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COMPOSITION, DENSITY AND DISTRIBUTION OF ZOOPLANKTON IN SOUTH WEST AND EAST LAKES OF BEIRA LAKE SOON AFTER THE RESTORATION OF SOUTH WEST LAKE

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ABSTRACT

A study was carried out in restored South West Lake and non-restored East Lake, of Beira lake with the objective of determining the species composition, density and distribution of zooplankton. Water was sampled from the surface and at a depth of 1 m, from February to March, 2005 between 0900-1130 h. Three rotifers species; *Brachinonus calyciflorus, Keratella tropica, Filinia* sp., three cladocerans species; *Diaphanosoma excisum, Ceriodaphnia cornuta, Moina micrura* and one copepod species; *Thermocyclops decipiens* were recorded in both lake sections of Beira lake, while the rotifers *Brachinonus angularis* and *Brachinonus falcatus* were confined to East lake and the rotifer *Anuraeopsis* sp. was confined to South West lake. *B. calyciflorus* was the dominant species among the zooplankton. Among cladocerans, *C. cornuta* was the dominant species. Comparing the two lakes, densities of *B. calyciflorus, M. micrura* and *C. cornuta* was significantly higher ($P<0.05$) and *Filinia sp.* was significantly lower ($P<0.05$) in the East lake. No significant differences ($P>0.05$) were evident for *T. decipiens*, *K. tropica* and *D. excisum*. The exclusive occurrence of *T. decipiens* and the *B. calyciflorus* being the dominant rotifer and *C. cornuta* being the dominant cladoceran in the selected study areas of Beira lake indicate that the lake is in a highly eutrophic state. In addition, *B. calyciflorus, B. angularis* and *B. falcatus* which are indicator rotifer species of eutrophic condition signify that the non-restored East lake is at a higher trophic state compared to the restored South West Lake.

INTRODUCTION

The sequence, phytoplankton – zooplankton – carnivores forms the classical food chain in an aquatic environment. Zooplanktons are important as a link in the energy flow of such ecosystems. Eutrophication of aquatic ecosystems can greatly alter the structure of zooplankton communities (Sampaio *et al.*, 2002). Hence, zooplankton has been used as an indicator of a lake's trophic state (Sampaio *et al.*, 2002).

The study was carried out in the Beira lake, in which eutrophication was recorded from the late 1950s (Mendis, 1964). Beira lake (6^{o} 45' − 7^{o} 00' N 79^{o} 30' − 79^{o} 55' E) is a man-made lake located in Colombo, the commercial capital of Sri Lanka. The present surface area of the Beira lake is 65.4 ha comprising four main sections; East lake (43.3 ha), South West lake (11.4 ha) Galle Face lake (2.6 ha), and West lake (8.1 ha) (Dissanayaka and Pereira, 1996) (Figure 1). The main basin and the Kelani valley basin which are secluded from the main East lake are considered as a part of the East lake (Mendis, 1964).

Identifying the potential of the Beira lake as a recreational source, restoration of the deteriorated lake commenced in 1995 under the "Beira Lake Restoration Project". Under this project restoration of the South West lake was completed in December 2004 and restoration of the East lake commenced in January 2005 (personal communication, Sri Lanka Ports Authority).

The objective of this study was to determine the present status of the Beira lake with respect to species composition, density and distribution of zooplankton in the restored South West lake and non-restored East lake sections and to compare the changes in its zooplankton in relation to past records. Some of the previous studies on zooplankton in Beira lake are by Nahallage and Piyasiri (1997), Costa and de Silva (1978) and Mendis (1964). However, the non-restored sections of the lake, the West and Galle Face lakes were not studied because they were in a high security zone.

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MATERIALS AND METHODS

Forty five stations from the East lake and 13 stations from the South West lake were randomly selected and sampled from February to March, 2005. The number of stations selected from a lake section was equivalent to approximately one station per one hectare of surface area. The locations of sampling stations are given in Fig 1. At each sampling station water was sampled at the surface using a 2 l Ruttner sampler of 0.5 m height. In stations in which the depth exceeded 1.5 m, water samples were also taken at a depth of 1 m. Accordingly, depth samples were obtained from 30 stations in the East lake and from 6 stations from the South West lake. All stations were reached by motor boat provided by Sri Lanka Ports Authority and sampling was carried out between 09.00 – 11.30 h.

At each sampling point, the two liters of water collected was filtered through a plankton sieve (80 μm) to obtain the zooplankton. The zooplankton samples were then preserved in 4% formalin and stained with Rose Bengal G at the site. Samples from the surface and from 1 m depth were filtered and preserved separately.

In the laboratory, each sample was brought to 50 ml in a 100 ml flat bottom glass flask with distilled water. While stirring the sample in a zigzag motion, a sub-sample of 1ml was removed using a stemple pipette. This sub-sample was then transferred into a one ml Sedgwick Rafter Counting Chamber to determine the species composition and density of zooplankton. All the zooplankton in the counting chamber was observed and identified using standard keys (Alekseev, 2002; Korinek, 2002; Kutikova, 2002) and counted under an inverted microscope (Nikon, Japan, model: TMS-F) under high power (x 100). The densities of rotifers, cladocerans and copepods and densities of individual species were then computed according to the following equation:

$$\text{Zooplankton density} = \frac{\text{No. of individuals in 1 ml X Sample volume (ml)}}{\text{Volume of water filtered (liters)}}$$

Three sub-samples from each sample were removed and analyzed. Then the average density (Number of individuals per liter) of zooplankton in three sub-samples was computed for each sampling point in terms of number of individuals per liter. For each sampling station from which 1 m depth samples were obtained the average density of zooplankton between surface and depth was computed. The entire sample at each sampling point was screened under a zoom microscope (Nikon, Japan, model: SMZ-2T) to check for any unobserved species during sub-sampling under high power (x100).

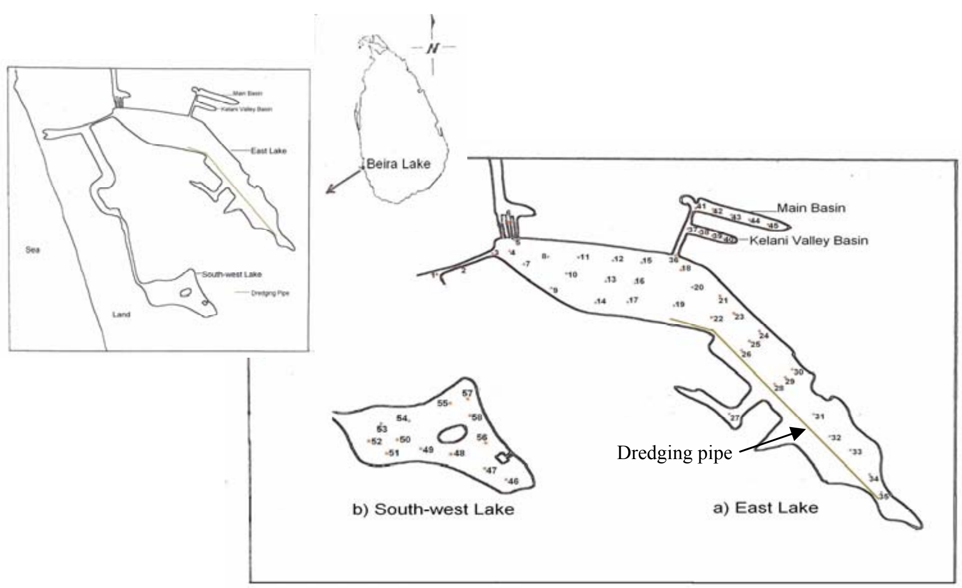

Figure 1. Beira lake and locations of sampling stations (Source: Dissanayaka and Pereira, 1996).

Dominance and abundance of the species was analyzed according to the criteria proposed by Lobo and Leighton (1986, cited in Sampaio *et al.*, 2002). A species was considered abundant when the number of individuals was higher than the mean density of all occurring species and dominant when their numerical density was higher than 50% of the total number of individuals present.

A t-test was carried out using MINITAB to determine whether there is a significant difference in zooplankton abundance between the South West and the East lakes.

RESULTS

During the study period a total of 10 zooplankton species were found, eight species from the South-west lake and nine on species from the East lake, belonging to the three main groups, copepoda, cladocera and rotifera were recorded. The species recorded and the number of sampling stations in which each species was recorded in surface and 1 m depth of the South West lake and the East lake are given in Table 1.

The copepod *Thermocyclops decipiens* and rotifer *Brachinonus calyciflorus* were recorded from all surface and 1 m depth samples in both South West and East lake sections. The two rotifers, *Brachinonus angularis* and *Brachinonus falcatus* were recorded only from the East lake. *B. falcatus* showed the most restricted distribution where it was only recorded from the surface samples of five stations in the Main Basin area of the East Lake (stations 41, 42, 43, 44, 45) where the depth was less than 1.5 m. *Anuraeopsis* sp. was confined only to the 1 m depth samples of the South West lake while *Keratella tropica* was more prevalent in 1 m depth samples than in surface samples in both South West and East lakes.

According to the criteria of Lobo and Leighton (1986, cited in Sampaio *et al.,* 2002), of the recorded zooplankton species, the dominant in South West lake is *T. decipiens* and in the East lake it is *B. calyciflorus.* In addition *B. calyciflorus* and *Filinia* sp in the South West lake and *T. decipiens* in the East lake are also categorized as the most abundant species. The above criteria of Lobo and Leighton (1986, cited in Sampaio *et al.*, 2002) were also applied separately to the rotifers and cladocerans. Accordingly, in the East lake the most abundant rotifers were *B. calyciflorus* and *B. angularis* with the dominant of the two species being *B. calyciflorus.* In South West lake *Filinia* sp. and *B. calyciflorus* are the most abundant and of which the *Filinia* sp. is the dominant. Among the cladocerans all three species could be categorized as the most abundant in both South West and East lakes. However, none of the cladocerans were found to be dominant in South West lake but *C. cornuta* was categorized as the dominant cladoceran in the East lake.

Table 1. Species composition of zooplankton and the number of sampling stations in which each species was recorded on the surface and 1 m depth of the South West lake and the East lake.

Group	Species	South West lake		East lake	
		Surface n=13	1 m depth n=6	Surface n=45	1 m depth n=30
	Anuraeopsis sp.	—	6	—	—
Rotifera	*Brachinonus angularis*	—	—	32	15
	Brachinonus falcatus	—	—	5	—
	Filinia sp.	13	6	3	10
	Keratella tropica	1	6	7	19
Cladocera	*Ceriodaphnia cornuta*	11	2	43	29
	Diaphanosoma excisum	12	5	30	21
	Moina micrura	8	2	41	27
Copepoda	*Thermocyclops decipiens*	13	6	45	30

— not recorded
n – number of stations in which species were recorded

When both South West and East lakes were considered together and criteria of Lobo and Leighton (1986, cited in Sampaio *et al.,* 2002) were applied to all recorded zooplankton species (all species of rotifers, cladocerans and copepods were considered together), *B. calyciflorus* was the dominant and the most abundant species and in addition *T. decipiens* was also categorized as the most abundant. When the above criteria were applied to rotifers and cladocerans separately, the dominant and the most abundant species were *B. calyciflorus* and *C. cornuta* respectively in the entire study area of the Beira lake.

The mean density ±standard deviation (SD) of the three main zooplankton groups and the three cladoceran species in the South West lake and the East lake are shown in Figure 2 and Figure 3 respectively and the mean density ±SD of rotifer species recorded from the two lake sections are given in Table 2.

When the density of the three main zooplankton groups were considered, rotifers and cladocerans were significantly low ($P<0.05$) in the South West lake compared to the East lake while there was no significant difference ($P>0.05$) in copepods between the two lake sections.

When zooplankton species were considered separately the density of *B. calyciflorus, M. micrura* and *C. cornuta* was significantly high ($P<0.05$) and *Filinia* sp. was significantly low ($P<0.05$) in the East lake compared to the South West lake. There was no significant differences ($P>0.05$) in density of *K. tropica* and *D. excisum* between the two lake sections. The densities of *B. angularis, B. falcatus* and *Anuraeopsis* sp. were not subjected to comparison since they were confined only to one lake, either South West lake or East lake.

Table 2. Mean density ±SD of rotifer species recorded from South West lake and East lake during the sampling period.

	South West Lake Mean ±SD (No. per liter)	East Lake Mean ±SD (No. per liter)
B. calyciflorus	439±271	1993±1539
B. angularis	–	76±122
B. falcatus	–	10±34
Filinia sp.	493±162	25±39
K. tropica	6±9	14±24
Anuraeopsis sp.	82±118	–

– not recorded

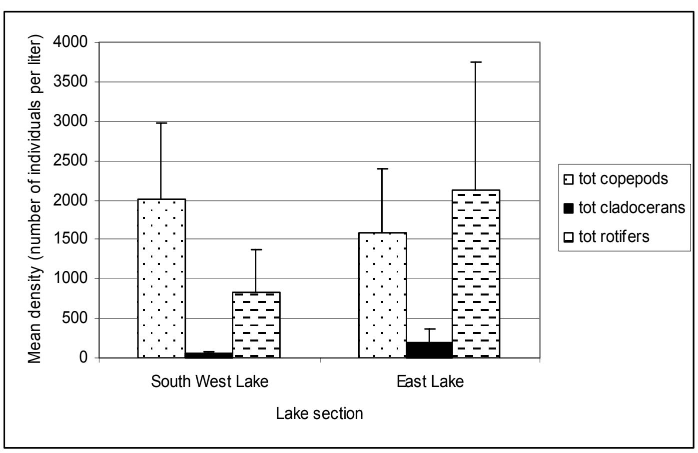

Figure 2. Mean density ± SD of the three zooplankton groups identified from South West lake and East lake during the sampling period.

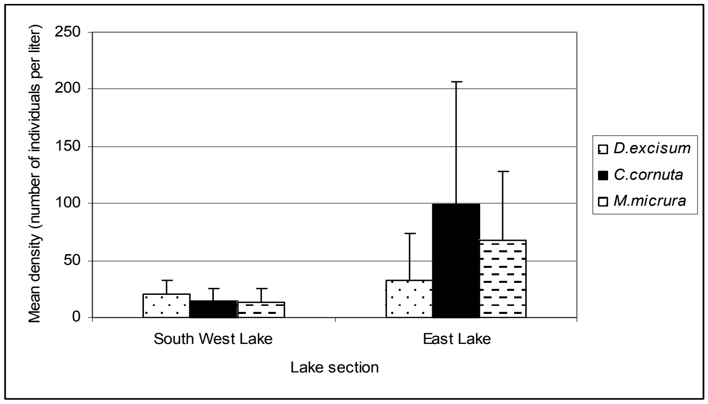

Figure 3. Mean density ± SD of cladoceran species identified from South West lake and East lake during the sampling period.

DISCUSSION

The number of zooplankton pecies recorded from the selected study areas of Beira lake in this study is similar to the number of species recorded in the previous study of Nahallage and Piyasiri (1997). Both studies recorded ten species with respect to rotifera, cladocera and copepoda. Studies of zooplankton in Beira lake prior to Nahallage and Piyasiri (1997) by Costa and de Silva (1978) and Mendis (1964) do not give the number of species alues and therefore cannot be used for comparisons.

The number of species recorded of Beira lake recorded during the present study is very low when compared to that in other standing water bodies of the country, Kotmale Reservoir- 28 species (Piyasiri and Chandrananda, 1998), Victoria Reservoir- 22 species (Piyasiri and Jayakody, 1991), Randenigala Reservoir- 24 species (Pathmalal and Piyasiri, 1999), Kalawewa- 36 species (Jayatunga, 1982), Giritale Tank – 26 species (Cooray and Jayatunga, 2000). According to the available literature, Beira lake has under gone continuous eutrophication as evident from the increase in trophic status of the lake: in 1972 the lake was in a eutrophic state (Costa and de Silva, 1978), in 1994 the lake was in between eutrophic−hypereutrophic states (Nahallage and Piyasiri, 1997) and in 2005 the lake is in a hypereutrophic state (Kamaladasa and Jayatunga, 2005). Many zooplankton species disappear due to eutrophication as a consequence of algal toxins or the clogging of filter-feeding apparatus during algal booms especially of Cyanophyceae (Sampaio *et al.,* 2002). Therefore, low zooplankton species richness in the both South West and East lakes in the present study compared to the above mentioned standing water bodies (Kotmale Reservoir, Victoria Reservoir, Randenigala Reservoir, Kalawewa and Giritale Tank) could be due to its very high trophic state at present which is determined as hypereutrophic by Kamaladasa and Jayatunga (2005), whereas none of the above water bodies are recorded as hypereutrophic.

It is evident that with eutrophication some tolerant species may flourish assuming nuisance proportions (Jeffries and Mills, 1990). This is clearly observed in both South West and East lakes at present where *B. calyciflorus* and *T. decipiens* are recorded in very high densities compared to other existing species. These two species are greatly tolerant to disturbed and nutrient-enriched environments and are considered as bioindicators of eutrophication (Sampaio *et al.,* 2002).

With eutrophication, predominance of zooplankton species change from large herbivores such as calanoid copepods and large cladocerans to small size consumers such as rotifers, small cladocerans and cyclopoid copepods characterizing a detritic food chain (Sampaio *et al.,* 2002; Bays and Crisman, 1983). This scenario is clearly observed in Beira lake at present confirming the eutrophication of the lake.

Calanoid copepods were recorded in Beira waters together with cyclopoid copepods by Costa and de Silva (1978) and Mendis (1964). But the present study and the study of Nahallage and Piyasiri (1997) have recorded only a cyclopoid copepod but no calanoids. The recorded cyclopoid is one of the abundant zooplankton species in the selected study area of the Beira lake at present.

In previous records of cladocerans in Beira lake, Mendis (1964) recorded *Daphnia* sp., *Moinodaphnia* sp. and *Bosmina* sp. and Costa and De Silva (1978) recorded only the dominant cladoceran during their study which was *Diaphanosoma singhalense*. Nahallage and Piyasiri (1997) have recorded three cladocerans, *Diaphanosoma* sp., *Moina* sp. and *Ceriodaphnia* sp. from the same lake and the *Diaphanosoma* sp. was recorded as the dominant cladoceran. The cladocerans *Daphnia* sp., *Moinodaphnia* sp and *Diaphanosoma* sp are considered to be large cladocerans (Sampaio *et al.,* 2002). However, of these only *Diaphanosoma* sp. is recorded at present but it is not the dominant species. The dominant species in Beira waters at present is *Ceriodaphnia cornuta*. According to Sampaio *et al.,* (2002) *C. cornuta* is a small cladoceran.

The predominance of small cladocerans such as *Ceriodaphnia* sp. in more eutrophic waters is generally related to the interference of filamentous or toxic blue-green algae, which dominate the phytoplankton under eutrophic conditions. Filter-feeding mechanisms of large cladocerans such as *Daphnia* sp. and *Diaphanosoma* sp. may be damaged as a consequence of the blocking of filtering apparatus by filaments or by the sticky mucilage of large Cyanophyceae colonies (Lampert, 1987). *Athrospira* sp. which is a filamentous blue-green alga is dominant in the water column throughout the Beira lake (Kamaladasa, 2005) and this could be one of the reasons for the predominance of *C. cornuta* over *Diaphanosoma* sp. and the disappearance of certain large cladoceran genera from lake waters.

The only copepod recorded from the entire study area of the Beira lake is the cyclopoid, *Thermocyclops decipiens*. According to Sampaio *et al.* (2002), exclusive occurrence or dominance of *T. decipiens* amongst the copepods is observed under highly eutrophic conditions. Therefore, recording T. decipiens as the only copepod in Beira lake during the present study could be another indication of the very high trophic state of the lake.

Largest fraction of species recorded during the present study is rotifers. According to the evaluation given in Sládecek (1983), the four rotifer species recorded, *B. angularis, B. calyciflorus, B. falcatus* and *K. tropica,* are indicators of a eutrophic condition. Since the *Filinia* sp. and the *Anuraeopsis* sp. are not identified to the species level their indicator status can not be confirmed.

Presence of *B.calyciflorus* and *K.tropica* in both South West and East lakes indicate that both sections have undergone eutrophication. However, the mean density of *B. calyciflorus* is significantly higher in the East lake compared to the South West lake and it is the dominant species among the zooplankton and the rotifers in the East lake. In addition the other two eutrophic indicators, *B. angularis* and *B. falcatus* are only recorded from the East lake. It has been identified that *B. angularis* is one of the six rotifer species that still occurs in the most strongly eutrophicated water (Sládecek, 1983). These aspects signify that the non-restored East Lake is more eutrophic or at a higher trophic state compared to the resorted South West lake.

The above disparity in trophic condition as indicated by zooplankton species, is supported by the computed Carlson Trophic Status Index (TSI) based on Chlorophyll ‘a’ and Secchi disc depth for South East Lake and East Lake by Kamaladasa and Jayatunga (2005). The computed TSI values South West lake is lower compared to East lake.

This difference in trophic state between the South West lake and the East lake is also supported by the difference in the cladoceran population as well. In the non-restored East lake the cladocerans are dominated by *C. cornuta* which is a small cladoceran and its density is significantly high compared to the South West lake. While in the restored South West lake there is no dominant cladoceran species. As mentioned before small cladocerans predominate in more eutrophic waters (Sampaio *et al.,* 2002).

When the distribution of the zooplankton species between the South West and the East lakes are considered only the rotifer species showed a restricted distribution. The rotifer, *B. falcatus* was only recorded from the surface samples of five stations in the main basin area of the East lake hence showing the most restricted distribution. Generally rotifers are easily carried away by water which facilitates easy dispersal (Sládecek, 1983). Therefore a reason for this restricted distribution could be that there is minimum mixing of water in East lake sections of Beira lake. A further observation in rotifer distribution is that *K. tropica* prefers the depth water than surface waters in both South West and East lakes and *Anuraeopsis* sp. seems to avoid surface waters in the South West lake where it was recorded. A possible explanation for this could be that both species attempt to avoid direct sunlight. However, the absence of *Anuraeopsis* sp. from the surface samples cannot be entirely explained by avoidance of direct sunlight suggesting the influence of other factors in governing its distribution.

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REFERENCES

Alekseev, V.R. (2002). Copepoda. *In:* C.H. Fernando (eds) *A Guide to Tropical Freshwater Zooplankton*. Leiden, Backhugs Publishers, 123-188pp.

Bays, J.S. and Crisman, T.L. (1983). Zooplankton and Trophic State relationships in Florida lakes. *Canadian Journal of Fisheries and Aquatic Sciences* **40**: 1813-1819.

Cooray, P.L.M. and Jayatunga, Y.N.A. (2000). Preliminary investigations on density, abundance and distribution of Zooplankton in Giritale Tank. *Annual Research Sessions, University of Colombo*, *Colombo*, Pp. 33 (Abstract).

Costa, H.H. and de Silva, S.S. (1978). The Hydrobiology of Colombo (Beira) Lake III-Seasonal fluctuations of Plankton. *Spolia Zeylanica* **32**: 35-53.

Dissanayaka L. and Pereira R.C. (1996). Restoring Beira lake: An Integrated Urban Environmental Planning Experience in Colombo, Sri Lanka. Colombo Metropolitan Environmental Improvement Programme.

Jayatunga, Y.N.A. (1982). Studies on Hydro-biology and zooplankton in the Kalawewa H_1 Area. M.Phil. Thesis, University of Colombo, Sri Lanka.

Jeffries, M. and Mills, D. (1990). *Freshwater Ecology: Principles and Applications*. 3rd edition. Belharen Press, London.

Kamaladasa, A.I. (2005). Study of selected physiochemical parameters and planktons in East Lake and South-west Lake of Beira lake. Dissertation submitted as a part of B. Sc. Degree, University of Colombo, Sri Lanka.

Kamaladasa, A.I. and Jayatunga, Y.N.A. (2007). Trophic status of South-west and East lakes of Beira lake soon after the restoration of South West lake. *Journal of the National Science Foundation of Sri Lanka* (in press).

Korinek, V. (2002). Cladocera. *In*: C.H. Fernando (Eds) *A Guide to Tropical Freshwater Zooplankton*. Backhugs Publishers Leiden, 69-122.

Kutikova, L.A. (2002). Rotifera. *In*: C.H. Fernando (Eds) *A Guide to Tropical Freshwater Zooplankton.* Backhugs Publishers Leiden, 23-68.

Lampert, W. (1987). Laboratory studies on zooplankton-cyanobacteria interactions. *New Zealand Journal of Marine and Freshwater Research* **21**: 483-490.

Mendis, A.S. (1964). A contribution to the limnology of Colombo Lake. *Bulletin of Fisheries Research Station Sri Lanka* **17**: 213-220.

Nahallage, C. and Piyasiri, S. (1997). Trophic status of Beira lake. *Vidyodaya Journal of Science* **7**: 33-42.

Pathmalal, M.M. and Piyasiri, S. (1995). The Chlorophyll a content, species composition and population structure of phytoplankton in Randenigala Reservoir in Sri Lanka. *Vidyodaya Journal of Science* **5**: 29-41.

Piyasiri, S. and Chandrananda, W.P.N. (1998). Studies on the population structure of zooplankton in the Kotmale Reservoir. *Journal of the National Science Council of Sri Lanka* **26**: 59-76.

Piyasiri, S. and Jayakody, J.K.U. (1991). Ecology of zooplankton in Victoria Reservoir, Sri Lanka: I. Composition and population structure of zooplankton. *Verh. Internat. Verein. Limnol.* **24**: 1430-1435.

Sampaio, E.V., Rocha, O., Matsumura-Tundisi, T. and Tundisi, J.G. (2002). Composition and abundance of zooplankton in the limnetic zone of seven reservoirs of the Paranapanema River, Brazil. *Brazilian Journal of Biology* **62**: 525-545.

Sládecek, V. (1983). Rotifers as indicators of water quality. *Hydrobiologia.* **100**: 169-201.