

DEVELOPMENT AND EGG SAC PRODUCTION OF *ACHAEARANEA TEPIDARIORUM* (C. L. KOCH) (ARANEAE, THERIDIIDAE) UNDER LONG AND SHORT PHOTOPERIODS

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ABSTRACT

The development and egg sac production of *Achaearanea tepidariorum* were investigated at 25°C and long (16L-8D) or short (10L-14D) photoperiod. The development of nymphs was completed in 30-80 days in 4-6 molts in the male and in 40-100 days in 5-7 molts in the female. Under the long photoperiod, the development of males was accelerated by the omission of one or two molts when food conditions were favorable, but under the short photoperiod such an acceleration tended to be cancelled by prolongation of either the last instar or the last and penultimate instars. This tendency was also observed in the female, but not so clearly as in the male. The development proceeded more speedily in complete darkness than under light. Adult females produced a mean of 9.7 egg sacs at intervals of 8.1 days. The mean egg number per sac showed a gradual decrease with time. The mean total egg number produced per female was 1812.7, and the mean longevity was 116.5 days in the female and 33.9 days in the male.

INTRODUCTION

The house spider, *Achaearanea tepidariorum* (C. L. Koch) is a cosmopolitan species, and quite abundant in many areas. However, studies on the biology and ecology of the spider are unexpectedly few. Although the life history of the spider must have a close connection to the seasonal change of environmental conditions in different localities, there are no detailed analyses on developmental characteristics in relation to the seasonal change in temperature and photoperiod.

In the present paper, I report the results from investigations on the development and egg sac production of the spider under laboratory conditions, with long and short photoperiods.

MATERIALS AND METHODS

The place where all experimental animals were collected was Abiko City (140°02'E—35°52'N), Chiba Prefecture, Japan.

First-instar spiderlings collected in June, 1984, were reared separately in vials 1.4cm in diameter by 3.0 cm in height. The vial size was increased as the development of each spider proceeded, adults being contained in vials 3.8cm by 10.5cm. In each vial, a strip of thick paper was placed as a substrate.

Spiders were reared at 25°C and long (16L-8D) or short (10L-14D) photoperiod. Light source was a 6w fluorescent tube, which gave 250-300 lux. Relative humidity fluctuated from 55% to 85%.

Rearings were divided into two experiments, A and B, according to the difference in food conditions. In the former, feeding intervals were 3-4 days, but in the latter 2-3 days for first and second instars only. Additionally, two groups were kept at 23°C, one in complete dark except for feeding and vial change, the other under 14L-10D in order to investigate the development under darkness.

Spiders were fed collembolans, mainly *Sinella cuspidatus*, during first and second instars and *Drosophila melanogaster* from third instar to adult. An excess number of collembolans was provided at each feeding. The number of fruit flies provided was changed from one to six following the process of the spiders' development.

The number of individuals used in each experiment varied from 12 to 30. The mortality ranged from 30% to 40% in first and second instars. After this period deaths occurred sporadically due to ecdysis failure.

Wild adult and last-instar females were collected in May 1984, and reared at 25°C and long photoperiod to investigate egg production. Each female was fed a single well-grown larva of *Phaenicia sericata* at the intervals of 3-4 days. Virgin females, except three, were mated with males in the laboratory. The egg sacs produced were removed together with first-instar spiderlings when they had emerged, and the number of spiderlings was counted as an indicator for total eggs since healthy egg sacs rarely contained dead eggs.

RESULTS

Effects of photoperiod on development.—Fig. 1 shows the difference in development of the males reared at 25°C and long or short photoperiod. In experiment A, the development was not significantly affected by photoperiod. The number of days required for the development from first instar to adult was 50-60 days, and the number of molts was five or six.

In experiment B, in which the food regimes during first and second instars were improved, the development was quite accelerated only under the long photoperiod. The development was concluded in 30-40 days, and the number of molts was five, except one individual which molted only four times. Under the short photoperiod, the development required 60-80 days and five or six molts. This difference was mainly due to the prolongation of either the last instar or both the last and penultimate instars. In other words, under the long photoperiod the developmental period becomes short by the omission of one or two molts, if food conditions are favorable. Under the short photoperiod, however, there occurs a tendency to prolong the last instar or both the last and penultimate instars, irrespective of difference in food conditions.

Fig. 2 shows the result for females. The result was essentially the same as the males show in Fig. 1. Developmental acceleration was also observed under the long photoperiod in experiment B. The prolongation of the last instar or both the last and penultimate instars was not clearly observed under the short photoperiod, although one female in experiment B molted seven times and spent more than 40 days in the last instar.

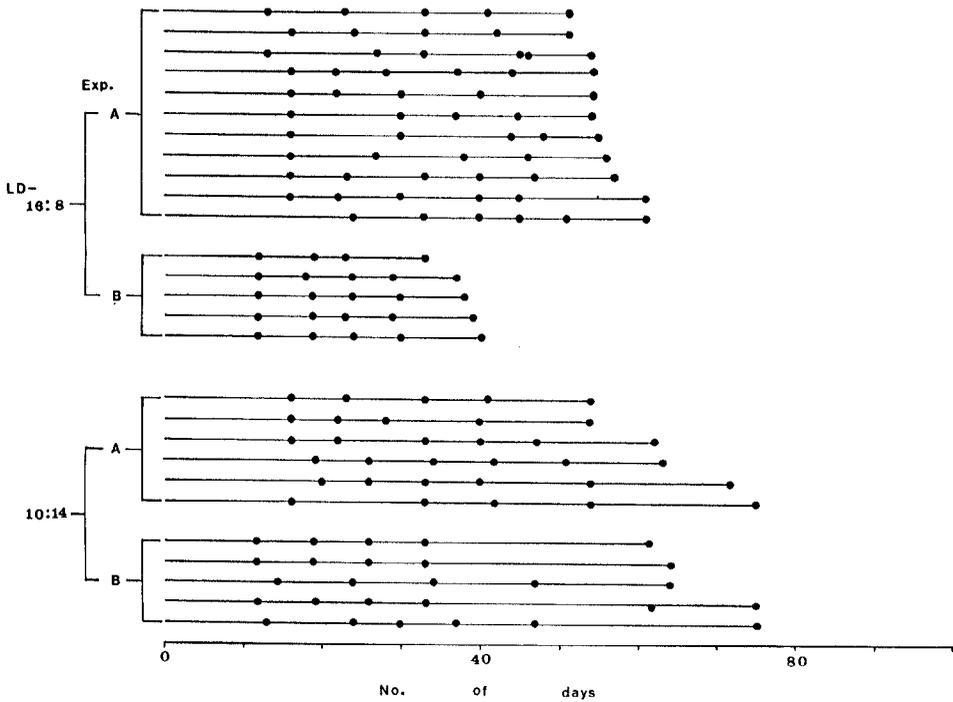


Fig. 1.—Development of males reared at 25°C and 16L-8D or 10L-14D. The length of horizontal line indicates the number of days required for development in each individual. Solid circle shows molt. In experiment A feeding intervals were 3-4 days, in experiment B 2-3 days for first and second instars.

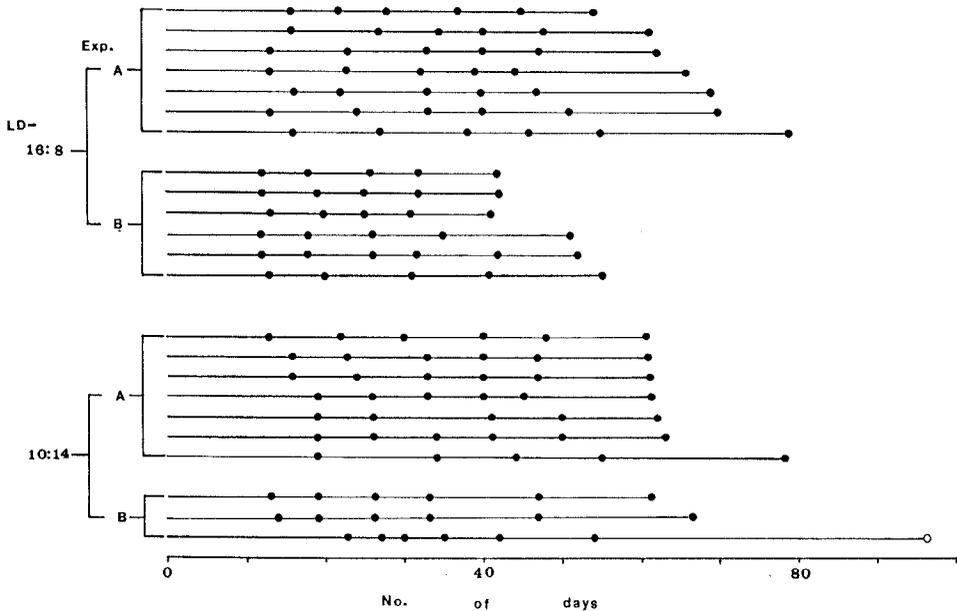


Fig. 2.—Development of females reared at 23°C and 16L-8D or 10L-14D. Symbols and experimental conditions are the same as in Figure 1. The bottom horizontal line with a hollow circle on the tail indicates the individual that passed the longest last instar and molted seven times.

Table 1—Carapace widths of adult *A. tepidariorum* obtained from laboratory rearings vs those collected from the field. The former were the individuals obtained from the experiments shown in Figs. 1, 2, and 3, and the latter those used for the experiment in Fig. 4.

Source	Sex	No. of molts	No. of indiv.	Mean (mm)	Range (mm)
Laboratory	Males	4	1	1.31	—
		5	20	1.50 ± 0.14†	1.31 — 1.75
		6	6	1.52 ± 0.08	1.38 — 1.63
		Total	27	1.49 ± 0.21	1.31 — 1.75
Laboratory	Females	5	3	1.71 ± 0.03	1.69 — 1.75
		6	12	1.83 ± 0.13	1.63 — 2.06
		7	1	2.25	—
		Total	16	1.95 ± 0.22	1.63 — 2.25
Field	Females	Unknown	16	2.16 ± 0.19*	1.94 — 2.41

† SD, * Significant in *t*-test(5%).

It should be noted that the body size of the females reared in the laboratory was significantly smaller than that of the individuals collected from the field (Table 1). Schaefer (1977) also noted that the body size of the reared *Clubiona phragmitis* C. L. Koch was smaller than that of individuals collected from the field. The cause(s) are unknown, but it could be due to a simplified menu in the laboratory rearing.

Development under complete darkness.—Fig. 3 shows the development under complete darkness as compared with that under 14L-10D. The graph shows that development under complete darkness proceeded more speedily than under 14L-10D. In four of the five females, the number of molts was also reduced. It can be said from these results that this spider is able to perform prey capture and feeding normally without visual sense. However, the reason why the development is accelerated under complete darkness is not understood.

Effects of photoperiod on egg sac production.—Fig. 4 shows the egg sac production of 15 females reared under either long or short photoperiod. The females which mated successfully either in the field or in the laboratory produced egg sacs during 2/3 or more of life span, irrespective of the difference in photoperiod. When mating was delayed, egg sac production was also delayed. When mating was prohibited, no egg sac was produced, except for one female which produced a sterile egg sac. It seems that the female receives enough spermatozoa to fertilize almost all the oöcytes in her body by a single mating.

The number of egg sacs produced per female differed from individual to individual. In addition, sterile egg sacs were occasionally produced in a series of otherwise healthy egg sacs. The total healthy egg sacs per female varied from 5 to 15. The mean was 9.7 ± 2.9 when three females which were prohibited to mate were excepted. Similarly, the mean egg sac production interval was 8.1 days when the sterile egg sacs were included. The mean egg sac production intervals for each individual are shown by the figures attached on the tails of each horizontal line in Fig. 4. The mean longevity was 116.5 ± 10.3 days. The mean egg period from egg sac production to the emergence of spiderlings was 11.0 ± 1.5 days.

In males reared under the same conditions, the mean longevity was 33.9 ± 4.4 days.

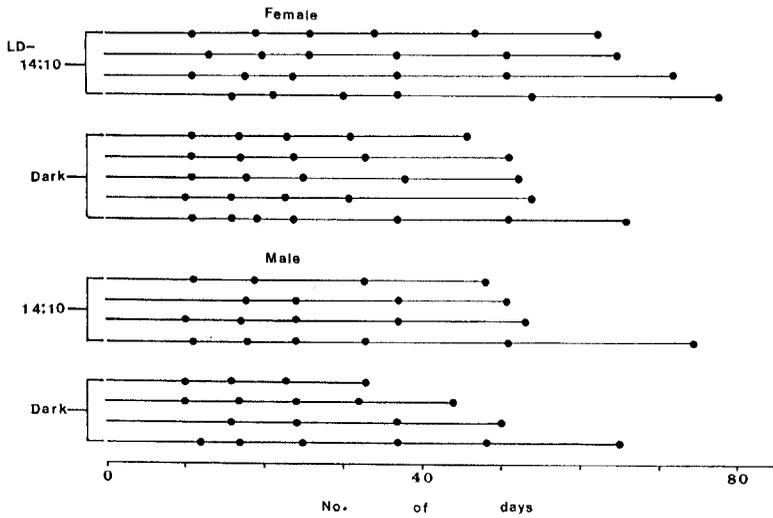


Fig. 3.—Development in both sexes reared at 23°C in complete darkness or 14L-10D. Symbols are the same as in Figure 1. Feeding intervals were 3-4 days.

Egg number per sac in relation to egg sac sequence.—Fig. 5 shows the relationship between the number of eggs per sac and egg sac sequence. In the graph, the sterile eggs were included in counts of the egg sac sequence but omitted in the calculation of the egg number per sac.

As shown by vertical lines, the range of variation in the egg number per sac was large irrespective of the egg sac sequence. However, the mean number of eggs per sac shows a gradual decrease with time. This tendency somewhat differs from that reported by Valerio (1976). He investigated egg sac productions at natural

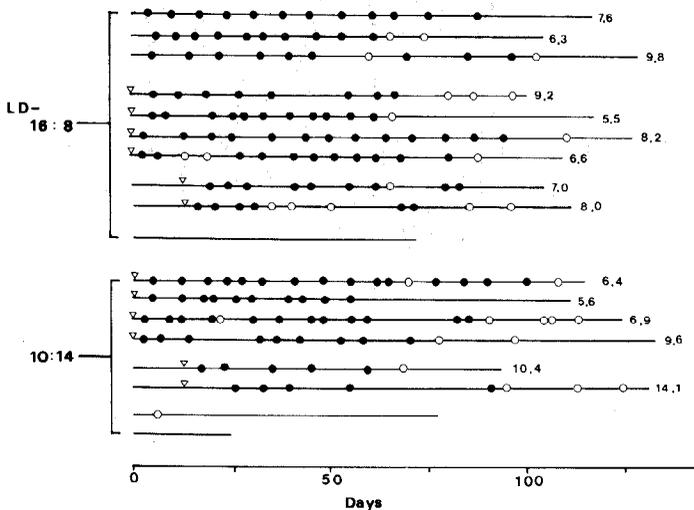


Fig. 4—Egg sac production at 25°C and 16L-8D or 10L-14D. Feeding intervals were 3-4 days. The lengths of horizontal lines indicate longevities in days for each female. Solid or hollow circles show healthy or sterile egg sacs, respectively. The upper three individuals were females mated in the field, and triangles indicate matings in the laboratory. Figures attached on the tails of each line indicate the mean interval between egg sacs.

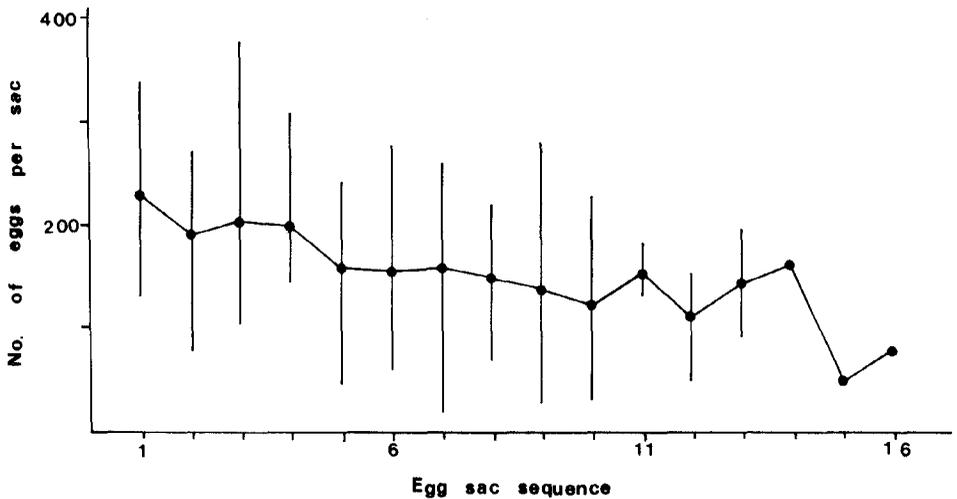


Fig. 5—The relationship between egg number per sac and egg sac sequence. Vertical lines and solid circles indicate the ranges and means of egg number per sac in relation to position in the sequence.

room temperature in the tropics, Costa Rica, and presented the result which indicated a downward curve with two peaks related to the females' ages.

The mean total egg number produced per female was 1812.7. This figure was quite small as compared with Valerio's 3211.9 in the tropics. As shown in Fig. 4, the female continued to produce egg sacs through 2/3 of her life, but the frequency of sterile egg sacs was somewhat increased in the latter half of adult life. In addition, several females began to construct incomplete, thin egg sacs from which eggs often dropped out when touched.

DISCUSSION

The development of the house spider seems to be very flexible. As shown in Figs. 1 and 2, when food conditions were favorable, the development at 25°C and long photoperiod was accelerated by omission of one or two molts. According to Kaston (1970), even under careful rearing at 25°C, the number of molts varied from three to six in the male and five to eight in the female of *Latrodectus hesperus* Chamb. and Ivie, and three to seven in the male and five to eight in the female of *L. mactans* Fabr. The same fact was also reported by Schaefer (1977) in *Clubiona phragmitis* C. L. Koch, *Tetragnatha montana* Simon, and *Alopecosa accentuata* (Latreille), and by Mansour et al. (1980) in *Chiracanthium mildei* L.Koch. Deevey (1949) reported that the developmental period and the number of molts in *L. mactans* were strongly affected by the available food amount. Miyashita (1968) also reported the same fact in *Lycosa t-insignita* Boes. and Str. It can be said, therefore, that the developmental flexibility of the house spider is connected closely to such a variability in number of molts. In addition, this flexibility will be reinforced further by a strong resistance to fasting. As shown in Table 2, the spiderlings emerging from the egg sac could survive for 16-30 days without food and water. It is of interest that the mean longevity was significantly shorter when they were kept in solitary than when kept in a group. The reason for this is unknown.

Table 2.—Mean longevities in days of spiderlings in solitary and group under fasting at 23°C and 4L-10D.

Condition	No. of indiv.	Longevity	
		Mean	Range
Solitary	33	15.5 ± 1.5†	12-23
Group	38	30.4 ± 1.8**	14-36

† SD, ** Significant in *t*-test (1%).

According to Schaefer (1977), there are two different groups among spiders in reaction to photoperiods, one retains normal development irrespective of the difference in photoperiod, and the other retards development under short photoperiod. If we follow this classification, the house spider seems to belong to the latter group. Hamamura (1982) reported that in *Philodromus subaureolus* Boes. and Str., the development in early life was accelerated by a short photoperiod but retarded by a long one, although this characteristic was reversed in overwintered nymphs developed up to middle stage.

In the house spider, a developmental acceleration occurred under the long photoperiod when food conditions were favorable, but a prolongation of the last instar or both the last and penultimate instars occurred under the short photoperiod (Fig. 1). This characteristic seems to have a close connection with the overwintering of this species. In the field, overwintering populations generally consisted of nymphs at different instars and of adults, but mainly nymphs, in the last instar or the penultimate one. Such a structure of the overwintering population will reasonably be explained by the above-mentioned characteristics in reaction to the short photoperiod, since egg sac production in the field mainly occurs during June and July.

When the overwintering nymphs were collected from the field at different dates during winter and early spring, and incubated at 23°C and 14L-10D, the length of period from the commencement of incubation to the resumption of molting became gradually shorter from winter to early spring as shown in Table 3. The same phenomenon was already reported by Miyashita (1969) in *L. t-insignita*, but in the house spider, the shortening degree in that length was rather small. Among overwintering adult females, both mated and virgin individuals were included, and the former collected in December of the previous year and January began to

Table 3.—Change in the period from the commencement of incubation to molt occurrence in the overwintering nymphs collected on four different dates. Incubation was made at 23°C and 14L-10D.

Condition	No. of indiv.		Longevity	
			Mean	Range
25 Dec. 1983	Female	4	15.2 ± 3.5†	10-21
	Male	1		
15 Jan. 1984	Female	3	14.4 ± 2.8†	11-20
	Male	2		
16 Feb. 1984	Female	4	11.2 ± 1.3†	3-13
	Male	2		
24 Mar. 1984	Female	2	8.0 ± 0.9†	7-10
	Male	3		

† SD

produce egg sacs after 20-30 days from the commencement of incubation. When the females which had developed to the adult stage during incubation were mated with the males obtained under the same condition, they began to produce egg sacs only 10 days from that mating. In addition, as shown in Fig. 4, egg sac production in the female was scarcely affected by photoperiod. It appears that the overwintering individuals are in a status similar to dormancy or diapause among certain insects and mites, but the degree of the spider's dormancy is not so strong, because every individual resumes feeding soon after the commencement of incubation. Bonnet (1935) inferred that this spider originated in the tropics. If this is true, an acquisition of the above-mentioned characteristics will probably have had an adaptive significance for expanding their habitat into the temperate regions of the world.

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