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NATALITY STUDY OF FEMALE COCOA POD BORER RELATED TO CLIMATE CHANGES

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ABSTRACT - *This study was carried out in two different times. The first study was carried in year 1993 at Quoin Hill Research Station Tawau. The second times of study was carried out in year 2017 at Cocoa Research and Development Centre, Tawau. The experiment was repeated using similar method with the previous study. Three (3) studies were carried out on egg stage of Cocoa Pod Borer (CPB). Study were carried out on fecundity of CPB on actual and potential egg of the female CPB, egg laying pattern of the CPB and egg mortality of the CPB. The result was compiled to compare either the egg laying activities of Cocoa Pod Borer (CPB) change in 24 years times. This study was carried out to compare the natality, fecundity, fertility and mortality of the CPB egg within 24 years times. Results from this study showed that the climate change may give an impact on fecundity of CPB on actual and potential egg in 24 years times. It is shown that the total number of egg laid by female CPB was reduced tremendously. Climate change within 24 years times also affected on egg laying pattern by female CPB. It caused that the female CPB reduce the capability to laid egg in longer period. It showed that the female CPB are less productive to laid egg in longer period. It is shown that the changes in temperature might change the capability of female CPB in duration of egg laying process. Study on CPB egg mortality showed that climate change has not affected the egg mortality factor during the last 24 years.*

Keywords: Cocoa pod borer, egg, fecundity, mortality, climate change.

INTRODUCTION

Natality is considered or defined as the number of births rate of the proportion of births to some segment of the general population (John *et al*., 2014). It is also known as the number of living egg laid. Natality also known as the reproductive rate or the number of young produced per reproductively mature female of animals. Fertility and fecundity can also define under natality study. Fertility describe as the number of viable eggs laid by female. Meanwhile, fecundity is known as measure of the total egg production by the female and it is always easier to calculate (Southwood, 1978). Some insect where the eggs are matured on emergence or during laying process, the total potential fecundity may calculate directly by keeping females caged under laboratory.

Potential fecundity of female also can be measured directly under natural condition as possible in the field to record the total number of eggs laid (Huffaker and Spritzer., 1950; Spiller, 1964). Whereas, some insect such like CPB, total potential fecundity calculated two ways by direct counting and estimated the number of ovaries (Davidson, 1956). Estimation of the ovaries can be done by dissecting the sphermatophore inside the reproductive organ of the female dead CPB after egg laying process is complete. Direct counting on the number of egg laid by the female CPB can be conducted either in laboratory or in the cocoa field.

Fertility of the CPB can be measured by viable eggs distinguished from non-viable ones (Fewkes, 1964). Fecundity factor can be included egg cannibalism which can interfere the fecundity estimation. This can be calculated by a known number of marked eggs (Rich, 1965). One of the major factor affected the rate of oviposition is climate especially temperature. This study was carried out to compare the natality, fecundity, fertility and mortality of the CPB egg within 24 years times. In fact, study by

(Meriam, 2017; Meriam, 2018) showed that the composition of the insect in Madai and composition of ants in Tawau was affected by the climate change. Study by (Curtis and Abby, 2019) and (Curtis *et. al.*, 2018) showed that global warming could increase both the number and appetite of insect pests. This study also showed that for the three most important grain crops such as wheat, rice, and maize, the yield lost to insects will increase by 10 to 25% per degree Celsius of warming in the temperate zone. Study by (John *et. al.*, 2019; Nigel *et. al*., 2013; Sigrid and Axel, 2010) also showed that climate change will give biological impact on many aspects of insect and other animal life history. Therefore, this study was carried out in year 1993 at Quoin Hill Research Station Tawau to compare with the study conducted in year 2017 at Cocoa Research and Development Centre, Tawau.

MATERIALS AND METHODS

Study on egg stage of CPB

a. ***Fecundity study on actual and potential egg of the female CPB***

Three pairs of male and female CPB which is merged from rearing pupa cage 48 hours for mating. Female CPB then transfer into the cage which is contain hang cocoa pod for egg laying. Cocoa pod replace with a new one and with new female CPB and examined every day for egg. Adult CPB were feed with honey solution as food source. Dead female CPB were dissected under the microscope for ovarioules as a potential egg. The same process in year 1993 was repeated in year 2017. Matured cocoa pod was hanged up into the plastic aquarium tank as a cage for egg laying process (Figure 1(a)).

It was examined every day up to eight day and the number of egg lay recorded Figure 1 (b). Figure (c) showed close up photos of pair CPB with cocoa pod hanged in the plastic aquarium cage. Figure (d) showed the dead female CPB was dissected under the microscope for ovarioules as a potential egg. Figure (e) showed the newly dead female of CPB ready to be dissected under the microscope. The gravid female of CPB newly dissected to be exposed the ovarioules shown in Figure 1 (f). Figure (g) showed closed up ovarioules pull out from the sphermatophore inside the reproductive organ of the female CPB.

Three pairs of male and female CPB which is emerged from rearing pupa were cage for 48 hours for mating. Female CPB was then transfer into the cage which contain hang cocoa pod for egg laying. After 24 hours hang in the plastic aquarium tank, cocoa pod was replaced with a new one and examined every day for egg. Adult CPB was feed with honey solution as food. Dead female CPB was dissected under the microscope for ovarioules as a potential egg by female CPB. The same process in year 1993 was repeated with new female CPB in year 2017.

Figure 1 (a)

Figure 1 (b)

Figure 1 (c)

Figure 1 (d)

Figure 1 (e)

Figure 1 (f)

Figure 1 (g)

Figure 1(a-g): Actual and potential egg process.

Egg laying pattern of the CPB

The process was similar with study 1(a) on actual and potential CPB egg laying. Cocoa pod replace with a new one and examined every day until no egg laid by female CPB. Total number of egg laid by female CPB was recorded daily. Adult CPB were fed with honey solution as food. The same process in year 1993 was repeated with new female CPB and in year 2017.

Egg mortality study of the CPB

For egg laying process, three (3) pairs of adult CPB was caged to the cocoa pod under natural field condition. The cocoa pod contains CPB eggs expose to the egg mortality factors up to three days (3). Then, the cocoa pods were brought back to the laboratory. The cocoa pod with CPB eggs were cut into a small pieces then placed in the petry dish and checked under the microscope for egg hatchability and egg mortality factors. The same process in year 1993 was repeated with new female CPB in year 2017.

Figure 2 (a) showed the female CPB cage to the cocoa pod in field condition using muslin cloth for egg laying. The cocoa pod was protect from mammalian pest and rainfall using the wire mesh cage and cover with a plastic sheet. It was shown in Figure 2 (b). The cocoa pod was examined daily for the CPB egg as shown in Figure 2 (c) then the CPB egg egg was marked as a cycle as shown in Figure 2 (d). Figure 2 (e) showed that the cocoa pod contain CPB egg cut into small pieces and placed in the petry dish. The CPB egg was examined for egg mortality under the microscope. It is showed in Figure 2 (f).

Figure 2 (a)

Figure 2 (b)

Figure 2 (c)

Figure 2 (d)

Figure 2 (f)

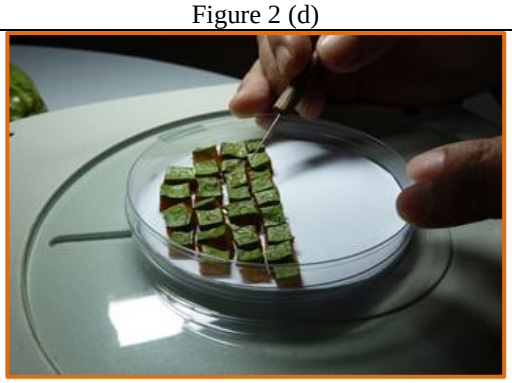

Figure 2 (g)

Figure 2 (a – g): Egg mortality study carried out under field condition.

RESULTS AND DISCUSSION

Study on egg stage of CPB
a. Actual and potential egg of the CPB

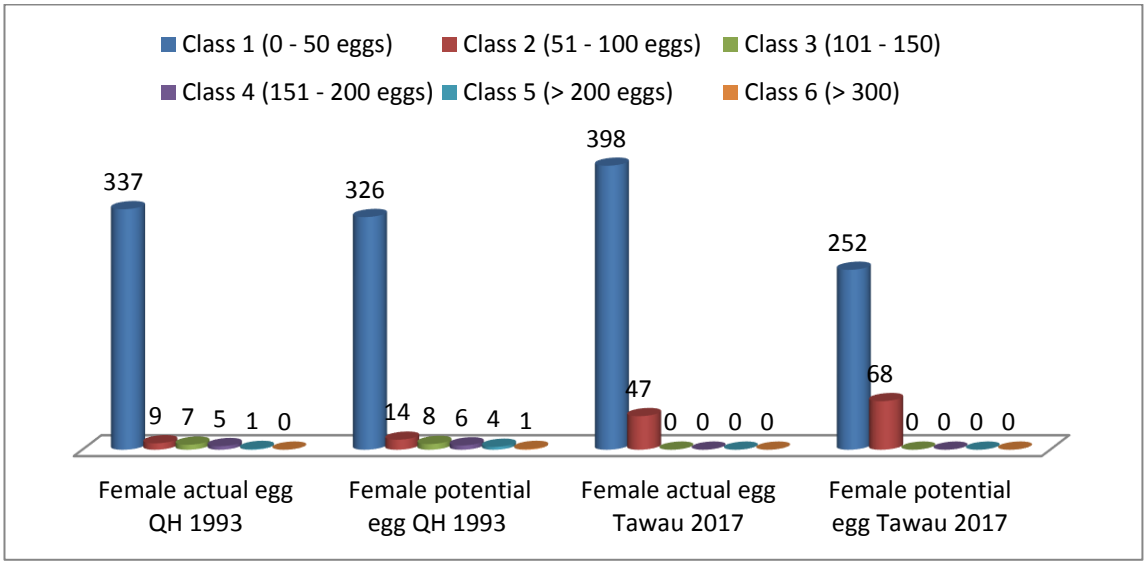

Figure 3: Potential and actual number of egg lay by gravid female CPB.

This study showed that most of the total number of egg laid by the gravid female fall in class 1 and class 2 which the total number of egg is in range from 0 to 100 eggs. Result from study in year 1993 showed that the gravid female from cocoa area at Quoin Hill Tawau had a potential to have total number of eggs fall in Class 6 which is total number of egg are more than 300 eggs. Whereas, study carried out in year 2017 showed the gravid female from Tawau only have total number of egg fall in Class 1 and 2. This result showed that gravid female from Tawau cocoa area had less total number of egg compared to the gravid female from Quoin Hill cocoa area. Even CPB found mated more frequent but the total number of egg laid by female CPB is reduced tremendously from year 1993 to year 2017. Study by (8) and (9) showed that the temperature was increased 2^0C within year 1993 and year 2017 in Tawau area. Result in Figure 3 also showed that increasing of temperature will give an impact on the decreasing the total number of egg lay by female CPB.

b. *Egg laying pattern of the CPB*

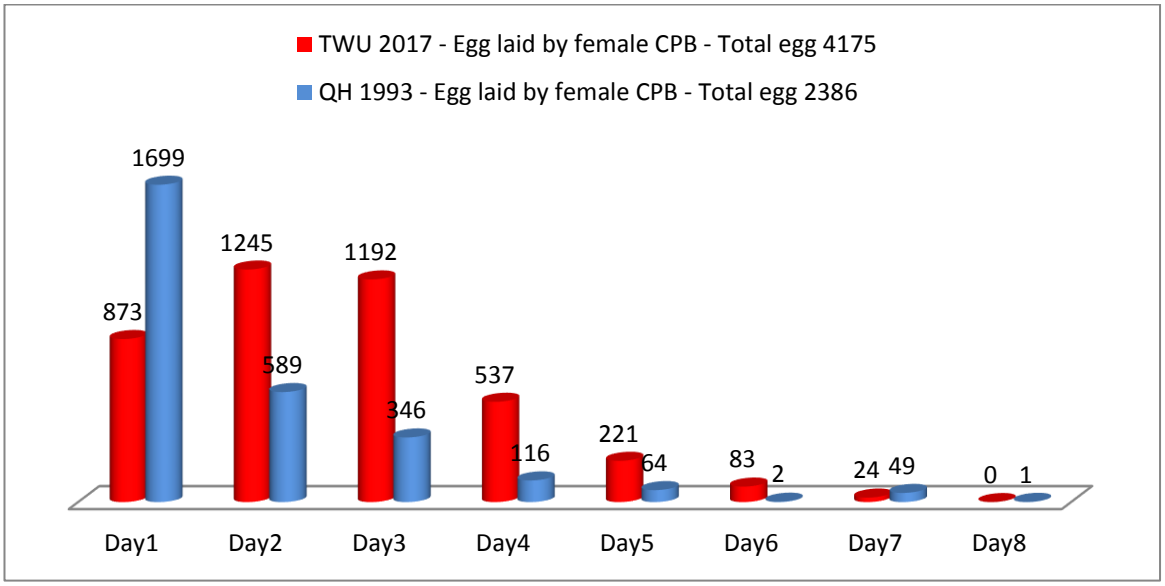

Figure 4: Egg laying pattern of CPB

Result from this study showed that highest egg produced by gravid female CPB on day 1, day 2 and day 3 after mated at least 24 hours. This result also showed that after mated at least 24 hour, study in year 2017 found that female CPB from Tawau only capable to laid egg up to day 7 compare to study in year 1993 showed that female CPB from Quoin Hill capable to laid egg up to day 8. This result showed that female CPB from Quoin Hill capable to lay egg longer than female from Tawau. Result from Figure 4 showed that highest number of eggs laid by female CPB from Tawau is on day 2 followed by day 3 and day 1 and decreasing tremendously from day 4 up to day 7. This study showed that the change in temperature would reduce the capability of female CPB to lay egg in longer period. Study by (John *et al*., 2014) and (Meriam, 2017) showed that the increasing temperature by 2^0C in Tawau area within 24 years' time will reduce a day of the capability for female CPB to lay egg from 8 to only 7 days.

c. *Egg mortality study of the CPB*

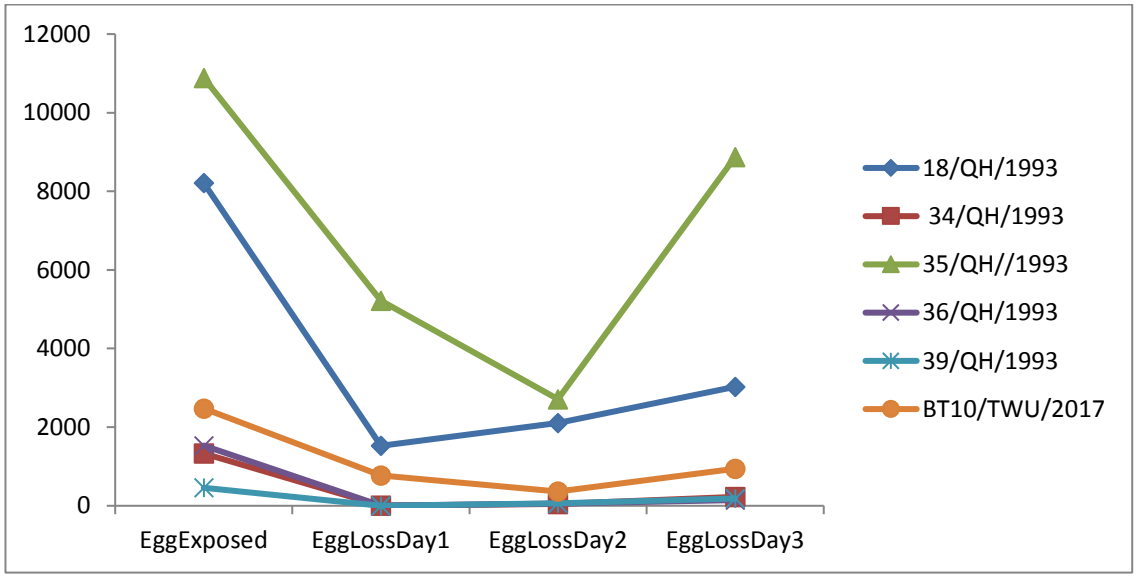

Figure 5: Egg mortality of CPB by duration under field condition.

Result study on egg mortality of CPB egg at germplasm area CRDC Tawau in year 2017 from Figure 5 showed similar pattern of CPB egg losses with the study which is conducted in year 1993 at five (5) different fields at cocoa area in Quoin Hill Tawau. The result showed that CPB egg lost due to the predator was higher on day three (3) after released in the field. This result may be consequences by the time of the egg going to had hatched on day three (3) after laid by the gravid female (Roger, 1985). Study by (Enid and Wigglesworth, 1913) proved that a spoon-shaped depression often appears on either side of the insect egg a few days before hatching and even up to the time of hatching, the egg can be deformed by the slightest force the embryo certainly increases in size very rapidly before hatching. This is the reason why the insect egg easily detected by the predator on the third day after laid by the gravid female.

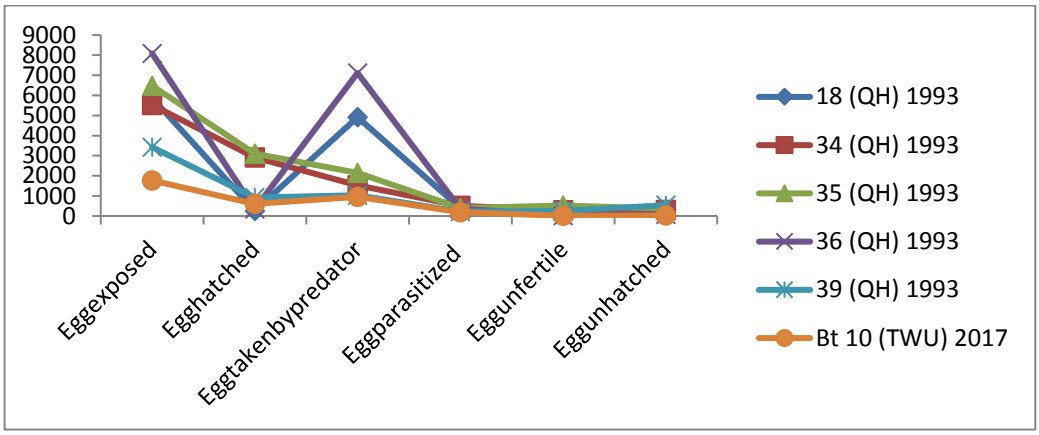

Figure 6: Egg mortality of CPB by natural factor under field condition

Study in year 2017 at CRDC Tawau on egg mortality of CPB showed the similar trend of study carried out in year 1993 at Field 18 and Field 36 Quoin Hill for total number egg hatched, egg taken by the predator, egg parasitized by the egg parasitoid, egg unfertile and egg un-hatched. Mostly, number of egg taken by the predator is higher compared to others CPB egg mortality factors. Only at Field 34 and 35 Quoin Hill showed the result which is total number of egg hatched are higher compared to the other field. This results showed that natural enemies such as ants, praying mantis, spider and other natural enemies exist abundantly in cocoa field which is seldom use chemical as management agent for controlling insect infestation. For record, Field 18 and 36 Quoin Hill and germplasm field CRDC Miles 10 Tawau using an egg parasitoid as biological control agent for CPB management. Result from Figure 6 showed that the changes in climate within 24 years' time especially on the increasing of temperature would not give an impact on the trend of mortality for CPB egg due to natural mortality factors such as by predator and parasite.

CONCLUSION

The result from actual and potential egg showed that in 24 years times the total number of egg laid by female CPB was reduced tremendously. This may be due to climate in Tawau area especially temperature was increased within this period of time (Meriam, 2018). Result from study on egg laying pattern by female CPB showed that the female CPB reduce the capability to laid egg in longer period within 24 years times. It showed that the female CPB are less productive to laid egg in longer period. It is showed that the changes in temperature might change the capability of female CPB in duration of egg laying process.

The result on egg mortality study showed that CPB egg lost due to the predator was higher on day three (3) after released in the field. This situation happened because of a spoon-shaped depression often appears on either side of the insect egg a few days before hatching and even up to the time of hatching. The egg also can be deformed by the slightest force the embryo certainly increases in size very rapidly before hatching. This is the reason why the insect egg easily detected by the predator on the third day after laid by the gravid female.

Study on egg mortality of CPB showed the similar for total number egg hatched, egg taken by the predator, egg parasitized by the egg parasitoid, egg unfertile and egg un-hatched. Mostly, number of egg taken by the predator is higher compared to others CPB egg mortality factors. This results showed that natural enemies such as ants, praying mantis, spider and other

natural enemies exist abundantly in cocoa field which is seldom use chemical as management agent for controlling insect infestation. This result also showed that the climate change not much affected the egg mortality factor within 24 years times.

REFERENCES

Curtis A. D; Joshua J.T; Michelle T; David S.B; Scott C. M; Raymond B.H. and Rosamond L.N, 2018. Increase in crop losses to insect pests in a warming climate. *Science* 2*018:* (361) 6405, pp. 916-919. DOI: 10.1126/science.aat3466.

Curtis P. and Abby S., 2019. Climate Change and Agriculture: Promoting Practical and Profitable Responses III - Climate Change Effects on Insects and Pathogens. Climate Change Effects on Insects and Pathogens - panna.org www.panna.org/sites/default/files/CC insects...

Davidson A., 1956. A method of counting Ephemeropteran eggs. *Ent. Mon. Mag.* 92, 109.

Enid K.S and Wigglesworth V.E., 1913. The hatching of insects from the egg and the appearance of air in the trachea system. London School Hygiene and Tropical Medicine. Pp. 165 - 192.

Fewkes D.W., 1964. The fecundity and fertility of the Trinidad sugar-cane froghopper *Aeneolamiaxaria saccharina* (Homoptera: Cercopidae) *Trop. Agriculture. Trin.* 41, 165-8.

Huffaker C.B. and Spritzer C.H. 1950. Some factors affecting red mite populations on pears in California. *J. Econ. Ent.* 43, 819 – 31.

John M.M; Alan M.S. and Pamela P., 2019. High natality rates of endangered Steller Sea Lions in Kenai....alaskafisheries.noaa.gov/sites/default/files/...

John M.M; Alan M.S; Pamela P.; Milo D.A. and Daniel E.C., 2014. A longitudinal study of Steller Sea Lion natality rates in the Gulf of Alaska with comparisons to census data. PLoS One. 2014; 9(11): e111523. Published online 2014 Nov 10. doi: 10.1371/journal.pone.0111523. PMCID: PMC4226517. PMID: 25383865.

Meriam M.Y. 2017. The changes of ant composition in cocoa germplasm area in 11 years' time – Related to climate change. 23 – 26 October 2017. MASW 2017. Hotel Grand Borneo, Kota Kinabalu, Sabah.

Meriam M.Y. 2018. Changes in Weather Pattern Affect Insect Composition in Madai, Sabah. Pelita Perkebunan 34 (1) 40 - 49.

Nigel R.A; Sarah J.H; Matthew B; Md Habibullah B; Emma V. R; Myung P. J.; Chris F; Michelle Y. and Mohammad K., 2013. Assessing insect responses to climate change: What are we testing for? Where should we be heading? *Peerj*. 2013; 1: e11. Published online 2013 Feb 12. doi: 10.7717/peerj.11 . PMCID: PMC3628384. PMID: 23638345.

Rich E.E., 1956. Egg cannibalism and fecundity in Tribolium. Ecology 37, 109 – 20.

Roger K.D, 1985. Control of the Cocoa Pod Borer *Conopomorpha cramerella*. PhD Thesis. University of London. 330 pp.

Sigrid N. and Axel S., 2010. Potential effects of climate change on insect herbivores in European forests-General aspects and the pine processionary moth as specific example. Science Direct 259, (4), Pp. 831-838.

Southwood T.R.E. 1978. Ecological Methods. With Particular Reference to the Study of Insect Population. The English Language Book Society and Chapman and Hall. *The university Printing House, Cambridge.* 523 pp.

Spiller D. 1964. Numbers of eggs laid by *Anobium punctatum* (Degeer). *Bull. Ent. Res.* 55, 305 – 11.