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Seasonal changes in the rotifer (Rotifera) diversity from a tropical high altitude reservoir (Valle de Bravo, Mexico)

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Abstract: *We studied the zooplankton community composition at different depths (2, 4, 8, 12 and 20 m) of Valle de Bravo, a drinking water reservoir in central Mexico during December 2005 to November 2006. Temperature, dissolved oxygen, pH and chlorophyll a were measured simultaneously. While physicochemical values were similar to those found in previous studies, total zooplankton abundance was higher (mean 847 ind. l^{-1}), doubling the mean abundance found in the previous year. Nevertheless, Zooplankton remained dominated by the rotifer genera Keratella, Polyarthra and Trichocerca, which constituted nearly 80% of the total numerical abundances. We encountered 23 rotifer species of which 5 of them (Lepadella rhomboides, Cephalodella catellina, Trichocerca elongata, T. porcellus and Dicranophorus forcipatus) were recorded for the first time from this reservoir. Shannon Wiener diversity index showed that the annual mean species diversity index was similar at depths of 2, 4 and 8 m, but were reduced at 12 and 20 m. Regardless of depth, the highest diversity value of 1.82 was observed during January, while the lowest (0.07) during March. Principal component analysis showed that temperature, dissolved oxygen, water column depth and chlorophyll a have combined effects on the abundance of dominant rotifer species. The highest rotifer density was observed in April (>1600 individuals l^{-1}), while the lowest was recorded during January (<50 ind. l^{-1}). During the study period, the most abundant rotifer species were Keratella chochlearis, Polyarthra vulgaris, Trichocecra elongata and Anuraeopsis fissa.*

Key words: *Zooplankton, Limnology, Plankton, Physico-chemical variables, Eutrophication*
PDF of full length paper is available with author ***(*ssssarma@gmail.com)***

Introduction

Among the Mexican drinking water reservoirs, Valle de Bravo (19°21' 30" N, 100° 11' 00" W and 1830 m above mean sea level, area 18.55 km^2) is important as source of water supply, fish cultivation and tourism (Olvera-Viascan *et al*., 1998). The zooplankton community composition of Valle de Bravo reservoir is mainly composed of rotifers while cladocerans and copepods comprise <10% of the total zooplankton abundance (Nandini *et al*., 2007). Physico-chemical factors and eutrophication (Merino-Ibarra *et al*., 2008) may influence the density and diversity of rotifers in Valle de Bravo. Intra-zooplankton interactions such as competition and predation are probably less important as compared to the influence of phytoplankton abundance (Ramírez-Garcia *et al*., 2002). Thus, early larval fish in this reservoir probably feed on rotifers while fingerlings feed on benthic invertebrates such as larval chironomids.

In Valle de Bravo, the predatory rotifers are composed mainly of *Asplanchna* and particularly *A. brightwellii* and *A. priodonta*. While the former is zooplanktivore, the latter feeds on phytoplankton and therefore its influence, if any, on other herbivorous zooplankton is probably insignificant (Wallace *et al*., 2006). In Valle de Bravo *Asplanchna* is numerically much less abundant (<1%) than other genera such as *Keratella* or *Polyarthra*. In addition, *Brachionus*, a typical pantropical genus (Koste, 1978), is nearly absent even in surface samplings.

For Valle de Bravo typical dry season lasts from November to May and precipitation occurs regularly from June to October. While surface water temperature varies annually only about 4°C, depth related differences are higher (about 6°C) (Merino-Ibarra *et al*., 2008). Previous studies have shown that anthropogenic influence is homogeneous throughout the reservoir and hence zooplankton are expected to show natural variations in both density and diversity in relation to temporal patterns rather than due to anthropogenic factors. Studies on plankton can be useful for effective management of waterbodies (Bhuiyan and Gupta, 2007; Tas and Gonulol, 2007). It is therefore desirable to have quantitative records of the zooplankton community structure through time, which could be helpful for the management of this reservoir too.

Here we document changes in the zooplankton density as function of season, selected physico-chemical variables and depth of water column during 2005-2006.

Materials and Methods

Zooplankton sampling was done using a plankton net (mesh size 50 μm) filtered (50 l, in replicates) using a Jabsco model 36680-2000 diaphragm pump. The sampling was done during early hours (9-11 a.m.) and once every month from December 2005 to November 2006 from the south eastern region of the reservoir. Sampling was done at 5 depths (2, 4, 8, 12 and 20 m). However, during dry period, when the lake was shallower, it was not possible to collect zooplankton below a depth of 12 m. Zooplankton samples were preserved in 10% formalin immediately after collection. Standard physico-chemical variables (temperature, dissolved oxygen, pH, conductivity and chlorophyll *a*) were quantified using an YSI 6600 multi-parameter instrument.

Identification of zooplankton species was done using standard works (Smirnov, 1974; Koste, 1978; De Smet and Pourriot, 1997). Rotifers (where needed the trophi isolated) and cladocerans were identified to species level while the copepods were to the genus level only. We also enumerated the developmental stages (naupliar to copepodite) but did not specifically assign them to any particular genus. Quantification of different zooplankton species individual per liter (ind. l^{-1}) was done using Sedgewick Rafter cell under inverted microscope (Nikon Eclipse TS100) and 2 to 3 aliquots of 1 ml each from the sample. Zooplankton species diversity index (H') and evenness (J') were derived using the Shannon-Wiener formulae (Krebs, 1993):

$$H' = \sum_{i=1}^{s} (Pi)(log2\ Pi)$$

$$J' = H' / log2\ S$$

where H' is the Shannon-Wiener Index of diversity, Pi = proportion of S made up of the i^{th} species of zooplankton, total number of zooplankton species.

Principal component analysis was employed to detect the combined influence of different factors on the abundance dynamics of zooplankton (SPSS version 10, USA). Where needed simple correlations were also tested following Sokal and Rohlf (2000).

Results and Discussion

Data on the selected physico-chemical variables are presented in Table 1. In general, the mean values of the variables observed during this period are comparable to those recorded earlier

Table - 1: Data on the selected physico-chemical variables of Valle de Bravo.Temperature (T), dissolved oxygen (DO), pH and chlorophyll-*a* recorded monthly during December 2005 to November 2006. Averages were obtained for epilimnion (e) (2, 4 and 8 m) and hypolimnion (h) (12 and 20 m)

Mon.	Physico-chemical variable							
	T (°C)		DO (mg l^{-1})		pH		Chl-*a* (µg l^{-1})	
	e	h	e	h	e	h	e	h
Dec.	19.6	19.4	5.1	2.3	7.5	7.2	14.0	10.2
Jan.	17.8	17.7	5.9	5.8	7.4	7.4	2.5	1.5
Feb.	18.0	17.5	—	—	8.8	8.4	5.2	2.4
Mar.	19.2	18.2	7.0	2.0	9.0	7.8	27.0	11.8
Apr.	20.0	18.7	4.3	0.4	8.7	7.9	10.9	1.4
May	21.6	19.5	6.1	1.1	8.9	8.0	14.3	1.7
Jun.	22.5	20.8	4.2	0.1	8.9	7.5	10.2	2.3
Jul.	22.2	21.0	3.0	0.1	8.7	7.5	6.7	—
Aug.	22.3	21.1	5.3	0.1	8.9	7.5	19.7	4.4
Sep.	22.0	21.2	4.2	0.1	8.7	7.6	14.1	1.1
Oct.	21.8	21.0	4.8	0.9	8.2	7.4	11.9	1.5
Nov.	21.3	20.8	5.3	3.1	7.9	7.7	14.4	3.8

Table - 2: Mean zooplankton densities (ind. l^{-1}) from Valle de Bravo during December 2005 to November 2006. Data from different depths (2, 4, 8, 12 and 20 m) were pooled to derive mean densities

Month	Zooplankton groups			
	Rotifera	Cladocera	Copepoda	Total
Dec.	571	83	148	802
Jan.	44	13	19	76
Feb.	489	36	62	587
Mar.	988	21	17	1026
Apr.	1683	30	84	1797
May	1160	106	59	1325
Jun.	952	60	70	1082
Jul.	1309	77	73	1459
Aug.	550	19	96	665
Sep.	400	25	72	497
Oct.	181	33	47	261
Nov.	518	18	46	582

Table - 3: Shannon-Weiner diversity index (H') and evenness (J') of zooplankton from Valle de Bravo during December 2005 to November 2006. — indicates no data are available due to reduced water column depth

Month	Water column depth (m)									
	2		4		8		12		20	
	H'	J'	H'	J'	H'	J'	H'	J'	H'	J'
Dec.	1.76	0.63	2.23	0.79	1.42	0.55	1.12	0.43	0.78	0.34
Jan.	1.36	0.86	1.88	0.81	2.36	0.84	1.72	0.86	1.84	0.79
Feb.	1.95	0.65	1.99	0.71	1.67	0.72	1.66	0.72	—	—
Mar.	0.12	0.07	0.08	0.08	0.06	0.04	0.08	0.04	—	—
Apr.	0.61	0.20	1.24	0.42	1.83	0.71	0.65	0.65	—	—
May	0.75	0.29	0.64	0.20	0.65	0.25	1.16	0.73	—	—
Jun.	2.17	0.60	2.23	0.62	2.29	0.69	1.30	0.82	—	—
Jul.	2.22	0.70	1.24	0.48	2.33	0.83	0.72	0.72	—	—
Aug.	1.87	0.62	1.86	0.62	1.41	0.71	—	—	—	—
Sep.	1.82	0.61	1.71	0.66	0.99	0.43	1.72	0.74	1.46	0.92
Oct.	2.19	0.73	1.92	0.61	1.62	0.81	1.71	0.74	—	—
Nov.	1.43	0.41	1.22	0.38	0.99	0.38	2.00	0.67	1.25	0.48

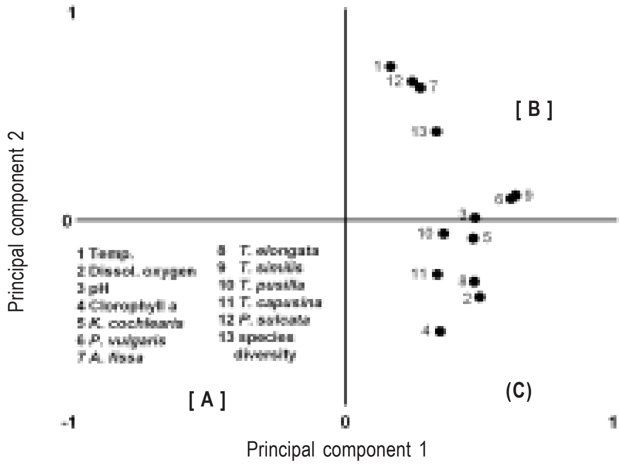

Fig. 1: Data on the frequency distribution and abundance of rotifers encountered in this study.

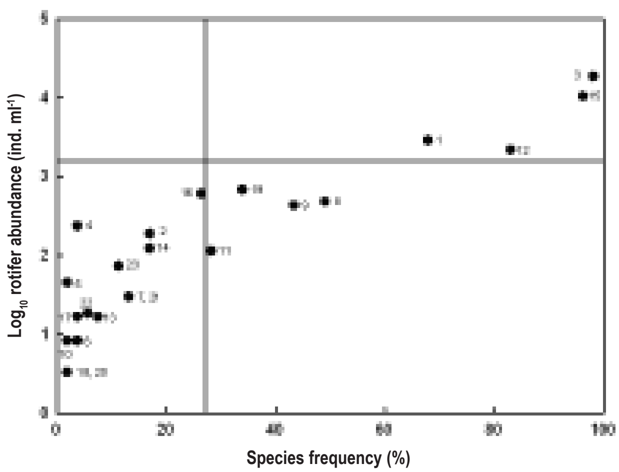

Fig. 2: Principal component analysis of physico-chemical variables on the dominant rotifer species in Valle de Bravo.The numbers represent the species as: 1. *Anuraeopsis fissa*, 2. *Kellicottia bostoniensis*, 3. *Keratella cochlearis*, 4. *Euchlanis dilatata*, 5. *Lepadella rhomboides**, 6. *Lecane lunaris*, 7. *Cephalodella catellina**, 8. *Trichocerca capucina*, 9. *T. elongata**, 10. *T. porcellus**, 11. *T. pusilla*, 12. *T. similis*, 13. *T. weberi*, 14. *Ascomorpha ovalis*, 15. *Polyarthra vulgaris*, 16. *Synchaeta pectinata* , 17. *Asplanchna brightwellii*, 18. *Dicranophorus forcipatus**, 19. *Pompholyx sulcata*, 20. *Testudinella patina*, 21. *Conochilus unicornis*, 22. *Hexarthra intermedia*, 23. *Filinia longiseta*. * = new records to Valle de Bravo

(Merino-Ibarra *et al*., 2008). In contrast, the annual mean zooplankton density in Valle de Bravo was about 847 ind. l^{-1} during 2006 (Table 2), which doubles the total abundance found during the period November 2004 to October 2005.

As in the previous years (Ramirez-Garcia *et al*., 2002; Nandini *et al*., 2007), during 2005-2006 period too, the zooplankton in the Valle de Bravo reservoir was dominated by rotifers (90%). The genera *Anuraeopsis*, *Keratella*, *Polyarthra* and *Trichocerca* were dominant and constituted nearly 80% of the total rotifer numerical abundances (Fig. 1).

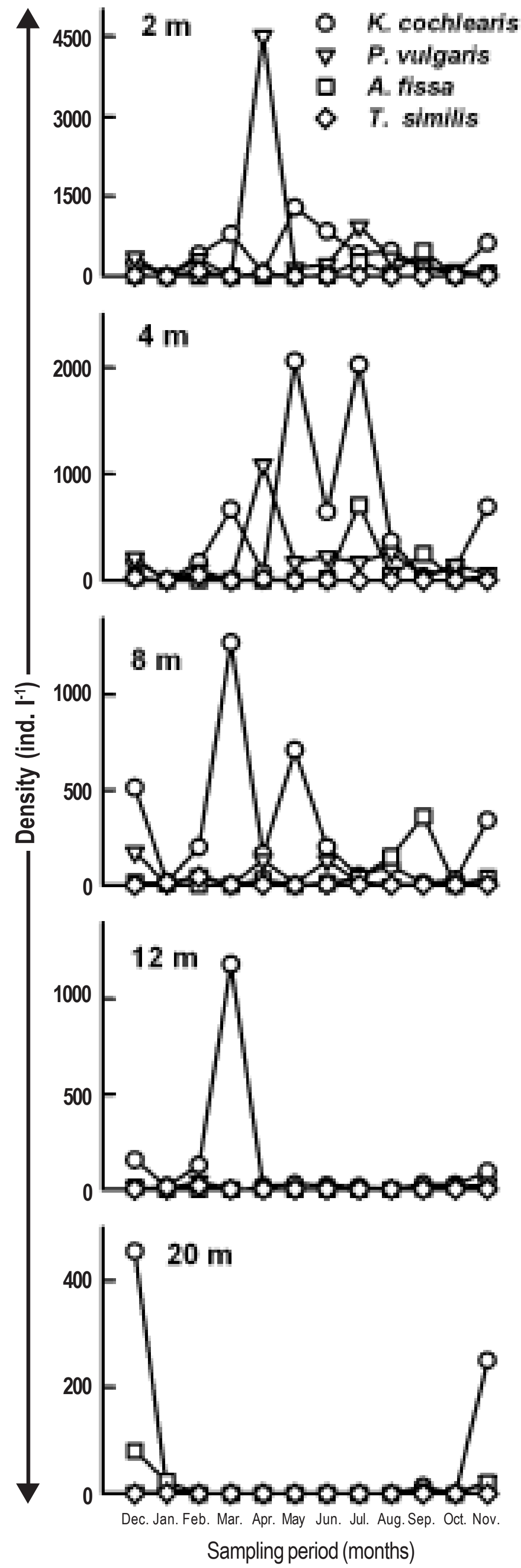

Fig. 3: Seasonal changes in the abundances of dominant rotifer species from Valle de Bravo during December 2005 to November 2006

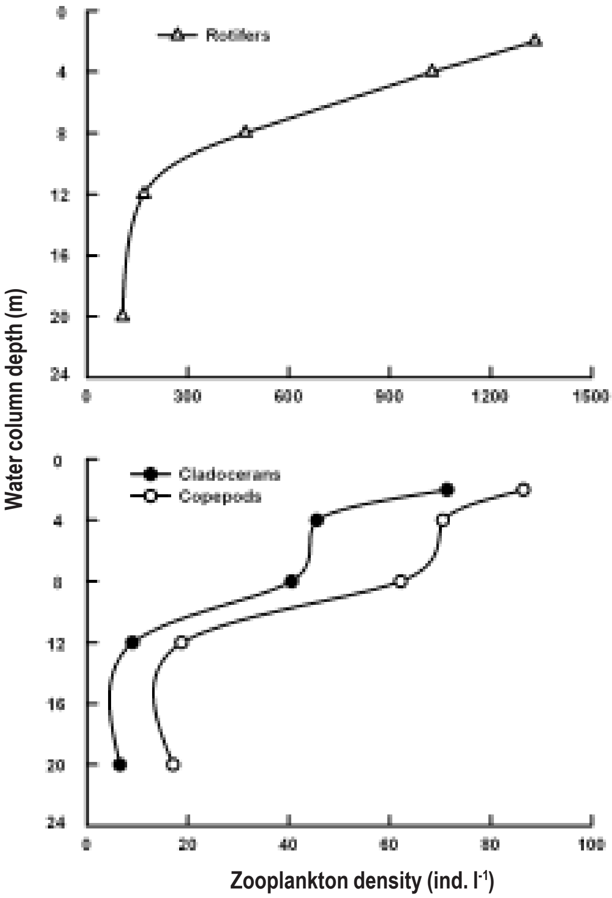

Fig. 4: Distribution of mean zooplankton density in relation to reservoir depth

We encountered a total of 23 rotifer species of which 5 have not been recorded earlier from this reservoir. This suggests that Valle de Bravo is highly dynamic with reference to its rotifer diversity. Shannon Wiener diversity index showed that the annual mean species diversity index was similar at depths of 2, 4 and 8 m, but reduced at 12 and 20 m, as also reported during the previous year. Evenness varied from 0.04 to 0.92 (Table 3). Regardless of depth, the highest diversity value of 1.82 was observed during January, while the lowest (0.07) during March.

Principal component analysis (Fig. 2) showed that temperature, dissolved oxygen and pH have strong effects on the abundance of dominant rotifer species and explained about 70% of the variation in zooplankton in this period. Temperature increase was related to an increase in the rotifer diversity. *K. cochlearis* showed an inverse relation with the diversity. Regardless of sampling depth and the season, the highest rotifer density was observed in April (>1600 ind. l^{-1}) and the lowest during January (<50 ind. l^{-1}) (Table 3). *Keratella cochlearis*, *Polyarthra vulgaris*, *Trichocerca similis* and *Anuraeopsis fissa* showed relatively higher abundances during March to July (Fig. 3). Predation by *Asplanchna* probably has much less importance since all these rotifer prey species which occurred in large numbers in Valle de Bravo have different strategies to escape from this predator (Sarma and Nandini, 2007). Cladocerans were mostly represented by *Daphnia laevis* and *Bosmina longirostris*, while copepods were composed mainly of cyclopoids (*Mesocyclops* spp.) and the naupliar stages.

The low abundances of cladocerans and copepods in Valle de Bravo reservoir appear to be due to mainly predation pressure from fishes and the food (phytoplankton) quality rather than the quantity. Occasionally cyanobacteriral (*Microcystis aeruginosa*) blooms develop in this reservoir. While *M. aeruginosa* is toxic to many zooplankton species (Alva Martinez *et al*., 2007), only *D. laevis* appears to have adapted to grow on this cyanobacterium (Nandini *et al*., 2000). Therefore, in our study, the dominant cladoceran was *D. laevis*. Sometimes *B. longirostris* too was dominant, but it is a specialist feeder, avoiding toxic phytoplankton and hence this species persists in this reservoir (DeMott and Kerfoot, 1982; Ferrao-Filho *et al*., 2000).

Chlorophyll *a* data observed in this study as well as that recorded from the same reservoir earlier indicated that the lake should be regarded as mesotrophic or eutrophic (Merino-Ibarra *et al*., 2008; Miracle *et al*., 2007). In mesotrophic reservoirs, the mean zooplankton density is about 1000 ind. l^{-1} (Conde-Porcuna *et al*., 2002), which is close to the abundances observed in this study. Since Valle de Bravo is a high altitude reservoir, it has bout 6°C below the typical temperature level of tropical lakes of Mexico (Torres-Orozco *et al*., 1996). Consequently, tropical genera of rotifers (*e.g. Brachionus*) (Koste, 1978) and cladocerans (*e.g. Diaphanosoma*) (Sarma *et al*., 2005) are missing. The predominantly temperate water cladoceran genus *Daphnia* is represented by *D. laevis*. Zooplankton abundances decreased with increasing depth of the water column (Fig. 4). This is due to lower phytoplankton densities and lower levels of dissolved oxygen in the hypolimnion (Table 1). Thus at higher depths, though predation pressure from visual predators is minimal (Park *et al*., 2007), unsuitable oxygen levels and lack of sufficient densities of phytoplankton appear to limit rotifer density and diversity (Dhua and Patra, 2006; Nandini *et al*., 2007).

In conclusion, our results confirm earlier findings that Valle de Bravo reservoir is dominated by rotifers, mainly of the genera *Keratella*, *Polyarthra* and *Trichocerca*. Though this reservoir is mesotrophic, the cladocerans occurred in low densities (<5% of the total zooplankton abundances). However, for this period we have found a two fold increase in mean total zooplankton abundance that should be further investigated.

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