Int. J. Indust. Entomol. Vol. 15, No. 2, 2007, pp. 157~160

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International Journal of
Industrial Entomology

Artificial Diet for Mass Rearing the Emma Field Cricket, *Teleogryllus emma* (Orthoptera: Gryllidae)

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(Received 30 October 2007; Accepted 26 November 2007)

Nymph of the emma field cricket, *Teleogryllus emma*, were reared on several types of artificial diets. The development period of nymphs were 55.4 days when only a single food, wheat bran, was provided, and it did not show a significant difference compared to the rearing results of the Danong diet and mixed diet. The supplying period of fish meal as the animal feed, the high emergence rates were obtained at 3rd instar with 90% and 4th instar with 100%. For the added amount test, when more than 40% of the diet was added, it confirmed that the insect weight increased. The characteristics of development according to each added amount of the vegetable food (dry bean-curd residue and corn powder) were investigated to minimize the dangers of the degeneration of diet when rearing with a single feed during the 1st~3rd instar period. First, as the added amount of bean-curd residue increased, nymphal development period became longer and the emergence rate became low. With corn powder as the single diet, all died before becoming adult. However, when corn powder was added up to 30%, no difference existed in the breeding results.

Key words: Cricket, *Teleogryllus emma,* Diet, Development

Introduction

Lately, insects are being perceived not only as practical resources for agriculture and the biotechnology industry but also as genetic resources with an infinite amount of potential. In addition, interest in these potential uses has been gradually rising. Research on obtaining and breeding various insects (Yoon et al, 2000; Seol and Kim, 2001; Kim and Seol, 2003; Kim et al, 2007) is fundamental in order to find, mass rear and preserve a lineage of useful insect resources.

Crickets have been kept in captivity for thousands of years as many people consider the singing of the adult males to be pleasant. More recently they have been kept by many people as a live food source for a great variety of carnivorous animals. They are also an excellent fishing bait. However, they can also be kept purely for the joy of viewing them as they are small, attractive animals with a real charm of their own.

Field crickets spend the winter as eggs laid in the soil. These eggs hatch in late spring or early summer, and tiny immature crickets called nymphs, which look like the adults except for their smaller size and absence of wings, emerge. The adults mate and lay eggs in the late summer before succumbing to old age or freezing temperatures in the fall. Chirping, one of the hallmarks of crickets, is done only by the males as a way to attract females of their own species. Chirping is produced by rubbing the wings together. Field crickets (Gryllinae, especially Gryllus spp.) have many advantages for use in field and laboratory studies of insect ecology and behavior (Choo and Choi. 1983; Doherty and Storz 1992; Gray, 1999; Fitzpatrick and Gray 2001; Bertram, 2002). They are widely distributed, easily collected, large in size and easily sexed. Most crickets are omnivorous and feed on just about anything. They will eat plants, dead insects, seeds, leather, paper and old cloth (especially if the cloth is stained by food or perspiration). They are particularly fond of wool and silk. Feeding crickets the proper diet is important for two reasons: first, they need adequate nutrition to survive and breed and second, nutrition from the crickets will be

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Table 1. Comparison of nymphal growth in *T. emma* reared on different food substrates. Nymphs were reared under a photoperiod of 16L : 8D at 28°C. Means in columns followed by the same letter are not significantly different by Tukey's HSD multiple range test ($P = 0.05$).

Food	Development period of nymphs (Mean ± SD, days)	Emergence rate (%)	Adult weight (mg)
Wheat bran	55.4 ± 5.10a	95.6	482 ± 14a
Mixed diet[1]	50.2 ± 5.22a	92.2	635 ± 58a
Danong diet[2]	54.0 ± 2.73a	71.3	562 ± 11a
Anchovy powder	65.5 ± 2.12b	48.9	401 ± 40a

[1]Mixed diet 3% wheat germ, 30% mouse diet, 20% rice bran, 23% wheat bran, 20% corn powder, 3% vitamin compounds and 1% wesson's salt compounds by weight.
[2]Danong diet; commercial cricket diet.

passed on to the reptiles or amphibians that eat them, so it is important to keep them healthy. Crickets require a high-protein diet. Without - and often with - an adequate diet, the crickets will prey on each other. Commercial cricket food sold at pet shops are very expensive. The food is based on commercial dried cat food. Artificial diets are useful for mass rearing. Therefore, this paper carried out experiments with the purpose of developing artificial diet in order to improve the productivity utilizing cheap diet supply when rearing *Teleogryllus emma* for the purpose of establishment of the successive rearing method of the crickets in a room condition.

Materials and Methods

T. emma were obtained from fields in the Suwon region of Korea in September, 2002. Cricket rearing was carried out in the laboratory regulated at 28 ± 1°C, 60% R.H. under a 16h light 8h dark photoperiod. The *T. emma* were reared in the laboratory for more than 1 year before individuals were used in the experiments (Kim et al, 2005). Hatched nymphs were individually reared in a plastic container under the same conditions described earlier. The various plastic containers used for rearing were as follows: a small container (9.0 cm diameter and 1.5 cm height) for the 1st through the 4th stage, and a large container (15.0 cm diameter and 2.5 cm height) for the 5th through the 9th stage. An artificial diet was fed during the 1st through the 4th nymph stage in a container with wheat bran and water using flower foam, Oasis® (4 cm × 2 cm × 2 cm), and during the 5th through the 9th nymph stage, with wheat bran mixed with 40% fish powder and distilled water provided in a small container with artificial cotton at the bottom (4 cm × 2 cm × 2 cm).

Single food (wheat bran), mixed diet, Danong diet provided by Danong Natural Inc., and animal food (anchovy powder) were tested for the identification of a low-price diet satisfying the nutritional requirements of *T. emma*. The mixed diets consisted of 3% wheat germ, 30% mouse diet, 20% rice bran, 23% wheat bran, 20% corn powder, 3% vitamin compounds and 1% wesson's salt compounds by weight. Since hatched nymphs easily die by drowning, after placing gardening Oasis® (Floral form for flower arrangement) soaked with distilled water in the Petri dish (9.0 cm diameter and 2.5 cm height), the developmental period of the nymphs was examined at each developmental stage by individually rearing each cricket and checking daily to see if it molted or not. After reaching the 4th instar, the insect's body became larger, and it began to eat Oasis®, so artificial cotton was placed in a small container instead of Oasis®, and distilled water was put inside. In addition, the rearing container was replaced with a slightly larger Petri dish (15.0 cm diameter and 2.5 cm height). For each diet, ten insects were tested once, and this process was carried out three times.

In order to study the effects of the timing of food provision, we studied the nymphal developmental period and emergence rate and the weight of the new adults after adding 50% of the fish meal at each instar. To test the amount of food required, during the 4th instar the amount of fish meal added was 10, 20, 30, 40, and 50%. Insects were tested as described above.

Each test was carried out by supplying dry bean-curd residue and corn powder as substitutions for wheat bran, which was provided as feed during the 1st through 3rd instar period. The test involved adding 10, 20, 30, 40, and 50% dry bean-curd residue and corn powder to the diet, while controls received only the substitute diet. The test insects, rearing conditions, and experimental methods were the same as those used in the development of the artificial diet.

Statistical analysis

Differences in developmental period and adult weight were tested by analysis of variance (ANOVA). If signifi-

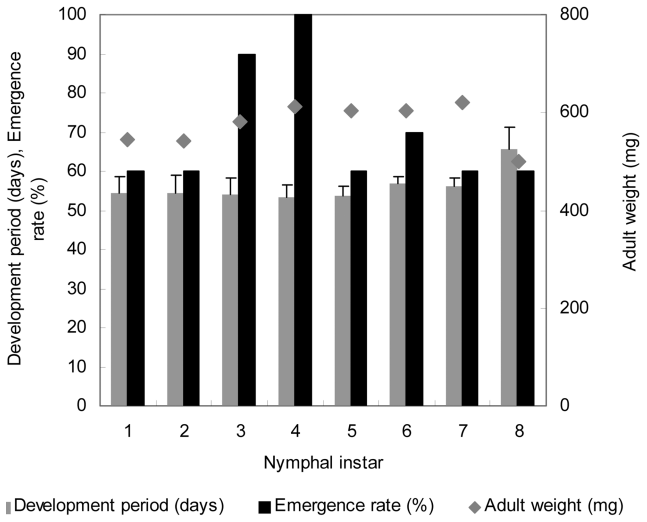

Fig. 1. Development of *T. emma* reared on the diets containing fish meal at each instar. Nymphs were reared under a photoperiod of 16L : 8D at 28°C. Development period of nymphs: $P < 0.001$, Adult weight: no significantly different by Tukey's HSD multiple range test ($P = 0.05$).

cant differences were detected, multiple comparisons were made using Tukey's HSD multiple range test ($P = 0.05$).

Results and Discussion

There was a marked difference in the nymphal survivorship reared on the 4 diets: In the case of the wheat bran and mixed diet, it was 95.6% and 92.2%, which was much more satisfactory by far than with Danong diet (71.3%) and animal food (48.9%). The development period of nymphs were 55.4 days when only a single food, wheat bran, was provided, and it did not show a significant difference compared to the rearing results of the Danong diet and mixed diet. On the other side, the weight of the adults was heavier with the mixed diet, but no statistical significant difference was found. Meanwhile, when rearing with solely animal food, the nymph development period became longer and the weight of the new adults decreased remarkably (Table 1).

The results of investigating the supplying time of fish meal as the animal food along with wheat bran in order to

Table 2. Effect on nymphal growth of adding animal diet (fish meal) to wheat bran. Nymphs were reared under a photoperiod of 16L : 8D at 28°C. Means in columns followed by the same letter are not significantly different by Tukey's HSD multiple range test ($P = 0.05$).

Amount fish meal (%)	Development period of 4th ~ 9th instar nymphs (Mean ± SD, days)	Emergence rate (%)	Adult weight (mg)
10	43.14 ± 5.24a	70	452 ± 116a
20	39.33 ± 2.35ab	90	499 ± 101a
30	39.13 ± 4.29ab	80	529 ± 84a
40	37.63 ± 3.99ab	80	697 ± 99b
50	40.00 ± 3.62b	100	690 ± 185b

Table 3. Effect on nymphal growth of adding bean-curd dregs to Wheat bran. Nnymphs were reared under a photoperiod of 16L : 8D at 28°C. Means in columns followed by the same letter are not significantly different by Tukey's HSD multiple range test ($P = 0.05$).

Amount Bd (%)	Development period of 1st ~ 3rd instar nymphs (Mean ± SD, days)	Total development period of nymphs (Mean ± SD, days)	Emergence rate (%)	Adult weight (mg)
Wheat bran	13.35 ± 1.192a	62.82 ± 6.32ab	90	582 ± 97a
Bd 10%	13.11 ± 1.031a	60 ± 5.46a	73.3	560 ± 100a
Bd 20%	13.80 ± 1.031ab	66.63 ± 5.40b	63.3	520 ± 119a
Bd 30%	14.55 ± 1.213bc	64.41 ± 6.35b	70	526 ± 115a
Bd 40%	14.67 ± 1.246bc	70 ± 6.9cd	43.3	520 ± 80a
Bd 50%	15.14 ± 1.569c	72 ± 7.22d	50	462 ± 115a
Bd	-	-	-	-

–, No measurement due to 100% death.
Bd, Bean-curd dregs

Table 4. Effect on nymphal growth of adding corn powder to Wheat bran. Nymphs were reared under a photoperiod of 16L : 8D at 28°C. Means in columns followed by the same letter are not significantly different by Tukey's HSD multiple range test ($P = 0.05$).

Amount Cp (%)	Development period of 1st ~ 3rd instar nymphs (Mean ± SD, days)	Total development period of nymphs (Mean ± SD, days)	Emergence rate (%)	Adult weight (mg)
Wheat bran	14.18 ± 0.83ab	61.00 ± 3.13a	93.3	570 ± 96b
Cp 10%	14.55 ± 1.35ab	61.17 ± 4.77a	80	532 ± 94ab
Cp 20%	13.83 ± 1.053a	61.89 ± 4.36a	93.3	539 ± 100ab
Cp 30%	14.20 ± 0.89ab	60.96 ± 4.07a	86.7	559 ± 89ab
Cp 40%	14.73 ± 1.34b	63.46 ± 4.17a	76.7	499 ± 75ab
Cp 50%	14.75 ± 1.08b	64.43 ± 5.16a	70	493 ± 83a
Cp	-	-	-	-

–, No measurement due to 100% death.
Cp, Corn powder.

satisfy the requirements of animal food that is generally demanded by omnivorous insects are shown in Fig. 1. The nymph development period did not have a significant difference when adding animal food to each instar from 1st instar to 7th instar, but when adding animal food at 8th instar a tendency in which the growing period prolongs showed. All emergence rates were over 60%, and high results were obtained especially at 3rd instar with 90% and 4th instar with 100%.

The results of rear testing on the added amount confirmed that the nymph development period and the emergence rate showed only a slight difference according to the added amount of the fish meal. Yet, for the weight of the adults, when more than 40% of the diet was added, it confirmed that the insect weight increased (Table 2).

The characteristics of development according to each added amount of the vegetable food (dry bean-curd residue and corn powder) were investigated to minimize the dangers of the degeneration of diet when rearing with a single feed during the 1st ~ 3rd instar period. First, as the added amount of bean-curd residue increased, the nymphal period became longer and the emergence rate became low (Table 3). In addition, in the case of only being supplied with bean-curd residue, all of the nymphs died. Similar phenomenon also occurred when corn powder was provided. With corn powder as the single diet, all died before becoming adult. However, when corn powder was added up to 30%, no difference existed in the rearing results (Table 4).

Considering the results above, when rearing *T. emma* in mass rearing, it is judged that providing wheat bran during the 1st ~ 3rd instar and providing 40% animal food during the 4th ~ 9th instar are appropriate diets for the nymph development in terms of improving productivity by supplying cheap diet that satisfies nutritional requirements.

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