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Seasonal Food Supply for the House Spider, *Achaearanea tepidariorum* (Araneae, Theridiidae) in Northern Japan

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Abstract Seasonal food supply for the house spider, *Achaearanea tepidariorum*, was investigated from 1985 to 1986 on the campus of Hirosaki University, Aomori Prefecture. A total of 1490 animals caught by the spider were collected in the two years census and classified into 15 orders of arthropods, in which wingless animals predominated. The abundance of the wingless animals in the diets might be due to the web structure of this spider. Though the spiders fed at any time, more than half of the prey items were captured during the daytime (6: 00–18: 00). The seasonal food supply as inferred from the rate of predation shows an unimodal pattern with a peak in July. The result corresponded well with the seasonal trend of the number of possible prey animals collected by sticky traps in the same field. As this spider continues to reproduce over a long period of time, its nymphal development should be considerably affected by the seasonal food supply.

Introduction

Seasonal availability of food resource might be expected to be an important factor in the evolution of life cycle strategies in arthropods. In order to elucidate this question, I carried out preliminary investigations of the seasonal food supply for a house spider, *Achaearanea tepidariorum*, in natural condition at Hirosaki, Aomori Prefecture. In this paper, I will describe the results of this field survey and discuss the feeding activity characteristics and the seasonal food supply in this spider.

Materials and Methods

I marked spiders by fixing numbered pieces of sticky tape to the nesting sites on the outside walls of buildings on the campus of Hirosaki University from March to November, in 1985 and 1986. I counted and collected the prey animals being captured on the spider's web every 3 hr for a period of 24 hr. The feeding rate of spiders was represented by the number of captured prey per spider per 24 hr. Since the handling time of spiders for a small-sized prey might be shorter than 3 hr, the feeding rate might be to some extent underestimated. This survey was made on 24–25 March and 31 March – 1 April, 28–29 April, 5–6, 12–13 and 26–27 May, 30 June –

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1 July, 21–22 and 28–29 July, 11–12 and 24–25 August, 8–9 and 15–16 September, 10–11 and 27–28 October and 17–18 November in 1985, and on 30–31 March, 13–14 and 20–21 April, 5–6 and 25–26 May, 8–9, 14–15 and 29–30 June, 6–7, 13–14, 20–21 and 27–28 July, 3–4, 17–18 and 24–25 August, 14–15 and 23–24 September, 5–6 and 26–27 October and 23–24 November in 1986. Number of marked spiders in each survey was 136, 176, 185, 221, 156, 115, 96, 68, 80, 124, 165, 213, 278, 278, 301 and 145 from 24–25 March to 17–18 November in 1985, and 140, 175, 208, 208, 269, 138, 111, 65, 53, 50, 42, 48, 51, 217, 264, 386, 382, 319, 201 and 107 from 30–31 March to 23–24 November in 1986.

The seasonal abundance of small flying insects such as chironomids and other dipterans, aphids and winged ants was estimated by means of the number of those animals collected with sticky traps in 1986. Three sticky traps were set up in the study site at 2.0 m intervals for each 24 hr survey. The top of each trap was situated at a height of about 1.6 m from the ground.

Results

1. *Prey composition*

A total of 583 prey items were collected in 1985, and 907 in 1986. Most of them were identified to the order level (Table 1). At least 15 orders were recognized. In both years, Hymenoptera accounted for about 30% of all and most of them were ants. Other common prey animals were Diptera, Hemiptera, Isopoda and Acarina. Only 7 house spiders were recorded as prey throughout the two years census. The fact suggests that the cannibalism is rare in this spider.

The prey composition varied with season, but the seasonal changes were similar in 1985 and 1986. In both years, Dipterans were abundant prey animals in March – April, but it rapidly decreased in May – June. On the other hand, ants (workers) and mites in the menu rapidly increased in May – June. Ants (workers) were also abundant from July to August, but mites were not. In addition to workers, many winged ants emerged and were captured in June, 1985 and July and August, 1986. Proportion of ants in the summer food was therefore very high and the maximum was 59.2% in July, 1985. Although the proportion of ants in the prey gradually decreased from September to November, they were important prey items available throughout the active season. The prey composition in the autumn differed to some extent from that in the summer. For example, the September samples included about 30% of isopods. In October – November, many dipterans and hemipterans were involved (Table 1). Such seasonal change of the prey composition might reflect the seasonal activity of the prey species.

The prey items were classified into two categories. One is winged and the other wingless. The latter is marked in Table 1. It is noticeable that about half of the prey items (52.0% in 1985 and 47.1% in 1986) were wingless. This suggests that those wandering on the wall or ground such as ants, mites and isopods are important

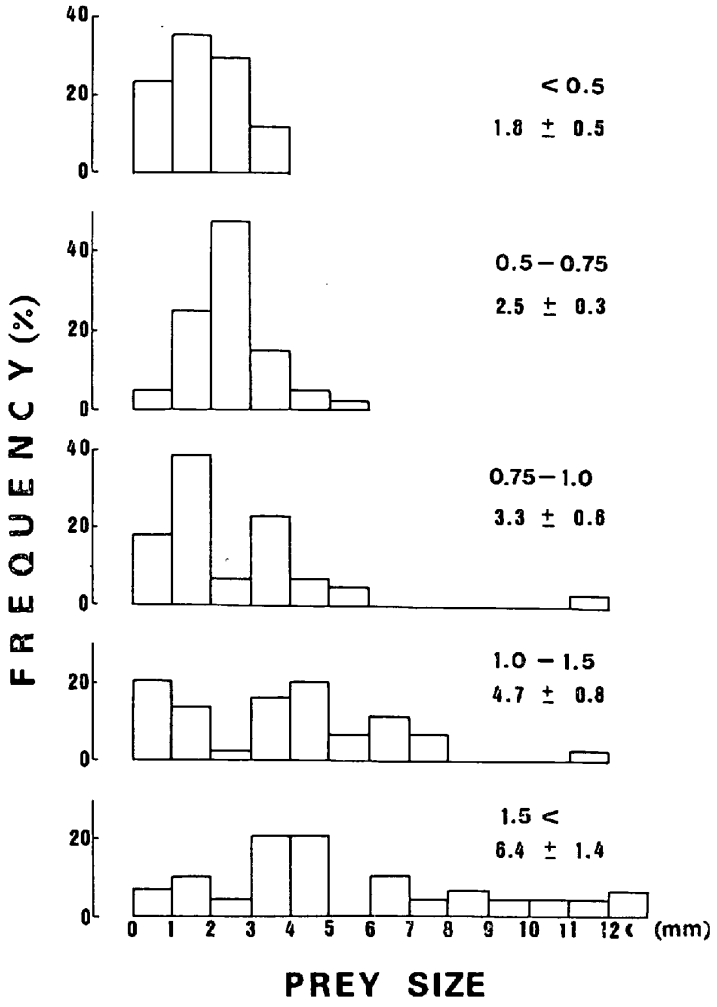

Fig. 1. Frequency distribution of body length of prey items captured by various sized house spider, *Achaearanea tepidariorum*. Numerals in the figure indicate size group of spiders (carapace width) and the mean prey size (mean±95%C. L.). Sample size: 17, 40, 44, 44 and 29 from top to bottom.

food for this spider.

2. *Prey size*

In order to elucidate the relationship between spider size and prey size, both spider and its prey items were collected on the campus in August, 1986 and the carapace width of the spider and the body length of prey were measured as indicators of body size. Spiders were divided into 5 size groups by means of the carapace width (<0.5, 0.5–0.75, 0.75–1.0, 1.0–1.5 and 1.5<).

Figure 1 shows the frequency distribution of prey size captured by each size group of spiders. The menu of small spiders with the carapace width less than 0.5 mm consisted of only small animals of less than 4 mm in body length. On the

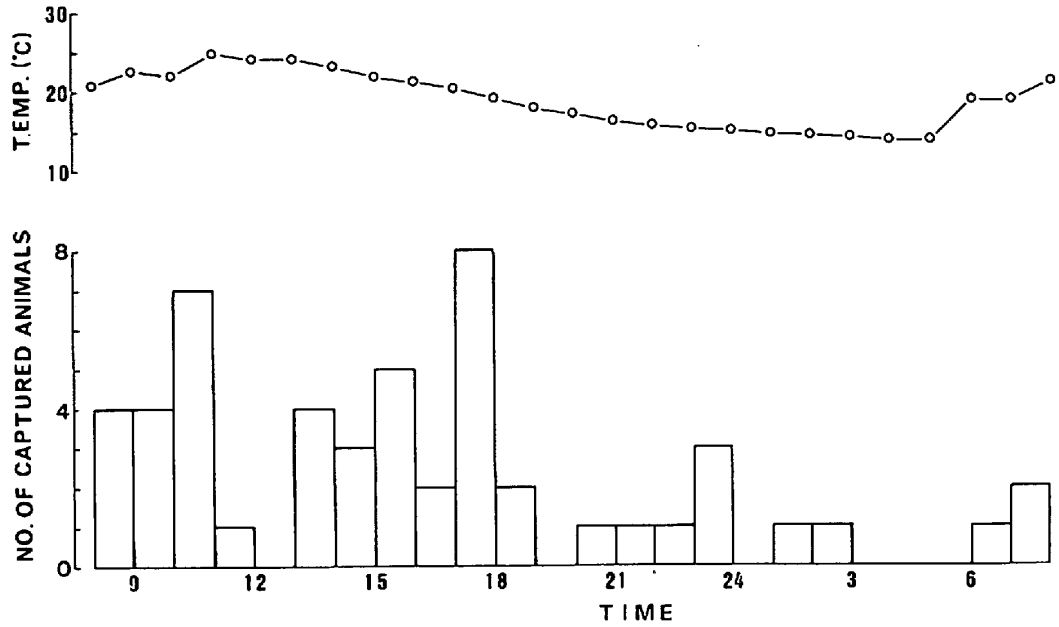

Fig. 2. Daily feeding activity of the house spider, *Achaearanea tepidariorum* and temperature on the campus in 20–21 July, 1986. Each histogram represents the number of captured prey items every 1 hr.

other hand, the large spiders with the carapace width more than 1.5 mm caught larger prey items than the small spiders, and the upper limit of the prey size was at least more than 12 mm. The prey size and its range thus increased with the carapace width of spiders and the body size of spiders limited their prey items.

3. *Daily feeding activity*

The daily pattern of activity of the spider might have a great effect on the number of its prey animals. Then I investigated the daily feeding activity by counting the captured prey items every 1 hr for a period of 24 hr in 20–21 July, 1986.

Figure 2 shows the result. The spiders fed at any time, but the number of animals they captured during the daytime was three times as many as that in the night. In order to elucidate whether this was a general trend or not, the numbers of animals eaten by the spiders during 6: 00–18: 00 hours and during 18: 00–6: 00 hours were compared in the monthly samples (Fig. 3). Except for the Septeber samples, more than half of the pery items were captured during the daytime both in 1985 and 1986. It is unknown whether this difference depends on the daily activity rhythm of the spider itself or on that of prey animals, or, on the other hand, on other conditions (temperature, light, humidity, etc).

4. *Seasonal fluctuation of food supply*

The food supply may be reflected in the rate of predation (the number of cap-

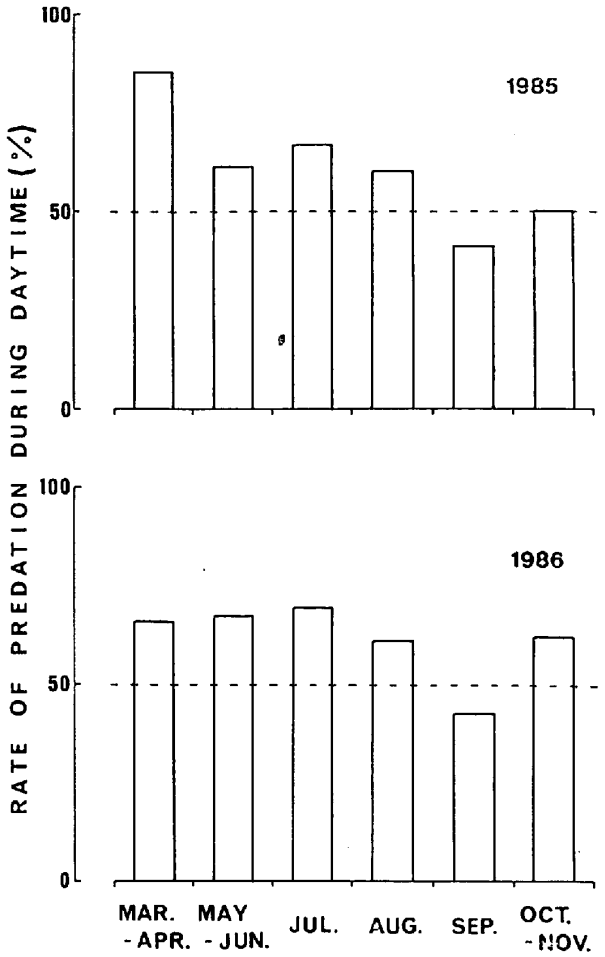

Fig. 3. Seasonal change of the daytime predation rate (6: 00–18: 00) in 1985 and 1986. Each histogram represents the relative percentage of daytime predation in each monthly total.

tured prey per spider per 24 hr). Figure 4 shows the seasonal change of the rate of predation in 1985 and 1986. In both years, it increased abruptly in July and reached a peak in mid or late July. In August, it began to decrease and any predation was not observed in winter. Consequently, the seasonal change of the feeding activity of the spider shows an unimodal curve.

5. *Seasonal prey abundance*

The number of flying insects captured by sticky traps were given in Fig. 5, which shows an unimodal pattern with a peak in early August. This trend closely corresponds with that of the rate of predation in 1986 (Fig. 4). Although no data are available for the crawling animals that account for about half of the prey animals taken by the spider, this correspondence suggests that the prey abundance is significant for the rate of predation.

Table 1 (on pp. 848–849). Prey animals caught by the house spider, *Achaearanea tepidariorum* in 1985 and 1986 shown as percentages of each monthly and yearly totals.

Order	1985						
	Mar.–Apr.	May Jun.	Jul.	Aug.	Sep.	Oct.–Nov.	Total
Hymenoptera	28.6	21.8	60.5	45.5	29.6	13.3	32.4
* Ants(worker)	28.6	21.0	25.9	45.5	27.0	13.3	26.8
Ants(winged)	—	—	33.3	—	1.3	—	5.0
Wasp	—	0.8	1.2	—	1.3	—	0.7
Coleoptera	3.6	10.5	7.4	—	3.1	1.1	4.5
Diptera	39.3	4.8	1.2	10.9	3.1	20.0	8.9
Chironomids	32.1	2.4	—	10.9	—	—	3.9
Others	7.1	2.4	1.2	—	3.1	20.0	5.0
Lepidoptera	—	—	—	—	1.3	—	0.3
(adults)	—	—	—	—	—	—	—
* (larvae)	—	—	—	—	1.3	—	0.3
Hemiptera	—	13.7	—	5.0	8.8	21.1	9.4
Aphids	—	13.7	—	1.0	4.4	16.7	6.9
Others	—	—	—	4.0	4.4	4.4	2.6
Orthoptera	—	0.8	1.2	—	1.9	1.1	1.0
Dermaptera	—	0.8	—	—	—	—	0.2
*Isopoda	14.3	12.1	11.1	1.0	28.3	20.0	15.8
*Acarina	3.6	25.0	1.2	4.0	1.9	4.4	7.5
*Araneae	3.6	0.8	—	1.0	0.6	2.2	1.4
A. tepidariorum	—	—	—	1.0	—	1.1	0.5
Others	3.6	0.8	—	—	0.6	1.1	0.9
*Scolopendromorpha	—	0.8	—	—	—	—	0.2
Unidentified	7.1	8.9	17.3	31.7	20.8	16.7	18.4
Total no. of animals	28	124	81	101	159	90	583

* Wingless animals.

Discussion

The results of this survey indicate that the house spider is a polyphagous predator, eating various kinds of insects and other arthropods (Table 1). The larger proportion of the menu occupied wingless animals (Table 1). This may be due to the preying behaviour. The house spider is a scattered line weaver (RIECHERT & CADY, 1983). From the center of the web, many sticky threads are pulled to the ground or wall and these are called gum-footed threads (YOSHIKURA, 1986). This structure of the web is suited to trap animals wandering around. Known records of the pery items of the house spider in the field (ORI, 1976, RICEHERT & CADY, 1983) also indicate the abundance of crawling animals.

The spider feeds at any time, but more than half of the prey items are captured during the daytime (Figs, 2–3). The number of prey capture per day might have

Order	1986						
	Mar.–Apr.	May–Jun.	Jul.	Aug.	Sep.	Oct.–Nov.	Total
Hymenoptera	8.0	30.2	35.6	46.3	22.3	12.9	30.2
* Ants(worker)	6.0	27.6	20.6	32.0	20.5	11.9	22.6
Ants(winged)	—	1.7	14.4	14.3	—	—	6.7
Wasp	2.0	0.9	0.6	—	1.7	1.0	0.9
Coleoptera	18.0	4.3	3.9	1.3	3.5	4.0	4.0
Diptera	46.0	4.3	16.7	19.0	18.8	30.7	19.4
Chironomids	38.0	2.6	8.3	2.6	5.7	5.0	6.7
Others	8.0	1.7	8.3	16.5	13.1	25.7	12.7
Lepidoptera	—	0.9	—	—	0.4	4.0	0.6
(adults)	—	0.9	—	—	0.4	1.0	0.3
* (larvae)	—	—	—	—	—	3.0	0.3
Hemiptera	—	13.8	24.4	5.6	7.9	27.7	13.1
Aphids	—	13.8	23.9	3.0	7.0	21.8	11.5
Others	—	—	0.6	2.6	0.9	5.9	1.7
Thysanoptera	—	—	—	2.6	0.4	—	0.8
Isoptera	—	0.9	—	—	—	—	0.1
Dictyoptera	2.0	—	—	—	0.4	—	0.2
*Blattodea (nymph)	—	—	0.6	0.4	0.4	—	0.3
*Isopoda	4.0	2.6	9.4	6.5	34.9	12.9	14.3
*Acarina	4.0	32.8	1.7	10.4	1.3	2.0	7.9
*Araneae	2.0	—	—	0.4	4.4	1.0	1.4
A. tepidariorum	—	—	—	—	1.7	—	0.4
Others	2.0	—	—	0.4	2.6	1.0	1.0
*Scutigeromorpha	—	—	—	0.4	—	—	0.1
Unidentified	16.0	10.3	7.8	6.8	5.2	5.0	7.4
Total no. of animals	50	116	180	231	229	101	907

* Wingless animals.

been overestimated, if counts were made only during the daytime. Only in September, the number of prey eaten during the daytime decreased to 41.5% in 1985 and 42.7% in 1986 (Fig. 3). The prey composition in September was characterized by a large number of isopods (Table 1). The decreased daytime predation in September seems to be caused by the increase of the nocturnal isopods in the diets. The daily feeding rhythm of the spider thus may be influenced by the diel activity of prey animals.

The prey size and its range increased with the carapace width of the spider (Fig. 1). This suggests that the availability of prey varies with the body size or developmental stage of the spider. To study the seasonal food supply, therefore, it is desirable to observe animals of the same developmental stage throughout the year.

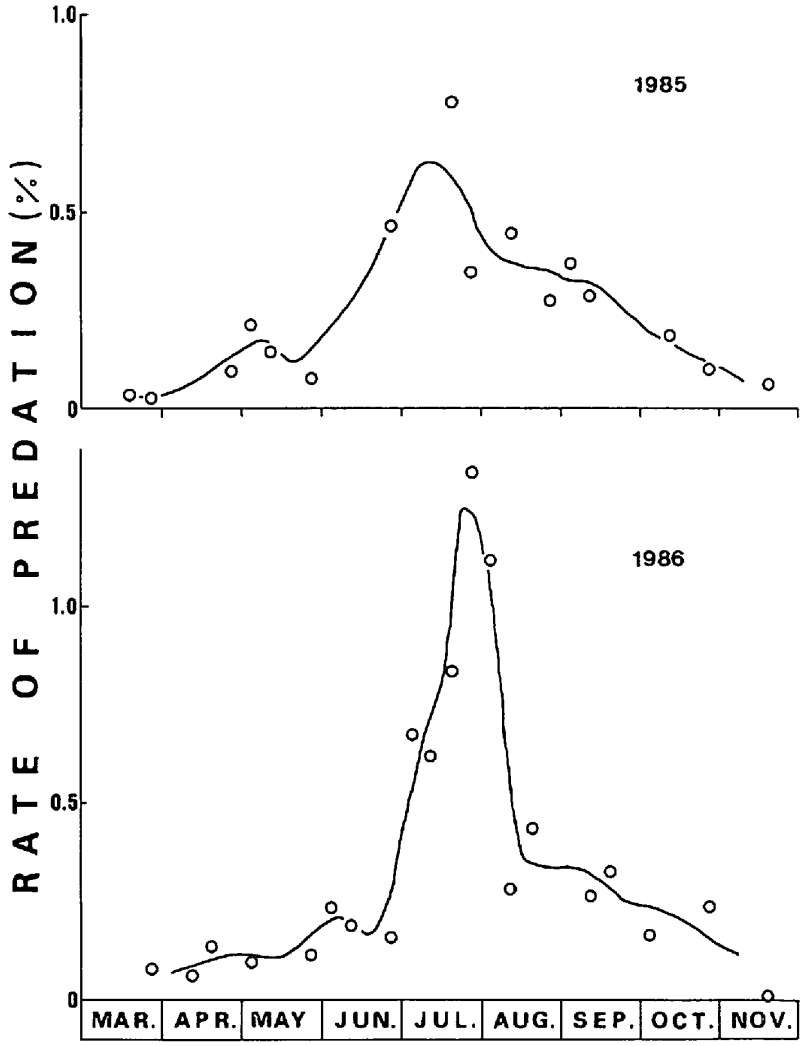

Fig. 4. Seasonal change of the rate of predation (number of captured prey per spider per 24 hr) in 1985 and 1986.

In the house spider, although the age structure and population density vary with the season, almost all nymphal instars and adults are found throughout the year (TANAKA, 1989). Therefore, we can roughly infer the seasonal food supply for this spider from the seasonal change of the rate of predation. Both in 1985 and 1986, the rate showed an unimodal pattern with a peak in July (Fig. 4). The results also well corresponded with the seasonal prey abundance (Fig. 5). The feeding conditions of this spider, thus, varied with the season.

The feeding status in the field has been examined in several species of spiders (MIYASHITA, 1968; ANDERSON, 1974; WISE, 1975). These studies show that spiders generally live with poor food supply. However, some authors have described the seasonality of food supply. ROBINSON and ROBINSON (1970) carried out a whole

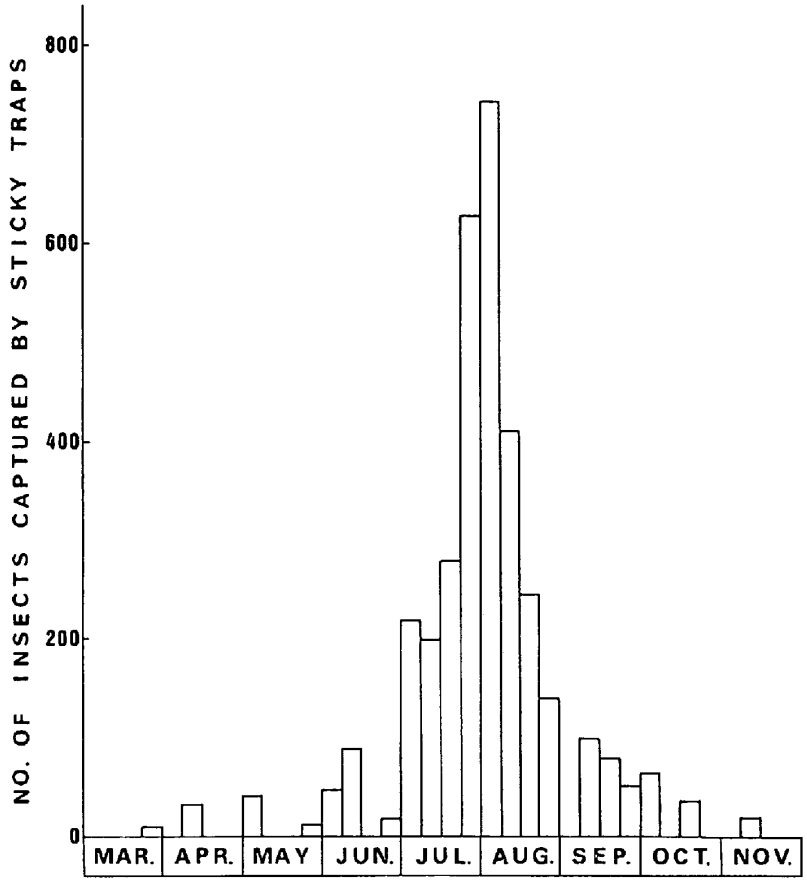

Fig. 5. Seasonal change of number of flying insects captured by three sticky traps over a period of 24 hr in the study area, 1986.

year census of prey capture of the spider, *Argiope argentata* in Panama. Even in the toropical region, the number of prey capture shows some extent of seasonality. It fell off during the dry season from February to mid-April. In the temperate regions, MIYASHITA (1986) recorded the rate of predation in the spider, *Nephila clavata* from July to October in Ibaraki Prefecture. The rate gradually declined from June to August, but it again increased in September and October. MATSURA (1986) estimated the seasonal food supply of the ant-lion larvae, *Myrmeleon bore*, by the rate of predation throughout the active season from March to December at Kyoto, and found little seasonal change.

In the house spider, the food supply was seasonally variable and relatively large in summer (Fig. 4). Because this spider continues to reproduce for a long period from June to October at Hirosaki (TANAKA, 1989), the food availability for newly emerged spiderlings varies with the hatching date. Early hatched spiderlings develop under a rich food supply in summer, whereas late hatched ones under a poor food supply in autumn. In this spider, food supply as well as temperature is a factor influencing the developmental rate and the determination of diapausing instar

(TANAKA, unpublished observations). The nymphal development of this spider may therefore vary with the hatching date and the seasonal feeding conditions.

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