LIFE CYCLE

Instars

A part of the present study deals with the life cycle of *Hippasa greenalliae* (Blackwall) (Syn. *H. Pantherina*) (Lycosidae) (Pocock, 1900) for the first time. It reveals the number of instars found in its life history as well as the duration of each instar. An attempt has been made to find out the relationship between the number of instar and its carapace width. This connection will help to identify a particular developmental stage or instar of the spider when they are collected from the field and compared with the laboratory reared ones. The width of the carapace is taken as a criterion to identify the instar because it is the least changing part in spiders (Dondale, 1961). The width of the carapace has been measured for each instar, from the 1st to the 8th instar. The line of measurement should pass through the same point of the carapace in all instars. The histological studies have been carried out to identify the instar in which the reproductive organs of the female begin to develop and in which they attain maturity. Simultaneous examination has also been done to find out the stage in which the neurosecretory cells become functional.

Observations show that in the cocoons separated from the adult females the eggs hatch after 16 days of oviposition. The first moult takes place within the cocoon after 13 days of hatching (Table 1). After the 1st moult the spiderlings become active within the cocoon. The adult females, which carry the cocoons sensing the movement of the young ones begin to tear the wall of the cocoon with the help of their chelicerae while rotating the cocoons with the help of the
Table 1. Duration and carapace width of the different instars of *Hippasa greenalliae*.

<table>
<thead>
<tr>
<th>Instar number</th>
<th>Duration in days ± S.D.</th>
<th>Carapace width in mm ± S.D.</th>
<th>Log. carapace width in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>13 ± 0.94</td>
<td>0.75 ± 0.07</td>
<td>-0.125</td>
</tr>
<tr>
<td>2nd</td>
<td>18 ± 1.48</td>
<td>0.75 ± 0.07</td>
<td>-0.125</td>
</tr>
<tr>
<td>3rd</td>
<td>20 ± 1.54</td>
<td>1.50 ± 0.17</td>
<td>0.176</td>
</tr>
<tr>
<td>4th</td>
<td>22 ± 1.26</td>
<td>3.00 ± 0.12</td>
<td>0.477</td>
</tr>
<tr>
<td>5th</td>
<td>25 ± 1.30</td>
<td>3.80 ± 0.12</td>
<td>0.580</td>
</tr>
<tr>
<td>6th</td>
<td>26 ± 1.34</td>
<td>5.00 ± 0.13</td>
<td>0.699</td>
</tr>
<tr>
<td>7th</td>
<td>30 ± 1.60</td>
<td>6.00 ± 0.14</td>
<td>0.778</td>
</tr>
<tr>
<td>8th</td>
<td>36 ± 1.26</td>
<td>7.60 ± 0.16</td>
<td>0.881</td>
</tr>
</tbody>
</table>
legs and spinnerets. They usually begin their cocoon opening activity in the late night and release these 2nd instar spiderlings between 3.10 a.m. and 3.50 a.m. (Maya, et al., 1984). The width of the carapace of the 1st instar is 0.75 mm (Table 1). The 2nd instar spiderlings mount on the body of the mother as soon as they are released from the cocoon. The duration of the 2nd instar spiderlings extends for 18 days. The maximum number of days for the 2nd instars are 20 and the minimum are 16. The maximum width of their carapace is found to be 0.8 mm and the minimum is 0.7 mm. The average width of the carapace is 0.75 mm.

It has been noticed that the widths of the carapace of the 1st and 2nd instar spiderlings are the same. The 1st instar spiderlings spend their time within the cocoon. The 1st and the 2nd instars are in the non-feeding stages. They are dependent upon the yolk stored in the abdominal region for their growth and development. A similar condition has been reported in other spiders also (Hagstrum, 1971). The 2nd instar spiderlings of *H. greenalliae* are dark in colour and actively move on the body of the adult. During the later period of the 2nd stadium they are separated from the adult and kept in separate vials. After moulting they reach the 3rd instar. From the 3rd instar onwards the spiderlings become independent and they start feeding because, by this time, the reserve yolk material is exhausted. The legs and chelicerae of the 1st and 2nd instar spiderlings are weak and so they are not in a position to follow the prey and kill them. In order to avoid starvation and death some amount of yolk is stored in their abdomen. This is an adaptation found among spiders and other animals with large yolky eggs. It has been already reported in the spider, *Tarentula kochi* (Hagstrum, 1971).
The 3rd instar is extended to 20 days. This instar is completed in 22 days in the maximum and 18 days in the minimum. The average width of the carapace is 1.50 mm. The maximum width of the carapace of the spiderling is 1.70 mm and the minimum is 1.30 mm.

The spiderlings take 22 days on an average to complete the 4th instar. The maximum days spent by them are 24 and the minimum number of days are 20. The width of their carapace is 3.00 mm on an average. The maximum width of the carapace recorded in them is 3.10 mm and the minimum is 2.90 mm.

The 5th instar spiderlings spend 25 days on an average. The maximum number of days spent by them to complete this stadium are 27 days and the minimum number of days are 23 days. The average width of their carapace is 3.80 mm. The maximum width of the carapace is found to be 4 mm and the minimum width is 3.60 mm.

In the case of the 6th instar it has been noticed that it takes 26 days on an average to complete the instar. The maximum number of days required to complete this instar are 28 and the minimum number of days required are 24. The average width of their carapace is 5.00 mm. The maximum width of their carapace is 5.20 mm and the minimum width is 4.80 mm.

The 7th instar lasts for 30 days on an average. The maximum period of this instar is found to have 34 days and the minimum period is of 26 days. The average width of the carapace of this instar is 6.00 mm. The maximum width of the carapace in them is 6.20 mm and the minimum width is 5.80 mm.
In the case of 8th instar 36 days on an average are required to enter the next instar. The 8th instar takes 38 days in the maximum to complete the stadium and 34 days in the minimum. The width of the carapace for the 8th instar is 7.60 mm on an average. The maximum width of the carapace in the 8th instar is 7.80 mm and the minimum width is 7.40 mm.

It can be noticed that the number of days required for each instar is also different. The 2nd instar takes 5 days more than the 1st instar. The 3rd instar takes 2 days more than the 2nd instar. The 4th instar requires 2 days more than the 3rd instar. The 5th, 6th, 7th and 8th instars require 3, 1, 4 and 6 days more than their previous instars respectively. A comparative study on the days required for the 8 instars of _H. greenalliae_ shows that the 1st instar requires the minimum number of days and the 8th instar requires the maximum number of days (Fig. 1). The total number of days needed to attain maturity in _H. greenalliae_ from the date of oviposition are 190 days (Table 1).

The increase in the width of the carapace has been calculated in each instar. The width of the carapace of the 1st instar is the same as that of the 2nd instar, i.e., 0.75 mm. The increase of the width of the carapace in the 3rd instar is 0.75 mm. In the case of 4th instar the carapace width has become doubled and the increase is by 1.50 mm. The increase of the width of the carapace from the 4th instar to 5th instar is 0.80 mm. The increase in the width of the carapace in the 6th, 7th and 8th instar takes place by 1.20, 1.00 and 1.60 mm respectively. It can be noticed that the width of the carapace is continuously increasing. But the increase in each instar is not found to be uniform (Fig. 2).
FIG. 1 DIAGRAMMATIC REPRESENTATION OF THE LIFE SPAN OF FIRST TO EIGHTH INSTAR OF H. GREENALLIIAE.
FIG. 2  DIAGRAMMATIC REPRESENTATION OF THE RELATIONSHIP BETWEEN THE CARAPACE WIDTH AND THE INSTAR NUMBER OF H. GREENALLIAE.
Therefore, an attempt is made to study the linear relationship between the carapace width and the instars. The data presented in the table 1 are recalculated as log values and a graph is plotted against log carapace width and instars (Fig. 3). It is found that the increase of carapace width is linearly related to advancing number of instars for H. greenalliae. The linear equation is \( y = -0.291 + 0.158 \times \).

The life cycle of every species of spiders has its own characteristic features. Therefore variations in the length of the instars and the width of their carapace have been noticed in many spiders. For example Gabritschevsky (1926) has reported that the 3rd instar of Misumena vatia lasts for 12 days which is the shortest duration found in this species. Its 8th instar extends for 80 days which is the longest period.

According to Bonnet (1930) the developmental stages of spiders donot conform to a standard time schedule. Studies on Tegenaria atrica show that the instars of a single brood have similar durations but the durations of the instars belonging to different parentage differ significantly (Browning, 1941). Deevey (1949) is of the opinion that the variations found in the duration of the instars in Latrodectus are due to the influence of inheritance. The 3rd instar of this species is found to have the highest survival rate. According to Whitcomb, et al., (1966) the 1st instar of Paucetia viridans has the shortest period i.e., 12 days. The duration of the instars from 2nd to 8th of this spider has 64, 79, 65, 37, 31, 21 and 18 days respectively. It can be noticed that the 3rd instar has the longest duration. It is interesting to note that in this spider the periods of instars are found to be reduced in the successive
FIG. 3 THE REGRESSION LINE SHOWING THE RELATIONSHIP BETWEEN THE LOG. CARAPACE WIDTH AND INSTARS OF H. GREENALLIAE.
instars. Whitcomb, et al., (1966) have further shown that the width of the carapace from the 2nd to 8th instar measures 0.90, 1.09, 1.33, 1.65, 2.03, 2.44, 3.04 and 3.66 mm respectively. Here it can be seen that though the width of the carapace increases in the successive instars the rate of increase is not uniform. Eckert (1966) has reported that in *Coelotes terrestris* the 1st instar has the shortest period, i.e., 5 days. The 2nd instar has 8 days. Its 3rd instar has 20 days whereas the 4th instar has 14 days. Their subsequent instars have increasing number of days. Thus, no uniformity has been found in the duration of the instars of *C. terrestris*. From the 1st to the 8th instar the width of their carapace measures 0.9, 1.1, 1.3, 1.8, 2.2, 2.6, 3.1 and 3.7 mm in length respectively. As in the case of other spiders the width of the carapace is found to increase but the rate of increase is not uniform. Subsequent studies on lycosids by Whitcomb (1967) show that though their developmental patterns are uniform the duration of each instar is found to vary. The results of the later studies on various species of spiders regarding the period of instars and rate of growth of their carapace concur with those of the earlier studies. For example, Miyashita (1968b) has indicated that the rate of growth of the carapace width in different instars of *Lycosa T. insignita* is not uniform. The width of carapace of its 1st to 4th instars increases by 1.7, 1.3, 3.4 and 2.6% respectively. In the case of *Pardosa lapidicina* Eason (1969) has shown that the duration of each instar varies from that of the other. Of them the 3rd instar has the shortest period, i.e., 8.8 days, and the 8th instar has the longest period, i.e., 41.2 days. After the 3rd instar the periods of the successive instars are found to increase, but not uniformly. Likewise the width of the carapace from the 1st to 8th instar increases
i.e., 0.58, 0.73, 0.91, 1.08, 1.37, 1.68, 2.04 and 2.4 mm respectively but not uniformly. According to Hagstrum (1970a) the 4th instar of *Tegenaria kochi* has 29 days to complete which has the shortest duration and the 7th instar has 40 days which has the longest duration. The width of the carapace from the 1st instar to 12th instar has been found to increase from 0.72 to 3.64 mm respectively without showing a uniform rate of increase. But Hagstrum (1971) has reported that the width of the carapace of the 1st to 6th instar of *T. kochi* increases 0.15 mm/stadium and in the 7th to 12th instar it increases 0.32 mm/stadium. Later Peck and Whitcomb (1970) have shown that the 1st instar of *Chiracanthium inclusum* has 9.5 days which is the shortest period. The 3rd instar has 14.7 days. The 5th instar has the longest period i.e., 23.9 days. The width of the carapace of the instar 5th is the same as that of the 6th instar. The carapace width of the other instars shows an increase in the successive instars but the uniformity in the increase is absent as in the case of other spiders. These data regarding the growth of the carapace and the duration of various instars are in accordance with the present findings on *H. greenalliae*. The absence of uniform rate of growth of the carapace in different instars may be due to the fact that each instar takes different number of days to complete the stadium which depends upon the genetic factors. Further it has been observed that there is no uniformity among spiders in the instar in which maturity is attained.

**Maturity**

Most of the females of *H. greenalliae* have been found to attain maturity in the 8th instar. A small number of these spiders have been observed to reach maturity in the 7th instar or in the 9th instar. There
is no particular instar in which all the spiders are found to mature. The lack of uniformity regarding the instar in which the spiders attain maturity has been observed in other spiders also. For example, Lawson (1933) has found that Latrodectus mactans reaches maturity in the 9th instar. Coeloces terrestris (Eckert, 1966) and Pardosa lapidicina (Eason, 1969) attain maturity in the 8th instar. According to Peck and Whitcomb (1970) Chiracanthium inclusum reaches maturity at any stage starting from the 6th to the 11th stadium. Levi (1970) has observed that the spider Thomisus onustus matures from the 7th instar to the 9th instar. Sadana (1972, 1974) has reported that Lycosa chaperi attains maturity in the 11th instar. Recent studies on Heteropoda venatoria show that they reach maturity at any stage after the 7th to the 9th moult (Jakubowski, 1981). Observations by Opell (1982) indicate that the male and the female spiders mature in the 6th instar itself. Forester and Kingsford (1983) have noticed that Latrodectus katipo and L. atritus mature only after 6 mouls, i.e., in the 7th instar.

The present study on the life cycle and development of female reproductive system of H. greenalliae shows that in the 3rd instar its ovary appears as a streak of tissue beneath the hepatopancreas. The growth of the ovary has been followed in the subsequent instars. Observations show that a large number of cells in the ovary begin to divide in the 4th instar and the yolk formation begins in the 5th instar. This has been inferred by the size, opacity of the oocytes and biochemical quantitative estimation. The process of yolk formation continues with greater momentum in the following instars till the females reach 8th instar where they attain maturity or become ready to mate. In different species of spiders the process of yolk deposition has been elaborately
analysed (Andre and Rouillar, 1957; Sotelo and Trujillo-cenoz, 1957; Andre, 1958; Nath, et al., 1959; Sareen, 1964; Osaki, 1971, 1972; Seitz, 1971; Verma, et al., 1975; Gowan, 1985). But studies in relation to the specific stage in which yolk deposition takes place in the spiders are very few. For example, Bertkau (1875) and Koch (1929) have noticed the deposition of yolk from the 5th stadium onwards. Eckert (1966) has observed the deposition of yolk in the 5th instar of Coelotes terrestris.

Observations on the development of neurosecretory cells in the central nervous system in H. greenalliae show that they are active only from the 3rd instar onwards. Their degree of activity has been inferred by the staining intensity. Different types of neurosecretory cells appear in the 4th and 5th instars. Each group is considered to control certain important activities. So far only in a few spiders the role of neurosecretory cells has been studied in relation to ovarian growth and yolk formation (Kühne, 1959; Legendre, 1959a; Seitz, 1971; Babu, 1973). In the present study it has been established that the neurosecretory cells of the brain influence the growth of the ovary and formation of yolk in H. greenalliae.