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Comparative Study of Artificial Diet and Soybean Leaves on Growth, Development and Fecundity of Beet Armyworm, *Spodoptera exigua* (Hubner) (Lepidoptera : Noctuidae)

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ABSTRACT

An artificial diet and soybean leaves were used in rearing the larvae of beet armyworm, *Spodoptera exigua* (Hubner) (Lepidoptera : Noctuidae) in laboratory condition. The artificial diet was composed of soaked mungbean, baking yeast, methyl paraben, sorbic acid, ascorbic acid, casein, choline chloride, agar, vitamin, formalin and distilled water. Survival of larvae on artificial diet (96.67%) was higher than those reared on soybean leaf (63.64%). Weight of larvae and pupae reared on artificial diet were significantly higher than those of the larvae and pupae fed with soybean leaves. The larval and pupal periods of those fed with artificial diet were 15.7 ± 0.84 and 6.73 ± 0.51 days respectively, whereas, those fed with soybean leaf were 18.65 ± 0.83 and 8.5 ± 0.52 days respectively. The average number of eggs laid was 577.9, when the larvae were reared on artificial diet. However, it was 472.5 when the larvae were reared with soybean leaf. The female and male life spans were 14.6 and 11.4 days on artificial diet and were 13.1 and 10.2 days with soybean leaf. Without feeding, the adult showed a life span of 6.29 ± 1.42 and 5.3 ± 0.66 days in artificial diet and soybean leaf respectively. Three consecutive generations were reared on artificial diet. Pupal ratio from larvae was found closer among the generations. The sex ratio was more or less similar in the first and second generations but in the third generation males number increased considerably (1:1.72).

Key words : beet armyworm (*Spodoptera exigua*), artificial diet, soybean leaf, fecundity, mass rearing, sex ratio

INTRODUCTION

Beet armyworm, *Spodoptera exigua* (Hubner) (Lepidoptera : Noctuidae) originated in Southern Asia and has spreaded to temperate and tropical countries. It is a pest of soybean, sugar beet, cabbage, cauliflower, brussel sprouts, tomato, maize, cotton, lettuce, peanut, alfalfa, shallot, pastures crops as well as various wild hosts, including mallow, pigweed and plantains.

The continuous maintenance of laboratory colony of insect species are needed for insecticide bioassay and resistance development studies. With the development of artificial diets, the mass rearing of insect species has become greatly facilitated. Artificial diet is more convenient than natural medium because it is easy to handle and a large number of insect can be reared with minimum time

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and labor. Large scale rearing of larvae is difficult in natural medium because it is needed to change the diet frequently and there is possibility to be diseased. Shorey and Hale (1965) developed an artificial diet for rearing the larvae of noctuid species including *S. exigua*. The investigation was aimed at determining and comparing the feasibility of mass rearing of *S. exigua* on artificial diet in comparison with the natural diet, soybean leaves.

MATERIALS AND METHODS

Biology of beet armyworm

To study the biology of beet armyworm, larvae were collected from the host plants in the field. The collected larvae were reared on artificial diet until pupal stage. Moths were allowed to lay eggs, and eggs were then collected and placed on soybean leaves and artificial diet. For this purpose, 25 eggs were placed on soybean leaves and artificial diet separately in a plastic box ($7 \times 9 \times 4.5$ cm) with four replications. After hatching, each first instar larva was placed separately on soybean leaves and artificial diet. The incubation period, larval period and weight, pupal period and weight, and adult life span were recorded accordingly.

Ten pairs of adults from those fed with artificial diet and soybean leaves were collected after emergence. A pair of male and female was placed in a rearing tin can (diameter 13 cm, height 18 cm) for laying egg. Honey solution (10%) soaked in cotton wool was placed in a cup for adults feeding. A piece of wax paper was inserted in the tin can on which the female to lay eggs. The number of eggs were recorded every day and allowed to hatch. The hatching percentage was recorded and adult life span was also observed.

Mass rearing of *S. exigua*

The following procedures were adopted for mass rearing of *S. exigua*. The larvae were collected from the field and fed with artificial diet until they pupated. Pupae were taken out of diet. After the color of pupae turned brown, they were soaked in 10% formalin for 10 minutes. Pupae were allowed to air dry and then placed in the moth emergence tin can (diameter 13 cm, height 18 cm). Tin can was wrapped inside with white paper.

The moths were separated into a new tin can. They were fed with diluted honey (10%) on cotton wool. A piece of wax paper was inserted inside the tin can and the tin can was covered with a cheese cloth. Diet of moths was changed everyday. The eggs were collected from the wax paper and cheese cloth and soaked in formalin (10%) for 10 minutes, then was passed through the running water twice and air dried. The cluster of eggs was placed in the diet box upside down. The box was sealed with sticky tape. After the larvae hatched out for a week, the wax paper and cheese cloth were removed from the box.

If the larval population in the hatching box was too high, the larvae were transferred into small cups (diameter 6 cm, height 4 cm), 2–3 larvae per cup and were allowed to grow and pupate in the cup. The total number of larvae used for rearing on artificial diet were 1240, 1000 and 600 in F_1, F_2 and F_3 generations respectively.

Composition of artificial diet

The composition of artificial diet were soaked mungbean, baking yeast, methyl paraben, sorbic acid, ascorbic acid, casein, choline chloride, agar, vitamin stock, 40% fomalin and distilled water with the amount of 150 g, 10 g, 2.5 g, 1.5 g, 3.0 g, 3.0 g, 0.5 g, 14 g, 10 ml, 2.0 ml and 750 ml respectively. The vitamin stock were a mixture of niacin, calcium pantothenate, thiamine, riboflavin, pyridoxin monohydrochloride, folic acid, biotin, vitaminB_{12}, inositol, choline chloride and distilled water with the amount of 6.0 g, 6.0 g, 3.0 g, 3.0 g, 1.5 g, 1.5 g, 120 g, 12 g, 10 g , 25 g and 1000 ml

respectively. This diet was modified from Shorey and Hale (1965).

Preparation of diet

Agar was boiled in 400 ml of water and was mixed properly. The diet ingredients and vitamin stock with 350 ml of water were blended together using blender without agar. Then boiled agar was added into the blender for final blending. The diet was poured into plastic box ($18.5 \times 27.5 \times 10$ cm). Diet was allowed to solidify at room temperature and was kept in the refrigerator until used. The vitamin stock was prepared by weighing and dissolving all the components in water and kept in the refrigerator for longer use.

This research was carried out at Central Laboratory and Greenhouse Complex, Kamphaeng Saen Campus, Kasetsart University, Nakhon Pathom, Thailand.

RESULTS AND DISCUSSION

The survival and developmental stages of *S. exigua* were investigated using two diets, artificial diet and soybean leaves. There was statistically significant difference between the survival of larvae using artificial diet (96.67%) and soybean leaf (63.64%) (Table 1). The pupal survival was also significantly higher on artificial diet (86.11%) than the pupae reared on soybean leaf (80%). Shorey and Hale (1965) recorded that the survival of larvae and pupae on artificial diet were 89% and 94%, respectively. They also found that the survival of *S. exigua* from egg to adult was 44% on artificial diet. In this present (modified from Shorey and Hale, 1965) artificial diet, the survival of *S. exigua* from egg to adult (62%) was found to be superior than diet reported by Shorey and Hale (1965). It indicated that by using this modified diet 18% adult more could be obtained. In case of soybean leaf, the survival of larvae and pupae of *S. exigua* were 63.64% and 80% respectively while the survival of eggs to adult (24%) was much lower than those reared on artificial diet.

The differences in the developmental periods of different stages on artificial and soybean leaf

Table 1 Survival of *Spodoptera exigua* (Hubner) on artificial diet and soybean leaf at 27°C and 80% R H, November, 1998.

Stages	Artificial diet[1/] (No.)	Soybean leaf[1/] (No.)
Eggs	25.00	25.00
Larvae	18.75*	13.75
Pupae	18.00**	8.75
Adult	15.50	6.00
% egg viability	75.00	55.00
% larval survival	96.67	63.64
% pupal survival	86.11	80.00
% survival egg to adult	62.00	24.00

* significant at 5% level.

** significant at 1% level.

1/ mean based on 4 replications.

were statistically significant. Highly significant difference in the larval period was observed in soybean leaf (18.65 ± 0.83 days) and using artificial diet (15.70 ± 0.84 days) (Table 2). The pupae from soybean leaf showed longer period (8.5 ± 0.52 days) than on the artificial diet (6.73 ± 0.51 days). The adults reared from artificial diet had longer life span (6.29 ± 1.42 days) than those reared on soybean leaf (5.3 ± 0.66 days). The total period from eggs to adult emergence on soybean leaf and artificial diet were 30.15 ± 1.81 days and 25.43 ± 1.82 days respectively. Life cycle of beet armyworm has been investigated by Baldwin (1994). He reported that it required 36 days at 26.7°C but shorter during summer (24 days) and egg hatched in 2–5 days. It required about three weeks for larvae to develop through five instars. The results of this investigation was similar to Shorey and Hale (1965) who reported that the development *S. exigua* completed its life cycle from eggs to adult emergence in 26.8 days when reared at 27°C on an artificial medium. Boldt *et al*. (1975) reported that larvae required 18 ± 0.3 days for development at 25°C on soybean leaf in laboratory condition which was also similar to this observation. Bhattacharya and Rathore (1980) reported that the larval period consisted of five to seven molts in 17 to 22 days, followed by six to eight days pupation in the soil, and its life cycle was 30 to 35 days. Fye and McAda (1972) stated that the development of *S. exigua* from eggs to adult takes about two weeks at 30°C which differed from our results. It might be due to high temperature. The effect of temperature on *S. exigua* reared on an artificial diet in the laboratory was investigated by Lee *et al*. (1991). They reported that the larval period at 30, 25 and 20°C were 10.5, 17.3 and 32.2 days, respectively. They also found reduced oviposition period and increased larval mortality at high temperatures. Development thresholds were estimated to be 13.2, 15.4 and 15.4°C for the eggs, larvae and pupae respectively. The requirements for degree days were 37.2, 155.8, 78.5 and 271.0, respectively for the completion of the egg, larva, pupa and egg to adult stages (Lee *et al*, 1991). Wu

Table 2 Developmental stages (days) of *Spodoptera exigua* (Hunber) on artificial diet and soybean leaf at 27°C and 80% R H, November, 1998.

Stages	Duration (days)[1/] (mean ± S.D)	
	Artificial diet	Soybean leaf
Eggs	3.00 ± 0.47	3.00 ± 0.47
Larvae	15.70 ± 0.84**	18.65 ± 0.83
Pupae	6.73 ± 0.51**	8.50 ± 0.51
Adult	6.29 ± 1.42*	5.30 ± 0.66
Eggs to adult emergence	25.43 ± 1.82	30.18 ± 1.81
Larval weight (max.)	185.40 ± 13.20 (mg)**	146.00 ± 4.34 (mg)
Pupal weight	78.70 ± 5.21 (mg)*	59.50 ± 4.12 (mg)

* significant at 5% level.

** significant at 1% level.

1/ mean based on 4 replications.

and Chu (1992) reared newly hatched larvae of *S. exigua* on a natural diet (Welsh onion, *Allium fistulosum*) and artificial diet (mainly composing of crushed flowering bean, *Phaseolus coccineus*) at 27°C. They observed the larval periods to be 15.4–17.5 and 14.9–15 days on natural diet and artificial diet respectively. Our observation indicated similar larval period reared on artificial diet but slightly different in case of soybean leaf since they used welsh onion instead. No report was available for comparing its life stages including fecundity between artificial diet and soybean leaves.

Eggs of *S. exigua* were laid in masses composing of 50 -150 eggs, covered with hairs and scales from female body. Average number of eggs laid per female reared on artificial diet and soybean leaf were 577.9 and 472.5 respectively (Table 3). Atkins (1960) reported that beet armyworm produced an average of 520 eggs which was very close to our results. Turnipseed (1973) observed a female laying eggs in masses of 80 eggs, with a total of 1300–1500 eggs which hatched in two to three days. In our investigation, when the larvae were reared on artificial diet and soybean leaf, the hatchability was 53.18 and 32.42 % respectively (Table 3). The adult life span was also recorded in both media with diluted honey on cotton wools. Female longevity was greater on both diets compared to that of male. The females reared from artificial diet had 14.6 days life span and that of male 11.4 days. Feeding with soybean leaf, the life span of female and male were 13.1 and 10.2 days respectively.

In this experiment, the beet armyworm was reared on artificial diet up to three consecutive generations. In the first generation, 705 pupae were obtained from 1240 larvae and developed to a total of 325 moths. In the second generation, a total of 1000 larvae were placed on diet and 640 pupae and 438 adults were obtained. There were 600 larvae reared in the third generation, which produced 380 pupae and 234 adults. The sex ratio were more or less static in the first and second generations. However, in the third generation, the number of males increased considerably (Table 4). Goh *et al* (1991) reported that the population of *S. exigua* reared in the laboratory on a synthetic diet for ten generations. They observed a constant adult emergence for five generations. Wu and Chu (1992) stated that percentage of males increased with each generation, with greater increase in the noctuids reared on artificial diet. These reports satisfy the present observation by showing the increased number of males in the third generation.

CONCLUSION

This study revealed that artificial diet was more convenient than soybean leaf for rearing the larvae of *S. exigua* (Hubner). The survival of larvae

Table 3 Fecundity of *Spodoptera exigua* (Hubner) reared on artificial diet and soybean leaf at 27°C and 80% R H, November,1998

	Artificial diet				Soybean leaf			
	Eggs (No.)	Hatch (%)	Female (day)	Male (day)	Eggs (No.)	Hatch (%)	Female (day)	Male (day)
Mean[1/]	577.9	53.18	14.6	11.4	472.5	32.42	13.1	10.2

[1/] Data were based on 10 pairs of adults insects (♂ + ♀).

Table 4 Number of *Spodoptera exigua* (Hubner) on artificial diet up to three generations in laboratory condition[1/].

Generations	Larvae	Pupae	Female	Male
F_1	1240	705	165	160
F_2	1000	640	226	212
F_3	600	380	86	148

[1/] based on 4 replications.

was found superior on artificial diet than those fed with soybean leaf. The duration of life cycle of the insect was found shorter when larvae were reared on artificial diet than when reared with soybean leaf. Adults produced higher number of eggs and their hatchability was also higher when larvae were allowed to feed on artificial diet. So it could be concluded that mass rearing of beet armyworm larvae by using artificial diet is more suitable than soybean leaf.

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