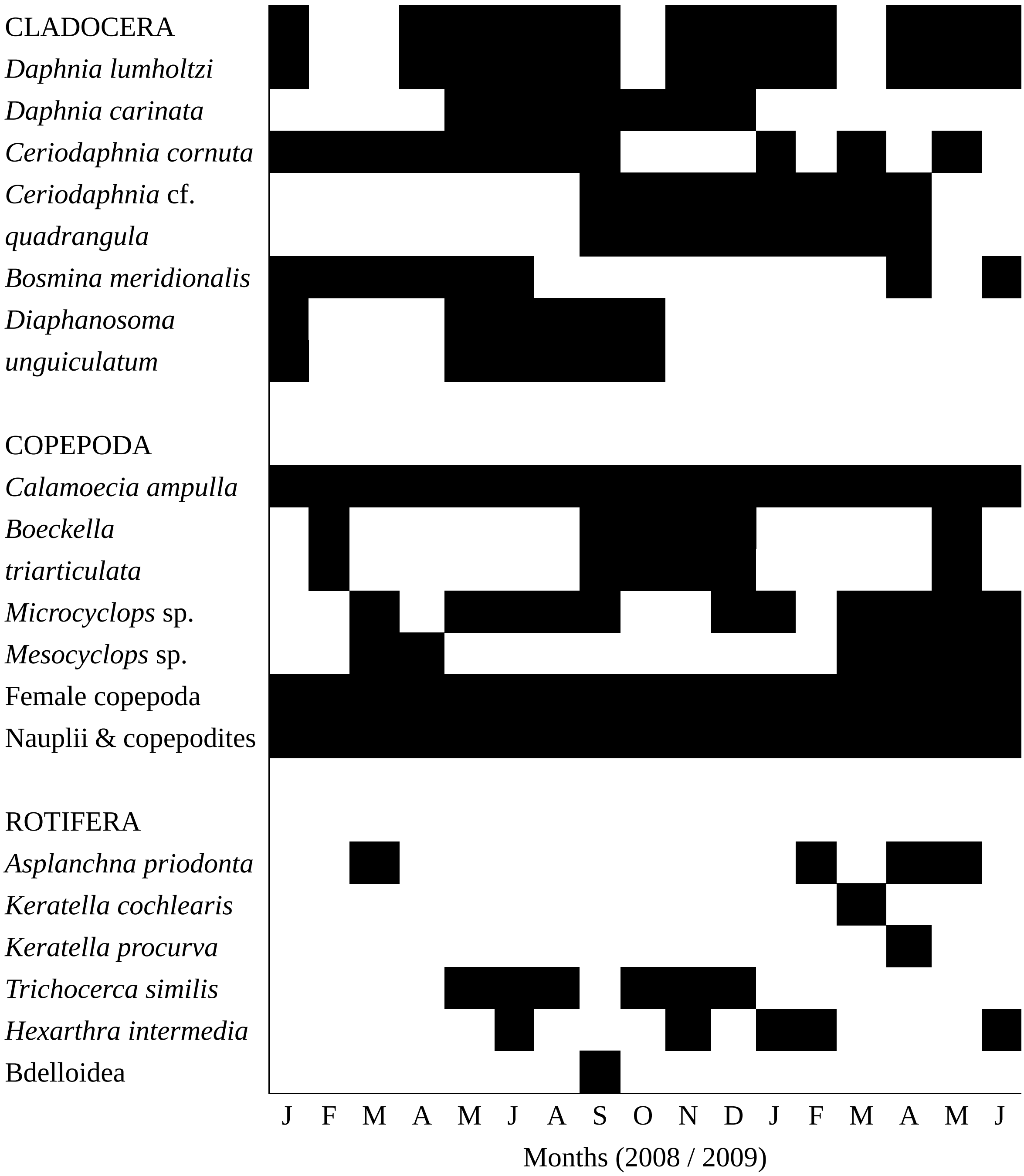

Figure 3.1. Occurrence of zooplankton taxa (black shading) in Myponga Reservoir from January 2008 – July 2009 in exception on June 2008

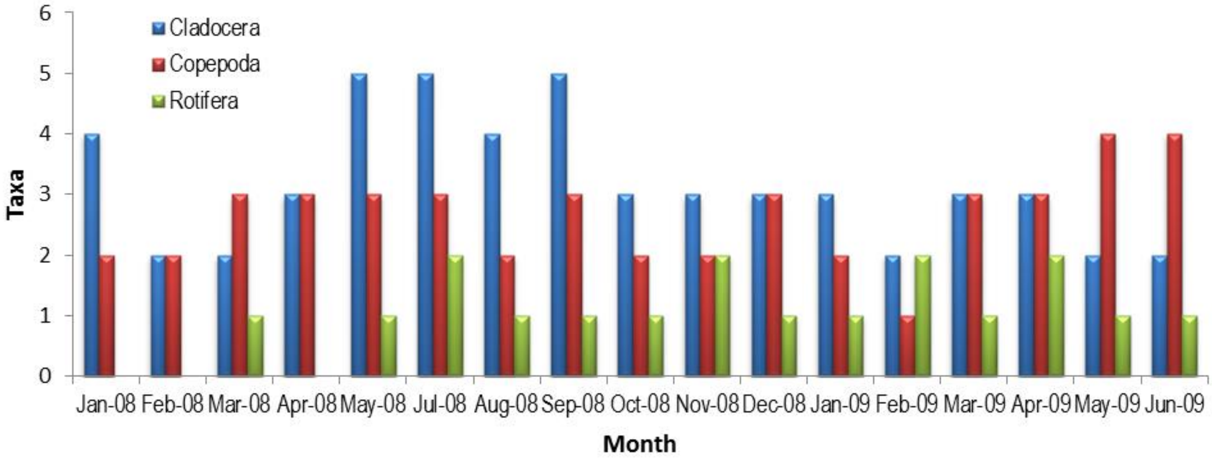

Figure 3.2. Composition of zooplankton taxa at Myponga Reservoir during the study period

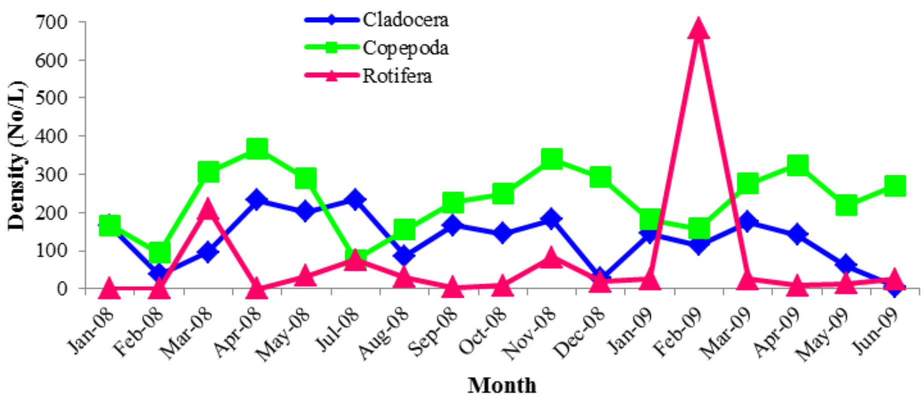

Figure 3.3. Changes in the density of zooplanktonic groups at Myponga Reservoir during the study period

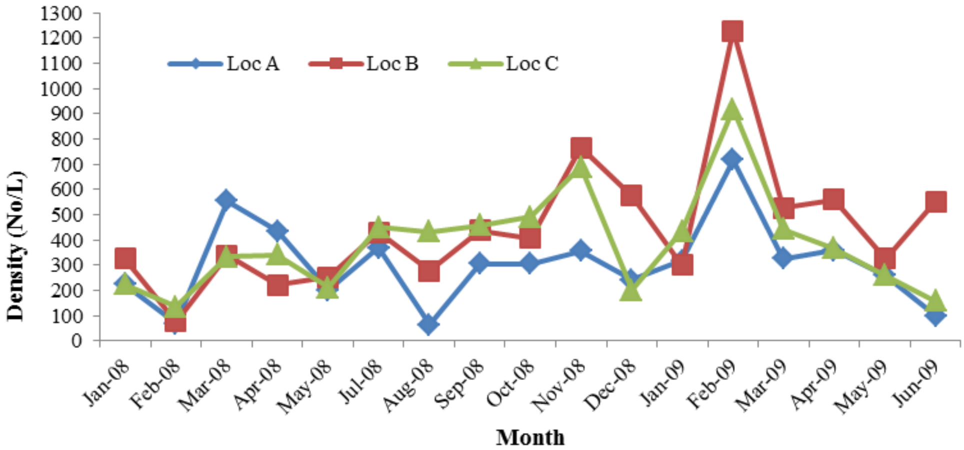

Figure 3.4. Comparative total zooplankton density at Location A, B and C

Table 3.1. Percentage of zooplankton species and taxonomic groups to total zooplankton density in Myponga Reservoir during the study period

Taxonomic group	Percentage of total zooplankton
CLADOCERA	28.12
Daphnia lumholtzi	3.31
Daphnia carinata	2.13
Ceriodaphnia cornuta	5.31
Ceriodaphnia cf. *quadrangula*	11.07
Bosmina meridionalis	5.09
Diaphanosoma unguiculatum	1.20
COPEPODA	54.71
Calamoecia ampulla	6.92
Boeckella triarticulata	0.55
Microcyclops sp.	3.10
Mesocyclops sp.	0.57
Female copepoda	20.61
Nauplii & copepodites	22.96
ROTIFERA	17.17
Asplanchna priodonta	13.60
Keratella cochlearis	0.04
Keratella procurva	0.04
Trichocerca similis	2.01
Hexarthra intermedia	1.36
Bdelloidea	0.12

Table 3.2. Results of an ANOVA performed on zooplankton density in Myponga Reservoir

Source of Variation	SS	df	MS	F	P
Month	190.316	16	11.895	25.343	0.000*
Group	501.389	2	250.694	534.125	0.000*
Location	4.459	2	2.229	4.750	0.009*
Month * Group	264.552	32	8.267	17.614	0.000*
Month * Location	49.690	32	1.553	3.308	0.000*
Group * Location	7.499	4	1.875	3.994	0.003*
Month * Group * Location	87.145	64	1.362	2.901	0.000*
Error	430.868	918	0.469		
Total	4001.309	1377			
Corrected Total	1832.174	1376			

*. The mean difference is significant at the 0.05 level.

In natural waters, generally, there is a variety of factors influencing herbivorous zooplankton populations such as food level (Duncan, 1984), predation (Brooks & Dodson, 1965; Sommer *et al.*, 1986), competition (Shurin, 2000) and temperature (O'Connell & Andrews, 1977, Mitchell & Williams, 1982). In fact, fish predation is suggested as having a significant impact on the zooplankton community (Fernando & Rajapaksa, 1983; Jeppesen *et al.*, 1997). In addition, low density of zooplankton would be in line with the low nutrient levels available for primary production.

Zooplankton densities were much higher at the shallow than at the deep locations as evidenced in Figure 3.4. In support of this view, the study by Cummins *et al.* (1969) indicated that zooplankton densities reported in shallow water bodies are usually as great as or greater than the average recorded in the deep one. Shallow lakes without thermal stratification tend to have higher phytoplankton biomass than deep lakes with similar levels of nutrients (Pridmore *et al.* 1985). Variation in zooplankton composition across the sampling locations is likely due to the differing in environmental conditions or food concentration (Duggan *et al.*, 2001). Nevertheless, the spatial variability of environment conditions such as temperature and dissolved oxygen during the present study were low. An additional possible explanation for difference in zooplankton abundance between sampling locations might be because of the occurrence of macrophytes particularly in shallow area. Talbot & Ward (1987) point out that macrophytes greatly influence the spatial structuring of micro crustacean communities in the lakes by providing a large surface area on which epiphytic algae can grow and also provide shelter from water turbulence and predators.

D. carinata is an important species observed in Myponga Reservoir. Other than *D. carinata*, about 35 species of Australian Dapniidae have been recorded until March 2008 (R. J. Shiel, unpublished data, 2008). *D. carinata* is widely distributed through Victoria and New South Wales, being most abundant in weedless ponds and dams, but occasionally occurs in lakes and reservoirs. *D. carinata* seems to be a cool-water species, reaching peak densities during the winter and usually die out during the summer months as found around Sydney (Hebert, 1977a). Some similar patterns arise in this present study as *D. carinata* generally were observed in the samples collected on May until December 2008. This species completely disappeared during mid summer and then was replaced by *C.* cf. *quadrangula*. These findings are in accord with work by Hebert (1977b). In addition, Mitchell & Williams (1982) reached similar conclusions that *D. carinata* reached peak densities in autumn and late winter-early spring as it re-established from ephippial eggs in early autumn and then entered diapause during summer. These results however contrast with investigations by Lund & Davis (2000) who recorded the presence of *D. carinata* in Lake Monger, Perth during summer.

Other than Africa and Asia, *D. lumholtzi*, with an anterior helmet on its head, has been recorded in a range of Australian regions including South Australia, Queensland, Victoria and New South Wales (Hebert, 1977a). For instance, Benzie (1988) indicated that *D. lumholtzi* are widely distributed in south-western Asia, Australia and Africa in a variety of lakes and ponds ecosystems. In this study, *D. lumholtzi* was a common species observed in the samples particularly during autumn-winter. The observations of this study however do not corroborate the finding that the *D. lumholtzi* population was the highest during midsummer in Missouri reservoirs (Havel *et al*., 1995). So the difference may merely indicate that *D. lumholtzi* in the present study was similar with other native *Daphnia* which show midsummer declines in Lake Texoma (Threlkeld, 1986). Both *C. cornuta* and *C.* cf. *quadrangula* appeared to respond to low temperature. For instance, *C. cornuta* was abundant during winter 2008 while *C.* cf. *quadrangula* exhibited a spring pulse and gradually decrease in the other months.

Obviously, *Boeckella*&*Calamoecia* were common genera observed in the samples. It seems like *Calamoecia* species are the best colonizers of the lake based on the occurrence of adult females in the data sets. *Calamoecia ampulla* was present throughout the year with consistent population densities ranging on the average from 5 – 45 ind L^{-1}. In addition, nauplii were the predominant stage in terms of density. The results of a present study are consistent with Maly's (1991) interpretation that climate conditions of Australia appear to produce an extremely excessive calanoid copepod fauna as some species are able to complete a generation while the others produce diapausing eggs. Moreover, this finding was in accord with the works by Timms (1968) in southern Queensland dams, Tait *et al.* (1984) in Northern Territory billabongs, Andronikova (1996) in Lake Ladoga in Europe and Sager & Richman (1991) in Lake Michigan.

Overall, copepods including naupliar and copepodite stages were the most frequent group (55%) found in Myponga Reservoir over the study period. Nevertheless, concerning the few stages of population cycles, we did not differentiate between calanoid and cyclopoid nauplii and copepodites instead combined as total numbers for analyses. On the other hand, the timing of the high appearance of *B. triarticulata* between September and November was in agreement with the study by Mitchell & Williams (1982) in a pond at Gumeracha, South Australia. In fact, Green & Shiel (1999) stated that *B. triarticulata* was known to be carnivorous while Kobayashi (1993) observed that the species ingested rotifers in Lyell Reservoir.

Rotifera were the most diverse group in the present study. However, in comparison to the high number of rotiferan taxa reported from reservoirs in south eastern Australia (Shiel *et al.*, 1987), Myponga Reservoir rotifer diversity was relatively poor. Nevertheless the total number of rotifer species recorded in the present study (6 species) was comparable with King (1979) based on monthly collection from three sites in North Pine Dam, Queensland. A slightly higher number of Rotifera species was recorded in Lake Alexandrine (15 species), a shallow lake which the Murray River is the major river to flow into the lake (Geddes, 1984). Generally, the density of rotifers particularly during winter was much lower than copepods as evidence in Figure 3.3. The results fit well with Koste *et al.*'s (1983) expectation that cyclopoid copepods were capable of restricting rotifer communities. However, previous workers point out that the disappearance of rotifers from the lake in winter was possibly because of competition for food resources (Hurlbert & Mulla, 1981).

The diversity of the rotifer in Myponga Reservoir is likely due to temporal change induced by thermal seasonality which is a common phenomenon encountered in temperate lakes (Lewis, 1979). The changeover in dominance of *Asplanchna priodonta* on February 2009 might be due to a brief period when conditions are favourable to this predacious rotifer. Surprisingly, *A. priodonta* was absent in the samples collected on March 2009. This condition might be due to their short life span (Mengestou *et al.* (1991). Therefore, short-term studies such as daily, weekly or even shorter intervals would detect the changes in abundances as well as could provide additional knowledge in understanding the dynamics of rotifer species.

Meanwhile, artificial mixing in Myponga Reservoir might probably increase the species density for instance, boosting *A. priodonta* responses over relatively short periods. Hutchinson (1967) suggested that the fluctuation was probably because of the fast response of rotifers to changes in abiotic and biotic conditions. Furthermore, Matsumura-Tundisi & Tundisi (2005) stated that the dominance of rotifers is an outcome of an unstable environment which favours the growth of r-strategist species which was observed in Barra Bonita Reservoir.Nonetheless, it is important to note that the relatively infrequent sampling work which was done at monthly intervals highlighted the rapid change in zooplankton community taxa. Thus, some community fluctuations were unobserved in detail.

The occurence of blooms of rotifers such as that observed for *A. priodonta* have also been noted. *A. priodonta* had undergone population explosions and declines within short periods as observed in the present study. In this regard, they can be thought of as fugitive species which expand their population quickly during short reductions or absences of superior competitors (Benzie, 1984). On the other hand, the decline or disappearance of zooplankton species during the study might be attributed to increased predation pressure or greater abundance of cyanobacteria of *Microcystis* and *Anabaena*. This suggested that cyanobacteria assemblages may inhibit the growth of all zooplankton and directly affect the occurrence of the grazers in the reservoir.

5. CONCLUSION

The present findings revealed low species diversity of zooplankton in the managed Myponga Reservoir. Observations showed relatively consistent species diversity and density throughout the study except for low densities during summer for the Cladocera and Copepoda groups. The inedible and nutritionally poor cyanobacteria may have been responsible for the decline of zooplankton in summer 2008.The zooplankton community of the Myponga Reservoir generally was dominated by *Calamoecia* and *Ceriodaphnia*. Nevertheless, the dynamics of the community as a whole were complex. It has been shown that *A. priodonta* occurred at high population densities only during summer. Thus, revealed that the occurrence of the predacious rotifer is periodically particularly when conditions are favourable.The results of the present study showed that the shallow location has higher zooplankton densities compared to the deep location as postulated by Masundire (1994). Additionally, high densities of copepods fauna and low densities of rotifers were also a feature of the Myponga Reservoir zooplankton.

We must take into account the fact that physico-chemical factors particularly water temperature and biological factors including the occurrence of green algae and cyanobacteria may influence the dynamics of the community. Fluctuations in zooplankton abundances and species richness may be due to seasonal variations in water quality, food availability and may, to a lesser degree, be affected by competition and predation. Finally, all data on zooplankton indicate that Myponga Reservoir has features typical of a moderately productivity even though the nutrient concentrations varied with season.

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Contents