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Anisops bouvieri predation and advantages of cephalic expansion in *Daphnia cephalata* King and the impact of predation on *Daphnia similis* Claus under laboratory conditions

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Abstract. Experiments were conducted with *Anisops bouvieri* as predator to study the advantages of helmet development in cyclomorphic form *Daphnia cephalata* King and the results were compared with another non-helmeted *Daphnia similis* Claus. The helmeted *Daphnia cephalata* avoided *Anisops bouvieri* predation better than the non-helmeted form *Daphnia similis*. The predator selectively preys upon smaller sized *Daphnia similis* than the larger *Daphnia cephalata*.

Keywords. *Anisops bouvieri* predation; advantages of cephalic expansion; *Daphnia cephalata* King; *Daphnia similis* Claus.

1. Introduction

Cyclomorphosis is a phenomenon which involves a dorso-anterior expansion of the cephalic area so that a laminate crest is produced in some species of the cladoceran genus *Daphnia*. It is believed so far that due to the influence of environmental factors all members of a population possessing the same body form vary it over the year. The adaptive significance of such phenotypic changes has been argued for many years (Coker and Addlestone 1938; Brooks 1946, 1947; Hrbacek 1959; Jacobs 1961; Hebert 1978a, b). Until recently, the cephalic expansion (helmet) in *Daphnia* was related to all possible field as well as the laboratory factors, since the degree of change in size of the cephalic region, the body and the tail spine is variable in different populations of the same species. At present, suggestions are that crest development is a predation avoidance mechanism, evation being the most important factor (Grant and Baily 1981). The original theory on the cephalic expansion as a function to lessen sinking rates in less dense or viscous water has little credence. The present study on this aspect focuses on the advantage of helmet development on *Daphnia cephalata* King and the impact of predation on *D. similis* Claus by a hemipteran (Notonectidae) predator *Anisops bouvieri*, to substantiate the theory proposed by Dodson (1974) that the mortality due to vertebrate and invertebrate predators may be reduced by a change in morphology of the prey species.

2. Material and methods

To study the advantage of helmet development on *D. cephalata* and the impact of predation on *D. similis*, parthenogenetic females were separated from the field collections. *A. bouvieri* (predator) which had been netted from the same ponds where the daphnids were collected, were conditioned to the laboratory by feeding them with both the species for a few days and then starving the predator for 36 h before an experiment. All the experiments were carried out under the laboratory illumination in tap water and it was quite easy to observe the activities of the predator because they hang motionless in the water until a prey comes within close range, eliciting an attack.

To study the effect of prey density on predation, *A. bouvieri* (adult and young) were offered *D. similis* in three 500 ml beakers in 50, 100 and 200 concentrations. Another series of test individuals were provided with *D. cephalata* in the same densities as mentioned above. Experiments were repeated thrice and 90 min were given for each experiment.

To study the prey preference, a predator was offered equal number of (10 + 10) both *D. similis* and *D. cephalata* for a period of 90 min. Throughout the experiment, the prey density was kept constant by introducing a prey as and when it was preyed.

3. Results and discussion

The first set of experiments dealing with the effect of density on predation, shows that adult *A. bouvieri* preyed more *D. similis* (figure 1, $a = 0{\cdot}439$) than the young ($a = 0{\cdot}162$) and with increase in the density of the prey, predation also increased (adult $P < 0{\cdot}001$, highly significant; young $P < 0{\cdot}001$, highly significant). In experiments using *D. cephalata* also, the number of prey consumed by the predator increases with the increasing density of prey (young $P < 0{\cdot}001$, highly significant; adult $P < 0{\cdot}05$ significant) (figure 2). Comparison of both the prey species reveals that *D. similis* is more susceptible than the helmeted *D. cephalata* for *A. bouvieri* predation (figure 3).

The study on prey preference shows that the number of *D. similis* consumed by *A. bouvieri* is more than that of *D. cephalata* ($P < 0{\cdot}001$, highly significant, figure 4). An average of 45 *D. similis* were preyed by *A. bouvieri* which is approximately 3 times

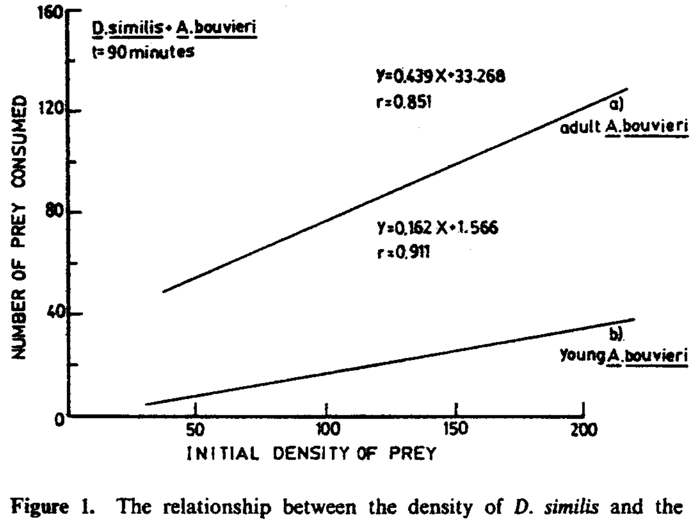

Figure 1. The relationship between the density of *D. similis* and the number of prey consumed by *A. bouvieri* (adult and young).

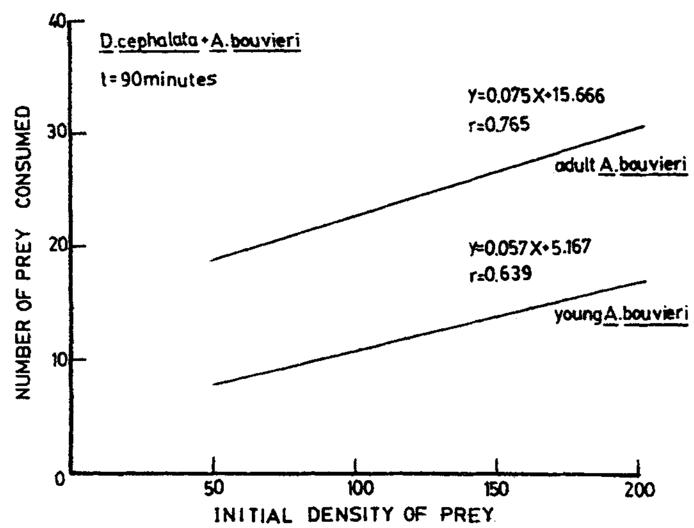

Figure 2. The relationship between the density of *D. cephalata* and the number of prey consumed by *A. bouvieri* (adult and young).

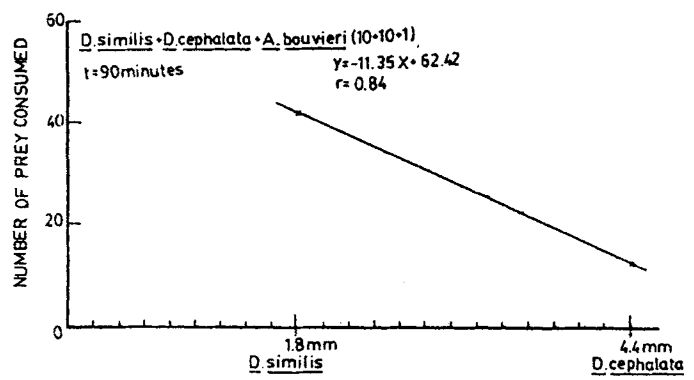

Figure 3. Histogram showing the number of prey consumed by adult and young *A. bouvieri* at 3 different densities of *D. similis* and *D. cephalata*.

higher than the predation of *D. cephalata* (16) (table 1). It is evident that the helmeted *D. cephalata* is less susceptible to *A. bouvieri* predation than *D. similis*.

O'Brien and Vinyard (1978) observed that during predation experiments with *A. bouvieri*, the crested *D. cephalata* better avoided predation than did the uncrested *D. similis*. O'Brien *et al* (1980) stated that the crest on *D. longiremis* f. *cephalata* protected it from invertebrate predation without altering the visual body size. Jacobs (1966) has also shown that the helmeted morph of *D. galeata mendotae* was preyed upon less than the non-helmeted morph. O'Brien *et al* (1980) also supported the theory that the presence of helmet is advantageous for the prey, *D. longeremis* f. *cephalata* and further stated that the presence of crest is an example of ingenuity of natural selection in equipping animals to survive in the face of selective pressures.

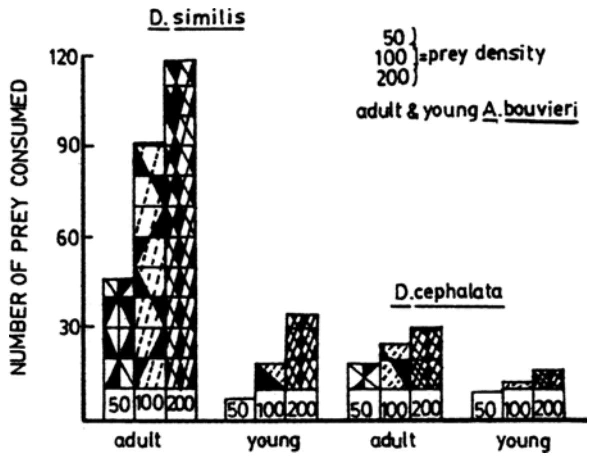

Figure 4. The relationship between the number of prey consumed by *A. bouvieri* (adult) exposed to equal number of both *D. similis* and *D. cephalata* (10 + 10).

Table 1. Predation experiments in which *A. bouvieri* was exposed to both *D. similis* and *D. cephalata* (density = 10 each) for 90 min. The density of the prey species was maintained constant by adding as and when one prey was killed.

Experiment No.	Number of *D. similis* preyed	Number of *D. cephalata* preyed	Number of observations
1	32·33 ± 3·51	8·33 ± 2·52	3
2	57·66 ± 5·86	23·30 ± 5·50	3
Average	45·00	16·00	6

Likewise, the presence of 'Nackenzahne' is the only protective mechanism in *D. minnehaha* to reduce the predator's (*Chaoborus*) handling efficiency (Krueger and Dodson 1981).

The same mechanism may be involved in the reduction of predation on exuberent varieties of other zooplankton species. In Gilbert's (1963) study of the rotifer *Branchionus* sp. short spined parental forms suffered greater predation than their offspring with long predator-induced spines. Zaret (1972a, b) reported that the exuberent horned morphs of *Ceriodaphnia cornuta* was preyed upon less often by the fish predator. Kerfoot (1977) and O'Brien *et al* (1979) showed that some of the exuberent structures of *Bosmina* sp. reduce predation by copepods.

Thus, the presence of helmet in *D. cephalata* may be advantageous to avoid predation than the non-helmeted *D. similis* and acts as an 'antilock and key' as suggested by Dodson (1974), O'Brien and Vinyard (1978) and O'Brien *et al* (1980).

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