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Study of the biology of *Chilo partellus* (Swinhoe.) on artificial and natural diets

VSL Saranya and K Samiayyan

Abstract
The biology of maize stem borer, *Chilo partellus* (Swinhoe) was studied under laboratory conditions on three different formulations of semi-synthetic diets (no.1, 2 & 3) as well as on sweet corn. Diet no.1 and 2 were prepared by modifying the basic plant factor of the existing standardized diet composition of *C. sacchariphagus indicus* and diet no.3 was prepared by following the standardized diet composition of NBAIR for mass rearing of *C. partellus.* Of all the diets tested, *C. partellus* completely failed to develop on semi-synthetic diet no. 1 & 2, but successfully completed its lifecycle on diet no.3 and sweet corn. The observation on the total duration of life cycle, egg period, larval period, pupal period, pupal weight, adult longevity, oviposition period, fecundity and percent egg hatchability revealed that, the insect development was poor and prolonged on the artificial diet, but was normal on its natural diet *i.e.*, sweet corn.

Keywords: *C. partellus***,** semi-synthetic diet, sweet corn, biology, growth and development

1. Introduction

The maize stem borer, *Chilo partellus* (Swinhoe) is a serious pest of maize (*Zea mays* L.) and the damage extent of this pest was worked out to be 26.7 per cent to 80.4 per cent in different agro-climatic regions of India [1]. The pest usually attacks the plant at vegetative stage or before harvest resulting in economic loss of the crop. The whole life cycle of *C. partellus* usually takes about 3-4 weeks, varying according to temperature and other factors. Five or more successive generations may develop in favourable conditions [2]. In regions where there is sufficient water and an abundance of host plants, the stem borer can reproduce and develop all year-round. In order to study these economically important pests extensively under laboratory conditions, so far many artificial diet compositions were proposed and developed for their maintenance and continuous rearing [3, 4]. Although there has been some success in the efforts to rear successive generations of these insects entirely on an artificial diet, in many cases there is loss of both fitness and reproductive potential which results in longer development times and lower fecundity [5]. Life history study can be very useful for analyzing and understanding the impact of factors that influence the growth, survival, and reproduction, rate of increase and adaptability of artificially reared insects to field conditions. The other factors like the quality of the rearing units and the expertise of the personnel also influence their growth and development [3]. In nature an insect locates a host plant through a sequence of behavioral and biological responses like orientation and settling, feeding, metabolism of ingested food, growth, survival, fecundity and oviposition [6]. In the present study, three different formulations of artificial diet were prepared and tested on *C. partellus* in order to standardize a formulation and also, its life cycle was observed and studied in detail on these semi-synthetic diets, in comparison with one of its natural host *i.e.,* sweet corn, under laboratory conditions.

2. Materials and Methods

The experiment was conducted in the insectary, Tamil Nadu Agricultural University (TNAU), Coimbatore during 2013 - 2014.

2.1 Buildup of initial culture: *C. partellus* eggs were allowed to emerge at the room temperature and then transferred to fresh sweet corn cobs as well as semi synthetic diet simultaneously.

2.2 Mass culturing of the insect on the sweet corn cobs: For this, plastic boxes of 20 x 8 x 8 cm dimension were used, the lids of which were hollowed in the centre for aeration and covered with muslin cloth from inside. The newly emerged neonate larvae were transferred by a fine moist camel hair brush to fresh sweet corn cobs placed inside these boxes. The boxes were cleaned and surface sterilized with 70 per cent ethanol once in a week and the cobs were replaced with fresh ones to avoid any fungal contamination. The pupae formed were surface sterilized with 70 per cent ethanol and transferred to petriplates lined with tissue paper, placed inside plastic containers of (15 x 10 cm) containing butter paper surrounding their walls. The butter paper served as a surface for egg laying by the adults. Ten percent sugar solution containing few drops of vitamin mixture was provided as adult food through cotton swab kept in 5 ml penicillin vial. The container was covered with dark cloth and kept in dark, as adults are photosensitive in nature. The butter paper was frequently checked until all the adults died. The eggs laid were collected and incubated at 60+10 per cent RH, $28^{\circ C}$. The freshly emerged neonate larvae were transferred to new sweet corn cobs for starting another generation. Three such generations were maintained on the sweet corns cobs and the observations were recorded.

2.3 Mass culturing of the insect on the semi-synthetic diet: The freshly emerged neonate larvae were transferred to plastic containers of 15 x 10 cm dimension, containing the semi synthetic diet, using a fine moist camel hair brush. The pupae formed are then surface sterilized with 70 per cent ethanol and transferred to petriplates lined with tissue paper, placed inside plastic containers of (15 x 10 cm) containing butter paper surrounding their walls. The butter paper served as a surface for egg laying by the adults. Ten percent sugar solution containing few drops of vitamin mixture was provided as adult food through cotton swab kept in 5 ml penicillin vial. The container is covered with dark cotton cloth and kept in a dark place as adults are photosensitive in nature.

2.4 Diet preparation: Three different types of artificial diet compositions were prepared for mass culturing of the test insect, *C. partellus*. Two of the diet compositions were prepared by modifying the basic plant components/factors of the already existing diet compositions, standardized earlier by the researchers for mass culturing of the sugarcane internode borer, *Chilo sacchariphagus indicus*. Therefore, in the case of semi synthetic diet no.1, the plant component/factor *i.e.,* sugarcane powder was replaced by maize leaf powder and in the case of semi synthetic diet no.2 the plant component/factor *i.e.,* sugarcane shoot powder was replaced by maize shoot powder and the third semi-synthetic diet was prepared by following the standardized diet composition of NBAIR for mass rearing of *C. partellus.* The methodologies followed for preparing the diets are detailed hereunder.

2.4.1 Semi-synthetic diet no.1: The diet composition used by Chatterji and his co-workers, Dang and his co-workers, for rearing sugarcane internode borer, *Chilo sacchariphagus indicus* was tried to prepare this diet [7, 8]. Sugarcane powder was replaced with maize leaf powder (Table 1) which was prepared by chopping maize leaves into small bits, drying them for 3-4 days in the hot air oven at a temperature of 60-70^{0}F, and then powdering in a mixer. This was stored in air tight jar. A stock solution of the vitamins was made by dissolving vitamin mixture in distilled water at the rate of 1 gram per 10 ml of water.

The various constituents were divided into 3 fractions, indicated as A, B and C in the list of ingredients. The total water required was divided into 3 parts *i.e.,* 2 parts of 100 ml each and 1 of 50 ml. In preparing the diet, fraction A was mixed well in 50 ml of water in a beaker. To this 15 ml of the vitamin stock solution and 0.62 ml of 10 per cent Formalin was added. The whole was then heated to 60^{0}F and to this fraction B, maize leaf powder, was added. This mixture was added to the mixture in the blender and the whole was blended again for 2 minutes at high speed. Remaining 100 ml of water was boiled and immediately agar powder was dissolved in this and then this was allowed to cool down to about 60 ^{0}C. This was then blended with the diet mixture for 3-4 minutes at high speed to ensure thorough mixing. The warm medium thus prepared, was poured into eight 250 ml pre-sterilized specimen jars with Bakelite screw caps to a depth of about 15-20 mm. Once the diet was poured, the jars were covered with clean towel, and allowed to stand as such over-night, in order to prevent excessive moisture condensation. Next day these were closed tightly with the lids. Nearly 50 newly emerged larvae were directly introduced into one medium bottle.

2.4.2 Semi-synthetic diet no.2: The diet 2 was prepared using the same methodology followed for preparing the diet 1, but the composition of the ingredients was changed as mentioned in the Table 1. Also in the place of maize leaf powder, maize shoot powder was used and the total water *i.e.* 400 ml was divided into 3 parts-2 parts of 160 ml each and 1 part of 80 ml.

2.4.3 Semi-synthetic diet no.3: This diet was prepared following the methodology adopted by NBAIR, Bengaluru for mass culturing *C. partellus* (Table 1). The plant component used in this diet preparation was maize leaf powder. All the ingredients except agar were added to 400 ml of distilled water and mixed thoroughly. To this mixture, agar dissolved in 300 ml of boiled water was added and mixed thoroughly. The mixture was poured into plastic containers of 15 x 10 cm dimension and covered with clean towel, and allowed to stand as such over-night, in order to prevent excessive moisture condensation. Next day these were closed tightly with the lids. Nearly 50 newly emerged larvae were directly introduced into each plastic container.

2.5 Biology of the insect: Biology of *C. partellus* was studied, both on the sweet corn cobs and artificial diet and the following observations were recorded *viz.,* fecundity**,** egg period**,** per cent hatching**,** larval period**,** pupal period**,** pupal weight and adult longevity.

i. Egg: The number of eggs laid till the death of the female was observed. The total number of eggs hatched was worked out using the formula given below

$$\text{Per cent hatching} = \frac{\text{Number of eggs hatched}}{\text{Total no. of eggs laid per female}} \times 100$$

ii. Larva: The no. of days taken for the larvae to complete its growth, from the neonate stage to pupal stage is observed and noted.

iii. Pupa: Ten pupae had been used to note the pupal period and the mean was worked out. The weights of the pupae were also recorded.

iv. Adult: Ten male and female moths were kept in plastic containers with 10 percent sucrose solution to study the adult longevity.

Each experiment was replicated four times and the arithmetic mean and mean square error (standard deviation) were estimated for all the parameters/observations. Maximum and minimum values were also estimated by pooling up the replication data for each parameter. The results were then compared for the artificial and natural diets.

3. Results and Discussion

3.1 Standardization of artificial diet for mass rearing of *C. partellus*: Among the three artificial diet compositions experimented in the present study for mass rearing of *C. partellus,* two of the diet compositions (*i.e.,* semi synthetic diet no. 1 and semi synthetic diet no. 2) failed completely, as all the neonate larvae that emerged from the eggs died within 1-2 days after emergence when introduced into the artificial diet. But in the case of semi synthetic diet no.3, the newly emerged larvae established themselves and completed their larval and pupal stages inside the diet and successful emergence of adults from the pupae was recorded. But, the adults totally failed in laying eggs. These results were found to be in contrast with the earlier results, as many of the scientists previously reported successful diet formulations for mass rearing of *C. partellus* [8, 9].

3.2 Biology of maize stem borer: The results revealed that, the growth and development of *C. partellus* was poor as well as prolonged when reared on semi-synthetic diet as compared to its natural diet *i.e.,* sweet corn. The total developmental period of *C. partellus* on sweet corn cobs was 36.3 days (Table 2) and the incubation period was 4.5 days on sweet corn cobs and 3.5 days on artificial diet (Table 3). The mean larval and pupal periods were found to be 20.5 days and 5.6 days respectively. The adult longevity of males and females were 4.6 days and 3.9 days respectively. Whereas, in the case of insects reared on artificial diet (semi synthetic diet no. 3) the larval and pupal periods were found to be 43.5 days and 8.2 days respectively. The adult longevity of males and females were 5.4 days and 4.9 days respectively (Table 3). Adult fecundity was found to be 203 eggs per female and the hatching percentage was 49.2 per cent when reared on sweet corn cobs (Table 5). Mean pupal weights of male pupae and female pupae, reared on sweet corn cobs were 52.6 mg and 98.5 mg respectively. Whereas, the mean pupal weights of female and male pupae were 50.3 mg and 86.8 mg respectively in the case of artificially reared insects (Table 4).

The results were found to be in line with the previous report which stated that *C. partellus* when reared on maize based artificial diet completed its life cycle within 35 to 42 days with an incubation period of 5 to 6 days, larval period of 28 to 35 days, pupal period of 7-10 days, adult male longevity of 3 to 8 days, adult female longevity of 3 to 7 days and mean oviposition period of 4.1 days. The mean pupal weight was 200 mg and mean fecundity was 155 eggs per female [10]. Similarly, the results were also found to be in accordance with the previous studies in which it was reported that, the *C. partellus* completed its life cycle in 30 to 69 days with an incubation period ranging from 3 to 6 days, larval period of 20 to 51 days, fecundity rate of 262-657 eggs and male and female adult longevity of 3 to 8 days and 3 to 7 days, respectively under laboratory conditions [11]. Also, it was earlier reported that *C. partellus* has a fecundity of 278.6 eggs per female and that the mean pupal weight was 81 mg when reared on maize leaf powder based artificial diet [12]. Another report shows that the fecundity of artificially reared *C. partellus* adult was 150 eggs per female with an incubation period of 4-5 days, larval period was 30-32 days and pupal period of 8 days [4].

Table 1: The modified semi-synthetic diet compositions

Ingredients	Diet no. 1	Diet no. 2	Diet no. 3
Shoot/ leaf powder (B)	24 g (Maize leaf powder)	75 g (Maize shoot powder)	10 g (Maize leaf powder)
Agar (C)	6 g	9 g	10 g
Ascorbic acid (A)	2.5 g	9 g	3 g
Casein (vitamin free) (A)	7.5 g	22.5g	30 g
Formaldehyde 10 per cent (A)	0.62 ml	2 ml	2 ml
Methyl-para-hydroxy Benzoate (MPH) (A)	0.62 g	2 g	2 g
Sorbic acid (A)	0.3 g	1 g	1 g
Water	250ml	400 ml	400 ml
Yeast (Bakers) (A)	3 g	9 g	10 g
Bengal (Kabuli) gram powder (A)	15 g	60 g	100 g
Vitamin mixture (A)/ capsules	1.5 ml	5 no. s	2 no. s
Sucrose (A)	11.25 g	19 g	-
Hostacycline (veterinary grade) (A)	1 g	1.5 g	-
Streptomycin sulphate	-	-	0.25 g
Salt mixture*	-	-	1.5 g

* The salt mixture is a combination of Calcium carbonate (21 g), Copper sulphate (0.039 g), Ferric phosphate (1.47 g), Manganous sulphate (0.02 g), Anhydrous magnesium sulphate (9 g), Potassium aluminium phosphate (31 g), Potassium chloride (12 g), Potassium dihydrogen phosphate (31 g), Potassium iodine (0.005 g), Sodium chloride (10.5 g), Sodium fluoride (0.057 g), Tri calcium phosphate (14.9 g).

Table 2: Duration of life stages of *Chilo partellus* reared on sweet corn cobs under laboratory conditions

S. No.	Stage	Minimum* (days)	Maximum* (days)	Mean ± S.Ed
1	Egg period (25eggs)	3	6	4.5 ± 1.26
2	Larval period (10 larvae)	18	23	20.5 ± 1.64
3	Pupal period (10 pupae)	4	7	5.6 ± 1.34
4	Adult longevity (male) (10 males)	3	6	4.6 ± 1.17
5	Adult longevity (female) (10 females)	3	5	3.9 ± 0.87
6	Oviposition period (10 females)	3	4	3.5 ± 0.52
7	Life cycle	28	45	36.3 ± 6.01

***** Mean of the four replications

Table 3: Comparison of the life cycles of *Chilo partellus* reared on sweet corn cobs and artificial diet under laboratory conditions

S. No.	Life stages	Mean ± S.Ed (On sweet corn cobs)	Mean ± S.Ed (On artificial diet)
1	Egg period (25eggs)	4.5 ± 1.26	3.5 ± 1.29
2	Larval period (days)*	20.5 ± 1.64	43.5 ± 7.47
3	Pupal period (days)*	5.6 ± 1.34	8.2 ± 1.22
4	Adult longevity of males (in days)*	4.6 ± 1.17	5.4 ± 1.89
5	Adult longevity of females (in days)*	3.9 ± 0.87	4.9 ± 1.52

***** In each case, 10 individuals were subjected to study in each replication (four replications)

Table 4: Comparison of pupal weights of *Chilo partellus* (male and female) reared on sweet corn cobs and artificial diet

Rearing medium	Pupal weights of male pupae (10 individuals) (in milligrams)	Pupal weights of female pupae (10 individuals) (in milligrams)
On Sweet corn cobs (1st generation)	55.8 ± 10.85	99.6 ± 13.44
On Sweet corn cobs (2nd generation)	50 ± 9.29	96.6 ± 16.54
On Sweet corn cobs (3rd generation)	52.1 ± 11.35	99.4 ± 11.74
On artificial diet	50.3 ± 6.12	86.8 ± 6.06

Table 5: Mean fecundity and per cent egg hatchability of *Chilo partellus* reared on sweet corn cobs under laboratory conditions

Different generations on sweet corn cobs	Fecundity (10 females per replication)	Per cent egg hatchability (25 eggs per replication)
1st generation	206.8 ± 50.29	46.8 ± 9.89
2nd generation	196 ± 33.56	47 ± 11.22
3rd generation	193 ± 42.41	53.8 ± 17.84

4. Conclusion

The ineffective results and prolonged duration in the growth and development of the artificially reared *C. partellus* (reared on semi-synthetic diets) may be attributed to either the lack of any essential nutrient in the diet or the higher temperatures that prevailed during the mating and oviposition periods of the study.

5. References

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