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Comparative Biology of Coconut Leaf Beetle (Clb) *Brontispa longissimi* (Gestro) (Coleoptera: Chrysomelidae) on Selected Coconut Varieties

Gladys R. Cabelin[1], Maria Juliet C. Ceniza[2]

[1]Agriculture Department College of Agriculture and Natural Resources
Bohol Island State University Zamora, Bilar, Bohol 6317,
[2]Department of Plant Protection College of Agriculture and Food Science
Visayas State University ViSCA, Baybay City, Leyte 6521

Email for correspondence: rosalesgladysb@gmail.com

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Abstract

Comparative biology and development study of *B. longissima* Gestro was conducted using different coconut varieties namely: Baybay tall (BAYT) green, Baybay tall (BAYT) brown, Malayan Red dwarf (MRD), Malayan Yellow dwarf (MYD), Albuera dwarf (ALD), and Tacunan dwarf (TACD) varieties was investigated in the laboratory. The duration of the developmental period of *B. longissimi* was influenced by the different coconut varieties used as host plant. Duration from egg laying to hatching of eggs of *B. longissima* on tall varieties ranged from 3 to 5 days, while on dwarf varieties it took 4 to 5 days. In all varieties, *Brontispa* beetles underwent 5–6 instars. In addition, it was observed that the fifth and sixth instars took a longer time period compared to other instars. The total mean developmental period of *Brontispa* on BAYT (green and brown) was shorter in days compared to all dwarf varieties except to ALD. The results generally showed that BAYT (green and brown) seemed to be a preferred variety. There was considerably higher larvae mortality in dwarf variety like MRD (40%) than those reared in the BAYT green and brown (22.21%, 19.12%), respectively. Beetles reared on BAYT (brown) also had the highest fecundity which was statistically different from the rest of the varieties. In addition, results showed that adults reared in both BAYT (green and brown) had the highest longevity observed compared to other varieties

Key Words: *Brotispa longissima* ,comparative biology,tall varieties, dwarf varieties

Introduction

The Coconut Leaf Beetle (CLB), scientifically known as *Brontispa longissima* Gestro, is an introduced species which is becoming an alarming pest of coconuts in the Philippines. The infestation caused by this pest is considered to be most damaging to all stages of coconuts including a range of ornamental palm species. Both larvae and adults of *B. longissima* infest the developing, unopened coconut fronds as they emerge from the heart. When the leaf opens, it quickly dries out and the leaf

tissues die. Damage ranges from severe, heavy, moderate to light moderate. Severe infestation by the beetle can cause complete defoliation of the palm and if prolonged, will result in death of the tree. This would lead to significant production losses (Guo, 2005). Up to 17 species of palms including oil palm, betel palm, nipa palm, and several ornamentals may be attacked (Wilco & Chapman, 2006).

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

The newly hatched larvae are whitish in color. Later, they will turn 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 beetles undergo four instars larval stage with duration of 30–40 days. Larvae are less active (Nguyen et al., 2004). The pupal 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 eggs laid per female averaged 153±20 to 43±108 eggs (Viet, 2004).

Eastern Visayas houses good coconut populations, including the Baybay Tall (BAYT), an outstanding tall coconut cultivar first discovered in Leyte which was observed to have much higher yield than the other known tall coconut varieties in the Philippines. It is regarded to be comparable to some outstanding Philippine Coconut Authority (PCA) D x T hybrids (Rivera et al., 2005) and is being recommended by PCA for the national coconut replanting program together with the outstanding PCA hybrids.

Over the years, the National Coconut Research Center has accumulated a number of coconut varieties grown in its germplasm and for several decades now has carried out characterization studies of the different tall and dwarf varieties collected. However, there were limited information on the life history studies of *Brontispa* beetle on different varieties of coconuts. Thus, the present study investigated the effect on the biology and development of the CLB reared on the different tall and dwarf varieties in the laboratory, so that they could be correlated to the degree of damage they cause on each variety.

Materials and Methods

Collection and mass rearing of *Brontispa longissima* on selected coconut varieties for stock culture

Brontispa beetles that were collected from the selected coconut varieties were used to start the stock culture. These were maintained in the laboratory and were provided with the necessary culture care. The beetles were mass reared using different coconut varieties. Adult beetles were allowed to lay eggs on each coconut varieties. The eggs were collected to start the life history studies in different coconut varieties (Figure 1).

Figure 1
Mass Rearing of *B. longissima* for Stock Culture

Comparative Biology Study of *Brontispa longissima* Gestro on Selected Coconut Varieties

Adults of *B. longissima* were collected from infested coconut fronds of selected coconut varieties in the vicinity areas of Visayas State University. They were placed in a container with young coconut leaves which serve as their substrate, and were brought to the laboratory. The different recommended coconut varieties with the presence of beetles were used as substrate in the biology study. The young leaves were checked daily for the presence of eggs. The eggs that were laid at the same time were collected and were placed in another container for incubation at room temperature and were allowed to hatch. The date the eggs were laid were recorded. Daily observations were made to note any change of the egg until hatching. The incubation period and percentage hatchability were recorded.

The newly emerged larvae were placed individually in a disposable plastic container (3.5cm h, 10cm d) with fresh young leaves in it (Figure 1). The cover of the container was cut to make a hole and were covered and pasted with nylon tulle. Moistened cotton wads were placed on one end of each leaflet to keep it fresh for few days. The coconut leaflets were replaced every 2 days to ensure a fresh supply of food for the larvae.

The larvae were reared and allowed to develop until adult stage. A camel's hair brush was used to transfer and handle the larvae to fresh substrates. Daily inspection and observation were done to determine the changes in appearance of the larvae, number of instars, duration of each stadium, pupal period, and total developmental period. Cleanliness of the culture container was maintained throughout the study in order to ensure the growth and keep the larvae from microbial infection. A minimum of 50 individual cultures per host plant were maintained for the biology study. Larval instars were differentiated by the presence of exuviae. Body measurements were taken for all the larval instars, pupae, and adults. Mortality of the different stages were also noted and recorded. Moreover, the longevity and fecundity of adults were observed.

Adults that emerged from the cultures were sexed and paired and then allowed to mate. They were placed in plastic containers (4.1 cm diameter, 6.5 cm height) provided with fresh leaves of each host plant as oviposition substrate. Reproductive behavior, fecundity data, and longevity of adults were noted and recorded. Sex ratio were computed. The paired adults were allowed to lay eggs. The eggs which were collected from these first-generation adults were again allowed to hatch to be able to start the second generation life history studies.

Description of the Developmental Stages

The different developmental stages of *B. longissimi* namely: egg, larva, pupa, and adult were examined and described with the aid of a stereo microscope. These stages were photo documented using a digital camera. Morphological characteristics of the different stages were taken.

Results and Discussion

Biology of *Brontispa longissima* Gestro on Different Coconut Varieties

The total developmental period of *B. longissima* on the different selected coconut varieties is presented in Table 1. The result shows that there are variations in the duration of the different developmental stages of the beetle when reared on the different coconut varieties. However, as can be seen from the results, the duration of the incubation period and the pupal period were not statistically different among the different coconut varieties used as host plants. However, the duration of the specific larval instars showed some significant differences among the varieties. It was observed that the varieties which were found to be not preferred by the beetles, such as MYD and MRD gave the longest developmental period (55.64, 53.53 days) respectively under laboratory conditions but comparable to TACD with 52.22 days. In contrast, BAYT Green and Brown gave the shortest developmental period (48.37 and 47.93 days, respectively) among the other varieties although statistically comparable to ALD (51.58 days). The latter varieties appeared to be the most preferred varieties which are evident in the shorter duration of the total developmental period of the beetles. The different characteristics of the life stages of the beetles exhibited in the different varieties are summarized below.

Incubation Period

The duration from egg laying to hatching in tall varieties ranged from 3 to 5 days, while in dwarf varieties it ranged from 4 to 5 days. Lumentot et al. (2013) in Malang Indonesia found that between tall and dwarf varieties, the egg of *Brontispa* developed in a shorter period on Mapanget Tall Coconut (MTC) than those on Brown Dwarf Coconut (BDC) varieties.

Table 1

*Comparative Mean Duration *(days) of the Different Developmental Stages of Brontispa longissima reared on Selected Coconut Varieties under Laboratory Conditions*

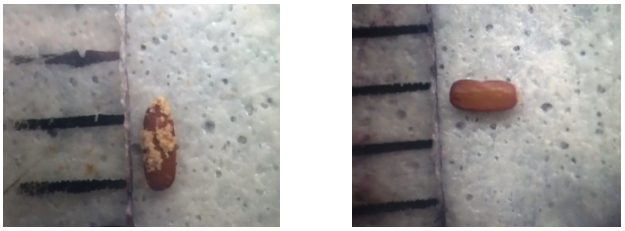
Coconut Variety	Incubation Period	1st instar	2nd instar	3rd instar	4th instar	5th instar	6th instar	Total larval period	Pupal period	Total Dev't Period
BAYT Green	4.30 ^{a}	4.48 ^{a}	5.36 ^{ab}	4.75 ^{c}	6.00 ^{b}	9.18 ^{a}	8.93 ^{b}	38.70 ^{c}	5.37 ^{a}	48.37^{c}
BAYT Brown	3.88 ^{a}	4.49 ^{a}	4.77 ^{b}	4.97 ^{c}	5.99 ^{b}	10.39 ^{a}	8.42 ^{b}	39.03 ^{c}	5.02 ^{a}	47.93 ^{c}
MYD	4.21 ^{a}	4.64 ^{a}	5.95 ^{a}	5.91 ^{ab}	6.59^{ab}	11.03 ^{a}	10.48 ^{ab}	44.60^{ab}	4.72 ^{a}	53.53 ^{a}
MRD	4.07 ^{a}	4.40 ^{a}	5.41^{ab}	6.41 ^{a}	6.78 ^{a}	10.58 ^{a}	13.09 ^{a}	46.67 ^{a}	4.90 ^{a}	55.64 ^{a}
TACD	4.13 ^{a}	4.43 ^{a}	5.83 ^{ab}	5.37 ^{bc}	6.55^{ab}	10.35^{a}	10.76^{ab}	43.29^{ab}	4.80 ^{a}	52.22 ^{ab}
ALD	4.21 ^{a}	3.89 ^{a}	5.84 ^{a}	6.74 ^{a}	6.75^{a}	9.52 ^{a}	9.44 ^{b}	42.18^{ab}	5.19 ^{a}	51.58 ^{bc}

**Mean of first generation and second generation*

Furthermore, regardless of the variety, the eggs were laid singly or in groups of up to six eggs surrounded by debris and excrement in a linear position in the unopened leaflets. The brown eggs were elliptical (Figure 2) that measured 1.2 mm in length and 0.5 mm in width with each end broadly rounded. The eggs were whitish when newly laid and turned to dark brown until they hatched.

Figure 2

Eggs (10X) of *Brontispa longissima* reared on Malayan Red Dwarf (MRD) under laboratory conditions



Development, Characteristics, and Behavior of the Larval Stages of *Brontispa* Reared on Different Coconut Varieties in the Laboratory

Table 1 also shows the duration (in days) of the different larval stages of *B. longissimi* reared on selected coconut varieties. Regardless of the variety, the beetles underwent 5–6 larval instars, but the duration of the total larval period was longest in MRD (46.57 days) which was significantly different from BAYT green and brown but not with the rest of the varieties. However, in all varieties, it was observed that the fifth and sixth instars took longer than the earlier instars. Development of the sixth larval instar reared on MRD variety had a mean duration of 13.09 days which was significantly longer compared to other varieties except MYD and TAC dwarf. This may indicate a slight varietal reaction; however, specific mechanism was not known in this study.

The coconut hispine beetles undergo four instars larval stage with duration of 30–40 days. Larvae are less active (Nguyen et al., 2004). The pupal 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 eggs laid per female averaged 153±20 to 43±108 eggs (Viet, 2004).

The number of larval instars varies widely across the insect species. Although instar number is frequently considered to be invariable within species, intraspecific variability in the number of instars is not an exceptional phenomenon. Intraspecific variability in the number of larval instars is widespread across insect taxa, occurring in most major orders, in both hemimetabolous and holometabolous insects. Various factors have been observed to affect the number of instars. Temperature, photoperiod, food quality and quantity, humidity, rearing density, physical condition, inheritance, and sex are the most common factors influencing the number of instars (Toomas et al, 2007). As far as characteristics and behavior of the larval instars reared on different coconut varieties were concerned, there were no significant differences observed. Below are the general larval behavior and characteristic observed in the laboratory.

First instar larvae

As observed, the newly hatched larvae regardless of the variety were whitish, which later turned yellowish. The head of the first instar larva was comparatively large compared with the body and measured 2mm long (Figures 4a & 5a). A seta arose from about the middle of the lateral margin of each thoracic segment, with two setae on each of the abdominal lateral processes and had a distally U-like hook, longer than broad.

Second instar larvae

The second instar larva resembled the full-grown larva more than the first instar. The larva was white in color but the dark digestive system could already be seen clearly when newly molted especially those reared in tall coconut varieties. The larva turned yellowish brown a day after molting (Figures 4b & 5b).

Third and fourth instar larvae

The third and fourth instar larvae reared in the different coconut varieties also had no significant differences. They were whitish in color when newly molted and later turned yellowish brown. The pseudolegs were quite visible and the larva had a dorsally flattened body. The head of the larvae had the same width with their body (Figures 4c, d & 5c, d).

Regardless of the coconut varieties, the larvae had a pincer-like appendage at the rear end of the body which was visible and got bigger as the larva grew. The pincer-like appendage appeared transparent with brown color at the tip.

Fifth and sixth instars larvae

In both tall and dwarf varieties, the fifth and sixth instar larvae had the pincer-like appendage at the rear end of the body which was brown to dark brown in color. The abdominal cavity was very visible. The body became broader than the head as the larva grew because the larval body became robust and round. The typical dot markings were visible on the dorsal part of the larva and the eight pairs of pseudolegs were very visible on the ventral side of the body. In all varieties, the fifth and sixth instars larvae had a longer development than the earlier instars (Figures 4e, f & 5e, f).

Generally, as mentioned earlier, the total development of larvae reared in the BAYT varieties was slightly shorter (38.70 and 39.03 days, respectively) compared to dwarf varieties such as MYD, MRD, and TACD (44.60, 46.67, and 43.29 days, respectively).

Pupa

When the larva was about to pupate, the larval movement became less or it just stayed motionless on the leaf. Prior to pupation, the larva crawled and started to molt until the exuvia was removed. In some cases, the exuvia remained attached to the pincer-like appendage at the rear end of the body. The larva bent its body and tried to get rid of the exuvia through its three legs. During the pupal stage, the exuvia remained attached to the head capsule. Results also showed that there were no significant differences in the pupal period of the *Brontispa* beetles reared in the tall and dwarf coconut varieties.

The pupa was less mobile. Newly formed pupa was slightly yellowish in color and later turned yellow as pupation progressed. The pincer-like appendage at the rear end of the body turned dark brown in color during the pupal stage.

Adults

After 5–6 days, the pupa darkened which was an indication that it was ready to emerge to an adult. The newly emerged adult had soft wings and had a pale black body. The head and thorax were orange/light brown in color which later on turned dark hours after emergence. After a week, the beetle became a fully developed dark-colored adult. After the wings hardened, the adult beetle started to crawl and feed on the leaf. This was observed on *Brontispa* reared in selected coconut regardless of varieties. The females were generally larger than the males. The body measurement of various stages was shown in Figure 3. In terms of size, the adult male is generally smaller than the female and measures 7.5–10 mm long and 1.5–2 mm wide (Hosang et al, 2010). As per morphological observation, there was no distinct sexual dimorphism observed in the adults. Both the males and females had the same body coloration and pattern. However, as mentioned earlier, it is the size of the female and male adults that generally varies slightly.

Figure 3

Adults of *Brontispa longissimi* reared on MRD and BAYT

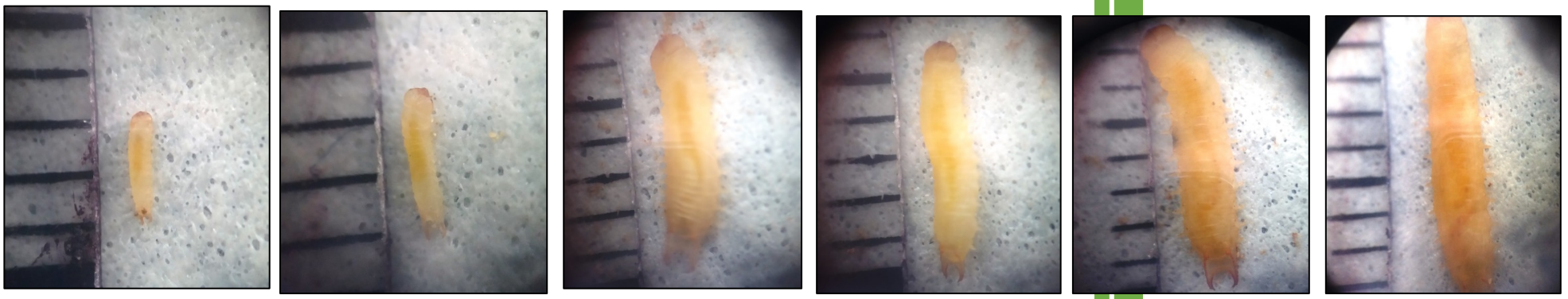


Figure. 4. *Brontispa* larval instar reared on BAYT (brown) (10X) A) First instar; (2 mm); B.) second instar (3mm), C.) third instar (5mm), D.) fourth instar (6mm), E.) fifth instar (7mm), and F.) sixth instar (8mm).

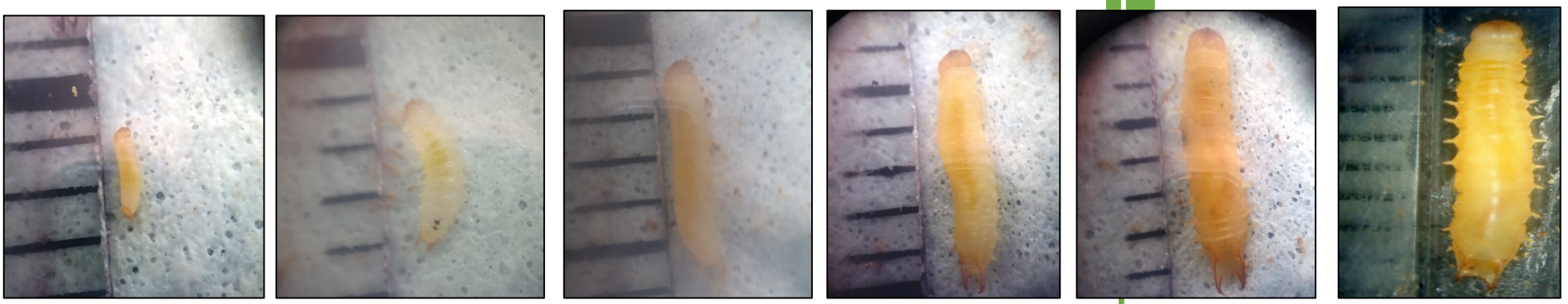


Figure 5. *Brontispa* larval instar reared on MRD (10X.) First instar (2mm), B.) second instar (3mm), C.) third instar (4.5 mm), D.) fourth instar (6.5mm), E.) fifth instar (7mm), and F.) sixth instar (9mm).

Hatchability, Emergence of *Brontispa* Adults, and Sex Ratio

Hatchability

Table 3 shows the *percent* hatchability and emergence of the *B. longissim*a on selected coconut varieties. BAYT green and brown variety obtained the highest percent hatchability of 90% and 94%, respectively, which was significantly higher with the rest of the varieties. On the other hand, MRD obtained the lowest percent hatchability of 80% which was significantly different with the other varieties. This result further confirmed the suitability of BAYT variety to *Brontispa* over the other varieties.

Table 2

*Hatchability (%) and Emergence (%) of the Different Stages of Brontispa longissima Gestro Reared on Selected Coconut Variety**

Variety	Hatchability	Emergence	Fecundity	Longevity	Sex-Ratio
BAYT Green	90.00 [a]	72.00 [b]	71.10[b]	57.78 [a]	1.4:1
BAYT Brown	94.00 [a]	76.00 [a]	113.00 [a]	57.50 [a]	1.71:1
MYD	88.00 [b]	64.00 [cd]	66.00 [c]	53.83 [b]	1:1.66
MRD	80.00 [c]	62.00 [d]	63.00 [d]	47.08 [c]	1:1.88
TACD	88.00 [b]	66.00 [c]	69.53 [bc]	54.86 [b]	1.35:1
ALD	88.00 [b]	64.00 [cd]	76.46 [b]	56.40 [a]	1.66:1

** Data based on 50 individuals*

Emergence

BAYT (brown) had the highest percent emergence of 76% which was significantly different with the rest of the varieties. MRD, on the other hand, had 62% of emergence which was significantly different with BAYT green and brown and TAC dwarf but not significantly different form the rest of the varieties.

Upon emergence of the adult, they were pale and not yet fully sclerotized. Newly emerged adults had soft wings and had a lighter color, which later on turned dark hours after emergence. After a week, they became fully developed dark-colored adults. After the wings hardened, the adult beetle started to crawl and feed on the leaf. This was observed on *Brontispa* reared in selected coconut regardless of varieties.

Sex-Ratio

Table 3 shows the sex ratio of adults emerging from different varieties. Among those adults that successfully emerged in BAYT green variety, 21 were males and 15 were females giving a male to female sex- ratio of 1.4:1 followed by BAYT (brown), MYD, MRD, TAC, and ALD varieties with a male to female ratio of 1.71:1, 1:1.66, 1:1.88, 1.35:1, and 1.66:1, respectively.

Fecundity and Longevity of *B. longissimi*

Table 3 presents the fecundity and longevity of *B. longissima* reared on different coconut varieties. BAYT brown variety had the highest fecundity with (113 eggs) which was significantly higher compared with the other varieties. On the other hand, MRD obtained the lowest number of eggs (63) which were significantly different from the rest of the varieties. This result again supports the evidence that BAYT brown is more preferred by *B. longissima* for oviposition and breeding. The results are similar to the study of Lumentut (2013) in Malang Indonesia which reported that there were a higher number of *Brontispa* eggs laid in Mapanget Tall coconut varieties compared to Brown dwarf coconut varieties.

According to O'Connor (1940), the female lays an average of 50–100 eggs until 117 eggs. The report of Tjoa (1953) cited by Hosang et al. (2010). Viet (2004) also mentioned that the number of eggs laid per female averaged 20±153 to 43±108 eggs. There were preoviposition period of 1–2 months and 100 or more eggs could be laid.

Mortality Rate of the Different Developmental Stages

Table 4 summarizes the mortality rates of the different instars of *Brontispa* reared in different coconut varieties. It is shown that regardless of coconut varieties used, higher mortality was noticed in the first and second instar larvae. Larval stages were less sclerotized and therefore more delicate thus, they were prone to mechanical damage. This was generally expected since mortality might be attributed to handling the insect. Earlier larval instars were soft and fragile and were more vulnerable to handling than the later instars. In this study the cause of insect death was attributed to handling especially in transferring the larvae from one container to another, particularly when brushing them off from the leaf upon transferring the larva. It was also possible that the insect was drowned by the amount of water (moisture) being added to each container to keep the moisture of the leaves and keep them fresh. For the mortality of pupa, there was 4.44% mortality of pupa observed from the total number of larva reared in BAYT green that underwent pupation followed by TAC and ALD varieties which both have 2.27% pupa mortality. This means that most of the beetles reached pupation. Mortality of pupa in BAYT brown, MYD, and MRD varieties was not observed. Mechanical handling was assumed to be the mortality factor for pupa mortality.

For the total mortality, a generally lower percentage was observed in Tall varieties obtaining only 19.12% for BAYT brown and 22.21% for BAYT green. On the other hand, among the dwarf varieties, beetles reared in MRD had the most mortality of 40%, followed by ALD (27.26%), MYD (27.14 %), and TACD (24.98%). This result supports the earlier findings that BAYT varieties are suitable host plants of the *Brontispa* over the other varieties. Observations on the dead larvae showed a microbial infection was found on the insect's dead body. Hyphal bodies grew on the surface of the elytra as shown earlier in Figure 6. These microorganisms were thought to be coming from the young leaves of the selected coconut varieties which served as substrate for the adult.

Overall, those reared on the BAYT (green and brown) varieties succumbed to less mortality compared to other selected varieties. On the other hand, MRD variety obtained the highest mortality rate compared to other varieties. Again, the result of the study supports the findings that BAYT varieties were the most preferred and suitable host of the *Brontispa* over the other varieties. However, as to the specific factor that contributed to its being a preferred or suitable host, further studies may be conducted along this line.

Table 3

Mortality (%) of the different stages of *Brontispa longissima* reared on selected coconut varieties

Developmental Stages	Coconut Variety					
	BAYT Green	BAYT Brown	MYD	MRD	TACD	ALD
Larval instar						
First instar	8.89	8.51	6.81	15.0	11.36	11.36
Second instar	4.44	4.25	6.81	10.0	6.81	9.09
Third instar	2.22	0.0	2.27	0.00	0	0.00
Fourth instar	2.22	2.12	0.00	5.0	2.27	2.27
Fifth instar	0.00	2.12	2.27	0.00	2.27	0.00
Sixth instar	0.0	2.12	2.27	0.00	0.00	2.27
Pupa	4.44	0.00	0.0	0.00	2.27	2.27
Adult	0.00	0.00	6.81	10.0	0.00	0.00
TOTAL	22.21	19.12	27.14	40.00	24.98	27.26

Conclusion

1. Development of beetle from egg to adult took a shorter period in BAYT Green and Brown (47 and 48 days respectively) indicative of highly preferred host. MYD had the longest duration and maybe considered not a suitable host.
2. Duration of time from egg laying to hatching of eggs of *B. longissima* on tall varieties ranges 3 to 5 days, while on dwarf varieties this was 4 to 5 days.
3. *Brontispa* beetles underwent 5–6 instars. In all varieties it was observed that the fifth and sixth instars took longer than the earlier instars.
4. .*Brontispa* beetles reared on BAYT brown had the highest fecundity (M=113 eggs), while those beetles reared in MRD obtained the lowest number of eggs (M=63). For longevity of adults beetles, BAYT green and brown gave the highest longevity observed while MRD gave the lowest longevity observed compared to other varieties
5. *Brontispa* beetles reared in BAYT green and brown varieties succumbed to less mortality compared to those reared on other selected varieties. The highest beetle mortality was obtained in MRD variety. The results support the findings that BAYT varieties were the most preferred and suitable host of the *Brontispa* over the other varieties.

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References

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.

Guo, J. 2005. Coconut beetle management in Hainan Island, China: assessment of issues, new developments and future plans. In developing an Asia-pacific startegies for forest invasive species. The coconut leaf beetle-Bridging agriculture and forestry, eds. Approach S., Simh. Asia Pacific Bangkok 47-57.

Hosang, M. L. A., J. C, Alouw And H. Novarianto. 2004. Biological control of *Brontispa longissima* (Gestro) in Indonesia. Indonesian Coconut and other Palm Research Institute. Indonesia. 10 pp.

Lumentut N.Karinda, S.2013 OSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) e-ISSN: 2319-2380, p-ISSN: 2319-2372.Volume 6, Issue 2 (Nov. - Dec. 2013), PP 33-37 www.iosrjournals.org

Nguyen Ht, Oo Tt, Ichiki Rt, Takano S, Murata M, Takasu K, Konishi K, Tunkumthong S, Chomphookhiaw N, Nakamura S, 2004. Parasitisation of Tetrastichus brontispae (Hymenoptera: Eulophidae), a biological control agent of the coconut hispine beetle Brontispa longissima (Coleoptera: Chrysomelidae). Biocontrol Science and Technology, 22(8):955-968. http://www.tandfonline.com/loi/cbst20

O'connor, B.A. 1940. Notes of the coconut leaf hispid, *Brontispa froggatti* Sharp and its parasites. New Guenea Agric. Gaz. 6:36-40.

Rivera, R. L., G. A. Santos, S. M. Rivera, E. E. Emmanuel, And G. B. Baylon. 2005. Development of synthetic variety of coconut: PCA Syn Var 001 I. Status and Prospects. CORD 24 (1): 90-112

Rethinam, P. And Singh Sp, 2007. Current status of the coconut beetle outbreaks in the Asia-Pacific region. RAP Publication [Developing an Asia-Pacific strategy for forest invasive species: the coconut beetle problem - bridging agriculture and forestry. Asia-Pacific Forest Invasive Species Network workshop, Ho Chi Minh City, Vietnam, 22-25 February 2005.], No.02:1-23.

Sankaran, K. V. 2006. Coconut leaf beetle: *Brontispa longissima* Gestro. Kerala Forest Research Institute, India. 2 p.

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.

Wilco, L. And Chapman, K. (2006). "Impact and control of the coconut Hispine beetle, *Brontispa Longissimi* Gestro (Coleoptera: Chrysomelidae)". In: Report of the expert consultation on coconut beetle outbreak in APPPC member countries. Bangkok, Thailand: FAO RAP Publication 2004/29

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.