Seasonal Changes of Population Density and Some Characteristics of Overwintering Nymph of 
*Lycosa T-insignita* Boes. et Str. 
(Araneae: Lycosidae) 

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The seasonal changes in density of a *Lycosa T-insignita* population in an area of Tokyo showed two peaks, one appeared in spring and the other in autumn. The spring peak consisted mainly of the overwintered last instar nymphs and the adults which had emerged from these nymphs. The autumn peak also consisted of the nymphs larger than 1.0 mm in carapace width and the last instar nymphs which should overwinter. It was considered that this spider generally repeated two generations annually, since the adult emergence showed two peaks which appeared in spring and summer. According to the incubation experiment started in a different period from November of 1967 to March of 1968, it could be said that the overwintering last instar nymphs were inhibited in their development into the adult stage during late autumn and winter, suggesting that they were in a state of diapause. The degree of this inhibition of their development appeared most strongly in the period from November to December. The development during this period seemed to be partly advanced when food was provided during the incubation period. The disappearance of the inhibition of development began to occur in January and thereafter accelerated as the season progressed. The intensity of resistance against hunger among overwintering individuals changed parallel to the change in the degree of inhibition of the development into adult.

INTRODUCTION

*Lycosa T-insignita* Boes. et Str. is a common species of the hunting spider which lives in grasslands. However, the studies on the biology of this spider are quite unsatisfactory, and even its life history is not yet known. In this paper, I describe the seasonal change of population density and some characteristics observed in the overwintering individuals, especially the changes in the state of diapause, and in resistance against hunger.

MATERIALS AND METHODS

The seasonal change of population density was examined by using regular samplings of spiders from the field of our institute, in Tokyo, during 1967–1968.
The sampling of spiders was made by hand collection which was fixed in regard to time and place; i.e. the collection was carried out for 30 minutes walking about in an area of about 0.8 acre. The place where the collections were made was a plot overgrown with weeds. The collections were made once every month on a day when there were fine weather conditions at the beginning of the month. The spiders collected were preserved in 70 per cent alcohol for measuring carapace width.

In order to assess whether or not the overwintering individuals were in a state of diapause, the seasonal change in the length of the period from the start of incubation to occurrence of moult was examined in a laboratory where the temperature was kept at 27-28°C with an illumination of about 8,000 lux by fluorescent lamps for 16 hours a day. The individuals used were the last instar nymphs collected from the field during the period from October of 1967 to May of 1968. The spiders were kept individually in a test tube, 1.5 cm in diameter and 2.0 cm in length, with a cotton stopper. In this test tube, a very small glass tube with wet cotton and a long piece of thick paper were placed. The former is used for furnishing humidity for the spider and the latter for providing a foothold. The individuals kept in such a manner were arranged in two groups; i.e. one group was provided with 20–30 Drosophila melanogaster flies as food every second day, but food was withheld from the other group. In the latter case, the spiders were kept until the end of their life in order to assess the length of life under fasting conditions. The number of individuals used in each incubation experiment was 15, and the carapace width was measured with an ocular micrometer.

RESULTS AND DISCUSSION

1. Seasonal Changes of Population Densities and Number of Generations per Year

Fig. 1 shows the seasonal changes of population densities observed by monthly samplings of spiders in the field. In this graph, the fluctuations of the population densities of the small nymph, large nymph, the last instar nymph, adult, and the total of all of them, were shown respectively. In the cases of the last instar nymph and the adult, the population was divided into female and male. The classification of spiders into these groups was made according to the size of the carapace width and the sexual characteristics which appeared in the last instar and adult stages. However, this classification is only a rough estimate, since it was revealed by Miyashita (1968b) that the instar of this spider could not be determined exactly by the size of the carapace width. According to Miyashita's data, the "small nymph" described in this paper included the 1st to 3rd instars, and the "large nymph" the 3rd to 7th instars. In the "last instar female nymph", the 6th and 7th instars would be included partly, because discrimination between the last instar female nymph and the one for the preceding instar was very difficult. In addition, there is a considerable difference in the size of the carapace width between adults which emerged in the spring and in the summer. That is, the average carapace width of the adults emerged in spring (March-May) was 0.4–0.5 mm larger than that of the adults emerged in summer (July-September) as shown in Fig. 2. From this fact, it is suspected that the nymphs emerged in the summer were small in carapace width as compared with those emerged in
the other seasons. Therefore, in the case of individuals collected in summer (June-August), the larger nymphs of more than 1.6 mm in carapace width were excepted from the "large nymph" and included in the "last instar female nymph". In the case of individuals collected during the other seasons, those which were 1.0-2.0 mm in carapace width were classified as "large nymph".

![Graph showing seasonal fluctuations of population densities observed by monthly samplings of spiders from the field of the National Institute of Agricultural Sciences, Tokyo.](image)

As shown in Fig. 1-A, it is clear that the seasonal fluctuation in the total number of spiders was indicated by a curve with two peaks, one appearing in spring and the other in autumn. It was reported by some workers that a similar tendency was observed even in the mixed populations of spiders living in the forests (Elliott, 1930; Vitè, 1953) and orchard (Dondale, 1958). In these cases the spring peak was thought to be attributed mainly to an influx of spiders from overwintering places, and the autumn one to the emergence of the next generation. Although the above explanation may also be applicable to L. T-insignita, the autumn peak mainly consisted of large nymphs and the last instar nymphs which should
overwinter. Meanwhile the spring peak of the next year consisted of the overwintered last instar nymphs and the adults which had emerged from these nymphs. Thus, both peaks of the total number observed in autumn and spring of the next year were attributed mainly to the same population for the periods before and after the overwinter. A fall of the curve during winter seems to have resulted largely from the reduced rate of collection, because the overwintering individuals are very difficult to discover in the field at that time due to their inactivity, and this is especially true in the period from December to February.

The cause of the decrease in the total number of spiders during summer is not clear, but a heavy mortality in the summer generation can be suggested.

On the other hand, the adult population also showed a seasonal fluctuation with two peaks; the one appeared in spring and the other in summer (see Fig. 1-B♀ and B♂). Thus, it can be said that L. T-insignita generally repeats two generations annually in the Tokyo area, but the boundary between the overwintered generation and the summer one is not distinct, since both generations overlap considerably. This overlapping of generations seems to be caused mainly by the fact that the overwintering populations contain young nymphs in considerable numbers besides the large and last instar nymphs, and that some females make the second, or, at times, third oviposition without additional copulation (see Table 1).

Table 1. **Number of Females Which Made the First, Second, and Third Oviposition, Average Number of Eggs Produced in Each Oviposition, and Unhatched Eggs plus Nymphs Dead in Egg-Sac Shown in Per Cent (No. of Females Examined was 13)**

<table>
<thead>
<tr>
<th>Oviposition</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. females</td>
<td>13</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>No. eggs produced</td>
<td>60.1±17.0</td>
<td>38.5±19.8</td>
<td>34</td>
</tr>
<tr>
<td>Unhatched eggs and dead nymphs</td>
<td>3.6</td>
<td>18.2</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The females used were collected on May 1, 1968.
Changes of Population Density of Lycosa T-insignita

Since the generations overlap, age distribution of the total population in summer and early autumn was rather complex, but that in late autumn and early winter consisted mainly of the large size individuals, especially the last instar nymphs. The explanation of why such a tendency occurred is very difficult to give, but a suspected cause is that the development of individuals which have reached the last instar by middle to late autumn is inhibited or retarded due to their overwintering.

2. Some Characteristics of Overwintering Individuals

Under the field conditions, it has frequently been observed that the overwintering individuals actively run about on the ground even during winter, when weather conditions are fine and warm. In addition, it was confirmed that the overwintering last instar nymphs showed a strong appetite when they were provided food in a warm room (Miyashita, 1968a). From these facts, there arose a question as to whether or not the overwintering individuals are in a state of diapause like that of certain insects and mites.

Fig. 3 shows seasonal changes in the percentage of individuals that developed into adults when the last instar nymphs in the field were collected and incubated on different dates during the period from November of 1967 to March of 1968, and the length of the period from the start of incubation to the occurrence of moult.

When the spiders were incubated, withholding food, the individuals collected in October and early November did not moult, but the moultng began to occur in the individuals collected in late November and thereafter. The percentage of moulted individuals increased gradually from November to February of the next year, and reached 100 per cent in the middle of March. When the spiders were
incubated, providing food, on the other hand, all the individuals moulted normally irrespective of the difference in the dates of incubation. This fact suggests that, if the overwintering individuals are allowed to take food, their development is partially advanced even in the overwintering period, especially during the early period of overwintering.

From the incubation data for the individuals which moulted in each experiment, it is possible to calculate the average number of days from the start of incubation to the occurrence of moult for the groups of spiders incubated on different dates in winter and early spring. These average numbers of days indicated the length of the period required for the moult into adult among the individuals which had experienced different lengths for the overwintering period. As shown in Fig. 3, the length of the period required for the moult in the incubation experiment, withholding food, was 12-14 days during the period from late November to late December, but it showed a sharp reduction in January. After January, this length of time was reduced gradually, and it finally became 1-2 days by the middle of March. Therefore, the curve showing the seasonal change in the length of the period was bent downward at around early January. In the incubation experiment providing food, the result was also similar, but the length of time began to be reduced from early December. Therefore, the curve did not bend strongly, so that it became rather smooth instead.

According to field observations, the first emergence of the male adults from the overwintered last instar nymphs was found in late February, and about 90 per cent of the overwintered last instar male nymphs were estimated to have developed into adults by the middle of March. In the female nymph, only 10-13 per cent had developed into adults by this period.

It is clear from the above results that the development of the overwintering last instar nymphs to adults was inhibited in different degrees during the respective periods of overwinter. In other words, it can be said that the overwintering individuals are in a state of diapause. This inhibition of development appeared most strongly in the individuals collected during the early period of overwinter, especially during the period from early November to late December. The disappearance of the inhibition began to occur in January, and was accelerated thereafter as the season progressed.

Fig. 4 shows a change in the average length of life under fasting conditions among individuals which were collected on different dates during the period from October to May. This average length of life under fasting conditions is thought to represent the intensity of resistance against hunger. The curve of the seasonal change in the length of life under fasting conditions showed a sharp rise from October to December, and then dropped thereafter.

The commencement of this drop in the curve coincided with the time of a sharp reduction in the length of the period from the start of incubation to the occurrence of moult. In other words, the seasonal change in the length of life under fasting conditions was closely related to the seasonal change in the length of the period from the start of incubation to the occurrence of moult. Thus, it can be said that the change in the resistance to hunger is closely connected with the change in the state of diapause.

As shown in Fig. 4, the curves showing the seasonal changes in the average
Changes of Population Density of *Lycosa T-insignita*

Fig. 4 Seasonal changes in the length of life in the last instar nymphs under fasting conditions (thick solid and dotted lines) and 10-days averages of air temperature at Nishigahara, Tokyo (fine solid and dotted lines).

Lengths of life under fasting conditions in 1967 and 1968 were very similar in shape, but differed in height. The cause of this difference was not clear. No relationship between this difference and the difference in seasonal changes in 10 days averages of air temperature was found. It seems, however, that this may be caused by the difference in food conditions during the period from late autumn to early winter in both years.

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REFERENCES

K. MIYASHITA


