

ADDITIONAL INFORMATION ON THE BIOLOGY OF *ACROCERCOPS*  
*CRAMERELLA* SNELLEN (LEPIDOPTERA: GRACILARIIDAE)  
IN THE PHILIPPINES

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The total development period obtained at 28°C and 79% R.H. was 28.3 days which may be broken down as follows: mean incubation period, 3.4 days, mean larval period 15.2 days, and mean pupal period (including prepupal period) 9.8 days. Hatchability was 98.14%.

The five larval instars were completed inside the cacao pod while pupation took place outside the pod. Adult moths were observed to be phototropic and lived for an average of 3.87 days. The sex ratio of the cultured and field populations was 1 female: 0.8 male.

The female laid eggs singly on the grooves of pods with ovipositional preference for rough and matured pods. The mean fecundity rate based on a sex ratio of 1:1 was  $21.30 \pm 4.98$  with a mean potential fecundity of  $4.30 \pm 10.82$ . It is thus possible for a female to produce 274,000 progenies in 5 generations. When the male population was increased to 3 males: 1 female ratio, the potential fecundity and fecundity rate increased significantly. The opposite was observed when the female population was increased at 3:1 male. Females mated several times.

The natural enemies found limiting the abundance of *A. cramerella* were: *Trichogrammatoidea* Sp., an egg parasitoid, two ichneumonid pre-pupal parasitoids *Paraphylax faciatipennis* and *Goryphus* Sp., and a Formicid Predator.

Cacao pod borer, *Acrocercops cramerella* Snellen is rated as the most serious pest of cacao in the Philippines and considered one of the limiting factors in cacao production. Heavy infestation of the pod borer led to the collapse of a once flourishing cacao industry in the Philippines.

The destructive larva bores inside the cacao pod, bores its way through the central placenta and funicle and feeds between the seeds. As a consequence, the food supply for the development of the seeds is completely impeded, thus resulting in poorly and abnormally developed seeds. Cacao pod borer infestation ultimately results in production of low grade and poor quality cacao beans. Heavily infested pods have dark colored beans and clumped together which are rendered useless.

In the past, control measures were initiated whenever there was an outbreak of cacao pod borer, but they were found expensive and ineffective. The failure of any control measure against a certain pest could be attributed to one's limited knowledge of the biology of the target pest. To be able to formulate an effective control program against the pest necessitates a comprehensive understanding of the pest biology and behavior.

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This paper will present the biology of the *Acrocercops cramerella* to serve as a guide in formulating a practical and effective pest management program against the pest.

## MATERIALS AND METHODS

Life history observations included the following data: incubation period, number of larval instars, duration of each stadium, pupation, habits, fecundity, sex ratio and longevity of adult moths.

Collecting and rearing of *A. cramerella* pupae from infested cacao trees were done first to obtain adult moths. Newly emerged male and female moths were paired and each pair was released in a caged pod provided with honey and distilled water in cotton balls. The number of eggs laid, the incubation period and the percentage that hatched were noted. The larvae that issued were observed for changes in the measurements of the body and head capsule. These helped in determining the number of larval instars and the duration of the different larval stadia.

Duration of prepupal and pupal stages were observed. The sex ratio of the population was determined from adult moths that emerged from pupae in caged pods and pupae collected in the field for 15 days. Likewise, the longevity of the adult moths were determined from 125 pairs of males and females. The daily rate of mortality of both sexes was recorded.

Potential fecundity was based on the total number of eggs laid plus the remaining eggs found in the ovary after death while actual fecundity was based on the total number of eggs laid. The duration of the laying period was recorded.

## RESULTS AND DISCUSSION

### Life History and Habits

Table 1 shows the duration of the different stages of *A. cramerella*. The developmental period at 28°C and 79 percent relative humidity of the different stages ranged as follows: 3 to 4 days incubation period, 14 to 17 days larval period and 8 to 10 days pupal period, or a total developmental period of 26 to 31 days for an average of 28 days.

**Eggs.** The minute yellowish white eggs measuring 0.99 mm long and 0.61 mm wide are elliptical, flat at the bottom and with numerous longitudinal transverse ribs dorsally. The eggs have an elastic chorion for protection against egg parasite. Incubation ranged from 3 to 4 days. The percentage hatchability obtained was 98.1%.

**Larval stages.** The larva that issued bored straight into the pod on the spot where the eggs are laid. Five larval stadia were observed during the larval development period. Lim et. al. (1982) reported only four larval instars. The recent study of Bernardino (1983) confirmed that the *A. cramerella* in the Philippines has five larval instars. The different larval instars were observed and determined by the changes in the length and width of the body, and size of the head capsule (Table 2). Previous studies in the Philip-

piners did not report on the duration of the different stadia. The duration of each stadium observed in this study ranged from 3 to 4 days for the first and second instars, 3 to 5 days for the third and fourth instars, and 3 to 4 days for the fifth instar. Table 1 gives total developmental period of the larval stages which ranged from 14 to 17 days with a mean of 15.2 days. The larva is consistently pale yellowish green. The larva penetrated deeper into the pod tissue as it grew, feeding on the mucilage of the central placenta and the funicle between the seeds. The resulting larval galleries were filled with frass. It was observed that infected tissues hardened and the seeds clumped together making it difficult to separate them individually. The beans that developed from infested pods were small, abnormal and failed to germinate as compared to beans from healthy pods.

**Pre-pupa.** The full grown larvae leaves the pod by boring its way out. Outside the pod, it hangs by a silk thread coming from the mouth and lowers itself until it comes in contact with the leaves and trunk but usually on dried leaves on the ground where it spins a cocoon. The pre-pupa is pale, yellowish green, measuring 10.44 mm long and 2.29 mm wide and could be seen through the transparent white cocoon. The pre-pupal period lasts only a day.

**Pupa.** The next day, the pupa turns grayish yellow and could be seen actively wiggling inside the cocoon. The pupa, complete with appendages, measures on the average 7.68 mm long and 2.50 mm wide. The pupal period lasts from 8 to 10 days.

**Adults.** The adult moth that emerge from the cocoon was described previously by Zehnter (1901), Roepke (1917) and Wurth (1909) as a very delicate insect with forewings decorated with white crossline and hind wings crowned with long fine marginal setae. The antennae are fine and longer than the body. The moth measures 15.13 mm long, 2.58 wide, with a wing span of 12 mm. The segmentation of the antennae ranged from 22 to 24 for both sexes. The distinguishing external morphological characteristic between the female and male was observed on the last segment of the abdomen. The last abdominal segment of the male is covered with dark gray setae which are wanting in the female. The adults are phototropic. At twilight they are usually seen in shaded trees on the underside of a branch.

The life span of the adults ranged from 1 to 8 days. As presented in Figure 1, the rate of mortality of males and females was significantly higher on the second day. The mean longevity of the adults is 3.87 days. Table 3 shows that adults which emerged from collected pupae and those cultured in caged pods, had a similar sex ratio of 0.8 male: 1 female. However, it may vary depending on environmental conditions.

Some of the present findings and observations on the life history and habits of *A. cramerella* confirms those reported by Zehnter (1901), Roepke (1917) and Wurth (1909). In the Philippines, Otones (1936) reported the duration of the different stages of *A. cramerella* as follows: incubation of 6 to 9 days, larval period 15 to 18 days, pupal period 5 to 8 days, and the total life cycle ranging from 26 to 35 days. Bernardino (1983) obtained the following results: incubation  $4.0 + 0.43$ , larval period  $16.92 + 3.30$ , pupal

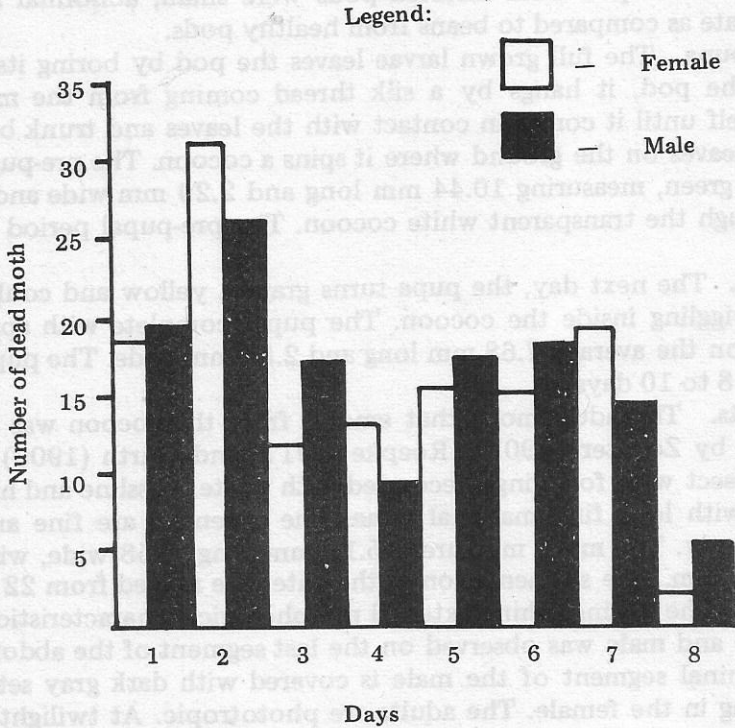


Figure 1. Mortality rate per day of female and male *Acrocercops cramerella* Snellen.

Some of the present findings and observations on the life history and habits of *A. cramerella* confirms those reported by Jenner (1901), Hoop (1917) and Wirth (1909). In the Philippines, Omas (1936) reported the duration of the different stages of *A. cramerella* as follows: incubation 6 to 8 days, larval period 15 to 18 days, pupal period 5 to 8 days, and the total life cycle ranging from 26 to 35 days. Bernardino (1933) obtained the following results: incubation  $4.0 \pm 0.43$ , larval period  $16.92 \pm 3.30$ , pupal

period  $7.86 + 1.15$ , and the total life cycle from 24 to 35 days. The different observations on the life cycle may be attributed to differences in temperature, relative humidity and varieties of cacao used.

### Female Fecundity

Female moths released in a caged cacao pod were observed to lay eggs usually 12 hours after emergence. Eggs were laid singly on the grooves of pods. Females exhibit some degree of preference to oviposit on rough and older pods instead of smooth and young pods. However, young pods measuring three inches long were also infested. According to Zehnter (1901), Roepke (1917) and Wurth (1909), when *A. cramerella* are abundant in the field and mature pods are not available for oviposition. It is presumed that the ovipositional preference of the females could be due to the odor emitted by matured pods which stimulate oviposition of the females. The larvae feed on the mucilage for growth and development and young pods do not contain sufficient amount of mucilage in the central placenta necessary to complete larval development. Likewise, it was observed that larvae in young pods never reached the adult stage.

It was noted that pods with rough surface holds eggs more firmly as compared to pods with smooth surface. Eggs on pods with smooth surface are easily washed-out by rain, thus pods with smooth surface have less borer infestation than pods with rough surface. A similar observation was reported by Zehnter (1902).

**Effect of sex ratio on fecundity.** With the ratio of 1 female: 1 male, a female laid a mean of  $21.30 + 4.95$  eggs in  $2.10 + 1.28$  days with a potential fecundity mean of  $41.30 + 10.82$  (Table 4). During the oviposition period, 70.3 percent of the eggs were laid on the first day, 22.9 percent on the second day, and 7.8 percent on the third day. Based on the result that the potential number of eggs laid by a female is 50.42 and considering the sex ratio of the population to be 1:1, it is possible to calculate that a female will produce 274,010 progenies in five generations. Zehnter (1902) calculated a similar number of progeny in five months based on the assumption that a female lays 20 eggs on the average with a sex ratio of 1:1.

It was likewise observed that the fecundity rate of a female significantly increase when the number of males per female was increased. Table 5 shows the effect of increasing the population density of male per female. With the ratio of 3 males : 1 female, the mean fecundity per female is about three times the number of eggs laid at a normal ratio of 1:1. of 66.67 eggs, a highly significant result. Likewise, the potential fecundity of 3 males: 1 female shows a significantly higher increase in the number of eggs per female (Table 7). However, the number of eggs in the ovary of a female after death did not show significant difference among treatments (Table 8).

On the other hand, when the number of females per male was increased, the fecundity rate decreased significantly. As shown in Table 6, with the ratio of 3 females:1 male, fecundity rate averaged 13.67 eggs per female which is significantly lower as compared to the ratio of 1:1. Similarly, the number of eggs laid decreased by 17.1 percent. However, the potential

fecundity and the number of eggs in the ovary after death did not show any significant difference among treatments.

The significant results obtained in this study show that the fecundity rate and potential fecundity increased with a ratio of three males per female in the population. Likewise, it implies that the females mated several times after emergence.

#### Natural Enemies

**Egg Parasitoid.** A *Trichogrammatid* was recovered by Dr. H. Nagaraja at Leyne's Farm, Digos, Davao del Sur, attacking eggs of the pod borer. It was observed abundant during the month of December when eggs of the pod borer were also abundant. Four species of the family Trichogrammatidae namely: *Trichogramma australicum*, *Trichogramma chilostraea*, *Trichogrammatoidea bactrae*, and *Trichogrammatoidea nana* were tested under laboratory condition for several times but the results were negative. The recovered species of the Genus *Trichogrammatoidea* is presently mass-reared in eggs of *Corcyra cephalonica* and the percentage of parasitism on the pod borer eggs is further studied.

**Pre-pupal parasitoids.** Ichneumonid parasites identified as *Paraphylax faciatipennis* and *Goryphus* sp.<sup>1</sup>, were found attacking the pre-pupal stage of the pod borer. The most predominant pre-pupal parasitoid in the experimental field was *P. faciatipennis*. Both were ecto-parasites and solitary in nature. The same parasitoids were observed by Bernardino (1983) attacking the pod borer at the pre-pupal stage.

**Predator.** One predator of the family *Formicidae* was found attacking the cacao pod borer pupae. This tiny ant were observed abundant in fields planted to cacao.

These natural enemies were observed responsible in limiting the abundance of *A. cramerella*.

<sup>1</sup>Identified by Dr. Clare R. Baltazar, Professor of the Department of Entomology, UPLB, College, Laguna.

Table 1. Duration of different developmental stages of *Acrocerops cramerella* Snellen

Developmental period	Range (days)	Mean (days)
Incubation period	3-4	3.27
Total larval period	14-17	15.20
1st instar	3-4	
2nd instar	3-4	
3rd instar	3-5	
4th instar	3-5	
5th instar	3-4	
Pre-pupal period	1	1.0
Pupal period	8-10	8.87
Total developmental period	26-31	28.34

<sup>1</sup>Reared on caged pods.

Table 2. Body measurement and head capsule of different larval instars.

Larval instars	Body measurement <sup>1</sup>		Head capsule <sup>1</sup>	
	Length (mm)	Width (mm)	Length (mm)	Width (mm)
1st instar	1.28	0.24	0.18	0.20
2nd instar	2.00	0.25	0.19	0.23
3rd instar	5.73	0.61	0.33	0.48
4th instar	6.69	1.73	0.93	1.46
5th instar	11.29	2.67	1.21	1.88

<sup>1</sup>Mean of 10 larvae per instar.

Table 3. Sex ratio of *Acrocercops cramerella* Snell, based on collections and culture.

Treatment	N	Adult emergence		Sex ratio	
		Male	Female	Male	Female
Collected pupae	150 <sup>a</sup>	67	83	0.1 :	1
Cultured pupae	594 <sup>b</sup>	275	319	0.8 :	1

<sup>a</sup>Pupae collected from infested cacao trees for 15 days at 10 pupae per day.

<sup>b</sup>Pupae from cultures.

Table 4. Fecundity and laying period of a female.

Treatment	N	Mean + S.E.	C.V.
Potential fecundity	10	41.30 + 10.82	4.78
Fecundity rate	10	21.30 + 4.98	2.21
Laying period (days)	10	2.10 + 1.28	0.57

N = number of female.

Table 5. Fecundity rate as influenced by density of male per female.

Treatment	No. of eggs laid			Total	Mean
	I	II	III		
1 male : 1 female	20	24	20	64	21.33
2 males : 1 female	59	59	40	158	47.00
3 males : 1 female	69	72	59	200	66.67**

C.V. = 16.15%

LSD at = .05 = 15.128

.01 = 22.915

\*\* — Highly significant

Table 6. Fecundity rate as influenced by density of female per male.

Treatment	No. of eggs laid			Total	Mean
	I	II	III		
1 female : 1 male	20	24	20	64	21.33*
2 females : 1 male	12	18	15	45	15.00
3 females : 1 male	14	14	13	41	13.67

C.V. = 13.27%

LSD at = .05 = 4.417

.01 = 6.692

\* — Significant

Table 7. Potential fecundity of a female in relation to density of male per female and density of female per male.

Treatment	No. of potential eggs per female			Total	Mean
	I	II	III		
1 female : 1 male	35	49	40	124	41.33
2 females : 1 male	32	43	43	118	39.33
3 females : 1 male	54	34	35	123	41.00
1 female : 2 males	79	84	60	223	74.33
1 female : 3 males	99	98	82	279	93.00**

C.V. = 16.76%

LSD at = .05 = 17.61

.01 = 25.05

\*\* — Highly significant

Table 8. Number of eggs in the ovary after death in relation to the density of male per female and density of female per male.

Treatment	Number of eggs in the ovary per female			Total	Mean
	I	II	III		
1 female : 1 male	15	25	20	60	20.00
2 females : 1 male	30	25	28	83	27.67 ns
3 females : 1 male	40	20	22	82	27.33
1 female : 2 males	20	25	20	65	21.67
1 female : 3 males	30	26	23	79	26.33

C.V. = 23.93%  
 ns — Not significant

Table 9. Potential fecundity of female in relation to density of male per female and density of female per male.

Treatment	No. of potential eggs per female			Total	Mean
	I	II	III		
1 female : 1 male	35	43	40	118	41.33
2 females : 1 male	22	43	23	88	29.33
3 females : 1 male	24	35	25	84	28.00
1 female : 2 males	19	34	30	83	27.67
1 female : 3 males	22	38	28	88	29.33

C.V. = 16.78%  
 LSD at .05 = 17.61  
 .01 = 23.05  
 \*\* — Highly significant

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