POPULATION ABUNDANCE OF OIL PALM POLLINATING WEEVIL, *Elaeidobius kamerunicus* FAUST AND ITS RELATION TO FRUIT SET FORMATION IN MINERAL AND PEAT SOIL AREAS IN PENINSULAR MALAYSIA

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ABSTRACT

The oil palm pollinating weevil, *Elaeidobius kamerunicus*, plays a vital role in the oil palm fruit formation process. An insufficient pollinator population may cause poor fruit set formation, resulting in a high number of parthenocarpic fruitlets and malformed fruit bunches. This study examines the population level of *E. kamerunicus* at two sites in Peninsular Malaysia and its relation to the fruit set formation. Each site represented different soil types, viz, mineral and peat soil. Preliminary results of the study showed that both sites had high adult weevil population density, averaging at 68662.87/hectare and 89270.93/hectare for peat soil and mineral soil, respectively. The average sex ratio of inflorescences in peat soil area (58.09%) was significantly higher than those at mineral soil area (45.01%, $F = 6.75$, $P = 0.016$). The average fruit set percentage in both study areas was satisfactory (more than 60%). The average fruit set in mineral soil area (83.08%) was significantly better than those recorded at the peat soil area (69.47%, $F = 4.42$, $P < 0.05$). Even though there are differences in terms of the population level of the pollinator, the fruit set formation in both areas is still satisfactory.

Keywords: *Elaeidobius kamerunicus*, oil palm, pollinator, population monitoring

ABSTRAK

Kumbang pendebunga kelapa sawit, *Elaeidobius kamerunicus* memainkan peranan yang amat penting dalam proses pembentukan buah sawit. Populasi pendebunga yang rendah boleh menjejaskan peratusan set buah dan mengakibatkan peningkatan bilangan buah partenokarpi. Kajian ini dijalankan bagi mengetahui tahap populasi *E. kamerunicus* dan kadar pembentukan buah di dua tapak kajian yang terletak di jenis tanah (gambut dan mineral) yang berbeza di Semenanjung Malaysia. Dapatan awalan kajian mendapati bahawa kedua dua tapak kajian mempunyai tahap populasi kumbang dewasa pendebunga yang tinggi, iaitu pada purata kumbang 68662.87/hektar (tanah gambut) dan 89270.93/ hektar (tanah mineral). Purata nisbah jantina bunga sawit di kawasan tanah gambut (58.09%) adalah jauh lebih tinggi berbanding dengan purata di kawasan tanah mineral (45.01%, $F = 6.75$, $P = 0.016$). Purata set buah di kedua-dua kawasan kajian adalah memuaskan, iaitu melebihi 60%. Purata set buah di kawasan tanah mineral adalah ketara lebih tinggi (83.08%) jika dibandingkan dengan purata set buah di kawasan tanah mineral (69.47%, $F = 4.42$, $P < 0.05$). Walaupun terdapat perbezaan dari segi tahap populasi pendebunga, kadar pembentukan buah di kedua-dua tapak kajian masih berada pada tahap yang memuaskan.

Kata kunci: *Elaeidobius kamerunicus*, kelapa sawit, pendebunga, pemantauan populasi

INTRODUCTION

Oil palm is one of the most important commodity crops in Malaysia. In 2019, the industry contributed to an export revenue of RM64.84 billion (Parveez et al. 2020). The production of palm oil and its derivatives largely depends on the yield of the crop itself, which stresses the importance of satisfactory fruit bunch production. Pollination services in oil palm are mainly rendered by the oil palm pollinating weevil, *Elaeidobius kamerunicus* Faust.

The weevil is an exotic species in the Southeast Asia region, having been introduced from Africa in the early 1980s to improve the pollination of the crop. Before the importation of the weevil, *Thrips hawaiiensis* Morgan was the main pollinating agent of the crop, but it was found to be an inefficient pollinator (Syed 1979). Recently, increasing cases of poor fruit set formation were reported. The insufficient population level of the pollinator may cause poor fruit set formation, resulting in a high number of parthenocarpic fruitlets and malformed bunches. Parthenocarpic fruits are fruits with no kernels (Harun & Noor 2002). These fruits, especially the white ones, produce no oil (González et al. 2013).

An excessively high number of parthenocarpic fruits can negatively affect the palm oil extraction rate, resulting in lower oil production. It has been reported that poor fruit formation indicates insufficient pollination due to the low population of the oil palm pollinating weevil (Prasetyo et al. 2014). The population of the weevil is affected by various factors such as excessive insecticide application (Asib & Musli 2020; Ismail et al. 2020; Ming & Bong 2017; Prasetyo et al. 2018; Prasetyo & Susanto 2019; Yusdayati & Hamid 2015), predator activities (Amit et al. 2015; Muhammad Luqman et al. 2017) and spikelet number/characteristics (Latip et al. 2018; Mohamad et al. 2020). In addition to pollination efficiency, the soil types also influenced the production of the crop.

In some cases, yields of 30t fruit bunches/ha have been reported in peat soil areas, however, the crop yield on the mineral soil was generally better. The lower yield in peat soil areas was reported to be due to leaning palms and unsuitable soil conditions, such as waterlogged and drying soils (Paramananthan 2013). However, information on the population levels of the pollinating weevil between the different soil types in Malaysia is still lacking. As such, this paper investigate on the population abundance levels of *E. kamerunicus* and its pollination efficiency in peat and mineral soil area in Peninsular Malaysia.

MATERIALS AND METHODS

Location of the Study

The study was conducted from June 2017 until June 2018 at two sites consisting of similar planting material (*Elaeis guineensis* Jacq. DxP palms) and palm age profile (7 years after planting). Site 1 is located in Sg Bebar, Rompin, Pahang (N3˚14’55” E103˚21’26”), while Site 2 is located at Chuping Estate, Perlis (N6˚29’5.60292” E100˚19’40.3896”). Site 1 was chosen to represent the oil palm cultivated in the peat soil area, while Site 2 represented the mineral soil cultivation. Both sites received a fairly similar average monthly rainfall between 180-220mm.

Site Preparation

A study plot of 10 hectares was selected within the selected oil palm estates. The main criteria for the selection of the study plot were the age of the palm and the general condition of the palms within the plot, making sure that the palms within the plot are healthy, and similar management practices were applied to the selected plots. Selection of the recording palms was conducted by marking every tenth palm within the study plot. In total, 150 recording palms were marked in the study plot.

Sampling of *Elaeidobius kamerunicus*

The adult *E. kamerunicus* was sampled to estimate the weevil population within the study area. The monthly sampling was conducted on ten fully anthesising male inflorescences on the recording palms. From each inflorescence, three spikelets each were sampled from different parts of the inflorescence, namely the top, middle, and bottom part, following procedures by Basri et al. (1987) and Latip et al. (2018). The sampled spikelets were then stored in individual plastic bags and brought to Entomology Laboratory 1, Malaysian Palm Oil Board Headquarters, Bangi, Selangor, Malaysia where the dead weevils were counted and sexed.

The total number of spikelets at the anthesising male inflorescences was also counted. This figure, in combination with the adult weevil’s spikelet^{-1}, was then used to estimate the population of adult weevils hectare^{-1}. The following formula was used for the estimation of adult weevils hectare^{-1} (AWH) used in this calculation:

$$\boldsymbol{AWH} = No.of\ weevils\ spikelet^{-1} \times Mean\ no.of\ spikelets\ inflorescence^{-1} \times Sum\ of\ anthesising\ male\ inflorescences\ in\ a\ hectare\ of\ the\ study\ plot$$

Inflorescence Census

Census of the inflorescence was conducted on the recording palms every month to determine the density of both male and female inflorescences in the studied areas. The anthesis stage was classed based on the phenological scale suggested by Forero et al. (2011). The anthesis stage of male inflorescences (phenological stage 607) was divided into four stages; ¼, ½, ¾, and full anthesis, depending on the length of the opened flowers of each spikelet. Meanwhile, the female anthesis stage is divided into three class, viz. pre-anthesis (phenological stage 602 & 603); at-anthesis (phenological scale 607, with over 70% of tepals openly display the tri-lobed cream-colored tepals), and post-anthesis (phenological scale 609, progressive change in the color of the stigma lobes was observed, which became purple, indicating that the flowers have been pollinated). From the census, the total sex ratio of the inflorescences was obtained.

$$\boldsymbol{Inflorescence\ sex\ ratio}: \frac{Total\ number\ of\ female\ inflorescences}{Total\ number\ of\ inflorescences}\ x\ 100$$

Fruit Set Counting

Monthly fruit set counting was conducted to determine the pollination efficiency in the studied areas. Fifteen ripe bunches from the recording palms were sampled monthly before being chopped into individual spikelets to facilitate fruit set counting. The counting was conducted by dividing the total number of fertile fruits, indicated by the presence of kernel and shell (i.e., complete fruit set) by the total number of fruits. The following formula was used:

$$Fruit\ set\ \% = \frac{Total\ number\ of\ fertile\ fruitlets}{Total\ number\ of\ fruits\ within\ the\ bunch}\ x\ 100$$

Statistical Analysis

The population abundance of *E. kamerunicus*, the inflorescence sex ratio, and fruit set percentages for both study sites were analyzed using two-way ANOVA in Minitab 19 and SigmaPlot 10. Where significant differences were detected, mean comparisons were then conducted using Tukey LSD ($P < 0.05$) in similar software.

RESULTS AND DISCUSSION

Population Levels of *Elaeidobius kamerunicus*

Adult Weevils Spikelet^{-1} (AWS) and Adult Weevils Hectare^{-1} (AWH)

Census was conducted at both sites on monthly basis throughout the study period, except for January 2018, when the study plot at Site 1 was flooded due to heavy rainfall. Adult weevils spikelet^{-1} refers to the number of adult oil palm pollinating lodged in one individual spikelet of the anthesising male inflorescence. It was found that the AWS reading for both sites fluctuated throughout the recording period. For Site 1, the AWS reading during the study period ranged from 8.64 to 103.22 adult weevils spikelet^{-1}, averaging at 58.34 adult weevils spikelet^{-1}. Meanwhile, a higher population average (84.97 adult weevils spikelet^{-1}) was recorded at the mineral soil in Site 2. The AWS at the site ranged from 25.67 to 140.29 adult weevils spikelet^{-1}. Statistically, no significant difference between the two sites was detected ($P > 0.05$, $P = 0.071$).

Adult weevils' hectare^{-1} is an estimated population density of the oil palm pollinating weevil for the study area. The AWH reading for both sites fluctuated during the period of the study (Figure 1). It was also found that the AWH peak and trough for both sites happened almost at a similar period viz; minimum AWH for both sites were during 2nd to 3rd yearly quarter, while the maximum AWH occurred in the earlier part of the year (i.e., the first quarter of the year). The AWH at Site 1 ranged from 6,929.45 to 147,211.62 AWH, while for Site 2, the range was between 14,683.24 to 272,106.48 AWH. However, statistical analysis revealed no significant difference existed in terms of AWH for both sites ($P > 0.05$, $P = 0.403$).

The population of *E. kamerunicus* in the study sites varied throughout the study period, which supports a similar observation mentioned by Tuo et al. (2011). The density of the male inflorescences in the area influenced the population levels of the oil palm pollinating weevil. Other than the lack of resources availability, the weevil population can be obliterated by excessive insecticide application, especially broad-spectrum chemical insecticides, such as trichlorfon, fipronil (Ismail et al. 2020), dimehypo, carbosulfan, deltamethrin (Setyawan et al. 2019), and cypermethrin (Ming & Bong 2017), which was mainly used to control the population of oil palm bunch moth (*Tirathaba* sp.) (Mohamad et al. 2017). The reduced fecundity of the weevil, due to improper application of acaricides and insecticides (Setyawan et al. 2019) and heavy infestation of nematode, *Elaeolenchus parthenonema* (Poinar et al. 2002) also affected the overall population of the insect.

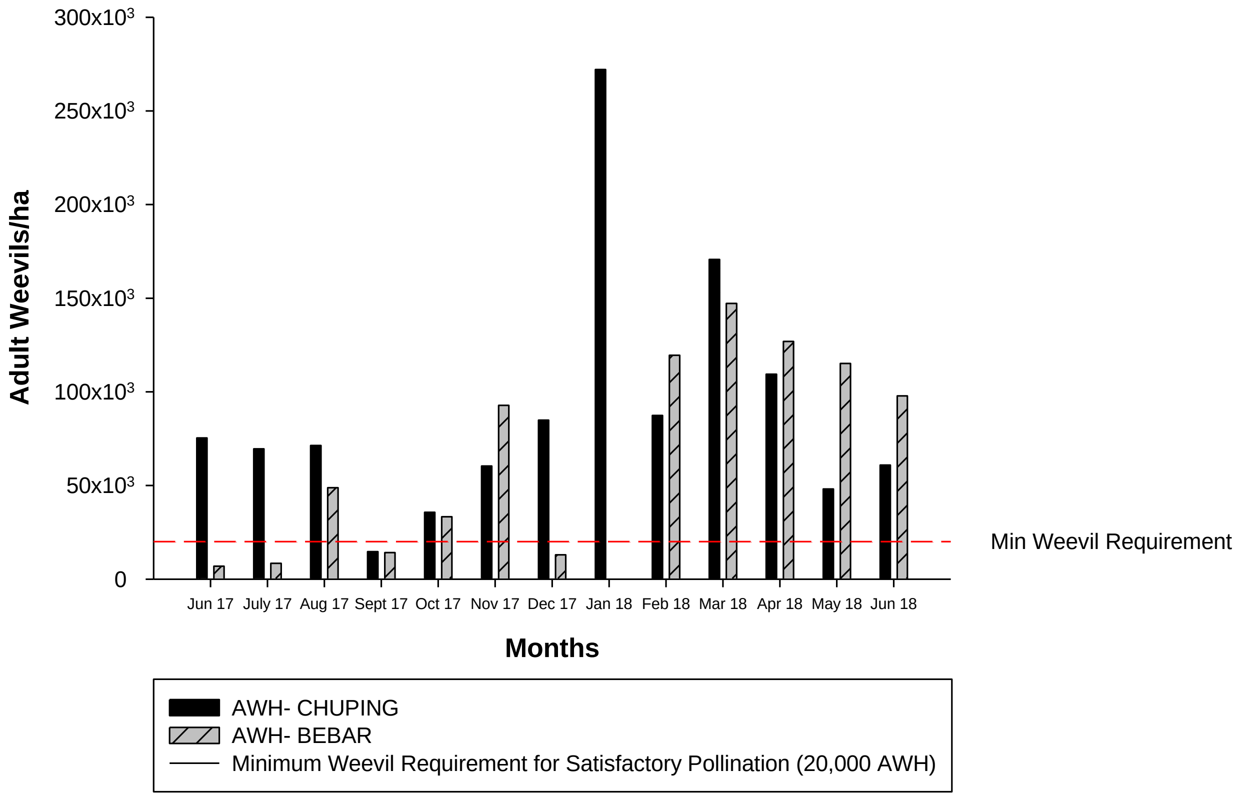

Figure 1. Monthly weevil populations at both study sites

Fruit Set Formation

Fruit set percentage is the indicator of the pollination efficiency in the studied areas, i.e., the rate of pollinated florets in female inflorescence. A fruit set of 60% is sufficient to obtain an oil to bunch ratio (O/B) of 23%, after which the O/B percentage plateaued and decline (Othman et al. 2019). The fruit set percentage at both study sites fluctuated throughout the study period (Figure 2). At Site 1, located on peat soil area, the fruit set percentage ranged from 58.53% to 84.58%. Only on one occasion (July 2017), where the fruit set percentage was less than 60%. This was coinciding with the monthly weevil population of fewer than 20000 individuals. Whereas in other months, the fruit set formation was satisfactory. The average fruit set percentage in Site 1 was 69.47% (Figure 3). Meanwhile, at Site 2 on the mineral soil area, the fruit set formation was satisfactory in every month of sampling, ranging from 72.22% to 93.34%, indicating a very efficient pollination at this site. The average fruit set percentage in this area was recorded at 83.08%. Comparison of fruit set between these two sites showed that site 2 has significantly higher fruit compare to site 1 ($F = 4.42$, $P <0.05$). The weevil population density per hectare and the fruit set percentage were found to be positively correlated, although no significant correlation was detected ($r = 0.041$).

Based on the data collected during the study period, the satisfactory fruit set percentage obtained when the weevil populations in the area were above 20000 individuals. According to Donough et al. (1996), 20,000 weevils per hectare are required to achieve fruit set formation of 55%. Interestingly, in the current study, weevil populations of 14,000 individuals per hectare were enough to obtain the fruit set percentage of 65%. Fruit set of less than 63% was obtained when the weevil populations were less than 10,000 individuals. This was evident at Site 1 in June and July 2017, when the weevil populations ranged between 6,929.45 and 8,407.68 individuals ha^{-1}, the resulting fruit set percentage was only 58.53% and 62.84% respectively. It was also observed that high weevil populations (e.g., >100,000 weevils individuals) do not necessarily contribute to a higher fruit set. For example, at Site 2, the fruit set percentage in January 2018 was lesser (79.45%) compared to December 2017 (83.96%), even when the weevil populations in January 2018 (272,106.5 weevils ha^{-1}) were greater than the previous month (84917.45 weevils ha^{-1}). It is possible that the pollen transfer to the stigma of florets on female inflorescences was disrupted due to the extremely high weevil population in the area. An excessively high population of the pollinating weevil may lead to intraspecific competition for nutrients and space, thus affecting the pollination (Prasetyo 2013; Wahid & Kamarudin 1997).

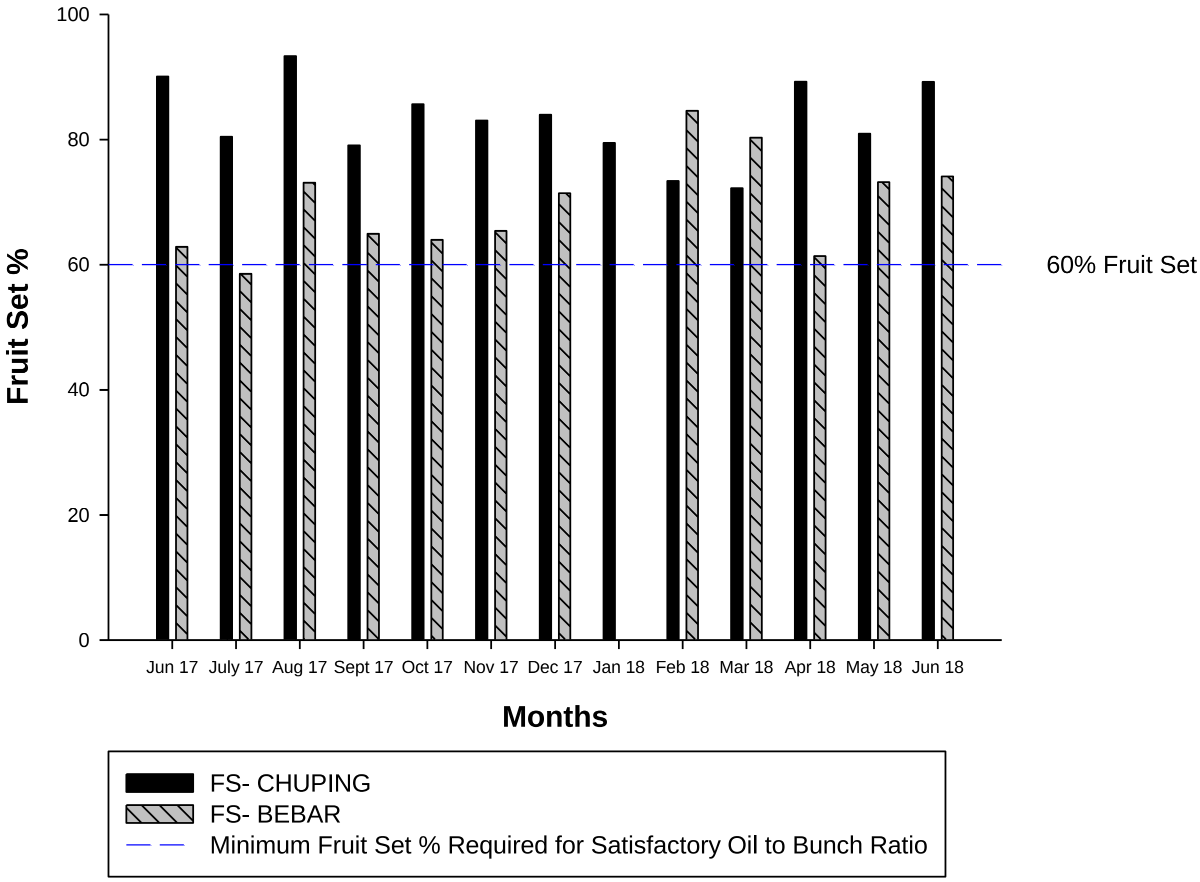

Figure 2. Monthly fruit set percentage (adjusted to 6 months after the inflorescence census) at both study sites

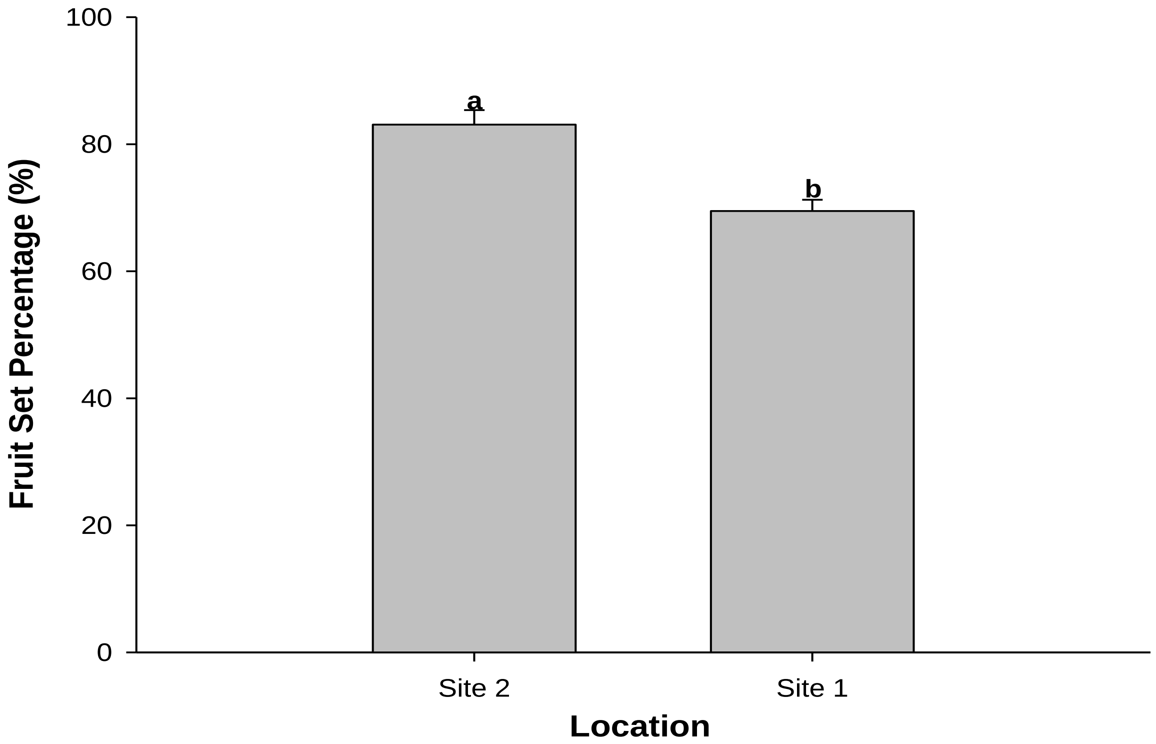

Figure 3. Comparison between the mean fruit set percentage in the studied sites. Means that do not share a similar letter are significantly different

The Sex Ratio of the Inflorescences

Being a monoecious crop, oil palm produced male and female flowers separately on the same plant, usually in the alternate cycle (Corley & Tinker 2003). The sex ratio of the inflorescences reflects the density of female inflorescences in the studied areas (Corley & Tinker 2003). During the study period, the sex ratio of the inflorescences in Site 1 (58.09%) was significantly greater than the sex ratio in Site 2 (46.01%) (Figure 4, $F = 6.75$, $P < 0.05$). A higher sex ratio indicated a greater presence of female inflorescences in the area. The healthy density of female inflorescences, which later develop into fruit bunches, are an important indicator of the estate's productivity. In short, the production of female inflorescences guarantees yield return. However, a high sex ratio also means that the density of male inflorescences in the area was comparatively low. The weevil depends on the male inflorescences for food and breeding sites (Sambathkumar & Ranjith 2011). As such, the lack of male inflorescences in the area will negatively affect the population of the weevil. Also, the lack of male inflorescence will contribute to lower pollen density in the area, which affects the pollination and oil palm fruit set formation. To a certain extent, the lower density of male inflorescences in Site 1 has affected the weevil population and the pollen density in the area, which hampered the formation of higher fruit set percentages.

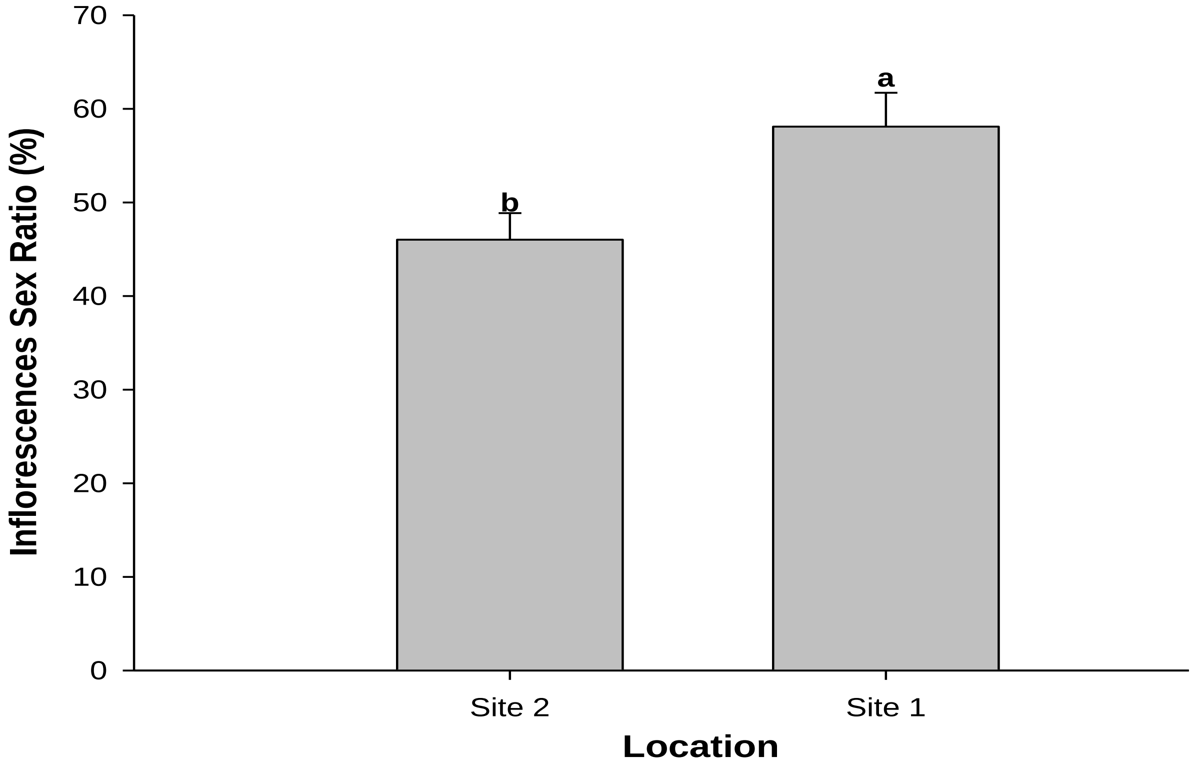

Figure 4. Mean comparison of the inflorescence sex ratio in the studied sites. Means that do not share a similar letter are significantly different

CONCLUSION

The density of the male inflorescences in the area influenced the population levels of the oil palm pollinating weevil. However, based on the monthly data, the fluctuation in the weevils population does not affect the fruit set formation as the percentage of the fruit set on both sites was satisfactory. Weevil populations of 14000 individuals per hectare were enough to obtain 65% of the fruit set. A significantly better fruit set percentage was recorded at the mineral soil as compared to the peat soil. A significant difference between the sex ratio of the inflorescences has possibly affected the pollen availability in the study area, resulting in a significantly lower fruit set percentage at Site 1. The study highlighted the population level and the pollination efficiency of *E. kamerunicus* in mineral and peat soil areas and the importance of having sufficient male inflorescences to preserve the pollinator population.

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