POLISH JOURNAL OF ECOLOGY (Pol. J. Ecol.)	55	1	191–193	2007

Research note

Patricio De los RÍOS[1], Doris SOTO[2]

[1] Catholic University of Temuco, Natural Resources Faculty, Biological and Chemical Sciences School, PO-Box (Casilla) 15-D, Temuco, Chile, e-mail: prios@uct.cl
[2] Austral University of Chile, Aquatic Ecology Laboratory, PO-Box (Casilla) 1327, Puerto Montt, Chile (actual address: Inland Water Resources and Aquaculture Service (FIRI), Fisheries Department, FAO, Via delle Terme di Caracalla, 00100, Rome, Italy)

EUTROPHICATION AND DOMINANCE OF DAPHNIDS (CRUSTACEA) IN A DEEP PATAGONIAN LAKE (LAKE LLANQUIHUE, CHILE)

Chilean Patagonian lakes are mainly oligotrophic, with low dominance of daphnid cladocerans in zooplankton assemblages, mainly of the genera *Daphnia* and *Ceriodaphnia*, and a high dominance of calanoid copepods, mainly of the genera *Boeckella* and *Tumeodiaptomus* (Soto and Zúńiga 1991). This pattern is contrasting to that in North America lakes where daphnids tend to dominate in zooplankton assemblages (Soto and Zúńiga 1991, Gillooly and Dodson 2000). Nevertheless currently in Chilean lakes between 38 and 41°S, a gradual transition from oligotrophic to mesotrophic state has been reported (Campos *et al.* 2001, Woelfl *et al.* 2003). This eutrophication has been caused by an increase of nutrient inputs from human activities (Soto 2002). The increase in chlorophyll *a* concentration may result in an increase of daphnid abundance (De los Rios and Soto 2006).

In the present study the indicators of trophic status and daphnid abundance are presented for two periods 1992–1993 and 2001–2002 and for different bays: polluted (close to urban areas) and unpolluted ones, in deep subtropical lake – Llanquihue Lake.

The Llanquihue Lake (area: 870 km^2; max. depth: 317 m) belongs to the so-called Araucanian lakes, which are located between 38–41°S. The first studies described this lake as oligotrophic one (Campos *et al.* 1988, Soto and Zuńiga 1991). The lake is characterized by the presence of numerous bays close to towns or aquaculture farmings which are exposed to pollution and human impact. However, few lake parts remain without direct human impact (Soto 2002). The following bays have been considered as the polluted ("urban") sites: Puerto Octay (40°58'47"S; 72°53'08"W), Frutillar (41°07'36"S; 71°01'05"W), Llanquihue (41°15´39"S; 70°00'07"W) and Puerto Varas (41°19'20'S; 72°58'09"W). The *Ensenada* Bay (41°12'15"S; 72°32'32"W) was considered as the unpolluted (control) site. The samples were collected in spring and summer in 1992–1993 and 2001–2002, i.e. in the seasons when zooplankton abundance was very high (Campos *et al.* 1988). Nutrients, i.e., soluble reactive phosphorus (SRP) and dissolved inorganic nitrogen (DIN), as well as chlorophyll *a* concentrations, were measured according to the methods described by Soto (2002). The relative daphnid abundance (per cent in total zooplankton) was

Table 1. Trophic parameters (average ± standard error; in ug l^{-1}) and relative abundance (percent in total zooplankton abundance) of daphnids at the sites differently polluted. SRP – soluble reactive phosphorus, DIN – dissolved inorganic nitrogen.

Sites	Period	n	SRP	DIN	Chl*a*	Daphnidae (%)
Polluted bays	2001–2002	6	1.95 ± 0.31	8.85 ± 1.63	8.42 ± 4.78	52 ± 13
Unpolluted (*Ensenada*) bay	2001–2002	3	1.00 ± 0.00	3.83 ± 0.55	4.53 ± 1.51	3 ± 3
Polluted bays	1992–1993	10	1.92 ± 1.08	16.38 ± 3.59	0.67 ± 0.06	2 ± 1
Unpolluted (*Ensenada*) bay	1992–1993	7	1.13 ± 0.27	6.19 ± 1.04	0.88 ± 0.11	0.00

estimated according to De los Rios and Soto (2006). The obtained data were analyzed using t-test and assuming non homogenous variance (Zar 1999).

The data revealed a relative oligotrophic status and low daphnid percentage for data collected in 1992–1993. An increase in chlorophyll a concentration and daphnid percentage in polluted bays as well as in unpolluted *Ensenada* bay was noted in 2001–2002, whereas there was no directional changes in the nutrients concentrations in the above periods (Table 1). The significant differences for SRP (P <0.027), DIN (P <0.027) and daphnid relative abundance (P <0.012) were found for polluted and unpolluted bays in 2001–2002, whereas the average values of Chl *a,* although being much higher in polluted sites are not significantly different from unpolluted one (Table 1) *(P* <0.468). For the period 19911992 the significant differences for DIN (P <0.021) and daphnid relative abundance (P <0.027) were found, whereas no significant differences for SRP (P <0.499) and Chl *a* (P <0.123) were noted. The results of inter-period comparison of polluted bays did not reveal significant differences for SRP (P <0.976), Chl *a* (P <0.166), but a weak (marginally significant) differences for DIN (P <0.080) and daphnid relative abundance (P <0.084). Finally, for unpolluted *Ensenada* bay (Table 1) no significant differences were found between periods for SRP (P <0.653), Chl *a* (P <0.135), and daphnid relative abundance (P <0.438), whereas a weak (marginally significant) difference (P <0.080) was stated for DIN.

The obtained results agree with similar ones for Araucanian lakes, such as Rińihue lake at 39°S (Woelfl *et al.* 2003), that has an oligo mesotrophic status, with relative high daphnid abundance (De los Rios and Soto 2006). The similar relation between trophic status and daphnid dominance was described for New Zealand lakes (Jeppensen *et al.* 2000), that share the same zooplankton genera with Chilean lakes (Soto and Zuńiga 1991). Also, the Llanquihue lake is a typical subtropical warm monomictic lake (Campos *et al.* 1988), such as the Chilean Patagonian lakes (Soto 2002, Soto and Zuńiga 1991), and this condition would allow sustain abundant daphnid populations, considering that optimal temperature for daphnids is between 15–20°C (Gillooly and Dodson 2000).

ACKNOWLEDGEMENTS: This study was funded by projects of IAI (Enhanced Ultraviolet B Radiation in Natural Ecosystems as an Added Perturbation Due to Ozone Depletion), Project DID-UACH D2001-11, CONICYT (Scholarship supporting doctoral thesis, and Doctoral Grant), and the Research Direction of the Catholic University of Temuco.

REFERENCES

Campos H., Hamilton, D., Villalobos L., Imberger J., Javan A. 2001 – A modeling assessment of potential for eutrophication of Lake Rińihue, Chile – Arch. Hydrobiol. 151: 101–125.

Campos H., Steffen W., Aguero G., Parra O., Zúńiga L. 1988 – Limnological study of lake Llanquihue (Chile) morphometry, physics, chemistry and primary productivity – Arch. Hydrobiol. (Suppl) 1: 37–67.

De los Rios P., Soto D. 2006 – Effects of the availability of energetic and protective resources on the abundance of daphnids (Daphnidae, Cladocera) in Chilean Patagonian lakes – Crustaceana, 79: 23–32.

Gillooly J.F., Dodson S.I. 2000 – Latitudinal patterns in the size distribution and seasonal dynamics of new world, freshwater cladocerans – Limnol. Oceanogr. 45: 22–30.

Jeppensen E., Lauridsen T.L., Mitchell S.F., Christoffersen K., Burns C.W. 2000 – Trophic structure in the pelagial of 25 shallow New Zealand Lakes: changes along nutrient and fish gradients – J. Plank. Res. 22: 951–968.

Soto D. 2002 – Oligotrophic patterns in southern Chile lakes: the relevance of nutrients and mixing depth – Rev. Chilena Hist. Nat. 75: 377–393.

Soto D., Zúńiga L. 1991 – Zooplankton assemblages of Chilean temperate lakes: a comparison with North American counterparts – Rev. Chilena Hist. Nat. 64: 569–581.

Woelfl S., Villalobos L., Parra O. 2003 – Long-term changes of trophic parameters in a north Patagonian lake during 1978 – 1997 (lake Rińihue: Chile) evidence for eutrophication process? – Rev. Chilena Hist. Nat. 76: 459–474.

Zar J.H. 1999 – Biostatistical analysis. Fourth Edition – Prentice Hall, Upper Saddle River, New Jersey, USA, 663 pp.

(Received after revising July 2006)