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## **Brood Care in *Scolopendra cingulata* LATREILLE** (Chilopoda: Scolopendromorpha)

by

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**Abstract:** Behavioural aspects and proximate factors of brood care in *Scolopendra cingulata* were studied under laboratory conditions. The life history of *S. cingulata* is characterized by a long-lasting juvenile phase before reproductive activity starts in the third year after hatching. In early summer females spend approximately 54 days caring for their eggs and larvae without leaving the brood chamber. Egg number is positively correlated with the female's weight before oviposition. Energy loss during development of the offspring was measured and gave no hint of a transfer of nutrients from the female. Nevertheless eggs and larvae younger than 35 days do not survive if they are isolated from the female. After moulting to the second larval stage the larvae pass through a short period of rapid hydration which is not possible without the female.

The function of the female concerning protection of the eggs from bacterial and fungal infections as well as the importance of female morphology for the hydration of larvae is discussed.

### **1. Introduction:**

A female strategy to maximize reproductive success is to increase the offsprings' chances of survival by brood care. Maternal care of the eggs and larvae has evolved in the epimorphous group of centipedes. The aim of this study is to investigate the proximate factors, that are responsible for the existence of brood care.

*Scolopendra cingulata* is a relatively large (up to 12 cm body length) centipede, common in the mediterranean region. During brood care females remain coiled around their eggs and larvae. Brood care in *S. cingulata* has been observed by HEYMONS (1901) and KLINGEL (1960), as well as in *Cormocephalus a. anceps* PORAT by BRUNHUBER (1970). Nevertheless the function of the maternal care is still uncertain. Therefore some data and experiments concerning the importance of brood care for the development of eggs and larvae are presented.

### **2. Material and Methods:**

Specimens of *Scolopendra cingulata* were caught in the north of Spain (Catalonia) in April and May 1987 and 1988, and kept in the laboratory in a climate chamber. Temperature of 30° C at daytime (7 - 17 h) and 20° C at night (17 - 7 h) and a light period of 15 hours were provided during brood care. Brood caring females were kept in non-transparent red plastic boxes (8 x 8 x 5 cm), filled with moist soil. Females accepted these boxes for oviposition and were observed by removing the lid of the boxes under dim red light. Eggs and larvae could be removed or replaced with pincers after moving aside the legs of the female.

A Mettler balance (AE 163) was used for weighing. Eggs and larvae were desiccated at 60° C for one week for the determination of dry weight. Caloric values were obtained by incenerating dried samples in a calorimeter (Fa. Morat, Mk 200).

For isolation experiments wire cages of 2 x 2 x 2 cm lined with aluminium foil were placed in a corner of the red plastic box, while the female with the offspring was coiled up in the centre of the box.

### 3. Results:

#### 3.1. Life History and Reproductive Success:

The time span in the laboratory from hatching to first reproduction is more than three years. Females oviposit only once each year in May or June ( $n = 50$ ) and never produce a second batch of eggs in the same year, even if the first is lost ( $n = 14$ ). Five females caught in 1987 successfully reproduced in four summers and are still alive. The number of eggs is positively correlated with the weight of the females before oviposition (Fig. 1) and varies from 10 to 49. Females smaller than 1.75 g in May did not oviposit.

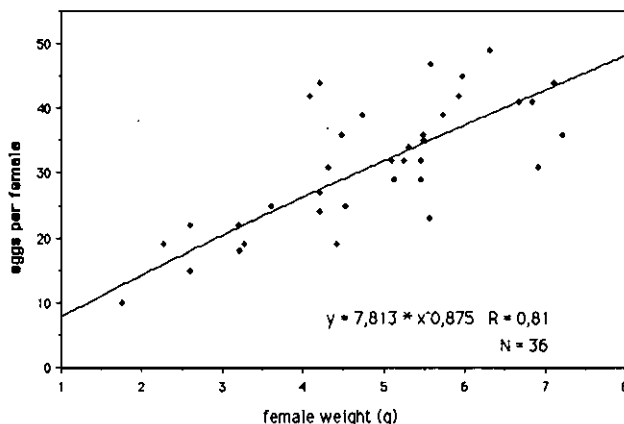


Fig. 1: Significant correlation of the female weight before oviposition and the number of eggs per female laid in one batch ( $r = 0.81$ ,  $p < 0.001$ ).

#### 3.2. The Development of Eggs and Larvae:

Contrary to HEYMONS (1901), "eggs" as here defined include the first embryonic stage. Three larval stages follow during brood care (second embryonal stage, fetus and first adolescent stage in HEYMONS 1901). The eggs are ovoid with a length of  $3.52 \pm 0.18$  mm ( $n = 10$ ) and width of  $3.30 \pm 0.32$  mm ( $n = 10$ ) and are filled with yellow yolk cells (for weight Tab. 1).

L1 is the first larval stage (fresh weight  $24.03 \pm 2.33$  mg, age 20 days,  $n = 26$ ); it remains motionless in a curved position and becomes apparent after the shedding of the chorion which takes place 19 days after oviposition under laboratory conditions.

L2 is the second larval stage which lasts 16 days (29th to 46th day after oviposition) and has an average fresh weight of  $45.31 \pm 6.12$  mg (age 37 days,  $n = 25$ ). L2-larvae are able to move around between the legs of the female but cannot feed.

After 47 days of brood care the larvae moult to the third larval stage (L3). They are pigmented and can feed (for weight Tab. 1). A few days after the larvae have moulted to the third larval stage brood care is terminated and the female leaves the brood chamber.

#### 3.3. Weight Changes of the Offspring:

Figure 2 shows the increase in fresh weight of eggs and larvae during brood care, as well as the slow decrease in dry weight. A gain in dry weight during brood care was never observed. Real energy loss in 53 days is 119.32 J, i.e. the difference between energy contents of eggs and larvae (see Tab. 1). An estimate of minimal and maximal amounts of energy required for development was gained by calculating the metabolic rates for eggs and L3-larvae from a regression graph of  $O_2$ -

Table 1: Comparison of actual energy loss by offspring during brood care and energy costs of metabolism.

	Eggs (1 day)	L3 (54 days)
Fresh weight [mg]	19,70 ± 1,12 (n = 42)	43,22 ± 6,54 (n = 36)
Dry weight [mg]	11,90 ± 0,74 (n = 42)	8,94 ± 1,52 (n = 36)
Energetic value <sup>1)</sup> [J · mg <sup>-1</sup> ]	28,44 ± 0,24 (n = 20)	24,51 ± 0,51 (n = 17)
Energy content per item [J]	338,44	219,12
Energy loss in 53 days [J]		119,52
Metabolic rate <sup>2)</sup> [μl O <sub>2</sub> · h <sup>-1</sup> · mg <sup>-1</sup> ]	0,117	0,105
Energy costs for metabolism <sup>3)</sup> [J · h <sup>-1</sup> · mg <sup>-1</sup> ]	0,00234	0,00210
Minimal and maximal energy needed for 53 days [J]	58,64	to 115,45

1) 2 samples each of eggs and larvae incinerated.

2) Calculated by extrapolation: O<sub>2</sub> consumption μl O<sub>2</sub> · h<sup>-1</sup> · g<sup>-1</sup>] = 66,24 · fresh weight [g]<sup>-0.146</sup>;  
R = 0,84; n = 7; p < 0,01; RADL, unpubl.

3) 1 μl O<sub>2</sub> = 0,02 J (value for lipids, SCHMIDT-NIELSEN 1979).

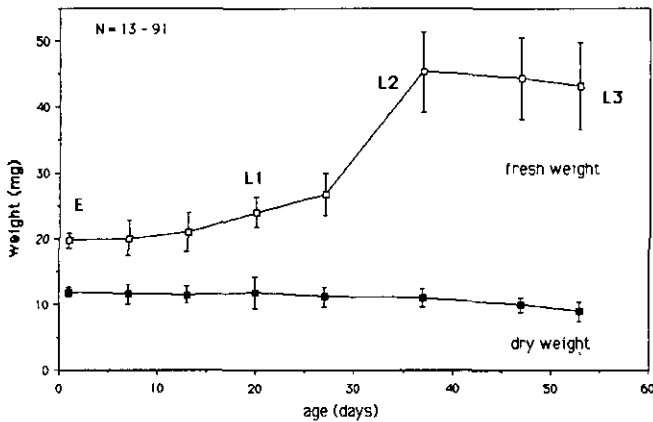


Fig. 2: Growth of eggs and larvae during brood care ( $\bar{x} \pm SD$ , data of 27 females).  
E: eggs, L1 to L3: first to third larval stage.

measurements with older larvae. The data obtained show (Tab. 1) that energy reserves in the eggs are sufficient for development to L3-larvae. Also the observation of maternal behaviour during brood care gives no evidence that eggs or larvae are provided with nutrients.

### 3.4. The Significance of Brood Care:

Can eggs and larvae survive without the mother? Eggs or larvae of different ages were isolated in the wire cages mentioned above in a corner of the red plastic boxes. The external appearance of the isolated offspring was compared with "controls" remaining with the mother.

Figure 3 shows the average number of days that eggs or larvae can survive in the wire cages. Isolated eggs and L1 do not survive longer than 2.5 days, by which time the surface is covered with bac-

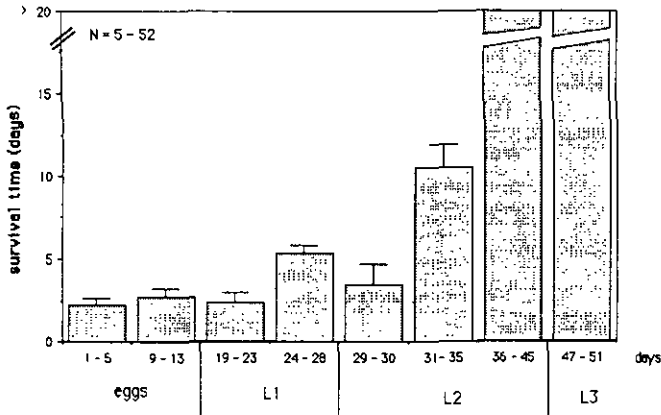


Fig. 3: Survival time of eggs and larvae isolated from the female in a wire cage ( $\bar{x} \pm SD$ ; data of 29 experiments).

teria and mold. Only larvae older than 36 days can survive without their mother and in no way differ in appearance from larvae in care of the female. After moulting to L2-larvae survival time in isolation is still very short. This was studied in another series of experiments.

Shortly before moulting to L2, larvae were isolated in wire cages as mentioned above and weighed regularly. L2-larvae with the female undergo rapid hydration, i.e. an uptake of water during the 60 hours following the moult (Fig. 4). Isolated larvae do not achieve this hydration and all die during the following days. Similar results are obtained even if the larvae were isolated up to 12h after moulting to L2 (U-test,  $p > 0.05$ ). During the period of water uptake I observed a parallel orientation of the larvae at the intersegmental folds of the female sternites.

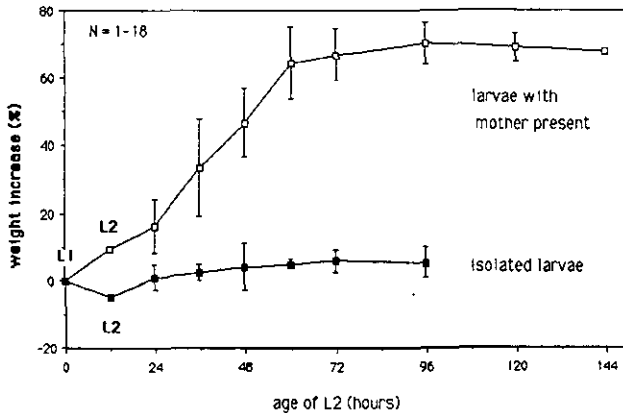


Fig. 4: Growth of L2-larvae (percentual weight change): larvae with mother and larvae isolated in a wire cage ( $\bar{x} \pm SD$ ): data of 1 to 8 females).

### 3.5. The End of Brood Care:

Moulting to L3 is possible even if the larvae are removed from the mother. There are no differences in weight or external appearance as compared with larvae with the female (U-test,  $p > 0.05$ ).

Approximately seven days after moulting to the third larval stage (i. e. 54 days after oviposition) the female leaves the larvae during the night and feeds outside. Sometimes the female returns to the larvae during the daytime, but never provides them with food. A few days later the larvae leave the burrow and live alone.

#### 4. Discussion:

HEYMONS (1901) and BRUNHUBER (1970) already reported that the eggs did not develop if separated from the mother. Why is the female necessary for survival of the offspring? The eggs or larvae are not provided with nutrients. In many insect species lipids constitute the major source of energy in embryogenesis (AGRELL & LUNDQUIST 1973). The decline of lipid content during development from egg to L3 in *Scolopendra cingulata* (RADL, unpubl.) and the decrease of caloric values per mg dry weight prove that lipids are used as energy-yielding substrates in this species.

However, isolated eggs or L1-larvae, although kept under the same temperature and humidity conditions as the controls with the female, cannot survive. The fresh weight of isolated specimens does not differ of that from controls (RADL 1991). Therefore the water balance of eggs and L1-larvae is not influenced by the mother. It seems essential for eggs and larvae younger than 35 days to be in permanent contact with the female to ensure protection from bacterial and fungal infections. Although eggs or larvae are not cleaned individually, except after contamination with soil particles, the female frequently cleans her own legs and sternites and never lets the offspring contact the ground. The transfer of anti-microbial agents from the female's accessory glands at oviposition or additionally from the surface of the maternal sternites is currently under investigation.

The hydration of the L2-larvae seems to require the mechanical properties of the female. By using water-soluble dyes in other experiments, I could show that water is absorbed in this period through the intersegmental cuticle of the larvae, and that hydration is also possible if L2-larvae are transferred to another female, which still has L1-larvae (RADL, unpubl.). Water drops on the mother's surface which run down in the intersegmental folds are absorbed by the larvae. Obviously, water drops which condense on the aluminium foil in the wire cages cannot be absorbed by the L2-larvae. It is still uncertain whether only the morphological structures of the female are involved or whether additional chemical properties are responsible for the hydration of the larvae.

#### 5. Acknowledgements:

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