Biology of *Hyphantria cunea* DRURY (Lepidoptera: Arctiidae) in Japan

IV. Effects of Group Size on Survival and Growth of Larvae*

Naoshi WATANABE and Kenji UMEYA

Research Division, Yokohama Plant Protection Station

Introduction

It is well known that the larvae of *Hyphantria cunea* is a colonial feeder living in the nest-web. But the survival value of this habit has little been studied.

The authors reared larvae at various levels of group size in order to analyse the effect of group size on the population dynamics of this insect.

This is the fourth report from the study group on the biology and population dynamics of *H. cunea* in Japan.

Material and Methods

Fresh adults that emerged from overwintered pupae were collected in the suburb of Yokohama City in June 1966. These adults were kept in a rearing cage and allowed to mate and oviposit. Four egg-masses laid on leaves of cut shoot of *Platanus acerifolia* were used for experiments. All experiments were carried out in a biotron where 25°C 70% R.H. and 16 hr. photoperiod were maintained. Larvae were fed on leaves of *P. acerifolia*.

Experiment 1.

Small leaf-cages were attached to leaves of cut shoots of *P. acerifolia* inserted into water flasks. The cages were comprised of foamed-styrol boards (4×4×1 cm), each with a central hole (3 cm in diameter) and covered by a transparent styrol board (4×4×0.2 cm). For ventilation a small central hole was cut on both sides and covered by nylon net (Fig. 1.)

Just before hatching, each egg batch was divided as to obtain six portions containing 1, 2, 4, 8, 16 and 32 eggs, respectively. They were enclosed in leaf cages. Each treatment was replicated and a total of 32 larvae was available in every rearing. The larvae were reared for 5 days after hatching and the number of survivors was recorded everyday.

Experiment 2.

All larvae from single egg-mass were reared together till the fourth day from hatching, after which they were divided into groups of different sizes in the same way as mentioned above. The total number of larvae in each group size was again 32. The experiments were repeated 3 times.

Each group was reared in a glass tube, 1.5 cm in diameter and 3.5 cm in height, during the 1st and 2nd instars, and in a petri-dish, 9 cm in diameter and 3.5 cm in height, during the latter stages. The larvae

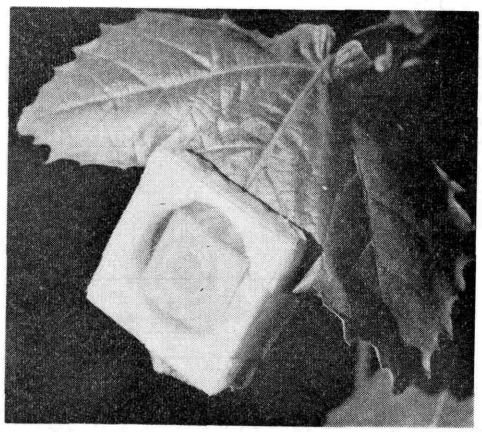

Fig. 1. A leaf-cage.

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were counted and transfered everyday to a cleaned container and provided with an enough amount of fresh leaves. In order to avoid injuries through manipulation, the larvae were counted and tansfered with leaves on which they were feeding and these old leaves were removed after the larvae abandoned them.

The number of survivors, dates of ecdyses, pupation and adult emergence were recorded. The length of fore-wings of adults was measured as an indicator of the body size. The abdomens of female adults were stored in 70% alcohol, later dissected under a microscope and number of eggs counted.

Results

Experiment 1.

Fig. 2 shows the survival till the fifth day of larval life. When the initial group pize was 8, 16, or 32 per cage, almost all larvae survived, while most of the larvae died by the third day when the group size was less than 4 per cage. It is, however, noted that in the latter case a few individuals which were alive on the third day survived till the end of the experiments. No evidence of feeding is found in the cages in which all the larvae were found dead before the third day.

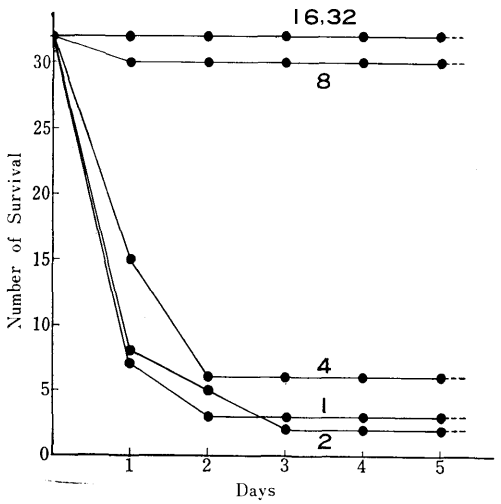

Fig. 2. Survivorship of larvae reared in different group size till 5th day of larval life.

Experiment 2.

Survival

Mortality during the larval stage is shown in Table 1. The groups of 16 individuals were discarded because of an accident. From Table 1, it is clear that there is no significant difference in mortality among different group sizes. The survivorship curves reveal, however, differences in the sequence of mortality among these rearings (Fig. 3).

In isolated larvae and in the group of two larvae, mortality during the early larval stage is higher than in the groups of 4, 8 and 32 individuals. On the

Table 1. Larval mortality at different levels of group size.

Group size	N. of dead larvae				Mortality (%)
	Replicates			mean	
	I	II	III		
1	6	11	4	7.0	22
2	13	6	12	10.3	32
4	4	5	9	6.0	19
8	6	9	7	7.3	23
32	4	11	6	7.0	22

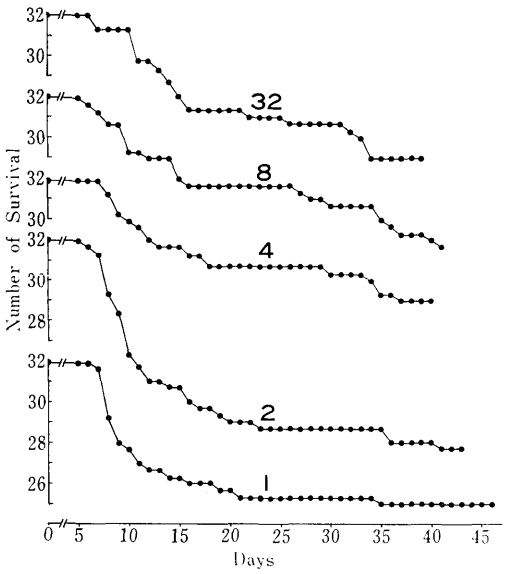

Fig. 3. Survivorship of larvae reared in different group size after 5th day of larval life. Each curve is based on 3 replicates.

other hand, the mortality of larvae in the small groups during the later stage is low as compared with that in the larger groups.

Mortality during the pupal period is low and there is no significant difference among different groups (Table 2).

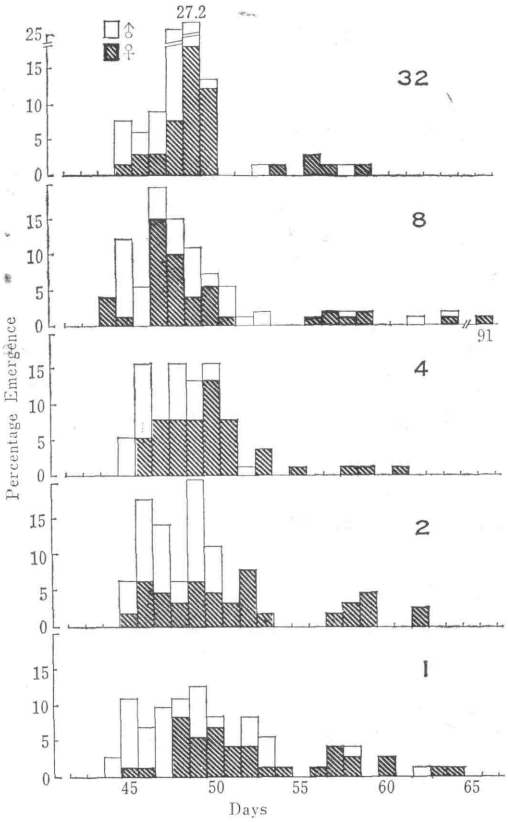

Fig. 4. Time of adult emergence.

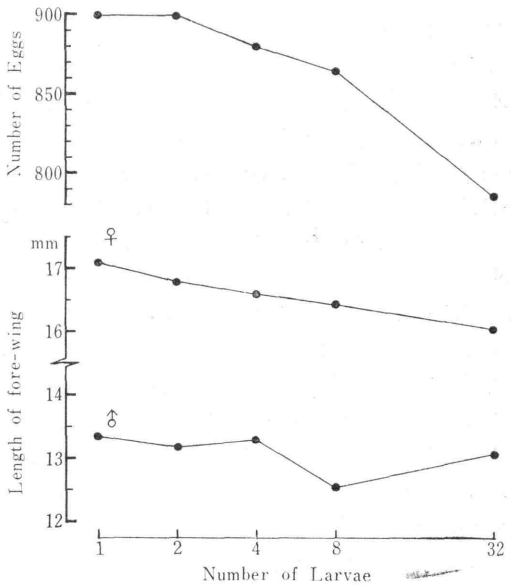

Fig. 5. Fecundity and length of fore-wing of adults raered in different group sizes.

Table 2. Pupal mortality at different levels of group size.

Group size	N. of dead pupae/N. of pupated larvae				Mortality (%)
	Replicates I	II	III	Total	
1	1/26	0/21	2/28	3/75	4
2	0/19	0/26	2/20	2/65	3
4	1/28	0/27	0/23	2/78	3
8	1/26	0/23	0/25	1/74	1
32	0/28	5/21	1/26	6/75	8

Table 3. Mean and variance of the duration from hatching to the 3rd and 5th ecdyses, pupation and adult emergence.

Group size	Duration								
	3rd Ecdysis		5th Ecdysis		Pupation		Adult emergence m	Male	Female
	m	v	m	v	m	v		m v	m v
1	15.4	2.5	23.6	3.2	37.4	7.6	48.5	(47.6 : 7.2	49.7 : 4.4)
2	15.3	0.9	23.6	1.1	37.0	6.6	48.2	(47.6 : 2.7	49.1 : 5.8)
4	15.1	0.9	22.8	0.9	36.1	4.1	48.3	(47.3 : 2.9	49.1 : 5.2)
8	14.9	0.7	22.4	0.6	35.4	4.1	47.8	(47.5 : 5.6	48.4 : 2.1)
32	15.6	0.7	22.2	1.1	35.7	2.6	48.1	(47.6 : 1.9	48.6 : 1.8)

The Duration of Larval and Pupal Development

Table 3 shows the mean and variance of the duration from hatching to 3rd and 5th ecdyses, pupation and adult emergence. There is no significant difference in the period from hatching to 3rd ecdysis among different group sizes, but the variance is remarkably larger in isolated rearings than in grouped ones. The duration from hatching to the 5th ecdysis seems to be shortened with the increace of group size. The variance in isolated larvae is still larger. The whole larval stage also seems to be shortened with the increase of group size, except the group of 32 individuals showing a slightly longer duration. The variance decreased with the increase of group size.

Fig. 4 shows the time of the adult emergence. There are two peaks of emergence. The latter peak is probably due to delayed development at a high temperature (Umeya and Masaki, unpublished). Such pupae are excluded in calculating the mean developmental time. There is no significant difference in total developmental time among different group size.

Adult Body Size

In the lower part of Fig. 5 the length of fore-wing of adults reared in different group sizes is shown. Each point represents a mean of about 30 individuals. In the female, the wing length is decreased with the increase of group size, while in the male, no such relationship is conceivable.

Fecundity

The top of Fig. 5 shows the relation between the mean number of ovarian eggs based on about 30 females and the initial group size. It is clear the number of eggs decreased with the increase of group size. This confirms the well known density-dependent process.

Discussion

In his report of isolated and group rearings of the jack pine sawfly, *Neodiprion pratti banksianae*, Ghent (1960) recognized two types of mortality. One is the "establishment mortality" due to the death of larvae that had failed to feed and the other is the "maintenance mortaity" due to the death of larva that had succeeded to feed to a limitted extent. In Ghent's experiments, isolated rearing showed higher establishment mortality than a grouped one. In the present experiments, the isolated and small-group rearings caused higher mortality during the early stage. This may be considered the establishment mortality, because no evidence of feeding was seen on the leaves when all the larvae were found dead. It was found further that even in the isolated and small-group rearings, those larvae having once established could survive till the end of experiments. This fact indicates the importance of the first establishment in the survival of larvae. In Experiment 2, isolated and paired larvae sufferd higher early mortality than did the more crowded rearings, though the larvae had been reared in the natural group size during the first 4 days and had once established on host leaves. This indicate; that larvae in a group of adequate size have higher ability of re-establishment at the first instar, when the larvae were accidently removed from their feeding site. In many colonial species such as *Euproctis pseudoconspersa* (Hosoya 1956; Mizuta 1960), *Chilo suppressalis* (Morimoto 1960), *Artona funeralis* (Sugimoto 1962) and *Neodiprion sertifer* (Henson 1965), the early mortality is found to increase when they are reared in isolation.

In the authors' experiments, mortality in the late larval stage was higher in the crowded rearings than in the isolated or less crowded rearings. *H. cunea* normally lives in the nest-web, forming a colony until the 5th ecdysis and then disperses. From this habit, it may be expected that the mortality after the 5th moult is increased by the "density effect", overcrowding being unfavourable for large larvae. Increased mortality due to crowded rearings during the late larval stage is also reported for *C. suppressalis* (Morimoto 1960) and *A. funeralis* (Sugimoto 1962). That the size and fecundity decreased with the increase of group size in authors's rearings is in agreement with the observations reported in *C. suppressalis* (Morimoto 1960).

E. pseudoconspersa lives in group through the larval life. Isolated rearing of this moth at early larval in-

star is quite difficult. It was reported that the isolated rearing prolongs the larval development and increases the number of larval instars. Moreover, the growth rate per unit time is lower in isolated rearings than in crowded ones and, consequently, the ultimate size is similar in isolated and crowded rearings (Hosoya 1956; Mizuta 1960).

Ito et al. (unpublished) reported that mortality of *H. cunea* under field condition was remarkably low during the band-forming stages as compared with many other species of Lepidoptera. The authors' experiments show that group formation is not indispensable for the development and survival of once established larvae. It seems doubtless, however, that aside the defensive role of the nest-web against natural enemies and harmful weather, the colonial habit of *H. cunea* may play an important role in the first establishment of larvae on host leaves. The success of the first establishment is evidently responsible for further survival.

Summary

The larvae of *Hyphantria cunea* DRURY were reared in isolation and in different group size and the survival and growth were observed.

1. In the initial period of larval stage, isolated and small group showed remarkably high mortality as compared with large-group rearings. In the later stage, when the larvae dispersed under the natural conditions, rearings in large groups showed rather higher mortality than in isolated rearings. The difference in early mortality is mainly due to the success or failure of the first establishment by the larvae on host leaves. Hence, this falls to the same category as establishment mortality defined by Ghent (1960). The difference in the later mortality may be due to the density effect.

2. There is no significant difference in the duration from hatcing to adult emergence among different group sizes, but the isolated rearings showed the largest variance of the length of larval stage.

3. Body size and the number of eggs in ovaries decreased with the increase of group size.

4. Once the larve have established on the host leaves, the group formation may not be indispensable for their further growth.

Aknowledgements

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摘　要

アメカシロヒトリの生物学的研究

IV. 幼虫の集団の大きさが生存と発育に及ぼす影響

渡辺　直・梅谷献二

横浜植物防疫所調査課

アメリカシロヒトリの幼虫を種々の虫数に分離して飼育し，集団の大きさと生育・生存との関係について解析を試みた結果，以下のことが明らかになった。

1. 単独または小集団の飼育では，大きい集団の飼育に比べて著しく幼虫初期の死亡率が高くなった。いっぽう野外で幼虫が分散をする時期にあたる後期においては，多虫数区が少虫数区よりも高い死亡率を示した。初期の死亡の飼育虫数による違いは，餌となる葉面に食いつけない個体によって起ったものと考えられ，後期の違いは多虫数区におけるこみ合いによる死亡によって起ったものと考えられる。

2. 生育日数では飼育虫数の差による明瞭な差は見られなかったが，各脱皮時期の個体変異は単独区のみ著しく大きく，蛹化時期の個体変異も少虫数区ほど大きくなる傾向を示した。

3. 羽化成虫の大きさ，蔵卵数は少虫数区ほど増加する傾向が見られた。

4. 孵化した幼虫が一度餌場に定着すれば，集団というものが発育にとってはさほど重要な影響を与えていないことが明らかになった。