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Oviposition, Feeding and Developmental Characteristics of *Riptortus linearis* (Hemiptera: Alydidae), a Pest of Soybean

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Narayan S. Talekar, Li-Yi Huang, Hsing-Hua Chou and Jyan-Jong Ku (1995) Oviposition, feeding and developmental characteristics of *Riptortus linearis* (Hemiptera: Alydidae), a pest of soybean. *Zoological Studies* **34**(2): 111-116. Various biological characteristics of the soybean pest *Riptortus linearis* (F.) were studied in a series of laboratory and greenhouse experiments. The premating period lasted 89 hours with most of the mating taking place between 12:00 and 20:00 hours. The preoviposition period lasted 118 hours, and most oviposition occurred between 12:00 and 20:00 hours, with a peak between 14:00 and 18:00 hours. Oviposition took place between seven to twelve days after emergence of adult. Eggs were laid singly mostly on leaves and only on soybean plants having pods. Daily removal of eggs from soybean plants resulted in insects laying three times as many eggs as when none were removed. The durations of egg incubation and each nymphal stadium decreased proportionately as temperature increased from 20°C to 35°C. At 20°C durations of egg incubation and nymphal stadia were 12.75 and 35.47 days, respectively, whereas at 35°C, these periods were 4.13 and 11.52 days, respectively. Fifth instars suffered greater mortality than other instars. The first instar did not feed but feeding activity of the second through the fifth instars progressively increased. The seed size and seed germination rate decreased when *R. linearis* adults fed on developing seeds from R2 to R7 growth stages. When no food was provided, all adults died within 8 days; provision of green pods or dry seeds lengthened survival periods to as long as 28 to 31 days. Highly significant positive correlations were found between the number of instars and body and antennal lengths.

Key words: Fecundity, Temperature effect, Damage, Mating, Feeding habits.

Soybean, *Glycine max* (L.) Merrill, an economically important food, feed and oilseed crop in Asia, is attacked by a plethora of insect pests throughout the season starting soon after germination up to harvest and sometimes even in storage (Talekar 1987). Pod-sucking pentatomids and alydids are among the most damaging and difficult to control. *Riptortus linearis* (F.) and *R. clavatus* Thunberg (Hemiptera: Alydidae) are two of the most common pests of soybean in Asia and at least one of them is always found wherever soybean is grown in that continent (Kobayashi 1972 1976, Talekar 1987). Third, fourth and fifth instars and adults of *R. linearis* feed on developing green seeds. As a result of their feeding, seeds either do not develop at all or are small and shriveled. To control *R. linearis* economically on a sustainable basis, entomological research at the Asian Vegetable Research and Development Center (AVRDC) in southern Taiwan is trying to develop an integrated pest management (IPM) system with major emphasis on host-plant resistance. However, lack of knowledge of the biology and nature of damage caused by this pest has made it difficult to develop a simple IPM package. Therefore, several basic biological experiments were carried out to understand certain aspects of oviposition, feeding and developmental characteristics of this insect pest.

MATERIALS AND METHODS

Insect rearing

Adults were collected from a soybean field and placed inside a round acrylic cylinder (20 cm diame-

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ter) containing one R4-R5 stage soybean plant. The top of the cylinder was covered by muslin cloth fastened by rubber bands. Insects readily fed on the pods and laid eggs on the plant and even the muslin cloth. Eggs were collected every 24 hours and used for mass rearing of the insect.

Mating and oviposition periodicities

One pair (1 female + 1 male) of freshly emerged adults was placed in each of four rearing cylinders, each of which contained one soybean plant. The cylinders were placed in the laboratory at 25 ± 2°C. The insects were observed every hour for mating to determine length of premating period. The insects were maintained until initiation of oviposition to determine preoviposition period.

In a separate study, twenty pairs of freshly emerged adults were placed inside each of four rearing cylinders containing one soybean plant each. The number of insects copulating were recorded once every two hours throughout a 24-hour period to determine mating periodicity. After mating and initiation of oviposition, the same twenty pairs of adults were also used to determine the number of eggs laid every two hours throughout a 24-hour period to determine oviposition periodicity.

Duration of oviposition

One pair of newly emerged adults was placed in each of two acrylic cylinders containing one green podded soybean plant each. The number of eggs laid was recorded daily until oviposition ceased; eggs were removed after each observation.

Oviposition sites

One soybean plant in R3-R4 stage was placed in each of two rearing cylinders described earlier and a pair of freshly emerged adults added to each cylinder. One week later we recorded the number of eggs laid on leaves, inflorescence, stems and pods.

Influence of soybean pods on oviposition

One soybean plant in R3-R4 stage was placed in each of the sixteen rearing cylinders. We removed pods from eight plants. We placed two pairs of freshly emerged adults inside each cylinder. Eggs were removed daily from four depodded and four intact plants. Total eggs laid was recorded for 21 days.

Effect of temperature on duration of nymphal instars and mortality

Fifty freshly laid eggs were transferred to each of sixteen Petri dishes lined with moist filter paper. Four Petri dishes were maintained at each of the following temperatures: 20, 25, 30 or 35°C. Number of eggs hatched was recorded twice a day. Those that failed to hatch after two weeks were discarded. The incubation period was determined for each temperature.

Approximately 25 first instars were placed in each of four rearing cylinders, each containing four to six R5-R6 stage soybean pods. The cylinders were placed in an incubator maintained at one of four temperatures: 20, 25, 30 or 35°C. The insects were observed twice a day to record their molting status. Upon emergence, they were transferred into new cylinders. Mortality and the duration of each instar were recorded. After emerging, adults were maintained at the same temperature until all nymphs from that particular temperature became adults. Adult mortality was also recorded. Cumulative mortality of eggs, nymphs and adults was determined.

Feeding habit of nymphs

Five newly emerged nymphs of each instar were confined in an acrylic cylinder (one cylinder per instar) containing a soybean plant in R4-R5 stage. These nymphs were allowed to feed for five days. The green pods were harvested and pod pericarps were dipped in staining solution (Bowling 1990). The number of stylet sheaths in each pericarp was recorded.

Effect of feeding on seed size and germination

Four soybean plants of each growth stage, ranging from R2 to R7, were individually confined in acrylic cylinders. Five adults were then placed in each cylinder. When the plant entered the next growth stage, the insects were removed. Afterwards, the plants were maintained in an insect-proof room until harvest. In a separate set of four plants, five adults were allowed to feed on soybean plants from R2 to R7; in another, four plants were maintained insect free. Dry seeds were harvested from all sets. Weight of 100 seeds from each plant was determined. Later, 100 seeds from each replicate were placed in individual Petri dishes lined with moist filter paper to determine germination. Number of seeds that germinated was recorded.

Adult longevity

Twelve groups of fifty adults were confined in twelve rectangular wooden frame nylon net cages (30 cm × 30 cm × 30 cm), one group per cage. Into four cages were placed twenty freshly harvested soybean pods of R5 stage. The petioles of all pods were covered with moist cotton to keep the pods fresh. The pods were replaced with fresh ones every three to four days. Into four cages, were placed 100 g of dry soybean seeds over the nylon net top. The seeds were changed with fresh ones once a week. In the third set of four cages no food source was provided. The number of dead insects was recorded daily. These observations were continued until all insects had died.

Morphological observations

Lengths of body and antennae were measured for five insects in each of the five instars. Measurements were analyzed statistically to study the correlation between instar and lengths of body and antennae, and between body length and antennal length.

Statistical analysis

In experiments where more than two treatments were used, data were analyzed using an analysis of variance (ANOVA) and means were compared by the test of least significant difference (LSD) at $p = 0.05$ and $p = 0.01$. For comparison of only two treatments, data were analyzed by Student's t test. For correlation between two morphological characters, and temperature and duration of nymphal instars, data were analyzed using a method described by Little and Hills (1975).

RESULTS AND DISCUSSION

Mating and oviposition periodicities

The results of the mating periodicity are summarized in Fig. 1. The premating period lasted 89 hours (range: 67 to 111 hours). Most mating occurred between 12:00 and 20:00 hours and peaked between 14:00 and 16:00 hours. Some mating was observed between 02:00 and 04:00 hours. Most mating took place on the plant; very few pairs mated on the floor or walls of the cage. Average duration of each mating was about thirty minutes. Some insects mated up to three times a day.

The preoviposition period lasted 118 hours (range: 106 to 130 hours). Most oviposition occurred between 12:00 and 20:00 hours, peaking between 14:00 and 18:00 hours (Fig. 2). Before laying eggs, the female held firmly to the plant surface and moved up and down for more than one minute. Eggs were laid singly and attached to the pubescens of the plant surface. Initially the eggs were green-brown or blue but later turned dark brown. They were about 1 mm in diameter.

Duration of oviposition

The results of the duration of oviposition are summarized in Fig. 3. Females began laying eggs soon after mating but laid few eggs on the first day. Preoviposition period was shorter in this than in our earlier study (AVRDC 1990). Oviposition was initiated on third day after adult emergence and continued until 24 days after adult emergence. In this study, on an average, a single female laid 175 eggs during her oviposition period of 22 days. Kobayashi (1972) found a female of a related

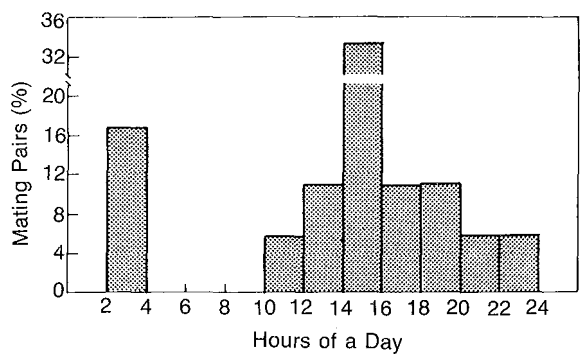

Fig. 1. Mating periodicity in *Riptortus linearis*.

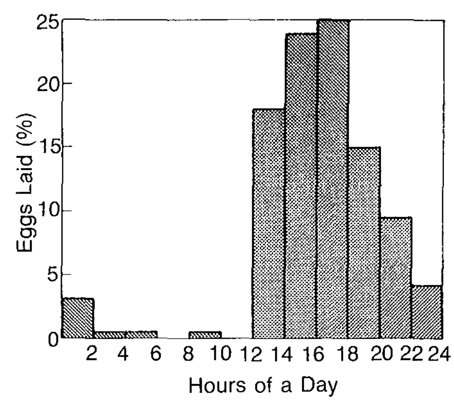

Fig. 2. Oviposition periodicity in *Riptortus linearis*.

species, *R. clavatus* would lay 55 to 72 eggs in her lifetime in Japan.

Oviposition sites

Most eggs (83%) were laid on the leaves. Two-thirds of these were placed on the leaves originating from the fourth through sixth nodes (starting from the apex) on the stem. Each axil of these nodes had soybean pods. Eggs were roughly equally distributed between upper and lower leaf surfaces. No eggs were found on the pods and only 3% and 14% were found on the stem and inflorescences, respectively, where they were hidden from view.

Influence of soybean pods on oviposition

Although our previous study indicated that *R. linearis* does not lay eggs on the pods (AVRDC 1990), in this study, we found that the presence of pods is essential for insects to lay eggs on the plant. Females did not lay eggs on depodded soybean plants (Table 1). This happened whether we allowed the eggs to accumulate on the plants or whether we removed them from the plants daily. It is tempting to suggest that the insect probably lays eggs only when its progeny has an assured food supply - the developing soybean seeds in green pods. This suggestion is indirectly supported in this same study by our observations that when we allowed eggs to remain on the plant, total production was much lower than when we removed eggs daily. In fact, when we removed eggs daily, the insect laid three times as many eggs. Females thus seem to lay only enough eggs so that the progeny from these eggs will have adequate food on which to survive.

Table 1. Influence of pods on oviposition by *Riptortus linearis*

Pod status	No. eggs/plant (mean ± SD)	
	Eggs not removed	Eggs removed
Intact plant	14.00 ± 9.00	48.33 ± 31.47
Depodded plant	0.03 ± 0.58	0
t[a]	2.14	3.07[b]
df[c]	6	6

[a]Student's t test.
[b]t value significant at 5% probability level.
[c]Degrees of freedom.

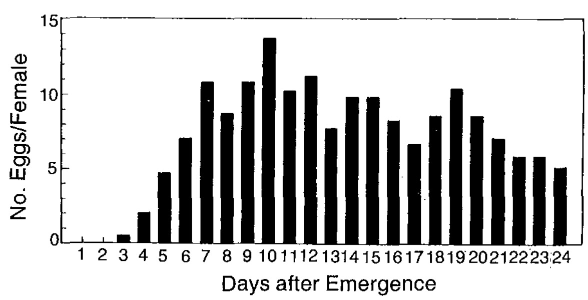

Fig. 3. Daily oviposition pattern of *Riptortus linearis*. Each bar is a mean of two insects.

Effect of temperature on biology

Temperature had a significant impact on the duration of egg and nymphal instars (Table 2). As the temperature increased from 20°C to 35°C, egg incubation periods decreased from 12.75 to 4.13 days. Reduction in duration of five stadia also occurred at these same temperatures. The correlation between temperatures and duration of the egg incubation and nymphal stadia was highly significant (r = −0.953 ± 0.013). The temperature range used in our study simulates temperatures in the tropics and subtropics where this insect is a serious pest.

Table 2. Duration of egg and various nymphal instars of *Riptortus linearis* reared at different temperatures

Temperature	Duration (days)[a]						
	Egg	Nymphal instars					Total nymphal period
		1	2	3	4	5	
20°C	12.75 ± 0.54	4.23 ± 0.45	6.37 ± 0.61	5.31 ± 0.53	7.32 ± 0.62	12.29 ± 1.17	35.47 ± 0.99
25°C	7.88 ± 0.32	2.41 ± 0.27	3.69 ± 0.07	3.38 ± 0.13	4.44 ± 0.42	8.16 ± 0.48	22.01 ± 1.69
30°C	5.25 ± 0.54	1.64 ± 0.26	2.47 ± 0.15	2.45 ± 0.15	2.67 ± 0.23	5.01 ± 0.78	13.78 ± 0.56
35°C	4.13 ± 0.61	1.45 ± 0.26	1.83 ± 0.09	1.77 ± 0.19	2.32 ± 0.35	4.33 ± 0.89	11.52 ± 1.27

[a]Data are means (± standard deviation) of 50 eggs and varying number of nymphs in different instars.

Table 3. Feeding habits of nymphal instars of *Riptortus linearis*

Nymphal instars	No. of pods observed	Mean no. of stylet sheaths/pod[a]	Range
First	30	0	0
Second	11	8.20 ± 3.79	3-15
Third	14	10.35 ± 7.68	1-27
Fourth	13	22.38 ± 7.68	6-40
Fifth	16	41.75 ± 7.05	12-59

[a]Data are means (± standard deviation) of designated number of pods in column 2.

Table 4. Influence of *Riptortus linearis* infestation of soybean plants during reproductive growth stages on seed size and germination

Plant stage[a]	100-seed wt (g)[b]	Germination[b] %
Control[c]	13.90 ± 0.61	92.33 ± 2.62
R2	8.77 ± 0.95	67.33 ± 11.09
R3	8.37 ± 0.85	59.00 ± 9.89
R4	5.19 ± 1.36	45.00 ± 5.72
R5	6.30 ± 0.75	60.33 ± 8.58
R6	3.66 ± 1.05	11.33 ± 4.92
R7	3.15 ± 0.67	1.00 ± 1.41
LSD 5%	1.98	15.39
1%	2.74	21.36

[a]Plant growth stage at which insect infestation occurred.
[b]Data are means (± standard deviation) of 3 replicates.
[c]Insect-free plants.

Insect mortality was highest in the fifth instar at all temperatures (mean 48%); most deaths occurred just before molting into adults. Mortality was lowest in the egg stage (mean 2.9%). In most nymphs and adults, mortality was high at both the lowest and the highest temperatures: 20°C and 35°C.

Feeding habit of nymphs

The first instar nymphs did not feed on soybean pods as was evidenced from the absence of stylet sheaths in pod pericarps (Table 3). Singh (1973) also reports absence of feeding by the first instar of another hemipteran, *Nezara viridula* L., a worldwide pest of soybean. Feeding began with the second instar and increased through each nymphal stadium as evidenced by the increasing number of feeding sheaths in the pod pericarp. Increasing number of feeding sheaths represents increased probing through the pod pericarp in search for food, the developing seeds. The increased probing by older instars, we assume, is related to the increasing amount of feeding by bigger insects.

Effects of feeding on soybean seed

The effects of *R. linearis* feeding on seed size and seed germination are summarized in Table 4. Insect feeding at each individual plant growth stage from R2 to R7, reduced seed size and seed germination. Both parameters decreased as the plant growth stage at which feeding occurred increased. When adults were allowed to feed on the same plants from R2 through R7 stages, the pods on these plants were practically empty. The "seeds" from these plants, which were very thin, did not germinate at all. On the other hand, pods of insect-free plants had seeds with 100-seed weight of 13.9 g, a normal seed size for cultivar "KS9", and germination was the highest at 92.3%. Daugherty et al. (1964) and Jensen and Newsom (1972) also found varying levels of reduction in germination of soybean seeds infested by *N. viridula* and another hemipteran, *Euschistus servus* (Say), in the United States. The reduction in seed size and germination by *R. linearis* feeding on any single reproductive stage indicates the potential of this insect in reducing yield and quality of soybean seed.

Adult longevity

When no food was given, adults died within eight days (Table 5). Provision of green pods increased longevity about three times in both male and female insects. Dry seeds lengthened the life span by more than four times in males and almost four times in females. This insect, thus, can survive on dry soybean seeds in the absence of soybean crop. *R. clavatus* feeds on at least 30 species belonging to five plant families (Kobayashi 1972). These alternate hosts, along with the residual

Table 5. Influence of food sources on average longevity of *Riptortus linearis* adults

Food source	Longevity (days)[a]	
	Male	Female
Green pods	17.15 ± 2.55	24.00 ± 2.64
Dry seeds	30.85 ± 4.98	27.55 ± 4.10
None	6.70 ± 1.69	7.50 ± 0.41
LSD 5%	6.23	5.38
1%	8.95	7.73

[a]Data are means (± standard deviation) of four replicates.

soybean crop left in the field after normal harvest time, will serve as a reservoir of *R. linearis* as well wherever soybean is cultivated.

Morphological observations

Like all hemimetabolous insects, as the *R. linearis* nymphs grew older and molted into successive instars, the lengths of their body and antennae also increased. The growth of both antennae and body was the highest and practically identical – 1.77 times and 1.81 times, respectively — when *R. linearis* nymphs molted from the first into the second instar. In the remaining instars, the growth in successive instars ranged from 1.15 to 1.27 for antennae and 1.13 to 1.44 for the body. A highly significant correlation was found between the number of instars and body length (r = 0.974, df = 4) and antennal length (r = 0.911, df = 4). A highly significant positive correlation (r = 0.987, df = 4) was also found between the length of the body and the antennae.

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大豆害蟲黃條細緣椿象(*Riptortus linearis*)之產卵、取食及發育特性

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本研究在實驗室及溫室裡，對大豆害蟲黃條細緣椿象，進行一系列的多重生物特性調查。結果顯示，黃條細緣椿象成蟲的交尾前期爲89小時，成蟲於中午12時至下午 8 時進行交尾。產卵前期爲118小時，產卵活動在中午12時至下午 8 時，其產卵高峰爲下午 2 時至 6 時止。羽化後約7-12天爲成蟲的產卵期。當大豆開始結莢時，大部份的卵才會逐一地散產在葉片上。如果每天將大豆植株上的卵移走，則黃條細緣椿象在此植株上的產卵量是沒有移卵時的三倍。當溫度爲20°C至35°C之間時，卵期、若蟲期會隨著溫度升高而縮短發育期。當溫度爲20°C時，若蟲期爲35.47天，卵期爲12.75天，而溫度在35°C時，若蟲期則只有11.52天，卵期則縮短爲4.13天。

在若蟲發育期間，五齡蟲的死亡率較其它齡期爲高。一齡蟲不取食，而二齡蟲至五齡蟲則隨齡期增加而取食活動升高。當大豆結莢爲R2至R7的發育時期，如果受到黃條細緣椿象成蟲的取食爲害，則種子變小，發芽率也降低。在不供應食物的情況下，成蟲會於八日內死亡；如果供應含有結莢的大豆植株或乾燥的種子則成蟲可存活28天至31天。蟲體的齡期、體長及觸角長度間有顯著正相關。

關鍵詞：產卵量, 溫度效應, 危害, 交尾, 取食習性。

[1] 臺南縣善化鎮亞洲蔬菜研究發展中心