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Rate of Oviposition and Effect of Crowding on Egg Cannibalism and Pre-adult Mortality in *Martianus dermestoides* Chevrolat (Coleoptera, Tenebrionidae)

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Introduction

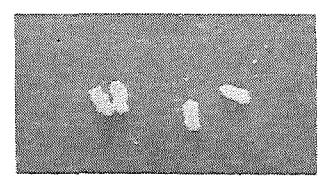
The Japanese common name of *Martianus dermestoides* Chevrolat, 'Kyûryû-chû', means a beetle introduced from Chiulung. Chiulung or Kowloon is the British colony on the south-eastern coast of China. It is said that the Chinese has a custom to take an alive adult beetle of *M. dermestoides* as an analeptica. The custom was brought to Japan in 1939—1940 and became popular in the 1960's, but now it seems to have died out. Hitherto, in Japan, *M. dermestoides* does not occur at field including flour mill and warehouse.

M. dermestoides is euryphagous. The beetle feed on rice bran, wheat flour, bread, apple, pollen, dried yeast, yeast extract, saccharose and royal jelly (TAKEUCHI, HAGIWARA, WADA, MIYOSHI, and TANIGISHI, 1970). They have a high rate of increase and are able to overwinter at any heated place. Therefore, it seems that *M. dermestoides* is a potential pest having the possibility of becoming a serious pest of stored products in the future. Little information is available on the biology of *M. dermestoides*. In the present paper some of the population biology of *M. dermestoides* was investigated in the laboratory conditions.

Life-history of *Martianus dermestoides*

All experiments in the present paper were conducted in a cabinet controlled at about 30°C and 61—75 per cent R. H. using insects bred in rice bran unless otherwise noted.

In these conditions the mated female of *M. dermestoides* begins to oviposit about 7 days (5—9 days) after emergence. The egg is whitish, slender, and cylindrical in appearance, measuring approximately 1 mm in length. It is adhesive when laid, and becomes coated with particles in which it is laid (Fig. 1). The oviposition-period of the mated female ranges from 35 to 50 days. The total number of eggs laid per female is about 160. The egg hatches after about 3—4 days of incubation period. The larval period is about 35 days and is increased with crowding to about 50 days when 32 larvae are reared in 9×1.5 cm glass tube containing 1 g of the rice bran. The pupae require about 3—4 days for emergence. The complete life cycle requires about 42 days.



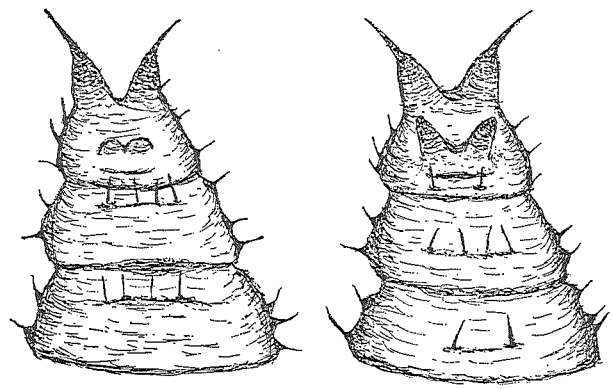
1 mm

Fig. 1. Eggs of *Martianus dermestoides*: coated with particles of flour.

Sexual difference in the pupal stage

The sexual difference of *M. dermestoides* is found in the pupa in the form of the genital appendages. The male has two globular papillae, but the papillae of female

are strongly protuberant (Fig. 2). The sex of pupae is readily distinguished by this difference of papillae.



Male Female

Fig. 2. Terminal segments of pupal abdomen, ventral view. Pupal genital papillae : male, globular ; female, protuberant.

Rate of oviposition

The oviposition rate per female was measured in the following manner. The experimental beetles were maintained in 8 × 5 cm plastic vessels, a lid having a central hole, 2.8 cm in diameter, covered by a vinyl cloth. The bottom of vessel was covered with a rough paper. This helped the beetles to upturn when they fell on their backs. The insects were sexed in the pupal stage and the sexes kept apart until the adults emerged. Each pair of adults aged less than 24-hr were placed in the vessels con-

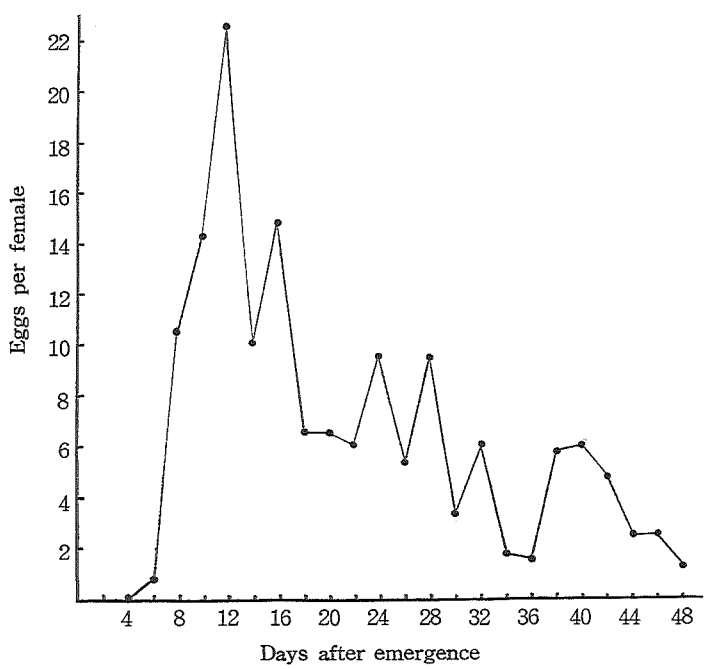


Fig. 3. Rate of egg production per female per two days. Average of four replicates.

taining 1.0 g wheat flour on the rough paper. Every other day the eggs deposited were sieved from the flour using the 60-mesh sieve. The eggs were removed and counted. The beetles were returned to the vessel. The flour was renewed at intervals of five days. The experiment was replicated 4 times.

The result of experiment was shown graphically in Figure 3 on the average. The female began to oviposit at 4—6 days after beginning of experiment. The rate of egg-laying rapidly reached its maximum at 10—12th day, after which the rate fell off gradually. The maximum number of eggs deposited in the two successive days per female in all the experiments was 32.

The procedure used in the experiment may affect the oviposition rate, it may depress the rate, or may delay the onset of oviposition. The cannibalism of eggs by adults also may depress the rate, and thus may not give a true picture of the oviposition pattern.

Cannibalism of eggs by a male adult at different egg densities

The cannibalism is found in almost all the pests of stored products. In the first place the rate of cannibalism of eggs by male adults was measured at various degrees of egg density. The method of experiment was almost the same with the experiment on the rate of oviposition. One male adult less than one week old was introduced into the vessels, each containing 1.0 g of wheat flour, together with 5, 10, 20, 40 and 80 eggs aged less than 24-hr. The eggs were mixed at random into the flour. The eggs were ceived and removed at each 24-hr intervals and the number of eggs eaten during the interval was counted. The same procedure was repeated for five successive days. Every day the male was returned to the vessel in which each number of fresh eggs was put. The flour was not renewed during the experiment. Each density was represented by 5 replicates.

The result of experiment was shown in Table 1. In the experiment, not all the

Table 1. Cannibalism of egg by *M. dermestoides* male adult and egg density

No. eggs	No. male observed cannibalism (per cent)	Average no. days observed cannibalism per female ± S.D.	Average no. eggs eaten per male per day ± S.D.	Cannibalism rate ± S.D. ($\times 10^2$)
5	0 (0)	0.0 ± —— †	0.00 ± —— †	0.00 ± ——
10	2 (40)	0.6 ± 0.917*	0 20 ± 0.577*	2.00 ± 5.770
20	3 (60)	2.0 ± 1.673	0.68 ± 1.030	3.40 ± 5.150
40	5 (100)	2.6 ± 0.490**	1.00 ± 1.190**	2.50 ± 2.975
80	5 (100)	3.4 ± 0.800**	1.56 ± 1.417**	1.95 ± 1.771

†) The difference between * and ** is significant at the 5 per cent level.

males showed cannibalism. At the egg density of 5 no cannibalism was found in all the experiments. At 10 eggs only two males and at 20 eggs three males were found to eat eggs during the five days. At higher densities of 40 and 80 eggs all the males showed cannibalism at times during the experiment. The beetles did not eat eggs every day, but ate continuously for several days (average : 1.938 days, S.D. : ±0.899, range : 1—4 days) and ceased eating for one or two days (average : 1.250 days, S.D. : ± 0.433). As the egg density increased the average number of days observed to eat eggs per female increased. With increase of density, the average number of eggs eaten per male per day also increased. But the cannibalism rate, the fraction of eggs eaten per beetle per day, increased as the egg density increased from 5 to 20 and reached a maximum at the egg density of 20, beyond which it decreased with increase of density.

Crowding effect of the male adult on the egg cannibalism

Next, the effect of crowding of male adults on the cannibalism rate was measured using 2, 4, 8 and 16 males, less than one week old, per vessel containing 40 eggs mixed with 1.0 g wheat flour. The flour was sieved at one-day interval, and the eggs removed were counted and the males were returned to vessels each containing 40 fresh eggs. The experiment was continued for five days and replicated 5 times.

The result of experiment was summarized in Table 2. The crowding of beetles lowered the rate of cannibalism. As the adult density increased, the average number of eggs eaten per male per day and the cannibalism rate both decreased rapidly.

Table 2. Crowding effect of male adult on egg cannibalism

No. males	Average no. eggs eaten per day ± S.D.	Average no. eggs eaten per male per day ± S.D.	Cannibalism rate ± S.D. ($\times 10^2$)
2	0.64 ± 0.93	0.320 ± 0.467*†	0.800 ± 1.167*†
4	0.68 ± 0.79	0.170 ± 0.197*	0.425 ± 0.491
8	1.32 ± 1.67	0.165 ± 0.208	0.413 ± 0.521
16	1.16 ± 1.38	0.073 ± 0.086**	0.181 ± 0.215**

†) The difference between * and ** is significant at the 5 per cent level.

Effect of crowding on pre-adult mortality

The effect of crowding on the mortality in developmental period was investigated starting from egg stage. Cultures of the experiment were maintained in glass vials, 9 × 1.25 cm, and cotton cloth covering was put on their opening end and it was fixed by rubber bands. Six initial densities of eggs less than 24-hr old were used, 2, 4, 8, 16, 32 and 64 eggs per vial containing 1.0 g rice bran. Each density was replicated 5 times. Daily examination of the vials was made for adults from the 40th day after beginning of experiment and was discontinued when 5 days elapsed without an adult emerging.

The result of experiment was indicated in Figure 4 in survival-rate. Any two

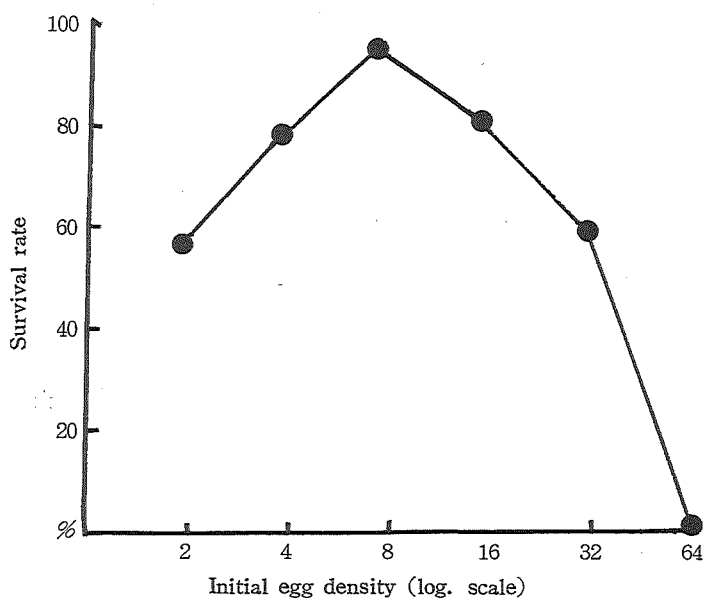


Fig. 4. Effect of crowding on the survival-rate in developmental period.

average survival-rates at 6 different egg densities were significantly different at the 5 per cent level, excepting between 2 and 4, 2 and 16, 2 and 32, 4 and 16, and 4 and 32 initial egg densities. The beetle was markedly tolerable to overcrowding. The maximum number of adults emerged in the experiment was 25 at the egg density of 32. One beetle was able to complete his development on a little amount of 0.04 g rice bran on the average in these conditions. At the highest density of 64 eggs all rice bran was consumed and almost all the beetles died out with starvation.

Discussion

DICK (1937) distinguished four types of oviposition cycle in Coleoptera. In the pests of stored products we can recognize two types of these :

(A) Short-lived species which lay all of their eggs in a few days.

(B) Long-lived species laying continuously over a long period.

The pests of Brucidae and Lepidoptera typically belong to the A category, and that of *Tribolium*, *Sitophilus* and *Oryzaephilus* spp. belong to the B category. *M. dermestoides* seems to belong to the A type, although the beetle lay eggs over a considerable long period.

RICH (1956) determined cannibalism rates for males and females of *Tribolium confusum* using 32 adults of various sex-ratios and 200 marked eggs introduced. The estimated cannibalism rate for males was 0.2983 ($\times 10^2$) while the rate for females was 2.0119 ($\times 10^2$). The ratio of female rate to male rate was approximatly 7. SONLEITNER (1961) carried out an almost identical experiment with *T. castaneum* and found cannibalism rate of 0.109 ($\times 10^2$) for males and 2.112 ($\times 10^2$) for females. Females were some 19 times more voracious than were males. In the present experiment it was found that cannibalism rate for male *M. dermestoides* was 0.181—3.400 ($\times 10^2$) depending on density. It seems probable that *M. dermestoides* is as voracious as *Tribolium* spp. and the females of this species eat eggs at a rate some times greater than that of males.

PARK, NATHANSON, ZIEGLER and MERTZ (1970) view cannibalism as density-related predation and PRUS and PARK (1973) claim that "cannibalistic predation" plays a primary role in the control of population numbers. BOYCE (1946) indicated that the proportion of eggs eaten by male beetle of *T. confusum* increased when the number of eggs initially introduced into the culture was increased, and SONLEITNER (1961) found that when the initial density of marked eggs was increased, there was a significant increase in cannibalism rate with *T. castaneum*. For *M. dermestoides* the average number of eggs eaten per male per day increased with egg density, but for cannibalism rate a tendency toward an optimum density at 20 eggs was shown. Cannibalism of eggs by one male occured intermittently, the beetle continued to eat eggs for several days and ceased eating for one or two days, these alternating with each other. And the number of beetles found to eat eggs and the number of days shown cannibalism per beetle both increased as the egg density increased. These tendencies in cannibalistic predation seem to be important at lower prey and predator densities.

The egg cannibalism was intensified by an increase in adult density for *T. confusum* (BOYCE, 1946; RICH, 1956). In the present experiment that tendency was not exhibited decidedly, but the average number of eggs eaten per day tended to reach a maximum at the density of 8 males. Nevertheless cannibalism rate per beetle of *M. dermestoides* decreased with increase in adult density. The latter relation was similar to that demonstrated for *T. confusum* (RICH, 1956) and *T. castaneum* (SONLEITNER, 1961).

Summary

1) The life-history of *Martianus dermestoides* Chevrolat bred in rice bran was presented briefly at the laboratory conditions of 30°C and 61—75 per cent R. H.

2) Sexual difference in the pupal genital appendage was illustrated.

3) Mean rate of oviposition (age-specific net fecundity) was shown graphically.

4) Cannibalism of eggs by a male adult was investigated at different egg densities. Cannibalism occured intermittently, a beetle continued to eat eggs for 1—4 days and ceased eating for 1 or 2 days. The number of both beetles and days observed to cannibalize increased with density of eggs introduced. As the egg density increased, the average number of eggs eaten per male per day also increased.

5) Crowding of the male effected on the egg cannibalism. As male density increased the average number of eggs eaten per male per day and the cannibalism rate, the fraction of eggs eaten per beetle per day, both decreased rapidly.

6) Effect of crowding on pre-adult mortality was investigated initiating at various degrees of egg density. The beetle was markedly tolerable to overcrowding.

Acknowledgement

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キュウリュウチュウ (*Martianus dermestoides*) の成虫による卵の共食いと発育期の死亡率への密度効果および産卵曲線

吉　田　敏　治
(岡山大学農学部応用昆虫学教室)

1) キュウリュウチュウは食性が広く，増殖率が高いから，将来，重要な貯穀害虫になる可能性を持った潜在害虫である．2) 温度30℃，関係湿度61～75パーセントの実験室内で，米ぬかを餌に実験を行なった．3) この条件下での生活史を簡単に述べた．4) 蛹の生殖器の形が違うので，これで性が容易に区別できることを示した．5) 産卵曲線を明らかにした．6) 卵密度が雄成虫による卵の共食いにどう響くかを調べた．卵の共食いは間欠的に行なわれ，卵密度がますと，共食いを行なう日数，個体数，1日1匹当りの平均共食い卵数は増した．しかし，共食い率（そこにあった卵のどれほどの割合が，1日1匹当りで，食べられるかという率）には最適密度があるらしく，その卵密度との関係ははっきりしなかった．7) 成虫密度を変化させると，共食い率は成虫密度が増すほど低下した．8) キュウリュウチュウは高密では餌がほとんどなくなるまで食い尽くし，高密に極めて強いことがわかった．