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Effects of Rainfall, Number of Male Inflorescences and Spikelets on the Population Abundance of *Elaeidobius kamerunicus* (Coleoptera: Curculionidae)

(Kesan Hujan, Bilangan Jambak Bunga Sawit Jantan dan Spikelet ke atas Kelimpahan Populasi *Elaeidobius kamerunicus* (Coleoptera: Curculionidae))

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ABSTRACT

Elaeidobius kamerunicus *was first introduced to Malaysia from Cameroon as an oil palm pollinator in 1981. Since then, oil palm pollination has improved and the need for assisted pollination has reduced. Fruit set development and fruit production also saw significant improvements, until a reported decline that began in the late 1980s. Several factors may have contributed to such decline, but most researchers believe it is due to the low* E. kamerunicus *population. Therefore, a study was conducted to determine whether the amount of rainfall and the number of male inflorescences and spikelets influenced the population abundance of* E. kamerunicus *in Ladang Lekir, Perak, Malaysia. Sampling was performed each month in oil palm subplots, three for each age of palm age, from October 2015 to September 2016. A total of nine spikelets (three from the top, middle and base of a male inflorescence) were randomly selected from each male inflorescence on each chosen palm. They were cut early in the morning to avoid the weevil's most active time, thus making collection easier. The number of weevils congregating on each spikelet was then counted. The average number of* E. kamerunicus *per hectare (ha) living on oil palms aged four and six were 21,086 and 25,712, respectively. The amount of rainfall and the number of male inflorescences and spikelets were found to positively correlate with the* E. kamerunicus *population. The number of male inflorescences showed strong correlation with the* E. kamerunicus *population. However, in-depth study is needed to determine the relationship between* E. kamerunicus *and fruit set.*

Keywords: Coleoptera; Elaeidobius kamerunicus*; oil palm; oil palm pollinator; population abundance*

ABSTRAK

Elaeidobius kamerunicus *mula diperkenalkan ke Malaysia dari Cameroon sebagai serangga pendebunga kelapa sawit pada tahun 1981. Sejak daripada itu, pendebungaan kelapa sawit bertambah baik dan keperluan untuk pendebungaan berbantu telah berkurang. Pembentukan set buah dan pengeluaran buah juga menunjukkan peningkatan yang ketara, sehingga terdapat laporan penurunan bermula pada akhir 1980-an. Beberapa faktor mungkin menyumbang kepada kemerosotan pendebungaan ini tetapi kebanyakan penyelidik percaya kemerosoton ini disebabkan oleh kelimpahan populasi* E. kamerunicus *itu sendiri. Oleh itu, satu kajian telah dijalankan untuk menentukan sama ada jumlah hujan, bilangan jambak bunga sawit jantan dan spikelet mempengaruhi kelimpahan populasi* E. kamerunicus *di Ladang Lekir, Perak, Malaysia. Pensampelan dilakukan pada setiap bulan di subplot kelapa sawit, tiga untuk setiap umur kelapa sawit, dari Oktober 2015 hingga September 2016. Sebanyak sembilan spikelet (tiga dari atas, tengah dan bawah bunga sawit jantan) telah dipilih secara rawak daripada setiap bunga sawit jantan matang yang dipilih. Spikelet dipotong pada awal pagi untuk mengelakkan waktu paling aktif kumbang pendebunga supaya proses pensampelan menjadi mudah. Bilangan kumbang yang terkumpul di setiap spikelet bunga jantan matang kemudiannya dihitung. Purata kelimpahan populasi* E. kamerunicus *setiap hektar pokok kelapa sawit berumur 4 dan 6 tahun masing-masing adalah 21,086 dan 25,712 kumbang. Jumlah hujan, bilangan jambak bunga sawit jantan dan spikelet didapati berkorelasi positif dengan populasi* E. kamerunicus*. Bilangan jambak bunga sawit jantan menunjukkan korelasi yang kuat dengan populasi* E. kamerunicus*. Walau bagaimanapun, kajian yang lebih mendalam diperlukan untuk menentukan hubungan antara* E. kamerunicus *dengan set buah.*

Kata kunci: Coleoptera; Elaeidobius kamerunicus*; kelapa sawit; kelimpahan populasi; pendebunga kelapa sawit*

INTRODUCTION

Oil palm, *Elaeis guineensis* Jacquin, belongs to the Arecaceae and is the most important industrial crop in Malaysia. It is monoecious - meaning one plant has both male and female flowers, and cross pollination is needed. In the natural world, pollination via insect is vital for many crops. In Cameroon and West Africa, approximately 10 species of insect belonging to the *Elaeidobius* were identified as oil palm pollinators (Syed 1979). However, Mega (2011) reported that oil palm pollinators in Indonesia were bees, thrips (*Thrips hawaiiensis*), and weevils (*E. kamerunicus*). According to Tan and Basri (1985) and Basri and Norman (1997), *Thrips hawaiiensis* and *Pyroderces* sp. (Lepidoptera: Cosmopterygidae) were oil palm pollinators in Malaysia, but there is no additional information on the population and performance of these species in the pre-weevil era.

Elaeidobius kamerunicus was introduced to Malaysia from Cameroon in 1981 at Ladang Pamol, Sabah, and the Pamol estates, Kluang Johor. This increased pollination and fruit set production, resulting in the lower abortion of fresh fruit bunches. It also greatly reduced the need for assisted pollination or hand pollination (Syed 1982). *Elaeidobius kamerunicus* is the most efficient insect pollinator for oil palm because it carries more pollen grains than any other species (Basri et al. 1987). Furthermore, it is well adapted for the wet season (Dhileepan 1994). Oil palm is a specific host for *E. kamerunicus,* which are unable to breed on any other species of plant (Syed 1984). Pollination via insect is important as it can increase the oil palm fruit set (Ponnamma 1999). As an adult, *E. kamerunicus* feeds and breeds on the anther-the main part of the male flower containing pollen grain (Sambathkumar et al. 2011). The larvae of *E. kamerunicus* feed on decomposing male inflorescences, and pupate within flower (Tuo et al. 2011).

Ponnamma (1999) reported that the oil palm fruit set increased from 36.9% to 78.3%. However, fruit set is reported to have declined lately, indicating that pollination via *E. kamerunicus* is not at optimum levels due to a low weevil population (Prasetyo et al. 2014). Pamol Estate Sabah lost more than RM300,000 in 1993 due to poor fruit set in young oil palm crop (Donough et al. 1996). Another factor causing a decline in the abundance of weevils is predation by rats-which feed on *E. kamerunicus'* eggs, larvae, pupae and adults on post-anthesis male inflorescences (Syed & Saleh 1988). Spiders and mites (Syed 1982) as well as nematodes, *Elaeolenchus parthenonema* (Poinar et al. 2002) were also factors.

In this study, we have attempted to clarify the influence of rainfall, the number of male inflorescences and spikelets, as well as the age of oil palms, on the variation in *E. kamerunicus* population abundance.

MATERIALS AND METHODS

STUDY SITE

The study of the population abundance of the oil palm pollinator, *E. kamerunicus* was carried out in two oil palm fields planted in 2011 and 2009 at Ladang Lekir in Perak, Malaysia. They held four- and six-year-old oil palms, respectively. The study was conducted from October 2015 to September 2016. The areas were selected due to the poor fruit set observed in four-year-old oil palms. The older palms (six years old) were included for comparison. The number of *E. kamerunicus* in the male inflorescences in each plot was recorded once a month for a year in palms that were systematically selected prior to the experiment.

SAMPLING PROCEDURES

The study areas (plots) mentioned previously was subdivided into three subplots (replicates). Each subplot had four subsites. There were approximately 100 oil palms per subsite but only 25 oil palms were systematically selected (Figure 1). In each subsite, male inflorescences at the anthesis stage were randomly selected each month. A total of nine spikelets from an anthesising male inflorescence (three each from top, middle, and bottom) were randomly selected and cut between 8 a.m. and 9 a.m., thus avoiding the weevils' most active times and making it easier to collect *E. kamerunicus* (Dhileepan 1994) and then placed into plastic bags. The number of *E. kamerunicus* on each male inflorescence was counted. The number of anthesising female flowers seen among the marked palms during the census was also determined (Basri & Norman 1997).

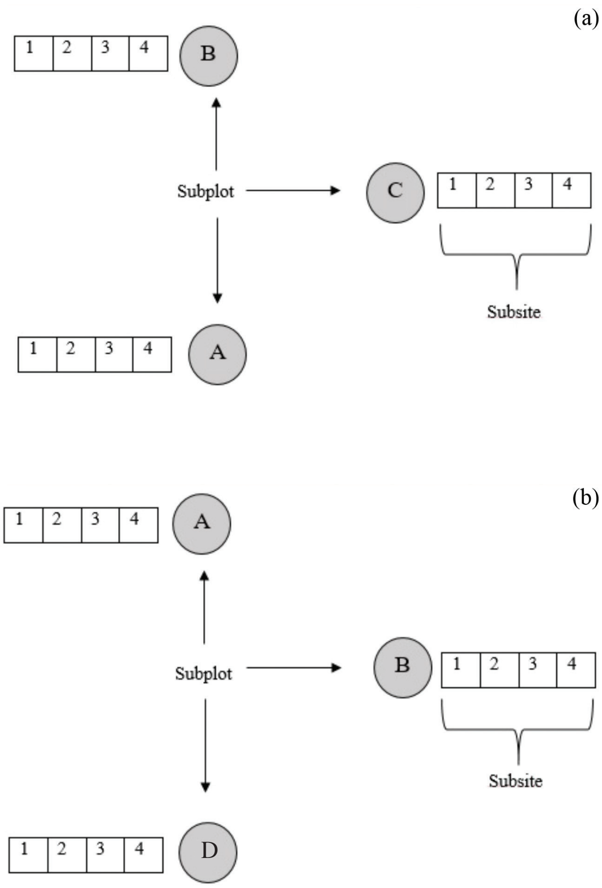

FIGURE 1. Schematic diagram for experimental plot layout for four-year-old oil palm (a) and six-year-old oil palm (b) where each plot has 3 subplots (A, B and C/D) and each subplot (replicates) contains 4 subsites (subsite 1, subsite 2, subsite 3 and subsite 4) while each subsite has approximately 100 oil palms and only 25 oil palms from each subsite were randomly selected for spikelet sampling from male inflorescence. For this study, 1 ha plot has 148 oil palms and only 100 oil palms (4 subsites) were randomly selected

DATA ANALYSES

The population abundance of *E. kamerunicus* or the number of weevil individuals per ha was calculated based on the following formulation:

> The population abundance of *E. kamerunicus* per palm = (total number of *E. kamerunicus* per spikelet × total number of spikelet per male inflorescence × total number of male inflorescence per plot)/100 oil palm trees (25 oil palm trees for each subsite)

> The population abundance of *E. kamerunicus* per hectar = the population abundance of *E. kamerunicus* per palm × 148 oil palms (equivalent to 1 ha)

Rainfall data was taken from the monthly rainfall recorded at Ladang Lekir, Perak. Data was shifted one month backward due to the weevil's one-month life cycle (Tuo et al. 2011). The population abundance of *E. kamerunicus* (dependent variables) per month for both ages of oil palm (independent variables) was analyzed by two-way ANOVA, followed by Tukey's test ($p = 0.05$). The correlation coefficient (r) was also determined to quantify the relationship between rainfall, the number of male inflorescences and spikelets per bunch, and the population abundance of *E. kamerunicus* per ha. The population abundance of *E. kamerunicus* per month for both of oil palm ages was normalized by square root transformation before being analyzed. All analyses were conducted using Minitab 16 software.

RESULTS AND DISCUSSION

EFFECT OF RAINFALL ON THE POPULATION ABUNDANCE OF *E. kamerunicus* PER HA

The average *E. kamerunicus* population (number of individuals) per ha of four-year-old oil palm was 21,086 with the highest and lowest numbers being 78,640 (October 2015) and 1.575 (May 2016) weevils per ha. For six-year-old oil palm, the highest and lowest number of weevils were recorded at 44,725 (December 2015) and 5,558 (March 2016) per ha, with an average of 25,712 weevils per ha. The population abundance of *E. kamerunicus* per ha in four-year-old oil palm was highest in December 2015, during which rainfall was 130 mm and lowest in May 2016, during which rainfall was 87 mm. Meanwhile, the population abundance of *E. kamerunicus* per ha for six-year-old oil palm was highest in October 2015 and lowest in March 2016 when rainfall was at 269 and 113 mm, respectively (Figure 2(a)). The population abundance of *E. kamerunicus* recorded in Ladang Lekir, Perak, for both oil palm ages indicated that there were sufficient weevils per ha to pollinate the female inflorescences. This contention is supported by Donough et al. (1996), who reported that the number of weevils per ha required to produce 55% fruit set was between 20,000 and 80,000 weevils per ha. Basri and Norman (1997) also showed that more than 60% fruit set could be obtained with very low numbers of *E. kamerunicus* (4,711 weevils per ha), while in India, 7,000 weevils per ha (Dhileepan 1994) were needed. Although an adequate population abundance of *E. kamerunicus* per ha was found to pollinate the female inflorescences, the pollinating efficiency was suppressed by high rainfall.

Two-way ANOVA showed that the month of sampling ($F_{11,48} = 2.89$, $p = 0.005$) had significant effects on the population abundance of *E. kamerunicus* per ha. However, the age of the oil palm ($F_{1,48} = 4.23$, $p > 0.045$) and their interaction were insignificant ($F_{11,48} = 1.86$, $p > 0.069$). The mean population abundance of *E. kamerunicus* per ha for both of the oil palm ages were significantly higher on October 2015 (60,257 ± 15,931) than other sampling months that were not differed significantly among them with mean population abundance of *E. kamerunicus* range between 10,000 to 30,000 weevils per ha (Figure 2 (b)).

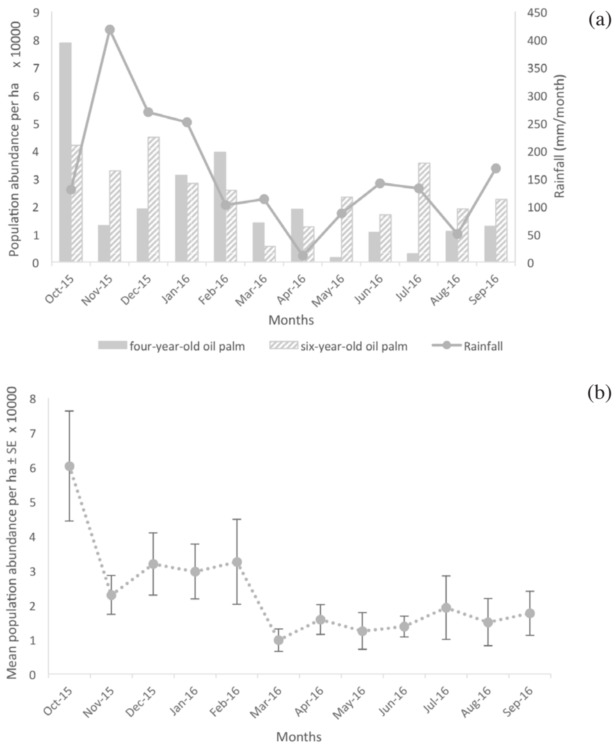

FIGURE 2. (a) Population abundance of *E. kamerunicus* per ha (based on formulation) in both four- and six-year-old oil palm (Rainfall was shifted one month backward) and (b) Mean population abundance of *E. kamerunicus* per male inflorescence per ha between months of sampling from October 2015 to September 2016

The population abundance of *E. kamerunicus* per ha showed a weak positive relationship with monthly rainfall for both four-year-old oil palm ($r = 0.395$, $p = 0.05$) and six-year-old oil palm ($r = 0.495$, $p = 0.05$) (Figure 3). This indicates that the wet season is favorable for breeding of *E. kamerunicus,* as reported by Basri et al. (1987) and Dhileepan (1994). According to Prasetyo et al. (2010), high rainfall has a significant effect on the population and aggressiveness of *E. kamerunicus*. This is supported by Syed (1982) and Dhileepan (1992), who stated that very hot and dry weather may cause a decline in weevil populations in West Africa and India. Similarly, Sugih et al. (1996) reported that in Riau, Sumatra, *E. kamerunicus* activity was practically absent during very low rainfall. However, this study shows that the population abundance of *E. kamerunicus* per ha in both ages of oil palm was low when monthly rainfall was the highest in November 2015 (417 mm) and declined sharply to its lowest level in April 2016 (11 mm) (Figure 2(a)). This occurrence may be due to other factors, such as the number of male inflorescences and spikelets on both ages of oil palm. Besides that, the wet season could cause low fruit set because of reduced pollen density on the bodies of weevil pollinators, as reported by Hardon and Turner (1967).

In contrast, Rizuan et al. (2013) reported that the dry season played a major role in weevil populations on male spikelets, because no reduction in pollinating efficiency was observed despite the abundance of weevils declining during the dry season. Therefore, in-depth studies need to be carried out to clarify these contrasting reports and correlate the multiple factors that may influence the population of *E. kamerunicus* and oil palm fruit set.

EFFECT OF NUMBER OF MALE INFLORESCENCE PER HA AND NUMBER OF SPIKELET PER BUNCH ON THE POPULATION ABUNDANCE OF *E. kamerunicus* PER HA

There were significant and strong positive correlations between the number of male inflorescences at anthesis stage and the population abundance of *E. kamerunicus* per ha (Figure 4) for both four-year-old oil palm (r = 0.875) and six-year-old oil palm (r = 0.842) (p<0.05). Thus, the number of male inflorescences strongly influences the population abundance of *E. kamerunicus* per ha. *Elaeidobius kamerunicus* is a host-specific insect pollinator-it needs the male inflorescence of oil palm to serve not only as a food source but also as a breeding site (Chee et al. 1999; Eardley et al. 2006; Ednan 2010; Syed 1982). This study shows that the population abundance of *E. kamerunicus* per ha increased with the number of male inflorescences at anthesis stage per ha for both ages of oil palm studied. This indicates that the population of weevil pollinators depends on the availability of oil palm male inflorescence (Dhileepan 1994). In addition, Basri et al. (1987) reported that male inflorescences had a great influence on weevil population, as it correlated with the occurrence of anthesising in male inflorescences (Chee et al. 1999). The latter will provide higher amounts of pollen on the male inflorescence and spikelet, which consequently increases the emergence of weevils as the palm ages (Dhileepan 1992).

Mean population abundance of *E. kamerunicus* per ha was higher in six-year-old oil palm compared to four-year-old oil palm (Figure 5(a)) even though there were insignificant. This occurrence could be due to the higher mean number of spikelets per bunch in six-year-old oil palm compared to four-year-old oil palm ($F_{1,70}$ = 4.99, p < 0.05) (Figure 5(b)). However, Matthew et al. (2011) reported that less rainfall and the greater pollen load on older palms' male inflorescences both impacted on the spikelet, as well as on *E. kamerunicus'* presence in the large canopies of older oil palms. This contrasting report may be due to the ages of oil palm in their plantation. However, the pollen load per weevil and fruit set was not determined in this study.

The number of spikelets per bunch for four-year-old oil palm was moderately positively correlated with the population abundance of *E. kamerunicus* per bunch (r = 0.538). There was a weak positive relationship with the population abundance of *E. kamerunicus* per bunch for the six-year-old oil palm (r = 0.411, p = 0.05) (Figure 6). Hence, the number of spikelets per bunch may also have

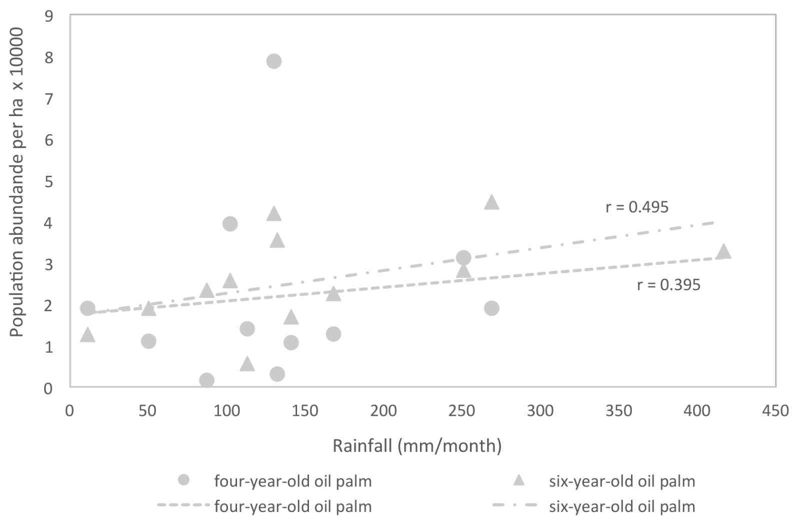

FIGURE 3. Correlation between rainfall and the population abundance of *E. kamerunicus* per ha for four- and six-year-old oil palm

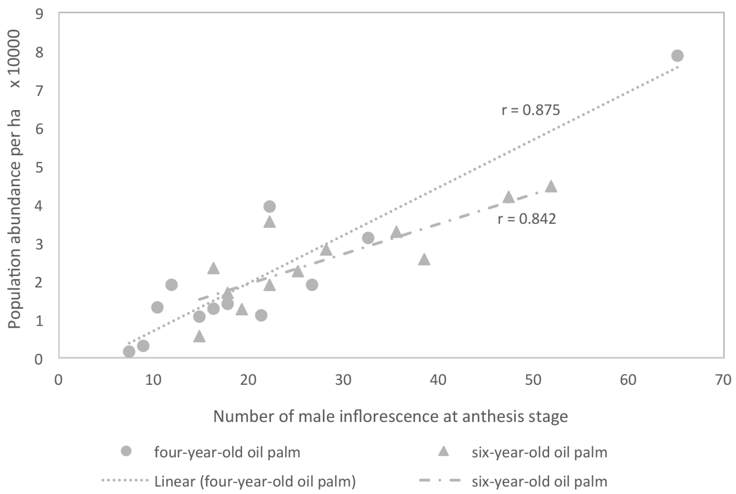

FIGURE 4. Correlation between the number of male inflorescence at anthesis stage per ha and the population abundance of *E. kamerunicus* per ha for four- an d six-year-old oil palm

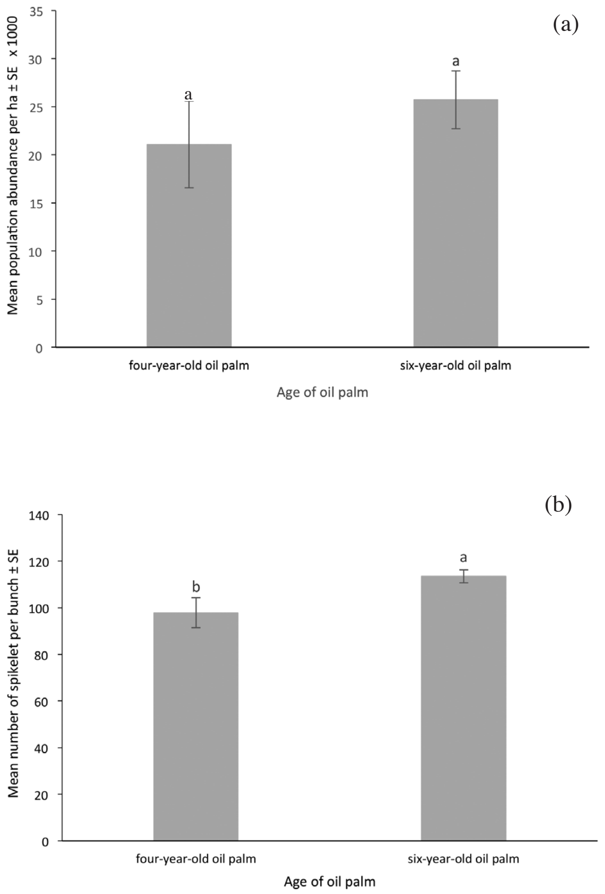

FIGURE 5. (a) Mean population abundance of *E. kamerunicus* per ha ± SE and (b) Mean number of spikelet per bunch ± SE between age of oil palm (four- and six-year-old oil palm)

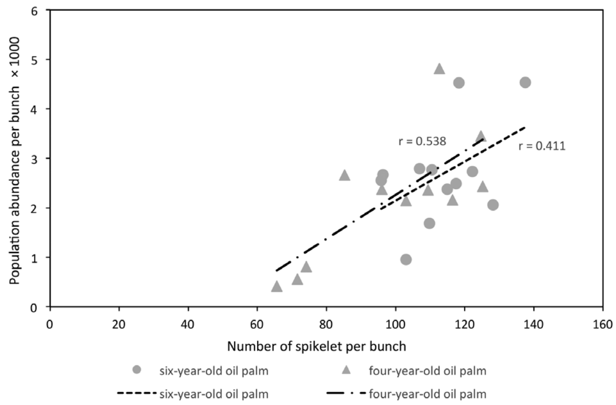

FIGURE 6. Correlation between the number of spikelet per bunch and the population abundance of *E. kamerunicus* per bunch for four- and six-year-old oil palm

influenced the population abundance of *E. kamerunicus* per ha. In this study, the population abundance of *E. kamerunicus* per bunch increased with the number of spikelets per bunch for both ages of oil palm. This indicates that the population also depends on the number of oil palm spikelets providing more pollen to *E. kamerunicus*. According to Young (1982), the number of spikelets affected the amount of pollen produced and degree of attraction for *E. kamerunicus*. This is supported by Mega (2011), who stated that insects are generally attracted to flowers because of the pollen and aroma they produce.

CONCLUSION

The population abundance of *E. kamerunicus* recorded for Ladang Lekir in Perak, Malaysia was more than enough to pollinate the female inflorescences. The *E. kamerunicus* population increased with palm age due to the higher oil palm male spikelet that existed at this site. Although it is clear that the wet season is favorable for *E. kamerunicus,* rainfall was seldom recorded at more than 400 mm per year. This means that the negative effects of severe rainfall toward the *E. kamerunicus* population could not be observed. Furthermore, the number of male inflorescences plays a major role in the life of *E.*

kamerunicus, as they serve as a food source and breeding sites. However, the number of male inflorescences and spikelets were determined by various climatic factors. We suggest that further studies are needed to correlate the number of rainy days and rain times per day, the pollen load per weevil pollinator, the temperature, and fruit set production with the population abundance of *E. kamerunicus*. The results of this study could be useful for future studies, especially when correlating them with the fresh fruit bunch (FFB), the fruit-to-bunch ratio, and the fruit set in order to determine the performance of *E. kamerunicus* and the plantation itself.

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