BIOLOGICAL STUDY OF COCONUT HISPINE BEETLE, *Brontispa longissima* GESTRO (COLEOPTERA: HISPIDAE) AND ITS NATURAL ENEMIES

INTRODUCTION

Coconut, *Cocos nucifera* L., is one of the most economically important crop of Thailand. It is important source of food, fuel and wood for people and coconut plams symbolizes exotic holidays and in deed tourism is a very important source of income for southern of Thailand. In coconut production a common limiting factor is the attacked by various coconut pests among of these, insect pest complex plays the most significant role of all the coconut insect pest complexes, the coconut hispine beetle, *Brontispa longissima* Gestro (Coleoptera: Hispidae) is considered as the most important insect pest.

Coconut hispine beetle, *Brontispa longissima* Gestro (Coleoptera: Hispidae) are exotic pests, but in the last few years this species was the most important pest and outbreak in some areas such as in the southern of Thailand (Sindhusake and Winothai, 2004). The coconut hispine beetle, *B. longissima* is an important insect pest of coconut in many of countries such as Malaysia, Indonesia, Viet Nam and Thailand.

The objective of this study is investigation on the biological attributes, including the construction and analysis of the life table of *B. longissima,* a survey and evaluation of natural enemies of coconut hispine beetle including studies on biology of the important natural enemies, studies on population of *B. longissima*. These investigation were carried out with a prospect of utilizing the natural enemies of *B. longissima* as biological control agents in Thailand.

LITERATURE REVIEW

Approximately 1,000 species of insects are associated with coconut worldwide. Over 40 species of coleopteran pests have been recorded most are under effective natural control but some require interventions (Rethinam and Singh, 2005).

The coconut hispine beetle, *Brontispa longissima* Gestro (Coleoptera: Hispidae) is one of the most serious insect pest of coconut in Asia and the Pacific. *B. longissima* is believed to be endemic to Indonesia and possibly also to Malaysia, Papua New Guinea and the Solomon Islands. The coconut hispine beetle however was not recorded from continental Southeast Asia countries until the late 1990 it was first detected in the Mekong Delta in Viet Nam (Wilo and Keith, 2004).

Hosang, *et al*. (2004) reported that the total life cycle of *B. longissima* from egg to adult emergence was 5-7 weeks or 5-9 weeks (Sankaran, 2006). Adult females lay singly or in groups of two to four on the still-folded leaflets of both young and mature coconut palms (Rethinam and Singh, 2005). The eggs hatch after an incubation period of about 5 days (Yueguan, and Yankun, 2004) or 3-7 days (Sankaran, 2006). The newly hatched larva begins to feed between and inside unopened leaflets (Yueguan, and Yankun, 2004).

The newly hatched larvae are whitish, later turn to yellowish and have an average length of 2 mm. The older larvae have an average length of 8-10 mm (Hosang, *et al*., 2004). The coconut hispine beetle are four instars larval stage with a duration of 30-40 days. Larvae are less active (Nguyen, *et al*., 2004). The pupa period is 6 days The adult coconut leaf beetle is 7.5-10 mm long and 1.5-2 mm wide, with a flat body that is black in color with an orange head and shoulders. The adult beetle is fully mature 2 weeks after emergence from the pupa and lives for 2-3 months (Sankaran, 2006; ASEAN IPM Knowledge Network Management, 2007).
The number of egg laid per female averaged 153±20 to 43±108 eggs (Viet, 2004).

Both larvae and adults of the coconut hispine beetle feed on tissues of developing, unopened leaves of the trees (David, 1995). Prolonged attack, particularly to palms that are young or suffering from poor growing conditions, may result in death of the tree (Wilo and Keith, 2004; Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, 2007). The adult beetles feed on the spongy tissue of the coconut leaflet by chewing a series of fine grooves on the lower surface, sparing a thin layer of the upper epidermis. The adult beetles feed on the spongy tissue of the coconut leaflet by chewing a series of fine grooves on the lower surface, sparing a thin layer of the upper epidermis. The larva feeds and mines inside the leaf and feeds on the parenchymatous leaving the upper and lower epidermis intact. In severe infestation leaftips generally turned brown, shriveled and curled downward giving the palms a scorching appearance (Othman, 2004).

YongYue, *et al*. (2004) reported that the feeding behaviour of *B. longissima* was observed and the leaf area of *Cocos nucifera*, *Roystonea regia*, *Chrysalidocarpus lutescens* and *Caryota ochlandra* as alternation last.

During 1919 to 1934, *B. longissima* had been recognized as a pest of coconut palm in five provinces in Indonesia (Hosang, *et al*., 2004). Yueguan, and Yankun (2004) reported that in 2002, in chaina the coconut leaf beelte was first recorded in Haikou city in Hainan province.

In Viet Nam the beetle was first recorded in Dong Thap Province in with a few plants infected, in April 1999 (Viet, 2004). In the Maldives the pest was first noticed in December 1999 on Sun Island resort and found on ornamental palms from nurseries in Malaysia and Indonesia (Shafia, 2004).

In Thailand, Sindhusake and Winothai (2004) reported that damage caused by *B. longissima* was first recorded in Narathiwas province, near border of Malaysia, in 2002. Heavy infestation was first reported in February 2004 in southern provinces including Surat Thani and Prachuap Khiri Kan.

The parasite complex of *B. longissima* comprises of three egg parasites, *Hispidophila brontispa* Ferriere (Hymenoptera: Trichogrammatoidae), *Trichogrammatoidea nana* Zehntner (Hymenoptera: Trichogrammatoidae) and *Ooencyrtus podontiae* Gahan (Hymenoptera: Encyrtidae),two larvae parasite, *Asecodes hispinarum* Boucek (Hymenoptera: Eulophidae) and *Chrysonotomyia* sp. (Hymenoptera: Eulophidae) and a parasite of the larvae and pupae, *Tetrastichus brontispa* Ferriere (Hymenoptera: Eulophidae). The earwing *Chelisoches morio* Fabricius (Dermeptera: Chelisochidae) has been reported as natural enemies of *B. longissima* in Malaysia and Indonesia (Wijesinghe, 2004; Rethinam and Singh, 2005; Othman, 2004, Viet, 2004). The black earwig appears to be a native of Numerous island in the Pacific Ocean (Langston and Powell, 1975). In nurseries if parasites do not give enough control the chemicals should be used with care (French, 1986).

In Viet Nam, Viet (2004) studied the biology of *A. hispinarum* and reported that its life cycle was completed in 17±1 days. The longevity of adult was 3-4 days and sex ratio averages about 1:3 male and female. *B. longissima* are usually kept under control by an introduced parasite. The larval parasite *A. hispinarum* was collected in Viet Nam and introduced and reared in Thailand in August 25, 2004 (Sindhusake and Winothai, 2004).

MATERIALS AND METHODS

Laboratory study of the coconut hispine beetle, *Brontispa longissima* was conducted at National Biological Control Research Center (NBCRC), Central Regional Center (CRC), Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand. The studies included rearing of *B. longissima* as stock culture, biological study of *B. longissima* and its natural enemies.

Stock culture of *Brontispa longissima* Gestro

The stock culture of the coconut hispine beetle, *B. longissima* were obtained by collecting adult of coconut hispine beetle from the coconut fields. They were reared in the insect rearing cage measuring 60x60x90 cm in dimension, with pieces of coconut leaves. After oviposition occurred on the coconut leavae there coconut leaves were taken out from the insect rearing cage and new plastic boxes of fresh coconut leaves substituted. After oviposition, eggs were collected from the coconut leave for hatching in the plastic boxes measuring 22 cm in diameter and 6 cm in height with pieces of young they were leaves coconut changed every two day until larvae of *B. longissima* became to pupation. The pupae were kept in the plastic boxes measuring 22 cm in diameter and 6 cm in height until the adult of *B. longissima* emerged and then transferred to the insect rearing cage. Using this method, it was possible to maintain a stock culture of coconut hispine beetle, *B. longissima* for study on the biological attributes, construction of the life tables and other various experimental purposes on a continuous basis. The stock culture of *B. longissima* were maintained at the room temperature of 28-30 ^{o}c (Figure 1).

Biological studies of *Brontispa longissima* Gestro

The newly laid egg of *B. longissima* were collected from the stock culture and transferred into circular-shaped plastic boxes measuring 22 cm in diameter and 6 cm in height. The cover of plastic boxes were cut open with hole which was covered with a organza screen for ventilation, some cut pieces of young leaves of coconut were provided as food of larvae. The observation of the incubation period was done.

Figure 1 Stock culture of reared in the insect rearing cage in the insectary

The newly hatched larvae were reared singly in plastic boxes, measuring 22 cm in diameter and 6 cm in height with cut pieces of young leaves of coconut.

The cut piece of coconut leaves was changed every two day until pupation. After pupation, pupae were kept singly in plastic, measuring 22 cm in diameter and 6 cm in height with cut pieces of young leaves of coconut. Daily observation was made and necessary data recorded throughout the span of development period. The width of the head capsule of each larval instars was measured by an ocular micrometer to determine the growth increment.

A pair of emerged adult was transferred into the oviposition plastic boxes, measuring 22 cm in diameter and 6 cm in height with pieces of young leaves of coconut. The number of egg laid by the female adults on the leaves of coconut were counted everyday. The number of eggs per batch and the oviposition site were noted, and they were kept of further observation on incubation period, and other biological studies.

Life Table Study of *Brontispa longissima* Gestro

Biological life table study

Biological life table study of *B. longissima* were carried out by using 500 newly laid eggs of *B. longissima* from the stock culture. The newly laid eggs were kept in the plastic boxes, measuring 22 cm in diameter and 6 cm in height with cut pieces of young leaves of coconut. The newly hatched larvae was transferred to ten plastic boxes, measuring 22 cm in diameter and 6 cm in height with some pieces of young coconut leaves as food of larvae. New pieces of coconut leaves were changed every three days or whenever necessary. Daily observation was made and data on number of individual larval and pupal survived recorded every three days until adult emerged. The adults were reared in the plastic boxes, measuring 22 cm in diameter and 6 cm in height with pieces of young leaves of coconut were provided for adult survival and oviposition. The young leaves of coconut were changed daily. Data on the number of adults survived and eggs laid were recorded every daily until emerged

adults died. These recorded data were used for the construction of the biology life table using techniques given by Allee *et al*. (1949) Laughlin (1965), Southwood (1968), Harcourt (1969), Napompeth (1973), and Varley and Gradwell (1970).

The net reproductive rate of increase (R_o) is caluculated from equation:

$$R_o = \sum_{X=o}^{\alpha} l_x m_x \quad \ldots(1)$$

Where, 0 to α = life span

l_x = proportion at birth of females being alive at age X

m_x = number of female births during age X

$l_x m_x$ = egg curve

The cohort generation time (T_c) is calculatedfrom the equation:

$$T_c = \sum_{X=o}^{\alpha} l_x m_x .X \,/\, \sum_{X=o}^{\alpha} l_x m_x \quad \ldots(2)$$

The capacity for increase (r_c) of Laughlin (1965) is as approximation of the innate capacity for increase (r_m) the calculation of which was complicated. The r_c could be calculated from the equation:

$$r_c = \frac{\log_e R_o}{T_c} \quad \ldots(3)$$

The finite rate of increase (λ) is calculated from the equation:

$$\lambda = \text{antilog}_e\, r_c \quad \ldots(4)$$

The population doubling time (DT) is calculated from the equation:

$$DT = \frac{\log_e 2}{r_c} \quad \ldots(5)$$

The egg curve was obtained by plotting $l_x m_x$ against X. This curve represented the egg schedule of births and deaths in terms of the age-schedule fecundity and probability at birth of females being alive at each age group and the egg productivity within each age group through the life history.

Partial ecological life table study

The partial ecological life table study of *B. longissima* were carried out by using newly laid eggs on coconut learves from stock culture. The newly laid eggs were kept in plastic boxes, measuring 22 cm in diameter and 6 cm in height. The newly hatched larvae were transferred to and other plastic boxes, measuring 22 cm in diameter and 6 cm in height. Each plastic boxes contained 50 larvae provided with fresh cut pieces of young coconut leaves until they pupated. The pupae were kept under narmal condition with coconut learves in a plastic boxes, measuring 22 cm in diameter and 6 cm in height. Daily observation was made and the number of individuals survived in each development stage was recorded for construct the partial ecological life table using techniques given by Napompeth (1973).

Survey of the Natural Enemies of *Brontispa longissima* Gestro

Field survey of natural enemies of *B. longissima* was done by collecting and examining all stages of these coconut hispine beetle covering area and locations where coconut was cultivated in Kamphaeng Saen, Nakhon Pathom. The eggs, larvae and pupae of these coconut hispine beetle were brought of the laboratory. Eggs were kept in the test tubes measuring with 2.2 cm diameter and 15 cm long; larvae and pupae were kept in plastic boxes, measuring 22 cm in diameter and 6 cm in height with some cut pieces of young coconut leave. Daily observation was done until the emergence of the parasites. The adult parasites were hold for proper identification. Predator were observed in the fields and some of them were reared in laboratory for identification. The more important natural enemies were reared, if possible and used for establishing stock cultures for further biological study.

Biological Studies of Important Parasite of *Brontispa longissima* Gestro

Egg Parasites

Adults of egg parasites obtained from field survey were kept in the test tubes, 2.2 cm diameter and 15 cm long, with small drop of honey on wax paper as food for the parasites and the tube plugged with cotton wool. The newly laid eggs of coconut hispine beetle obtained from stock culture were exposed in the test tubes for parasitization. The eggs were changed after they had been parasitized and kept in the test tubes plugged with cotton wool. These test tubes with parasites were kept in the room temperature at 28-30 ^{o}c until the adult parasites emerged. Daily observation was made and biological data of parasite were recorded.

Larval Parasites

Adults of larval parasites collected from field survey were kept in the test tubes, 2.2 cm diameter and 15 cm long, with small drop of honey on wax paper as food for the parasites and the tube plugged with cotton wool. The fourth instar larvae of coconut hispine beetle obtained from stock culture were exposed in the test tubes for parasitization. After parasitization had taken place the larvae were changed and reared in new plastic boxes, measuring 22 cm in diameter and 6 cm in height with some cut pieces of young coconut leaves as food of larvae. Daily observation was done and biological data of parasite were recorded.

Pupal Parasites

Adults of pupal parasites collected from field survey were kept in the test tubes, 2.2 cm diameter and 15 cm long, with few drop of honey on wax paper as food for the parasites and the tube plugged with cotton wool. The newly pupated pupae of coconut hispine beetle obtained from stock culture were exposed in the test tubes for parasitization. The pupae were changed after they had been parasitized and kept in the test tubes plugged with cotton wool. These test tubes with parasites were kept in the

room temperature at 28-30 ^{o}c until the adult parasites emerged. Daily observation was made and biological data of parasite were recorded.

Biological Studies of The Important Predator of *Brontispa longissima* Gestro

Biological studied of important predator was done by using newly laid eggs from the field. There egs were kept in plastic boxes, measuring 22 cm in diameter and 6 cm in height with adequate moisture provided with water-soaked cotton wool until the nymph of predator emerged. The coconut leaves with first instar larvae of coconut hispine beetle were placed in plastic boxes for food of predater. Daily observation was made and life history data recorded throughout the span of the developmental period.

Population Study of *Brontispa longissima* Gestro

The population study of coconut hispine beetle was carried out at Kamphaeng Saen, Nakhon Pathom province. The area used for study was about one rai at Kamphaeng Saen. Nakhon Pathom. Data collection was done twice a month.

The sampling program was set by using 5 leaves as a sample unit and 16 sambles per location. A border row of 10 meters was maked for all sides location survey 4 plots per location and 4 coconut plant per plot and 5 leaves per plant and each point space 10 meters. The number of eggs, larvae, pupae and adults of *B. longissima* were recorded from the emergence of coconut tree and followed through for 7 month.

The data thus collected was utilized for the analysis of various population parameters of coconut hispine beetle. The method of analyzing the data in these field experiments were done by using the techniques given by Napompeth (1973) and Southwood (1968). The population study was carried out from August 2006 to February 2007.The climatological data at Kamphaeng Saen, Nakhon Pathom during the period of investigation was show in Figure 2.

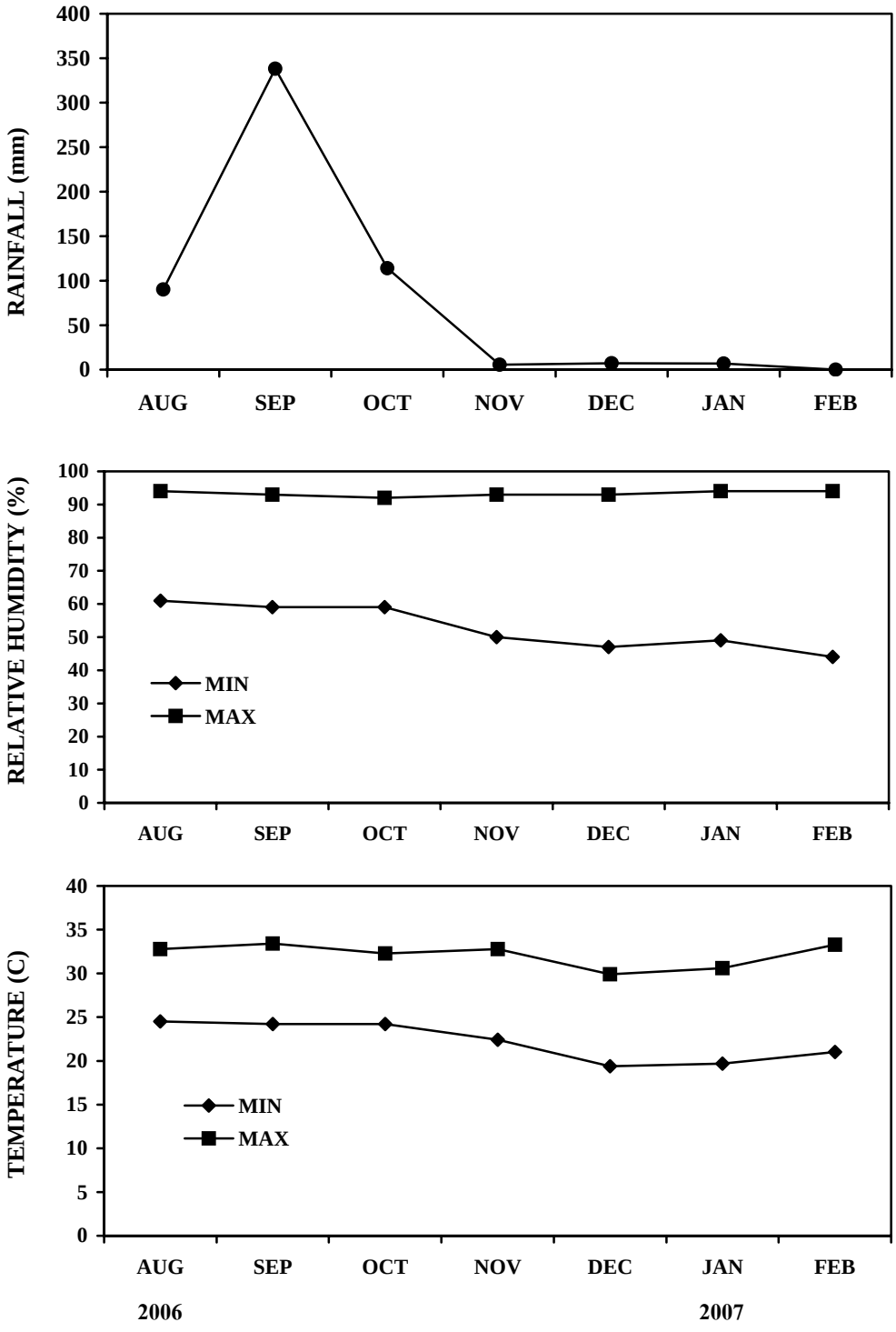

Figure 2 Monthly average of Rainfall (mm), relative humidity (%) and Temperature (^{o}C) at Kamphaeng Saen, Nakhon Pathom during August 2006 to February 2007

RESULTS

Biological studies of *Brontispa longissima* Gestro

Description of Stages of Development of *Brontispa longissima* Gestro

Egg

Adults of *B. longissima* are usually laid egg singly or in groups on between and inside unopened leaves of coconut at night. The newly laid egg were whitish in color and turned to brown before hatching (Figure 3). The individual egg was elliptical, slightly convex upper surface has the chorion with a honeycomb sculpturation. The size of individual egg was 0.47±0.012 mm in width and 1.65±0.013 mm in length.

Larva

The newly hatched larvae are whitish, later turn to yellowish. The head of the first instar larva was comparatively large compared with the body. A seta arises from about the middle of the lateral margin of each thoracic segment, with two setae on each of the abdominal lateral processes and have distally U-like hook, longer than broad. The head capsule of the first instar larva was comparatively large compared with the body. The fully developed larva has the body moderately flat, almost parallel-sided, very slightly and gradually narrowed from the prothorax towards the apex. The larva of *B. longissima* preferred to feed on tissues of developing, unopened leaves of coconut.The larva of *B. longissima* had four instars before became to pupation (Figure 4).

Figure 3 Eggs mass of *Brontispa longissima* Gestro

Figure 4 Larvae of *Brontispa longissima* Gestro

The average size of the body of the frist instar larval measured 0.53±0.013 mm in width and 1.86±0.037 mm in length. The second instar larval measured 0.61±0.182 mm in width and 4.53±0.127 mm in length. The third instar larval measured 1.79±0.156 mm in width and 7.77±0.155 mm in length. The fourth instar larval measured 2.54±0.102 mm in width and 12.36±0.343 mm in length.

The width of head capsule and U-like hook can be used for determining the successive instars of *B. longissima*. The mean width of head capsule of the first to four instars were 0.52±0.013 mm 0.75±0.013 mm 1.02±0.041 mm 1.23±0.034 mm respectively that conformed to the Dayr's Low (pooled $x^2 = 0.0129$, df = 3, P = 0.01). The mean width of U-like hook of the first to fourth instars were 0.35±0.013 mm 0.65±0.013 mm 0.80±0.022 mm 0.99±0.030 mm respectively that conformed to the Dayr's Low (pooled $x^2 = 0.0553$, df = 3, P = 0.01). Larva in each subsequent instas assumed the growth, as expressed by the increasing width of head capsule and U-like hook, a geometric progression with and average ration of 1.3309 for head capsule and 1.4435 for U-like hook (Table 1 and Table 2). The straight line relationship was obtained during the growth increment as shown in Figure 5 and 6 using the width of head capsule and U-like hook successive larval instars.

The pupa

Before pupation the body of larva become shortened during 1 to 2 days of prepupal stage.

The last larval exuvim is always retained on the prongs of the U-like hook. The newly-formed pupa were yellowish-white, later turn to yellowish. Male pupa measured 9.37±0.072 mm in length and 1.64±0.075 mm in width, female pupa measured 11.35±0.073 mm in length and 2.49±0.072 mm in width. The size of female pupa was slightly larger than of the male pupa (Figure 7).

Table 1 Width of head capsule of *Brontispa longissima* Gestro in successive instars (n=30)

Larval instar	Widtth of head capsule (mm)		Head capsule growth ratio	Calculated Width of head capsule (mm)	χ^2
	Mean±S.D.	rang			
Instar I	0.52±0.013	0.51-0.54		0.5241	0
			1.4356		
Instar II	0.75±0.013	0.74-0.77		0.6975	0.0043
			1.3484		
Instar III	1.02±0.041	0.97-1.08		0.9283	0.0080
			1.2087		
Instar IV	1.23±0.034	1.20-1.31		1.2535	0.0006
	Mean geometric progression ratio = 1.3309			Pooled χ^2	= 0.0129

Table 2 Width of U-like hook of *Brontispa longissima* Gestro in successive instars (n=30)

Larval instar	Widtth of U-like hook (mm)		U-like hook growth ratio	Calculated Width of U-like hook (mm)	χ^2
	Mean±S.D.	rang			
Instar I	0.35±0.013	0.33-0.36		0.3490	0
			1.8679		
Instar II	0.65±0.013	0.64-0.67		0.5039	0.0435
			1.2212		
Instar III	0.80±0.023	0.77-0.82		0.7274	0.0065
			1.2413		
Instar IV	0.99±0.030	0.95-1.02		1.0500	0.0053
	Mean geometric progression ratio = 1.4435			Pooled χ^2	= 0.0553

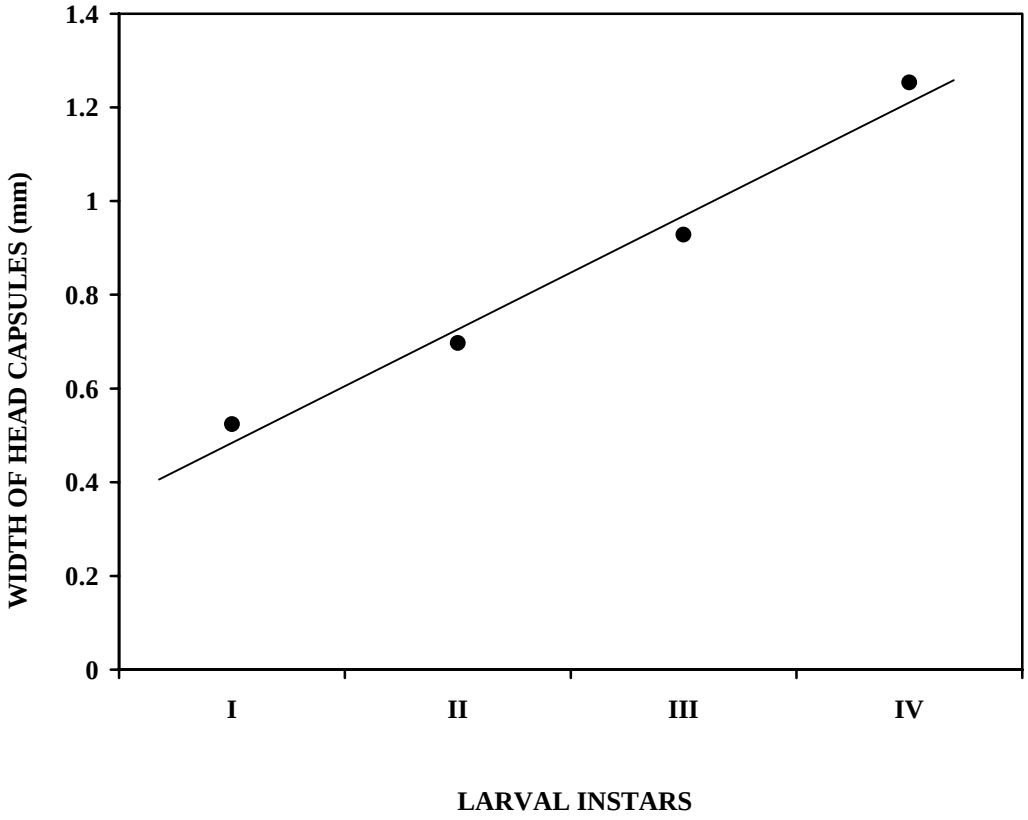

Figure 5 The relationship between the width of head capsule and the larval instars of *Brontispa longissima* Gestro

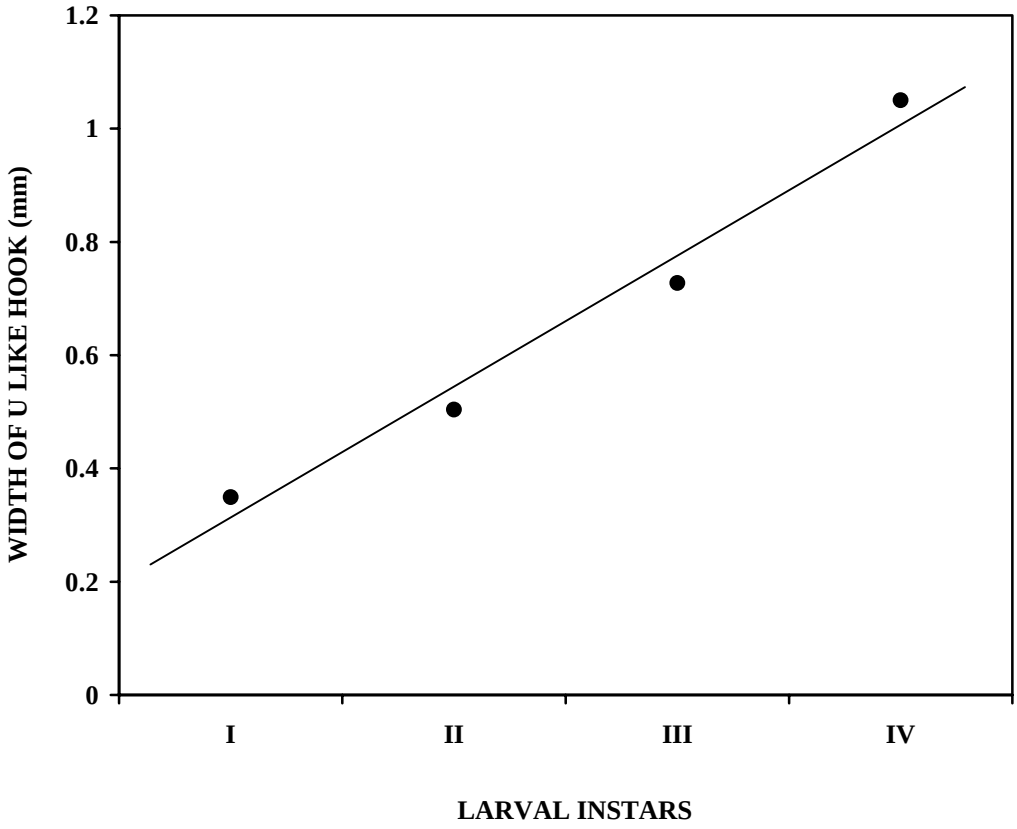

Figure 6 The relationship between the width of U-like hook and the larval instars of *Brontispa longissima* Gestro

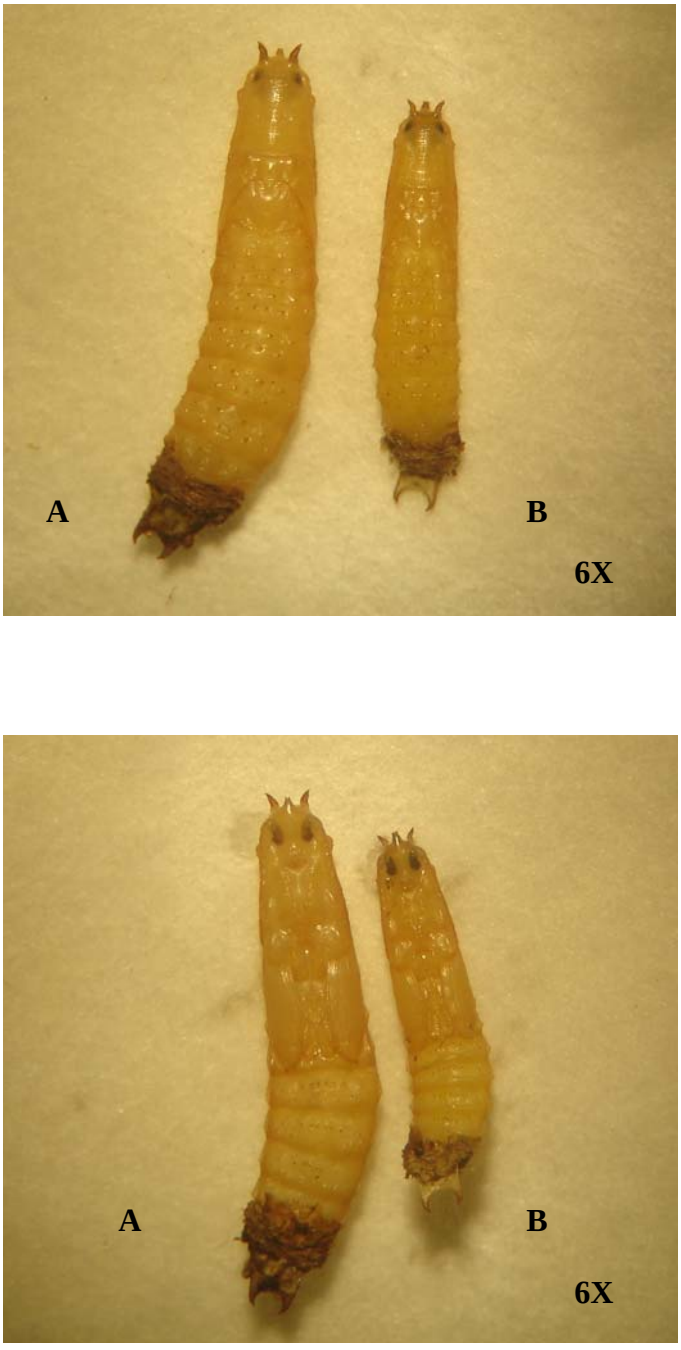

Figure 7 Pupae of *Brontispa longissima* Gestro**:** male (A) and female (B)

The adult

The adult stage of *B. longissima* was black in body color and orange head and pronotum. Adult of the beetle feed on tissues of developing, unopened leaves of coconut. They avoid light and stay inactive between or inside unopened leaf during day time and active fly and attack coconut at night. The females were generally larger than males (Figure 8). The average size of females were 2.32±0.060 mm in width and 10.95±0.067 mm in length. The average sizes of males were 1.34±0.072 mm in width and 9.37±0.072 mm in length. The body measurement of various stage was shown in Table 3.

Duration of developmental stages of *Brontispa longissima* Gestro

The oviposition period of adult *B. longissima* was 128.36±15.31 days ranging from 102 to 148 days. The number of egg laid per female averaged 120.00±14.73 eggs, ranging from 93 to 142 eggs. The incubation period was 3.25±0.52 days, ranging from 3 to 5 days.

The larva of *B. longissima* underwent third moultings. The duration of each successively instars larva were 5.46±0.50 days, ranging from 5-6 days, 5.53±0.59 days, ranging from 5-7days, 5.10±0.81 days, ranging from 4-6 days, 5.84±0.97 days, ranging from 4-7 days, respectively. The total larval period was 21.82±1.74 days, ranging from 18-25 days. The duration of prepupal stage was 2.22±0.48 days, ranging from 1-3 days. The male pupa period was 6.31±0.75 days, ranging from 5 to 7 days and the female pupa 6.74±0.54 days, ranging from 5 to 7 days. The longevity of male and female were 94.31±5.81 days, ranging from 90-105 days and 143.96±17.70 days, ranging from 120-162 days respectively. The total life cycle of *B. longissima* was 159.81±28.87 days, ranging from 118 to 197 days The data of various developmental stages of *B. longissima* were presented in Table 4.

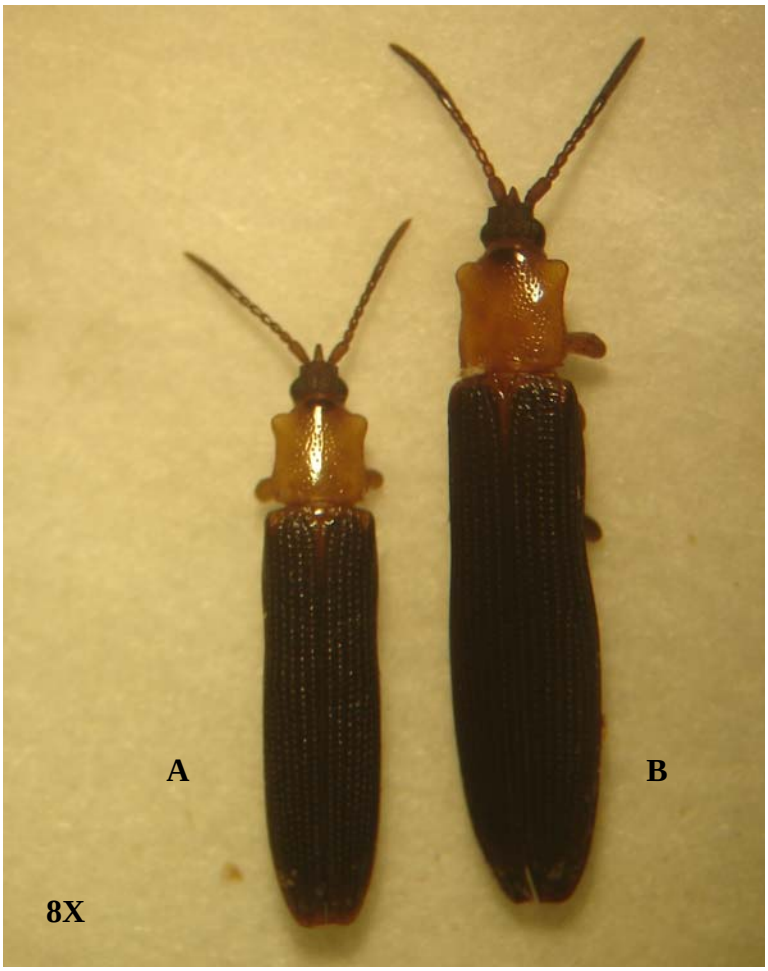

Figure 8 Adults of *Brontispa longissima* Gestro**:** female (A) and male (B)

Table 3 Body measurement of various stages of *Brontispa longissima* Gestro

Stage of developmant	Width (mm)		Length (mm)	
	Mean±S.D.	range	Mean±S.D.	range
Egg:	0.47±0.012	0.4-0.5	1.65±0.013	1.6-1.7
Larva: Instar I	0.53±0.013	0.5-0.6	1.86±0.037	1.8-1.9
Instar II	0.61±0.182	0.5-0.9	4.53±0.127	4.4-4.7
Instar III	1.79±0.156	1.6-2.0	7.77±0.155	7.5-8.0
Instar IV	2.54±0.102	2.4-2.7	12.36±0.343	11.7-12.9
Pupa: Male	1.64±0.075	1.6-1.7	9.37±0.072	9.3-9.4
Female	2.49±0.072	2.4-2.6	11.35±0.073	11.3-11.4
Adult: Male	1.34±0.072	1.3-1.4	9.37±0.072	9.3-9.4
Female	2.32±0.060	2.3-2.4	10.95±0.067	10.9-11.0

Table 4 Duration period of various developmental stages of *Brontispa longissima* Gestro under laboratory condition (28±2 ^{o}C and 75±2 %RH)

Stage of development	N	Mean±S.D. (days)	Range (days)
Egg:	100	3.25±0.52	3-5
Larva: Instar I	50	5.46±0.50	5-6
Instar II	43	5.53±0.59	5-7
Instar III	40	5.10±0.81	4-6
Instar IV	38	5.84±0.97	4-7
Total: first to last instar		21.82±1.74	18-25
Prepupa:	36	2.22±0.48	1-3
Pupa:	36	6.58±0.65	5-7
Adult: Male	13	94.31±5.81	90-105
Female	23	143.96±17.70	120-162

Life table of *Brontispa longissima* Gestro

Both biological and partial ecological life tables of *B. longissima* was investigated.

Biological life table

By proper planning and regular observation on the life history of coconut hispine beetle, it was possible to obtain data for construction of a biological life table. From the construction of biological life table of coconut hispine beetle, the biological attributes obtained from the investigation were the net reproductive rate of increase (R_o), the capacity for increase (r_c), the finite rate of increase (λ) and the cohort generation time (T_c). The net reproductive rate of increase (R_o) was the multiplication per generation. It was expressed as the ratio of total female births in two successive generations. The capacity for increase (r_c) was an approximated value of the innate capacity for increase (r_m), it was an instantaneous growth coefficient when the population was increasing in an unlimited environment. The finite rate of increase (λ) was the multiplication per female in unit of time and could be calculated from the approximated valve of the innate capacity for increase. The cohort generation time (T_c) was the mean time from birth of parents to birth of offspring biological life table dealing primarily with the female portion of the population and male were not included. The biological life table of *B. longissima* was illustrated in Table 5.

Table 5 Biological life table, age-specific fecundity rate and net reproductive rate (R_o) of *Brontispa longissima* Gestro under laboratory condition (28±2 °C and 75±2 %RH)

Pivotal age in days (X)	Proportion at birth[1/] of female being alive at age X (l_x)	Age-specific[2/] Fecundity (♀egg/♀/X) (m_x)	Egg curve[3/] ($l_x m_x$)	
0	1.0000	-		
3	1.0000	-		
6	0.8400	-		
9	0.7900	-		
12	0.7720	-		
15	0.7320	-		
18	0.7160			
21	0.6980			Immature stages
24	0.6740	-		
27	0.6600	-		
30	0.6440	-		
33	0.6260	-		
36	0.6260	-		
39	0.6200	-		
42	0.6120	-		
45	0.6040			
48	0.5960			Preoviposition period
51	0.5920			
54	0.5920	0.4560	0.2699	
57	0.5920	0.6047	0.3579	
60	0.5860	0.7952	0.4659	
63	0.5800	0.6793	0.3939	
66	0.5740	0.8710	0.4999	
69	0.5700	0.9684	0.5519	

Table 5 (Continued)

Pivotal age in days (X)	Proportion at birth[1/] of female being alive at age X (l_x)	Age-specific[2/] Fecundity (♀egg/♀/X) (m_x)	Egg curve[3/] ($l_x m_x$)
78	0.5520	1.8297	1.0099
81	0.5020	1.9482	0.9779
84	0.4980	3.5984	1.7920
87	0.4940	4.8299	2.3859
90	0.4920	4.7967	2.3599
93	0.4860	4.7695	2.3179
96	0.4800	5.4291	2.6059
99	0.4780	6.3891	3.0539
102	0.4780	5.2469	2.5080
105	0.4720	5.6398	2.6619
108	0.4720	5.0975	2.4060
111	0.4720	4.5296	2.1379
114	0.4720	3.1779	1.4999
117	0.4600	6.2391	2.8699
120	0.4600	6.0260	2.7719
123	0.4520	6.2832	2.8400
126	0.4500	5.6089	2.5240
129	0.4140	6.3864	2.6439
132	0.4000	7.3800	2.9520
135	0.3840	6.3281	2.4299
138	0.3840	6.8750	2.6400
141	0.3740	6.0374	2.2579
144	0.3580	4.4972	1.6099
147	0.3500	4.9828	1.7439
150	0.3220	5.1863	1.6699
153	0.3080	5.3701	1.6539

Table 5 (Continued)

Pivotal age in days (X)	Proportion at birth[1/] of female being alive at age X (l_x)	Age-specific[2/] Fecundity (♀egg/♀/X) (m_x)	Egg curve[3/] ($l_x m_x$)
156	0.2960	6.1486	1.8199
159	0.2900	4.4069	1.2780
162	0.2680	5.0671	1.3579
165	0.2540	5.4567	1.3860
168	0.2380	4.8403	1.1519
171	0.220	3.8360	0.8439
174	0.2020	2.7722	0.5599
177	0.1820	3.4725	0.6319
180	0.1600	2.8750	0.4600
183	0.1440	3.0000	0.4320
186	0.1200	1.7000	0.2040
189	0.0960	1.3333	0.1279
192	0.0720	2.1666	0.1559
195	0.0580	2.0344	0.1179
198	0.0580	1.1034	0.0639
201	0.0400	1.5000	0.0600
204	0.0280	1.5714	0.0439
207	0.0240	1.3333	0.0319
210	0.0180	1.4444	0.0259
213	0.0100	1.6000	0.0160
216	0.0060	0.6666	0.0039
			R_o = 72.9699

[1/] l_x = The probability of individual being alive at the beginning of the age-interval.

[2/] m_x = The number of female eggs of offsprings for each age-interval.

[3/] $l_x m_x$ = After Laughlin (1965)

The biological attributes calculated from the life table were the net reproductive rate of increase (R_o) = 72.9699. The capacity for increase (r_c) = 0.0354, the finite rate of increase (λ) = 1.0360 and the cohort generation time (T_c) = 121.0865 days. It meaned that a population of *B. longissima* could multiply = 72.9699 times in each generation or it could multiply 1.0360 times in every three days. The biological attributes of *B. longissima* was shown in Table 6.

According to Laughlin (1965), when l_xm_x was plotting against X, the egg curve was obtained as shown in Figure 9. The female began to lay eggs affer a preoviposition period of 13 days.

Partial ecological life table

The partial ecological life table of *B. longissima* was constructed by using laboratory life history data and presented in Table 7 was shown to be high mortality in the egg stage and second larval instar. The mortality could differ if compared with the investigation in the field and it was anticipated that the mortality should be much high because under the field condition they were limited by various biological factors such as parasites, predators, insect pathogens and other physical factors. The survivorship curve of *B. longissima* was constructed by using the number of individuals survived in development stages (l_x) against stage of development (x) as shown in Figure 10. The mortality was less doing subsequent of development.

Table 6 Parameters calculated for biological attributes of *Brontispa longissima* Gestro under laboratory condition (28±2 ^{o}C and 75±2 %RH)

Biological attributes	Notation	Calculated value
Net reproductive rate of increase	R_0	72.9699
Capacity for increase	r_c	0.0354
Finite rate of increase	λ	1.0360
Cohort generation time	T_C	121.0865

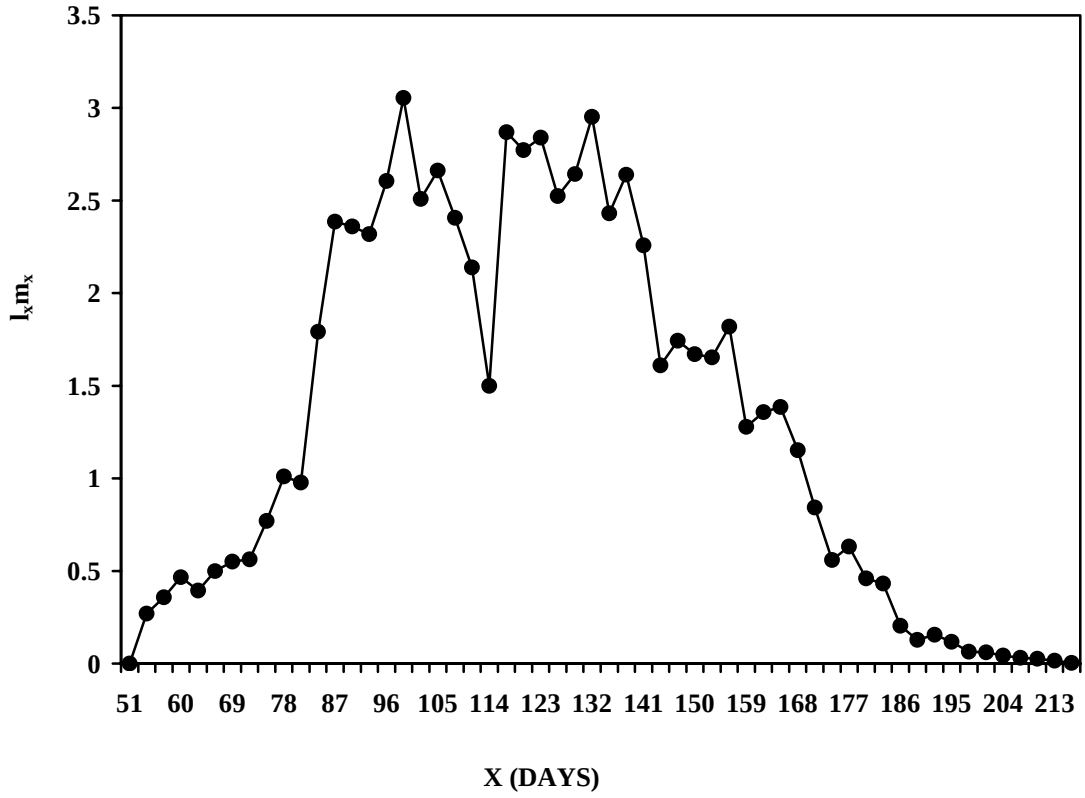

Figure 9 Eggs curve of *Brontispa longissima* Gestro under larboratory condition (28±2 ^{o}C and 75±2 %RH)

Table 7 Partial ecological life table of *Brontispa longissima* Gestro under laboratory condition (28±2 ^{o}C and 75±2 %RH)

Stage of development (x)	No. surviving in X (l_x)	No. dying in X (d_x)	Percent mortality (100 q_x)	Generation mortality (100 d_x/n)
Egg:	300	30	10.00	10.00
Larva:	270			
Instar I	270	12	4.44	4.00
Instar II	258	34	13.18	11.33
Instar III	224	14	6.25	4.67
Instar IV	210	16	7.61	5.33
Pupa:	194	5	2.58	1.67
Adult:	189	-	-	-
Male	53	-	-	-
Female	136	-	-	-

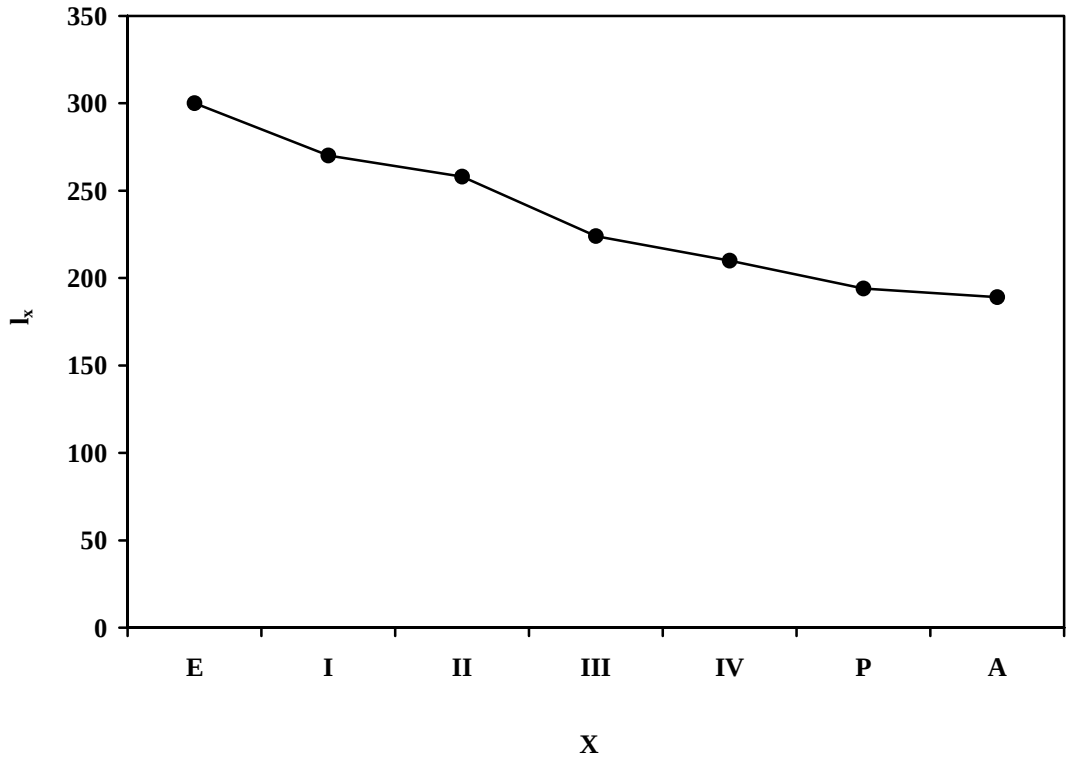

Figure 10 Survivorship curve of *Brontispa longissima* Gestro under larboratory condition (28±2 °C and 75±2 %RH)

Survey of Natural Enemies of *Brontispa longissima* Gestro

Field survey and evaluation of natural enemies of coconut hispine beetle *B. longissima* were carried out at Kamphaeng Saen, Nakhon Pathom Nakonpathum province. The survey and evaluation of parasites and predators were conducted everytwo weeks from August 2006 to February 20006.

In the field survey of natural enemies of coconut hispine beetle *B. longissima*, two species of hymenopterous parasites, one species of earwings, which feed on larva of coconut hispine beetle and some species of ants were found. Among the hymenopterous parasites, *Asecodes hispinarum* Boucek (Hymenoptera: Eulophidae) was important larval parasite; *Tetrastichus brontispa* Ferriere (Hymenoptera: Eulophidae) was important larvae and pupae. The earwig *Chelisoches morio* Fabricius (Dermeptera: Chelisochidae) was important predator of *B. longissima*. *A. hispinarum* seem to play the most importat role in the natural control of *B. longissima*.

Biological Studies of Important Parasite of *Brontispa longissima* Gestro

Biological studies of *Asecodes hispinarum* Boucek

Description of stages of development of *Asecodes hispinarum* Boucek (Hymenoptera: Eulophidae)

Egg

The adult female of *A. hispinarum* laid eggs in the larva of *B. longissima*. The average number of eggs were 85.35±34.49 eggs and ranging from 36-140 egg.

Larva

The body color was white or pale yellow (Figure 11). They fed in the host body until the pupation. The larva was slightly slender at the anterior and posterior end and the segmentation was distinct. The last stage before pupation was pale brown and the average size was 1.04±0.09 mm, ranging from 0.90-1.15 mm in length and 0.32±0.03 mm, ranging from 0.28-0.03 mm in maximum width.

Pupa

The mature larva of *A. hispinarum* was a short and rather stout shape and pupation in the host larva (Figure 12). The pupae were white and became to plae yellow and black before adult emerged (Figure 13). The averagesize of female was 1.01±0.010 mm, ranging from 1.00-1.02 mm while that of the male was 0.88±0.015 mm , ranging from 0.87-0.90mm.

Adult

The head, thorax and abdomen of the adult of *A. hispinarum* was black, with very shining dark bluish or greenish, and the leg were brownish yellow. and the wings hyaline, with very faint broad. The female adult was stout in shape especially the abdomen, while the male was slender (Figure 14, 15). The size of male was smaller than female. The length from the head to abdomen of male and female adults were 0.68±0.03 mm, ranging from 0.65-0.70 and 0.73 ±0.05 mm, ranging from 0.68-0.72 mm respectively. The wings expansion were 0.52±0.01 mm, ranging from 0.51-0.52 and 0.55±0.01 mm, ranging from 0.54-0.56 mm in male and female respectively.

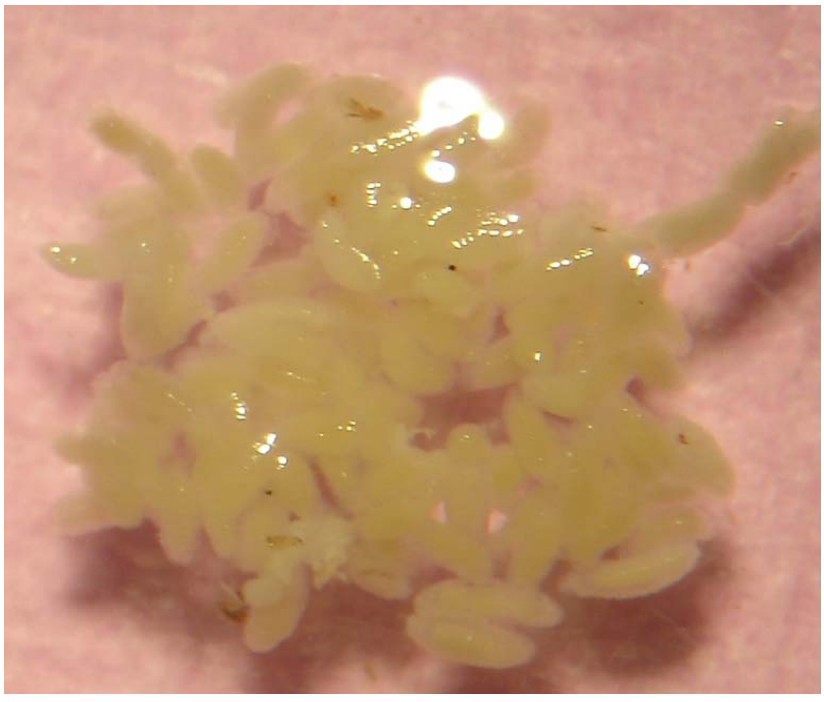

Figure 11 Larvae of *Asecodes hispinarum* Boucek

Figure 12 Pupae of *Asecodes hispinarum* in larva of *Brontispa longissima*

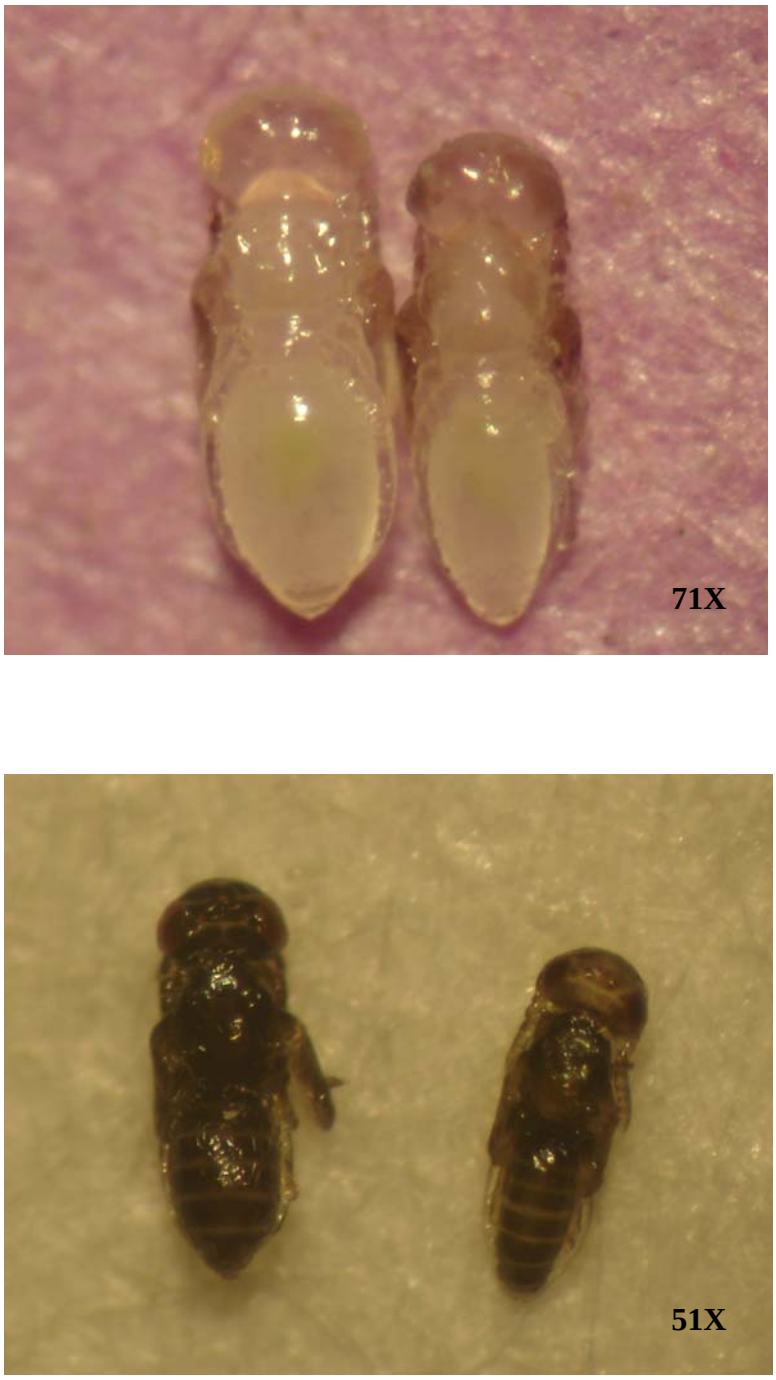

Figure 13 The pupae of *Asecodes hispinarum* were white became pale-yellow and became black before adult

Figure 14 Female of *Asecodes hispinarum*

Figure 15 Male of *Asecodes hispinarum*

Duration of developmental periods

The longevity of incubation period was 1-2 days. The longevity of egg stage to larval stage was 9.95±1.05days, raning from 9-12days. The prepupal stage was 1.80±0.41 days, ranging from 1-2 days and pupal stage was 5.40±0.50 days, ranging from 5-6 days. The longevity of male was 2.2±0.42 days, ranging from 2-3 days. The longevity of female was 2.7±0.82 days, ranging from 2-4 days. The total life cycle from egg to adult emergence was 19.6±1.64 days, ranging from 17-21 days. The number of adult parasite emerged from one host larva were 63.5±21.55, ranging from 28-90, as shown in Table 8. The sex ratio of male to female was 1:2 under laboratory condition.

Behevior of adult

Immediately after emergence the adult of *A. hispinarum* started to feed and mate, and a few hours later that it began to parasitize the host larva. The female adult walked around the host larva before attacking by grasping a host larva by their legs and folded her abdomen downward, and then inserted the ovipositor into the host pupa (Figure 16). The parasitization was completed in 30-40 minutes. The female adult of *A. hispinarum* laid egg into the host larva. The larvae fed inside the host pupa until pupation. The adult came out from the host larva by making an emergence hole (Figure 17). The investigation that female adult of *A. hispinarum* could be parasitized larvae of coconut hispine beetle in each stage of development especially in the third to fourth instars of *B. longissima*.

Table 8 Duration period of various developmental stages of *Asecodes hispinarum* Boucek under laboratory condition (28±2 °C and 75±2 %RH)

Stage of development	N	Mean± S.D. (days)	Range (days)
Egg: / Larval:	20	9.95±1.05	9-12
Prepupa:	20	1.80±0.41	1-2
Pupa:	30	5.40±0.50	5-6
Adult: Male	13	2.20±0.42	2-3
Female	23	2.70±0.82	2-4
Total: Life cycle		19.60±1.64	17-21

Figure 16 The female of *Asecodes hispinarum* inserted the ovipositor in to the larva for parasitization

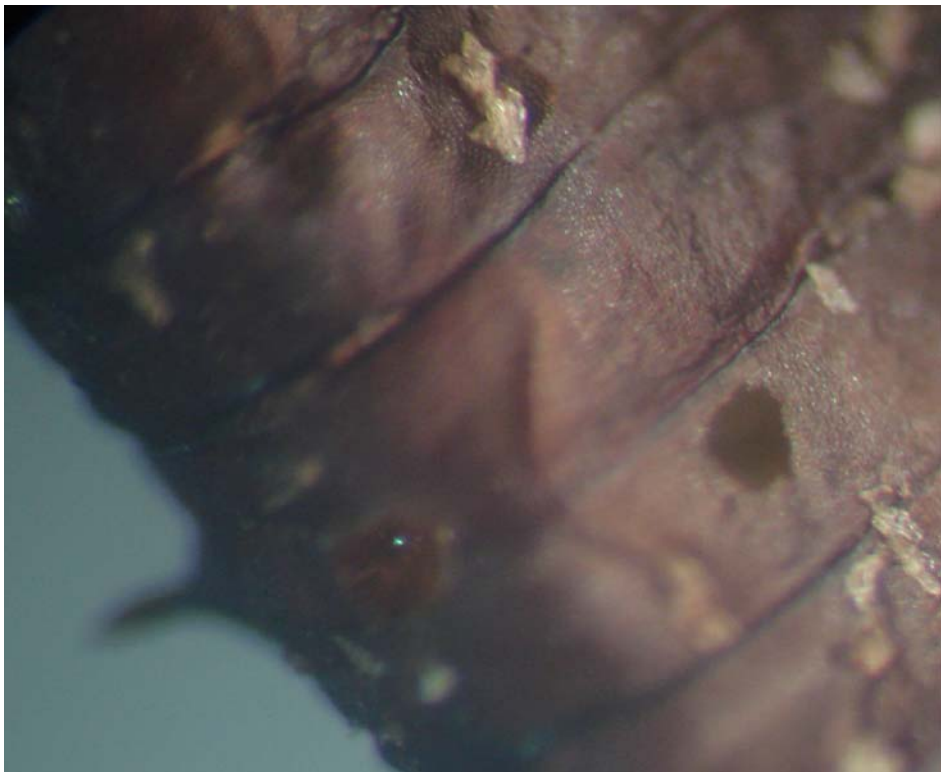

Figure 17 The adult came out from the host pupa by making an emergence hole

Biological Studies of Important Predator of *Brontispa longissima* Gestro

Biological studies of *Chelisoches morio* Fabricius (Dermeptera: Chelisochidae)

Description of stages of development of *Chelisoches morio* Fabricius (Dermeptera: Chelisochidae)

Egg

Adult of *C. morio* is usually laid egg in group inside the pockets of the leaf axils. The newly laid egg were creamy whitish in color and became to clear white before hatching (Figure 18). The average size of egg was 1.05±0.02 mm in length and 0.77±0.02 mm in maximum width. The average number of eggs per batch is 38.40±12.02 eggs and ranging from 20 to55 egg.

Nymph

The newly hatched nymph are whitish, later turn to dark brown .The head and abdomen were dark brown. The pronotun is considerably lighter in color, usually grayish or yellowish brown. The legs were whitish, with a dark ring around the femur. The cerci are moderately long, and not strongly curved. The second and third instar nymph very similar to first instar nymph differing primarily in size. The fourth instar nymph head, pronotun and abdomen are black in color. The legs were dark brown, but tarsus were plae-yellow. The cerci were moderately long, and strongly curved.
The wing were develop on side of mesothorax and metathorax in the fourth instar nymph (Figure 19). The number of antenna segments was most useful, thought this was mostly effective among the early instars. The number of antenna segments in frist to fourth instar nymph was 10, 12, 14, 18 respectively.

Figure 18 Eggs mass of *Chelisoches morio* Fabricius

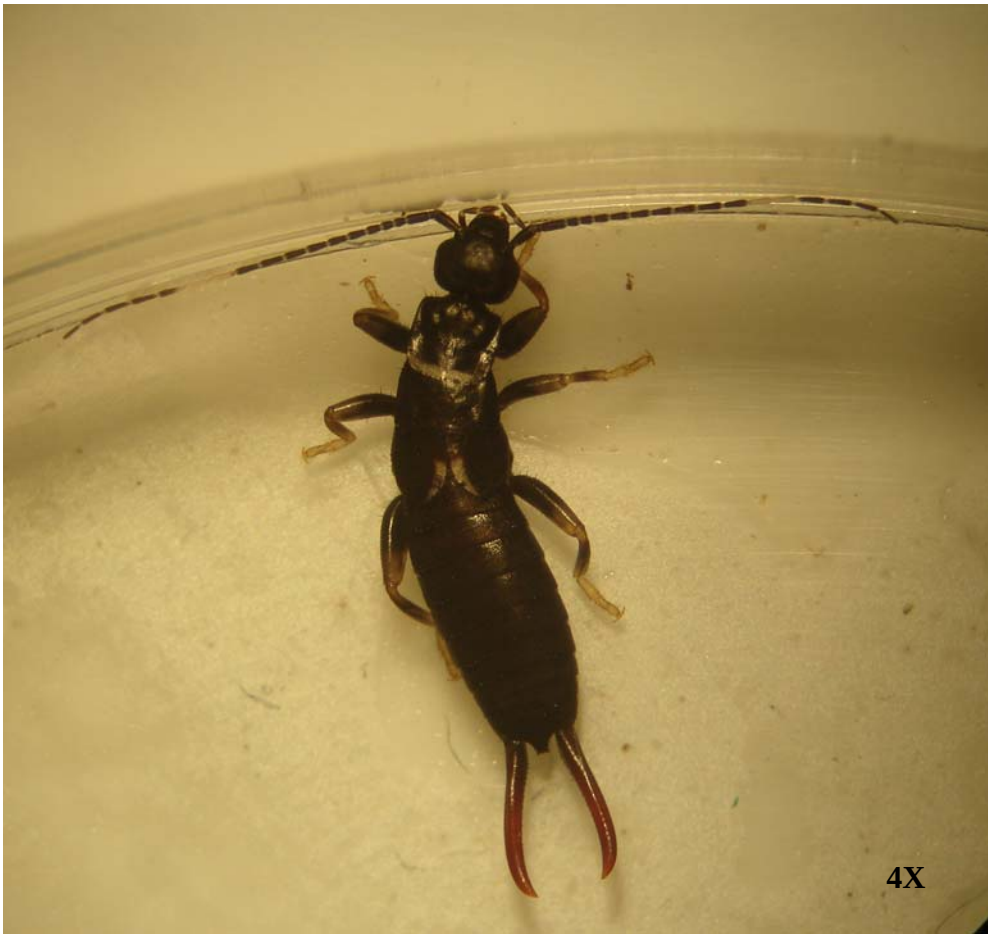

Figure 19 The wing were develop on side of mesothorax and metathorax in the fourth instar nymph

The average size of the body of the frist instar nymph measured 8.65±0.14 mm in length. The second instar nymph measured 12.20±0.07 mm in length. The third instar nymph measured 17.77±0.08 mm in length. The fourth instar nymph measured 23.31±0.09 mm in length.

Adult

The color of head, thorax, wingless and abdomen and legs of the adult of *C. morio* was black, and the leg are black, but tarsus were plae-brown (Figure 20). Sex differentiation could be detected in the adult stage using morphological differentiation at the cerci. The cerci of male shot and stout, while the female was longer and slender. The length from the head to cerci of male and female adults were 25.10±0.57mm and 30.80±1.14.mm respectively.

Figure 20 Adults of *Chelisoches morio* Fabricius**:** male (A) and female (B)

Duration of developmental periods

The averaged number of eggs laid per female were 140.30±11.56 ranging from 128 to 156 eggs. The incubation period was 7.85±0.37 days, ranging from 7 to 8 days.

The nymph of *C. morio* underwent third moultings. The duration of each successively nymph instars were 11.25±0.55 days, ranging from 11-13 days, 10.23±0.44 days, ranging from 10-11days, 12.54±0.78 days, ranging from 11-13 days, 19.62±0.65 days, ranging from 18-20 days, respectively. The total nymph period was 61.54±4.44 days, ranging from 59-64 days. The longevity of male and female were 76.75±1.28 days, ranging from 75-78 days and 51.40±0.89 days, ranging from 50-52 days respectively. The total life cycle of *C. morio* was 128.59±13.43 days, ranging from 109 to 141 days The data of various developmental stages of *C. morio* were presented in Table 9.

Behevior of adult

The female adult of *C. morio* drives the male from pockets of the leaf axils before lay eggs were produced. The female will protects the eggs clutch from fungi and intrudes, cleaning and relocating them if necessary (Figure 21). If female were disturbed, however, female may eat the eggs. The female care decreases soon after nymphs hatch, diasappearing after about 3 days.

Table 9 Duration period of various developmental stages of *Chelisoches morio* Fabricius under laboratory condition (28±2 ^{o}C and 75±2 %RH)

Stage of development	N	Mean± S.D. (days)	Range (days)
Egg:	20	7.85±0.37	7-8
Nymph: Instar I	20	11.25±0.55	11-13
Instar II	13	10.23±0.44	10-11
Instar III	13	12.54±0.78	11-13
Instar IV	13	19.62±0.65	18-20
Total: first to last instar		61.54±4.44	59-64
Adult: Male	5	51.40±0.89	50-52
Female	8	76.75±1.28	75-78
Total: Life cycle		129.59±13.43	109-141

Figure 21 Female and eggs of *Chelisoches morio* Fabricius

Population study of *Brontispa longissima* Gestro

The population study of coconut hispine beetle *B. longissima* was carried out at Khamphang Saeng, Nakhon Pathom province from August 2006. to February 2007. The graphical population modle of larvae and adults of *B. longissima* was shown in Figure 22.

The graphical population models of *B. longissima* revealed the changes of the population density of egg,larvae, pupae and adult of *B. longissima*. The population of *B. longissima* at Khamphang Saeng was high during September to October in 2006 and its was low during January to February, 2007.

The changes of population structure in terms of age structure were determined at Khamphang Saeng during 2006-2007.The age distribution of *B. longissima* was shown in Figure 23. The egg population was high in September and October 2006 and lowest in January and February 2007. In September to December 2006 the population consisted of larvae. pupae population was high in September in 2006 and January to February in 2007. The adult population was high January to February in 2007.

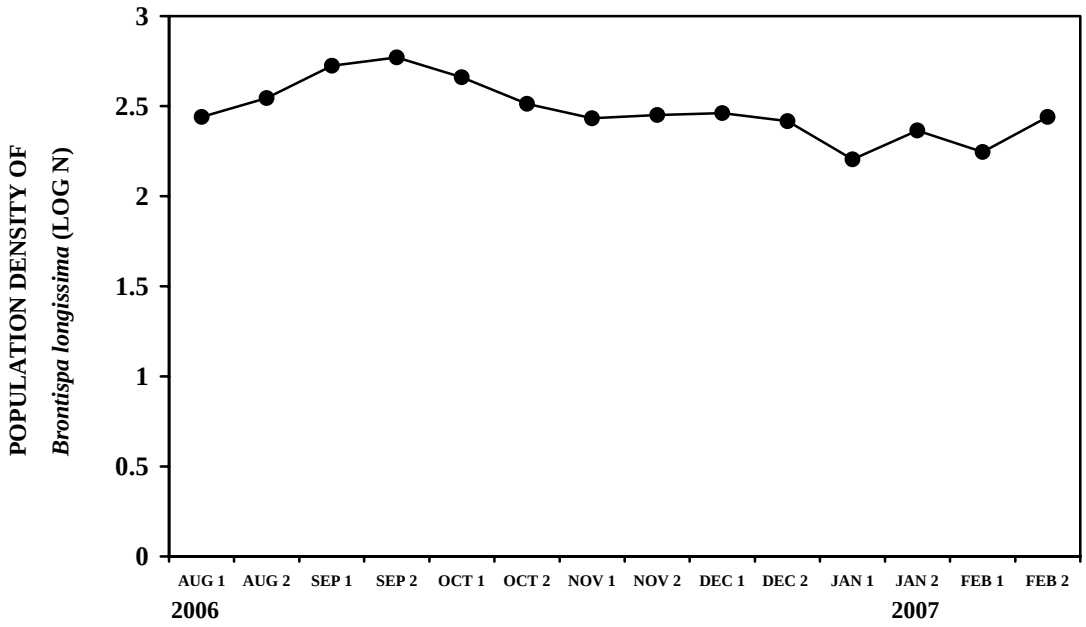

Figure 22 Population density of *Brontispa longissima* Gestro at Khamphang Saeng, Nakhon Pathom province during August 2006. to February 2007

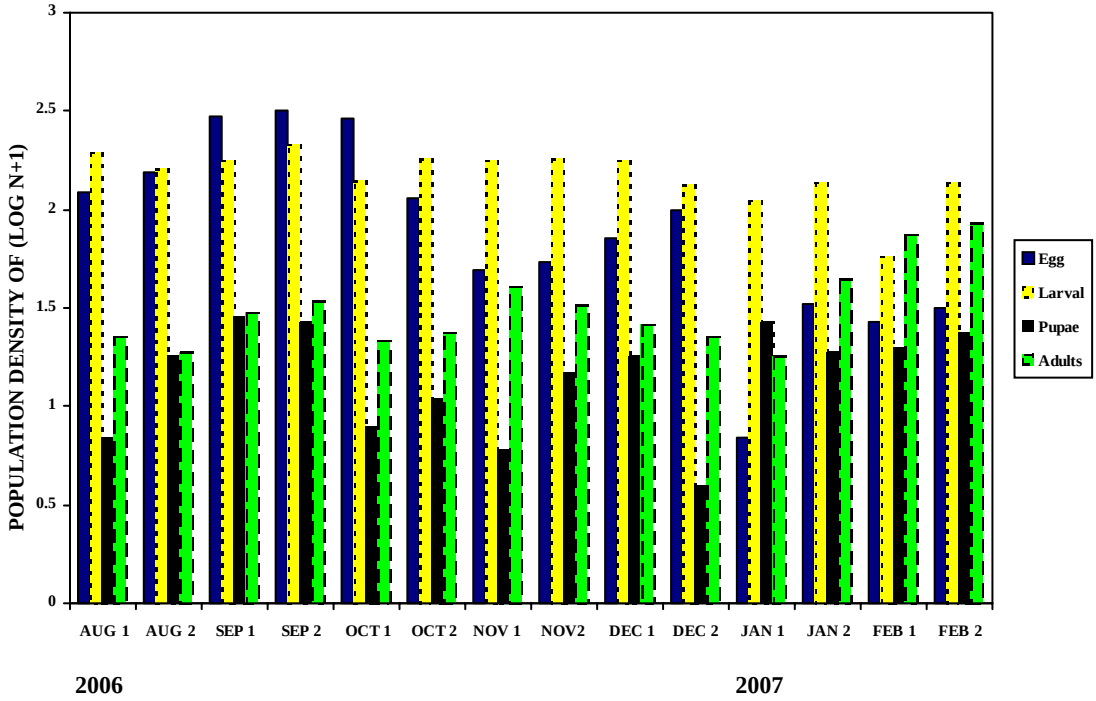

Figure 23 Age distribution of *Brontispa longissima* Gestro at Khamphang Saeng, Nakhon Pathom province during August 2006. to February 2007

DISCUSSION

The coconut hispine beetle, *B. longissima* was the most important insect pest of coconut. *B. longissima* play the most serious pest of coconut and heavy damage occurred in many area of Asia and the Pacific (Wilco, 2004).

The coconut hispine beetle, *B. longissima* was became serious pest of coconut in few years ago this species was outbreak in many areas of coconut plantation and outbreak in Khamphang Saeng, Nakhon Pathom provinces, during 2004-2006. The biological study of *B. longissima* revealed that four of larval instars. Both larvae and adults of coconut hispine beetle inhabit the developing, unopened leaves of the coconut they feed on leaf tissues. The larval in each stage differed considerably in head capsule. They could be used to some accuracy for identification of larval instars. However, the detection of different larval instar by using the width of U-like hook were much more precise although the method was relatively cumbersome.

The study on biological attributed of *B. longissima* revealed that the total larval periods of *B. longissima* with four larval instars were 21.82±1.74 days under laboratory condition. This was similar to Viet (2004) who reported that a the total larval periods of larval were 29.90±2.00days. The study on biological life table was completion. The method and rearing technique used in this study must be refined beacaues the larvae very frail. The partial ecological life table could given an information on the survival in each stage of development under favorable condition. Under the field condition the mortality should be higher, because of the existence of various regulatory factor in the environment.

The study on biological attributed of *A. hispinarum* revealed that the longevity was 19.6±1.64 day under laboratory condition. This was similar to Nguyen (2004) who reported that a the total life cycle of *A. hispinarum* was about 18-20 day under laboratory condition.

In the field survey of the natural enemies of coconut hispine beetle, *B. longissima* found the earwig, *C. morio* was native natural enemies an important role as biological agent of the coconut hispine beetle.

Sindhusake and Winothai (2004), reported that parasitoid of the larvae and pupae, *Tetrastichus brontispa* Ferriere (Hymenoptera: Eulophidae) of *B. longissima* but in this study was found these parasites in the field but could not reared in laboratory.

CONCLUSION

The investigation on biology of *B. longissima*, revealed that the number of egg laid per female averaged 120.00±14.73 eggs, ranging from 93 to 142 eggs. The incubation period was 3.25±0.52 days, ranging from 3 to 5 days. The total larval periods of *B. longissima* with four larval instars were 21.82±1.74 days, randing from 18 to 25 days. The full-grown larvae of *B. longissima* pupated in the between or inside the leaf of coconut. The pupal staged took about 5 to 7 days. The longevity of male and female was 90 to 105 and 120 to 162 dayd respectively. The total life cycle from egg to adult of *B. longissima* periods were 159.81±28.87 days, ranging from 118 to 197 days.

The biological attributes calculated from the table were the net reproductive rate of increase (R_o) = 72.9699. The capacity for increase (r_c) = 0.0354, the finite rate of increase (λ) = 1.0360 and the cohort generation time (T_c) = 121.0865 days. It meaned that a population of *B. longissima* could multiply = 72.9699 times in each generation or it could multiply 1.0360 times in every three days.

In the field survey of the natural enemies of coconut hispine beetle, *B. longissima*, two species of hymenopterous parasites, one species of earwings, which feed on larva of coconut hispine beetle and some species of ants were found. Among the hymenopterous parasites, *Asecodes hispinarum* Boucek (Hymenoptera: Eulophidae) was important larval parasite; *Tetrastichus brontispa* Ferriere (Hymenoptera: Eulophidae) was important larvae and pupae. The earwig *Chelisoches morio* Fabricius (Dermeptera: Chelisochidae) was important predator of *B. longissima*. *A. hispinarum* seem to play the most importat role in the natural control of *B. longissima*.

The changes of population structure in terms of age structure were determined at Khamphang Saeng, Nakhon Pathom provinces in August 2006. to February 20006. The age distribution of *B. longissima* was investigated. It was obvious that the aduts of *B. longissima* moved into the coconut field during the elongation stage of coconut.

The egg population was high in September and October 2006 and lowest in January and Feburary 2007. In September to December the population consisted of larvae. pupae population was high in Septemberin 2006 and January to February in 2007. The adult population was high January to February in 2007.

LITERATURE CITED

Allee, W.C., O. Park, A.E. Emerson, T. Park and K.P. Schmidt. 1949. **Principles of Animal Ecology**. Saunders, Philadelphia and London.

ASEAN IPM Knowledge Network Management. 2007. **The coconut leaf bettle, *Brontispa longissima* (Gestro).** Available Source://www. Aseanipm. da. gov. gh/brontispa. htm, June 17, 2007.

French, B.R. 1986. **Food Plants of Papua New Guinea: A Compendium.** Published privately, Sheffield, Tasmania.

Harcourt, D.G. 1969. The development and use of life table in the study of natural insect populations. **Ann. Rev. Ent.** 14: 175-196.

Hosang, M.L.A., J.C. Alouw and H. Novarianto. 2004. Biological control of *Brontispa longissima* Gestro in Indonesia. pp. 39-52. *In* **Report of the expert consultation on coconut beetle outbreak in APPPC member countries.** Bangkok, Thailand. October 26-27, 2004.

Jones, D.L. 1995. **Plams throughout the world**. Reed book, Australia.

Langston, R.L. and J.A. Powell. 1975. **The earwigs of California (Order Dermaptera)**. University of California Press. USA.

Laughlin, R. 1965. Capacity for increase: a useful population statistics. **Journal of Animal Ecology.** 34: 77-91.

Napompeth, B. 1973. **Ecology and population dynamics of the corn planthopper, *Peretrinus maidis* (Ashmead) (Homoptera: Delphacidae), in Hawwaii**. Ph. D. Dissertation, Univ. Hawaii.Varley, G.C. and G.R. Gradwell. 1970. Recent advance in insect population dynamics. **Ann. Rev. Ent.** 15: 1-24.

Nguyen, T.T.O., H.T. Nguyen and C.L. Le. 2004. Manual for mass-rearing *Asecodes hispinarum*, a parasitoid of hispine beetle, *Brontispa longissima*. pp 105-113. *In* **Report of the expert consultation on coconut beetle outbreak in APPPC member countries.** Bangkok, Thailand. October 26-27, 2004.

Othman, M.H. 2004. Current status of coconut Chrysomelid beetles in Malaysia. pp. 57-66. *In* **Report of the expert consultation on coconut beetle outbreak in APPPC member countries.** Bangkok, Thailand. October 26-27, 2004.

Philippine Council for Agriculture, Forestry and Natural Resources Research and Development. 2007. **Brontispa: a damaging coconut pest.** Available Source://www. pcarrd. dost. gov. ph/news/in%20the%20news /mar/int0306-044. htm, June 17, 2007.

Rethinam , P. and S.P. singh. 2005. Current status of the coconut beetle outbreaks in the Asia-Pacific region, pp. 1-23. *In* S. Appanah, H.C. Sim and K.V. Sankaran, eds. **Asia-Pacific Forestry Invasive Species Network Workshop.** Ho Chi Minh City, Viet Nam. February 22-25, 2005.

Sankara, K.V. 2006. **Coconut leaf beetle *Brontispa longissima*.** Newsletter of the Asia-Pacific Forest Invasive Species Network 1 (6): 3-4.

Shafia, A. 2004. Integrated control of coconut hispid beetle *Brontispa longissima* (Gestro) in Maldives. pp. 67-74. *In* **Report of the expert consultation on coconut beetle outbreak in APPPC member countries.** Bangkok, Thailand. October 26-27, 2004.

Sindhusake, C. and A. Winothai. 2004. Outbreaks and management of coconut hispine beetle (*Brontispa longissima*) Thailand. pp. 82-86. *In* **Report of the expert consultation on coconut beetle outbreak in APPPC member countries.** Bangkok, Thailand. October 26-27, 2004.

Southwood, T.R.E. 1968. **Ecological Methods with Particular Reference to the Study of Insect Poputations.** Methuen, London.

Viet, T.T. 2004. Classical biological control of coconut hispine beetle with the parasitoid *Asecodes hispinarum* Boucek (Hymenoptera: Eulophidae) in Viet Nam. pp. 90-99. *In* **Report of the expert consultation on coconut beetle outbreak in APPPC member countries.** Bangkok, Thailand. October 26-27, 2004.

_____. 2004. **Classical biological control of the coconut hispine beetle (*Brontispa longissima* Gestro) in Viet Nam.**
Available Source:// www.agnet.org/activities/sw/2006/954198798/paper-505395537.pdf, June 17, 2007.

Wijesinghe, M.A.K. 2004. Current status of key coconut hispine beetles in Sri Lanka. pp. 77-81. *In* **Report of the expert consultation on coconut beetle outbreak in APPPC member countries.** Bangkok, Thailand. October 26-27, 2004.

Wilo, L. and C. keith. 2004. Impact and control of the coconut hispine beetle, *Brontispa longissima* Gestro (Coleoptera: Chrysomelidae). pp. 19-25. *In* **Report of the expert consultation on coconut beetle outbreak in APPPC member countries.** Bangkok, Thailand. October 26-27, 2004.

YongYue, L., Z. Ling and L. GuangWen. 2004. Feeding behavior of *Brontispa longissima*. **Journal of South Chaina Agricultural University.** 25 (4): 50-52.

Yueguan, F. and X. Yankun. 2004. Occurrence and control of coconut leaf beetle in China. pp 35-38. *In* **Report of the expert consultation on coconut beetle outbreak in APPPC member countries.** Bangkok, Thailand. October 26-27, 2004.