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OBSERVATION AND TRAPPING OF INSECTS VISITING MALE AND FEMALE INFLORESCENCES OF OIL PALM

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ABSTRACT

The African oil palm, *Elaeis guineensis,* relies heavily on entomophily. The absence of insect pollinators will cause inadequate fruit setting and in extreme situations, triggering bunch failure, especially in young palms. Fruit bunches of high quality are produced with adequate pollination, ensuring a high rate of oil extraction. The presence of the oil palm pollinating weevil, *Elaeidobius kamerunicus* in both sexes of the oil palm inflorescence is well-documented. However, reports on the presence of other insects, which may provide complementary pollination services, are still lacking. In addition, the presence of native oil palm pollinators in Sarawak was not recorded before the introduction of the weevil in the early 1980s. As such, this study investigates the presence of insect visitors and activity on sixteen male and female oil palm inflorescences at MPOB Sessang Research Station, Sarawak, Malaysia. The male inflorescences attracted more insect visitors than the female, as 87.6% of the insects were captured on the male inflorescences. From a total of 16 insect morphospecies identified, the two most abundant species caught were *E. kamerunicus* and *Pyroderces* sp. In addition, a host of other insect species were also observed, frequenting both sexes of the inflorescences. These insects may serve their respective ecological functions on oil palm inflorescences. Here, the presence of one of the native oil palm pollinators, *Pyroderces* sp. in Sarawak was confirmed, which has not been previously reported.

Keywords: Oil palm pollination, *Elaeidobius kamerunicus*, *Pyroderces* sp., entomophily

ABSTRAK

Pendebungaan oleh serangga memainkan peranan yang amat penting bagi tanaman sawit, *Elaeis guineensis*. Kekurangan serangga pendebunga akan menjejaskan penghasilan set buah sawit terutamanya pada pokok sawit muda. Buah sawit yang mempunyai kadar perahan minyak yang tinggi dapat dihasilkan melalui proses pendebungaan yang mencukupi. Kehadiran dan peranan kumbang pendebunga sawit, *Elaeidobius kamerunicus* telah dilaporkan secara meluas. Namun begitu, maklumat berkenaan peranan dan jumlah serangga yang lain pada bunga sawit masih kurang dilaporkan. Tambahan pula, tiada rekod mengenai kehadiran serangga pendebunga tanaman sawit di Sarawak, Malaysia sebelum kumbang pendebunga sawit dibawa masuk ke Malaysia dari Cameroon pada awal tahun 1980an. Oleh yang demikian, kajian ini dijalankan bagi mengenalpasti kehadiran serangga yang melawat kedua-dua jantina bunga tanaman sawit. Pemerhatian dijalankan pada 16 bunga jantan dan betina sawit di Stesen Penyelidikan MPOB Sessang. Didapati bahawa bilangan serangga yang diperangkap melawat bunga jantan adalah melebihi bilangan serangga pelawat bunga betina. Daripada keseluruhan jumlah serangga yang berjaya diperangkap, 87.6% daripadanya diperolehi pada bunga jantan. Daripada 16 morfospesies serangga yang telah diperolehi sepanjang tempoh kajian, dua spesies yang paling banyak diperolehi adalah *E. kamerunicus* dan *Pyroderces* sp. Di samping itu, terdapat beberapa spesies lain yang didapati melawat kedua-dua jantina bunga sawit. Serangga-serangga ini berkemungkinan besar menjalankan fungsi ekologi masing-masing pada bunga sawit. Dapatan kajian mengesahkan kehadiran *Pyroderces* sp., salah satu daripada serangga pendebunga sawit asal di Malaysia, terdapat di Sarawak yang belum pernah dilaporkan sebelum ini.

Kata kunci: Pendebungaan sawit, *Elaeidobius kamerunicus*, *Pyroderces* sp., entomofili

INTRODUCTION

Insect pollination is vital for oil palm (Li et al. 2022; Rizali et al. 2019). The absence of insect pollinators will result in fruit bunch failure and severely affect crop productivity (Gintoron et al. 2023; Swaray et al. 2021). Before the introduction of *Elaeidobius kamerunicus* into Malaysia from Cameroon, the oil palm pollination in the country relied on native insect pollinators, such as *Thrips hawaiiensis* and *Pyroderces* sp. (Li et al. 2019). There were no prior reports on the composition of native pollinators in Sarawak, as the study was only conducted in Peninsular Malaysia and Sabah (Mohamad et al. 2023; Syed 1979). In the presence of the native pollinators, the fruit formation during the period was considered unsatisfactory, as both species were deemed inefficient pollinators (Gintoron et al. 2023; Hardon 1973; Lewis 1973; Li et al. 2019; Mohamad et al. 2023; Pardede 1990; Syed 1979). Poor fruit set formation was particularly observed on young palms, where wind pollination is limited (Mohamad et al. 2023; Pardede 1990; Syed 1979).

The importation of *E. kamerunicus* in the early 1980s has positively influenced the palm oil industry in Malaysia (Gintoron et al. 2023; Kang & Zam 1982; Mohamad et al. 2023).

Elaeidobius kamerunicus thrived well in the tropics and emerged as a single vital oil palm pollinator in Malaysia and Indonesia (Anggraeni et al. 2013; Li et al. 2022; Mohamad et al. 2023). However, the understanding of the role and presence of other insects that may render complementary pollination services in the oil palm ecosystem, especially in Sarawak, Malaysia is still lacking. As such, this study aims to investigate the presence of other possible insect pollinators of oil palm besides the dominant *E. kamerunicus*.

MATERIALS AND METHODS

Selection Sites

The observation of the activities of *Elaeidobius kamerunicus* and other possible pollinating insects in the field was conducted for a month at productive oil palm plots, consisting of palms aged 7 years old. This palm age profile was selected for their consistent yields (i.e. normal-sized fruit bunches) and has an ideal height for trap placement and monitoring. Furthermore, it was suggested that palm age has no significant effects on the abundance and types of insects visiting oil palm flowers (Rizali et al. 2019).

The oil palm has flowering cycles, dictated primarily by genetic and environmental factors, which explains the periodical and spatial variance in the number of oil palm inflorescences (Adam et al. 2011). Four sampling plots were selected, within the block covering an area of 17.60 hectares, with an average palm stands at 129 palms/ha. Each sampling plot consisting of 100 oil palms. Although it is unlikely for *E. kamerunicus* to visit the flowers of other plants due to its specificity, still, the understory management of all selected sampling plots was made uniform to minimise any possible errors in measuring the effects and presence of non-*E. kamerunicus* pollinators.

Selection of Anthesising Oil Palm Inflorescences and Trap Placement

It was suggested that within a plot of 100 oil palms, the minimum number of male and female inflorescences that can be found are 5 and 2 for each sex respectively (Rizali et al. 2019). As such, within each sampling plot, traps were installed on two anthesising male inflorescences and two receptive female inflorescences, following methods recommended by Rizali et al. (2019) and Beaudoin-Olliver et al. (2017).

The sampling of the oil palm inflorescences-visiting insects was conducted by using a sticky trap on the specified number of male and female inflorescence in each sampling plot. The double-sided yellow sticky traps for flight interception are made of plastic sheets and modified from methods recommended by Beaudoin-Olliver et al. (2017). Samples were obtained by trapping the flying insects around and within the vicinity of the inflorescences. Information on the trap placement (i.e. sex of the inflorescences and trap number) was labelled on each trap. The traps were set up in front of the anthesising male and female inflorescences twice daily, from 7.00 a.m. to 4.00 p.m. and from 4.00 p.m. to 7.00 a.m. To minimise the effects of the weather on the rate of insect visitation, the trapping was only conducted during.

Insects Identification

Trapped insects were quantified and identified using a portable microscope. Identification of the insects was conducted by referring to insect identification books (e.g. Bock 1976; Borror et al. 1996; Goulet & Huber 1993).

Data Analysis

Referring to the analysis used by Kato et al. (2008), principal component analysis was performed on the data set to identify the patterns of the insect visitors on both sexes of oil palm inflorescences. The analysis was conducted by using Minitab 19 software version 22.1.0.

RESULTS AND DISCUSSIONS

Compositions of Insect Visitors of Oil Palm Inflorescences

A total of 4,830 insect individuals were captured from the traps placed on 16 samples of male and female inflorescences (8 for each sex), with 4,267 (88.34%) individuals captured on the sticky trap placed on the anthesising male inflorescences. The most abundant species captured were the oil palm pollinating weevil, *E. kamerunicus* and *Pyroderces* sp. (Figure 1 & 2). The female *E. kamerunicus* was found to be more abundant than their male counterparts which were similar to the findings reported by Yue et al. (2015). *Pyroderces* sp. is recorded as a native species observed on the oil palm inflorescences in Malaysia (Mohamad et al. 2023; Syed 1979). The presence of flies (Diptera: Drosophilidae) was also observed on both sexes of oil palm inflorescences and are known to be fungus-eating insects (Rizali et al. 2019; Rosewell et al. 1990). The substantial presence of Drosophilid flies on the oil palm inflorescences may be due to the abundance of fungi and bacteria in the area, which was facilitated by *E. kamerunicus* feeding habits (Rizali et al. 2019). In addition to pollen and nectar sourcing, insect visitation in oil palm inflorescences was also associated with prey hunting (Muhammad Luqman et al. 2017). In addition, a relatively small number of *Gabrius* sp, *Microporum* sp., and earwigs (Dermaptera) were captured during the study.

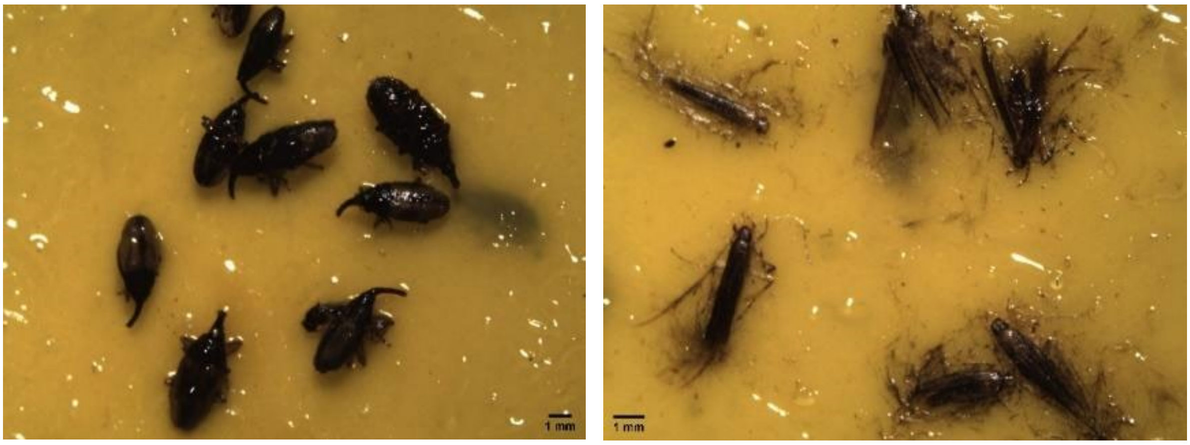

Figure 1. *Elaeidobius kamerunicus* and *Pyroderces* sp. were the two major species intercepted during flight towards the inflorescences of *Elaeis guineensis*

Figure 2. The majority of *Pyroderces* sp. was trapped from 1600 hrs to 0700 hrs, indicating its preferred activity period

The captured samples were then identified and classified into different morphospecies. The data revealed that 16 morphospecies were captured, with several individuals unable to be identified (Table 1). To obtain a general idea of the preferred peak activity period, the traps on each inflorescence were replaced twice a day; at 0700 hrs and 1600 hrs. A large number of insects were captured in both sampling periods, although the species compositions between the sampling period and the type of inflorescence differed significantly.

To better explain the variance in the visitors of the oil palm inflorescence, a principal component analysis was conducted. Based on the insects captured on the yellow-sticky trap, the inflorescence visitors were identified and classified into 10 groups for the male inflorescence (*E. kamerunicus* male & female, *Pyroderces* sp., gnats (Ceratopogonidae), Hymenoptera, Diptera, Lepidoptera, Isoptera, *Gabrius* sp. and *Microporum* sp.) and 14 groups for the female inflorescences (*E. kamerunicus* male & female, *Pyroderces* sp., gnats (Ceratopogonidae), Hymenoptera, Diptera, Hemiptera, Lepidoptera, Isoptera, Dermaptera, *Gabrius* sp. (Coleoptera), *Nomia* sp. (Hymenoptera), *Anthocoride* sp. (Hemiptera) and *Microporum* sp. (Coleoptera)).

Table 1. Number of different insects morphospecies captured on male and female inflorescences of oil palm at different sampling periods

No	Insect ID	Sex of the Inflorescences		Number of Individuals Captured (Trap collection)			
				1600 hrs – 0700 hrs		0700 hrs – 1600 hrs	
		Male	Female	Male Inflorescences	Female Inflorescences	Male Inflorescences	Female Inflorescences
1	*Elaeidobius kamerunicus* (Male)	√	√	37	4	394	13
2	*Elaeidobius kamerunicus* (Female)	√	√	151	11	1489	39
3	*Pyroderces* sp (Lepidoptera: Cosmopterigidae)	√	√	1495	82	3	8
4	Ceratopogonidae (Diptera)	√	√	331	114	165	98
5	Hymenoptera	√	√	21	15	58	39
8	Muscidae & Drosophilidae (Diptera)	√	√	27	30	49	66
9	Hemiptera		√	0	2	0	0
10	Lepidoptera	√	√	7	14	1	0
11	Isoptera	√	√	10	15	4	3
12	*Gabrius* sp. (Coleoptera: Staphylinidae)	√	√	7	3	1	0
13	Dermaptera		√	0	1	0	1
14	*Microporum* sp. (Coleoptera: Nitidulidae)	√	√	0	1	1	2
15	*Nomia* sp. (Halictidae: Hymenoptera)	√	√	1	0	14	1
16	*Anthocoride* sp. (Hemiptera)	√		1	0	0	0
17	Blattodea		√	0	1	0	0

The number of insects trapped was used in the principal components analysis. Eigenvectors of the first two principal components are shown in Figure 3. On the male inflorescences (Figure 3A), the first component, which contributed to 20.9% of the variance, indicated the dominance of [*E. kamerunicus*+*Pyroderces*] over [gnats+Lepidoptera+Hymenoptera]. Meanwhile, the second component, which contributed to 14.7% of the variance, corresponded to the dominance of *E. kamerunicus* over [gnats+flies] and [*Pyroderces*+*Gabrius* sp.+Lepidoptera]. The cumulative percentages of variance for the first two components were 35.6%, suggesting the additional influence of other variables on the total variance.

For the female inflorescences, the first two components (Figure 3B) represent 30.4% of the total cumulative variance. The first component, which contributed to 17.7% of the variance, explained the dominance of [Diptera+*Microporum* sp.] over [Ceratopogonid+Hymenoptera], while the second component, which represents 12.7% of the variance, corresponded to the dominance of *E. kamerunicus*. Based on this analysis, it was observed that the insect visitors for male inflorescences were dominated by *E. kamerunicus*, *Pyroderces* sp., and ceratopogonids. On the other hand, the visitors of female inflorescences were more diverse.

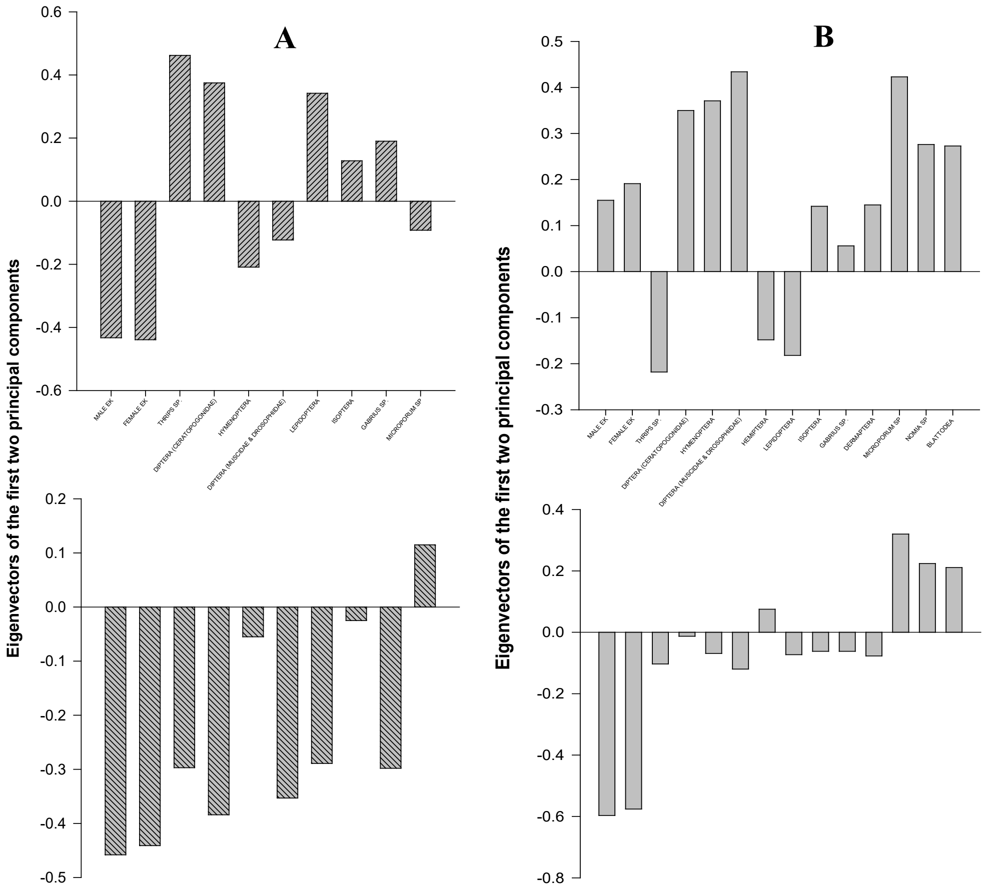

Figure 3. (A) (male inflorescences) and (B) (female inflorescences). The eigenvectors of the first two principal components analysis of the insect visitors of oil palm inflorescences

The Number of Trapped Insects in Response to The Anthesis Stage of Oil Palm Inflorescences

Based on the preliminary data acquisition, in the male inflorescences, the first four days of anthesis yielded the greatest number of insect visitors, before the number declined significantly. The highest number of captured insects was obtained on the second day of anthesis (1,881 individuals), followed by the first, third, and fourth days of anthesis (1,122, 938, and 355 individuals, respectively). Whereas, in the female inflorescences, insects were captured only in the first three days of anthesis, with the greatest number of captures obtained on the second day of anthesis (i.e. 252 individuals) (Figure 4). The findings in this paper are consistent with those reported by Yue et al. (2015), and Dhileepan (1994). These reports suggested that the number of pollinating weevils increased with days of anthesis. However, they also added that the maximum number of weevils can be obtained on the third day of anthesis, before the subsequent massive declination, from the fourth day of the anthesis. This is slightly different from the current finding, as the maximum number of weevils were obtained during the second day of anthesis. The reason for the difference in the findings is possibly due to different levels of volatile emission during anthesis, which can be influenced by the soil type (Muhamad Fahmi et al. 2016). The soil characteristics (e.g., pH level, moisture, and nutrient content) may influence the concentration of volatiles emitted (Buol et al. 2011), which affects plant-pollinator interactions (Wright & Schiestl 2009).

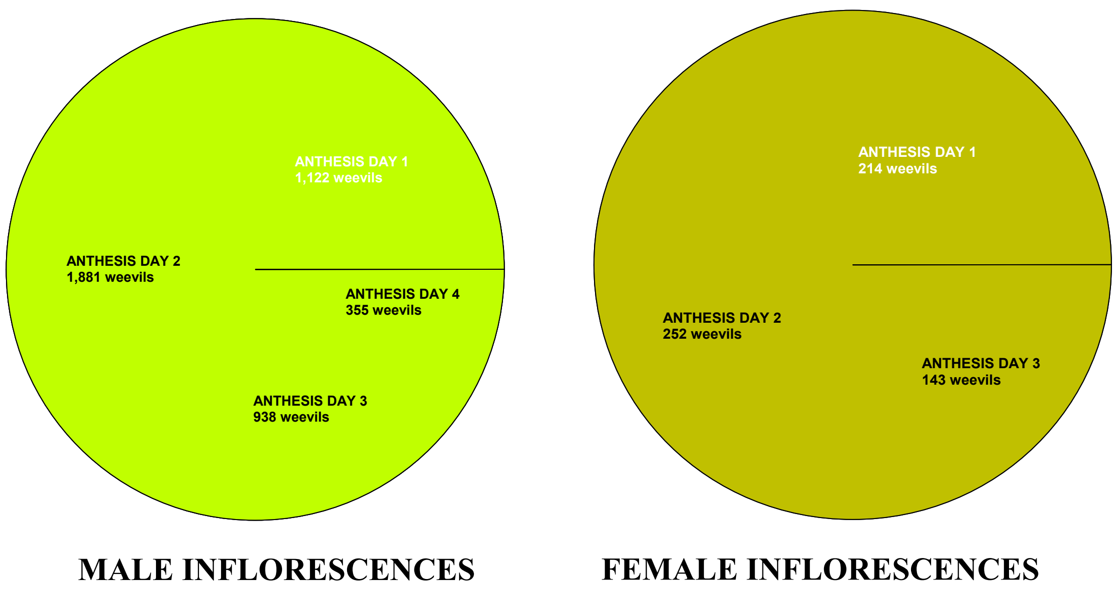

Figure 4. Chart showing the total number of insects captured on each day of anthesis

The Composition of Oil Palm Inflorescences Attracts Insect Visitors in Response to The Different Periods of Trap Collection

In the male inflorescences, a significantly greater number of *E. kamerunicus* was captured during the PM sampling period (trap placement: 0700 hrs – 1600 hrs), which indicates the species preferred active period during mid-day (Figure 5). On the contrary, during the AM sampling period (trap placement: 1600 hrs – 0700 hrs), most of the traps collected consisted of

Pyroderces sp., which corresponds to the moth species' foraging habits (Table 1). Basri and Norman (1997) suggested that both *E. kamerunicus* and *Pyroderces* sp. have different foraging behaviours, with *E. kamerunicus* suggested to be able to tolerate heat, and known to be more active towards mid-day (Anggraeni et al. 2013; Basri & Norman 1997; Yue et al. 2015). On the other hand, *Pyroderces* sp. were seen to be more active past sunset (Tan & Basri 1985). Syed (1979) suggested that *Pyroderces* sp. contributed towards the pollination of the crop, and established the moth as one of the native pollinators of oil palm in Malaysia, alongside *Thrips hawaiiensis*, which was a more dominant pollinator observed in Peninsular Malaysia. It was also noted that the moth has a significantly lower pollen-carrying capacity compared to *E. kamerunicus* (Dzulhelmi et al. 2022; Mohamad et al. 2023). There were concerns that the introduction of *E. kamerunicus* from Africa may jeopardise the populations of the native pollinators (Kang & Zam 1982), however, a later observation revealed that *E. kamerunicus*, *T. hawaiiensis,* and *Pyroderces* sp. were able to co-exist together (Basri & Norman 1997). The difference in the foraging activities has allowed the native species (*Pyroderces* sp. and *T. hawaiiensis*) and the introduced pollinator (*E. kamerunicus*) to co-exist in the oil palm plantations ecosystem (Anggraeni et al. 2013; Basri & Norman 1997).

The significantly high number of insects trapped in the yellow sticky traps placed on the male inflorescences compared to the female inflorescences indicated a highly significant difference in the level of attractiveness of each inflorescence. Similar results were also reported by Beaudoin-Olliver et al. (2017), who used a closely similar method to the one used in this trial. Rizali et al. (2019) and Yue et al. (2015), which employed different sticky trap placements, also suggested that *E. kamerunicus* is more abundant in male inflorescences compared to female inflorescences. The weevil depends on the male inflorescence for food and breeding sites (Mohamad et al. 2021; Mohd Zahari et al. 2019; Zulkefli et al. 2021). Both inflorescences emitted insect-attracting volatiles. Male inflorescences, at all anthesis stages, emit palmitic acid, estragole, and 1-dodecyne (Anggraeni et al. 2013). Female inflorescences also emit estragole, albeit in a lesser amount. A greater amount of volatile content was found in the male inflorescence compared to those in the female inflorescence (Anggraeni et al. 2013; Muhamad Fahmi et al. 2016). In the male inflorescence, out of the compounds reported, estragole has the highest concentration (Muhamad Fahmi et al. 2016). This compound is believed to be the main attractant of the pollinating weevil (Muhamad Fahmi et al. 2016; Lajis et al. 1985), and the differences in the volatile content and amount may explain the rather low number of weevils captured on the trap placed at the female inflorescence.

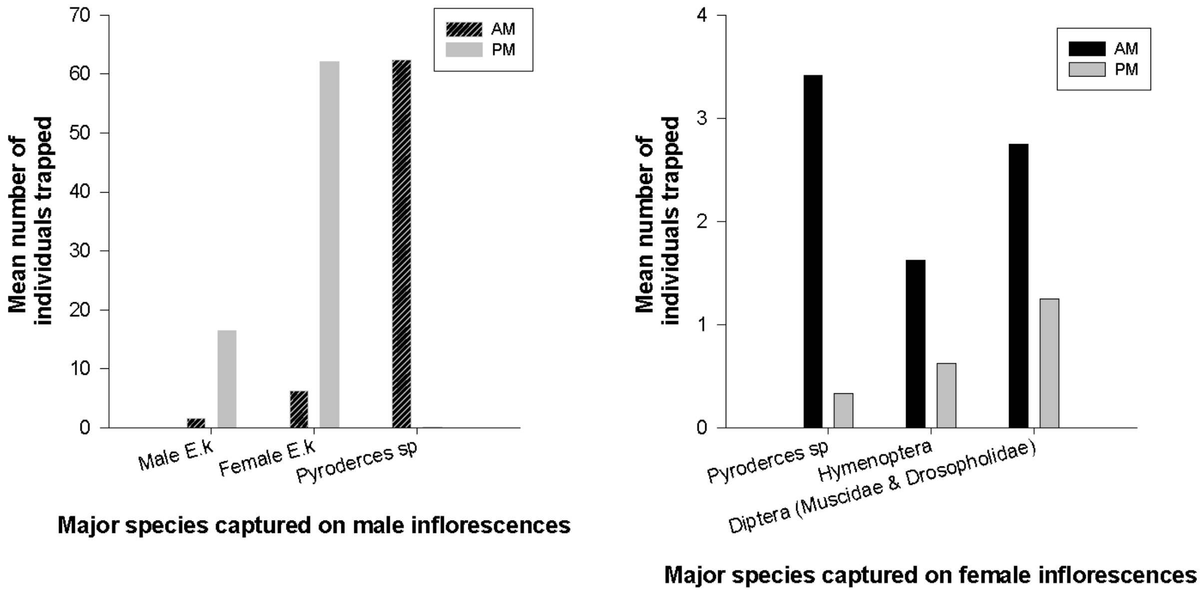

Figure 5. Major groups of insects captured on the male and female inflorescences of oil palm, during different sampling periods

CONCLUSION

It was observed that the majority of the insects captured in the traps installed around the oil palm inflorescences consisted of the oil palm pollinating weevil, *E. kamerunicus.* The significant presence of *Pyroderces* sp. indicated the ability of both species to co-exist in the oil palm ecosystem, mainly through adaptive foraging habits. A greater number of insects congregate at male inflorescences corresponding to the greater amount of volatiles released. Most of the species were found in both sexes of the inflorescences, which complies with their roles in pollination of the crop.

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