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Studies on some biological aspects of *Simocephalus vetulus* Schödler

Y. R. Malhotra and Seema Langer
Department of Biosciences, University of Jammu, Jammu 180 001, India.

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Abstract

A study of the life cycle of a daphnid cladoceran, *Simocephalus vetulus* (life span, number and duration of instars, egg production, growth and embryonic development of the organism at two different seasonal temperatures (13–15 and 28–30°C)) shows that it produces the maximum number of eggs (about 335) at low temperature in the optimum range (13–15°C) during a mean life span of 65–67 days. At both seasonal temperatures, it has four (sometimes five) pre-adult and ten adult instars. Embryonic development too is strongly temperature related.

Key words: *Simocephalus vetulus*, biology, temperature variations.

1. Introduction

Among all the cultured animals, fish is the most efficient converter of autotrophs and consumers (of basic trophic levels) into protein for human consumption. Though rearing techniques are known for many marine and freshwater fishes[1], the survival of fry is low due to lack of appropriate food[2-3]. Hence, a knowledge of various aspects of the life cycle is important for raising cultures of fish food organisms.

In the present study, *Simocephalus vetulus,* a cladoceran of importance as fish food, has been selected for intensive culture, involving the investigation of its various biological aspects in relation to seasonal temperature.

2. Material and methods

For life-cycle studies, laboratory-reared newly hatched young ones were isolated and each of these reared in a petri dish filled with culture medium (containing 40 ml of aqueous solution of cow dung at a concentration of 1g/l). Ten such identical experimental sets were studied. Level of nutrient medium (*ad libitum*) was maintained in each experimental set by replenishing it on alternate days. Daily recordings on the organisms were made regarding (i) length increment, (ii) number

of moults, (iii) number of eggs per brood, and (iv) duration of each instar, and total life span of an individual organism.

The eggs developing naturally (in the brood chamber of the mother) were continuously studied through the transparent carapace. Various stages of development were clearly visible under the microscope.

3. Results

The neonata measures 0·53 mm and is a miniature adult (Figs 1 and 2). After it is released from the brood pouch of adult, it passes through an average of four (sometimes five) pre-adult and ten adult instars. Various biological aspects of the neonata have been studied.

3.1. *Embryonic development*

Eight distinct stages were recorded in *S. vetulus*. Oviducts are narrow and when the eggs pass out they are constricted and resemble toothpaste coming out of a tube.

Stage I. The eggs become spherical, translucent, with a uniform mass of cells and the stage lasts for about 5 h (Fig. 3I).

Stage II (Early). This stage is characterized by the initiation of formation of fat cells in the translucent area of the egg.

Stage II (Late). The transparent peripheral zone of the egg increases slowly and in the centre of the egg a clear area is recognizable (Fig. 3II). These changes occur approximately in 8–10 h.

Stage III. The egg remains spherical. The central area is surrounded by cells which show a distinct cleavage. This stage lasts for about 16 h (Fig. 3III).

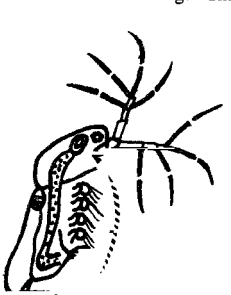

Fig. 1. A newly hatched individual of *S. vetulus* (×7).

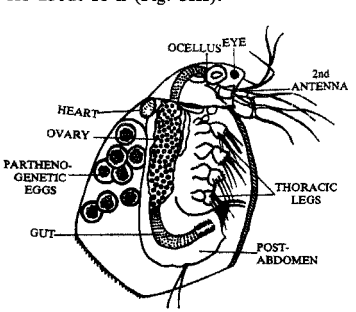

Fig. 2. Morphology of adult individual of *Simocephalus vetulus* (× 3·75).

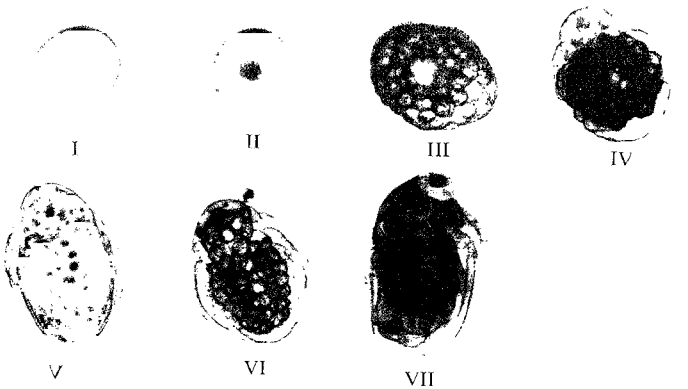

FIG. 3 Various stages of embryonic development in *S. vetulus*

Stage IV. During the next 8 h, the embryo elongates anterio-posteriorly. A distinct head is yet to be formed (Fig. 3III).

Stage V. The head rudiment is now distinctly formed. However, eyes are still not apparent. A pair of antennary rudiments are visible as short lobes on either side of the head. This stage extends for another 12–15 h (Fig. 3IV).

Stage VI. The embryo has further elongated. Head has become distinct. Rostrum appears. The alimentary canal becomes distinct. Rudiments of paired eyes, ocellus and limbs developed. All these changes take place during the next 18–20 h (Fig. 3V).

Stage VII. The antennae are now clearly visible. The paired eye patches approximate towards one another. This stage is of maximum duration in the entire developmental cycle (22–25 h, Fig. 3VI).

Stage VIII. The embryo reaches its maximum length with rudimentary paired eyes getting fully fused and becoming dark in colour. The development of alimentary canal is complete by now. Thoracic legs become distinct. After completing their last stage of development, juveniles emerge from the brood pouch. This stage takes 20–24 h (Fig. 3VII) to complete.

Embryonic period is greatly influenced by temperature variations. As compared to a minimum of 120 h duration at 13–15°C temperature range, embryonic development is completed in about 60 h at a higher temperature range (28–30°C).

3.2. *Maturity period*

The individuals of *S. vetulus* attain maturity at an average of 7 and 4 days at low (13–15°C) and high (28–30°C) temperature ranges, respectively.

3.3. *Number and duration of instars*

At both the temperature ranges, the average number of pre-adult instars was 4–5 and that of adults 10. Average durations of pre-adult instars are 0·92 and 3·0 days at 28–30 and 13–15°C temperature ranges, respectively. Similarly, average duration of adult instars observed is 2·5 and 5·3 days at 28-30 and 13–15°C, respectively.

3.4. *Brood size*

A comparatively small brood size with an average of 11.4 eggs (max. 25) was observed at 28–30°C, while at 13–15°C, an average of 30 eggs was recorded. A maximum brood size of 50-60 eggs was observed at the latter temperature.

4. Discussion

4.1. *Number and duration of pre-adult instars*

The neonata referred to as I pre-adult instar subsequently passes through an average of four (sometimes five) pre-adult instars. The incidence of five pre-adult instars is reported earlier in the life cycle of temperate *Daphnia pulex*[4] and *Moina macrocopa*[5] at 15–20°C, tropical *Daphnia carinata*[6] at 28–31°C and in the arctic *D. middendorffiana*[7] at 0–10°C. This similarity of *S. vetulus* to other cladoceran species from different climatic regions may be an indicative factor towards the common nature of this character in general, and points out that the number of pre-adult instars in *S. vetulus* is beyond the influence of temperature of the surroundings. However, temperature variation is observed to have a marked effect on the instar duration since at a temperature of 13–15°C, the duration of pre-adult instars at an average is 3 days whereas this period shortens to 0·8 to 1 day at higher temperature range (28–30°C).

4.2. *Number and duration of adult instars*

The number of adult instars recorded for *S. vetulus* is 10 as investigated presently at two temperature ranges (13–15 and 28–30°C). To our knowledge, in other related species belonging to the group Cladocera, there is a variation in the number with a maximum of such instars in the temperate forms (*Daphnia pulex*—15 adult instars), a minimum in the arctic forms (*D. middendorffiana*—4–5 adult instars). The tropical species (*D. carinata*—8 adult instars), however, occupy an intermediate position. It is ordinarily expected that the arctic and tropical forms have a reduced number of adult instars, probably a contrivance to complete their life cycle in the shortest period particularly adapted to optimal environmental conditions which are ordinarily limited in duration in these extreme climatic habitats. However, the differences in the number of adult instars observed in the present study may be species specific because it has been suggested that hereditary factors, and even differences in the culture media, may cause such variations in the number of instars[8]. In this regard, our results on culture studies provide a supporting evidence as revealed by the observation that rice bran proves to be the best culturing medium when compared to manures like poultry manure, rabbit droppings and cow dung[9].

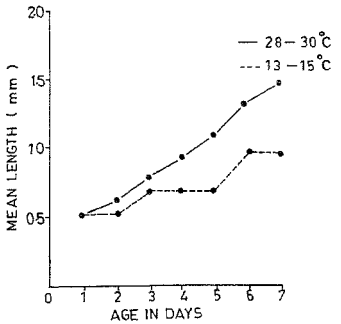

Fig 4. Mean length at different ages at two different temperature ranges (13–15 and 28–30°C).

An increase in the temperature from 13–15 to 28–30°C results in increased growth rate of *S. vetulus* which is essentially a consequence of shortening of duration of instars (Fig. 4). Similar conclusions have been arrived at earlier for *Daphnia* species[4,10].

Females of *S. vetulus* studied presently register a slow increase in size (Fig. 4) at low temperature but reach a larger (final) size earlier at higher temperature, although they live longer at lower temperature. This has also been reported for *D. magna*[11], *D. pulex*[4] and for several other cladoceran species[12-13].

Irrespective of the temperature range, the duration of the first adult instar (first egg-bearing instar) is distinctly longer than the longest pre-adult instar. Similar conclusion has been previously made for *Daphnia carinata*[6], *D. pulex*[4], *D. magna*[8] and *S. acutirostratus*[14]. However, contrasting results have been reported for a moinid, *Moina micrura*[15]; and the daphnids *Ceriodaphnia cornuta*[16] and *Scapholebris kingi*[17].

Among adult instars, it has been observed that in *S. vetulus* certain instars are of longer duration than the others, and such an increase is usually associated with a decrease in the number of eggs produced during the life of those instars. Similar results have been reported in *D. magna*[8] and *D. carinata*[6]. However, the longest duration during the present investigation is found to be fixed for last instar (10th adult instar) which also marks a decline in the number of eggs produced as has been reported for *D. carinata*[6].

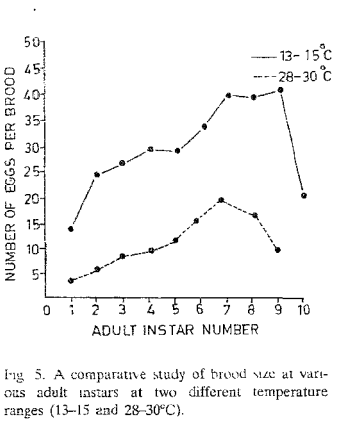

Fig. 5. A comparative study of brood size at various adult instars at two different temperature ranges (13–15 and 28–30°C).

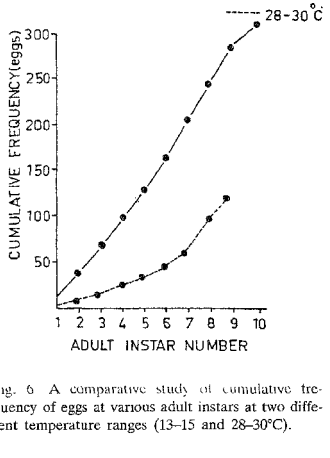

Fig. 6. A comparative study of cumulative frequency of eggs at various adult instars at two different temperature ranges (13–15 and 28–30°C).

4.3. *Egg production*

The mean number of eggs produced at each instar is graphically represented (Fig. 5). The number of eggs produced increases from the first adult instar till the penultimate instar when a sharp decline occurs as observed at the last instar (10th adult instar). This observation is in sharp contrast to that recorded for many temperate daphnids, *viz., D. pulex*[4], *D. longispina*[18] and *D. magna*[8] where peaks in egg production occur around the fifth adult instar followed by a decrease in egg production. In *S. acutirostratus,* two peaks in egg production (bimodal peaks) are observed, *viz.,* one at the 4th and the other at the 13th adult instars[14]. However, a similar pattern of increasing number of eggs till the penultimate instar has been observed in *D. carinata*[6] and *D. lumholtzi*[19], as in the case of *S. vetulus*.

Another observation made during the present investigation is that fecundity in *S. vetulus* increases with increase in body length and is an observation in accordance with those made by several earlier works on *Daphnia* species[20–23].

Brood size in *S. vetulus* is also influenced by temperature variations. At a low temperature range of 13–15°C, a maximum of 335 eggs were produced in comparison to a relatively low number of 125–150 eggs in the temperature range 28–30°C (Fig. 6). The effect of temperature on egg production has been studied by several earlier workers. Berg[24] found that if the temperature remained below 3 to 5°C for a long period, egg production stopped in *D. magna*, but started again when increased to 6 to 10°C. Tauson[25] studied *D. pulex* and found the temperature between 15 and 25°C

to be favourable for egg production but above and below these temperatures there was considerable diminution in the number of eggs produced. Similar effects at higher temperature have also been reported in *Ceriodaphnia* species[26] and *Moina macrocopa*[5].

4.4. *Embryonic development*

The embryonic developmental stages of *S. vetulus* are equally affected by temperature variations in the surrounding medium. The observed stages of embryonic development of *S. vetulus* can be compared with allied species of Cladocera, *S. acutirostratus* and *D. magna*. Green[20] and Murugan and Sivaramakrishnan[14] recorded eight stages in *D. magna* and *S. acutirostratus*, respectively. The duration of total developmental period was found to differ in all the three species with about 70 h (22°C) in *D. magna*, about 46 h (29°C) in *S. acutirostratus* and 120 h (13–15°C) in *S. vetulus*. These differences are evidently due to variations in temperature since in the present study the time of embryonic development was found to be about 60 h (28–30°C) which is close to that of *S. acutirostratus* (50 h at 29°C). Also, the available information on two other tropical daphnids, both reared at 28–31°C is similar to that of *S. acutirostratus* and *S. vetulus* (*C. cornuta* 38–40 h[26], and *D. carinata* 48 h[6]). Such fast rates of embryonic development in these species presumably enable them to build up dense populations in the prevailing high temperature of their habitats.

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