

Community structure of zooplankton and trophic status of some inland reservoirs in the low country intermediate zone of Sri Lanka

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Abstract

Diversity and abundance of zooplankton in relation to nitrate-N and total phosphorus levels of 20 minor and medium scale reservoirs in the low country intermediate zone of Sri Lanka were studied in June-October 2013. Total phosphorus content ranged from 0.029 mg L⁻¹ recorded in Wendaruwewa reservoir to 0.529 mg L⁻¹ recorded in Karangamuwa reservoir and Nitrate-N content varied from 1.186 mg L⁻¹ recorded in Adukkane reservoir to 5.625 mg L⁻¹ recorded in Anukkane reservoir indicating that all reservoirs studied are eutrophic. During the present study, a total of 43 species of zooplankton, comprising 31 species of rotifers, 9 species of cladocerans and 3 species of copepods were recorded. Number of zooplankton species in any one reservoir, which ranged from 4 to 13, was significantly correlated with the nitrate-N content ($p < 0.05$). The most widely distributed zooplankton species was *Diacyclops nanus*, which was present in 15 reservoirs. Abundance of zooplankton ranged from 4 individuals L⁻¹ recorded for *Alona monocantha* and *Chydorus parvus* in Wendaruwewa and Metiyagane reservoirs respectively to 1017 individuals L⁻¹ recorded for *Filinia terminalis* in Galewela reservoir. Margalef index which ranged from 0.532 in Adukkane reservoir to 2.096 in Dewahuwa reservoir, was significantly correlated with nitrate-N content of water ($p < 0.05$). Pielou index ranging from 0.65 in Galewela reservoir to 0.92 in Polpitiya reservoir and Shannon-Weiner index ranging from 0.91 in Munamaldeniya reservoir to 2.13 in Dewahuwa reservoir were not significantly correlated with nitrate-N and total phosphorus levels of water ($p > 0.05$). *Keratella quadrata* was present only in Anukkane reservoir where the nitrate-N content was the highest and therefore it may be considered as a bio-indicator of high levels of nitrate-N. Eutrophic conditions of these reservoirs may possibly be due to runoff of nutrients from agricultural fields as these are located in an intense agricultural area. Therefore, it is necessary to take immediate action to control the overuse of inorganic fertilizer in this area so that contamination of water bodies with nutrients can be minimized.

Keywords: Eutrophication, zooplankton, inland reservoirs, nutrients, bio-indicators

Introduction

Zooplankton have been identified as one of the faunal groups highly sensitive to physicochemical conditions of water bodies (Marneffe et al. 1998). Being an important link between primary producers and secondary consumers, zooplankton play an important role in aquatic ecosystems (James 1991). Hence a change in the zooplankton community will affect the entire ecosystem.

Several studies on the zooplankton of Sri Lankan waters have been carried out. Taxonomy of Sri Lankan zooplankton has been studied by Changalath et al. (1974), Fernando (1980a, 1980b), Rajapakse and Fernando (1982) and Fernando and Weerawardhena (2002). Several studies on the zooplankton of Parakrama Samudra, an ancient major irrigation reservoir in the dry zone of Sri Lanka have received the attention of many researchers (Duncan 1983, 1984; Duncan and Gulati 1983, Fernando and Rajapakse 1983). The effects of food and temperature on the life cycle of some zooplankton in Kalawewa, another ancient major irrigation reservoir in the dry zone of Sri Lanka have been studied by Jayatunga (1986). Studies on the composition, distribution and population dynamics of zooplankton in several other water bodies in Sri Lanka including Beira lake (Mendis 1964, Costa and De Silva 1978, Nahallage and Piyasiri 1997, Kamaladasa and Jayatunga 2007), Giritale reservoir (Cooray and Jayatunga 2000), Bolgoda lake (Wignarajah and Amarasinghe, 1983), Kotmale reservoir (Chandrananda and Piyasiri 1992, Piyasiri and Chandrananda 1998), Victoria reservoir (Piyasiri and Jayakody 1991, Fernando and Piyasiri 1994, Ariyaratne and Amarasinghe 2001), Randenigala reservoir (Pathmalal and Piyasiri 1999), Minneriya and Udawalawa reservoirs (Ariyaratne and Amarasinghe 2001), and Rantambe reservoir (Hettiarachchi and Piyasiri 1994) have also been carried out.

Although many studies have been carried out in other regions of the world to identify the zooplankton species which can be considered as bio-indicators of environmental conditions (Sládeček 1983; Matveeva 1991; Sampaio 2002), such studies in Sri Lanka are sparse. Silva et al. (2003) have studied the seasonal abundance of some zooplankton in relation to limnological characters in Kandy Lake, an urban reservoir in the central highlands of Sri Lanka. Abundance of zooplankton in Madu Ganga estuary, one of the Ramsar sites in Sri Lanka had been studied in relation to water quality parameters by Jayasiri (2007). Kamaladasa and Jayatunga (2007) have compared the composition, density and distribution of zooplankton in the restored and non-restored sections of Beira Lake, an urban reservoir in the metropolitan area of the city of Colombo while Wickramasinghe et al. (2012) have studied the zooplankton composition in Kotte-Kolonnawa wetland, which is also located in an urban area close to city of Colombo. Impact of BOD₅ on zooplankton in some tanks in the northern region of Sri Lanka has also been studied (Patrick et al. 2012). No studies have been carried out so far in Sri Lanka on the diversity and abundance of zooplankton in relation to nitrate and total phosphorus contents in water.

Due to ancient hydraulic civilization, there is a large number of inland reservoirs in Sri Lanka. The water collected in these reservoirs is used for agricultural purposes, particularly for paddy cultivation during the non-rainy months. These

reservoirs are located in a cascading system so that the water is used for agricultural activities to the maximum possible extent (Fernando and De Silva 1984). Sri Lanka is one of the countries with very high usage of fertilizer (IndexMundi 2015). Hence, there is a possibility of eutrophication of these reservoirs as a result of surface runoff of nutrients from agricultural fields. Although zooplankton is a group of organisms that are highly sensitive to water quality (Kumari et al. 2007), no studies have so far been carried out on zooplankton communities in the water bodies in the low country intermediate zone of Sri Lanka in relation to water quality parameters that are responsible for trophic status. The present study was therefore carried out to investigate the diversity and abundance of zooplankton in several closely situated inland reservoirs in an intense agricultural area of the low country intermediate zone of Sri Lanka in relation to nitrate-N and total phosphorus levels.

Materials and Methods

Twenty reservoirs located in the low country intermediate zone of Sri Lanka (Elevation: <100 m msl; annual rainfall: 1750-2500 mm) between latitudes 7°20'-7°50'N and longitudes 80°00'-80°40'E were used in this study (Fig. 1). Zooplankton were collected using a Patalas-Schindler sampler of 10 L capacity from June to October 2013. Zooplankton samples were immediately preserved at the sampling site using the method described by Dhargalkar and Verlecar (2004) and transported to the laboratory for further analysis. Zooplankton species were identified using Fernando (1990), Alekseev (2002), Korinek (2002), Kutikova (2002) and Fernando and Weerawardhena (2002). Abundance of each zooplankton species was determined by counting the number of individuals in each sample under an optical microscope using a Sedgewick rafter cell and then converting to the number L⁻¹ in reservoir water.

Water samples collected in 100 ml dark plastic bottles at the time of sampling of zooplankton were immediately preserved by adding 0.5 ml of concentrated sulphuric acid and the nitrate-N and total phosphorus levels were subsequently determined using the methods described by APHA (1998).

For each reservoir, species richness of zooplankton was determined using Margalef index and the evenness was determined using the Pielou index. The diversity of zooplankton was determined using the Shannon-Weiner index.

Statistical analysis was carried out using MINITAB version 14.0.

Results

Nitrate-N and total phosphorus contents in the reservoirs studied varied in a wide range (Table 1). The lowest nitrate-N content, which was 1.186 mg L⁻¹ was recorded in Adukkane reservoir while the highest value of 5.624 mg L⁻¹ was recorded in Anukkane reservoir. The lowest total phosphorus level of 0.029 mg L⁻¹ was recorded in Wendaruwewa reservoir while the highest value of 0.529 mg L⁻¹ was recorded in Karangamuwa reservoir (Table 1).

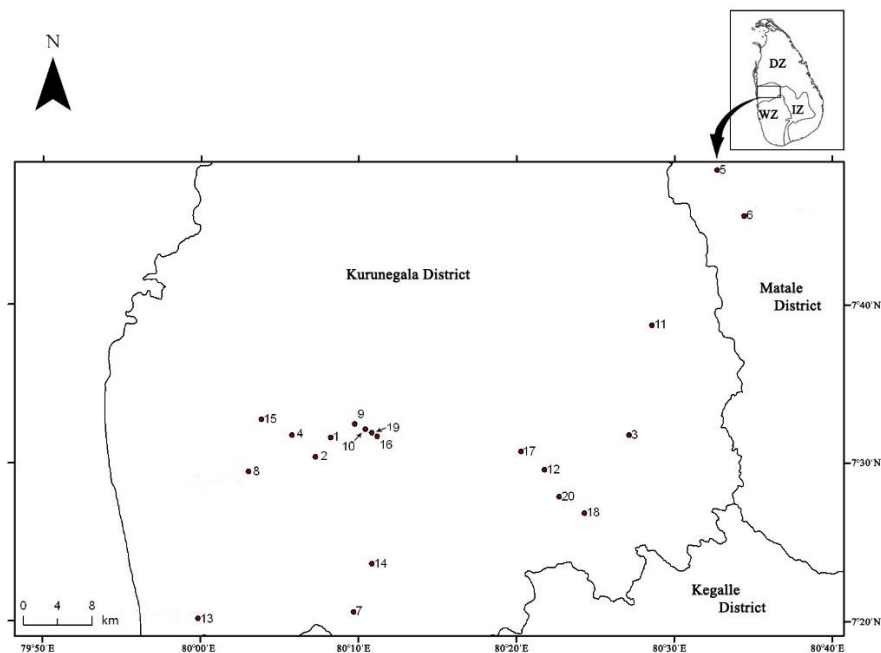


Figure 1. Location of the reservoirs studied. (WZ = Wet zone; IZ = Intermediate zone; DZ = Dry zone; The names of the reservoirs indicated by numbers are given in Table 1.

The total number of species of zooplankton recorded during the present study was 43 (Table 2). These included 3 species of copepods, 9 species of cladocerans and 31 species of rotifers. The number of species in any one reservoir ranged from 4 to 13. The lowest number of zooplankton species was recorded in 6 reservoirs (Adukkane, Anukkane, Makandura, Munamaldeniya, Polpitiya and Tampana) while the highest number was recorded in Galewela reservoir (Table 3). Only 4 reservoirs recorded ≥ 10 species of zooplankton. The most widely distributed zooplankton species was the copepod *Diacyclops nanus* (in 15 reservoirs) followed by another copepod *Diaptomus nadus* and rotifer *Trichocerca cylindrica* (in 10 reservoirs each). Eighteen species of zooplankton showed a narrow distribution being present only in one reservoir (Table 3).

Table 1. Total phosphorus content (TP), nitrate-N content (NO_3^-), number of species (S) and abundance of zooplankton, Margalef index (D_{Mg}), Pielou index (J') and Shannon-Weiner index (H') of the reservoirs studied.

No.	Name of reservoir	TP (mg L^{-1})	NO_3^- (mg L^{-1})	S	Total Abundance (Nos L^{-1})	D_{Mg}	J'	H'
1	Adukkane	0.046	1.186	4	280	0.53	0.78	1.07
2	Anukkane	0.086	5.624	4	121	0.63	0.69	0.96
3	Bathalagoda	0.075	2.403	5	1551	0.54	0.86	1.38
4	Bodhimulla	0.030	3.886	9	364	1.36	0.91	2.00
5	Devahuwa	0.060	3.416	12	190	2.10	0.86	2.13
6	Galewela	0.190	4.936	13	2417	1.54	0.65	1.68
7	Galpihilla	0.042	2.548	6	374	0.84	0.67	1.21
8	Gaiyawa	0.104	3.923	8	204	1.32	0.88	1.83
9	Kanogama	0.071	2.626	7	505	0.96	0.78	1.52
10	Karangamuwa	0.529	3.452	11	494	1.61	0.90	2.17
11	Kimbulwana	0.147	4.213	7	357	1.02	0.89	1.74
12	Kurunegala	0.164	2.620	6	444	0.82	0.76	1.37
13	Makandura	0.063	1.570	4	188	0.57	0.92	1.28
14	Methiyagane	0.065	4.574	10	256	1.62	0.86	1.99
15	Munamaldeniya	0.068	4.213	4	171	0.58	0.66	0.91
16	Polpitiya	0.309	2.294	5	347	0.68	0.93	1.49
17	Saragama	0.038	3.344	6	741	0.76	0.79	1.41
18	Tampana	0.046	1.932	4	276	0.53	0.84	1.17
19	Umangawa	0.057	2.765	9	669	1.23	0.70	1.55
20	Wendaruwewa	0.029	2.294	5	134	0.81	0.85	1.37

Table 2. List of zooplankton species recorded in 20 reservoirs studied.

Copepods

Acanthocyclops vernalis

Diacyclops nanus

Diaptomus nadus

Cladocerans

Alona monacantha

Chydorus eurynotus

Chydorus parvus

Diaphanosoma brachyurum

Diaphanosoma singhalense

Karualona karua

Leptodora kindti

Moinadaphnia macleayi

Pseudosida szalay

Brachionus urceus

Coelopus tenuior

Eothinia elongata

Euchlanis dilatata

Filinia terminalis

Hexarthra mira

Kellicottia longispina

Keratella earlinae

Keratella lenzi

Keratella quadrata

Lecane curvicornis

Monostyla bulla

Polyarthra dolichoptera

Rotifers

Asplanchna priodonta
Brachionus angularis
Brachionus budapestinensis
Brachionus caudatus
Brachionus donneri
Brachionus falcatus
Brachionus forficula
Brachionus patulus
Brachionus rubens

Polyarthra vulgaris

Rattulus tigris
Rotaria citrina
Testudinell elliptica
Testudinella patina
Trichocera cylindrica
Trichocera dixon-nuttali
Trichocerca similis
Trichotria pocillum

The highest abundance of zooplankton was recorded in Galewela reservoir (2417 individuals L⁻¹) followed by Bathalagoda reservoir (1551 individuals L⁻¹). All other reservoirs recorded less than 1000 individuals L⁻¹. The lowest abundance was recorded in Anukkane reservoir (121 individuals L⁻¹) (Table 3).

The highest abundance of copepods was recorded in Bathalagoda reservoir (622 individuals L⁻¹) while the lowest abundance (excluding the reservoirs where copepods were absent) was recorded in Dewahuwa reservoir (15 individuals L⁻¹). The highest abundance of cladocerans was also recorded in Bathalagoda reservoir (320 individuals L⁻¹) and the lowest abundance (excluding the reservoirs where cladocerans were absent) was recorded in Metiyagane reservoir (4 individuals L⁻¹). The abundance of rotifers ranged from 16 individuals L⁻¹ recorded in Adukkane reservoir to 2187 individuals L⁻¹ recorded in Galewela reservoir (Table 3). When all reservoirs were considered the most abundant zooplankton species was *Diacyclops nanus* and the least abundant species was the cladoceran *Alona monocantha* (Table 2). The most abundant zooplankton species when any one reservoir was considered was the rotifer *Filinia terminalis* (1017 individuals L⁻¹) recorded in Galewela reservoir while the least abundant was the cladocerans *Alona monocantha* recorded in Metiyagane reservoir and *Chydorus parvus* recorded in Wendaruwewa reservoir (4 individuals L⁻¹).

The relative densities of major taxa of zooplankton are shown in Fig. 2. Copepods were present in 18 reservoirs while cladocerans were present only in 12 reservoirs. Rotifers were recorded in all 20 reservoirs. Copepods showed the highest relative density in 9 reservoirs. In Adukkane, Anukkane and Munamaldeniya reservoirs they contributed for >70% of the zooplankton community (Fig. 2). The highest relative density of cladocerans (21%) was recorded in Bathalagoda reservoir followed by Adukkane reservoir (17%). In all other reservoirs, their relative density was ≤ 5% of the zooplankton community. In 11 reservoirs, rotifers showed the highest relative density among zooplankton. In two reservoirs, namely Polpitiya and Tampana, they were the only zooplankton species recorded. In Kurunegala, Galewela and Dewahuwa reservoirs they contributed for ≥ 90% of the zooplankton community

Table 3. Abundance of zooplankton in the 20 reservoirs of the present study (in numbers l⁻¹). The names of the reservoirs indicated by numbers are given in Table 1. Full scientific names of species are given in Table 2.

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Copepods																					
<i>A. vernalis</i>	-	83	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-	-	-	-	101
<i>D. nanus</i>	168		622	112	15	215	237	60	222	94		34		34	119		213		376	56	2577
<i>D. nadus</i>	48	13	-	35	-	-	-	-	128	94	69	-	55	81	-	-	249	-	46	-	818
Cladocerans																					
<i>A. mono-</i> <i>cantha</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	4
<i>C. eurynotus</i>	-	-	-	-	-	13	19	-	-	-	-	-	-	-	-	-	-	-	-	-	32
<i>C. parvus</i>	48	-	-	-	-	-	-	-	-	8	-	-	-	-	9	-	-	-	-	4	69
<i>D. brachy-</i> <i>urum</i>	-	-	-	-	5	-	-	6	47	-	-	-	-	-	-	-	-	-	-	-	58
<i>D. singha-</i> <i>lense</i>	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	20
<i>K. karua</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	-	-	-	29
<i>L. kindti</i>	-	-	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34
<i>M. macleayi</i>	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	6
<i>P. szalayi</i>	-	-	286	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	286
Rotifers																					
<i>A. priodonta</i>	-	-	-	-	-	-	-	30	-	-	-	-	-	-	-	-	-	-	-	-	30
<i>B. angularis</i>	-	-	-	-	-	-	-	-	-	-	-	246	-	-	-	-	-	-	-	-	246
<i>B. budapesti-</i> <i>nensis</i>	-	-	-	-	-	-	-	-	-	31	-	-	-	-	-	-	-	-	18	-	49
<i>B. caudatus</i>	-	-	-	-	-	-	-	-	-	24	117	-	47	-	-	53	-	-	-	-	814
<i>B. donneri</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69	-	-	69
<i>B. falcatus</i>	-	-	202	-	-	-	-	-	-	16	-	-	-	-	-	-	-	-	-	13	231
<i>B. forficula</i>	-	-	-	21	8	34	-	-	-	-	-	34	-	13	-	-	-	-	-	-	110
<i>B. patulus</i>	-	13	-	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	-	52
<i>B. rubens</i>	-	-	403	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	412
<i>B. urceus</i>	-	-	-	-	15	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	49
<i>C. tenuior</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	146	-	-	175

[illegible]

The relative densities of major taxa of zooplankton are shown in Fig. 2. Copepods were present in 18 reservoirs while cladocerans were present only in 12 reservoirs. Rotifers were recorded in all 20 reservoirs. Copepods showed the highest relative density in 9 reservoirs. In Adukkane, Anukkane and Munamaldeniya reservoirs they contributed for >70% of the zooplankton community (Fig. 2). The highest relative density of cladocerans (21%) was recorded in Bathalagoda reservoir followed by Adukkane reservoir (17%). In all other reservoirs, their relative density was $\leq 5\%$ of the zooplankton community. In 11 reservoirs, rotifers showed the highest relative density among zooplankton. In two reservoirs, namely Polpitiya and Tampana, they were the only zooplankton species recorded. In Kurunegala, Galewela and Dewahuwa reservoirs they contributed for $\geq 90\%$ of the zooplankton community (Fig. 2).

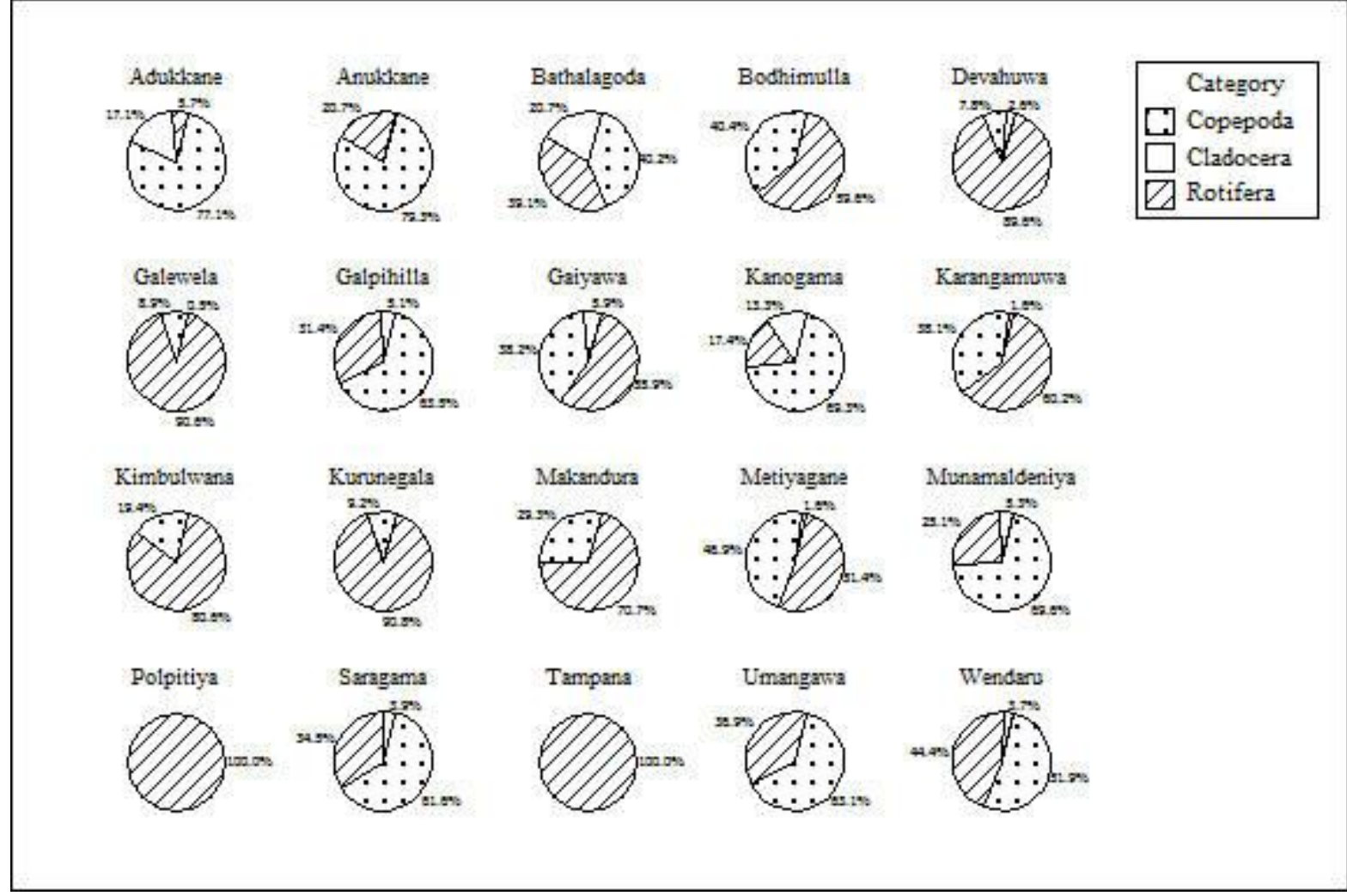
The highest values for Margalef and Shannon-Weiner indexes were recorded for Dewahuwa reservoir while the lowest values were recorded for Adukkane and Munamaldeniya reservoirs respectively. The highest and lowest values for Pielou index was recorded for Polpitiya and Galewela reservoirs respectively (Table 1).

Correlation coefficients of the total number of species, abundance, Margalef index, Pielou index and Shannon-Weiner index with nitrate-N and total phosphorus contents are given in Table 4. Only the correlation coefficients of the number of species and Margalef index with the nitrate-N content were statistically significant ($p < 0.05$).

The rotifer *Keratella quadrata* was present only in Anukkane reservoir where the nitrate-N content was the highest.

Table 4. Correlation coefficients for total number of species, abundance, Margalef index, Pielou index and Shannon-Weiner index with the Nitrate-N and total phosphorus contents of water. Values that are significant are indicated by asterisk ($p < 0.05$).

	Total Phosphorus content	Nitrate-N content
Number of species	0.330	0.452*
Total Abundance of zooplankton	0.153	0.177
Abundance of rotifers	0.241	0.287
Abundance of cladocerans	-0.109	-0.221
Abundance of copepods	-0.147	-0.098
Margalef Index	0.261	0.446*
Pielou Index	0.259	-0.270
Shannon-Weiner Index	0.393	0.277



Discussion

Eutrophication has been identified as one of the main problems in water bodies as it disturbs the natural balance of aquatic ecosystems due to nutrient enrichment (Smith et al. 2006). Although Rott et al. (2008) have classified highland reservoirs, dry zone reservoirs and urban reservoirs in Sri Lanka as oligo-mesotrophic, meso-eutrophic and hyper-eutrophic respectively, trophic status of low country intermediate zone reservoirs has not been studied until the present study. Total phosphorus level is one of the parameters used to determine the trophic status of water bodies. According to the standards stipulated by USEPA (2000), total phosphorus levels in oligotrophic, mesotrophic and eutrophic water bodies are <0.012 , $0.012-0.024$ and >0.024 mg L⁻¹ respectively. All the reservoirs of the present study have a total phosphorus level above 0.024 mg L⁻¹ and therefore can be classified as eutrophic. This high level of total phosphorus may possibly be due to surface runoff from agricultural fields. Sri Lanka is one of the countries with very high consumption of fertilizer. Since 2002, average amount of fertilizer used in Sri Lanka had been 250-305 kg ha⁻¹ of arable land (IndexMundi 2015). Kurunegala district where 18 of the studied reservoirs are located is one of the districts in Sri Lanka with the highest extent of paddy lands cultivated (DCS 2015). The area where the other two reservoirs are located is also an area with large extent of paddy lands. Hence fertilizer usage in this region may also be very high resulting in excess nutrients being ultimately washed away into these reservoirs. However, the total phosphorus contents recorded in the present study are lower than those recorded in the Negombo estuary, which is a coastal water body receiving urban waste water runoff and effluents from shrimp farms (Gammanpila 2010).

In the present study, the highest number of species of zooplankton was recorded among rotifers followed by cladocerans and copepods respectively. Similar trend has been recorded in several other water bodies in Sri Lanka including Randenigala (Pathmalal and Piyasiri 1999) and Kotmale (Piyasiri and Chandrananda 1998) reservoirs in the central highlands, Bolgoda (Wignarajah and Amarasiriwardene 1983) and Beira (Kamaladasa and Jayatunga 2007) lakes in the western coastal region of the wet zone and Parakrama Samudra in the low country dry zone (Fernando and Rajapakse 1983). However, Wickramasinghe et al. (2012) recorded lesser number of species of cladocerans than that of copepods in an urban wetland in the wet zone of Sri Lanka. However, in their study too the highest number of species was recorded for rotifers.

The number of species of zooplankton recorded in a single reservoir during the present study was less than those recorded for many other reservoirs in Sri Lanka including Parakrama Samudra (Fernando and Rajapakse 1983), Kalawewa (Jayatunga 1986), Giritale (Cooray and Jayatunga 2000), Randenigala (Pathmalal and Piyasiri 1999), Kotmale (Piyasiri and Chandrananda), and Victoria (Piyasiri and Jayakody 1991) reservoirs. Of these, the latter three reservoirs are highland reservoirs which are classified as oligo-mesotrophic (Rott et al. 2008). The other three reservoirs are dry zone reservoirs which are classified as meso-eutrophic (Rott et al. 2008). According to Sampaio et al. (2002), many zooplankton species disappear with

eutrophication mainly due to toxins produced by algal blooms especially by cyanobacteria blooms and also due to clogging of their filter feeding apparatus by algal cells. This may be the reason for the presence of lesser number of species of zooplankton in the reservoirs used for the present study, which are eutrophic. The number of species recorded in an eutrophic wetland (Wickramasinghe et al. 2012) and an eutrophic urban lake (Kamaladasa and Jayatunga 2007) in Sri Lanka are similar to those recorded in some reservoirs of the present study.

According to Sládeček (1983), the two rotifer species *Brachionus angularis* and *B. falcatus* are indicators of eutrophication. However, during the present study *B. angularis* was recorded only in one reservoir, namely Kurunegala and *B. falcatus* was recorded only in two reservoirs, namely Bathalagoda and Karangamuwa. Further, these two species have been recorded in Kotmale reservoir too (Piyasiri and Chandrananda 1998), which is classified as oligo-mesotrophic (Rott et al. 2008). In addition, *B. falcatus* has been recorded in Randenigala reservoir, (Pathmalal and Piyasiri 1999), which is another upland reservoir classified as oligo-mesotrophic (Rott et al. 2008) and in Parakrama Samudra (Fernando and Rajapakse 1983), which is considered as meso-eutrophic (Rott et al. 2008). Hence these two species are not confined to eutrophic water bodies they cannot be considered as bio-indicators of eutrophication in Sri Lankan waters. The rotifer species *Brachionus caudatus*, *B. forficula* and *Trichocerca similis*, which were recorded in the eutrophic reservoirs of the present study are also present in oligo-mesotrophic reservoirs. *B. caudatus* has been recorded in Randenigala (Pathmalal and Piyasiri 1999) and Kotmale (Piyasiri and Chandrananda 1998) reservoirs while *B. forficula* and *Trichocerca similis* have been recorded in Kotmale reservoir (Piyasiri and Chandrananda 1998). Hence these three species also cannot be considered as bio-indicators of eutrophic conditions. All copepod and cladoceran species as well as the rotifer species other than the five species stated above have not been recorded from any oligo-mesotrophic reservoir in Sri Lanka. Hence those species may be considered as bio-indicators of eutrophic conditions. However, more research covering a large number of reservoirs is required in this regard.

Although total phosphorus content in the reservoirs studied varied from 0.029 mg L⁻¹ to 0.529 mg L⁻¹, the abundance of any of the zooplankton species was not significantly correlated with the total phosphorus content ($p > 0.05$). Therefore, the abundance of the zooplankton species recorded during the present study cannot be considered as a parameter that indicates the level of total phosphorus and hence the degree of eutrophication of the inland reservoirs of the low country intermediate zone of Sri Lanka. Similarly the abundance of zooplankton species was also not correlated with the nitrate-N level. Hence it is not a parameter that indicates the level of nitrate-N too. However, since the rotifer species *Keratella quadrata* was present only in Anukkane reservoir which had the highest nitrate-N content of 5.624 mg L⁻¹ (Table 3), this species may be a bio-indicator of very high nitrate-N levels.

The number of species and the Margalef index, which is also a measure of species richness increased significantly with the nitrate-N content ($p < 0.05$) although these were not significantly correlated with the total phosphorus content. The nitrate-N content in these reservoirs may have increased due to nitrogen fixing cyanobacteria. However, more research on phytoplankton diversity is required in this

regard. Since Pielou Index and Shannon-Weiner index did not show a significant correlation with the total phosphorus and nitrate-N contents in water, in eutrophic water bodies the evenness and diversity of zooplankton appear to be not correlated with these water quality parameters.

Since the eutrophic condition of these reservoirs had resulted possibly due to surface runoff from agricultural fields as they are located in an area of intense agricultural activities, it is necessary to take immediate action to control the overuse of inorganic fertilizer in this area in order to minimize the contamination of reservoirs with nutrients so that further eutrophication could be controlled.

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