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USING CROWDING AND SPACING FOR RAISING THE ERI SILKWORM *PHILOSAMIA RICINI* HUTT

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ABSTRACT

The effect of spacing was studied by rearing *Philosamia ricini* larvae in separation and in crowding throughout the larval stage. The other treatments were separating larvae after passing the four sucessive instar larvae under crowding. During the last (fifth) instar, the general pattern of behaviour was examined. The crowds were generally more active than all conditions of separation. The highest activity devoted to feeding applied to those separated in the fifth instar. The crowds were active apart from feeding more than about three times as much as were the conditions of separation. It has been claimed that larvae which were separated from crowded condition in the fifth instar gave rise to the least mean total duration and highest rate of growth. The least average fresh weight of mature larvae was induced by crowded condition. The mature larval and coccon weights concerning conditions of separation were gradually increased with the increase of instars passed under crowding. The mortality of crowded larvae was lower in the first, three sucessive instars than separated conditions. In the remainder instars, the mortality of those separated from fourth and fifth instars was lower than all conditions.

Key words: Eri silkworm, *Philosamia ricini*, Crowdness, Spacing, Rearing conditions

INTRODUCTION

The effects of population density on the eri silkworm were early studied by **Wafa and Eid (1966).** The effect of separation was examined and a conclusion that separation in the two late instars would be advantageous had been drawn. A recondite study was therefore necessary to approach the most productive method for raising eirworm.

Mechanisms of, and responsiveness to crowding were studied by **Lee *et al* (1990), Haque and Hossain (1991), Talukder *et al* (1991) and Srivastiva and Misra (1997).**

The sensitivity of different larval instars to separation was ment-ioned by **Eid**

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(1967); Karaivanov (1988); Alok and Sahay (1996) and Mishra *et al* (1998). Crowding and spacing can modify expression of genetic and non genetic traits on growth (Alok and Sahay, 1992 and Kause *et al* 1999); development time (Eid, 1967; Talukder *et al* 1991; Kariman, 2000 and Mishra *et al* 1998); feeding and feeling habits (Kause *et al* 1999; Kariman, 2000 and Cui *et al* 2001).

High mortality in separated larvae during early instars was found by Hirata (1962), Eid (1967) and Kariman (2000).

The aim of the present work is to raise the eri silkworm under different rates of crowding and spacing for the purpose of finding out the most appropriate rate for rearing this beneficial insect.

MATERIAL AND METHODS

Rearing experiments were undertaken in the Autumn of 1999 and spring of 2000 under normal conditions in the laboratory. Larvae of *Philosoma ricini* were reared in oblong wooden frames ratlined to squares of 10 X 10 X 8.5 cm for separated larvae and 20 X 20 X 8.5 cm for crowded larvae.

The replicates of crowded larvae (C) and separated from hatching (S.H.) were set up with newly hatched larvae from one batch of eggs. The other treatments were as follows:

1. Larvae which had been crowded and separatged after the first moult (S.2), after the second moult (S.3.
2. Larvae which were kept in crowds for three instars and separated in the fourth (S.4) and those which were kept in crowds throughout the first, three instars and separated in the fifth instar (S.5).

1. The General Pattern of Behaviour

During the last instar two replicates (each 20 larvae) from each condition were selected, in a comparable stage of development, care being taken to avoid larvae which were approaching the prepupal period. The 40 larvae of every condition were marked with coloured spots. Observations were then made at 10 mn. intervals over a period of 5 hr of daylight and the behaviour of each larva in 12 replicates for 6 treatments was simply recorded as follows :

F: Feeding including masticatory movements.

A: Any form of activity not recorded as feeding.

R: Complete immobility regarded as resting.

The recording thermograph showed that the temperature remained constant within 2°C throughout this experiment. The duration, weight and mortality of every larval instar were recorded. Cocoons, after 5 days, were sexed and weighed.

RESULTS

1. The general pattern of behaviour

The results of the experiments are given in the following summary expressed as percentages based on the total of 60 occasions for each condition.

The analysis of the results showed significant differences except in case of differences between separation in first three instars. Assuming that these results reflected the total behaviour over the periods of the experiments more time was

Behaviour	C.	S.H.	S.2	S.3	S.4	S.5	L.S.D.
Feeding	31.3	20.9	21.3	23.2	29.9	34.6	2.3
Active	16.9	4.4	4.5	5.2	4.7	5.1	2.7
Resting	51.8	74.7	74.2	71.6	65.4	60.3	3.9

spent in resting by the separated larvae than by crowds. This means that the crowds were generally more active than all conditions of separation. Furthermore, it can be seen that the highest activity devoted to feeding applied to those separated in the fifth instar. Much more striking is the fact that the crowds were active apart from feeding more than about three times as much as were the conditions of separation. This could account for the impression of a greater restlessness in the crowds.

It can be seen that the crowded larvae when changed to separated conditions still spend less time resting, proportional to the time passed under crowding, than those separated from hatching.

2. Mean total duration (larval duration)

Examining the data obtained from both rearings, it is revealed that larvae of all conditions were affected by crowding as the development of all conditions was significantly accelerated as compared with those separated from hatching. Comparing mean total duration obtained, it has been claimed that those separated from hatching, from the second instar and from the third instar gave rise to longer larval duration which differed significantly from crowded condition in both seasons (Fig. 1).

It is indicated that S.4 and S.5, gave rise eventually to more reduced larval durations, when compared with C. condition. In both seasons, the differences were significant in case of S.5, only (Fig. 1).

Validity of this tendency could be extensively appreciated by relating instar period of every condition to its crowded counterpart. From Figure (1) it is revealed that rate of acceleration was markedly affected with the time passed under crowded conditions. Larvae of S.2, gave rise to higher growth rates than S.H., however, their growth rates were lower than their crowded counterparts (Fig. 1). In case of S.3, the growth rates were accelerated than C. for one instar only then reversed to be lower in the remainder instars (Fig. 1).

With regard to S.4, the growth rates were accelerated than crowds in the two remainder instars in Spring while reversed in the fifth instar in Autumn (Fig. 1), it was found that the highest rate of acceleration applied to 5.5 in both seasons (Fig. 1).

3. Larval growth

a) Larval size

An analysis of the size of mature larvae, expressed by their weights, showed that larval size was affected by crowding as well as separation. Average larval

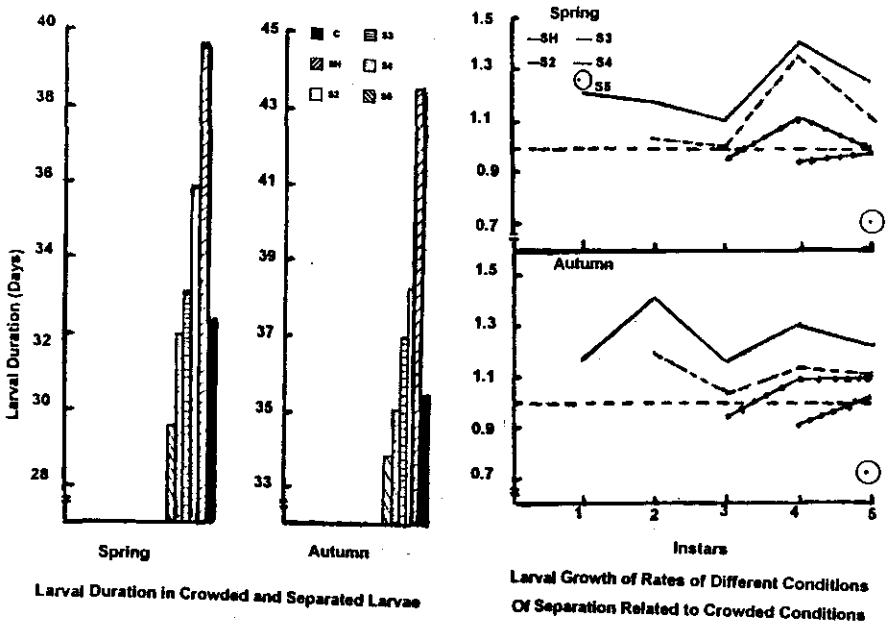

Fig. 1. Larval Duration and Growth Rates

weights of all conditions of separations were significantly higher than those of crowded condition in both seasons (Fig. 2). Despite the result that S.H. were higher than those of C., it is deduced that crowding had played as a controlling factor.

The mature larval weights of S.H., S.2 and S.3 were not significantly different in Spring. The differences between weights of S.3 and S.4were not significant in Autumn. In both seasons S.5 were significantly highest. Although the mature larval weights of conditions of separation were not always significantly different, the fresh weights were gradually increased by the increase of instars passed under crowding (Fig. 2).

b) The progression factors

In order to demonstrate the phenomenon of larval growth pattern, the progression factors of successive instar weights of every condition were calculated. In both seasons the values obtained for larvae reared in crowds were higher, till the third instar, than those S.H. and S.2. In the remainder instars the separated were higher than the crowds (Fig.2). The values obtained for S.3, S.4 and S.5 were higher than their crowded counterparts (Fig. 2).

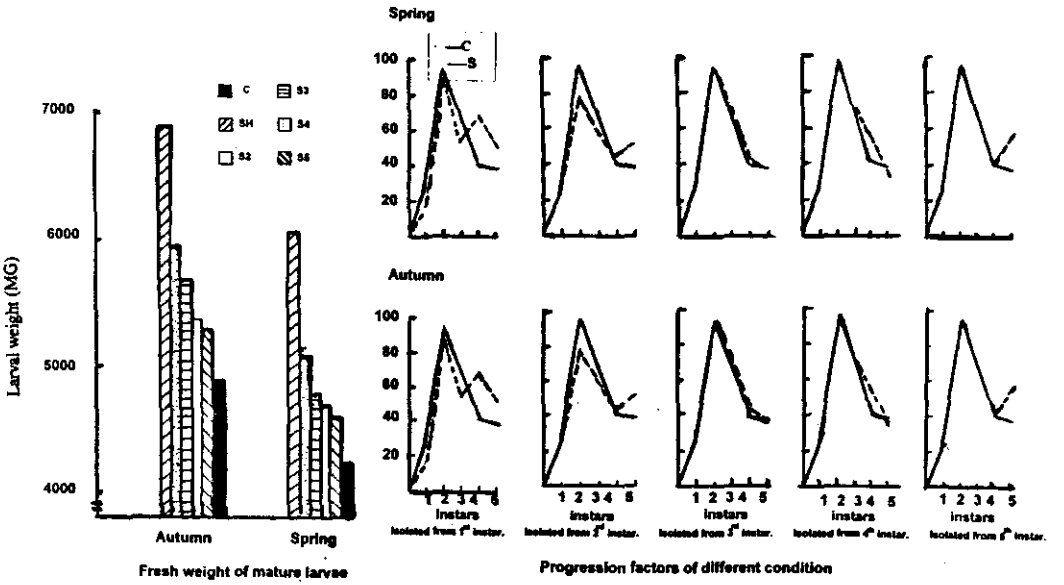

Fig. 2. Larval growth and Progression factors of crowded and separated larvae

4. Larval mortality

From the results obtained in two rearings as shown in Fig. (3), it could be pointed out that conditions which lead to relatively rapid development tended to keep the mortality to a minimum. It is indicated that the mortality of crowded larvae in the first, second and third instars of both seasons were significantly lower than separated conditions. In the remaining instars, the mortality of S.4 and S.5 were significantly lower than all conditions in both rears (Fig. 3).

5. Silk productivity

In the fore-going topic a definite trend of larval growth pattern have been demonstrated. A similar tendency could be expected as the average weights of coccons for both sexes and seasons reflected generally the same tendency, despite the differences between males and females.

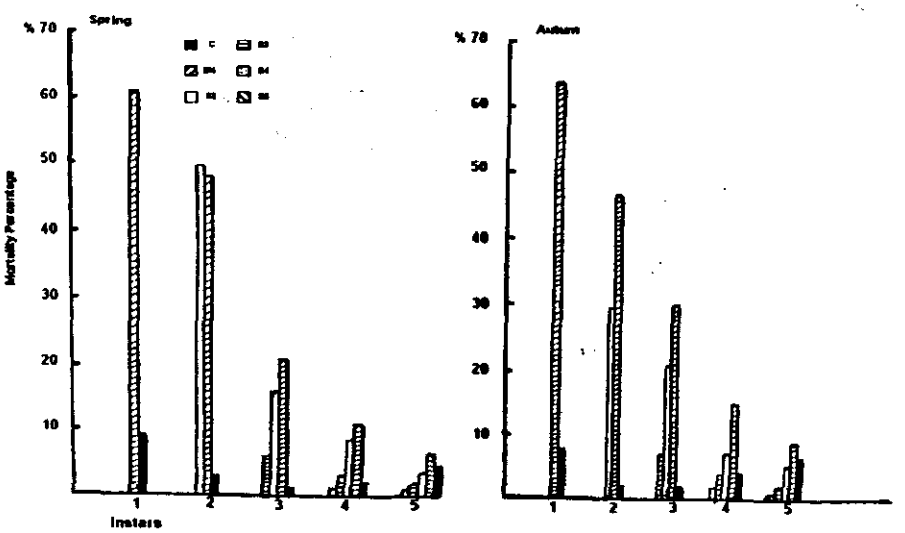

Fig (3):Mortality Percentage in Different Instars of Different Conditions

The results that larval weights of different conditions of separation were gradually increased with the increase of periods passed under crowding, were reflected more properly in Autumn than in Spring (Fig. 4).

DISCUSSION

Although many insect behaviour appear to be highly strerotyped in their form under typical conditions of arousal, such behaviour seldom is rigid and constant in pattern. To understand individual variability within a species, the change of aspects of the environment including characteristic stimulus objects must be considered. The basis of variation may be internal, either temporary depending upon short lived differences in the internal conditions of the individual governing susceptibility to external stimuli, or lasting.

From the results it could be concluded that crowding may lead to two distinct changes in behaviour of the eri silkworm.

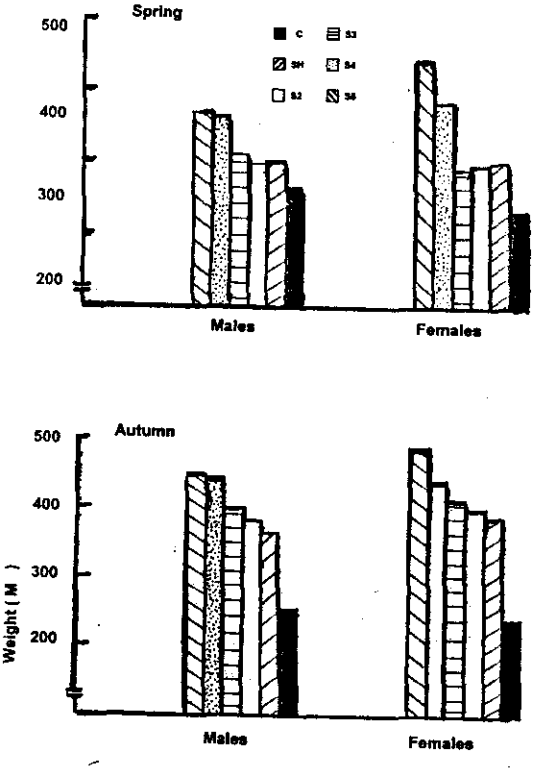

Fig. 4. Weight of Cocoons of Different Conditions

The first is the production of a change reflected in high level of activity which more probably involves non-feeding movements. The second is that the mechanical aspects of crowding may act as a stimulant to feeding activity in those separated after being in crowds. This result is in agreement with those of **Eid (1967)** and **Leonard (1969), Kause *et al* (1999) and Kariman (2000).** The much more striking is that the intensity of stimulation, in the last instar, seems to proportionate the time passed under crowding.

Growding as well as spacing represent environmental factors with a demonstrable biological significance in the normal behaviour of the eriworm. Thus departures from the normal tendency may lead to change in pattern of behaviour without necessarily involving a change in the basic behaviour. For example, crowding which is the normal tendency in the first instars showed higher activity involving non-feeding movements which was never shown by separated larvae. That this represents only a change in the general pattern of behaviour is shown by the fact

that the crowded larvae, when put in separation, their higher activity acted as a stimulant to feeding activity. The same tendency was reported by **Kariavanov (1988), and Kause *et al* (1999).**

The results of the mean total duration revealed that the development of crowded larvae was more rapid than those of separation in the first three instars, as found by **Lee *et al* (1990). Mishra *et al* (1998), and Kariman (2000),** while more retarded than those of separation in the two late instars. The least total duration applied to those separated in the last instar. Validity of this tendency was illustrated by the growth rates, which revealed that rate of acceleration was markedly affected with the time passed under crowded condition.

It could be concluded that a condition of stimulation among crowded individuals which caused extra stimuli in larvae and initiated responses over those experienced by the separated larvae, might propaby be due to a mechanical factor throughout successive instars from the simple mechanical effect of contact between larvae. **Eid (1967) and Kariman (2000).** This condition of stimulation might result in a higher feeding level, coupled with extra movement, which affected the internal physiological process and consequently the rate of development.

Crowding together with spacing are factors from the favourable complex of external conditions which had a desirable effect on the development and growth of the eriworm. Despite the result that larvae which practiced separation throughout the larval period weighed more than their crowded counterparts, the mature larval weights of the other conditions of separation were gradually increased with the increase of periods passed under crowding.

The demonstration of larval growth pattern by the progression factors revealed that the growth of crowded larvae was higher in the first three instars, however, a reversal response was deduced in the remainder instars and all conditions of separation were higher than crowds.

It could be suggested that a coaction between larvae acts as a growth promoting agency up to the third instar, but turns to operate in suppressive way at latter instars, where separation was advantageous. The result that crowding performed smaller larvae, is in agreement with those of **Eid (1967), Lee *et al* (1990), Srivastava *et al* (1997) and Kariman (2000).**

Concerning mortality, it could be deduced that conditions which lead to relatively rapid development tended to keep the mortality to a minumum. The least mortality incidence was achieved by rearing larvae in crowds till the fourth instar then in separation in the fifth instar.

The results concerning larval weights, were reflected on the weights of resulting coccons. The least and highest average cocoon weights applied to those of crowds and separation in the fifth instar, respectively. The silk production was found to have positive allometry in relation to body weight by **Eid (1967), Lee *et al* (1990), Talukder *et al* (1991), Alok and Sahay (1997) and Kariman (2000).**

This study must naturally lead to the question of the significance of these effects in raising the eriworm. Crowding followed by spacing proved to be behavioural performances with demonstrable biological significance

which could be potentially fruitful for achieving the most productive method for raising eriworm. Such goal could be approached by rearing larvae in intense crowing in the first two instars, in moderate crowding in the third and fourth instars and in separation in the last instar to gain the following : The least total larval duration, the highest larval growth, the least mortality incidence and the highest silk production.

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استخدام التزاحم والكثافة العددية القليلة فى تربية دودة الحرير الخروعية [٧٠]

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تم دراسة تأثير التزاحم بتربيـــة يرقـــات دودة حرير الخروع أما فردياً أو متزاحمـــة خلال الطور اليرقى . وفى تجربة أخرى تـم تربية اليرقات فى حالة تزاحم خلال الأربعـة أعمار يرقية الأولى ثم ربيت فرديا فى العمر اليرقى الأخير (الخامس) ، وقد تـم اختبـار السلوك العام لليرقات خلال العمـــر الـــيرقى الأخير . وقد وجد أن التزاحم كـــان أكـثر فعالية فى كل الأحوال عن التربية الانعزاليـة بينما كان السلوك المرتبط بالتغذية أعلى مـــا يمكن فى حالة اليرقات التى ربيت انعزاليـــا خلال العمر اليرقى الأخير . وفيما عدا ذلـك فإن التزاحم كان أكثر فعالية لليرقات بحوالي أكثر من ثلاثة أضعـــاف عنـــه فـــى حالـــة الانعزال .

فى حالة اليرقات التى ربيـــت متزاحمـــة خلال الأربعة أعمار الأولـــى ثـــم انعزاليـــا خلال العمر الخامس أمكن التحصل على أقل فترة حياة لليرقات وأعلى معدل نمو لـــها . أما المتزاحمة خلال فترة حياة اليرقـــة فقـــد كانت أقل الحالات وزنا فى العمـــر الـــيرقى الأخير . وفى حالة أوزان اليرقـــات التامـــة النمو والشـــرانق تحـــت ظـــروف التربيـــة الانعزالية فقد زادت تدريجياً بزيـــادة عـــدد الأعمار اليرقية التى ربيـــت منـــها تحـــت ظروف التزاحم . كما كانت نسبة الموت فى حالة اليرقات المتزاحمة أقـــل فـــى الثلاثـــة أعمار الأولى ، بالمقارنة بنفس النسبة فـــى حالة اليرقات التى ربيت فرديا . وفى بـــاقى الأعمار اليرقية ، كانت نسبة المـــوت فـــى اليرقات التى ربيت انعزالياً من العمر الرابـع والخامس أقل منـــها فـــى جميـــع الحـــالات الأخرى .

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