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PRELIMINARY STUDY ON EFFICIENCY OF DIFFERENT TIME AND LIGHT SOURCE IN LIGHT TRAPS FOR CAPTURING POPULATION OF ADULT OIL PALM BUNCH MOTH, *Tirathaba mundella* (Lepidoptera: Pyralidae)

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ABSTRACT

The oil palm bunch moth, Tirathaba mundella *(Lepidoptera: Pyralidae) is a pest of oil palm especially those planted on peat soil. The pest has a short life cycle, approximately 30 days (eggs four days, larvae 16 days and pupae 10 days) and therefore, its population build up rapidly and causing severe damage to the oil palm when proper control is not in place. A research was conducted to determine the efficiency of different design of the light traps in capturing the adult bunch moths and also, aimed to observe the moths' behaviour in terms of the night flight pattern in the areas with high level of infestation. The study was carried out in two oil palm estates in Sarawak; Location A, Daro and Location B, Sri Aman, from 17-19 July 2018 and 23-25 January 2019, respectively. Six light traps (Location A) and three light traps (Location B) were tested. Night flight activities were recorded for three different intervals; Interval 1 (1925-2125), Interval 2 (2130-2330) and Interval 3 (2335-0135). The result showed that, light Trap 6 was found to be the most attractive in Location A, capturing significantly higher number of moths (mean=38.6667, p<0.05). Whereas, in Location B, Trap 2 recorded the highest number of total individual moths captured but, not significantly different from other designs (mean=18, p>0.05). In terms of the moths' behaviour, the third interval showed significantly greater number of individual female moths captured compared to the other two intervals in Location A (mean=16, p<0.05). However, in Location B, it was found that the amount of captured female moths in the earlier time intervals (Intervals 1 and 2) was significantly greater (mean=8 and 9.6667 individuals, p<0.05) than final time interval (two individuals), which was opposite to the observations made in Location A. The cause of such behaviour is still unknown and thorough study is needed. Thus, in future study, the data as such additional climatic parameters need to be incorporated* (e.g. *ambient temperature, humidity, moon phase and wind speed) for further understanding of the behaviours and preferences of the pest. Furthermore, the study also indicates potential application of light trapping as one of the alternatives to the oil palm pest management.*

Keywords: light trapping, oil palm, *Tirathaba mundella*.

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INTRODUCTION

The oil palm industry in Malaysia is vital to the national economy. Data in 2019 showed more than 5.90 million hectares of land have been utilised for oil palm planting comprising of more than 60% of the total agricultural area in Malaysia (MPOB, 2020a). In 2017, palm oil and palm kernel oil production recorded close to one-third (75.17 million tonnes) of world total oils and fats production from a planted area of 19.04 million hectares, mainly from Indonesia and Malaysia (Norman *et al.*, 2019). It was reported

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by Parveez *et al*. (2020), Malaysian oil palm export revenue is contributing more than RM67.12 billion in 2018. In 2019, the number decline to RM64.84 billion as a result of weaker demand and lower export prices. Throughout 2019, the exports of more than 27 million tonnes of oil palm products have generated a value of more than RM63 billion (MPOB, 2020b).

A total of 666 038 ha of peatlands in Malaysia have been developed for oil palm cultivation and this includes 437 174 ha in Sarawak; 207 458 ha in Peninsular Malaysia and 21 406 ha in Sabah (Omar *et al*., 2010). Conversion of such a large area from heterogeneous climatic vegetation into a monospecies crop of oil palm had indirectly distraught the natural biological interaction between the host, pests and natural enemies. Therefore, oil palm cultivation in peat is facing the threats of pest as such termites, nettle caterpillars, bagworms, bunch moth, rhinoceros beetles and rats. Among these common pests, *Tirathaba mundella,* commonly known as the oil palm bunch moth is becoming a very significant bunch feeding pest on oil palm planted on peat soils.

Oil palm bunch moth, *T. mundella* (Lepidoptera: Pyralidae), is a pest that can cause serious damage to oil palms planted in peat soil (Lim, 2012; Zulkefli *et al.,* 2012). The life cycle from eggs to pupae is completed within 30 days (Lim, 2012). According to Yaakop and Shafariza (2015), the development stages of this pest consist of five larval stages, each differentiated by different sizes. The longevity of adult bunch moth is around 8-10 days. Khoo *et al*. (1991) described that the adult female moths lay eggs singly or in batches (4-20 eggs) in the fibrous spathe surrounding the base of the flower spike and adults' moth can survive for 9-12 days (Wood and Ng, 1974). The moth is active mostly in the late afternoon and early evening (Sudharto, 2004). The bunch moth infestation is easily characterised by the presence of long tubes of silk and frass constructed by the larvae (Wood and Ng, 1974; Lim, 2012; Mohamad *et al.,* 2017). Generally, it infests the young mature palms (Basri *et al.,* 1991). Damages are mostly caused by the larvae as they feed, scrap and later bore holes on immature fruitlets, causing severe damages to the fruitlet (Darus and Basri, 2000). Zulkefli *et al*. (2015) reported serious bunch moth infestation in various oil palm plantations on peats in Sarawak *viz*; Mukah, Sibu and Miri with prematurely abortive fruit bunches. Consequently, the fresh fruit bunches (FFB) yield of the infested areas was affected.

Currently, controlling of the *T. mundella* larvae relies heavily on insecticides. In findings reported by Lim (2012), cypermethrin is the most widely used by oil palm plantation to control the pest populations. The use of non-selective insecticide such as fipronil over a long period negatively impacted the population and activity of beneficial insects such as *Elaeidobius kamerunicus*, which is the primary pollinating insects in oil palm plantations. Furthermore, degradation rate of the compound is slow on peat (Prasetyo *et al.,* 2013; Prasetyo and Susanto, 2012; Ismail *et al.,* 2012). Other methods in controlling the pest population was elaborated by Basri *et al*. (1991), combining the application of insecticides and the cultural practices, such as field ablation for the control measures. Ming *et al.* (2016) conducted a similar study by comparing the ablation block to non-ablation block to suppress the larvae density in an infested area. Nevertheless, studies mentioned above are all focusing on controlling the larval stages of the pest population and thus the idea to examine the safer and environmental-friendly control methods such as the application of light trapping needs to be explored. It can provide the estate as one of the alternatives and less reliance on chemical insecticides.

Light traps are used to monitor the presence of insects and to determine the seasonal pattern of pest density, which provides useful information on the timing of relative abundance and species composition of the targeted pest. Therefore, it can be the most effective and environmentally safe tool used for the Integrated Pest Management (IPM) purpose as it records large number of species during a relatively short period (Kammar *et al.,* 2020). By using light trapping less chemicals are used and the problems of insecticides resistance are avoidable. Studies by various researchers (Kim *et al.,* 2018a; 2018b; Brehm, 2017; Infusino *et al.,* 2017; Keszthelyi *et al.,* 2016; Cheng *et al.,* 2016; Wölfling *et al.,* 2016; Spalding and Parsons, 2004) have reported light trapping efficiency in attracting lepidopteran. However, studies pertaining to the application of light trapping for monitoring and population control of *T. mundella* have yet to be conducted and there is lack of published information supporting the method. Hence, the main aim of this preliminary trial was to evaluate the efficiency of different light sources in the light traps in capturing and observing the behaviour such as night flight activities of the adult *T. mundella* for better management of the adult bunch moth.

MATERIALS AND METHODS

Experimental Site

The study was conducted in two oil palm estates, namely Location A, Daro and Location B, Sri Aman, both situated in Sarawak, Malaysia. The light traps deployed in both sites were different (*Tables 1* and *2; Figures 1-5*). The deployment of the light traps in Location A was carried out for two consecutive nights from 17-19 July 2018 with three different time intervals. The trapping activity was conducted for the duration of six hours, from 1925 hr (17 July 2018) to 0135 hr (18 July 2018). Meanwhile, trapping activity for Location B in Sri Aman, Sarawak was conducted from 23-25 January 2019 following similar methods as at Location A, Daro.

Sampling Method and Design

The light traps were installed and deployed along the main road of every trial site. The trap location was selected as its placement in open area can optimise the illumination from the light traps. Traps placed in the harvesting path were presumably to be less attractive, as the light illumination is limited and distrupted by the palms' canopy. In order to test this theory, light trap design 1 (Location A, Daro) and light trap design 2 (Location B, Sri Aman) were installed along the harvesting road, approximately 20 m from the planting row. Plastic sheets (74 cm x 90 cm) were used to capture the flying moths attracted to the light source. The plastic sheets were sprayed with aerosol glue (Anti Pest Sticky Spray; Chemi-Bond) on steel poles around the plastic container and tripod. Additionally, the plastic sheets served to amplify the brightness of the light source, hence increasing its attractiveness. The list of traps deployed for each sampling session are listed in *Tables 1* and *2*.

Data Collection

The number of individuals captured in each trap were recorded every 2 hr and the plastic sheets were cleaned before the start of the recording. This data collection represents the efficiency of the different light source in the light trap. The interval for each trapping sessions in Location A and B were divided into three session with Interval 1 (1925-2125); Interval 2 (2130-2330) and Interval 3 (2335-0135). The sexes of the individuals captured were also recorded until the end of trapping session. The data recording on individuals captured were then used to reflect with behaviour of the night flight activity of the moths (Altaf *et al.*, 2016). The sexes of the moth were identified according to the methods described by Mohamad *et al.* (2017); Moore (2001); Basri and Norman (2000) and Khoo *et al*. (1991). It was acknowledged that the study was only preliminary and with that, data related to moon phase was not recorded and the night flight behaviour of the moths' observation only focused on the interval intended. Thus, the light trap trials served as short term monitoring for preliminary information basis with regards to the *T. mundella* population density and its night flight behaviours.

TABLE 1. LIGHT TRAPPING DESIGN USED IN LOCATION A, DARO, SARAWAK

No.	Traps type	Watt	Description
1	Birdhouse design	25	A portable trap design with 1 m long stainless-steel rod as stand equipped with 0.2 m normal fluorescent light.
2	Tripod angel bulb with water basin	8	A joint of three stainless steel rods, slanted at 45°; equipped with normal standard bulb light, hanging 50 cm from the ground, and powered by diesel generator. Three plastic sheets (74 cm x 90 cm) was applied with aerosol glue sprayed (Anti Pest Sticky Spray; Chemi-Bond), and placed adjacently in triangular form to facilitate the moth trapping.
3	Spotlight with water-filled oil drum (3 m)	400	A spotlight hanging 3 m from the ground with a semi-rectangular wooden structure as the pillar; equipped with 50 litre oil drums, and powered by diesel generator.
4	Spotlight with water-filled oil drum (2 m)	400	A spotlight hanging 2 m from the ground with a semi-rectangular wooden structure as the pillar; equipped with 50 litre oil drums, and powered by diesel generator.
5	Fabricate plastic container with funnel	25	Fabricated-household plastic container and funnel; equipped with normal bulb light hanging 50 cm facing the funnel and powered by diesel generator. Three plastic sheets (74 cm x 90 cm) was applied with aerosol glue (Anti Pest Sticky Spray; Chemi-Bond) and placed adjacently in triangular form to facilitate the moth trapping.
6	Fluorescent tube light	8	Standard fluorescent white light tied (1 m) tied vertically, 2 m from the ground with a wooden pole stand; equipped with tarpaulin polyethylene (PE) Sheet (2.74 m x 3.65 m), and powered by diesel generator.

TABLE 2. LIGHT TRAPPING DESIGN USED IN LOCATION B, SRI AMAN, SARAWAK

No.	Traps type	Watt	Description
1	Fluorescent tube light	8	Standard fluorescent white light tied horizontally, 50 cm from the ground, on stainless steel rod slanted at 45°, with water basin for catching moth.
2	LED light	50	LED light with housing, vertically hanging 50 cm from the ground and powered by 220V car battery.
3	Spotlight with water basin	150	A spotlight vertically hanging 1 m from the ground, tied with 45° modified stand, and powered by diesel generator.

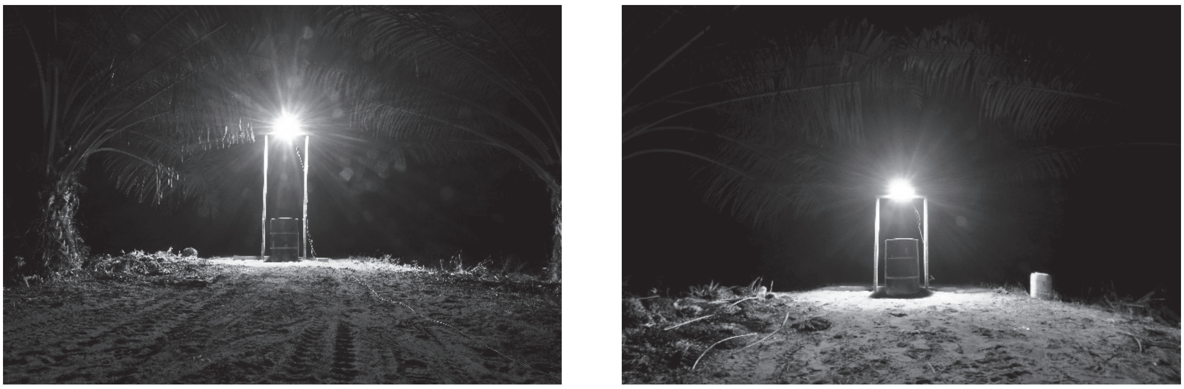
TABLE 3. TOTAL CAPTURES AND SEXED-CAPTURES IN LOCATION A ACCORDING TO TRAP TYPES

Types of trap	N	Mean total captures		Mean male captures		Mean female captures	
		Mean	P-value	Mean	P-value	Mean	P-value
1	3	1.3333b	0.035	1.3333a	0.291	0.0000b	0.023
2	3	14.3333ab		11.0000a		3.3333b	
3	3	16.0000ab		14.0000a		6.6667ab	
4	3	18.3333ab		3.6667a		12.3333ab	
5	3	20.6667ab		11.3333a		7.0000ab	
6	3	38.6667a		14.0000a		24.6667a	

Note: The same letter after numbers in the same column did not indicate a significantly different by Tukey's test at significant level 95%.

(a) (b)

Figure 1. Light trapping deployed in Location A. (a) Trap 1 was placed on the harvesting path, approximately 20 m from the main collection road. (b) Trap 2 in the middle of the collection road.



(a) (b)

Figure 2. Light trapping deployed in Location A. (a) Trap 3 and (b) Trap 4 both were placed on the collection road.


(a)


(b)

Figure 3. Light trapping installed in Location A. (a) Trap 5 and (b) Trap 6 both were placed on the collection road.


(a)


(b)

Figure 4. Light trapping installed in Location B. (a) Trap 1 located in the middle of the collection road. (b) Trap 2 located on the harvesting path inside the trial block.

Figure 5. Light trapping installed in Location B. Trap 3 was also located in the middle of the collection road.

Statistical Analyses

Interaction between the types of trap and the time intervals was analysed using two-way analysis of variance (ANOVA). When no interactions were found between the variables, the relationship both factors were then compared using General Linear Model (GLM) (Minitab version 19.0). Comparisons among means were conducted using pairwise multiple comparison procedures (Tukey's method) of significance test at 95%.

RESULTS AND DISCUSSION

The total captures of the adult *Tirathaba* moths were categorised according to the number of individuals captured in each type of traps (*Table 3*). Additionally, the sex of the moths was identified, and the individuals captured were quantified. In Location A, out of the six traps tested, it was found that Trap 6 had captured a significantly higher number of individuals (38.6667 individuals) compared to the other types of light trap (P<0.05). In contrast, it was observed that Trap 1 yielded a significantly lower number of captures (1.3333 individuals). No significant differences were observed in the number of males captured between the different types of trap design. However, Trap 6 captured a significantly higher number of female individuals (24.6667 individuals) compared to Trap 2 and Trap 1, which only managed to attract a mean of 3.3333 and 0 females, respectively. Traps 1, 2, 3 and 5 all had higher mean in males captured compared to females.

The high number of moths captured was likely due to the intensity of the light source and the colour of the campsite, which provided greater reflection, hence increasing their attractiveness. As reported by Bowden (1982), the effectiveness of the light trap is very much influenced by trap illumination, hence, the traps that provide better illumination attract more insects. However, although Trap 3 and Trap 4 were using the same types of light source, Trap 4, which was placed lower than Trap 3, was observed to be able to attract more moths. As such, the light source position and height also observed to be influencing its attractiveness. Traps 4, 5, and 6 were all positioned at 1.5 m or less, which made them more accessible to the moths. Previous studies reported that the number of captures could be influenced by trap placement, depending on insect preferences (Mulder *et al*., 2007; Cross *et al*., 2006; Prokopy *et al*., 2001; 2000). Insects such as *Anthonomus eugenii* and *Anthonomus rubi* were reported to be more attracted to traps placed at certain heights compared to others (Fountain *et al*., 2017; Riley and Schuster, 1994). No reports on *Tirathaba* moths light trapping were available prior to this study, so, based on the observation conducted, it can be assumed that the *Tirathaba* moths were more attracted to light traps that were placed under 1.5 m of height. Pyralidae group of moths, in which the *Tirathaba* moths are classed into, are known to be flying lower than other lepidopterans, such as Noctuidae and Sphingidae (Taylor and Brown, 1972), explaining the higher number of catches in lower-placed light traps.

Trap 1 had significantly lower number of captures compared to others. It was possible that the trap illumination was limited since the trap was placed in the harvesting path with frond overlapping making it looked dense compared to other light traps which were placed in the open areas on the main collection road within the oil palm estate. Furthermore, the blue-coloured birdhouse design with roof enclosing the light source was limiting the light emittance from the bulb, making it less attractive to insects. Observation by McGavin (2007), in dense habitats like forests, the range of illumination may be very small. Difference in the light trap design can affect the number of lepidopteran catches (Taylor and French, 1974). The blue-colour trap was unattractive to insects as it has the lowest reflectance compared to other colours (Taha *et al*., 2012). Study by Sridhar and Senthil Kumaran (2018), mentioned that a yellow bulb with 60 watts was found most efficient in attracting both sexes of Tuta moths, a pest of tomatoes under polyhouse conditions. Therefore, it was assumed that the low amount of the light emittance plus the unsuitable design led to low number of captures.

Only Trap 4 and Trap 6 captured more females than males. Trap 6 captured significantly more females compared to other traps. Interestingly, even when using similar type of light source, Trap 3 and Trap 4 yielded opposite results. The differences were again, as discussed in earlier part of this paper, was the height of the trap. Lower-placed traps (*i.e*. Trap 4 and Trap 6) attracted more females *T. mundella*. Yet, similarly low-placed traps (*i.e*. Traps 2, 3 and 5) attracted more males than females. This indicated that the preference of each gender of *T. mundella* was not conclusive, as various factors are influencing the attractiveness of a light trap. Kim *et al*. (2018b) reported that the phototactic response of another lepidopteran, *Mythimna separata* was significantly influenced by various factors, and sexuality of the moths is one of them. In their report, it was found that significant difference in the phototactic response between both sexes of moth, unmated and mated. This perhaps explains the difference in the number of males and females captured in different types of trap design and light source. Insect phototactic response varies even among similar species, depending on several abiotic and abiotic factors (Park and Lee, 2017; Cheng *et al*., 2011). As such, unless the objective of the trapping was to capture a single gender of *T. mundella*, maybe there was not much significant information that can be obtained from this observation.

In both field trials, the trapping was divided into three-time intervals. In Location A, comparison between the mean of the total individuals and males captured yielded no significant differences among the designated time intervals. However, it was found that for females, a significantly greater number of individuals were captured in the final time interval (16 individuals) compared to earlier periods (Time Interval 2: 8.5 individuals; Time Interval 1: 2.5 individuals). Based on these data, it was observed that the significantly more females preferred to appear later than the males. As the ambient temperature dropped, the female individuals became more active and easily attracted to light source. These individuals were waiting for suitable ambient temperature to move closer to the light source as weather might influence the effectiveness of light trap (Bowden, 1982; Banerjee, 1967). No information on the diel flight pattern of *T. mundella* were reported previously, and similarly, no literature on the influence of trap design on the number of males and females' catches were available. Several studies reported that various factors influence the flight behaviours of moths according to sexes. For example, in other moth species in the same group of Pyralidae, it was reported that the flight behaviour of males *Ephestia kuehniella*, *Ephestia cautella* and *Plodia interpunctella* is influenced by the pheromone emitted by the female's availability. The pheromone secretion is enhanced by the presence of constant, warm climate, which increases the flight activity of the moths (Levinson and Buchelos, 1981). The observation conducted in the current study was aimed to see the differences in the flight time among different sexes of *T. mundella*, and as such, details on the information related to pheromone secretion is not covered within the scope of this study, but still, in future studies, it is useful to consider this aspect of moths' behaviour.

Meanwhile, in the trial in Location B, three trap designs were evaluated for their attractiveness in mass-trapping the adult *Tirathaba* moths. Based on the results from the first phase of the trial at Location A, three trap designs with the highest number of captures were selected for the second phase of the trial at Location B, explaining the different number of traps deployed at the two study sites (*Table 5*). No significant differences were observed in the number of total moths captured among the traps tested. Similarly, no significant differences were observed in the number of females captured. However, when categorised according to its gender, it was found that Trap 2 (12.6667 individuals) significantly attracted more males than Trap 3 (3.3333 individuals). Trap 1 yielded a balanced number of males and females captured, while Trap 3 (9.333) was seen to be more attractive to the female individuals.

Trap 2 in Location B yielded the highest number of captures among the traps deployed. Trap 1, which was similar to Trap 6 in Location A (the trap design with significantly highest number of *Tirathaba* moths trapped), only managed to trap a mean total capture of 10 individuals, a distinct result compared to the first phase of the trial. It was assumed due to the placement of the light traps in Location A was under a shade by the tarpaulin PE Sheet, which acted as shelter from the wind. Trap 1 in Location B, was set up without any conditioning of shade. Kammar *et al.* (2020) mentioned that, it is possible to set up the trap where it is sheltered from wind. Best position for the light trap operators is with their backs to the wind as the insects fly upwind. The observation confirms earlier findings that the number of captures can be influenced by wide variety of factors, and does not depend on the trap design alone. A trap design, while seemingly working wonders on one night, does not necessarily guarantee a high number of captures in other nights. For example, the light intensity might affect the luminance, and thus the attractiveness of the trap. Increases in mean illuminance and wind speed were associated with decreased light-trap catch. Increase in mean temperature was associated with increased catch (McGeachie, 1989). The number of individuals caught in the light trap increased with temperature but decreased with the fullness of the moon (Yela *et al.*, 1997). Hsia (1972) also discussed on the insect behaviour in relation to light traps and categorising it into 'near' and 'far' phases. The 'near' phase (near the light source) is usually manifested in the number of captures, meanwhile the 'far'-phase influences behaviour of insect at farther distance at which the light traps are deployed. Various estimations were made on the distances at which insects appeared to respond to radiation from the light traps, varying from 50-250 m (Agee, 1972; Plaut, 1971; Stewar *et al.*, 1967). Thus, to optimise the light trap effectiveness, all of these aspects need to be factored in for future studies.

The number of moths trapped in the second time interval was significantly higher (18.3333 individuals) than the later intervals (6.3333 individuals). No significant differences were observed in the number of males captured in the three periods, however, in females, earlier time intervals (Intervals 1 and 2) had a significantly higher number (8 and 9.6667 individuals) of trapped moths compared to the final time interval (2 individuals), which was opposite to the observations made in Location A, at which the final intervals yielded significantly greater number of females than earlier intervals.

The difference in the appearance time between the two study locations can be attributed to the other environment factors (*i.e.* ambient temperature, moon phase and humidity), which were not recorded during the sampling time. Although no prior studies were conducted to specifically light-trap adult *T. mundella*, but based on previous studies, the number of individuals captured by insect traps can be influenced by the placement of the traps, as well as the trap colour (Taha *et al*., 2012; Hoback *et al*., 1999). Moreover, in addition to the trap location, the height of the trap placement might affect the number of captures (Bowie, 1999). In order to increase its effectiveness, these factors must be taken into consideration for future trapping. According to Zhong *et al.* (2017), *Tirathaba* sp. activity and rate of growth development are very much influenced by temperature. During this trial, the ambient temperature and relative humidity at the peak activity period were not recorded, but it was possible that during the trappings, the temperature was favourable for the moths' activity.

Similar distinctive pattern of appearance between the sexes of *T. mundella* was not observed in Location B (*Table 6*). More females were captured during the first interval compared to similar interval at Location A (*Table 4*). The differences in the pattern is attributable to environmental factors, such as temperature and humidity. As reported by Williams (1961) and Willams and Osman (1960), for a large group of insect taxonomic groups, the insect activity increases with the increase in temperature, from 18°C to the optimum temperature of 29°C. Temperature exceeding the optimum threshold resulted in declining insect activity. Similarly, less activity was detected on temperatures below the minimum threshold. Study by Hrdý *et al. (*1996) and Pinault *et al.* (2012) mentioned that the difference in flight behaviour could be due to temperature, which modulates the activity of nocturnal moths. Kammar *et al.* (2020) suggested that the best nights for insect trapping are warm, humid with cloud cover and little wind. Different species are active at different times of the year and night: some are trapped at dusk, others during the night and some others as daylight appears. Factors such their wing shape or flight times influence the likelihood of moths being captured (Lintott *et al.*, 2014; Fuentes-Montemayor *et al.*, 2012; Beck *et al.*, 2011; Beck and Linsenmair, 2000). As such, these factors should also be considered in future studies.

CONCLUSION

The findings from this study has provided preliminary information on the efficiency of different light sources in light trapping of *T. mundella*. Additionally, patterns of night flight behaviour of the pest were also observed. The information obtained from this study is certainly useful for future studies

TABLE 4. TOTAL CAPTURES AND SEXED-CAPTURES IN LOCATION A ACCORDING TO THE TRAPPING TIME INTERVAL

Time of trapping	N	Mean total captures		Mean male captures		Mean female captures	
		Mean	P-value	Mean	P-value	Mean	P-value
1	3	10.1667a	0.082	7.6667a	0.839	2.5000b	0.027
2	3	18.5000a		10.0000a		8.5000ab	
3	3	26.0000a		10.0000a		16.0000a	

Note: The same letter after numbers in the same column did not indicate a significantly different by Tukey's test at significant level 95%.

TABLE 5. TOTAL CAPTURES IN LOCATION B ACCORDING TO TRAP TYPES

Types of trap	N	Mean total captures		Mean male captures		Mean female captures	
		Mean	P-value	Mean	P-value	Mean	P-value
1	3	10.0000a	0.135	5.0000ab	0.043	5.0000a	0.048
2	3	18.0000a		12.6667a		5.3333a	
3	3	12.6667a		3.3333b		9.3333a	

Note: The same letter after numbers in the same column did not indicate a significantly different by Tukey's test at significant level 95%.

TABLE 6. TOTAL CAPTURES IN LOCATION B ACCORDING TO THE TRAPPING TIME INTERVAL

Time of trapping	N	Mean total captures		Mean male captures		Mean female captures	
		Mean	P-value	Mean	P-value	Mean	P-value
1	3	16.0000ab	0.037	8.0000a	0.294	8.0000a	0.008
2	3	18.3333a		8.6667a		9.6667a	
3	3	6.3333b		4.3333a		2.0000b	

Note: The same letter after numbers in the same column did not indicate a significantly different by Tukey's test at significant level 95%.

in monitoring the pest population in the field, and subsequently, will provide the oil palm plantations management another method to suppress the pest population. From this study, it was observed that different types of light source influenced the number of moths captured. Light-trapping by using fluorescent bulb has resulted in significantly higher number of captures, especially during the first phase of the study in Location A, whereas in the subsequent phase of the study, no significant differences in terms of the number of captures were observed. In this study, it was also observed that the different sexes of *T. mundella* have distinct flight night behaviour, although the observations in both phases of our study yielded inconclusive information. Based on this study, several improvements can be made for future studies related to this topic. It is suggested data such as ambient temperature, humidity, moon phase, and wind speed need to be comprehensively incorporated together for better understanding of the behavioural pattern prediction and pest population monitoring in oil palm plantations. Thus, light trapping of the adult moths of *T. mundella* can be practically applied in the oil palm plantations and can serve as alternative or complementary practices to the current method in controlling the pest population.

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