

# Effect of annual climatic changes on *Daphnia pulicaria* population in a high mountain lake



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## Study site and Methods

Rio Seco is a small (0.4 ha), oligomesotrophic, and shallow ( $Z_{max}=2.90$  m) lake of glacial origin located at 3,040 m above sea level in the Sierra Nevada mountains (southern Spain). The lake is ice covered from around October-November until June-July. The lake presents total Secchi disk visibility during the ice-free period. It is a fishless lake where the community, very simple, consists of ~ 10 nanoplanktonic algal species and 2 main zooplankton species, the calanoid *Mixodiaptomus laciniatus* and the cladoceran *Daphnia pulicaria*. Plankton was collected at five points in Rio Seco lake from July through October-November in 1996, 1997 and 1998. The lake area was divided into five zones and one sample was collected at a random point within each zone (Fig. 1).



Fig.1. Rio Seco lake photograph where the five sampling zones have been drawn

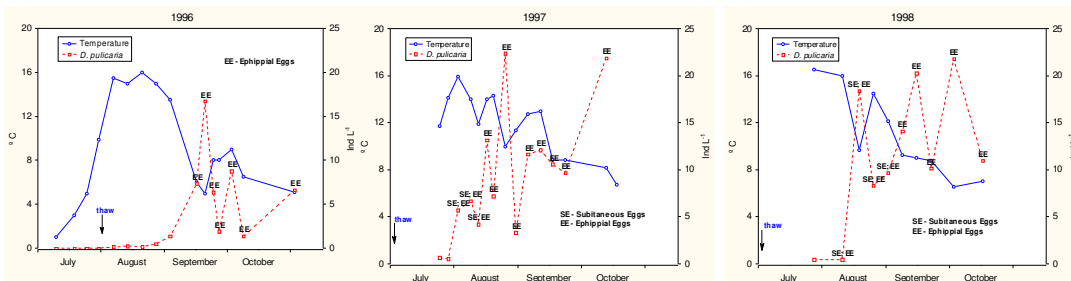


Fig.2. Temperature and *D. pulicaria* abundance values. Values are daily average for five sampling points

## Results and Discussion

*D. pulicaria* development was considerably later and their density significantly lower in 1996 than in 1997 or 1998 (ANOVA  $p < 0.05$  for interannual differences when daphnids  $> 1$  indiv.L<sup>-1</sup>; LSD post-hoc test showed no differences between 1997 and 1998) despite the higher phytoplankton biomass in 1996. These differences may be related to the shorter ice-free period of 1996 than in 1997 or 1998 (Fig. 2). The low temperatures and high rainfall amount delayed the thaw for one month in 1996, affecting the timing of *Daphnia* hatching.

*Daphnia* may colonize the lake every spring by hatching from ephippia. This hypothesis is based on observations of the size of the first individuals sampled (Fig. 3), especially in 1996, when sampling was carried out before the thaw. The first individuals sampled (July) were new-born or first instar *Daphnia*, while the first adults ( $> 1500$   $\mu$ m) were observed at early September. No "large" individuals ( $> 2200$   $\mu$ m) were observed at the beginning of summer time in any sampling year.

Production of subitaneous eggs was low and was restricted to the beginning of the population development whereas ephippia production was maintained and increased until the end of sampling period (Fig. 2). Parthenogenetical reproduction was not observed in 1996 probably because adult individuals did not appear until early September, when the time for reproduction had passed. The contribution of parthenogenetical reproduction to the population density and structure is insignificant (Barea-Arco *et al.*, 2001).

Species living in temporal habitats and under hard conditions as in Rio Seco lake need to adopt specific survival strategies. Moreover, species must deal with annual climatic variability. Hence, a cold year like 1996 implies strong changes in *Daphnia* population dynamics such as a low hatching and a lack of parthenogenetical reproduction and, consequently, a low population development.

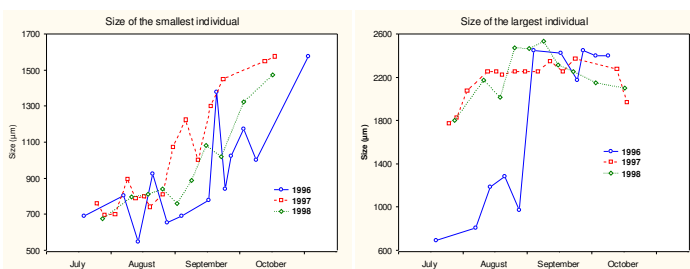


Fig. 3. Size of the smallest and largest individual for each sampling day of 1996, 1997 and 1998.

Hatching time is likely shorter and restricted to the beginning of the ice-free period. In 1996, when no subitaneous eggs were produced, no new born individuals ( $< 700$   $\mu$ m) were observed after early September (Fig. 3).

Our results indicate that thaw time seems to determine the beginning of hatching from ephippia. What kind of cues are operating? Probably water temperature but we think light intensity and/ or quality may be involved.

On the other hand, the photoperiod, as a cue for the arrival of winter, may regulate the end of hatching and subitaneous egg production.

## Acknowledgments

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## References

- Barea-Arco, J., Pérez-Martínez, C. & R. Morales-Baquero, 2001. Evidence of a mutualistic relationship between an algal epibiont and its host *Daphnia pulicaria*. *Limnol. Oceanogr.* 46: 871-88.