BIOLOGY OF TARO HORNWORM, *Hippotion celerio* L.

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ABSTRACT

The biology of taro hornworm, *Hippotion celerio* L., was studied in the laboratory. The eggs were laid singly or in groups on the nether surface of the leaf. Incubation period of eggs was from 3 to 5 days with 97% hatchability. The total developmental period ranged from 29 to 35 days for females and 28 to 35 days for males. It did not differ markedly between the two sexes, but adult longevity was longer in females than in males. Five larval instars were recorded. A male to female ratio of 1.00:1.31 was observed. Of the 6 alternate hosts tested, 4 species were preferred and two species were eaten only under stress of hunger. A hymenopterous parasite, *Trichogramma* sp., was found infesting the eggs of taro hornworms in the field.

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KEY WORDS: Taro. *Colocasia esculenta*. Taro hornworm. *Hippotion celerio*. Mass rearing. Life history and behavior. Host range. Natural enemies. *Trichogramma* sp.

INTRODUCTION

The taro hornworm *(Hippotion celerio* L.) is a serious insect pest of taro *(Colocasia esculenta* (L) Schott.) and is believed to contribute to considerable yield losses (Mercado, 1958). The larva is a voracious leaf feeder which can defoliate a taro plant in a day. Since taro can greatly help supplement the supply of rice and corn in times of scarcity, some measures must be introduced to increase its productivity such as the control of insect pests attacking it.

A study of the biology of taro hornworm should be the first logical step towards the formulation of a successful control program for this

pest. Additional information on its natural enemies in the field will provide invaluable tool for future biological control work. Likewise, knowledge of its host range is important in pest control and in selecting rotation crops and intercrops for taro. Most of the above information are scarce or non-existent. Therefore, this study was conducted to obtain detailed information on the life cycle and behavior of the taro hornworm and to determine its alternate host and natural enemies in the field.

MATERIALS AND METHODS

Mass Rearing of Insects. — Larvae of *H. celerio* of almost the same sizes were collected from the field to start a stock culture in the laboratory. The larvae were confined in glass jars (10 cm dia.) covered with fine-meshed nylon cloth. During the first three larval instars, they were provided daily with fresh taro leaves. Thereafter, food was provided twice each day. When pupation was about to occur, full grown larvae were transferred into jars filled with 7.6 cm of moist soil. Two or three days before emergence, the pupae were transferred to Petri dish halves which were placed in a wire screen cage.

Newly emerged adults in the oviposition cage were allowed to mate and lay eggs on leaves of potted taro plants placed inside the cage. Cotton balls were soaked in 25% sugar solution and hung on threads in the cage as source of food for the adults.

Eggs laid on the leaves were collected with the use of camel's hair brush. The eggs laid by a female everyday were counted and transferred into Petri dishes lined with tissue paper. The incubation period for each batch of eggs was recorded. The newly hatched larvae were used for the various studies conducted.

Study of Life History and Behavior. — One hundred newly hatched larvae for each generation were used for this phase of the experiment. They were reared individually in Petri dishes lined with paper. The behavior of the different instars and duration of each larval stadium were recorded. The length and width of the body and head capsule of each larval instar were taken using a foot rule with the aid of a stereoscopic microscope. Molting was determine by the presence of exuvia and head capsule.

The total developmental period, number of larval instars, manner of pupation, length of pupal stage, mortality rate and behavior of the insect were recorded. The sex of the emerging adults were determined by examining the genitalia. The number of eggs laid by the females, longevity of adults and their mating behavior were noted.

Determination of Host Range. — Laboratory-reared larvae of the same stages of growth were fed with leaves of different plant species found in and around the taro field. Other plants closely related to taro were also tested. Leaves of the

suspected hosts were placed in jars and the larvae were introduced. If the larvae fed on these leaves within 24 hr, these plants were further tested to determine whether the larvae would continuously feed on them and would complete their development. Similar observations as those noted in the first part of the study were obtained.

Identification of Natural Enemies. — Eggs, larvae and pupae were collected from the field to rear out the parasites that may be found in them. The behavior of parasitized and healthy hornworms were compared. Percentage of parasitism of field-collected samples was determined. Adult parasites that emerged were examined and identified. Predators attacking the different stages of the insect in the field were also collected and identified.

RESULTS AND DISCUSSION

Life History and Behavior.

Length of Life Cycle. — Table 1 shows the duration of the different developmental stages of *H. celerio*. The total developmental period did not differ markedly between the 2 sexes (mean of 31.31 and 30.60 days for the female and male, respectively). There were 5 larval stadia lasting for 15.19 days for the female and

Table 1. Duration (in days) of the developmental stages of *Hippotion celerio* reared on taro.

Developmental Period	Females (142 individuals)		Males (108 individuals)	
	Range	Mean[1]	Range	Mean[1]
Incubation of Eggs	3- 5	4.00 ± 0.53	3- 5	4.06 ± 0.14
Larval Period				
First Stadium	2- 3	2.14 ± 0.35	2- 3	2.09 ± 0.28
Second Stadium	2- 3	2.16 ± 0.37	2- 3	2.07 ± 0.26
Third Stadium	2- 4	2.48 ± 0.78	2- 4	2.13 ± 0.46
Fourth Stadium	2- 4	3.08 ± 0.53	2- 4	3.06 ± 0.20
Fifth Stadium	4- 7	5.33 ± 0.79	4- 7	5.14 ± 0.40
Total Larval Period	12-21	15.19 ± 2.82	12-21	14.49 ± 1.60
Pupal Period	11-13	12.12 ± 0.49	11-13	12.05 ± 0.26
Egg-Laying to adult Emergence	26-39	31.31 ± 3.84	26-39	30.60 ± 2.00
Longevity of Adults	4-15	9.20 ± 0.32	3- 8	5.50 ± 0.03

[1]Mean ±, standard deviation.

14.49 days for the male. The pupal period ranged from 11 to 13 days for both sexes.

Oviposition. Egg-laying started 3 to 4 days after the moths emerged and continued for 7 days. The eggs were laid singly or in groups on the nether surface of the leaf (Fig. 1). The eggs were held in place by an adhesive material secreted by the female moth. The highest number of eggs were laid on the first day of oviposition, becoming fewer each day thereafter. The females laid from 83 to 637 eggs with an average of 248.3 per day. During the first day of oviposition, a female moth laid an average of 138.9 eggs.

While laying eggs, the female stood squarely on its legs on the leaf surface and extended its slightly bent abdomen downward as the eggs were deposited. Eggs which were laid singly were broadly ovoid, but those laid in groups were usually compressed on both sides.

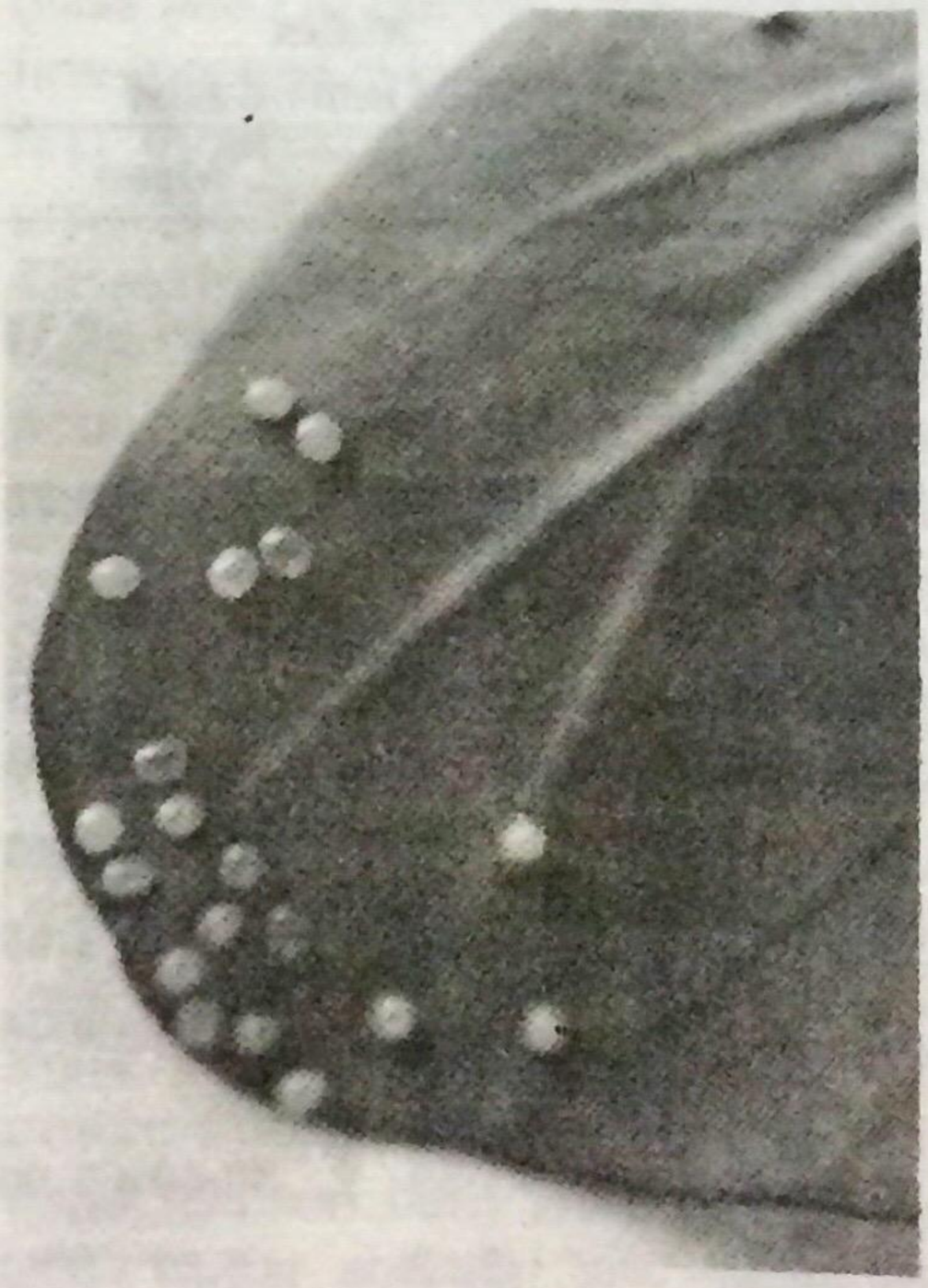

Fig. 1. Eggs of *Hippotion celerio* laid on underside of leaf.

Incubation of Eggs and Eclosion. The incubation period of eggs ranged from 3 to 5 days. The eggs, which are green in color at first, turn yellow and become transparent with the larva inside being visible on the outside just before hatching. A very high percentage of hatchability of eggs was observed in the laboratory with an average of 97.1%.

Hatching took place anytime of the day. At first, the larva cut a round slit at the free end of the egg using its mandibles. When the slit was large enough for the passage of the head and body, it stopped chewing. The first part of the body to emerge was the head, followed by the legs then the abdomen. When the legs were already anchored on the leaf surface and while the egg case was still attached to the larva by the posterior horn, it moved slowly until finally it was able to free itself from the egg case. It took a larva 15 to 60 min to come out from the egg case.

Larval Development. The body of the newly-hatched larva was yellowish in color with a purplish black horn near the tip of the abdomen. A few hours later, the color changed to pale yellowish green. Later instars were darker green in color.

The various instars could be differentiated by head and body measurements, body markings and size of horn in relation to body length (Fig. 2 and Table 2). Immediately after hatching, the larva ate

Fig. 2. First to fifth larval instars of *H. celerio* (from left to right).

Table 2. Distinguishing features of the different larval instars of *Hippotion celerio*.

Larval Instar	Distinctive Features
First	Dorsal part of head dark yellowish green; body lighter green; horn on ninth abdominal segment about 3/4 as long as body, black and purplish at base, tapered at tip.
Second	General body coloration green; 2 "ocelli" present on segment V white but ringed with black, "ocelli" on segment VI similar to those on segment V in color; horn blackish brown, about 2/3 as long as body.
Third	Head lighter green; body pale bluish green; "ocelli" on segment V with an oval green pupil; "ocelli" on segment VI ringed with black; horn black, about 2/5 as long as body.
Fourth	General body color green; "ocelli" on segments V and VI as in the third instar larva; horn 1/5 the length of body.
Fifth	Head and body grass green in color; with a darker green dorso-lateral stripe on each side of the body; "ocelli" on segment V oval with large oval, dark green pupil containing 5 to 6 round olive or pale green dots; horn about 1/8 as long as body.

the egg shell. Then, 2 to 4 hr later, it began nibbling on the leaf surface. When disturbed, the young larva dropped from the leaf by hanging on a silken thread.

In all the instars, the larva stopped feeding 2 to 4 hr before ecdysis. It took 20 to 40 min for a larvae to shed off its skin. Thirty to 40 min after molting, the larva ate the exuvium, leaving the head capsule and horn case. In most cases, the head capsule was removed ahead of the body skin; the reverse sequence was noted only in few instances. Shortly after eating the exuvium, the larvae started to feed on taro leaf.

Pupation. Two to three days before pupation, the full-grown larva turned brown, ceased feeding and became restless. Pupation usually occurred in the soil in an earthen cocoon formed by the prepupa. When soil was not available, the full grown larva concealed itself under-

Fig. 3. Pupae of *H. celerio*.

neath the dried taro leaves, also spinning a scanty cocoon. At first, the prepupa made a burrow in the soil and then it spins a cocoon. A loose silk web was prepared supported at the edge of the bottle and the soil. It then filled in the web with overlapping bundles of silk filaments. It took 3 to 4 hr to complete the cocoon. One to 2 days before emergence of the adult, the pupa turned dark brown and soft when touched. The pupa is reddish brown in color with elongate body (Fig. 3).

Emergence of Adults and Mating Behavior. The adults usually emerged from the cocoon at night. Twenty to 40 min before emergence, the silk threads of the cocoon became detached from the sides of the bottle by an alkaline secretion emitted by the pupa which dissolved the silk fibers. The pupa moved continuously until finally a slit was made at the anterior portion of the pupal case. At first, the head came out with the antennae folded back on the thorax and the legs held very close to the body. Then the legs were extended and immediately used for crawling. A newly emerged adult was torpid, its wings crumpled and it immediately discharged a reddish liquid. It took 30 to 60 min for the appendages and wings to straighten out and dry up after the adult emerged from the pupal case.

Mating was preceded by a brief courtship. It took place 1 to 2 days after emergence, usually in the evening and rarely during the day. Copulation lasted for 3 to 6 hr. When mating was about to occur, the male became very active and moved from one place to another, tapping the female with its antennae. The male behaved this way for 30 to 60 min, hovering and tapping around the female's body. The female, if not yet ready for copulation, moved away from the male. The male, on the other hand, followed it and continued to tap the female's abdomen until finally it was

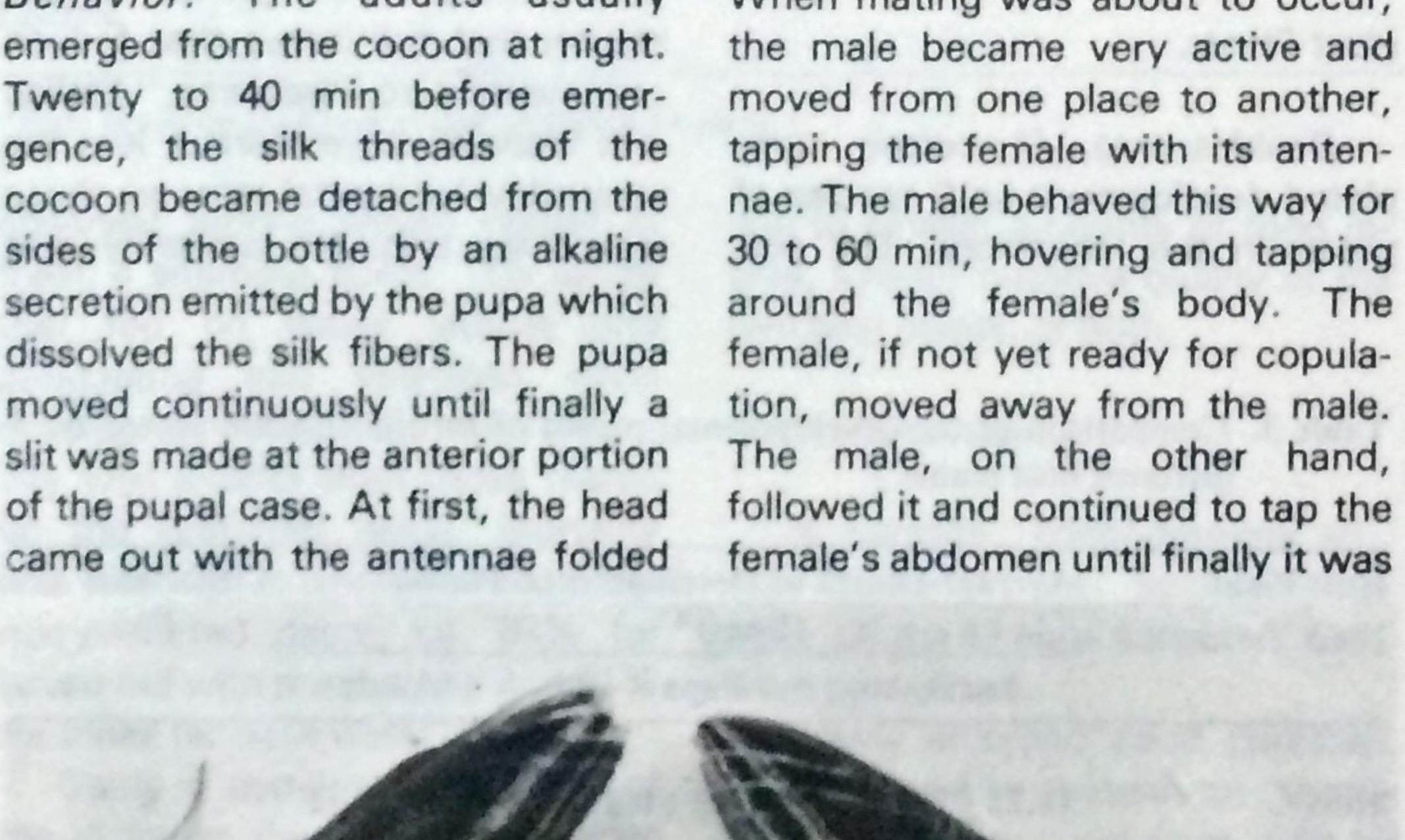

Fig. 4. *H. celerio* adults in copula.

able to position itself behind the female and copulation followed (Fig. 4). The pair faced at opposite directions and remained stationary where they had alighted. Under laboratory conditions, it was observed that copulation occurred once only before the female finally oviposited.

Male-to-Female Ratio. Out of a total of 250 adults that emerged from individual cultures in the laboratory, 142 were females and 108 were males giving a female-to-male ratio of 1.31:1.00.

Host Plants.

Besides taro, *H. celerio* completed development on 6 species of plants in the laboratory. The preferred alternate hosts include: ornamental taro, *Caladium bicolor* L.; "palawan," *Cystosperma* sp.; "talian," *Alocasia macrorrhiza* Schott; and "tannia," *Xanthosoma* sp. All these species are related to taro and belong to the Family Araceae. The plant species which were considered non-preferred hosts and eaten only under the stress of hunger are: water lettuce, *Pistia stratiotes* L. and *pungapong, Amorphophallus campanulatus* Roxb.

Table 3 compares the developmental periods of *H. celerio* reared on 7 different host plants. It was shown that the larvae that fed on ornamental taro, "palawan," "talian and "tannia" have more or less the same developmental rates as those reared on taro. No mortality was

Table 3. Comparison of the developmental period of taro hornworm reared on 7 different host plants. [1]

Host Plant	Average Length of Developmental Period (Days) [2]			Mortality (%)
	Larva	Pupa	Adult	
Taro	18.23 ± 0.57	12.12 ± 0:49	9.20 ± 1.32	0
Ornamental Gabi	18.71 ± 1.11	12.25 ± 0.25	9.16 ± 0.53	0
"Palawan"	18.58 ± 0.67	12.28 ± 0.02	9.68 ± 0.17	0
"Talian"	18.83 ± 0.56	12.46 ± 0.32	9.07 ± 0.24	0
"Tannia"	18.31 ± 0.51	12.15 ± 0.12	9.86 ± 0.35	0
"Pungapong"	24.00 ± 0.19	14.54 ± 0.19	3.00 ± 0.66	87
Water Lettuce	23.12 ± 0.90	15.60 ± 0.24	3.50 ± 0.25	91

[1] Data based on 24 larvae reared on each host plant.

[2] Mean ±, standard deviation.

Table 4. Comparison of sizes of the different developmental stages of taro hornworm reared on 7 different host plants. [1]

Host Plant	Average Size (mm) of Developmental Stages					
	Fifth Instar Larvae		Pupa		Adult	
	Length	Width	Length	Width	Length	Wing Span
Taro	56.27	7.50	41.20	11.63	39.70	60.68
Ornamental Gabi	55.60	7.54	40.85	11.40	39.58	60.59
"Palawan"	55.80	7.40	41.05	11.45	39.65	60.63
"Talian"	56.25	7.63	41.34	11.57	39.68	60.78
"Tannia"	55.59	7.46	40.80	11.55	39.63	60.54
"Pungapong"	52.40	6.20	36.50	8.76	34.32	54.86
Water Lettuce	52.05	6.21	35.80	8.54	34.21	54.80

[1]Data based on 24 larvae reared on each host plant.

observed among larvae reared in these 4 alternate hosts. The larvae that fed on water lettuce and *pungapong* had extended larval development and adult moth longevity was shorter than those reared on the preferred hosts. Mortality was very high in larvae reared on the non-preferred hosts, i.e. 87% for larvae fed with *pungapong* and 91% for those fed with water lettuce.

Table 4 compares the sizes of the different developmental stages of *H. celerio* reared on 7 different host plants. It was observed that insects that fed on ornamental taro, "palawan," "talian" and "tannia" were of the same sizes as those reared on taro. Fifth instar larvae, pupae and adults reared on water lettuce and *pungapong* were smaller than those fed with taro. This reduction in body size might have been due to smaller amounts of food intake, inferior nutritive quality of the two host plants, or both.

Natural Enemies.

A parasite, *Trichogramma* sp., was reared from field-collected eggs. Of the 49 eggs collected, 53% were parasitized.

Newly emerged adult parasites were allowed to oviposit on laboratory-reared hornworm eggs. One to 2 days after deposition of the parasite's eggs, the host eggs turned blackish gray and adult parasites emerged 3 to 4 days after the eggs were laid. It was noted that the number of adult parasites that emerged from an egg varied from 4 to 13 with an average of 8 individuals per egg.

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