BEHAVIOR OF MANGO PULP WEEVIL, *Sternochetus frigidus* (Fabr.) AT DORMANT MANGO, *Mangifera indica* STAGE

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ABSTRACT

The field location and daily activity pattern of mango pulp weevil (MPW) adults were determined during dormancy of mango trees in order to refine current integrated pest management strategies particularly, open-center pruning. During dormant stage of the mango trees there are more adult MPW found hiding on branches compared to trunks of mango trees. Among the adult MPW that stayed on branches an average of 4.2 $\pm$ 1.64 MPW were located at 1 m horizontal distance away from the trunk and an average of 4.8 $\pm$ 0.84 MPW found 2 m away from the trunk. Resting was the most frequent activity and had the longest duration for adult MPW during dormant stage of mango trees. The remaining time was divided between short walk and leg movement. The findings indicate that open-center pruning would be most effective if the inner canopy has to be removed by at least 25% diameter to expose the weevils to direct sunlight. The MPW behavior suggests it actually undergoes a period of dormancy that is specifically a diapause.

Key words: dormancy, diapause, quiescence, phenological stage, mango branches

INTRODUCTION

A striking feature of insect life cycles is their physiological and behavioral adaptations to the ubiquitous, seasonally changing environments. To synchronize activities to favorable times and to enhance survival during unfavorable periods, many species undergo a state of dormancy (Tauber and Tauber, 1976).

The term dormancy includes both possibilities of diapause and quiescence. For some tropical species the information available is too sketchy to allow adequate distinction between diapause and quiescence. Diapause refers to an arrest in development that occurs at a specific stage. Egg, larval, pupal and adult diapauses are all well documented, but for most species diapause can be expressed in only one stage of the life cycle. Diapause is programmed far in advance of the actual developmental arrest and thus differs from a simple quiescence that is an immediate response to adverse conditions (Denlinger, 1986). Diapause is a widespread form of dormancy among insects (Tauber and Tauber, 1976).

Adult diapause is reported commonly in the tropics, but more rarely in temperate zones. Insects that diapause in the tropics are confronted with several unique constraints. Tropical species must reduce metabolic requirements without the aid of low temperature. During diapause the insects retreat to protected sites. The diapause site typically provides protection and buffering of the physical environment (Denlinger, 1986).

In the Philippines, quiescence behavior was reported of the quarantined pest – mango pulp weevil (MPW), *Sternochetus frigidus* (Fabr.) during the dormant, flower bud-break and panicle elongation of mango since there were no active weevils observed on infested mango trees (Medina *et al.*, 2005; De Jesus *et al.*, 2003). This pest was probably introduced from Borneo into the southern part of Palawan, an island in southern Philippines, namely in the towns of Bataraza, Brooke's Point, Narra and Aborlan in 1987 (Basio *et al.*, 1994).

In 1995, infestation of MPW occurred sporadically in Puerto Princesa City, Central Palawan. In backyard trees in Brooke's Point, infestation of trees was as high as 43% (De Jesus and Cortez, 1998). The infestation, however, has been confined to these areas leaving Northern Palawan free of this pest.

An integrated pest management program (IPM) for mango specific for Palawan was developed to address in particular the management of MPW. This IPM program involved the use of control strategies, namely, cultural methods (open-center pruning and sanitation), pest monitoring and chemical control (Medina *et al.*, 2005).

The MPW was found to exclusively feed on mango varieties and does not infest other fruit crops (De Jesus and Gabo, 2000). The larvae of MPW are most destructive as it feeds and develops on the pulp leaving behind discolored tunnels on the pulp. The fifth instar prepares a pupal cell until it becomes an adult. While there is damage inside the fruit, there is no indication of damage on the fruit peel. The egg plugs are often gone by the time the fruits are harvested (De Jesus and Gabo, 2000). The activity of MPW within the tree changes according to the phenological stage of the tree. The mango flower at full-bloom stage and the developing mango fruit when it attains the size of the chicken egg are important in the life of MPW. At full-bloom stage, MPW crawls on the flower to feed. When the fruit attains the size of a chicken egg, it becomes the mating and oviposition site (De Jesus *et al.*, 2003).

The MPW behavior whether it is undergoing quiescence or diapause during dormant mango stage is not yet explored except for its reported absence at certain stages of the mango tree phenology. The MPW are hard to find because of their cryptic coloration (Kalshoven, 1981). Knowledge of diapause is essential for understanding the seasonal biology of an insect species, and such information is also required for the development of effective pest management strategies among others (Denlinger, 2008).

In this study we determined field location and daily activity pattern of MPW during dormancy of both weevil and mango tree in order that we could further refine the existing IPM recommendation.

MATERIALS AND METHODS

Field Location of Adult MPW

Observations were made to locate the hiding places of quiescent mango pulp weevil (MPW) adults within dormant 'carabao' mango trees in Brooke's Point, Palawan, Philippines in May-June 2012. The field observations were conducted on 5 'carabao' mango trees (one tree per sample, total of

5 samples [n=5]) of about 7.5 - 9 m height and an average of 10.7 m canopy diameter. Since mango trees are large, bamboo poles are tied to branches of trees for ease in mango production operations, e.g., insecticide and fungicide application and harvesting of fruits. These bamboo poles were left on the trees after harvest and were used in the search for MPW. Aside from the bamboo poles aluminum ladders were also used. Search for MPW adults were done on trunks and branches of 'carabao' mango trees at dormant stage from 0800 to 1700 hr when natural light conditions were good. Mango trees were dormant after harvest up to one month after harvest of fruits where no flushing yet occurs.

The total number of quiescent MPW adults found on trunks and branches of the mango trees were recorded. The location where the dormant MPW adults was found on branches also recorded, i.e., distance from the trunk and the distance from the ground.

Daily Activity Pattern

Observation was conducted continuously for a 24-hr period throughout the dormant stage by carefully searching randomly the trunk and branches from the ground up to about 9.8 ft (3 m) above the ground until the first adult was detected. The observer remained near the spot where the weevil was found for 5 to 240 min (median = ca. 85 min) to follow and record its activities as in the method of De Jesus *et al.*, 2003.

Four observers worked in shifts in the conduct of this experiment. The observers were familiar with the movements of the weevil after working for at least 6 yr on the mango pulp weevil in both laboratory and field experiments. We have also conducted several preliminary field observations during the previous fruiting season to ensure proper data gathering, including nighttime and daybreak observations to get accustomed with working under poor light conditions. Observation were taken at a distance of 30.5 cm with minimum movement by the observer, otherwise weevils would drop to the ground when disturbed. A flashlight was used for nighttime observation. It was found that adult weevils were not affected by flashlight kept 30.5 cm away (De Jesus *et al.*, 2003).

Activity was categorized as resting (identified as the weevil being motionless), crawling (short walk of up to a few inches from its original position) and leg movement (stretching and shaking of legs). Host parts where activities were observed included the trunk and branches. The length of time (minutes) spent by the weevils for each activity was recorded. The data are presented in terms of amount of time spent for each activity on host structure as well as in percentage of the total amount in 24 hr. The frequency of occurrence of an activity in 24 h was also recorded (De Jesus *et al.*, 2003).

RESULTS AND DISCUSSION

Field Location of Adult MPW

Field observations on mango trees have shown that an average of 11.8 $\pm$ 1.92 dormant weevils stayed on branches compared to only 4 $\pm$ 0.71 on trunks of mango trees (Fig. 1). Among the dormant weevils that stayed on branches an average of 4.2 $\pm$ 1.64 were located at 1 m horizontal distance away from the trunk and an average of 4.8 $\pm$ 0.84 found 2 m away from the trunk (Fig. 2). The least number of weevils (average of 0.6 $\pm$ 0.55) were located at 0.5 m distance away from the trunk although some weevils were also observed up to 3 m (average of 2.2 $\pm$ 0.84) away. The mango trees that were used in the field observation had an average of 10.7 m canopy diameter this means that the weevils stayed within the inner 28% of the tree canopy diameter.

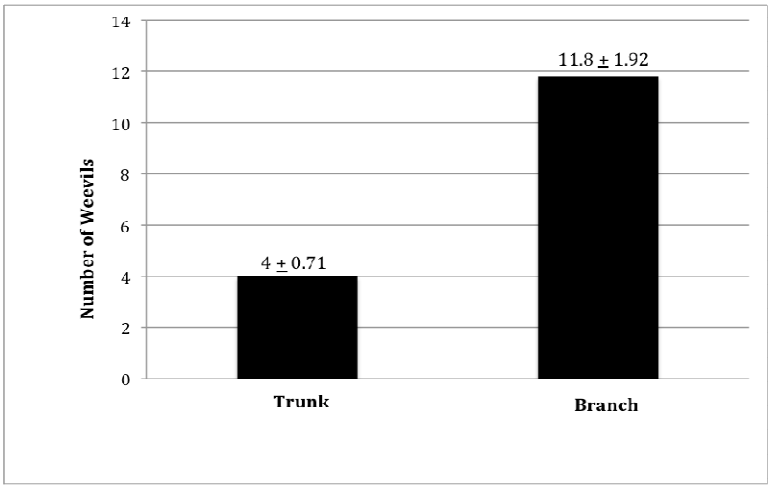

Fig. 1. Average number of MPW adults found hiding on trunk and branches of 15 yr old dormant 'carabao' mango trees (n=5).

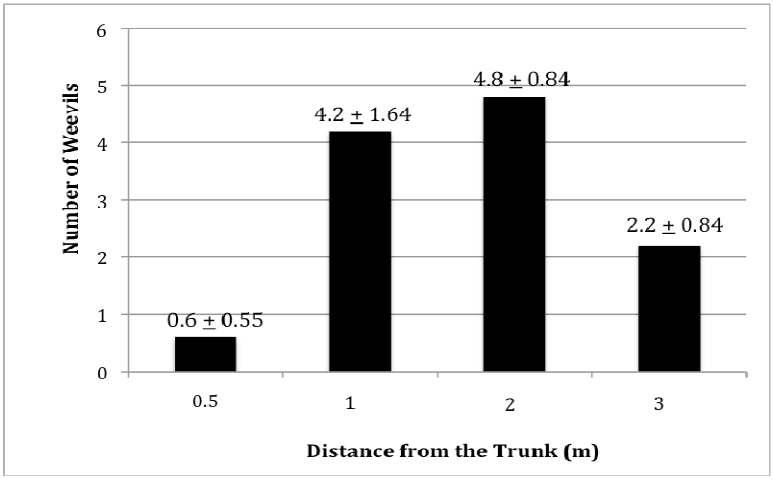

Fig. 2. Average number of MPW adults found hiding at different distances from the trunk of 15 yr old dormant 'carabao' mango trees (n=5).

This is the first report on the exact location or distance from the trunk of MPW hiding places on dormant mango trees. These findings suggests that the open-center method of pruning could be further refined because the recommendation of Medina *et al.,* 2005 for MPW control specified only the cutting of the topmost branch of the tree in order to expose the trunk and branches of mango trees to temperatures ranging from 34 - 36.5 ^{o}C to effect weevil mortality without indicating exactly the extent of the inner canopy diameter to be pruned. Our findings now show that open-center pruning would be most effective if the inner canopy has to be removed by 28% or for practical purposes at least 25% diameter to expose the weevils to direct sunlight especially towards midday when the temperature is highest.

Field observations on the height of the mango branches where dormant weevils were located showed that majority of the weevils (average of 4.8 ± 2.28) were found at the height of 2 m from the ground (Fig. 3). An average of 3.2 ± 0.45 weevils and 3 ± 2.45 weevils were found at the height of 1 m and 3 m, respectively. The least number of weevils (average of 0.8 ± 1.3) were found at the height of 0.5 m. The predominance of dormant MPW found at the height of 2 m above the ground is probably because it has little disturbance in that height since 2 m is already above the normal height of Filipinos. Also, the branches are bigger when closer to the ground than higher up the canopy and can provide better hiding places. Another factor could possibly be the temperature. The temperature under the canopy of mango trees range from 29-31 ºC (Medina *et al*., 2005). At above 2 m the temperature could probably start becoming unfavorable for MPW as sunlight penetrated into the canopy. As previously mentioned direct sunlight in Brooke's Point at 1000 – 1400 hr has a temperature range of 34.0- 35.5 ºC which cause mortality to MPW (Medina *et al.*, 2005).

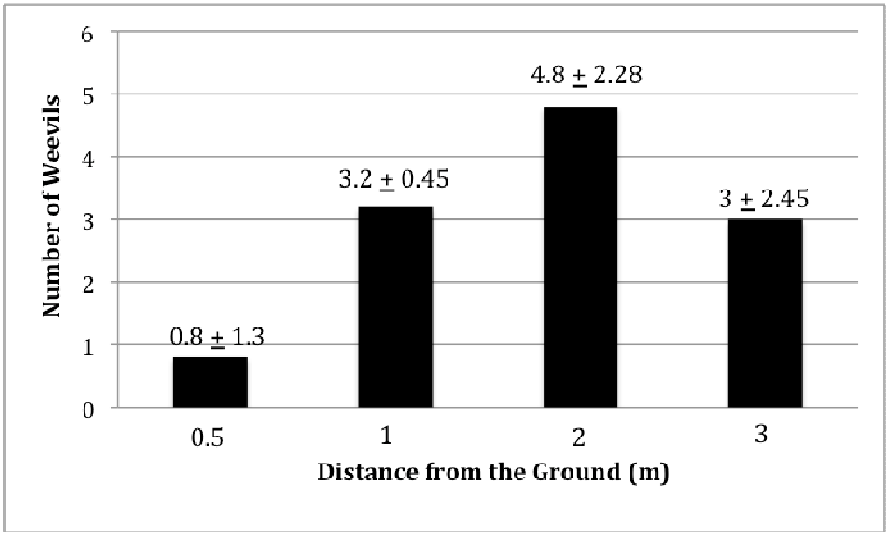

Fig. 3. Average number of MPW adults found hiding at different heights from the ground on 15 yr old dormant 'carabao' mango trees (n=5).

This is also the first report on the height of MPW hiding places within the dormant mango tree. This information strengthens the importance of improving current control strategies for the open-center pruning method of Medina *et al.*, 2005. The open-center pruning should ensure exposure of the trunk to sunlight up to 0.5 m from the ground because it also provides an optimum refuge for MPW. The information can also be useful in future experiments where bait traps for MPW will be used because this identifies the proper position of the traps within the mango tree. The only available information on intra-tree distribution of weevils was done during the fruiting stage of mango trees when MPW adults are active. No significant difference was found between height of tree and canopy direction on the mean number of weevils collected from 'carabao' mango trees (De Jesus and Cortez, 1998).

Daily Activity Pattern

There were 40 MPW adults observed for a total of 960 h for a 24 hr observation period during the dormant stage of mango trees. Resting was the most frequent activity and had the longest duration (Figs. 4 A & B). The remaining time was divided between short walk and leg movement.

Resting sites were confined to trunks and branches of mango trees. Even during rainy conditions dormant adult MPW in resting position remained immobile. During short walks MPW crawl at 1-24 inches (ave. = 6.3 inches) away from its original position. When there is leg movement of MPW adults it remains on the same spot but sometimes shift position towards the side and from upward to downward or vice versa. Apart from resting, short walk and leg movement no other activities were observed.

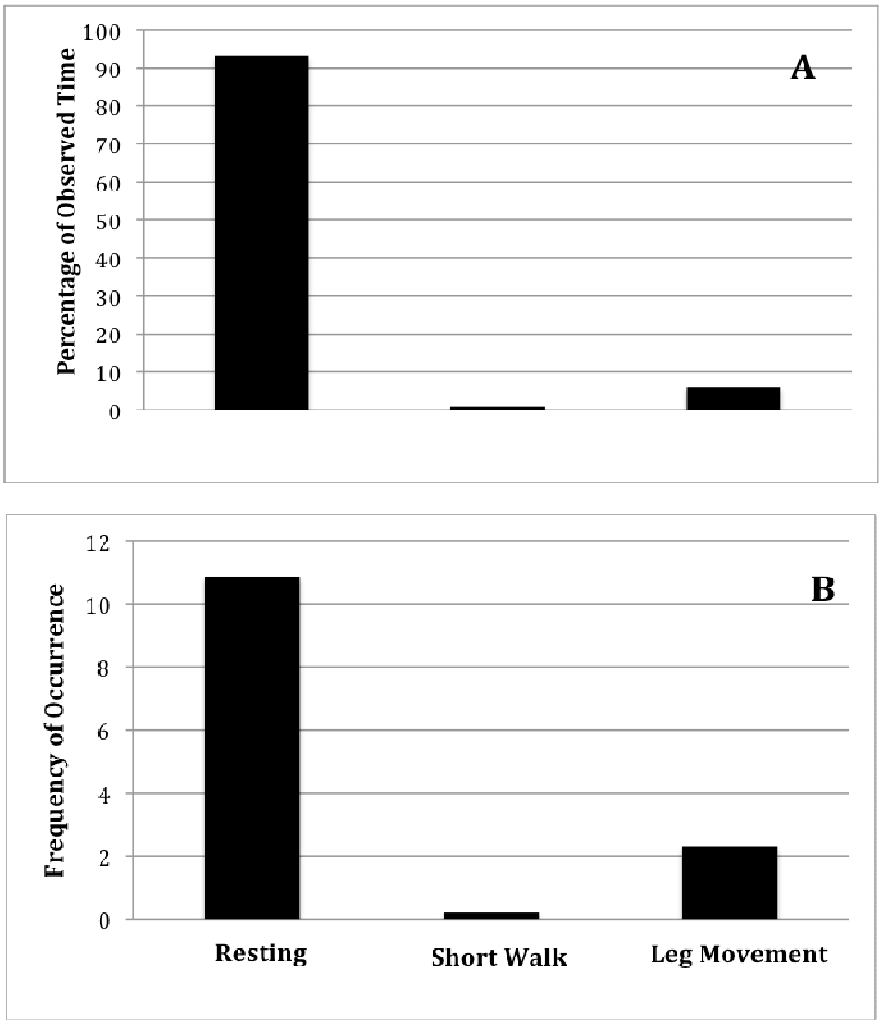

Fig. 4. (A) Percentage of observed time spent by MPW adults in each activity on branches of mango trees at dormant stage; (B) Average frequency of occurrence of each activity per MPW adult on branches of mango trees at dormant stage over 24 hr in Brooke's Point, Palawan.

The previous report on MPW indicated adult quiescence since during the dormant, flower bud-break and panicle elongation stages, there were no active weevils observed on MPW infested mango trees and only by careful examination of the tree trunk were 25 weevils found hiding individually in cracks of the bark (De Jesus *et al.*, 2003). However, the findings in this study suggests that MPW actually undergo a period of diapause and not just a simple quiescence that is an immediate response to adverse conditions as was earlier defined.

In other coleopterans such as the cotton boll weevil, *Anthonomus grandis* Boheman studies in Arkansas show that boll weevil diapause is related to changes in fruiting activity of the cotton plant. Diapause was highest as true cut-out approached (Carter and Phillips, 1973). In lepidopterous larvae and adults a link between diapause and seasonal patterns of coloration is best documented. The cryptic coloration is adaptive for adult Lepidoptera (Denlinger, 1986).

In diapause its onset, maintenance, and termination, the postdiapause developmental period, and the subsequent growth, development, and reproduction represent distinct phenological episodes in the life history of an insect species. The appropriate timing of these episodes subserves an organism's successful adaptation to favorable and unfavorable cyclic seasonal conditions in its biological and physical environment (Tauber and Tauber, 1976).

The MPW become active at full-bloom stage of mango flowers to feed while mating and oviposition occurs at fruit development stage when it attains the size of the chicken egg (De Jesus *et al.*, 2003). Availability of food and oviposition sites is influenced by mango tree phenology. This confirms with Delinger (1986) that diapause emerges as a potential development mechanism for both circumventing adversity and synchronizing the seasonal cycles of tropical species. The insects's habitat as well as availability of food and oviposition sites may be influenced profoundly by seasonal rhythms. Seasonal patterns of development also optimize reproduction efficiency by synchronizing mating.

CONCLUSION

During dormant stage of the mango trees there are more adult MPW found hiding on branches compared to trunks of mango trees. Among the adult MPW that stayed on branches an average of 4.2 $\pm$ 1.64 MPW were located at 1 m horizontal distance away from the trunk and an average of 4.8 $\pm$ 0.84 MPW found 2 m away from the trunk.

It is thus recommended that open-center pruning would be most effective if the inner canopy has to be removed by at least 25% diameter to expose the weevils to direct sunlight especially towards midday when the temperature is highest. On the other hand, this information can also be useful in future experiments where bait traps for MPW will be used because it also identifies the proper position of the traps within the mango tree.

Resting was the most frequent activity and had the longest duration for adult MPW during dormant stage of mango trees. The remaining time was divided between short walk and leg movement. This behavior suggests that MPW actually undergoes a period of dormancy that is specifically a diapause and not just a simple quiescence because it was not likely an immediate response to adverse conditions.

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REFERENCES

Basio, R. G., P. J. Johnson, D. R. Padua, H. T. Bergonia, C. C. Diloy, and E. L. Villegas. 1994. Mango pulp weevil [Sternochetus frigidus (Fabr.)] (Curculionidae, Coleoptera) found in Palawan. Phil. Ent. 9(3): 350-351.

Carter, F. L., and J. R. Phillips. 1973. Diapause in the boll weevil, Anthonomus grandis Boheman, as related to fruiting activity in the cotton plant. Arkansas Academy of Science Proceedings. 27: 16-20.

De Jesus, L. R. A., and F. Cortez. 1998. Field infestation and chemical control of the mango pulp weevil, *Sternochetus frigidus* (Fabr.), in Palawan. The Philipp. Agric. 81(3&4): 131-140.

De Jesus, L. R. A., and R. R. Gabo. 2000. Life history and host range of the mango pulp weevil, *Sternochetus frigidus* (Fabr.) in Palawan, Philippines. Philipp. Agric. Scientist. 83(2): 145-150.

De Jesus, L. R. A., S. M. F. Calumpang, J. R. Medina, and Kanju Ohsawa. 2003. Feeding and reproductive behavior of the mango pulp weevil, *Sternochetus frigidus* (Fabr.) at different phenological stages of mango *Mangifera indica* L. Philipp. Agric. Scientist. 86(3): 282-289.

Denlinger, D. L. 1986. Dormancy in tropical insects. Ann. Rev. Entomol. 31: 239-264.

Denlinger, D. L. 2008. Why study diapause? Entomol. Res. 38(1): 1-9.

Kalshoven, L. G. E. 1981. Pests of crops in Indonesia. Jakarta: Van Hoeve. 507 p.

Medina, J. R., O. S. Opina, L. R. A. de Jesus, and S. M. F. Calumpang. 2005. Development of an integrated pest management program for mango in Palawan, Philippines. Philipp. Agric. Scientist. 88 (4): 453-461.

Tauber, M. J., and C. A. Tauber. 1976. Insect seasonality: diapause maintenance, termination, and postdiapause development. Ann. Rev. Entomol. 21: 81-107.