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Effect on the Development and Survival of the Bagworm, *Metisa plana* (Lepidoptera: Psychidae) in Different Temperature

[1]Cynthia Eja Enting, [2]Siti Noor Hajjar Md Latip
[1]Faculty of Plantation and Agrotechnology,
[2]Crop Protection Research Group, Faculty of Plantation and Agrotechnology,
Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
noorhajar@uitm.edu.my

Abstract: *Metisa plana* (bagworm) is one of the major defoliator pest problems in the Malaysia oil palm plantation. Evolution occurs in the life cycle of this species make its presences are unpredictable and overlooked until it caused heavy defoliation to the infected plant. It could bring losses in the yield about 50% and take several years for the full recovery. Behavior and physiological adaptation such as temperature is one of the important abiotic factors in determines the life cycle, feeding behavior and survival of this species. Hence, it is significant to study the fundamental information on biology of this bagworm species, *Metisa plana*. This study will guide the growers to identify the exactly time to apply pesticides based on the climate changes by referring to the life cycle of bagworm, particularly, the stage that caused major damage to palm oil. The main objective of this study is to evaluate the effect of temperature on the development and survival of bagworm, *Metisa plana*. This species was observed and reared in a range of temperature between 20-36°C in the laboratory. This study was conducted from October 2017 until October 2018. Regression analysis was used to determine the relationship between temperature and the rate of life cycle duration of development. Result shows that bagworm completed its life cycle in a range of temperature between 20-36°C but did not survive in temperature under 16 and 40°C. The duration life cycle of this bagworm was significantly decreased with increased in the temperature. The optimum temperature recorded was between 32-36°C. Lowest mean of life cycle duration was recorded at 36°C. The highest percentage in bagworm's survival was recorded at 32°C. Thus, bagworm have evolved in both physiological and behavior to survive in extreme condition. This information can act as a benchmark and guideline, especially for oil palm growers to plan better strategy in pest management to control this bagworm at the right time. Hence, growers can prevent this species of bagworm outbreak from occur.

Key words: Temperature, development, survival, bagworm, *Metisa plana,* feeding behavior

INTRODUCTION

Generally, external temperature influenced the metabolic and physiological processes of living organism. Changing of external temperature in environment define the responds of insect's growth and development to make different types of adaptations in order to survive (Ibrahim *et al*., 2013). Hence, weather is one of the important factors to determine the insect behavior activity, geographic distribution and abundance (Sheikh *et al*., 2017).

Now a days, the climate change in the Malaysia is inconsistency and unpredictable. The temperature of our environment had become a lot warmer than before. Bagworm, *Metisa plana* reported having its outbreak in oil palm plantation in the year 2017 and had caused yield losses, especially to the growers. The abundance number of this defoliator upcoming generation species is hardly to predict. Thus, the number of pest population could increase in a short periodic of time. Beside, this crop loss will usually occur and noticeable due to extensive defoliation of serious attack by bagworm during the outbreak (Kamarudin and Arshad, 2016). This bagworm species has been reported as one of the dominant pest of oil palm in Southeast Asia.

Most of the FELDA estates in Malaysia are having this kind of problem (Noor *et al*., 2013). Hence, the bagworm population needs to be controlled in order to decrease the defoliation of the infestation. Thus, a lot of study is needed to give information in the bagworm

Corresponding Author: Siti Noor Hajjar Md Latip, Crop Protection Research Group, Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia, noorhajar@uitm.edu.my

development in order to identify when the right time to control the population. This research could become good references to prevent bagworm's outbreak and reduce oil palm from major attack. However, there is still lacking in the details study on the effect of temperature influence toward the development and survivorship of bagworm. Hence, the aims of this study are to evaluate the effect of temperature on the development and survival of bagworm, *Metisa plana*.

MATERIALS AND METHODS

Locations of sampling site: The samples were collected at FELDA Besout Sungkai, Perak where the outbreaks of bagworm, *Metisa plana* were occurring. Newly mated pupae of *Metisa plana* were collected from October 2017 until October 2018 and reared in the controlled laboratory condition.

Preparation of room different constant temperature: The pupae were reared and studied under different constant temperature such as at 16, 20, 24, 27.5, 32, 36 and 40°C in the laboratory. All temperatures were monitored every 8 h. Besides, the humidity of laboratory was monitored daily and maintained above 75% Relative Humidity (RH).

Rearing methodology of bagworm, *Metisa plana*: All of the mated pupae were put each in the clear plastic cup capped with small holes and placed it in the collapsible rearing cage. Five replications were examined under each treatment of temperature. The pupae were observed daily until the eggs hatched. The eggs hatching's day for each treatment were recorded. The number of neonate emergences also recorded for each temperature. Each of oil palm leaflets contained about five larvae. The leaves of the oil palm were place in upright position and changed every 3 days to maintain the freshness food sources for the bagworm. In this study, the larvae was studied undergo six instars stages. Both length of the case and length of caterpillar were measured daily in millimeter (mm) to identify the instars stages of the *Metisa plana* larvae. The identification was indicated based on Kok *et al.* (2011). The duration and survival rate of bagworm were observed and recorded at each of the stages. The relationship between temperature and the rate of development from birth to death were determined through regression analysis (Ibrahim *et al.*, 2013). Data between temperature as treatment and development in each growth stages was analyzed using one-way ANOVA at significant different, 0.05.

RESULTS AND DISCUSSION

Development growth of *Metisa plana*: Result in Table 1 shows that temperature in 16 and 40°C; the eggs of *Metisa plana* were unable to emerge due to the extreme temperature condition. Generally, insect unable tolerate in certain extreme temperature due to inactivation rate of biochemical reactions and physiological process (Sheikh *et al.*, 2017). The result is significant and aligns with finding by Ibrahim *et al.* (2013). The duration life cycle of *Metisa plana* was significantly decreased with increased in the temperature between the ranges at 20°C until 36°C. The duration of eggs emergences stages is shorter when the temperature is higher between 20°C until 36°C. The lowest mean duration of developmental stages is recorded at 36°C. Through observation the bagworm was more active at this high temperature that forces this species to feed on the oil palm leaves vigorously. Moreover, found that bagworm is more active feeding especially during evening. Meanwhile, the highest mean is recorded at temperature 20°C.

Result shows, the larvae stages of *Metisa plana* in this study is shorten when the temperature is increasing. Hence, increasing the temperature will usually shorten the stages of larval in the insect life cycle (Jaworski and Hilszczanski, 2013). The outbreak will occur especially at warmer weather. Hence, chemical control is widely use as

Table 1: Duration (days) of egg, larvae, pupa and adult stages of *Metisa plana* at different constant temperature

Development stages	Temperature (°C±1°C)						
($\bar{x}$ days±SE)	16	20	24	27.5	32	36	40
Egg emergences	0	17±0.79a	15±1.01b	11.2±0.63c	9±0.79d	6.8±0.31e	0
Instar 1-2	0	32.2±0.63a	29.8±1.19b	25.2±0.94c	18±1.41d	14±0.89e	0
Instar 2-3	0	49.4±1.30a	46.6±1.59b	41.0±0.00c	29±1.08d	23.4±1.59e	0
Instar 3-4	0	67.2±1.19a	62±1.67b	55.8±0.51c	41.8±1.46d	33.6±1.93e	0
Instar 4-5	0	82.6±1.49a	74.8±1.14b	67.6±1.89c	53.2±1.40d	42.6±2.36e	0
Instar 5-6	0	97.8±2.09a	87.8±1.66b	79.6±1.85c	65.4±1.26d	52.2±2.19e	0
Instar 6 to pupae	0	111.2±2.02a	99.8±2.15b	91.4±2.36c	74.4±1.78d	59.4±1.17e	0
Pupae to adult	0	122.2±0.87a	108.4±1.74b	99.6±1.89c	81.2±1.70d	64.8±1.25e	0

Means within rows for each species followed by the same letters are not significantly different at p = 0.05 using one-way ANOVA

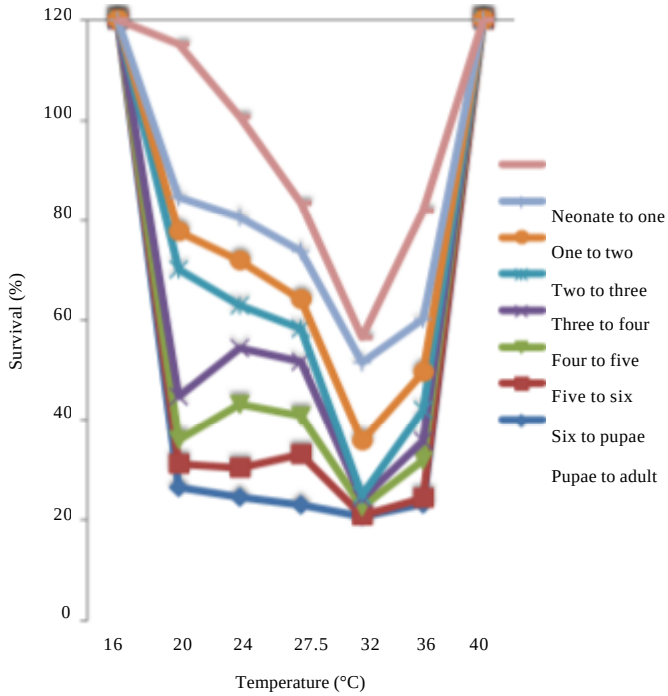

Fig. 1: Survival of *Metisa plana* at various stages of development at different constant temperature

it is the most effective and fastest method to prevent heavy defoliation from occur. However, it can caused pollution, hard to degrade and bring harmful to human health in a long term (Felsot and Racke, 2007). Hence, through this study the application of chemical to control bagworm will be reduced due to decreasing of outbreak.

Through one-way ANOVA analysis at 95% confidence level, there is significant different between the growth development and different constant temperature. Hence, observed that temperature shows different result of *Metisa plana* in life cycle. However, the development stages in each temperature of this bagworm shows no significant different. Thus, through this one-way ANOVA analyzed that temperature does play important role in determine the growth development and survival rate of bagworm, *Metisa plana*.

Survival rate of *Metisa plana*: In Fig. 1, temperature at 16 and 40°C shows the mortality result of *Metisa plana*. Recorded that *Metisa plana* not able to adapt and survive at this temperature. Temperature at 20°C recorded the lowest percentage at 5% only able to become adult stage. However, compare to previous study about 2.7% of survival rate had increased at 20°C of temperature (Ibrahim *et al*., 2013). In this study the graph recorded temperature at 32°C shows the highest percentage at 63% of bagworm's survival able to reach adult stages. However, based on the previous study by Ibrahim *et al*. (2013), the optimum temperature treatment was at 30°C. Besides, in this study observed that *Metisa plana* behavior in feeding activity is increasing when the temperature is higher, especially, at first instar until third instar. Observed that the new born larvae (neonate) were moved actively (Kok *et al*., 2011) and construct a self-enclosing bag before they start to feed as soon it crawl out from the case of female parent (Rhainds *et al*., 2009). However, some of the neonates observed were weaker and unable to develop to first instar stages of larvae. This is due to failure to construct its own bag. The bagworm's bag plays important role as the portable armour from the external physical barrier (Sugiura, 2016).

Hence, in a few years *Metisa plana* had become more successful and can adapt well at such temperature. Furthermore, the environment in Malaysia had become warmer and this enable for this species more successful to increase its survival rate. Thus, *Metisa plana* probability of outbreak to occur is high at this range of optimum temperature and become one of the potential major host plants, the oil palm (Ibrahim *et al*., 2013). Hence, it will bring losses in the yield about 50% at 4-6 months after the attack and will take several years for the full recovery of the area been infested (Kalidas, 2012). Besides, through this research the survivorship and mortality of this species could be predicted based on the climate temperature.

Table 2: Regression analysis of egg, larvae, pupa and adult stages of *Metisa plana*

Stages	Linear equation	R^2
Egg emergences	y = -2.64x+19.72	0.9889
Instar 1	y = -2.2x+18.6	0.8743
Instar 2	y = -2.12x+20.44	0.8937
Instar 3	y = -1.78x+19.54	0.9683
Instar 4	y = -1.42x+16.34	0.9349
Instar 5	y = -1.2x+16	0.8867
Instar 6	y = -1.54x+15.3	0.9364
Pupae to adult emergences	y = -1.3x+11.9	0.9602
Egg to adult	y = -14.12x+137.68	0.9827

Regression analysis: Table 2 shows the regression analysis of relationship between temperature and the rate of development *Metisa plana* in each stage. In this study, all R^2 value are almost near to 1 value in all development stages between temperature shows the strong correlation goodness of fit between two models. Ibrahim *et al.* (2013) prove the suggestion from Campbell *et al.* (1974), that data study under constant temperature is fair reflection with the field data if the former lies within the linear zone of the development rate temperature curve. Hence, all development stages in this study were fulfilled this fair condition. The R^2 value of egg to adult stages is at 0.9827. Thus, this means 98% of the variation in the dependent variable (development growth) can be attributed to the variation in the independent variables (temperature). Pupae to adult stages shows the linear line at y = -1.3x+11.9. The gradient of the linear line is sloping and shows that the duration of the *Metisa plana* from pupae to adult is decreasing when the temperature is higher from the range between 20°C until 36°C. However, the survival percentage of *Metisa plana* shows the rate of the survival is fluctuate at temperature 36°C, after increasing between 20°C until 32°C.

CONCLUSION

This study will give better understanding on temperature effect to the life cycle of bagworm, *Metisa plana*. Hence, this will provide essential fundamental information to predict the next cycle generation of this species by referring to the climate changes. Besides, through this study the information can act as a benchmark and guideline in formulating control strategies, especially in pest management.

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REFERENCES

Campbell, A., B.D. Frazer, N. Gilbert, A.P. Gutierrez and M. Mackauer, 1974. Temperature requirements of some aphids and their parasites. J. Applied Ecol., 11: 431-438.

Felsot, A.S. and K.D. Racke, 2007. Chemical Pest Control Technology: Benefits, Disadvantages and Continuing Roles in Crop Production Systems. In: Crop Protection Products for Organic Agriculture, Felsot, A.S. and K.D. Racke (Eds.). American Chemical Society, Washington, USA., ISBN13:9780841238817, pp. 1-18.

Ibrahim, Y., H.C. Tuck and K.K. Chong, 2013. Effects of temperature on the development and survival of the bagworms Pteroma pendula and *Metisa plana* (Lepidoptera: Psychidae). J. Oil Palm Res., 25: 1-8.

Jaworski, T. and J. Hilszczanski, 2013. The effect of temperature and humidity changes on insects development their impact on forest ecosystems in the expected climate change. For. Res. Pap., 74: 345-355.

Kalidas, P., 2012. Pest problems of oil palm and management strategies for sustainability. Agrotechnology, 1: 1-3.

Kamarudin, N. and O. Arshad, 2016. Diversity and activity of insect natural enemies of the bagworm (Lepidoptera: Psychidae) within an oil palm plantation in Perak, Malaysia. J. Oil Palm Res., 28: 296-307.

Kok, C.C., O.K. Eng, A.R. Razak and A.M. Arshad, 2011. Microstructure and life cycle of *metisa plana* walker (Lepidoptera: Psychidae). J. Sustainable Sci. Manage., 6: 51-59.

Noor, H.H., M.R. Cik and H. Suhaidi, 2013. Control measures and integrated approach for major pests of oil palm in FELDA. Proceedings of the International Conference on MPOB Palm Oil Congress (PIPOC), November 19-21, 2013, KLCC Kuala Lumpur, Kuala Lumpur, pp: 1-21.

Rhainds, M., D.R. Davis and P.W. Price, 2009. Bionomics of bagworms (Lepidoptera: Psychidae). Ann. Rev. Entom., 54: 209-226.

Sheikh, A.A., N.Z. Rehman and R. Kumar, 2017. Diverse adaptation in insects: A review. J. Entomol. Zool. Stud., 5: 343-350.

Sugiura, S., 2016. Bagworm bags as portable armour against invertebrate predators. Peer J., 4: 1-14.