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Reproductive Behaviour and Parental Care of the Leech *Helobdella californica* (Hirudinea: Glossiphoniidae)

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Abstract

The reproductive biology of the leech *Helobdella californica* Kutschera (1988) was investigated on animals kept in aquaria. After copulation by means of reciprocal transfer of pseudospermatophores the leeches produce cocoons. Four to 7 cocoons, each containing 2 to 8 eggs, are squeezed from the female gonopore and attached to the ventral side of the parent. The larvae which hatch from these eggs cling to the ventral side of the parent. After they have used up their yolk supply and have developed into juvenile leeches they remain attached to the belly of the parent for a further 3 to 4 weeks. During this time the young are taking up food from crustaceans (*Gammarus*), watersnails (*Physa*) and oligochaeta (*Tubifex*), which are caught by the parent. Owing to this access of food the young grow from 1 to about 5 mm in length and develop the typical pigmentation of the adults before they leave the parent to lead an independent life.

Introduction

Leeches are carnivorous clitellates with terminal suckers serving in attachment, locomotion and feeding (Sawyer 1986). They are the only group within the Clitellata which has developed a complex array of parental care patterns (Sawyer 1971, Kutschera and Wirtz 1986a). Species of the family Erpobdellidae remain above a new deposited cocoon for several minutes but then permanently leave it. Fresh cocoons are in danger of being eaten not only by predators such as watersnails but also by conspecifics (Sawyer 1970, Kutschera 1983, 1986).

The habit of brooding the cocoons and offspring is known only of members of the family Glossiphoniidae (Sawyer 1971) and has reached a very high degree in leeches of the genus *Helobdella* (Kutschera and Wirtz 1986a). For the species *H. europaea* Kutschera (1987) and *H. stagnalis* L. it has recently been shown that the parent, which carries its cocoons, larvae and young attached to its belly, captures *Tubifex*-worms and gives them to its young (Kutschera and Wirtz 1986a b, c). Due to this access of food the young grow considerably in size while being carried and probably have a better chance of survival after they have left the parent.

In the present report I will describe the reproductive behaviour and parental care of the recently described species *H. californica* (KUTSCHERA 1988), a leech which feeds preferentially on crustaceans.

Materials and Techniques

Observations and experiments were performed between February 1986 and August 1987. *Helobdella californica* (KUTSCHERA 1988) (adult size: 12—18 mm) were collected from the underside of rocks and leaves in Stow Lake, Golden Gate Park, San Francisco, California. The leeches were kept at room temperature (18—24°C) in small aquaria (18×13×12 cm) which contained a few plants from their native habitat. They were fed on crustaceans (*Gammarus*), which were very common in their habitat, watersnails (*Physa gyrina*), and oligochaeta (*Tubifex*).

Results

Transfer of Pseudospermatophores

Copulation is achieved by means of hypodermic insemination: a pseudospermatophore, which functions as an injection canula, is rammed into the epidermis of the partner and sperm is injected through it (BRANDES 1901, SAWYER 1986). Two leeches would embrace each other with the anterior part of their bodies for about 30—60 minutes. Attachment of the pseudospermatophore is mutual and usually on the anterior part of the body of the partner in the region of the gonopores. The pseudospermatophores of *H. californica* are very small (< 1 mm long) and only detectable on the body of the leeches with a magnifying lens. One day after copulation the pseudospermatophores were no longer detectable on the epidermis of the leeches, indicating that the sperm had moved into the body of the partner and that the canula had disappeared.

Cocoon Production

Four to 5 days after transfer of the pseudospermatophores the leeches begin to produce cocoons. A few hours before cocoon deposition the white eggs are detectable through the body of the leech in the considerably enlarged ovaries. A clutch of eggs is pressed into the clitellar region (segments X—XII) by means of rhythmic contractions of the body. The cocoon membrane is produced inside of the body by clitellar glands surrounding the female gonopore (KUTSCHERA 1988).

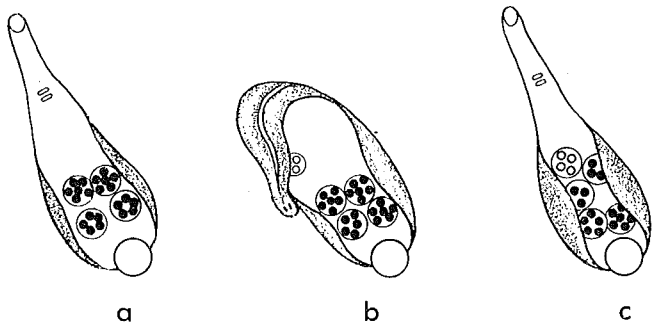

Fig. 1. Cocoon production. A leech already carrying 4 cocoons (a) bends the anterior part of its body and squeezes a cocoon from the female gonopore (b). The fresh cocoon is attached at the belly of the parent (c)

The leech bends the anterior part of its body to its ventral side, squeezes a cocoon from the largely expanding female gonopore, and attaches the fresh coccoon onto the ventral side of its body (Fig. 1a—c). The whole process takes about 1 to 2 minutes. After the cocoon is attached to the belly of the parent the leech starts to undulate its body flanks in a fanning motion until the white eggs, which are visible through the transparent cocoon membrane, turn to a pink colour (Fig. 1c). This process takes about 15 to 30 minutes. Then the leech produces the next cocoon, until a total of 4 to 7 cocoons are finally attached to the ventral side of its body (Fig. 1, 2a). The ball-shaped cocoons (diameter about 1—2 mm) contain 2—8 pink, yolk-rich eggs which are encased in a transparent, thin membrane (Fig. 2 b). During the whole time span of cocoon production the leech remains attached to the substrate with its posterior sucker.

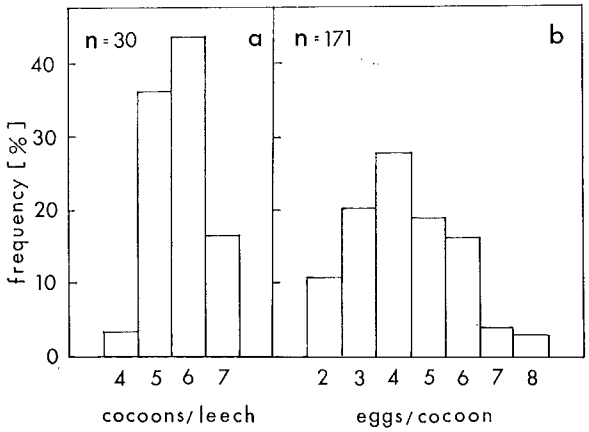

Fig. 2. Frequency distribution of cocoons per leech (a) and eggs per cocoon (b)

Parental Care

After the last cocoon is fixed at the belly the parent starts to move around and to forage. Leeches carrying cocoons continue to suck the blood from crustaceans (*Gammarus*), watersnails (*Physa gyrina*) and oligochaeta (*Tubifex*). The brood attached to the ventral side does not seem to have an adverse effect on the mobility and foraging behaviour of the leech.

Six to 7 days after cocoon production the larvae hatch and cling to the ventral side of the body by use of an embryonic attachment organ (NAGAO 1958). The larvae remain encased in the transparent cocoon membrane for about 2 days. Then the cocoon membrane decays and the larvae (about 0.5 mm in length) are thus no longer protected by a ventral cover. The leech can enfold its body flanks ventrally so as to cover the larvae completely. The developing offspring is hence effectively protected from potential predators. About 7 days after hatching the larvae have used up their yolk supply and are developed into about 1 mm long juvenile leeches which are fixed to the belly of the parent with their posterior suckers. The young leeches are transparent and have not yet developed the typical dark pigment pattern of the parent (KUTSCHERA 1988).

The juveniles are carried around by the parent for the next 3—4 weeks. During this time the young take up food from hosts which are caught and provided by the parent. A typical sequence of events as I could observe it about 20 times is depicted in Fig. 3a—d. A

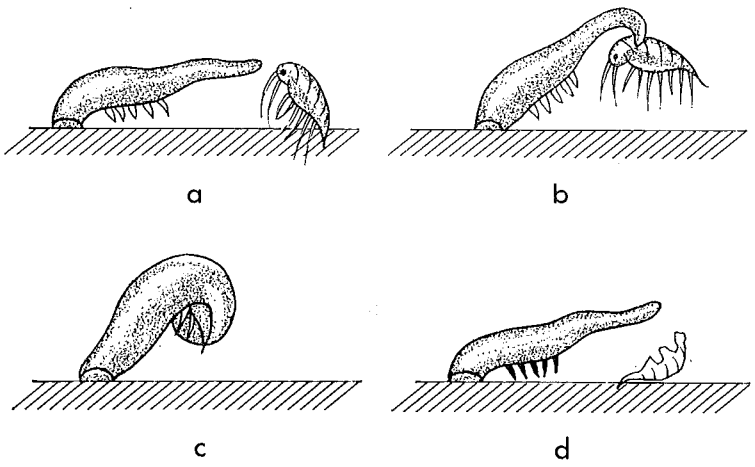

Fig. 3. Feeding behaviour. A leech carrying young encounters a *Gammarus* (a), captures it by inserting its proboscis (b), bends its body and sucks the haemolymph from the prey (c). The empty shell is discarded (d). Both the parent and the young have taken up food

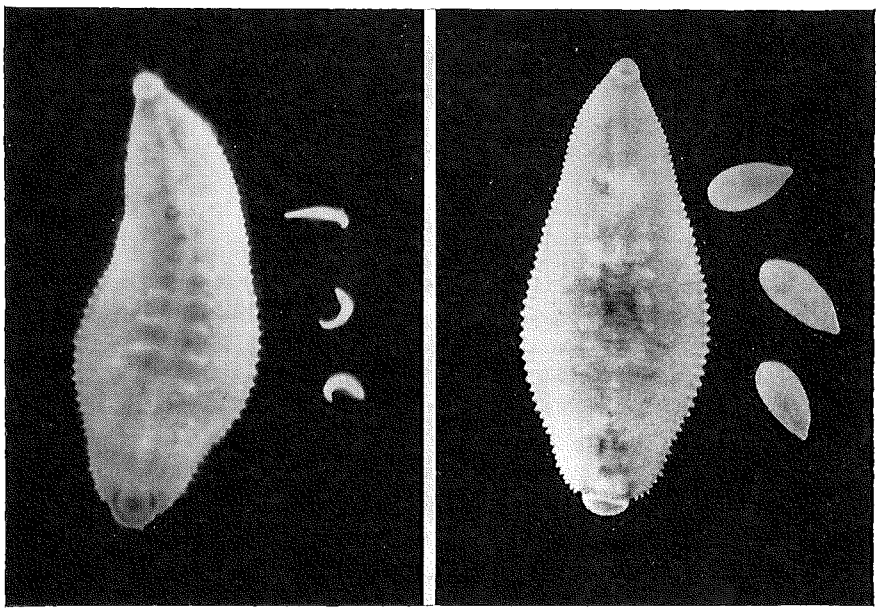

Fig. 4. *Helobdella californica* and young just after development from the larvae (left) and after a subsequent period of 3 weeks with the parent (right). The leeches were fixed in 80% ethanol and the young removed from the belly with a forceps (ventral view)

leech carrying young encountered a *Gammarus*, captured the prey by rapidly inserting its proboscis and bent the anterior part ot its body ventrally in order to prevent the prey from escaping. The parent and young would suck all body fluid from the *Gammarus* until the empty shell was discarded. The whole process took about 20—30 minutes. A similar behaviour was observed when watersnails (*Physa gyrina*) or oligochaeta (*Tubifex*) were offered as hosts.

Owing to this access of food the young grew from 1 to about 5 mm in length over the next 3—4 weeks and developed the typical pigmentation of the adults (Fig. 4). When the young had reached about 25 to 30% of the body length of the adult they used to sit on the dorsal side of the parent (Fig. 5a). The young leave the parent as a group after sitting together in a cluster over a period of several days (Fig. 5b). If *Tubifex*-worms were added

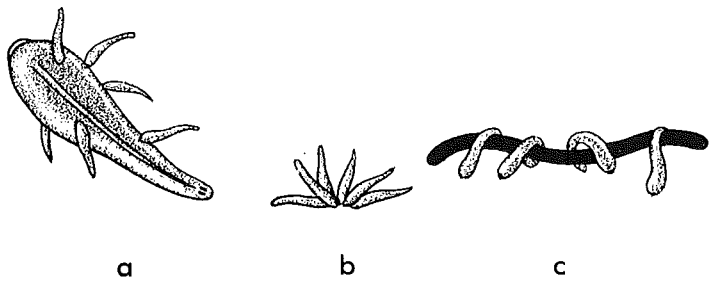

Fig. 5. *Helobdella californica* with young sitting on its dorsal side (a); young after leaving the parent (b) and young, sucking on a captured *Tubifex*-worm (c)

to the aquarium the young would capture the prey together by inserting their proboscises and suck the haemolymph until the pale, empty worm was discarded (Fig. 5c). If *Gammarus* or watersnails were added to the young no feeding was observed. Apparantly the young are not yet able to capture such agile and sturdy hosts.

Discussion

SAWYER (1971) was the first to propose a phylogenetic scheme of the possible evolutionary development of the brooding behaviour in the Hirudinea and to speculate on the probable selective pressures which led to this behaviour. The ancestral condition is represented by the Erpobdellidae and Piscicolidae which deposit their cocoons on the substrate and thereafter both eggs and young are unattended by the parent. Even the completely hardened surface of these flat cocoons does not protect the eggs and young from predatory attacks by watersnails (SAWYER 1970, KUTSCHERA 1983). SAWYER (1971) therefore suggested that the most likely explanation to account for the high degree of parental care in the Glossiphoniidae (which feed preferentially on snails) is that it evolved as a mechanism for protecting the eggs and young from predatory attacks by watersnails. This hypothesis is further supported by the finding that *Glossiphonia complanata*, a leech which shows only a moderate degree of parental care, actively defends its cocoons against watersnails (KUTSCHERA 1984). The protection is not perfect so that watersnails sometimes destroy all cocoons of the brooding parent (KUTSCHERA 1984).

Protection of the brood by the parent is much more advanced in leeches of the genus *Helobdella* which carry the cocoons and young attached to their belly. The recent discovery that *H. europaea* and *H. stagnalis* feed their young (KUTSCHERA and WIRTZ 1986a, b, c) has led to an extension and modification of SAWYER's phylogenetic scheme (KUTSCHERA und WIRTZ 1986a).

In the present report I have shown that the high degree of parental care as described for *H. europaea* and *H. stagnalis* is also established in *H. californica*. The cocoons and developing young are completely protected by the body of the parent so that predation by watersnails is prevented. Like *H. europaea* and *H. stagnalis*, *H. californica* captures hosts by inserting its proboscis and sucks the body fluid from its prey. The young participate in the meal and thus grow in size and develop their pigment pattern. In contrast to *H. europaea* and *H. stagnalis*, which feed their young with captured *Tubifex*-worms (KUTSCHERA and WIRTZ 1986a, b, c) I could never observe this behaviour in breeding *H. californica*. In all cases observed the parent took up food together with the young. The effect for the juveniles, however, remains in all three species the same: they leave the parent at an advanced state of development when they finally start to lead an independent life.

Zusammenfassung

Die Fortpflanzungsbiologie des Egels *Helobdella californica* Kutschera (1988) wurde untersucht. Nach Kopulation durch gegenseitiges Aufsetzen von Pseudospermatophoren produzieren die Egel 4—7 Kokons, welche am Bauch befestigt umhergetragen werden. Larven und Jungtiere werden ebenfalls am Muttertier befestigt getragen. Die Jungen saugen an vom Muttertier eingefangenen Krebsen (*Gammarus*), Schnecken (*Physa*) und Oligochaeten (*Tubifex*). Sie wachsen daher innerhalb von 3—4 Wochen von 1 auf 5 mm Körperlänge heran, bevor sie das Muttertier verlassen.

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