Evaluation of the Role of Pollinator Insect Population Density on Fruit Set and Average Bunch Weight of Oil Palm (*Elaeis guineensis* Jacq.)

Syamsu Rizal S Lubis, Kurniawan Sinaga, Hanifah Mutia Z. N. Amrul

Abstract

The activity of the pollinating insect Elaeidobius kamerunicus Faust strongly determines fertilization efficiency and the production quality of oil palm (Elaeis guineensis Jacq.). This study evaluated the effect of pollinator population density per hectare (individuals ha^{-1}) on two key production parameters: Fruit Set (%) and Average Bunch Weight (ABW, kg). Observations were made on two density groups K1 (< 20,000 individuals ha^{-1}, low density) and K2 (> 20,000 individuals ha^{-1}, optimal density) at PT Bahruny, Rimba Sawang Estate, Aceh Tamiang, over six months (August 2025–January 2026). Data were analyzed descriptively. The results showed that the higher density group (K2) achieved a markedly higher Fruit Set (77%) and ABW (11.5 kg per bunch) than the low-density group (K1), which recorded 60% and 10.4 kg per bunch. These findings indicate that maintaining a pollinator population above 20,000 individuals ha^{-1} is associated with better fruit formation and heavier bunches, and support pollinator population management as a strategy to improve oil palm productivity.

Keywords: *Pollinating, production, fruits set, Bunch Weight*

Syamsu Rizal S Lubis[1]
[1]Master of Agricultural Science, Universitas Pembangunan Panca Budi
e-mail: marianussitepu@mahasiswa.pancabudi.ac.id

Kurniawan Sinaga[2], Hanifah Mutia Z. N. Amrul[3]
[2,3]Master of Agricultural Science, Universitas Pembangunan Panca Budi
e-mail: kurniawansinaga@dosen.pancabudi.ac.id, hanifahmutia@dosen.pancabudi.ac.id,
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Introduction

Oil palm (*Elaeis guineensis* Jacq.) is a palm cultivated extensively in Indonesia because of its high vegetable-oil yield, which is used for cooking oil, industrial oil, and biodiesel [1]. As a leading plantation commodity, oil palm contributes substantially to the national economy, so improving its productivity remains a central objective of plantation management [9][14].

Oil palm flowers can be pollinated by wind, water, humans, vertebrates, and insects, but pollination is carried out mainly by insects. The weevil *Elaeidobius kamerunicus* Faust is the most effective pollinator: it reproduces well in male flowers and can reach female flowers located in the inner spikelets, producing more complete pollination [2]. Pollination by E. *kamerunicus* increases fresh fruit yield per bunch, bunch weight, and bunch production. Because the weevil carries pollen with more than 60% viability, its activity can increase oil palm fruit set by 15.04–21.05% [3].

The population density of E. *kamerunicus* in a plantation is therefore an important determinant of pollination success. However, the relationship between measurable pollinator density per hectare and key production parameters is not always quantified directly in commercial fields. Accordingly, this study evaluated the effect of pollinator population density per hectare on Fruit Set (%) and Average Bunch Weight (ABW) by comparing a low-density group (< 20,000 individuals ha^{-1}) with an optimal-density group (> 20,000 individuals ha^{-1}).

Literature Review

Elaeidobius kamerunicus as the Main Oil Palm Pollinator

E*laeidobius kamerunicus* Faust was introduced to Southeast Asia to overcome poor natural pollination and has since become the principal pollinator of oil palm. Its life cycle depends on male inflorescences: while the weevil crawls over the spikelets of male flowers, pollen grains adhere to its body and are subsequently deposited on the stigma when it visits female flowers to feed on nectar [5]. Studies confirm that the weevil is effective because it can reach female flowers in the inner clusters, resulting in more complete pollen transfer than wind pollination alone [2]. Its population and effectiveness have been documented across various Indonesian plantations [12].

Pollinator Population Density and the Effective Threshold

The success of pollination is closely linked to the abundance and visitation frequency of the weevil. Aminah [4] reported that fruit-set success depends on the frequency of E. *kamerunicus* visits to female flowers, with an optimum visitation level. Beyond visitation, several sources indicate a population threshold for effective pollination: benefits for fruit set and oil production can be achieved at a minimum population of about 20,000 individuals per hectare [5]. The abundance of the weevil in the field has also been shown to correlate with pollination performance [6], reinforcing the rationale for the two density classes (K1 and K2) used in the present study.

Population Density in Relation to Plant Age and Habitat

Weevil population density is not constant across a plantation; it varies with the availability of male flowers, plant age, and habitat conditions. Studies on plantations of

different ages have shown that the population of E. *kamerunicus* differs markedly with plant age, largely because the proportion and availability of male inflorescences change as palms mature [7][11]. This variability implies that pollinator management should account for the specific conditions of each block, since blocks with fewer male flowers may sustain smaller weevil populations and therefore poorer pollination.

Pollination, Fruit Set, and Bunch Weight

Fruit set the proportion of fertile, developing fruits in a bunch—is a direct indicator of pollination success. Good fruit set in oil palm is generally considered to be above 75%, and a typical well-pollinated bunch reaches around 80% fertile fruit, with the remainder parthenocarpic [3][6]. Higher fruit set increases bunch weight and quality, although individual fruit size may decrease as more fruits develop within the bunch [3]. The role of insect pollinators in fruit formation and bunch development has been documented [8], and studies of oil palm reproductive biology further show that inflorescence phenology and the synchrony between male and female flowering strongly influence the contribution of insect pollination to fruit set [13]. In plantations with high weevil populations, fruit set is dominated by E. *kamerunicus*, whereas in plantations with low weevil populations, other pollinating insects assume a greater role [2].

Economic Importance and Research Gap

Because bunch weight and fruit set translate directly into fresh fruit bunch yield and oil extraction, improving pollination has clear economic value for the oil palm industry [1][9][10][14]. Although many studies have examined weevil populations, visitation frequency, and fruit set separately, fewer have directly linked a measurable per-hectare population density to both Fruit Set and Average Bunch Weight in a commercial estate. The present study addresses this gap by comparing these two production parameters between low- and optimal-density groups.

Research Methodology

The study was conducted using a descriptive method with two observation groups, with a range of pollinator insect population densities per hectare in the K1 sample: <20,000 individuals/ha (low density) and the K2 sample: >20,000 individuals/ha (optimal density). The study was conducted in Rimba Sawang, Aceh Tamiang Regency, NAD, from August 2025 to January 2026. The tools and materials used included ladders, machetes, transparent plastic, stationery, calculators, digital scales, male flowers, and insect traps.

Two main production parameters were observed:

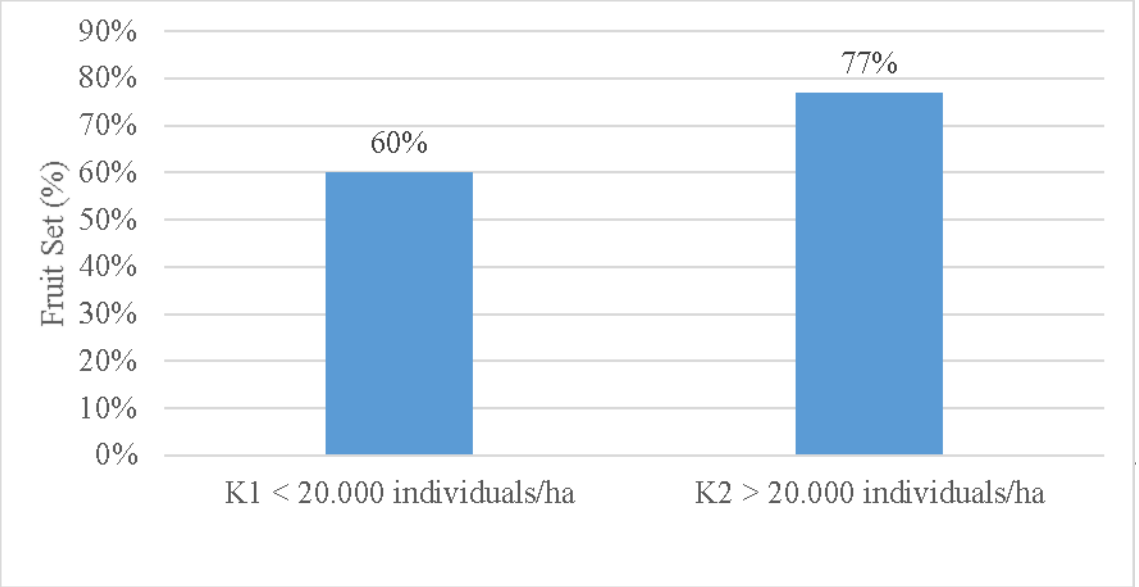
1. Fruit Set (%): calculated based on the percentage of mature (fertile) fruit divided by the total spikelets (fertile fruit + parthenocarpic) in a bunch.
2. Average Bunch Weight (kg): calculated by dividing the total weight of the harvested Fresh Fruit Bunches (FFB) by the number of bunches harvested per observation.

Data were collected and analyzed descriptively, and the results are presented as diagrams comparing productivity between the two density groups over the six-month observation period. Because the analysis is descriptive, differences between groups are reported as observed magnitudes rather than tested for statistical significance.

Results

Fruit Set Percentage (%)

Based on the results of observations, the range of pollinator insect population density per hectare has a significant effect on the percentage of fruit set in oil palm. A graph of the relationship between the population density range per hectare and the Fruit Set value is presented in the following figure.



The higher fruit set in K2 can be explained by the more even distribution of pollen to the stigmas of receptive female flowers when the weevil population is dense. The K2 value (77%) exceeds the 75% threshold generally regarded as good fruit set, while the K1 value (60%) falls below it [6]. This result is consistent with reports that increasing the E. kamerunicus population enhances pollination success [2][4].

Average Bunch Weight (kg)

The per-hectare density range was likewise associated with a difference in Average Bunch Weight (Figure 2). The optimal-density group K2 produced heavier bunches (11.5 kg) than the low-density group K1 (10.4 kg).

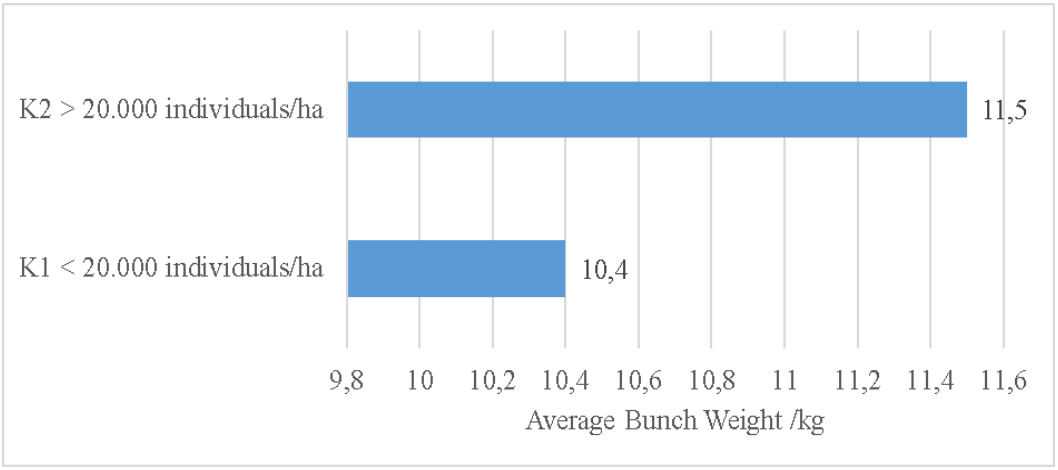


Figure 2. Average Bunch Weight (ABW) of Oil Palm Based on Population Density Range/ha

More complete pollination in K2 minimizes the formation of parthenocarpic (seedless) fruit, so that the spikelet space is more fully filled with dense, heavy, fertile fruit, raising bunch weight. This is consistent with the established link between higher fruit set and increased bunch weight and quality [3][8]. Taken together, the two parameters indicate that maintaining a pollinator population above about 20,000 individuals ha^{-1} is associated with better production performance; because the study is descriptive and other agronomic factors (plant age, male-flower availability, nutrition, and maintenance) also influence these parameters [7][11][13], the density effect should be interpreted as an association observed under the field conditions studied rather than as an isolated cause.

Conclusion

Variation in the per-hectare population density of pollinating insects was associated with differences in the Fruit Set and Average Bunch Weight of oil palm. The optimal-density group K2 (> 20,000 individuals ha^{-1}) showed the best performance, with a Fruit Set of 77% and an Average Bunch Weight of 11.5 kg per bunch, compared with 60% and 10.4 kg per bunch in the low-density group K1. These descriptive results indicate that maintaining the E. kamerunicus population above approximately 20,000 individuals ha^{-1} supports better fruit formation and heavier bunches, and they reinforce pollinator population management as a practical strategy for improving oil palm productivity. Further study using replicated blocks and statistical testing is recommended to confirm the magnitude of this effect.

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