

IMPACT OF ANTHESIS PERIOD AND ABIOTIC FACTOR ON THE POPULATION DENSITY OF *Elaeidobius kamerunicus* FAUST (COLEOPTERA: CURCULIONIDAE) IN OIL PALM PEAT AND MINERAL SOILS

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ABSTRACT

Poor fruit set impacts oil palm productivity on both peat and mineral soils. Despite the crucial role of the pollinator *Elaeidobius kamerunicus*, the relationship between weevil density and anthesis stages across different soil types remains underexplored. This study investigated *E. kamerunicus* density on anthesising male and female inflorescences on peat and mineral soils over one year. Sticky traps were used for female inflorescences (Day 1–4) and spikelet sampling for male inflorescences (Day 1–5). Results showed that *E. kamerunicus* population density on female inflorescences varied significantly ($P < 0.01$) across days of anthesis. Day 1 exhibited the highest population; however, Day 1 and 2 were statistically similar. Weevil population density (measured both per spikelet and per inflorescence) exhibited a highly significant variation ($P < 0.01$) across the male inflorescence anthesis stages. Weevil population peaked significantly on the Day 3 of anthesis. Crucially, population dynamics were consistent across both soil types, suggesting soil composition does not alter weevil visiting patterns. While the timing of peak visitation was similar across sites, the overall population density of *E. kamerunicus* was significantly greater on mineral soil than on peat soil. Correlations between weevil population and abiotic factors were generally low. Consequently, this study confirms a distinct relationship between the anthesis stage and *E. kamerunicus* density. These findings provide essential guidelines for timing field monitoring to improve oil palm management and ensure effective pollination.

Keywords: anthesising inflorescence of oil palm, *E. kamerunicus* population density, mineral soil, peat soil.

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INTRODUCTION

Malaysia's oil palm industry is a major contributor to the nation's economy, generating RM109.391 billion in export revenue from palm oil-based products in 2024, with a cultivation area of 5.612 million hectares (Parveez et al., 2025). This export revenue occurred despite the decrease in planting land from the previous years since 2023. Currently, the world consumption of palm oil for the year 2022/2023 was reported at

76.04 million tonnes (Shahbandeh, 2023). The oil palm, *Elaeis guineensis*, is a monoecious plant with both male and female inflorescences located at different positions on the palm and supporting the livelihood of the pollinating weevil.

Elaeidobius kamerunicus, which was introduced from Cameroon in the 1980s (Syed, 1981; Syed et al., 1982), has since been the main pollinator of oil palm in Malaysia. *E. kamerunicus* was established based on merits such as having an active search capability, a higher pollen load, being able to thrive in dry and wet climates (Syed, 1981), and being a unique host for the genus *Elaeis* (Kang & Karim, 1982; Syed, 1981). The introduction of *E. kamerunicus* reduced the assisted pollination cost, increased the bunch fruit set (Syed et al., 1982), and eventually ceased the need for assisted pollination (Teo, 2015).

Despite the effectiveness of *E. kamerunicus* in the production of fresh fruit bunches (FFB), there was concern about low fruit set in Malaysia (Kamarudin et al., 2018; Teo, 2015), where 88,000.00 ha of the 580,891.76 ha surveyed were found to have poor fruit set in peat and mineral soils (Kamarudin et al., 2018). Contrasting soil properties significantly influence oil palm floral development and weevil populations. Peat soils suffer from extreme water retention, poor drainage, high acidity and nutrient deficiencies (Bakri et al., 2025; Manalu et al., 2024; Md Talib et al., 2025; Santi et al., 2022). This challenging environment induces less uniform male spikelets (Mohamad et al., 2021b). Conversely, mineral soils provide optimal drainage, aeration and a neutral pH (Pan et al., 2018; Weil & Brady, 2017), supporting consistent spikelet development (Mohamad et al., 2021b). Consequently, these variations in spikelet length and quality directly influence the carrying capacity for weevil populations. Similarly, our neighbouring country, Indonesia, also reported incidences of low fruit set (Prasetyo et al., 2014) at 10% and below. Prasetyo et al. (2014) stated that a low weevil population will result in poor fruit set formation of bunches. A fruit set study conducted in oil palm against weevil population was among those reported by Mohamad et al. (2021a) and Riley et al. (2022). Both observed no relationship between *E. kamerunicus* and fruit set. This report on low fruit set raised a concern regarding the effectiveness of the pollinator weevil.

A recent review by Mohamad et al. (2023) categorised factors affecting pollinator effectiveness into intrinsic and extrinsic groups, identifying population density as a key intrinsic factor. While comprehensive reports on *E. kamerunicus* population density during anthesis day at both male and female inflorescences exist for China (Yue et al., 2015), India (Saravanan et al., 2024) and Indonesia (Permana et al., 2021), Malaysia currently

lacks similar detailed studies beyond early work by Chiu et al. (1985) and Swaray et al. (2021). Despite the available reports, the statistical association between the anthesis period and the weevil population is still lacking and unproven, with previous reported studies basically summarising the association of anthesis day with the highest population. Thus, statistical analysis can be a supporting factor in understanding the behaviour of the weevil.

This research was conducted to examine the daily population density of *E. kamerunicus* at anthesis on male and female inflorescences of oil palm planted on peat and mineral soil. The study also looked into the effect of abiotic factors on weevil population density during inflorescence anthesis. This report will provide insights into the weevil population under Malaysia's climate and compare it to the reported studies worldwide.

MATERIALS AND METHODS

Sampling Plot

The study on weevil population density was carried out between July 2022 and June 2023 in two types of cultivated soils: Namely mineral and peat soil. The first site, Bukit Payong Estate, Pekan, Pahang (2° 58' 21.792" N, 103° 22' 41.8656" E), consists of oil palms planted on peat soil in 2015. The second site, Felda Chuping 02 in Kangar, Perlis (6° 30' 53.2656" N, 100° 17' 40.2648" E), comprises oil palms established on mineral soil in 2016. This age criterion was essential because previous study by Tan et al. (2014) indicated that palms under 10 years old are typically less than 4 m tall, which significantly facilitated the daily observation and sampling of inflorescences. The study was conducted in a 4 ha sampling area. Both sites cultivated similar varieties, namely *dura* × *pisifera* planting material with a planting density of 148 palms/ha.

Weevil Population Density at Anthesising Inflorescence

The population density of *E. kamerunicus* was determined by studying anthesising male and female inflorescences across their different anthesis stages. The phenological stages for both inflorescences were defined based on methodologies described by Forero et al. (2012) and Mubarak et al. (2022).

For male inflorescences, anthesis was characterised by 70% flower opening from the base and pollen-laden anthers, emitting a distinct anise-like scent attributed to the chemical estragole (Forero et al., 2012; Mubarak et al., 2022). Anthesising female inflorescences were

characterised by the presence of whitish trilobed tepals covering 70% of the inflorescence (Forero et al., 2012; Mubarok et al., 2022). These specific anthesis characteristics for both inflorescence types were collectively designated as the phenological stage. Inflorescence sampling was conducted simultaneously over five days within the designated study area.

Weevil population density on female oil palm inflorescence. All 592 palms within the 4 ha sampling area were surveyed to determine female anthesis. The anthesis period for female inflorescence can be categorised into four days. The first day following the phenological stage PS607 characteristic is represented by whitish tepals with an opening around 70%, as described by Forero et al. (2012) and Mubarok et al. (2022). The following three consecutive days, with 100% tepal opening on Day 2, 3 and 4, carried reddish-coloured tepals. A yellow and odourless insect sticky trap (Chemibond) with a size of 33 x 21.5 cm was used to study the *E. kamerunicus* population density per inflorescence. The sticky trap is a commonly employed method for studying weevil populations (Auffray et al., 2017; Beaudoin-Ollivier et al., 2017; Yue et al., 2015).

In this study, a sticky trap was held up by an iron mesh wire of a similar size on top of the female inflorescence on Day 1 anthesis at 8 am. The sticky trap was left until 5 pm to obtain the number of weevils visiting the inflorescence. This process was repeated for the next three consecutive anthesis days. Sticky traps with the lodged weevils were covered with transparent plastic, and the weevil population was counted and categorised according to sex based on their morphology. Morphologically, male weevils have a larger body size than females, whereas females possess a longer proboscis (Abd Latip et al., 2019; Muhammad Nasir et al., 2020). The study was conducted for one year with monthly data collection, where two female inflorescences were sampled for each soil type.

Weevil population density on male oil palm inflorescences. A comprehensive census of all 592 palms within the 4 ha sampling area was performed before male inflorescence sampling. This initial step aimed to locate and track specific male inflorescences that commenced anthesis on the first day of the study period. Male inflorescence anthesis was assessed using a modified five-day scale, adapted from Chiu et al. (1985) and Yue et al. (2015). This modification specifically involved omitting original anthesis Days 6 and 7, as preliminary observations indicated no weevil presence during these later stages. The five stages were defined as Day 1 (25% flower opening start from bottom spikelet), Day 2 (50% flower opening),

Day 3 (100% flower opening), followed by Day 4 and 5, which exhibited a progressive reduction of pollen on the spikelet surface.

Sampling for the population density of *E. kamerunicus* began with collecting spikelets containing weevils. For each male inflorescence, the entire structure was divided into top, middle, and bottom sections, followed by two spikelets being taken from each section daily. The sampling method underwent a slight modification in comparison to Chiu et al. (1985), by reducing the number of sampled spikelets. The sampled spikelet was placed into a plastic bag (22 x 32 cm) and tightly sealed. Spikelet sampling was conducted daily between 8 and 10 am before the weevil's active period, as referenced in the study by Permana et al. (2021) and Yue et al. (2015). Sex-specific counts of the weevil population were performed. Male weevils are characterised by a larger overall body size compared to females, while females are distinguished by a longer proboscis (Abd Latip et al., 2019; Muhammad Nasir et al., 2020). The study was conducted for one year with monthly data collection, where two male inflorescences were sampled for each soil type.

Finally, the tabulated weevil population per spikelet was used to calculate the population density of *E. kamerunicus* per inflorescence using Equation (1) below:

$$\begin{array}{lcl} \text{Population density} & \text{Number of weevil per} & \\ \text{of } E. \text{ kamerunicus} & \text{spikelet} \times \text{Total spikelet} & (1) \\ \text{per inflorescence} & \text{per inflorescence} & \end{array}$$

Weather Data Collection

Weather data, including daily rainfall (mm), temperature (°C), and relative humidity (%), were collected. Daily rainfall data was sourced from the designated plantation weather station. For daily temperature and relative humidity, an Extech 45170 4-in-1 Environmental Meter (Extech Instruments, USA) was utilised. All weather data collection was performed daily, corresponding with the *E. kamerunicus* population sampling period times. This simultaneous data collection ensured a precise correlation between the weather and population density data.

Statistical Analysis

A normality test was performed on the weevil population data to determine its distribution and suitability for analysis. Normality tests on the weevil population density data revealed a non-normal distribution, and subsequent transformations were unable to normalise the data. Consequently, a non-

parametric statistical approach was employed. Kruskal-Wallis non-parametric analysis was conducted to compare the weevil population density (per inflorescence or spikelet) against the day of anthesis. The post-hoc test utilised the Dwass, Steel, Critchlow-Fligner (DSCF) pairwise comparison method to identify peak population densities during the anthesis period. The influence of the anthesis process on the weevil population density was statistically analysed according to the soil type.

Furthermore, Wilcoxon two-sample tests were performed to compare *E. kamerunicus* population density (per inflorescence and per spikelet) between soil types, identifying which soil contributed to a higher population. A correlation analysis was also carried out between abiotic factors and weevil population density, with consideration of soil type and anthesis day of inflorescences. Statistical analyses were performed using SAS 9.4 software (SAS Institute, USA).

RESULTS AND DISCUSSION

Elaeidobius kamerunicus Population Density on Anthesising Female Inflorescences Across Different Soil Types

Significant differences were observed in the total, female, and male weevil populations per inflorescence relative to the female inflorescence anthesising process in both mineral and peat soils. For mineral soil, the results were as follows: Total weevil/inflorescence $X^2 = 59.8440$, $P < 0.01$, female weevil/inflorescence $X^2 = 58.6865$, $P < 0.01$, and male weevil/inflorescence $X^2 = 62.2867$, $P < 0.01$. Similarly, on peat soil, significant differences were also found: Total weevil/inflorescence $X^2 = 62.4624$, $P < 0.01$, female weevil/inflorescence $X^2 = 63.7501$,

$P < 0.01$ and male weevil/inflorescence $X^2 = 55.5588$, $P < 0.01$.

Pairwise comparisons of anthesising female inflorescence development revealed no significant differences in any parameters studied between Day 1 and Day 2 for either soil type (Table 1). DSCF tests confirmed that soil type did not significantly influence weevil population density during these early anthesis stages (Day 1 and 2) for female inflorescences. Furthermore, on peat soil, anthesising female inflorescence Day 3 vs. 4 also showed no significant difference in the total weevil population per inflorescence, nor in the female or male weevil populations per inflorescence. This suggests that the population density remained relatively stable during these later anthesis stages on peat soil, contributing to the overall lower population density observed towards the end of the anthesis. Despite these consistencies within early stages and specific later stages on peat, other pairwise comparisons between soil types demonstrated highly significant differences in weevil populations during different anthesis days.

The mean population density per inflorescence was plotted against the anthesising days for both mineral and peat soil, as depicted in Figure 1. On both soil types, anthesising female inflorescences on Day 1 exhibited the highest mean population density. The results for mineral soil were 916.54 ± 325.51 for total weevils, 697.17 ± 251.71 for female weevils, and 219.38 ± 74.20 for male weevils. Meanwhile, on peat soil, it was 87.58 ± 18.09 for total weevils, 62.92 ± 14.45 for female weevils, and 24.67 ± 4.24 for male weevils. Comparing the female-to-male weevil population on anthesising female inflorescence, the population was approximately three times greater on mineral soil and two times greater on peat soil, indicating a higher visitation by female weevils on both soil types.

TABLE 1. PAIRWISE COMPARISONS OF OVERALL *Elaeidobius kamerunicus* POPULATION DENSITY PER INFLORESCENCE IN RELATION TO FEMALE INFLORESCENCE ANTHERIS DAY, BY SOIL TYPE

Soil	Anthesis (Day)	<i>E. kamerunicus</i> population/inflorescence		
		Total	Female	Male
		<i>P</i> -value		
Mineral	1 vs. 2	0.6425 ^{NS}	0.6812 ^{NS}	0.3855 ^{NS}
	1 vs. 3	<.0001**	<.0001**	<.0001**
	1 vs. 4	<.0001**	<.0001**	<.0001**
	2 vs. 3	0.0005**	0.0006**	0.0002**
	2 vs. 4	<.0001**	<.0001**	<.0001**
	3 vs. 4	0.0005**	0.0013**	0.0011**
Peat	1 vs. 2	0.1549 ^{NS}	0.1357 ^{NS}	0.0759 ^{NS}
	1 vs. 3	<.0001**	<.0001**	<.0001**
	1 vs. 4	<.0001**	<.0001**	<.0001**
	2 vs. 3	<.0001**	<.0001**	0.0006**
	2 vs. 4	<.0001**	<.0001**	<.0001**
	3 vs. 4	0.226 ^{NS}	0.0991 ^{NS}	0.4388 ^{NS}

Note: ** - Highly significant at $P < 0.01$ and ^{NS} - Non-significant at $P > 0.05$ by Dwass, Steel, Critchlow-Fligner (DSCF) comparison method.

Despite Day 1 having the highest reported population density, pairwise comparisons (Table 1) revealed no significant difference between anthesising female inflorescence on Day 1 and 2. This indicates that both days contributed comparably high weevil population densities per inflorescence. Further analysis, utilising the Wilcoxon two-sample test, compared weevil population densities per inflorescence between soil types on anthesising female inflorescence Day 1. The findings indicated a highly significant difference ($P < 0.01$) between soil types for the total, female and male weevil populations per inflorescence on anthesising female inflorescence Day 1. As evident from Figure 1, the weevil population was notably greater on mineral soil and was significantly different from that on peat soil. This confirms a consistently higher weevil population on mineral soil compared to peat soil.

Our study recorded peak *E. kamerunicus* visitation on anthesising female inflorescences on Day 1 of anthesis for both peat and mineral soils. This finding contrasts with previous worldwide reports, where peak visitation was documented on Day 2 of anthesis of female inflorescences in China (Yue et al., 2015), India (Saravanan et al., 2024), and Indonesia (Permana et al., 2021). However, a study by Chiu et al. (1985) on *E. kamerunicus* sampling methods reported a similar finding, with higher trap catches on Day 1 of anthesis. Phenological studies of *E. guineensis* inflorescences describe 70% opening of whitish-coloured trilobed tepals on Day 1 of anthesis in female inflorescences (Forero

et al., 2012; Mubarak et al., 2022), coinciding with the presence of an aniseed scent comparable to that reported by Yaakub et al. (2023). Although the specific peak anthesis day for female inflorescence visitation may vary across studies, our statistical analysis has demonstrated a significant similarity in weevil population per inflorescence between Day 1 and 2 of anthesis. This represents the first statistical comparison of weevil populations with corresponding anthesis days to establish peak visitation. Consequently, both Days 1 and 2 exhibited the highest weevil visitation rates compared to other anthesis days.

Previous studies on female inflorescence anthesis, conducted in Indonesia and China, reported observation periods of up to six days (Permana et al., 2021; Yue et al., 2015). However, no weevil visitation was recorded on Day 6 (Permana et al., 2021; Yue et al., 2015) and the anthesising period of female inflorescences was often found to be complete within 4 to 5 days (Permana et al., 2021). Consistent with these observations, our study recorded either no visitation or low population density after Day 4 of anthesis, a stage characterised by reddish-purple tepals. Similarly, a study in India reported no visitation after Day 4 (Saravanan et al., 2024). An early Malaysian study Chiu et al. (1985) also noted no *E. kamerunicus* visitation on Day 3 of female inflorescence anthesis, as inflorescences at this stage were already in the post-anthesis phase, characterised by a reddish tepal colour and reduced odour release.

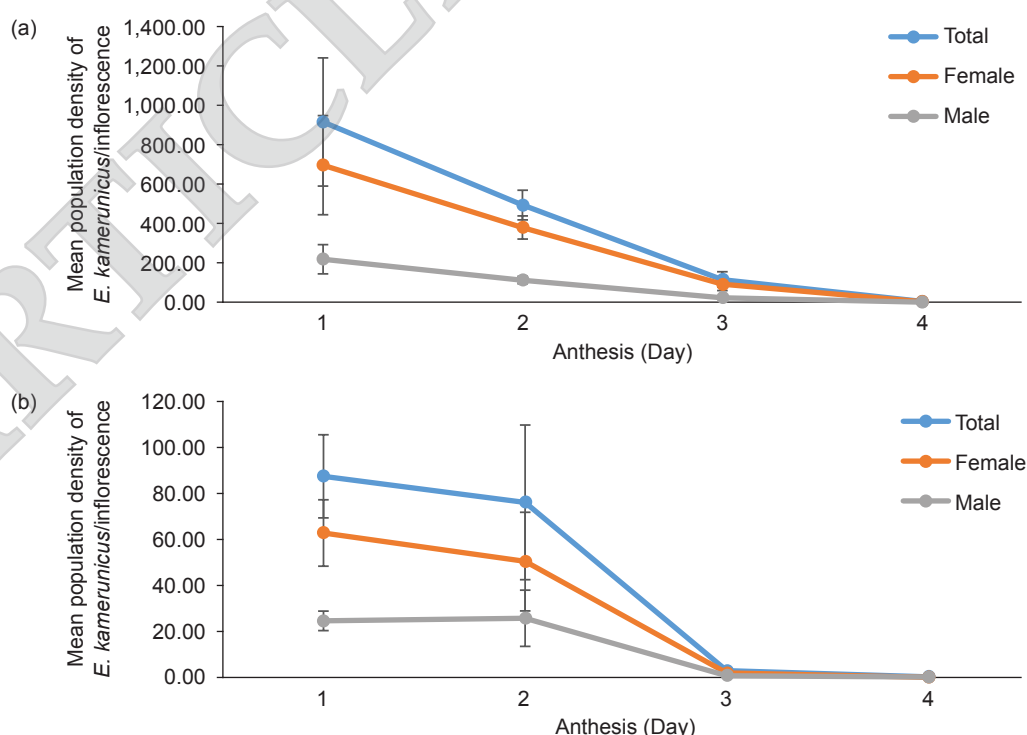


Figure 1. Mean *Elaeidobius kamerunicus* population density per inflorescence on different soil types across female inflorescence anthesis days (mean ± SE). (a) Mineral soil and (b) peat soil.

Elaeidobius kamerunicus Population Density on Anthesising Male Inflorescences Across Different Soil Types

Across both mineral and peat soil types, the total, female and male weevil populations (per spikelet and per inflorescence) on anthesising male inflorescences exhibited highly significant differences ($P < 0.01$) across the days of anthesis. On mineral soil, the results were as follows: Total weevil/spikelet $X^2 = 294.0739$, $P < 0.01$, female weevil/spikelet $X^2 = 291.2855$, $P < 0.01$, male weevil/spikelet $X^2 = 232.3957$, $P < 0.01$, total weevil/inflorescence $X^2 = 296.5589$, $P < 0.01$, female weevil/inflorescence $X^2 = 293.6903$, $P < 0.01$, and male weevil/inflorescence $X^2 = 236.3508$, $P < 0.01$.

In contrast, on peat soil, similarly significant differences were observed: Total weevil/spikelet $X^2 = 101.5247$, $P < 0.01$, female weevil/spikelet $X^2 = 93.4528$, $P < 0.01$, male weevil/spikelet $X^2 = 54.0403$, $P < 0.01$, total weevil/inflorescence $X^2 = 112.0256$, $P < 0.01$, female weevil/inflorescence $X^2 = 101.3456$, $P < 0.01$, and male weevil/inflorescence $X^2 = 62.2351$, $P < 0.01$.

On mineral soil, the highest weevil population densities per spikelet were observed during Day 3 of male inflorescence anthesis. The mean populations (mean $\pm$ SE) were total weevil (56.01 ± 3.52), female weevil (47.76 ± 2.99) and male weevil (8.25 ± 0.65), as shown in Figure 2a. Pairwise comparisons (Table 2) revealed a highly significant difference ($P < 0.01$) between anthesis Day 3 and Days 1,

2, 4 and 5 for the total, female and male weevil populations per spikelet. This indicates that Day 3 supported the peak weevil population per spikelet compared to other anthesising days on male inflorescences. Notably, the number of female weevils was 15 times that of male weevils on mineral soil.

Conversely, on peat soil, weevil population densities per spikelet peaked on Day 3 of anthesis of the male inflorescence, with mean densities of total weevil (6.72 ± 0.71), female weevil (5.48 ± 0.58) and male weevil (1.23 ± 0.17), respectively, as shown in Figure 2b. Pairwise comparisons showed highly significant differences ($P < 0.01$) between anthesis Day 3 and Day 1 and 5 for the total, female, and male weevil populations per spikelet. Additionally, Day 3 also differed significantly from Day 2 for female and total weevil populations per spikelet. Nevertheless, the pairwise comparison of anthesising male inflorescences on Day 3 and 4 showed no significant difference ($P > 0.05$) for any of the weevil population parameters per spikelet. This signifies that the weevil population densities on peat soil were comparable between Day 3 and 4. On peat soil, the population of female weevils was four times larger than that of male weevils.

There were highly significant differences ($P < 0.01$) in weevil population per spikelet between the soil types on the third day of anthesis of male inflorescences, indicating a consistently higher population on mineral soil compared to peat soil.

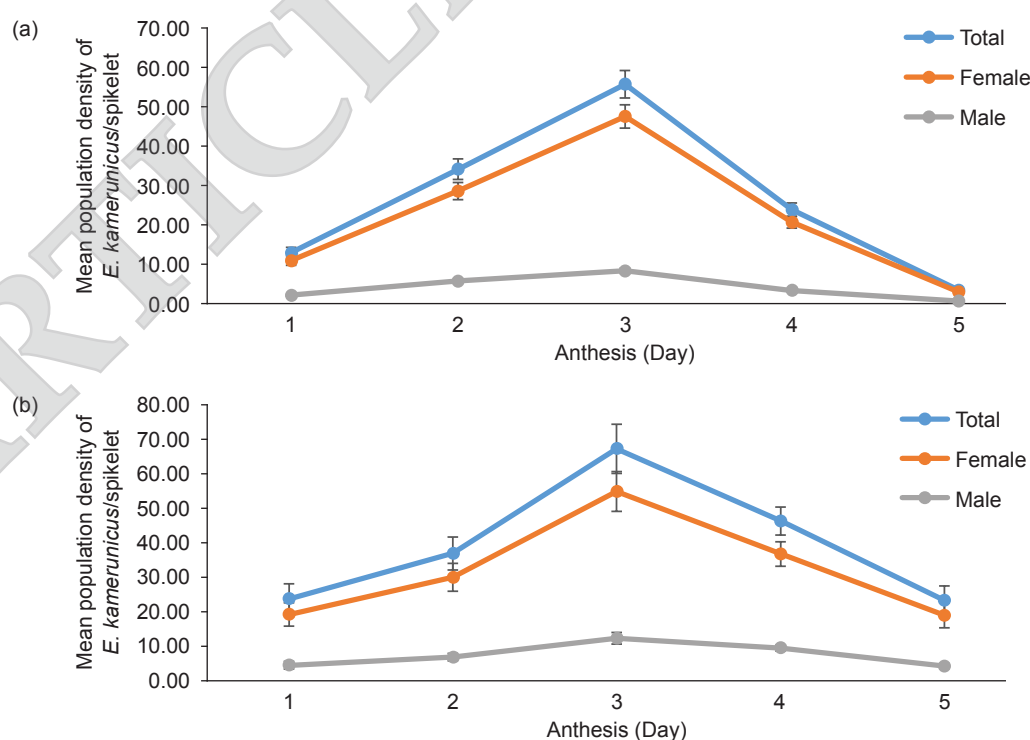


Figure 2. Mean *Elaeidobius kamerunicus* population density per spikelet on different soil types across male inflorescence anthesis days (mean $\pm$ SE). (a) Mineral soil and (b) peat soil.

For mineral soil, the overall weevil population per inflorescence peaked on the third male inflorescence anthesis day. The mean densities (mean $\pm$ SE) were total weevil (6,418.95 $\pm$ 413.72), female weevil (5,465.76 $\pm$ 348.44) and male weevil (953.19 $\pm$ 79.35), as shown in Figure 3a. Pairwise comparisons of anthesis days (Day 3 vs. Day 1, 2, 4 and 5) revealed highly significant differences ($P < 0.01$) for the weevil population per inflorescence across all parameters. Nevertheless, no significant difference was recorded between Day 2 and 4 for female and total weevil populations per inflorescence. Results are presented in Table 2. The population density of female weevils per inflorescence was five times greater than that of male weevils on anthesising male inflorescences.

On peat soil, mean total, female and male weevil populations per inflorescence also peaked on the third day of anthesising male inflorescences, with average values of 746.57 $\pm$ 78.21, 612.22 $\pm$ 63.02 and 134.35 $\pm$ 18.72, respectively, as shown in Figure 3b. Pairwise comparisons revealed highly significant differences ($P < 0.01$) between Day 3 and Day 1 and 5 for the total, female and male weevil populations per inflorescence (Table 2). Significant differences were also found between Day 2 and 3 for the female and total weevil populations per inflorescence. Nevertheless, pairwise comparisons of anthesising male inflorescences on Day 3 and 4 showed no significant difference ($P > 0.05$) for any of the weevil population parameters per inflorescence. The female weevil population per

inflorescence was four times greater than that of the male weevil population on anthesising male inflorescences.

Wilcoxon two-sample tests revealed a highly significant difference ($P < 0.01$) in weevil population per inflorescence on the Day 3 of anthesising male inflorescences between soil types. This highlights a greater weevil population on mineral soil compared to peat soil.

On anthesis of the male inflorescence, the peak *E. kamerunicus* population density was observed on Day 3 of anthesis, with similar patterns reported for both mineral and peat soils. This observation aligns with worldwide studies on weevil pollinators, which have reported similar peak visitation patterns in Indonesia (Permana et al., 2021), India (Saravanan et al., 2024), and China (Yue et al., 2015). Early studies on oil palm pollinators in Cameroon (Syed, 1981) described Day 3 of anthesis as having 100% floret opening, strong odour and yellowish pollen, consistent with the phenological growth stage detailed by Forero et al. (2012) and Mubarak et al. (2022). Yue et al. (2015) also observed similar characteristics on Day 3 of male inflorescence anthesis. An *Elaeidobius* spp. screening study in Cameroon (Syed, 1981) identified *E. kamerunicus* as the dominant weevil on Day 3 of male inflorescence anthesis, a factor that contributed to its selection and importation to Malaysia (Syed, 1979). Supported by similar worldwide findings, our study further statistically proved that weevil population peaked on the third anthesising day for male inflorescence.

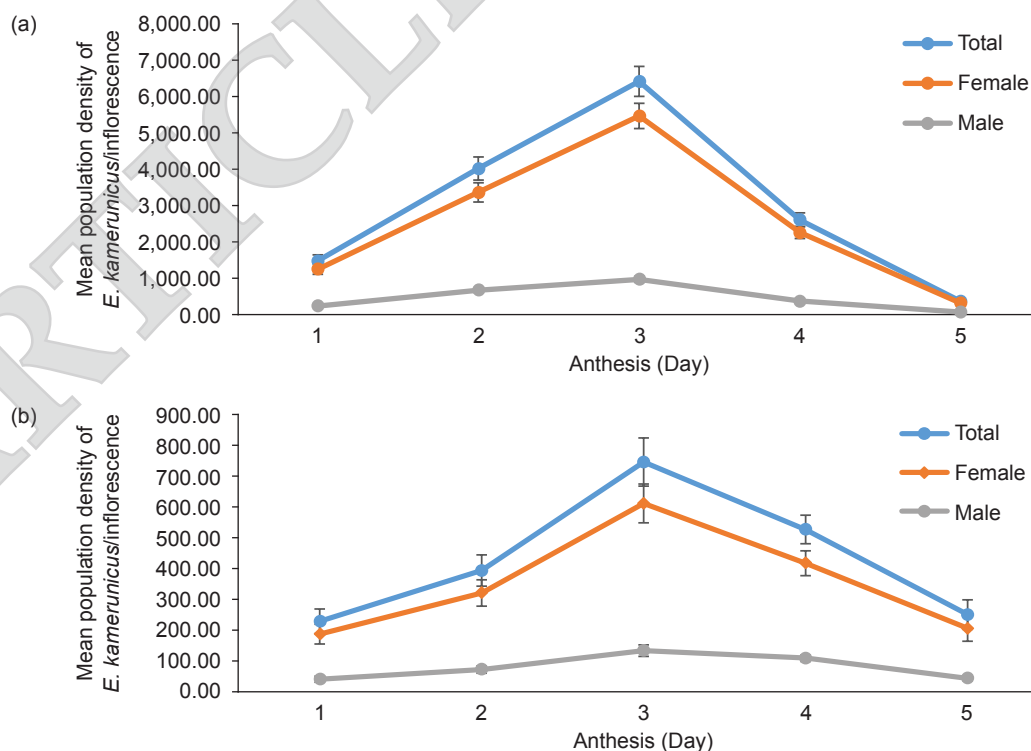


Figure 3. Mean *Elaeidobius kamerunicus* population density per inflorescence on different soil types across male inflorescence anthesis days (mean $\pm$ SE). (a) Mineral soil and (b) peat soil.

TABLE 2. PAIRWISE COMPARISONS OF *Elaeidobius kamerunicus* POPULATION DENSITY PER SPIKELET AND PER INFLORESCENCE IN RELATION TO MALE INFLORESCENCE ANTHESIS DAY, BY SOIL TYPE

Soil	Anthesis (Day)	<i>E. kamerunicus</i> population/spikelet			<i>E. kamerunicus</i> population/inflorescence		
		Male	Female	Total	Male	Female	Total
<i>P</i> -value							
Mineral	1 vs. 2	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
	1 vs. 3	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
	1 vs. 4	0.0003**	<.0001**	<.0001**	0.0005**	<.0001**	<.0001**
	1 vs. 5	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
	2 vs. 3	0.0117*	<.0001**	<.0001**	0.0235*	<.0001**	<.0001**
	2 vs. 4	0.0163*	0.2186 ^{NS}	0.1564 ^{NS}	0.005**	0.1027 ^{NS}	0.0708 ^{NS}
	2 vs. 5	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
	3 vs. 4	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
	3 vs. 5	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
	4 vs. 5	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
Peat	1 vs. 2	0.145 ^{NS}	0.0108	0.0034**	0.0859 ^{NS}	0.0077**	0.0016**
	1 vs. 3	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
	1 vs. 4	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
	1 vs. 5	0.9865 ^{NS}	0.6642 ^{NS}	0.8301 ^{NS}	0.9869 ^{NS}	0.5747 ^{NS}	0.7523 ^{NS}
	2 vs. 3	0.0501 ^{NS}	0.0007**	0.0009**	0.0621 ^{NS}	0.0005**	0.0006**
	2 vs. 4	0.0144*	0.0503 ^{NS}	0.0185*	0.0073**	0.0263*	0.0086**
	2 vs. 5	0.3458 ^{NS}	0.0001**	0.0002**	0.2241 ^{NS}	<.0001**	<.0001**
	3 vs. 4	0.9992 ^{NS}	0.4628 ^{NS}	0.7176 ^{NS}	0.9773 ^{NS}	0.562 ^{NS}	0.822 ^{NS}
	3 vs. 5	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**
	4 vs. 5	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**	<.0001**

Note: * - Significant at $P < 0.05$; ** - highly significant at $P < 0.01$; ^{NS} - non-significant at $P > 0.05$ by Dwass, Steel, Critchlow-Fligner (DSCF) comparison method.

Early studies in Indonesia and China documented a six-day observation period for male oil palm inflorescence anthesis (Permana et al., 2021; Yue et al., 2015). During this anthesising period, weevil population fluctuations were reported after the Day 3 peak, with no weevils observed on Day 6 and 7 of anthesis (Permana et al., 2021; Saravanan et al., 2024; Yue et al., 2015). Similarly, in our study, by Day 5 spikelets were characterised by a dull brown appearance and absence of pollen, indicating a post-anthesis stage.

For both soils used in the current study, the female weevil population was greater than the male weevil population on both male and female anthesising inflorescences. This aligns with prior reports indicating a consistently female-biased sex ratio (Permana et al., 2021; Saravanan et al., 2024; Yue et al., 2015), with Permana et al. (2021) confirming that the differences between the sex population densities are statistically significant. The overwhelming presence of females is closely tied to their distinct reproductive and foraging behaviours; biologically, female weevils exhibit greater mobility and foraging activity because they must actively seek out anthesising male spikelets to feed on anther filaments and pollen, as well as to locate suitable oviposition (egg-laying) sites (Abd Latip et al., 2022; Adaigbe et al., 2014). Morphometric studies explain how this sexual dimorphism supports their specific

ecological roles: Females possess a smaller overall body size but a longer proboscis, which they use to safely place their eggs deep into the flowers (Abd Latip et al., 2019; Muhammad Nasir et al., 2020). Conversely, while male weevils are less abundant and less active, they are morphologically built for pollination. Males are larger and possess distinct, dense pleural setae on their bodies (Dhileepan, 1992). Consequently, because of their larger body surface area and bristly hairs, male weevils consistently record significantly higher pollen depositions on their bodies than females (Dhileepan, 1992; Dzulhelmi et al., 2022; Permana et al., 2017; Syed, 1979; Tambunan et al., 2020b), making them highly efficient at pollinating the oil palm.

Oil palm is a monoecious plant with separate male and female inflorescences. Both inflorescence types release the scent known as estragole (Lajis et al., 1985) to attract the pollinator weevil, *E. kamerunicus*. This compound is found in the pollen (Opute, 1975) and both inflorescences (Lajis et al., 1985). Although weevils only utilise male inflorescences for feeding and breeding (Sambathkumar & Ranjith, 2011), the estragole lures them to briefly visit female inflorescences. As noted by Sambathkumar and Ranjith (2011), these short visits are not for breeding and feeding, but they successfully facilitate the pollination required to produce fresh fruit bunches (FFB).

Volatile organic compound (VOC) emissions are one factor associated with the weevil's effectiveness (Mohamad et al., 2023), and soil type is known to influence VOC concentration. An analysis by Muhamad Fahmi et al. (2016) on male inflorescence VOC extraction from sandy, clay and peat soils reported estragole VOC to be highest on sandy soil, followed by clay and lowest on peat. A study by Lubis et al. (2023) on female inflorescence attractiveness towards *E. kamerunicus* found the highest visitation to be on clay soil, significantly differing from visitation on sandy and peat soils. Estragole extraction from anthesising female inflorescences was only successful in clay soil-cultivated palms, with no extraction from sandy or peat soils (Lubis et al., 2023). The lowest visitation was on peat soil with female inflorescences. Clay soil also exhibited a greater diversity of VOCs than peat and sandy soils. This evidence suggests that VOC emissions from oil palm inflorescences are influenced by soil type and can, in turn, affect attractiveness and *E. kamerunicus* populations.

Quarterly Trends in Peak *Elaeidobius kamerunicus* Visitation on Female Inflorescences

Peak *E. kamerunicus* visitation on anthesising female inflorescences consistently fell on the first or second day of anthesis, though the specific

peak day varied quarterly and by soil type (Figure 4). Mineral soil generally exhibited a peak on Day 1 throughout the study period, with the exception of the October–December 2022 quarter when the highest density occurred on Day 2. The highest density overall was observed on Day 1 in January–March 2023 (1,964.83 ± 1,259.55 weevils/inflorescence). Conversely, on peat soil, the peak population was on Day 2 during July–September 2022, shifting to Day 1 for subsequent quarters up to June 2023. Peat soil recorded its highest peak (214 ± 122.82 weevils/inflorescence) on Day 2 during July–September 2023.

On mineral soil, the peak visitation exhibited a predictable quarterly rhythm, generally favouring the earliest day of anthesis. The highest total weevil population per inflorescence was recorded on the first day during the July–September 2022 and the January–June 2023 quarters. This pattern suggests that, for the majority of the year, the weevil population reached its maximum daily activity coinciding with the female flower's initial receptivity. However, a notable shift occurred during the October–December 2022 quarter, where the peak population density shifted to the second day of anthesis. This shift warrants further investigation, as it could be linked to a quarterly environmental variable (like rainfall or humidity) or a change in the synchronicity of male and female flowering in the area.

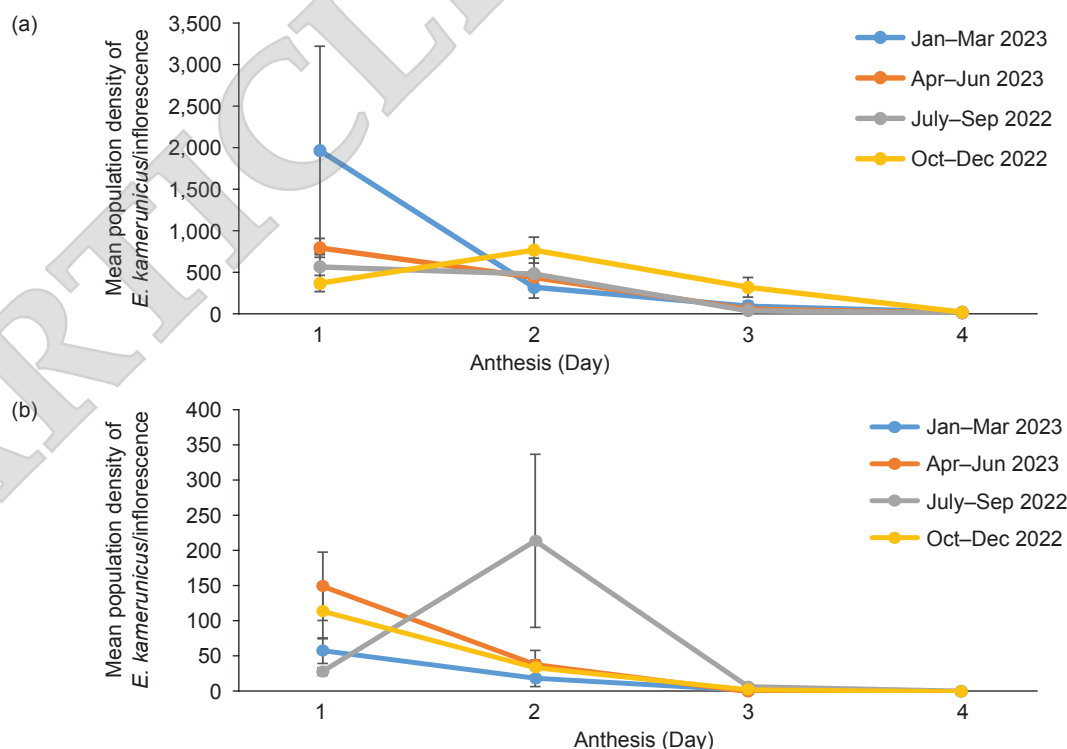


Figure 4. Quarterly *Elaeidobius kamerunicus* population density per inflorescence on different soil types across female inflorescence anthesis days. (a) Mineral soil and (b) peat soil.

The peat cultivated area displayed a distinct and generally lower overall magnitude of weevil population density compared to the mineral soil. The pattern of peak activity was also more variable. The highest recorded visitation on peat soil initially occurred on the second day of anthesis during July–September 2022. This contrasts with the mineral soil's pattern for the same period.

The data highlight a critical difference in the weevil population capacity between the two soil types, with mineral soil consistently supporting a far higher population density. Furthermore, the observation of a shifting peak anthesis day across quarters, especially the peak activity on Day 2 in certain periods on both soil types, suggests that environmental or floral factors can temporarily alter the weevil's optimal activity timing. For management practices, these quarterly and soil-specific patterns are vital for monitoring pollinator sufficiency and predicting potential pollination deficits.

Quarterly Trends in Peak *Elaeidobius kamerunicus* Visitation on Male Inflorescences

The analysis of *E. kamerunicus* population density on anthesising male inflorescences revealed a highly consistent pattern; peak congregation occurred predominantly on the third day of anthesis (Day 3) across all quarters and both soil types (Figure 5). This is biologically significant, as Day 3

typically coincides with the maximum release of mature, viable pollen and the highest emission of the weevil-attracting estragole scent. Following Day 3, population counts showed a rapid and expected decline at both sites, signalling that the inflorescences were moving into the post-anthesis stage and were no longer a primary source of fresh resources.

The most striking feature of the male inflorescence data is the massive difference in weevil capacity between the two soil types. The mineral soil environment supported an *E. kamerunicus* population an order of magnitude greater than the peat soil. The highest density recorded on mineral soil was a substantial $10,463.22 \pm 626.76$ weevils per inflorescence (Day 3) during the October–December 2022 quarter. Even the lowest peak density recorded on mineral soil ($2,671.17 \pm 346.59$ weevils/inflorescence) was significantly higher than the maximum recorded on peat soil. This indicates that mineral soil provides a far more favourable environment for the weevil population.

On peat soil, the highest peak density observed on peat soil was only $1,183.25 \pm 178.14$ weevils per inflorescence (Day 3), occurring in the same high-density quarter (October–December 2022) as the mineral soil peak. This lower population capacity is a known characteristic of peat cultivation, often linked to the morphological differences in the male spikelets

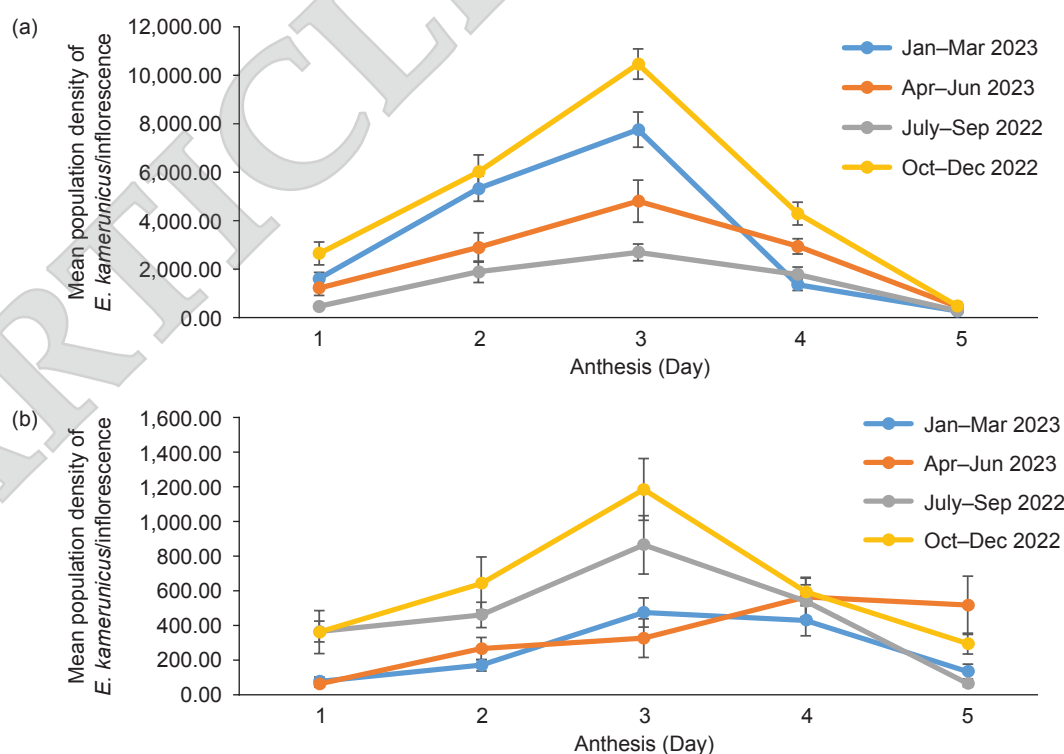


Figure 5. Quarterly *Elaeidobius kamerunicus* population density per inflorescence on different soil types across male inflorescence anthesis days. (a) Mineral soil and (b) peat soil.

(which are typically smaller or less uniform) and the generally more challenging growing conditions associated with peat.

While Day 3 was the dominant peak for both soil types during the majority of the study (July 2022 to March 2023), indicating similar responses to broad seasonal factors, the quarterly data highlights a critical anomaly on peat soil. A notable shift occurred during April–June 2023 quarter, with the peak density recorded on the fourth day of anthesis (Day 4). Furthermore, densities remained high on Day 4 during the preceding January–March 2023 quarter. This finding suggests a delay in the final congregation of weevils. Two possible mechanisms could drive this delay: Lower initial population pressure, where low overall weevil density allowed available resources to last until Day 4 or environmental influence on floral phenology, where environmental conditions specific to the peat site during that quarter slightly delayed the male flower's full anthesis and maximum scent emission. Further study is needed to explore the exact cause of this occurrence.

The complete analysis of *E. kamerunicus* density across the quarters reveals a critical asynchrony between resource availability and floral receptivity, alongside a profound soil type influence on the pollinator population. The peak weevil visitation on receptive female inflorescences consistently occurred on Day 1 or 2 of anthesis. This aligns with reported studies that observe higher visitation during this period when the stigma achieves receptivity, and the initial release of attractant scent occurs (Forero et al., 2012; Sambathkumar & Ranjith, 2011). Conversely, peak weevil congregation on the male inflorescences, where the primary sites for breeding and feeding were consistently concentrated on Day 3. This is supported by multiple studies linking Day 3 anthesis to the maximum release of viable pollen and peak estragole emission (Forero et al., 2012; Mubarak et al., 2022; Permana et al., 2021; Saravanan et al., 2024; Yue et al., 2015). This temporal offset between the female's optimal receptive phase and the male's optimal resource phase highlights the weevil's efficiency as a pollinator, as it transfers pollen collected during Day 3 of the male's cycle to newly opened female flowers.

The data further demonstrate that mineral soil consistently supports greater *E. kamerunicus* population density than peat soil (peak density on male inflorescence: Mineral soil ~10,000 vs. peat soil ~1,000 weevils/inflorescence). This substantial difference supports the consensus that peat soil areas provide a suboptimal ecological niche for the weevil, leading to lower population capacity and efficiency. The reduced capacity is often attributed to the poorer resource quality associated with peat cultivation, where a previous

study by Mohamad et al. (2021b) reported smaller and less uniform male spikelet lengths on peat cultivation areas, mainly on the top spikelet position, whereas in mineral soil there is more consistency in length of spikelet. Hence, this can limit the weevil's breeding and feeding. Furthermore, the observation of a shifting peak anthesis day across quarters, particularly the Day 4 anomaly on male flowers in the peat environment, suggests that this population is more susceptible to environmental and resource pressures. In a study at a deep peat cultivation area, the weevil population density on the fourth day of anthesis is higher compared to the second day of anthesis (Swaray et al., 2021) despite approaching post anthesis stage. It was stated that the environmental attribute can be seen impacting the fourth day of anthesis onward, such as the odour released by the inflorescence to attract the weevil (Swaray et al., 2021). These soil-specific and quarterly fluctuations are crucial indicators for monitoring pollinator sufficiency and developing targeted management strategies to mitigate potential pollination deficits in challenging environments like peat plantations.

Although soil type serves as a primary variable in this study, the observed difference in weevil density must be interpreted as a combined reflection of soil composition and distinct regional environmental profiles. Because the sampling sites are located in geographically distinct regions (Perlis vs. Pahang), they are subjected to entirely different macroclimates and monsoon profiles (Zulkefli et al., 2024). Consequently, it is difficult to isolate the effect of the mineral and peat soil structures from the regional climate, as variations in seasonal rainfall and localised humidity regimes are known to independently drive the population dynamics of *E. kamerunicus* (Cik Mohd Rizuan et al., 2013; Nurul Fatimah et al., 2019).

Relationship Between *Elaeidobius kamerunicus* Population Density and Abiotic Factors (Rainfall, Temperature and Relative Humidity) Based on Anthesising Female Inflorescence

On mineral soil, the peak weevil population on Day 1 showed no significant correlation with any of the abiotic factors. However, on Day 2, temperature was significantly correlated with the male, female and total weevil populations per inflorescence, with a weak and negative relationship. On the third day of anthesis, the weevil population per inflorescence showed a significant correlation with both temperature and relative humidity; temperature exhibited a negative and moderate correlation, while relative humidity had a positive and weak correlation. Finally, on Day 4 (the last day of anthesis), rainfall exhibited a significant,

weak and positive correlation with all weevil population parameters. These results are reported in Table 3.

Conversely, on peat soil, no significant relationship was observed between any abiotic parameter and the weevil population per inflorescence, with the exception of the female weevil population per inflorescence, which showed a weak and positive correlation with temperature on Day 4 of anthesis. These results are reported in Table 3.

Relationship Between *Elaeidobius kamerunicus* Population Density and Abiotic Factors (Rainfall, Temperature and Relative Humidity) Based on Male Inflorescence

On mineral soil, significant variations in the relationship between weevil population density and abiotic factors were observed throughout the anthesising days. On Day 1, both rainfall and relative humidity showed a significant correlation with weevil population density per inflorescence and per spikelet. However, the correlations were weak and positive for relative humidity and weak and negative for rainfall. On Day 2 of anthesis, relative humidity exhibited a significant, weak and positive correlation with *E. kamerunicus* population density per spikelet. During the peak population on Day 3 of anthesis, both temperature and relative humidity were significantly correlated with population density per spikelet and per inflorescence; temperature showed a weak and negative correlation, while relative humidity had a positive and weak correlation. On Day 4 of anthesis, female and total populations (both per spikelet and per inflorescence) showed a weak and positive correlation with temperature. Finally, on Day 5 (the last day of anthesis), no significant correlation was observed for any abiotic factor.

In contrast, on peat soil, no significant correlation was found between *E. kamerunicus* population density and any abiotic factor parameter. However, on Day 2 of anthesis, relative humidity showed a significant, weak, and positive correlation with female and total population densities. In this abiotic factor study, rainfall data could not be determined for most days due to no rainfall being recorded at the meteorological weather station. All results are presented in Table 4 for the anthesising male inflorescence of oil palm.

The efficiency of *E. kamerunicus* is influenced by climatic factors (Mohamad et al., 2023). Studies in India (Saravanan et al., 2024) and Columbia (Montes Bazaruto et al., 2018) reported no significant relationship between rainfall and weevil population, while a separate Malaysian study observed a weak correlation (Nurul Fatimah et al., 2018, 2019). This suggests rainfall has a minimal direct effect on

the weevil population, though it can impact the pollination process itself (Mohamad et al., 2023). Permana et al. (2021) documented a positive and moderate correlation between humidity and temperature with weevil abundance on male and female inflorescences. Conversely, humidity was negatively correlated with weevil abundance in male inflorescences. Overall, climatic factors appear to elicit varied responses, preventing a clear, universally consistent relationship with weevil population density. Despite our study recording low or no correlation between abiotic factors and weevil population density, further research is needed to model weevil behaviour under specific Malaysian climatic conditions.

While this study successfully establishes localised baseline data and accurately captures the significant drop in weevil density on peat soils, several limitations must be acknowledged. First, regarding inflorescence morphology, the scope of this study was restricted to population counting and did not measure physical inflorescence characteristics. Recent literature demonstrates that male inflorescences cultivated on peat soils often develop physical irregularities, including significantly shorter upper spikelets compared to those grown on mineral soils (Mohamad et al., 2021b; Zulkefli et al., 2026). This upper-spikelet shortening reduces available breeding and feeding space, which may be a fundamental root cause of the observed weevil density drop on peat soils.

Second, this study did not perform real-time VOC extractions. Modern chemical-ecological literature heavily links altered weevil visitation durations to the shifting emission profiles of VOCs, primarily estragole and methyl salicylate, across different soil horizons (Fahmi-Halil et al., 2025; Sendoya-Corrales et al., 2024). Because varying soil properties natively influence the concentration and diversity of estragole emitted by the inflorescences, neglecting real-time VOC mapping limits our ability to confirm if the density gap is chemically driven (Lubis et al., 2023; Muhamad Fahmi et al., 2016).

Finally, the data reflects a localised baseline trend and does not account for broader ecosystem stressors currently challenging the industry. For instance, recent phylogeographic studies warn that the introduced *E. kamerunicus* populations in Southeast Asia may be experiencing regional genetic narrowing (endogamy) and bottlenecks, which could weaken their adaptability and overall pollination efficiency (Haran et al., 2020; Tambunan et al., 2020a). Furthermore, shifting predatory thresholds involving spiders, ants, and insectivorous birds across different plantation environments may exert unaccounted top-down pressure on these pollinator populations (Muhammad Luqman et al., 2017).

TABLE 3. CORRELATION ANALYSIS OF *Elaeidobius kamerunicus* POPULATION DENSITY PER INFLORESCENCE ON DIFFERENT SOIL TYPES, WITH ABIOTIC FACTORS DURING FEMALE INFLORESCENCE ANTHESIS

Soil	Population density	Anthesis (Day)											
		Day 1			Day 2			Day 3			Day 4		
		Temp	RH	Rainfall	Temp	RH	Rainfall	Temp	RH	Rainfall	Temp	RH	Rainfall
Mineral	<i>E. kamerunicus</i> population / inflorescence												
	Male	0.11293 ^{NS}	-0.16932 ^{NS}	-0.15370 ^{NS}	-0.45222*	0.24219 ^{NS}	0.40331 ^{NS}	-0.52316**	0.41838*	-0.29363 ^{NS}	-0.02445 ^{NS}	0.06992 ^{NS}	0.41697*
	Female	0.11193 ^{NS}	-0.13161 ^{NS}	-0.13739 ^{NS}	-0.46760*	0.35992 ^{NS}	0.10252 ^{NS}	-0.55090**	0.44601*	-0.26420 ^{NS}	-0.01892 ^{NS}	0.04379 ^{NS}	0.42294*
Peat	Total	0.11230 ^{NS}	-0.14037 ^{NS}	-0.14128 ^{NS}	-0.47736*	0.34109 ^{NS}	0.18034 ^{NS}	-0.54724**	0.44210*	-0.27021 ^{NS}	-0.02057 ^{NS}	0.05148 ^{NS}	0.42227*
	<i>E. kamerunicus</i> population / inflorescence												
	Male	-0.03671 ^{NS}	0.08630 ^{NS}	0.06060 ^{NS}	0.31986 ^{NS}	-0.18221 ^{NS}	-0.12283 ^{NS}	0.02310 ^{NS}	0.08720 ^{NS}	-0.07011 ^{NS}	0.36393 ^{NS}	-0.36373 ^{NS}	0.27828 ^{NS}
Peat	Female	-0.05618 ^{NS}	0.10305 ^{NS}	0.10273 ^{NS}	0.33841 ^{NS}	-0.17022 ^{NS}	-0.11434 ^{NS}	-0.10880 ^{NS}	0.09860 ^{NS}	-0.03874 ^{NS}	0.40868*	-0.37283 ^{NS}	0.17410 ^{NS}
	Total	-0.05349 ^{NS}	0.10256 ^{NS}	0.09628 ^{NS}	0.33206 ^{NS}	-0.17477 ^{NS}	-0.11756 ^{NS}	-0.07448 ^{NS}	0.10191 ^{NS}	-0.05145 ^{NS}	0.39085 ^{NS}	-0.37955 ^{NS}	0.25582 ^{NS}

Note: * - Significant at $P < 0.05$; ** - highly significant at $P < 0.01$; ^{NS} - non-significant at $P > 0.05$; Temp - temperature; RH - relative humidity.

TABLE 4. CORRELATION ANALYSIS OF *Elaeidobius kamerunicus* POPULATION DENSITY ON DIFFERENT SOIL TYPES, WITH ABIOTIC FACTORS DURING MALE INFLORESCENCE ANTHESIS

Soil	Population density	Anthesis (Day)											
		Day 1			Day 2			Day 3			Day 4		
		Temp	RH	Rainfall	Temp	RH	Rainfall	Temp	RH	Rainfall	Temp	RH	Rainfall
Mineral	<i>E. kamerunicus</i> population / spikelet												
	Male	-0.08298 ^{NS}	0.18414*	-0.16663*	-0.06048 ^{NS}	0.19489*	0.10198 ^{NS}	-0.10695 ^{NS}	0.18128*	-	0.09659 ^{NS}	0.10282 ^{NS}	-
	Female	-0.04061 ^{NS}	0.18392*	-0.17559*	-0.11463 ^{NS}	0.19057*	-0.00271 ^{NS}	-0.22849**	0.24943**	-	0.24540**	0.00053 ^{NS}	-
Mineral	Total	-0.04803 ^{NS}	0.18725*	-0.17732*	-0.1068 ^{NS}	0.19501*	0.01661 ^{NS}	-0.21358*	0.24501**	-	0.22907**	0.01714 ^{NS}	-
	<i>E. kamerunicus</i> population / inflorescence												
	Male	-0.09638 ^{NS}	0.19292*	-0.16881*	-0.00831 ^{NS}	0.15398 ^{NS}	0.06941 ^{NS}	-0.08687*	0.16886*	-	0.06789 ^{NS}	0.07982 ^{NS}	-
Peat	Female	-0.05311 ^{NS}	0.19083*	-0.17514*	-0.05561 ^{NS}	0.14046 ^{NS}	-0.02603 ^{NS}	-0.21424**	0.24899**	-	0.19271*	-0.00349 ^{NS}	-
	Total	-0.06067 ^{NS}	0.19417*	-0.17693*	-0.04788 ^{NS}	0.1455 ^{NS}	-0.00887 ^{NS}	-0.1971*	0.24209**	-	0.17826*	0.00974 ^{NS}	-
	<i>E. kamerunicus</i> population / spikelet												
	Male	0.05821 ^{NS}	-0.02339 ^{NS}	-	-0.14331 ^{NS}	0.12556 ^{NS}	-	-0.09585 ^{NS}	0.00466 ^{NS}	-	0.00095 ^{NS}	-0.00329 ^{NS}	-
Peat	Female	0.04287 ^{NS}	0.0319 ^{NS}	-	-0.08703 ^{NS}	0.18538*	-	-0.03422 ^{NS}	0.03567 ^{NS}	-	0.05582 ^{NS}	-0.05575 ^{NS}	-
	Total	0.04835 ^{NS}	0.0189 ^{NS}	-	-0.10575 ^{NS}	0.18493*	-	-0.05032 ^{NS}	0.02996 ^{NS}	-	0.04898 ^{NS}	-0.04944 ^{NS}	-
	<i>E. kamerunicus</i> population / inflorescence												
	Male	-0.01535 ^{NS}	0.02612 ^{NS}	-	-0.07346 ^{NS}	0.10512 ^{NS}	-	-0.12984 ^{NS}	0.02956 ^{NS}	-	0.00704 ^{NS}	-0.05405 ^{NS}	-
Peat	Female	-0.04196 ^{NS}	0.08449 ^{NS}	-	-0.04762 ^{NS}	0.18601*	-	-0.08540 ^{NS}	0.06743 ^{NS}	-	0.04729 ^{NS}	-0.11105 ^{NS}	-
	Total	-0.03740 ^{NS}	0.07414 ^{NS}	-	-0.05723 ^{NS}	0.18123*	-	-0.0999 ^{NS}	0.06141 ^{NS}	-	0.04272 ^{NS}	-0.10868 ^{NS}	-

Note: * - Significant at $P < 0.05$; ** - highly significant at $P < 0.01$; ^{NS} - non-significant at $P > 0.05$; Temp - temperature; RH - relative humidity.

CONCLUSION

The highest visitation on anthesising female inflorescences occurred on Day 1 of anthesis, with no significant difference from Day 2. This indicates that *E. kamerunicus* is primarily attracted to the early anthesis period of female inflorescences. Conversely, the highest weevil congregation on anthesising male inflorescences was observed on Day 3 of anthesis, which coincided with peak inflorescence blooming. On both male and female oil palm inflorescences, female weevils constituted the greatest proportion of the population. Furthermore, mineral soil supported a higher *E. kamerunicus* population density, which was significantly greater than that on peat soil. Hence, this study provides valuable insights into the impact of the anthesis period on weevil population density, in the context of Malaysia's climate and varying soil types. This study will further be integrated to document the pollination activity of *E. kamerunicus*. Further research on the effects of abiotic factors during inflorescence development on weevil population and behaviour is essential for a more comprehensive understanding of the species.

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