Influence of Parental Age upon the Offspring in the
Green Rice Leafhopper, *Nephotettix cincticeps*

UHLER (Hemiptera: Deltocephalidae)

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In order to make clear the possible role of the age-related effects of parents on the ecology of the green rice leafhopper, females were allowed to deposit eggs under a constant experimental condition (25°C, 70% RH, 16 hr day-length) and the ensuing larvae from the eggs laid by the mothers of different ages were reared individually with the young seedling of rice plant as their food. Differences in the physiological characteristics were compared with each other among the progeny produced from parents of different ages. The daily oviposition rate and the hatchability and size of eggs laid, on 1st to 2nd, 6th to 7th, 11th to 12th, 13th to 14th and later than 15th days elapsed after the beginning of oviposition, increased at first, attaining their maxima on 6-7th or 11-12th days and then decreased with increasing maternal age, forming parabolic trends. Daily changes in the number of eggs laid by each female, however, showed a cyclic fluctuation at intervals of 3-4 days over her oviposition period. In each cycle, most of the eggs were laid on the first day, and the later the day in the cycle the fewer were the eggs deposited. The same cyclic trends were also detected in the daily hatchability and size of eggs laid over the whole oviposition period. It was considered, therefore, that female physiological activity gradually decreases after passing the postemergence maturation period so that the trend will become parabolic and that the unequal partitioning of maternal food reserves will cause a change for the worse in the viability of the progeny produced during the last half of individual ovipositional cycles. The incubation period of eggs and most characteristics in the larval period, the size of the hatchling, survival time of unfed hatchling, length of period from oviposition to adult emergence, survival at larval stage etc monotonously changed with the aging of mothers. This gap, between the parabolic trends observed at the egg stage and the monotonous changes at the later stage, may be accounted for by the possibility of many deaths of weak progeny that result from selective elimination which could be associated with the unequal partitioning of the egg substrate, and also from the postponed manifestation of age related qualitative difference of the progeny itself. The difference of parental age gave rise to the qualitative variability of the adult progeny. Young mothers brought forth their progeny with protracted preoviposition period, low fecundity and long life-span. On the other hand remarkably persevering adults which withstood starvation longer came into being from old mothers. It is suggested that both adult progenies will assume different functions in the life of this species.
INTRODUCTION

It has been noted among different kinds of insects that physiological changes in the parents, related with their aging, affect the bio- and physiological characteristics of the offspring (Rockstein, 1959; Howe, 1967 etc.). Howe (1967) reviewed the literature on the influence of the age of the parental adult; among the various characteristics, the larval developmental period was found to be influenced most consistently by the parental age and he postulated as the causes that there are age-related genetic changes or that some cytoplasmic influences of the mother's physiology are carried into the eggs.

In the western tent caterpillar, Malacosoma plumiale (Dyar), the different types of individuals among the progeny are located in different parts of the egg mass (Wellington, 1965); the most agile progeny came from some of the first eggs laid and the least viable were among the last deposited. From this finding he inferred that the serial decline in quality stems from unequal partitioning of the maternal food reserves during egg production. This relationship is similar to the results that have been demonstrated in the spruce budworm, Choristoneura fumiferana (Clem.) by Campbell (1962); the weights of eggs produced by the spruce budworm females gradually decreased over the whole oviposition period. Campbell inferred that the quantity of maternal food reserves available to the growing oocytes decreased progressively as inter-oocyte competition for egg substrate increased.

These two examples probably match the second cause, namely, cytoplasmic influences proposed by Howe (l.c.). But in both, the maternal food reserves for egg production is derived from feeding during the larval period. Particularly, in the western tent caterpillar, the female moth usually lays only one egg-mass in her life and hence the parental influence by aging *per se* seems to be negligible. Meanwhile, females of the green rice leafhopper, Nephrotettix cincticeps (Uhler), normally lay eggs in a mass almost day by day over two or three weeks. The number of eggs per egg-mass varies from one to about thirty. Thus, the green rice leafhopper may represent a typical pattern of insect oviposition whereby not only unequal partition of egg substrate among oocytes but also influences of the maternal age upon the offspring will likely occur. In this paper, an examination into how and to what extent physiological changes of the parents, which are age-related, influence the bio- and physiological characteristics of the offspring in the green rice leafhopper, have been made. Discussion on the possible role of age-related parental influences on the ecology of this species has also been attempted.

MATERIALS AND METHODS

Male and female adults of the first generation were collected from paddy fields at Kochi Prefectural Institute of Agriculture and Forest Science, in June, 1967. About 100 pairs of the collected adults were released in a cage (60 × 30 × 30 cm), and the cage was kept at 25°C, 70 per cent R.H. under natural day-length with rice seedlings grown on the floor plate. They were allowed to lay eggs for several days on the seedlings. After hatching of the eggs, the rice seedlings were changed twice a week until completion of the emergence of the ensuing larvae as adults.
Influence of Parental Age upon the Offspring

(For further details concerning the rearing device, please see NAKASUJI and KIRITANI, 1970). Adults which emerged in the first few days of adult emergence in the rearing cage were used as the experimental materials. A male and female of less than 24 hr after emergence were kept in a glass tube (3 cm in diameter and 20 cm high) with a young seedling of a rice plant, supported by a piece of polyuretan moistened with water. Fifty pairs of parents were divided in two groups (Exp. 1 and 2). All the experiments were carried out at 25°C, 70 per cent R. H. under 16 hr illumination. Each seedling was examined daily for the number of eggs laid and these were used as the material. When both or either of parents died just after the beginning of oviposition, these were discarded from the experiment.

Exp. 1: Usually 1-30 eggs with a mean of 10 are laid side by side in the tissue of the stem of the young rice plant. Egg masses were preserved individually in a small glass tube (10 cm in diameter and 45 mm deep) with a piece of filter paper moistened with water. The filter paper was renewed every day. Eggs were observed until completion of hatching of healthy eggs in a batch. Larvae derived from egg masses deposited on 1st to 2nd, 6th to 7th and 11th to 12th, 13th to 14th and later than 15th days after the beginning of oviposition were used for Exp. 1. The larvae within 24 hr of hatching were individually put into a glass tube (2.5 cm in diameter and 20 cm deep) with a young seedling of rice plant. The food plant was renewed on the 5th, 10th and 14th days after setting and thereafter every other day. Larval death or ecdysis was examined daily until adult emergence. On emergence, each female was paired with a male from the same age group. The experimental conditions were the same as in the parental generation except that the food plant was renewed every other day, on which the number of eggs laid was recorded.

Exp. 2: The eggs laid by each parental female during the 1st to 3rd day and those laid later than the 9th day after the beginning of oviposition were kept in small tubes. The larvae that hatched out of an egg-mass were divided into three groups; the 1st group was used for measuring the width of head capsule of hatchlings, the 2nd for the mean survival time of unfed hatchlings and the 3rd for measuring the mean survival time of unfed adults as well as the width of their head capsules. Rearing methods of the larvae were the same as in the Exp. 1. Head widths of unfed adults were measured after they were starved to death. Survival times of unfed larvae and unfed male adults were determined by keeping them individually in a small tube (10 mm in diameter and 45 mm deep) at 25°C, 70 per cent R. H., the condition under which they died within 10 hr. However, females lived longer and died mostly at night under the same condition. To avoid this inconvenience for observation, therefore, only females were kept at 20°C, 70 per cent R. H. so as to be able to follow their death during the daytime of the following day. Before starvation, larvae and adults were allowed to feed on rice seedlings for one day just after hatching and emergence, respectively.

Exp. 3: Fifth instar larvae collected from paddy fields in June were reared in the laboratory, and used as adults for experiments immediately after emergence. In the same way as in Exp. 1, eggs deposited were counted day by day and their lengths were measured without delay.

Exp. 4: Another experiment was conducted at 25°C, 70 per cent R. H. under
the natural day-length in September to get further information on the duration and hatchability of eggs.

RESULTS

Preoviposition Period and Life Span of Females

Preoviposition period and adult life span of the females were about 7 and 20 days on the average, respectively. As most of the females continued oviposition immediately before death, the mean oviposition period was about 13 days.

![Graphs showing oviposition period and life span of females.](image)

Fig. 1. Mean number of eggs laid per female per day (a, Exp. 1), mean hatchability (b, Exps. 1 & 4) and mean size (c, Exp. 3) of eggs, and mean duration of egg stage (d, Exps. 1 & 4) are plotted against days elapsed after oviposition by parental females. Also, (b) and (d) include both results from Exp. 1 (○) and Exp. 4 (□) which correspond to the above and below numerals under the horizontal axis, respectively. Daily number of eggs laid per female (e), hatchability (f) and incubation period (h) of eggs laid on the first day of each cycle (Exp. 1), and mean egg size in individual cycles (g) (Exp. 3) are plotted against the number of cycles. The last two (i, j) show larval survival and percentage of adult emergence for progeny produced from parents of various ages after the initiation of oviposition (Exp. 1).

Ovipositional Pattern of the Parental Females

Fig. 1-a illustrates changes in the mean daily number of eggs laid per female in relation to the days elapsed after the initiation of oviposition (Exp. 1). It decreased after attaining its maximum at the age of 11-12 days, forming a parabolic curve, as the female parents become old. But as shown in Fig. 2 daily changes in the number of eggs laid by each female showed a cyclic fluctuation at intervals of 3-4 days over a 2 week period. Thus, the whole oviposition period of an individual female may be composed of several recurrent periods, each separable from the others by the days when the number of eggs laid shows a local minimum value. Such recurrent periods of each female are called, in turn, 1st, 2nd, 3rd,
Influence of Parental Age upon the Offspring

---, and \( n \)th ovipositional cycle in order of the age of the female adult. The local minimum day was regarded as the final day of the previous cycle. The daily total of the number of eggs laid by females was divided by the number of females concerned to give the mean number of eggs laid per female per day. Since each ovipositional cycle was mostly composed of 3-4 days, eggs laid on the 4th and later days were excluded from the calculation to avoid probable errors due to the small sample.

In each cycle, most eggs were laid on the first day and the later the day in the cycle, the fewer were the eggs deposited (Fig. 3). The number of eggs laid on the first day of each cycle decreased for each successive cycle, after attaining its maximum on 2nd cycle (Fig. 1-c).

Hatchability and Size of Eggs

The same parabolic trend was observed for the age-related changes in the mean hatchability and size of eggs as in the case of the mean number of eggs laid per female per day (Exps. 1 and 3, respectively). The mean hatchability of eggs increased at first, attaining its maximum on the 6-7th day and then decreased with the aging of the mother (Fig. 1-b, solid circle). The mean size attained its maximum five days later than the hatchability (Fig. 1-c).

Hatchability of the eggs in relation to ovipositional cycles is shown in Fig. 3 with comparable oviposition rates of their parent females. Variation in hatchability within a cycle was great; the hatchability was high on the first day and decreased thereafter. As in the case of the oviposition rate, the hatchability on the first day of each cycle increased at first and finally decreased, forming a parabolic curve with the increase in the number of cycles (Fig. 1-f).

The same trend was observed for intra-cyclic changes in the size of eggs deposited (Exp. 3). Fig. 4 illustrates relationships between the cumulative number of eggs laid by each female during an individual cycle and the mean length of eggs laid daily in the cycle. In this case, females laid eggs with ovipositional cycles of 2 or 3 days in length, thus the number of cycles increased. Individual points were so scattered that any definite trend could not be detected. Nevertheless three correlation coefficients took negative values in the last three cycles, that is, the size
of eggs tended to be large at first and then reduced gradually within a cycle. On the other hand, the correlation coefficients for the first three cycles took small positive values, indicating no such relation or rather an inverse tendency. When the mean egg sizes in individual cycles are plotted against the order of cycles, the parabolic trend is observed (Fig. 1-g).

**Duration of Egg Stage**

As mentioned previously the hatchability of eggs varied with parental ages or oviposition cycles (Fig. 1-b, solid circle and Fig. 1-f). It should be mentioned that the observed duration of the egg stage is not concerned with all of the eggs laid, but with individuals which survived egg mortality. Mean values of the duration instead of being parabolic increased monotonously when plotted against the number of days elapsed after the initiation of oviposition (Fig. 1-d, solid circle). Intra-cyclic changes in the duration of egg stage was so variable that no definite trend can be detectable as observed in the number, size and hatchability of eggs (Fig. 5). However, a clear cycle-related trend was observed when mean values of the duration were plotted against the order of cycles (Fig. 1-h); they were monotonously increasing (Exp. 1).

The results from Exp. 4 were somewhat different from those of Exp. 1 (Figs.

![Graph](https://example.com/graph.png)
1-b, d; hollow circle). The hatchability increased as a whole and a parabolic trend in the duration of the egg stage was observed. Fewer deaths before eclosion suggest a possibility that weak individuals have a greater chance of surviving in Exp. 4 than in Exp. 1 and this must badly affect the rate of development as explained below.

**Duration of Larval Stage and Larval Survival (Exp. 1)**

Duration of larval stage was hardly age-related when it was plotted against the maternal age or days elapsed after oviposition (Fig. 6; Table 1). But the mean duration was significantly shorter for the female progeny from the mother aged 1-2 days after the beginning of oviposition than for those from 6-7 day-old mother. Notwithstanding the fact that the mean duration of the egg stage monotonously increased with aging of the mother, the difference in the total duration from egg to adult emergence was not significant between the offsprings from the

Table 1. **Relationship between the Larval Developmental Period in Days and the Maternal Age in Days Elapsed after Beginning of Oviposition**

<table>
<thead>
<tr>
<th>Maternal age in days after oviposition</th>
<th>1-2</th>
<th>6-7</th>
<th>11-12</th>
<th>13-14</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of samples 1</td>
<td>21</td>
<td>29</td>
<td>28</td>
<td>7</td>
</tr>
<tr>
<td>No. of samples 2</td>
<td>16</td>
<td>18</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>Mean± S. E. 1</td>
<td>19.33±0.22*</td>
<td>20.28±0.21*</td>
<td>19.68±0.18</td>
<td>19.00±0.44</td>
</tr>
<tr>
<td>Mean± S. E. 2</td>
<td>18.06±0.23</td>
<td>17.67±0.32</td>
<td>18.17±0.18</td>
<td>17.00±0.41</td>
</tr>
</tbody>
</table>

a. Significant difference between 1-2 and 6-7 at 95% level.

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![Fig. 6](https://example.com/fig6.png)

*Fig. 6. Relationship between days elapsed after oviposition and cumulative developmental periods from oviposition until emergence (Exp. 1). Left: females; right: males.*
parents of different ages. Thus the remarkable difference in the incubation period of eggs (Fig. 1-d, solid circle) was masked by the 4th and 5th instars (9) or during the 5th instar (8) (Fig. 6).

The larval survival was about 46 per cent in the progeny from females of 1-2 days old and it decreased with mother’s aging. But there was no significant difference in survival among the progeny from 6-14 day-old mothers (Fig. 1-i). Overall survival rates from egg to adult for all of the progeny were almost the same except for that of progeny from the oldest mother, notwithstanding that the parabolic trend was observed in the egg survival (Fig. 1-j).

Larval and Adult Head Widths (Exp. 2)

Frequency distributions of the head width of newly hatched larvae and emerged adults are illustrated in Fig. 7. The progeny from the young mother (1-3 days after the beginning of oviposition) were hardly different in size from the old mother's progeny (mother 9 or more days old). Notwithstanding that the larvae from the old parents tended to be slightly smaller in their head width, such tendency was not found in the adult head width.

![Fig. 7. Frequency distribution of head widths of hatched larvae, male adults (M) and female adults (F) (Exp. 2). Figures are separately shown for the progeny from young parents aged 1-3 days after oviposition and those from old parents aged 9 or more days after oviposition.](image)

Survival Times of Unfed Larvae and Adults (Exp. 2)

Emerged adults and hatched larvae were grouped in the same way as in the previous experiment, and survival times of the unfed progeny were measured (Fig. 8). As mentioned in the section of experimental methods, larvae and adults used for the starvation experiment were allowed to feed for 24 hr before depriving them of food. There were more individuals resistant to starvation among the larvae from young mothers than from old ones. On the other hand, any significant difference in the mean survival time was hardly perceivable between the adult progeny of young and old mothers. Among the female adults from old mothers, however, there appeared some very weak individuals which died within 9 hr and some very vigorous individuals which lived for 48-57 hr at 20°C, whereas such strong
Influence of Parental Age upon the Offspring

![Graph showing survival of larvae and adults](image)

Fig. 8. Percentage frequencies of survival times of unfed progeny produced from young (above) and old (below) parents (Exp. 2). Left: hatched larvae; middle: male adults; right: female adults.

Individuals were not detected among the female adults from young mothers. About 63 per cent of the male adults from old mothers survived at least for 10 hr at 25°C. This figure was about three times as large as the percentage of such individuals from young mothers (19 per cent). On the other hand, the proportion of very weak individuals among the progeny was not different between the two groups of male adults, it was about 10 per cent for both groups.

The head width of hatched larvae and the survival time of unfed larvae decreased with the increase of parental age. The head width of adults bear no relationship with the age of parents, but some individuals, which were extremely resistant or weak to starvation, were detected among the female adults from old mothers. Meanwhile the resistance of male adults to starvation greatly increased with the aging of parents.

Other Biological Characteristics Observed at the Adult Stage

Table 2 shows the preoviposition period, duration of adult life span, fecundity and number of egg masses per female, size of egg masses and percentage of non-reproductive females etc., that resulted from Exp. 1. The preoviposition period shorted with increasing maternal age; particularly female adults from the youngest mothers revealed extremely longer periods than those from older ones. The life span of female adults decreased with the aging of their mothers, but it was due rather to the decrease of the preoviposition period. As far as the life span of male adults is concerned, the progeny from 6-7 day-old mothers were long-lived, compared with the progeny from 1-2 or 11-12 day-old mothers, but no significant difference was detected.

Changes in the fecundity of the female progeny were not age-related. But the size of the egg-mass (number of eggs per egg-mass) deposited by daughters became gradually small with the aging of parents. The progeny from old mothers (13-14 days after oviposition) seemed to be more fecund than those from younger mothers. The proportion of non-reproductive females was slightly higher among the females developed from the eggs deposited by the old female. These individuals,
TABLE 2. PARENTAL AGE-RELATED EFFECTS ON THE LENGTH OF LIFE AND THE OVIPOSITIONAL PHYSIOLOGY OF THE PROGENY

<table>
<thead>
<tr>
<th>Maternal age in days after 1st oviposition</th>
<th>1-2</th>
<th>6-7</th>
<th>11-12</th>
<th>13-14</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of adult progeny (♂)</td>
<td>22</td>
<td>26</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>(♀)</td>
<td>17</td>
<td>17</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>Pre-oviposition period in days (♂)</td>
<td>10.67 ± 0.43 (^a,b)</td>
<td>6.55 ± 0.39 (^a,b)</td>
<td>4.83 ± 0.20 (^a)</td>
<td>4.33 ± 0.42 (^b)</td>
</tr>
<tr>
<td>(♀)</td>
<td>18.64 ± 1.46</td>
<td>13.65 ± 1.51</td>
<td>13.33 ± 1.39</td>
<td>11.11 ± 2.21</td>
</tr>
<tr>
<td>Adult life span in days (♂)</td>
<td>13.65 ± 2.46</td>
<td>19.29 ± 2.23</td>
<td>14.76 ± 1.86</td>
<td>15.75 ± 2.25</td>
</tr>
<tr>
<td>(♀)</td>
<td>18.57 ± 2.70</td>
<td>69.27 ± 11.22</td>
<td>88.44 ± 12.17</td>
<td>76.44 ± 25.22</td>
</tr>
<tr>
<td>Fecundity per female</td>
<td>83.57 ± 12.70</td>
<td>69.27 ± 11.22</td>
<td>88.44 ± 12.17</td>
<td>76.44 ± 25.22</td>
</tr>
<tr>
<td>Fecundity of reproductive female</td>
<td>101.50 ± 10.57</td>
<td>94.79 ± 10.24</td>
<td>103.83 ± 11.53</td>
<td>114.67 ± 25.46</td>
</tr>
<tr>
<td>Percentage of non-reproductive female</td>
<td>18.18</td>
<td>26.92</td>
<td>14.81</td>
<td>33.33</td>
</tr>
<tr>
<td>No. of egg masses per reproductive female</td>
<td>12.26 ± 1.36</td>
<td>11.70 ± 1.22</td>
<td>12.43 ± 1.32</td>
<td>17.00 ± 1.13</td>
</tr>
<tr>
<td>Size of egg mass</td>
<td>9.04 ± 0.49</td>
<td>8.38 ± 0.47</td>
<td>8.04 ± 0.55</td>
<td>8.01 ± 0.41</td>
</tr>
<tr>
<td>Adult life span in days per non-reproductive female</td>
<td>7.51 ± 1.65</td>
<td>7.57 ± 4.36</td>
<td>1.15 ± 0.50</td>
<td>4.33 ± 1.33</td>
</tr>
<tr>
<td>Adult life in days per reproductive female</td>
<td>21.11 ± 1.06</td>
<td>15.89 ± 0.98</td>
<td>15.39 ± 1.17</td>
<td>14.50 ± 2.11</td>
</tr>
</tbody>
</table>

a. Significant difference at 95% level between 1-2, 6-7 and 11-12.
b. Significant difference at 95% level between 1-2, 6-7 and 13-14.

however, were so short-lived that it was not sure whether they could be considered as sterile females (Table 2).

DISCUSSION

As regards the relationship between the size of egg-mass and the oviposition interval, for example—females of Nezara viridula lay eggs in a large egg-mass of 70-100 eggs with a long interval of about 1 week between the deposition of egg-masses, while in Scotoiphara turida and Eury dema rieomus which deposit small sized egg-masses with 12-14 eggs each, the ovipositions are spaced at rather short intervals of 1 or 2 days (Kiritan i and Hoky, 1965)—in the green rice leafhopper, groups of small egg-masses which are laid daily during individual cycles may be, comparable to large egg-masses which are to be deposited at intervals of several days. Probably an accumulation of egg substrate through feeding will follow the next ovipositional cycle. Therefore the phenomena mentioned above may be interpreted as follows. Each serial decline in the quality and number of eggs in an individual cycle will be influenced by the unequal partitioning of the maternal food reserve amongst the eggs, because each ovipositional cycle seems to be comparable to an egg cluster of Malacosoma in producing different quality of eggs, e.g., egg size, hatchability etc. (Wellington, 1965; Kiritan i, 1969). The possibility of such unequal partitioning of egg substrate amongst the eggs in individual egg-masses was not referred to in this paper, because eggs in an egg-mass were used without discrimination in Exps. 1 and 3. Influence of aging of parents would be
Influence of Parental Age upon the Offspring

rather trivial in *Malacosoma pluria*, because the maternal food reserve of this insect essentially stems from feeding during the larval period and all eggs are laid in an egg-mass.

The number of eggs laid and the quality of eggs such as hatchability and size were distinctly related to ages of their parents and to oviposition cycles. These values tend to depict a parabola, showing a maximum at middle age of their parents. The trend which has been most frequently observed in age-related phenomena (Howe, 1967), may be comparable to "metachemogenesis" or a post-emergence biochemical maturation which has been proposed by Clark and Rockstein (1964); for each species of holometabolus insects, there is an obligatory period of postemergence maturation; the maturation of the holometabolus imago is not truly complete with the emergence of the apparently fully developed adult. They suggested the moment when ATPase, cytochrome c, cytochrome oxidase, glycogen and so on are at their maxima varies from species to species (e.g. from about 1 day in the common house fly to about 10 days in the worker honey bee). Also, they pointed out this postemergence biochemical maturation may be directly related to the maturation of flight ability. In the green rice leafhopper, its flight is most active at about seven days after emergence, that is, just before the beginning of the oviposition at 25°C (Kiritani, unpublished). The same line of argument can be applied to postemergence maturation concerning reproduction.

The duration of the egg stage increased monotonously with the aging of the parents, but in another experiment it still showed the parabolic trend which was observed similarly in the hatchability and size of eggs. In general, it is considered that the difference amongst individuals that stems from the unequal partitioning of the maternal food reserve during egg production disappears gradually during feeding after hatching and some age-related influences of parents begin to become intense in place of the former. In the western tent caterpillar, there were marked increases in the proportions of unhatched larvae and partly developed embryos in the last half of the egg-mass. They were treated as the least successful representatives of the sluggish IIC category. In regard to larvae that manage to escape from eggs, the food consumed just after eclosion often restores some shrivelled and obviously starved sluggish type of hatchlings to the normal size and appearance, but it never improves their orientation or changes their behaviour; they are left with a permanent behavioural handicap that soon affects their feeding rate and their subsequent rate of development (Wellington, 1965). It is plausible, therefore, that unequal partitioning of the maternal food reserve will not only result in retardations in the embryonic stage, but also result in the failure of hatching of weak progeny. This selective influence during embryonic stage may also give rise to the reduction in the qualitative viability of hatchlings. Indeed, in the green rice leafhopper such biological characteristics as the head width of hatchlings, the surviving time of unfed hatchlings, the survival rate of larvae and the developmental period from egg to adult emergence changed with the aging of parents. These age-related changes may have partly resulted from the selective elimination of weak individuals in the egg and larval stages against the difference of quality, and partly from the manifestation of age-related qualitative difference of the hatchlings themselves.

Biotic performances of adults also changed with the aging of parents; female
progeny that originated from young mothers showed longer preoviposition period and longevity and low fecundity as compared with those from old ones.

As regards resistance to starvation, there was a great variation in the resistance, from very weak to very strong, amongst the progeny derived from old mothers. This may correspond to facts observed in the rice root aphid, *Rhopalosiphum rufiabdominalis*; that late-born apterous daughters produced by old apterous females when reared under crowded conditions show positive phototaxis and are considerably resistant to starvation as adults, while those reared individually are photo-negative and weak to starvation. This relationship turned thoroughly in the opposite direction for the progeny from young mothers, especially in regard to tolerance to starvation (Matsuzaki and Kiritani, unpublished). The significance of such variation in resistance to starvation as observed in the green rice leafhopper may be accounted for in future by rearing larvae of different age groups under various conditions, e.g. population density, food conditions etc.

Since it is technically impossible to examine reproductive ability in relation to resistance to starvation from the same individuals, no information is available in regard to this point. It is reasonable, however, to infer that in such an insect as the green rice leafhopper which develops on annual plants, e.g. rice, dispersal by flight is rather a regular and inborn process than a behavioural response to currently adverse factors in the environment (Johnson, 1967). The fact that the progeny from young mothers had a longer preoviposition period as well as a smaller fecundity than those from old ones may suggest that the former ones are the type adapted to dispersal. The weak resistance to starvation among the progeny from young mothers does not contradict the fact that in *R. rufiabdominalis*, alate forms are less resistant to starvation than apterous ones.

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Influence of Parental Age upon the Offspring

