Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(1): 488-492

Received: 10-11-2016
Accepted: 11-12-2016

Adoro L
Ramon Magsaysay Technological University, Iba, Zambales, Philippines

Domingo F
Ramon Magsaysay Technological University, Iba, Zambales, Philippines

Baysa J
Ramon Magsaysay Technological University, Iba, Zambales, Philippines

Dela Cruz B
Ramon Magsaysay Technological University, Iba, Zambales, Philippines

Dacayo N
Ramon Magsaysay Technological University, Iba, Zambales, Philippines

Garcia S
Ramon Magsaysay Technological University, Iba, Zambales, Philippines

Farin E
Ramon Magsaysay Technological University, Iba, Zambales, Philippines

Roxas A
Central Luzon State University, Munoz, Nueva Ecija, Philippines

Lutap L
Mariano Marcos State University, Batac, Ilocos Norte, Philippines

Correspondence
Adoro L
Ramon Magsaysay Technological University, Iba, Zambales, Philippines

Life history of mango twig borer, *Callimetopus capito* (Pascoe) Coleoptera, Cerambycidae

Adoro L, Domingo F, Baysa J, Dela Cruz B, Dacayo N, Garcia S, Farin E, Roxas A and Lutap L

Abstract
Mango twig borer (*Callimetopus capito*) completed its life cycle from 135 to 245 days. Eggs were cucumber shaped, shiny, off-white in color, with an average length of 3.7 mm and a diameter of 1.33 mm. Larvae had developmental period of 145-221 days with seven larval instars. The pupal stage ranged from 10-17 days. The average length and width of pupae were 1.87 cm and 0.51 cm, respectively. Adults appeared light in color when newly emerged but turned to dark brownish grey within a day.
Eggs were laid singly or in mass inserted beneath the young bark. A maximum of 31 eggs were laid throughout the female's life cycle. Larvae fed first on the bark, making narrow channels 12-61 days after hatching. The length of damaged twigs ranged from 13.5 cm to 52 cm and increased to about 90 cm when the larva was about to pupate.

Keywords: Life history, life cycle, development, mango twig borer, *Callimetopus capito* (Pascoe) coleoptera, Cerambycidae

Introduction
One of the most serious pests of mango in the Philippines is the mango twig borer [1]. High infestation adversely affecting yield and therefore, income of mango growers has been reported by LGU in Rizal Province [2] and by mango growers in Central Luzon and Ilocos Region [3]. Although the yield reduction potential of twig borers has not yet been established, the larval damage characterized by the drying up of shoots and death of twigs directly affects yield through significant reduction in the number of flowering shoots.
A detailed study on the life history of mango twig borer is an important component of integrated pest management to estimate relevant parameters in establishing effective management strategy.
Little has been known regarding the insect pest and no extensive study has been conducted regarding the pest, thus, the developmental period of the mango twig borer has not been fully established. Hence, several taxonomic studies has been conducted on twig borers, little has been known in the life history of mango twig borer specifically *Callimetopus spp.*
The study was undertaken to establish the life history of mango twig borer which will be the basis for the development of pest management strategies against mango twig borers. Efficient control of mango twig borer will benefit mango growers and contractors throughout the country.

Methodology
A. Period of the Study
The study was started in April 2007 to April 2010 conducted at the Research and Development Center Laboratory and in the field.

B. Mass Rearing
Infested mango twigs were collected and dissected for the presence of eggs, larvae and pupae. These were reared separately to observe incubation, hatching, feeding behavior and molting process of the larvae and the duration of the pupal stage. Adults were reared to observe mating behavior, oviposition and to determine the life span and fecundity of the female.

Twigs with eggs: Twigs with eggs were trimmed (leaves removed) and labeled. The edges of the incised bark where the eggs were deposited were covered with masking tape and the

locations of the eggs were marked by an arrow. The oviposition sites were inspected daily for possible hatching. If hatching occurred the tapes were properly placed to avoid contact with the larvae.

Newly hatched larvae were transferred to young shoots, one end of which was split and opened. A little tunnel at the center of this twig was made where the first instar larvae were carefully placed using a camel's hair brush. The split end of the twig was secured by either a tape or a rubber band. The twigs were opened every other day to observe any molting. As the larvae increased in size, they were transferred to new bigger twigs with drilled holes. The twigs were changed as they dried up until the pupal stage. The pupae were removed from the twigs and placed in wide mouthed bottles, 18 cm high with a diameter of 9.5 cm, or were left inside the twig to observe how and when the adults get out of the twig after emergence.

Twigs with Larvae: Twigs with larvae were piled on the table lined with moist muslin/cheesecloth to prevent desiccation. Daily inspection and cleaning were done. The larvae were transferred to new drilled twigs when the twigs dried out. During pupation, morphological changes were observed and the pupal period of the male and female pupae was determined.

Twigs with Pupae: Pupae were excised from the twigs and placed in rearing bottles (18.0 cm high and 9.5 cm in diameter). Emerged adults were sexed using the tip of the abdomen as criterion. Paired adults were confined in bottles to observe mating behavior, egg laying and fecundity of the female.

Field Collected Adults: One to two-week old male and female adults were paired and placed in rearing bottles with fresh mango twigs and some in caged mango seedlings to observe mating and feeding behavior. The fecundity of the female in rearing bottles was determined.

Results and Discussion

Egg: Newly laid eggs were cucumber-shaped (sub-cylindrical), shiny, white to off white in color and the length ranged from 3.3 mm to 4.0 mm with an average of 3.7 mm. The diameter ranged from 1.00 mm to 1.60 mm with an average of 1.33 mm. The anterior end of the egg was broader than the posterior portion.

The anterior portion of the egg where the head was positioned cracked first, followed by the rupture of the egg at the side forming a slit due to rapid movement of the larva inside. Hatching was completed within a day. Either a slit on both sides or a crack on the anterior portion of the egg initiated hatching. Hatching was faster in the egg with slits on the side than the egg with a crack in the anterior portion. Incubation period ranged from three to 13 days with an average of 6.86 ± 1.52 days.

A total of 584 *C. capito* eggs were initially used for rearing larvae. However, some of the eggs were not able to hatch and larval mortality was high (44.69%) due to stress in handling, desiccation, predators (ants & house lizard) and entomopathogens (fungi) were encountered, thus reducing the number of larval cultures to 261. These were used as initial cultures for the determination of larval instars.

Larvae: The developmental period of the pest's larvae ranged from 145-221 days with an average of 180.11 ± 27.42 days (Table 1).

Table 1: Developmental Period of the Different Larval Instars of MTB

	Incubation (egg) (n:261)	**1st Instar (n:154)**	**2nd Instar (n:130)**	**3rd Instar (n:82)**	**4th Instar (n:42)**	**5th Instar (n:13)**	**6th Instar (n:9)**	**7th Instar (n:9)**	**Total Larval Period**
Range	3-13	4-18	6-76	8-75	8-107	10-81	14-60	11-56	145-221
Mean ± SD	6.86 ± 1.52	8.98 ± 3.90	24.66 ± 16.00	32.24 ± 16.90	32.38 ± 21.34	35.54 ± 21.10	33.33 ± 13.59	32.56 ± 14.46	180.11 ± 27.42

Descriptions of the different instars:

First (1st) instar: Mean body length 5.13 mm; mean body width 1.04 mm; mean head capsule length 1.16 mm; mean head capsule width 0.93 mm; body color whitish, integument transparent; head oblong and extensible, exposed parts frons and vertex whitish; light brown; prothorax with a sclerotized dorsal plate; prothorax larger than either meso and metathoracic; light brown and with very few setae. abdominal ambulatory ampullae fleshy and not distinct; mesothorax spiracle not distinct; abdominal segments 1-8 with light orange spiracle; anal region trilobite but not too distinct/prominent.

Second (2nd) Instar: Mean body length 12.9 mm ; mean body width 2.95 mm; mean head capsule length 2.09 mm; mean headcapsule width 1.39 mm; body light cream; head oblong, extensible, invaginated into prothorax; exposed anterior part darker than posterior; median suture distinct; frontal suture not as distinct as the median suture, with few setae along the front margin of the frons; clypeus membranous and glabrous; labrum setose or hairy; cutting edge of mandible chisel-like with protruding small tooth; maxillary palpus 3-segmented; labial palpi conical; antenna still indistinct ; prothorax large with a wide collar and wider than mesothlrax and abdomen; dorsal plates slightly pubescent; mesothoracic spiracle absent; integument transparent, thus tracheae and tracheoles visible; a day-old 2nd instar larva showed roundish and colorless spiracles turned light brownish orange as it aged; ambulatory ampullae already distinct.

Third (3rd) instar: mean body length 19.33 mm; mean body width 2.69 mm; mean head capsule length 2.93/mm; mean head capsule width 1.91;, body light cream ; head oblong extensible, invaginated into prothorax; more than 10 setae above the fronto-clypeal suture; clypeus rectangular, membranous and glabrous; occipital foramen roundish and ventral; wide sclerotized gula proximal to submentum; labrum setose maxillary palpus-3 segmented; labial-palpi distinct and conical; cutting edge of mandible with a small sharp tooth-like projection.

Fourth (4th) instar: Mean body length 26.3mm; mean body width 3.5mm; mean head capsule length 3.46mm; mean head capsule width 2.53mm; head extensible and deeply invaginated into prothorax; oblong head capsule light brown with posterior lighter than anterior; median and frontal suture distinct; median suture divided frons into left and right

triangular plates; clypeus rectangular and membranous; labrum setose, mandible with cutting edge oblique with a small protruding tooth at the end of molar area; maxillary palpus 3-segmented; labia palpi distinct and conical; antenna 3-segmented, the third segment not as sclerotized as the first and second segments; prothorax large with a rectangular sclerotized dorsal plate, anterior portion light brown and posterior white; mesothorax without spiracle; 1-8th abdmominal segments with annular spiracles; 1-7th abdominal segments with fleshy ambulatory ampullae dorsally and ventrally; anal region trilobate with at least 100 short and long setae.

Fifth (5th) instar: Mean body length 30.30 mm; mean body width 4.5 mm; mean head capsule length 3.91mm; mean head capsule width 3.03 mm; head also extensible and light brown; oblong; clypeus membranous; frons similar with 4th instar; few setae at the epistoma; pronotum anteriorly beset with many setae, the white collar with only few setae at anterior part similar with previous instar; bigger and more pointed tooth at lower part of molar area; anal region with darker and bigger setae.

Sixth (6th) instar: Mean body length 29.72 mm; mean body width 4.66 mm; mean head capsule length 4.53 mm; mean head capsule width 3.26 mm; head slightly darker than the later instars; clypeus still membranous and hyaline; mandible similar with the 5th instar; anterior part of pronotum slightly more sclerotized than the previous instar; three lobes of anal region more prominent.

Seventh (7th) instar: Mean body length 30.30 mm; mean body width 4.91 mm; mean head capsule length 5.27 mm ; mean head capsule width 3.68 mm; mandibular tooth at molar area bigger; three anal lobes more pronounced; one pair of stemmata bulged at the edges of two fronto-clypeal suture; no significant changes from previous instars.

Percentage survival of the larvae was lowest in the 5th instar stadium which is 30.95% while there was 100% survival for 7th instar larvae.

The last larval instar prior to pupation sealed both ends of the tunnel with frass, similar to the last instar of *Metamasius mosieri* (Barber) (Coleoptera: Dryopthoridae). This blocks the entrance of rain water and predators like ants and may prevent rapid loss of moisture from the microhabitat [8] Cave, R.D. *et. al*., 2006). The larva also cuts5-15 small holes of about 1 to 2 mm in diameter (about 3-4 mm apart or even farther) in the twig for aeration and exit hole during adult emergence. Formation of exit holes occurred five to thirteen (5-13) days before prepupal period with an average of 10.23 days. Prepupal period ranged from 5 to 12 days with an average of 6.40 days (based from 30 individuals).

Feeding Behavior of MTB Larvae (from caged mango seedlings): Larvae fed on the shoot one day after hatching was indicated by the presence of fine shavings extruding from the slit where the egg had been deposited. The young larvae made narrow channels in the cortex and phloem tissues as they fed before going to the central portion of the twig. The tunnel became wider as the larvae increased in size. Upon reaching the central portion, a distance of about 13.50 cm had been traveled from the oviposition site for a period of five days. Usually, the larva made small holes (1mm in diameter) in the bark for aeration as it moved downward, consuming the entire wood (xylem tissue), thus cutting the movement of water upwards resulting to wilting of the leaves.

Prepupa: The prepupa was morphologically similar to last seventh instar larva but turned dirty cream; body more compact and movement changed from caterpillar (usual forward and backward body movement) to jerky motion; length somewhat shortened; head capsule still light brown; mandible dark brown to black; basal part of pronotum still brownish with left and right edge dark brown; the white collar setose basally; trilobate anal region very prominent; prepupa less mobile and non-feeding.

Pupa: Exarate; cream or milky white, turned clay-brown as it matured; average length, 1.87cm and width, 0.51cm; elongated and tapered posteriorly; cuticle with scattered spines and setae; head bent over prothorax, mouthparts extended posteriorly; vertex seen from above; antennae extending up to the second abdominal segment and slightly curved downward beneath the body and terminated between the front and the middle coxae; elytra glabrous; abdominal tergites 1-7 with several rows of spines; clypeus with at least 10 setae at the basal margin; labrum with numerous groups of fine setae across base; pronotum basally setose.

The pupal stage ranged from 10-17 days with an average of 13.50 days. The average length of 45 pupae measured was 1.87 cm and the average width was 0.51 cm.

A day old pupa appeared cream to very light brown with very light brown mandibles and some parts of the legs. The compound eyes were visible on the fourth day and the apex of the elytra also turned light brown. On the seventh day, the mandibles turned black. On the tenth day the frons, clypeus, wings, legs and antennae became darker.

A transverse rectangular protuberance is present posterior to the eight sternite, in the male pupa whereas in the female, this is represented by a pair of subcontiguous rounded lobes which often bear one or more pairs of setae [11].

Adults: Newly-emerged *C. capito* adults appeared light in color but turned to dark brownish grey within a day. In the female adult, a slit was present at the last visible abdominal segment which was absent in the male. Abdominal tip of the female was rounded and much broader than the the segments behind it, while that in the male, the last visible segment was as narrow as the segments behind.

Mating Behavior: Prior to mating, the male appeared to court the female by mounting her from behind, on the side or at the head portion, then positioned itself by extending its abdomen a little beyond the tip of the female's abdomen. The male clasped the female with his pro and mesothoracic legs which lasted for about 13 hours before mating (based from one pair only). During copulation, the male aedeagus which was about 0.50 mm in diameter and 1 cm long, protruded from the tip of the abdomen and inserted in the female genitalia. Their antennae were projected forward during the act. Insertion of the male aedeagus in the female genitalia lasted for about 10 to 30 seconds but there was an occasion when it was inserted up to 36 minutes. Though not exactly determined, copulation occurred several times within 24 hours.

Oviposition/Egg Laying: Before egg laying, the female made a shallow spiral groove or line around the base of a young twig. Shallow and deep bores were also made with her mandibles which were possible sites for oviposition. After making a bore she either moved forward until her ovipositor touched the bore, made a half turn until her ovipositor sensed the site. Thereafter, the ovipositor was inserted for 30 minutes to an hour. After oviposition, she again made a half turn and

gathered frass on the site to cover the bore together with her saliva. Short parallel lines were produced by the mandibles on the twig with the to and fro movement of the insect before and after egg laying.

A bulge on the bark with a shallow hole measuring about 0.70 mm was a positive sign of egg presence. The egg was inserted between the xylem fibers, or just beneath the young bark or deep beyond the bark reaching the central pith. The distance between the egg and point of insertion was about 2-3 mm. about the length of the ovipositor. [9] and [10] cited that only one egg is deposited per site but based on the observations in the field and in the laboratory, two to three eggs could also be deposited in one oviposition site.

Egg laying started almost two weeks after pairing of male and female adults which occurred earlier than egg-laying of laboratory cultured individuals. The maximum egg count laid by a female adult throughout its entire longevity of 41 days was 31 however; seven or 82% of the female did not lay egg after being paired. The maximum number of eggs laid by a female adult in a day was six and four of these hatched. The most number of eggs collected in a day from the 85 female adults in 2006 was 22. Eggs laid singly had higher percentage of hatchability compared to multiple-laid eggs. Multiple deposition in a single site resulted in deformed eggs that were infertile.

Temperature and relative humidity were found as two critical factors considered in the increase of eggs oviposited. More eggs were oviposited where the temperature and relative humidity in the laboratory were lower.

Fecundity of 12 mated female adults and percent hatchability of eggs oviposited under laboratory condition was determined (Table 2). Two of the14 mated females did not lay any egg. A maximum of 43 eggs were laid by a single female adult through out its entire longevity of 219 days. Total fecundity per female in *Metamasius mosieri* is correlated with longevity [8] similar to *C. capito* (Pascoe). However, only 58.14% hatched from the 43 eggs. The mean hatchability of *C. capito* eggs is 45.99 ± 33.76 percent. Factors that were accounted for low hatchability of eggs include: stress in handling/transferring, moisture content of the twig, number of egg laid per oviposition site and age of adult female at the time the eggs were laid.

Table 2: Fecundity of MTB Female Adults and Hatchability of Eggs Oviposited

Female No.	Total Eggs Oviposited	Longevity (days)	Eggs Hatched	Eggs Unhatched	Hatchability (%)
1	4	136	3	1	75.00
2	2	167	2	0	100.00
3	27	194	6	21	22.22
4	2	177	2	0	100.00
5	19	178	10	9	52.63
6	22	200	4	18	18.18
7	43	219	25	18	58.14
8	5	182	1	4	20.00
9	2	119	0	2	0
10	-	93	-	-	-*
11	-	47	-	-	-*
12	20	183	2	18	10.00
13	17	185	10	7	58.82
14	19	219	7	12	36.84
Mean	15.17	164.21	6	9.17	45.99 ± 33.76

Females 10 &11 were mated but did not lay egg.

Adult longevity

Unmated individuals whether male or female had longer lifespan than mated individuals. Female *C. capito* adult lived longer than male adults for both unmated and mated conditions. Longevity of unmated male ranged from 9-223 days with an average of 119.72 days while that of the mated male adults ranged from 8-187 days with an average of 79.48 days. On the other hand, longevity of unmated female ranged from 11-251 days with an average of 129.44 days while that of the mated female adults ranged from 8-219 days with an average of 111.68 days.

Developmental Period of MTB

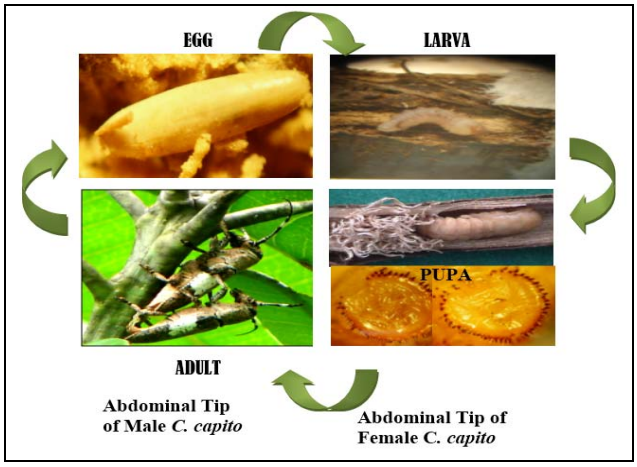

Fig 1: Life cycle of the mango twig borer

The developmental period of female MTB ranged from 135 to 245 days with an average of 206.25 ± 51.73 days, while that of the male ranged from 114-224 days with an average of 163.09 ± 34.03 days which is shorter than the female. Data obtained in the laboratory was within the range of 142-249 days similar to that reported by [7]. The number of moltings, however, was not properly monitored for these individuals.

The incubation period of MTB ranged from 5-12 days with an average of 7.96 days, about a day longer than the incubation period of 7.12 days under laboratory condition. The data showed that temperature and relative humidity did not affect much the incubation period of *C. capito* [5] egg. Both temperature and relative humidity were higher in the field than inside the laboratory room.

Newly-hatched larvae fed first on the bark making narrow channels as they moved. The first hole produced which was for aeration and discharge of excrements and wood frass was done from 12-61 days after hatching when the larvae were on their second to third instar stadia. The number of holes produced within a period of six months of feeding ranged from 3-11 with an average of six holes. Length of damaged and dried twigs ranged from 13.5 cm to 52 cm with an average of 30.8 cm and increased to about 90 cm long excluding the dried side shoots when the larva was about to pupate.

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