

Laboratory demonstration of morphological alterations in *Ceriodaphnia cornuta* Sars (1885) *fa rigaudi* induced by *Chaoborus brasiliensis* Theobald (1901)

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Received November 6, 2007 – Accepted March 5, 2008 – Distributed May 31, 2008

(With 1 figure)

Zooplankton populations in the field display morphological, physiological and behavioral changes as strategies to diminish predation pressure from both invertebrates and vertebrates (Kerfoot and Sih, 1987). Experimental studies on prey–predator interactions have shown that such changes can be induced by the presence of a predator (or chemicals produced by a predator) (Lass and Spaak, 2003). Although such alterations are known to occur in several zooplankton genera, the genus *Daphnia* has been the most thoroughly studied (Tollrian and Dodson, 1999).

Experimental and field studies have provided evidence that fish and/or fish-associated chemicals can induce changes in the life history and behaviour of *Ceriodaphnia* species (Rose et al., 2001; Seely and Lutnesky, 1998), as well as the growth of spines in the species *cornuta* (Zaret, 1969). Lüning-Krizan (1997) suggested that the negative feeding selectivity of *Chaoborus* on *Ceriodaphnia reticulata* recorded in a field study was due to the protective role of a head spine developed by the prey. Analyzing populations of *Ceriodaphnia cornuta* from field enclosures, Freitas et al. (2007) recorded the presence of head spines more frequently in enclosures containing *Chaoborus* than in those without this predator. Increases in head and fornix spine lengths were also found when *Chaoborus* was present. However, to our knowledge, no laboratory study has documented the induction by *Chaoborus* of spine growth in *Ceriodaphnia*.

There is an interesting controversy regarding the species *Ceriodaphnia cornuta* and the origin of its three morphological forms: *C. cornuta cornuta*; *C. cornuta intermedia* and *C. cornuta rigaudi*. The latter, without head, shoulder (fornix) or tail (mucron) spines, was originally described as a separate species (*C. rigaudi*), but this view was challenged by Rzoska (1956) and later by Zaret (1969).

Preliminary laboratory experiments carried out to investigate the occurrence of polymorphic forms of *C. cornuta* in Barra Bonita reservoir (São Paulo State,

Brazil) during the course of the year, and particularly the occurrence of *C. cornuta cornuta* during the summer, evidenced the appearance of spines on the head, caudal area, and side of *Ceriodaphnia cornuta fa rigaudi* in the presence of individuals of *Chaoborus* sp. and of substances released by the latter into the water (Rietzler et al., 1996). The present study is a continuation of those experiments, further investigating the effects of the presence of *Chaoborus brasiliensis* on the morphology of *Ceriodaphnia cornuta*.

In the present study, adult specimens of *C. cornuta fa rigaudi* maintained routinely in the laboratory were exposed to the presence of *Chaoborus brasiliensis* in the proportion of 1 predator to 15 prey in 500 mL of lake water, previously filtered through a net of 75 µm mesh size, and pre-conditioned for five days, from the Lagoa do Nado (Belo Horizonte - Minas Gerais), where the *Chaoborus* larvae had been collected, and also in 500 mL of laboratory culture water. All treatments were maintained at a constant temperature of 25 ± 1 °C. The *Ceriodaphnia* individuals were fed every other day with a suspension of *Pseudokirchneriella subcapitata* (Korshikov) F Hindak (10⁵ cells.mL⁻¹) and a food mix prepared with fish ration and yeast. After 4 and 8 days of exposure to the predator, prey individuals were photographed for analysis of the presence of morphological changes. On termination of the experimental phase with the predator, the *Ceriodaphnia* were observed for another fifteen days in lake water and laboratory water without the predator, being photographed after 5, 10 and 15 days of maintenance.

Figure 1a shows the morphology of *C. cornuta* in the control; as can be observed, no spines are present. For specimens exposed for 4 days in the laboratory culture water (treatment 1), mucral spine development was evident, while in the lake water (treatment 2), the mucro, the fornices and the head possessed spines. After 8 days of exposure to the predator (Figure 1b and c), all three locations presented spines, in both treatments. However,

it can be noted that spine lengths were smaller than registered in other descriptions of *C. cornuta cornuta*, resembling more the form *C. cornuta intermedia*. In the second phase of the experiment, without the presence of the predator, the specimens reverted to the original spineless morph known as *C. cornuta rigaudi* (Figure 1d). Thus, our data present experimental evidence supporting the view of Rzoska (1956) and Zaret (1969) that only a single polymorphic species may exist.

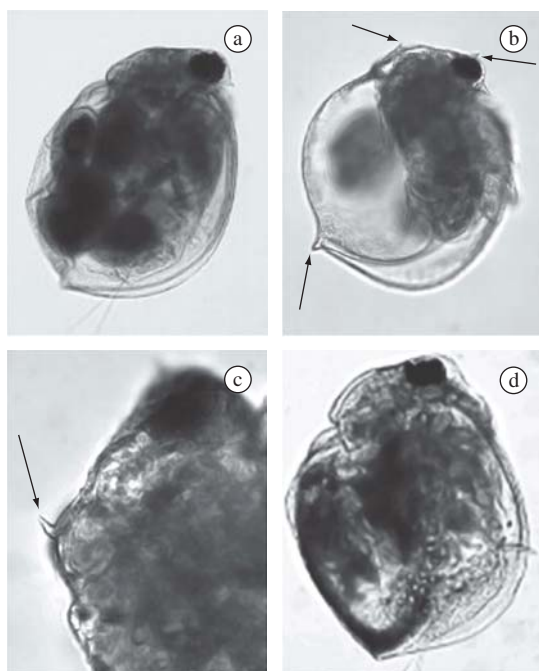


Figure 1. Photographs of experimental animals with arrows indicating the morphological alterations. a) in routine culture (Control) (20x); b) in the presence of the predator, in filtered lake water, after 8 days (20x); c) in the presence of the predator, in filtered lake water, after 8 days (40x); and d) after replacement in laboratory culture water without the predator, after 10 days (20x).

References

- FREITAS, GTP., CRISPIM, MC. and HERNÁNDEZ, MIM., 2007. Changes in life-history parameters of cladoceran *Ceriodaphnia cornuta* (Sars, 1886) in the presence of *Chaoborus* larvae. *Acta Limnol. Bras.*, vol. 19, no. 3, p. 295-303.
- KERFOOT, WC. and SIH, A., 1987. *Predation. Direct and indirect impacts on aquatic communities*. Hanover: The University Press of New England. 386 p.
- LASS, S. and SPAAK, P., 2003. Chemically induced anti-predator defenses in plankton: a review. *Hydrobiologia*, vol. 491, no. 1-3, p. 221-239.
- LÜNING-KRIZAN, J., 1997. Selective feeding of third- and fourth-instar larvae of *Chaoborus flavicans* in the field. *Arch. Hydrobiol.*, vol. 140, no. 3, p. 347-365.
- RIETZLER, AC., ROCHA, O. and ROCHE, KF., 1996. Alterações morfológicas em *Ceriodaphnia cornuta* fa *rigaudi* Richard induzidas pelo invertebrado predador *Chaoborus* sp. In I Simpósio de Ciências da Engenharia Ambiental / III Simpósio do Curso de Ciências da Engenharia Ambiental, Universidade de São Paulo - USP, São Carlos - SP, p. 90-92.
- ROSE, RM., WARNE, MSTJ. and LIM, RP., 2001. Factors associated with fish modify life history traits of the cladoceran *Ceriodaphnia* cf. *dubia*. *J. Plank. Res.*, vol. 23, no. 1, p. 11-17.
- RZOSKA, J., 1956. On the variability and status of the cladoceran *Ceriodaphnia cornuta* and *Ceriodaphnia rigaudi*. *Ann. Mag. Nat. Hist. Ser.*, vol. 12, no. 9, p. 505-510.
- SEELY, CJ. and LUTNESKY, MMF., 1998. Odour-induced antipredator behaviour of the water flea, *Ceriodaphnia reticulata*, in varying predator and prey densities. *Freshwat. Biol.*, vol. 40, no. 1, p. 17-24.
- TOLLRIAN, R. and DODSON, SI., 1999. Inducible defenses in Cladocera: Constraints, costs and multipredator environments. In TOLLRIAN, R. and HARVELL, CD. In *The ecology and evolution of inducible defenses*. (eds). Princeton: Princeton University Press, p. 177-202.
- ZARET, T., 1969. Predation-balanced polymorphism of *Ceriodaphnia cornuta* Sars. *Limnol. Oceanogr.*, vol. 14, no. 2, p. 301-303.