

Inter-population Variation of Life History Characteristics and Its Significance on Survival Process of an Herbivorous Lady Beetle, *Henosepilachna niponica* (LEWIS) (Coleoptera, Coccinellidae)¹⁾

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Abstract Population studies on a thistle-feeding lady beetle, *Henosepilachna niponica* were conducted for 1976-1980 by using mark-release-recapture method in two different habitats locating at an upstream site and a downstream site of the River Ado in the northwestern part of Shiga Prefecture. Some life history parameters such as adult longevity in reproductive season, timing of adult emergence, and length of pre-hibernating period of new adults were compared between the two local populations. The seasonal occurrences of eggs and larvae of upstream population were more delayed compared to those of downstream population. Reproductive adults at upstream site had a longer longevity compared with those at downstream site. In contrast, new adults exhibited a significantly shorter duration of pre-hibernating period at upstream than at downstream site. The duration from adult emergence to hibernation was more likely to be a main factor in determining the overall adult survival during this period.

Introduction

In the studies of natural insect populations, there have been some attempts to compare basic features of population dynamics such as key factors causing population fluctuations, magnitude and/or density-relationships of stage-specific mortality, among different local populations of a given species (e.g., WHITTAKER, 1971; GILBERT, 1980; RANDALL, 1981). However, little attention has been paid to significant roles of inter-population variation of life history characteristics with regard to insect population dynamics in the field.

Since 1976 we have studied several local populations living under different habitat conditions to clarify the population processes and life history strategy of a phytophagous lady beetle, *Henosepilachna niponica* (LEWIS). This lady beetle generally has one generation a year and feeds exclusively on leaves of a thistle, *Cirsium kagamontanum* (NAKAI) in the study area. The previous paper (OHGUSHI & SAWADA, 1981) revealed that the seasonal occurrence of reproductive adults tends to be prolonged in altitudinal order, i.e., from the downstream to upstream habitats.

1) Recently, KATAKURA (1981) reclassified *Henosepilachna pustulosa* (Kôno) into three distinct species and some unsettled populations. In this paper, species name followed his classification.

This paper compares life history parameters such as life-span of reproductive adults, timing of adult emergence, and duration of pre-hibernating period of new adults between local populations in two areas, one in downstream and the other in upstream habitats. Furthermore, possible effects of differential life history attributes are discussed on the population dynamics of the lady beetle.

Study Area

This study was carried out in six study sites (sites A–F) located in five different valleys of the River Aso and its branch, the River Ado, which flow through the northwestern part of Shiga Prefecture, central Japan. Here, we will show the results obtained from site A and site F as examples in the downstream and upstream habitats, respectively. The site A (60×30 m) was situated in the valley farthest downstream, at 220 m in altitude. The ground surface of the site was rather flat and open and consisted mainly of unhardened sandy deposits caused by the construction of a dam. The site F (90×15 m) was the highest and the most mountainous of the study sites, at 350 m in altitude. It was located 10 km upstream from the site A. A map and more detailed description of each study site were given in OHGUSHI and SAWADA (1981).

Methods

Intensive mark-release-recapture census of adult beetles was conducted from early May to early November throughout five years, 1976–1980. At intervals of 1 to 3 days, each thistle plant growing within the study plots was carefully checked for counting the numbers of eggs, fourth instar larvae, pupae, pupal exuviae, and

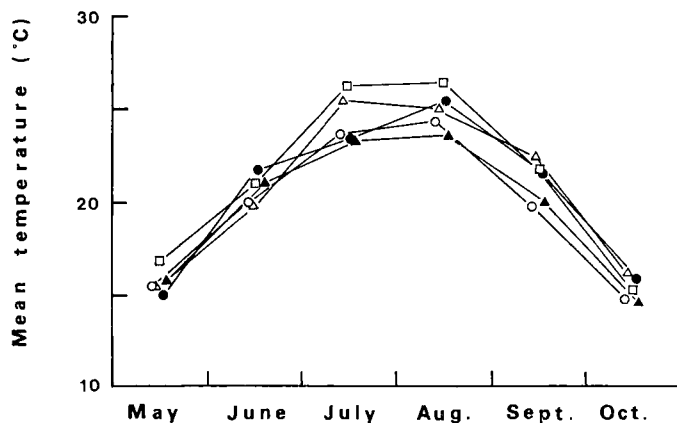


Fig. 1. Mean monthly temperature from May to November (1976–1980) measured at the meteorological station (200 m, in altitude) which locates 1 km northwest of site A. (○), 1976; (△), 1977; (□), 1978; (●), 1979; (▲), 1980.

adult beetles. All the adult beetles captured were marked individually with lacquer paint on four marking points on the elytra. Sex, body size, and recapture history in each time and place were recorded for individual beetles and newly-marked beetles were immediately released on the thistle plants where they were captured. On following censuses, the number of marked beetles was recorded directly by sight without recapturing. With this marking experiment, 5969 adult beetles at site A and 3507 beetles at site F were marked throughout the study course.

Mean monthly temperature for the census period was measured at the meteorological station which was located 1 km northwest of site A (Fig. 1).

Results

1. Seasonal changes in number of immature stages

Figure 2 shows the seasonal changes in numbers of eggs, fourth instar larvae, and adults emerged at sites A and F. At both sites, adult females which emerged from hibernacula began to lay their eggs around early May. Thereafter, oviposi-

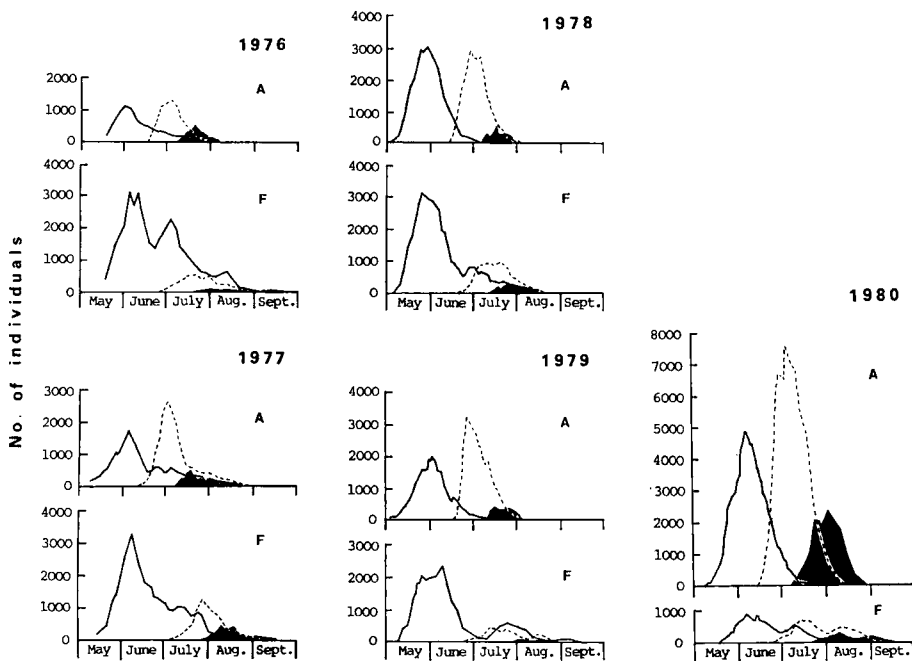


Fig. 2. Seasonal changes in numbers of eggs, fourth instar larvae, and newly-emerged adults in the downstream population (site A) and the upstream population (site F). Solid and dotted lines show the numbers of eggs and fourth instar larvae respectively. Black area indicates the number of new adults emerged at each census. ($\times 5$ scale except for eggs).

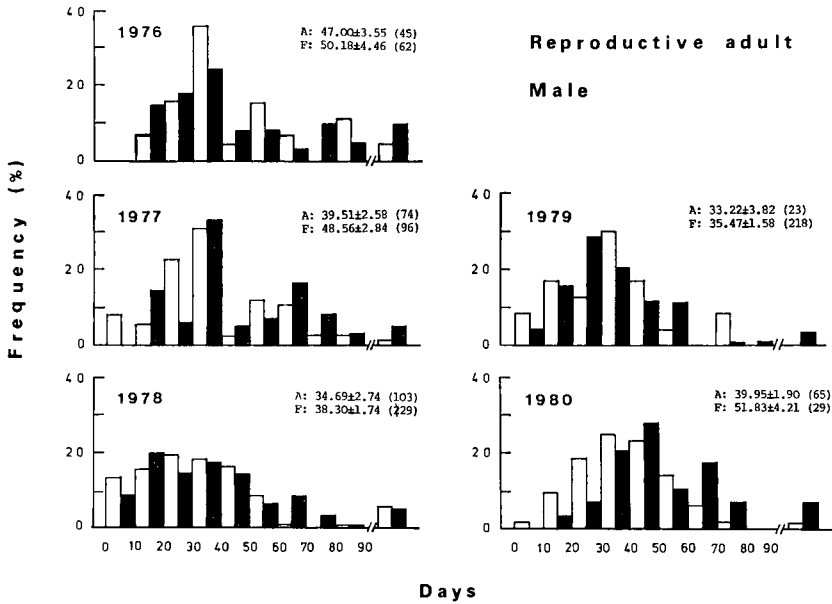


Fig. 3. Frequency distribution of life-span of reproductive male adult at downstream site A (open bars) and upstream site F (closed bars). Numerals in figures are mean \pm S.E. and number of adults examined (in parentheses).

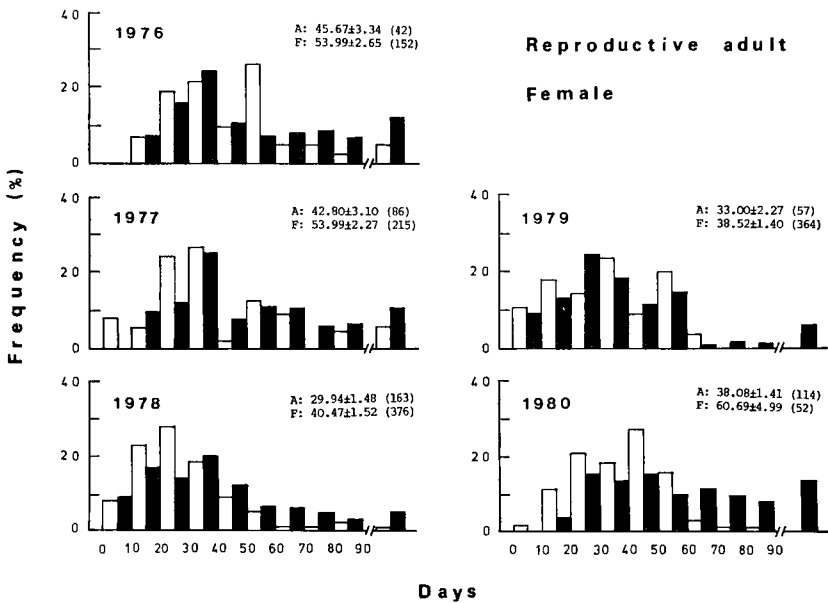


Fig. 4. Frequency distribution of life-span of reproductive female adult at downstream site A (open bars) and upstream site F (closed bars). Numerals in figures are mean \pm S.E. and number of adults examined (in parentheses).

tion extended until late July at site A, but at site F it continued mid-August. New adults at downstream site A emerged earlier, reaching a peak occurrence more rapidly as compared with those at upstream site F.

2. *Life-span of reproductive adults*

Life-span of individual beetles was assessed by using the data from adult marking experiments. Because of emigration and immigration, there was an underestimation of adult longevity. In this paper, we defined life-span of reproductive adults as the duration of period from 1 May to the last recapture date of individual adults, though the effect of emigrants was unavoidable. Frequency distributions of life-span of reproductive adults, thus obtained, are shown in Figs. 3 and 4 for males and females, respectively. In both sexes, average adult longevity at site F was longer than that at site A throughout five years. This tendency was more pronounced in females. There were significant differences in the longevity of adult females between the two populations in 1977, 1978, and 1980 ($P < 0.05$). Throughout this study course, the proportion of adult females surviving beyond 70 days ranged from 0% to 11.9% (5.8%, on the average) at site A and from 9.9% to 30.8% (20.9%, on the average) at site F. Besides, there observed a few adults survived two years at upstream site F (OHGUSHI & SAWADA, 1981). This additional evidence also supported that the reproductive beetles of the upstream population would have longer life-span as compared with those of the downstream population.

3. *Timing of adult emergence and pre-hibernating period*

Table 1 shows the date of 50% and 75% adult emergence of the two local populations, confirming that adult beetles at site A emerged earlier than those at site F. It should be also noted that the difference in timing of adult emergence between the two populations was greater as compared to the difference among the five years within each site.

Table 1. Dates of cumulative adult emergence on 50% and 75% points of the two populations for five years, 1976–1980.

Year	50% point for adult emergence			75% point for adult emergence		
	site A	site F	Difference among the two sites (days)	site A	site F	Difference among the two sites (days)
1976	19 July	12 August	24	24 July	23 August	30
1977	20 July	14 August	25	3 August	23 August	20
1978	16 July	30 July	14	21 July	6 August	16
1979	20 July	3 August	14	26 July	11 August	16
1980	26 July	9 August	14	1 August	28 August	27
Difference among 5 years (days)	10	15		13	22	

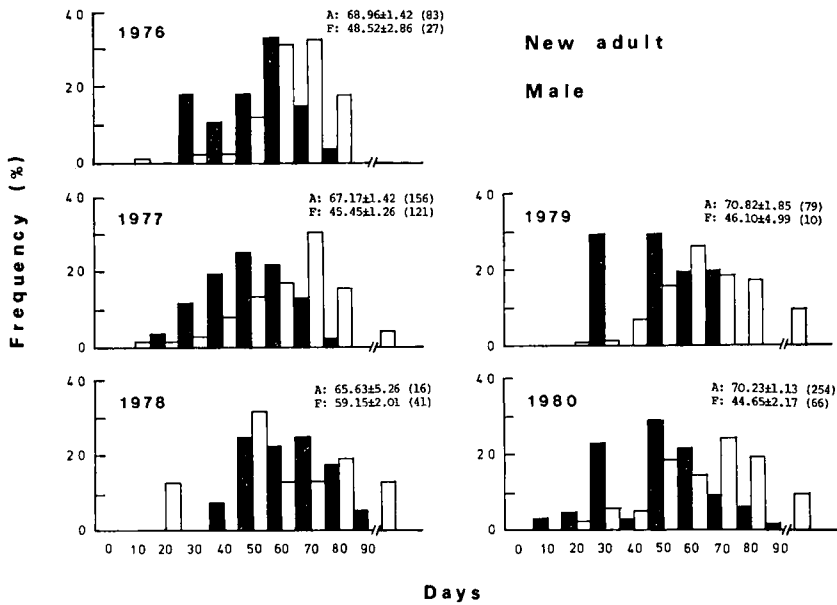


Fig. 5. Frequency distribution of the duration of pre-hibernating period of newly-emerged male adults at downstream site A (open bars) and upstream site F (closed bars). Numerals in figures are mean \pm S.E. and number of adults examined (in parentheses).

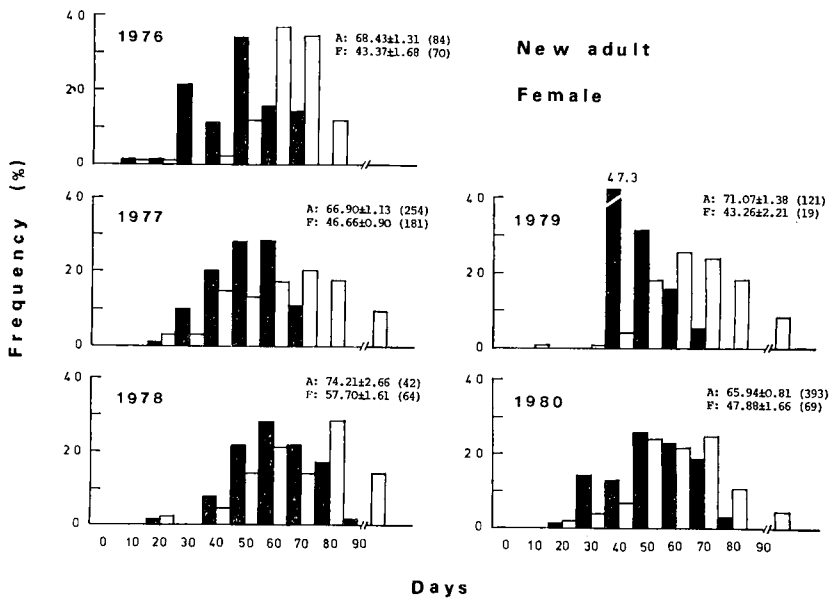


Fig. 6. Frequency distribution of the duration of pre-hibernating period of newly-emerged female adults at downstream site A (open bars) and upstream site F (closed bars). Numerals in figures are mean \pm S.E. and number of adults examined (in parentheses).

We next look at the duration from adult emergence to hibernation, i.e., pre-hibernating period of new adults. Since all newly-emerged adults surviving in mid-September had a possibility of entering hibernation (OHGUSHI, 1983), pre-hibernating period was, here, defined as duration from the first capture to the last recapture of individual new adults based on the data of marked adults remaining beyond 15 September. Frequency distributions of the length of pre-hibernating period of new adults are shown in Figs. 5 and 6 for males and females, respectively. In both sexes, the pre-hibernating period was significantly longer at site A (about 70 days) than that at site F (about 45 days). For example, throughout the study period, the proportion of adult females that survived more than 70 days ranged from 40.2% to 57.1% (48.3%, on the average) at site A but it was only from 0% to 18.8% (4.6%, on the average) at site F. Thus, the delayed adult emergence at upstream habitat resulted in considerably shorter length of pre-hibernating period of new adults.

Discussion

The two sites studied here were only 10 km apart but there observed no population interchange between them. The present study revealed some definite differences in life history characteristics between the downstream and upstream populations. In particular, the difference in timing of emergence of new adults was more obvious, and this timing of emergence was a main factor causing the difference in the duration of pre-hibernating period of adult beetles. One would expect that these difference would be more likely to be attributed to the difference in mean temperature between the two sites. In fact, mean temperature at downstream site A was about 1.0°C higher than that at upstream site F because of altitudinal difference. However, the difference in monthly temperature among the five years at a point near site A (about 4.0°C) was greater than that between the two study sites in each of the five years (see Fig. 1). If the temperature plays a significant role in causing the difference in the timing of adult emergence observed, the difference in timing of adult emergence within each study plot should be larger than that between the two populations within the same year. But, this was not true, suggesting that the slight difference in temperature between the two sites would be functionally less important in causing the difference in the timing of adult emergence, although there may be a possibility that the pattern of adult emergence could be an evolutionary consequence in response to mean temperature in the habitats. The delayed adult emergence at site F is more likely to be attributable to the longer oviposition period at the upstream (see Fig. 2). Since there was no clear difference in timing of first oviposition between the two populations, the longer oviposition period was obviously resultant from longer longevity of reproductive females as already shown in Fig. 4. Also, more intensified arthropod predation, which chiefly operated during the first half of reproductive season in time-specific manner, enhances the

delayed tendency of adult emergence of the upstream population (OHGUSHI, 1983).

Now, there remains possible effects of such inter-population variation of life history characteristics on demographic pictures of these local populations. OHGUSHI (1983) clarified that overall survival from adult emergence to hibernation at site F was higher than that at site A. It ranged from 22.5% to 45.7% (37.1%, on the average) at site A and from 36.3% to 59.6% (50.0%, on the average) at site F throughout this study course. But there was no clear difference in daily survival rate of new adults estimated by the JOLLY-SEBER method (OHGUSHI & SAWADA, 1981). Since overall survival during pre-hibernating period is largely dependent on both daily survival and length of this period, it is reasonably expected that the duration of pre-hibernating period will be a key component on overall adult survival until hibernation: namely, the longer the pre-hibernating period, the lower the overall adult survival. The results from Figs. 5 and 6 that the downstream population had a longer duration from adult emergence to hibernation compared to the upstream population support the proposed expectation that longer pre-hibernating period during which various mortality factors will occur may result in lower overall adult survival.

The results obtained here conclude that the pattern of adult emergence greatly influences overall adult survival during pre-hibernating period, one of key demographic components in characterizing the population dynamics of *H. niponica*.

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