BIOLOGY AND HOST RANGE OF THE CHINESE GRASSHOPPER, *Oxya chinensis* Thunberg

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ABSTRACT

The biology of the Chinese grasshopper, *Oxya chinensis* Thunberg, was studied in the laboratory. The eggs are laid in masses inside the gabi petiole with 1-2 egg masses laid at a time. The newly-laid egg is elongate, clear yellow and 3-4 mm in length. Just before hatching, the egg turns grayish or nearly black. Incubation period is from 19-24 days with 79.8% hatchability. The total developmental period for both sexes did not differ, with a mean period of 54.3 and 54.7 days for the male and female, respectively. There are 5 nymphal instars with each stadium lasting from 5.3 to 9.4 days for the second and fifth stadium, respectively. A male to female ratio of 1.36: 1.00 was recorded. Females lived longer than males with a difference of 11.3 days between sexes. A total mortality of 27.8%, which was mainly due to disease, was observed during the nymphal period. Five species of natural enemies were observed to attack the Chinese grasshoper at different stages of development. Aside from taro, which is the preferred host, *O. chinensis* can complete its development on 8 alternate host plants.

INTRODUCTION

Taro, *Colocasia esculenta* (L.), commonly called *gabi,* is fast becoming an important commercially cultivated crop in the Philippines. It is used as a staple food in many parts of the world. Presently, taro is grown extensively in tropical America, the Pacific Islands, tropical Asia and Africa.

Although taro has long been cultivated in the Philippines, its production per hectare is much lower compared to those in other countries (Knott & Deanon, 1970).

The average production in the Philippines is only 3.2 t/ha (NFAC, 1975) in comparison to 12 t/ha under experimental conditions at the Visayas State College of Agriculture. One of the cited causes of low yield of the crop is the damage caused by insect pests that sometimes completely defoliate the plants during severe infestation.

The Chinese grasshopper, *Oxya chinensis* Thunberg, is one of the important insect pests which attack taro in the Philippines. It also attacks other economic crops such as sweet potato, swamp cabbage and some graminaceous plants (Esguerra & Gabriel, 1969). This insect pest also causes serious problems on young paddy rice in Japan (Grist, 1975) and on sugarcane in Hawaii (Williams *et al.*, 1969).

In 1976, when propagation of taro in ViSCA began and when preliminary trials of this study was conducted, field population of this pest was low causing only insignificant damage. However, with increased acreage planted to taro and the introduction of foreign varieties into the area, the pest population has increased considerably causing much damage to the crop. The Hawaiian variety of taro has been found to be especially susceptible to Chinese grasshopper attack. Also recently, this pest was observed to cause damage to sweet potato. Duatin (1979) recorded it as one of the important defoliators of this crop in ViSCA.

This study was conducted to obtain detailed information on the life history of the Chinese grasshopper, identify the parasites and predators that attack the pest at different stages of its development, and determine the host range of the pest which is necessary in developing intercropping and crop rotation schemes involving taro.

MATERIALS AND METHODS

Mass Rearing of Insects. — Nymphs and adults of the Chinese grasshopper were collected from the field and were brought to the laboratory to start a stock culture of insects for experimentation. The adults were placed in cages provided with potted taro plants for food and for oviposition substrate. The nymphs were placed in separate cages provided with detached gabi leaves (Fig. 1) and reared until adult stage. The adults were allowed to mate and lay eggs. The eggs laid by these insects were used for the various studies conducted.

Study of Life History. — Eggs laid by field-collected grasshoppers were placed in sterile Petri plates lined with moist absorbent paper. They were incubated at room temperature and observed daily to take note of the appearance of the eggs during development of the embryo. Upon hatching, the nymphs were transferred to glass jars (Fig. 2) for individual cultures. Each jar was covered with fine-meshed nylon cloth tied with rubber band at the rim to prevent the escape of the insects. The cultures were fed daily with taro leaf pieces. At feeding time, the bottles were cleaned and the uneaten taro leaf pieces were removed. Morphological changes and behavioral characteristics were observed and recorded. Other biological data such as number of nymphal instars, days per stadium, mortality rate of nymphs, fecundity of the females and longevity of the adults were also recorded from these cultures.

Fig. 1. Wire-screen cage (40.6 cm H x 30.5 cm W x 30.5 cm L) used for maintaining stock culture of *Oxya chinensis*.

Fig. 2. Glass jars (10.2 cm H x 5.1 cm D) used in rearing *Oxya chinensis* individually.

Study of Natural Enemies. — Eggs, nymphs and adults of the Chinese grasshopper were collected from the field and were brought to the laboratory to rear out their parasites. The eggs were incubated at room temperature to allow the parasites to emerge. Nymphs and adults were reared separately and observed daily to note changes in the behavior of parasitized individuals. The number of parasitized insects per collecting period was noted. The parasites were identified upon emergence.

Field observations were also made to record predators feeding on the pest in the field. Specimens of predatory species were collected and identified. No attempts were made to assess their efficiency under field conditions.

Study of Host Range. — Plants in and around taro fields, which were suspected as possible host plants of the Chinese grasshopper and those cited by other workers, were collected and fed to laboratory-reared nymphs of known ages. Suspected host plants were offered to the nymphs at the same time to observe which of them will be readily eaten by the insects. Plants which did not show any feeding signs within 24 hr were regarded as non-host plants and were not tested further. Those readily fed on during the preliminary tests were used for rearing the insects for one generation. Comparison of the biological data obtained from insects reared on the alternate hosts was made with those reared on taro, the preferred host.

RESULTS AND DISCUSSION

Life History and Behavior

Mating Behavior. Prior to mating, the male produced a characteristic sound by rubbing the inner surface of its hind femur against the lower margin of the forewings. The male continued this behavior until its antennae touched the body of the female. If the female was not ready for copulation, it moved away but if it was receptive, it remained motionless. Then the male gradually raised its forelegs putting them on top of the body of the female. As soon as the male had mounted, it brought its abdominal tip towards the female's abdomen (Fig. 3A).

Copulation lasted from 1-4 hr and usually occurred in the morning. When disturbed, the insects separated but later resumed mating. Copulation started 10 days after emergence of the female. Egg laying followed 5 days after mating. Mated females produced 3-7 egg masses containing 5-14 eggs per egg mass.

Oviposition. The eggs were laid in masses inside the gabi petiole (Fig. 3B). The grasshopper lays eggs by inserting the ovipositor into the gabi petiole until about 3/4 of the abdominal region was within the tunnel. Oviposition lasted for about an hour with 1-2 egg masses laid at a time in different parts of the same petiole. An egg mass was bound together by slimy substance which was also used for sealing the hole after oviposition. The eggs were arranged so that the anterior ends were directed towards the entrance of the tunnel. This provided ease of escape of the young nymph after hatching and to facilitate gas exchange.

Development of Embryo and Incubation. A newly-laid egg is elongate, clear yellow and 3-4 mm in length. Its appearance changed as the embryo within the egg developed. Seven days after oviposition, the diameter of the egg increased to about twice the original size and the color changed from clear yellow to whitish yellow. Just before hatching the egg turned grayish to nearly black.

A total of 499 eggs were incubated. Of this number, 79.8% hatched, 12.6% did not hatch and

7.6% hatched but the nymphs were unable to emerge. The incubation period lasted from 19-24 days for both sexes.

Eclosion. During eclosion, the nymphs were not observed to bite the egg shell to free themselves like most insects. The egg shell slowly split dorsally as the nymph forced its thorax against the egg wall. Wigglesworth (1974) explained that in grasshoppers the mature embryo is aided by enzymes which dissolves the inner layer of shell shortly before hatching. The young continued this movement until the opening was

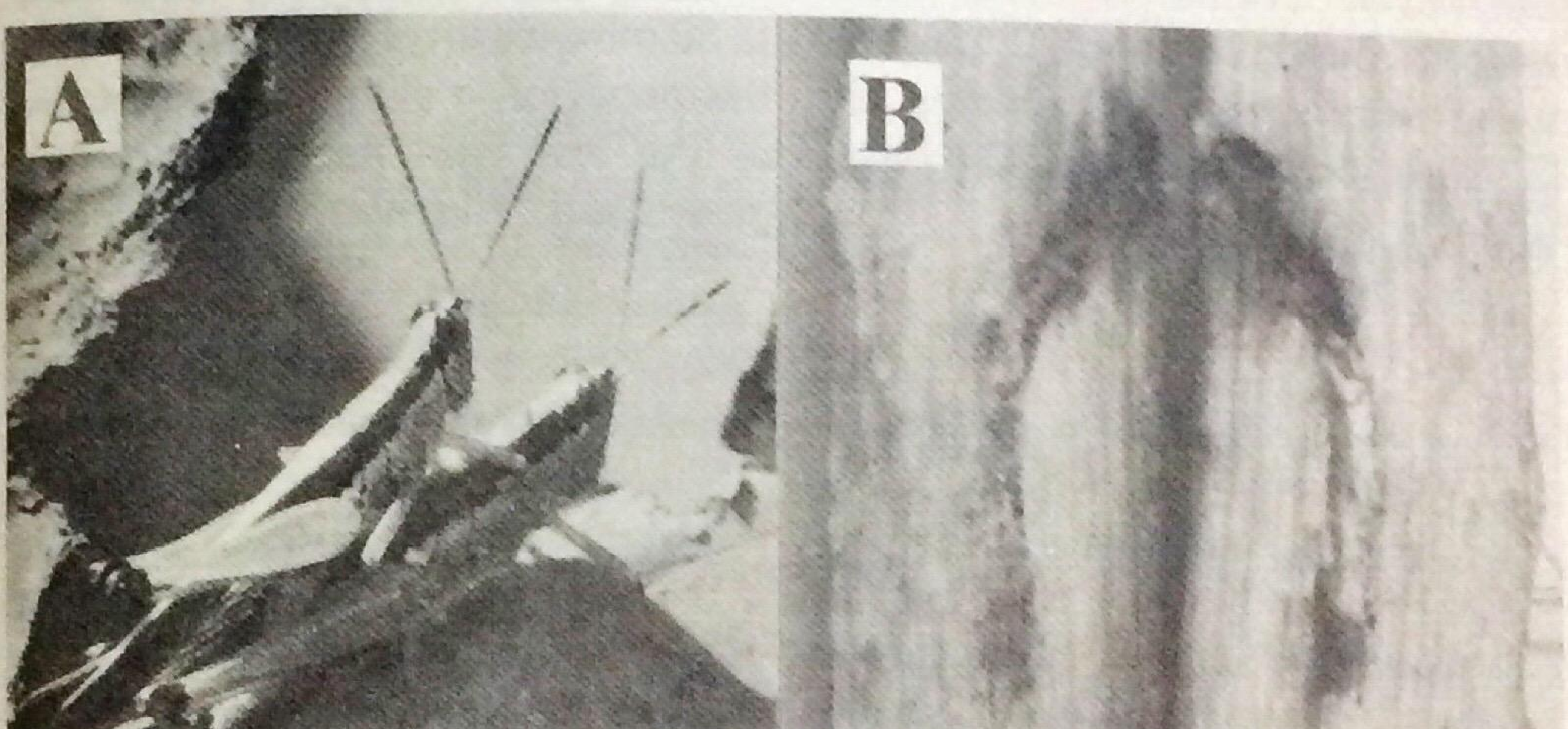

Fig. 3. Developmental stages of *Oxya chinensis*: A. Adults in copula (x = 2); B. Eggs inside petiole (x = 3); C. Nymphs and Adult (x = 1).

large enough for the nymph to slide its body out of the egg shell. It took 15-60 min for the insect to complete eclosion. Some nymphs that failed to come out of the shell during hatching died.

Development of Immatures. There are 5 nymphal instars with each stadium lasting from 5.3 to 9.4 days for the second and fifth stadia, respectively (Table 1). The total nymphal period did not differ between sexes, with an average of 32.8 days for the male and 33.4 days for the female.

The young nymphs (Fig. 3C) were highly motile and gregarious. A first instar nymph could jump a distance of about 30 cm immediately after hatching and can eat a leaf area of about 1 cm^2 within 24 hr, becoming more voracious with age.

The first molt occurred 6 days after the eggs hatched. Prior to each molt the nymph became less active and ate lesser amount of food. Ten to 30 minutes after a nymph showed this behavior, it clung to the surface of the leaf with its head pointed downward. This was followed by a

Table 1. Duration (in days) of developmental periods of *Oxya chinensis* reared on taro.

Developmental Period	Male (118 individuals)		Female (87 individuals)	
	Range	Mean [1]	Range	Mean [1]
Incubation Period	19-24	21.50 ± 1.03	19-24	21.34 ± .94
First Stadium	5- 8	6.19 ± .65	5- 8	6.36 ± .70
Second Stadium	4- 8	5.26 ± .73	4- 6	5.39 ± .54
Third Stadium	4- 7	5.57 ± .65	5- 7	5.92 ± .59
Fourth Stadium	5-10	6.33 ± .79	5- 9	6.48 ± .85
Fifth Stadium	7-12	9.42 ± 1.07	8-11	9.24 ± 1.0
Total Nymphal Period	29-39	32.77 ± 1.80	30-38	33.39 ± 1.85
Total Developmental Period (Egg to Adult Emergence)	49-61	54.27 ± 2.33	50-61	54.70 ± 2.39
Longevity of Adults	55-113	79.20 ± 18.01	67-118	90.50 ± 18.98

[1] Mean ± , standard deviation.

continuous expansion and contraction of the body until the integument split on the dorso-thoracic region of the body. The nymph continued this movement until the opening reached the head. The nymph then jerked its body and slowly slid out to free itself from the exuvium. It took 15-60 min for the insect to complete ecdysis. Some individuals died due to abnormal molting.

Emergence of Adult and Male to Female Ratio. The fifth molting marked the emergence of the insect to the adult stage. The manner of emergence was similar to the usual ecdysis described earlier. Upon emergence, the adult stretched its wings for 10-20 min to allow them to straighten and dry.

Two hundred eighty four nymphs were reared individually using taro as host. Of this number only 205 reached the adult stage, with 118 males and 87 females, giving a ratio of 1.36:1.00.

Total Developmental Period. Table 1 presents the duration of the different developmental stages of the Chinese grasshopper reared on taro. It was shown that the total developmental period (from egg laying to emergence of the adult) of the female (mean = 54.7 days) and for the male (mean = 54.3 days) were similar. However, the longevity of the adult male (mean = 79.2 days) was shorter compared to that of the female (mean = 90.5 days).

Mortality. The mortality rates of the different nymphal instar are shown in Table 2. The highest (19.0%) and lowest (1.1%) mortality occurred during the first and fifth instars, respectively. The data indicate that insects were more susceptible to the adversities of the environment during the early instars.

Table 2. Mortality rate (%) of different instars of *Oxya chinensis* reared on taro based on 284 individuals.

Nymphal Instar	% Mortality
First Instar	19.0
Second Instar	3.2
Third Instar	2.5
Fourth Instar	2.1
Fifth Instar	1.1
Total	27.8

Natural Enemies

Four species of parasites and one species of predator were observed attacking Chinese grasshoppers in the field. There were 2 species of hymenopterous parasites, one species of hymenopterous predator, a parasitic mite and a mermitid nematode.

Egg Parasites and Predator. The 2 species of egg parasites included *Scelio* sp. and a Eupelmid wasp. About 58% of the eggs collected from the field were observed to be parasitized by these wasps. A predatory ant species was observed to enter the tunnels in the petiole and sucked the contents of the eggs.

Nymph and Adult Parasites. A mite species was observed clinging to the body of both nymphs and adults with 1-8 mites per host insect. This parasite was considered less important because no mite-infested grasshopper died prematurely during the observation period due to the attack of this parasite.

A mermitid nematode was observed infesting only adult grasshoppers collected in the field. Only 1 out of 25 adults collected was attacked by the nematode.

Host Range

Of the 18 species of plants tested in the laboratory, only 8 were proven to be alternate hosts of the insect in the laboratory besides taro. They included: *Commelina diffusa* Burm., *Xanthosoma* sp., *Monochoria vaginalis* (Burm.) Presl., *Caladium bicolor* Ait., *Ludwigia octovalvis sessiliflora* Mich., *Manihot esculenta* Crantz, *Ipomoea aquatica* Forsk. and *Commelina benghalensis* Linn. Plants offered but not readily fed on included: coconut, *Cocos nucifera* Linn., kapok, *Ceiba pentandra* Linn., rice, *Oryza sativa* Linn., sweet potato, *Ipomoea batatas* Poir. and many weed species.

Table 3 shows a comparison of the duration of nymphal periods of Chinese grasshoppers reared on 9 different host plants. The data show that the insects reared on 8 host plants have extended nymphal periods compared to those reared in taro. Nymphs fed with taro had an average nymphal period of 32 days, whereas those reared on other host plants had a range of 39 days for insects reared on *C. diffusa* and 53 days for insects reared on *C. benghalensis.*

The differences in the duration of the nymphal period of insects reared on the different host plants clearly indicate that most plants have adverse effects on the insect development. This may be due to antibiosis. Painter (1951) explained that the effect of antibiosis on insects and their prolonged life cycle on resistant plant varieties may result from non-preference but equal food value to that of the susceptible varieties, or equal preference and difference in food value as measured by survival of the insect and other effects. In this study, variation in the developmental period might have been due to differences in nutritional value of the plants since the insects fed normally thereby discarding the possibility of non-preference.

Table 3. Comparisons of the nymphal period of the Chinese grasshoppers reared on 9 different host plants using detached leaves.[1]

Host Plants	Average duration (in days)[2] of the nymphal period of *Oxya chinensis*					
	First Stadium	Second Stadium	Third Stadium	Fourth Stadium	Fifth Stadium	Total Nymphal Period
Colocasia esculenta	5.80 ± .79	5.60 ± .70	5.67 ± .87	5.50 ± .53	8.62 ± 1.19	32.00 ± .76
Commelina diffusa	6.60 ± .84	6.40 ± 1.17	6.90 ± 1.10	7.90 ± 1.70	11.40 ± 2.06	39.20 ± 3.08
Xanthosoma sp.	8.40 ± 1.26	5.70 ± 1.16	6.30 ± 1.06	7.70 ± 1.06	12.60 ± .52	40.70 ± 1.42
Monochoria vaginalis	9.00 ± .82	6.30 ± .95	6.70 ± 1.16	7.90 ± 2.08	12.50 ± 2.22	42.40 ± 1.78
Ludwigia octovalvis sessiliflora	8.00 ± 1.63	8.88 ± 1.36	7.86 ± 2.17	11.57 ± 2.44	13.28 ± 2.06	49.14 ± 5.05
Caladium bicolor	6.60 ± 1.07	8.00 ± 2.33	8.86 ± 2.12	11.83 ± 1.17	12.50 ± 1.22	47.83 ± 2.40
Manihot esculenta	7.00 ± 1.22	7.12 ± .35	7.86 ± 1.68	10.00 ± 1.22	13.60 ± 2.07	46.20 ± .84
Ipomoea aquatica	8.50 ± 1.35	7.11 ± .93	10.50 ± 1.64	11.33 ± 2.36	12.00 ± 2.64	49.00 ± 3.46
Commelina benghalensis	6.88 ± 1.25	8.25 ± 1.67	7.71 ± 1.50	8.67 ± 4.62	18.00 ± 00	53.00 ± 00

[1] Data based on ten insects per host plant.
[2] Mean ±, standard deviation.

Table 4. Comparison of the mortality rate and percentage emergence of the Chinese grasshopper reared individually on different host plants using detached leaves.[1]

Host Plants	Nymphal Instars					Total	% Mortality	% Emergence
	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar			
Colocasia esculenta	0	1	1	0	0	2	20	80
Commelina diffusa	0	0	0	0	0	0	0	100
Xanthosoma sp.	0	0	0	0	0	0	0	100
Monochoria vaginalis	0	0	0	0	0	0	0	100
Ludwigia octovalvis sessiliflora	0	2	0	1	0	3	30	70
Caladium bicolor	0	2	1	1	0	4	40	60
Manihot esculenta	1	1	1	2	0	5	50	50
Ipomoea aquatica	0	3	2	1	0	6	60	40
Commelina benghalensis	2	0	1	4	2	9	90	10

[1] Data based on 10 nymphs per host plant.

Table 4 shows a comparison of the mortality rates and percentage emergence of Chinese grasshoppers reared on 9 different host plants. The data show that no mortality was recorded from nymphs reared on *C. diffusa, Xanthosoma* sp., and *M. vaginalis*. These host plants are therefore suitable for rearing the insect if taro is not available. However, nymphs reared on these plants showed extended developmental period.

The highest mortality (90%) was observed on insects fed with *C. benghalensis*. Differences in mortality rate and the prolonged developmental period of the nymphs may also be attributed to antibiosis as explained earlier.

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