

Impact of Chemical Treatments on the Pollinator Insect Population of Oil Palms in an Industrial Palm Plantation: The Case of Blidouba in the South-west of Côte D'ivoire

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IMPACT OF CHEMICAL TREATMENTS ON THE POLLINATOR INSECT POPULATION OF OIL PALMS IN AN INDUSTRIAL PALM PLANTATION: THE CASE OF BLIDOUBA IN THE SOUTH-WEST OF CÔTE D'IVOIRE

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Abstract

The oil palm (*Elaeis guineensis*), a plant whose flowers are highly dependent on pollinating insects, mainly Coleoptera of the genus *Elaeidobius*, which ensure effective fertilization. In industrial agro-ecosystems, the intensive use of insecticides to control pests can affect populations of beneficial insects. This study, conducted in a PALMCI plantation in Blidouba (southwest of Côte d'Ivoire), evaluated the incidence of three synthetic insecticides: Oxatop (0.188 g/l Oxamyl), Karate (0.188 g/l Lambda-cyhalothrin) and Evisect (0.94g/l Thiocyclam hydrogen oxalate) on the abundance and activity of pollinating insects. The experimental setup was based on a Fisher block with three treatments and three replicates. Observations focused on the inflorescences before and after treatment. The data collections were made: one month before application, as well as one, four days and one to two months after application. The results show low pollinator visitation from the very first day, with very high mortality rates: around 200,000 individuals killed by the insecticide Karate, compared with 150,000 by Oxatop and 25,000 by Evisect. The Kruskal-Wallis test, $p < 0.001$, confirms significant differences between the products. Karate proved to be more harmful due to its prolonged residual efficacy, causing high mortality rates right up to the fourth day. One month after treatment, pollinating insects had recolonised the area, and two months later, their abundance was broadly equivalent to that observed before treatment. These results demonstrate the negative impact of insecticides on pollinating insects.

Keywords : *Elaeis guineensis*, pollinating insects, insecticide, mortality, Côte d'Ivoire, pollination.

Introduction

The oil palm (*Elaeis guineensis*) is one of the perennial crops of great economic and social importance in humid tropical regions. It is the world's leading source of vegetable oil, used primarily in the food, cosmetics and pharmaceutical industries, and even in the production of biofuel (OECD and FAO, 2025). In Côte d'Ivoire, the oil palm sector continues to play a strategic role, with major players such as PALMCI (Palmier à Huile de Côte d'Ivoire), which operates extensive agricultural estates designed to supply the local and international markets (PALMCI, 2024). Thus, the productivity of the oil palm relies primarily on a key biological process: entomophilous pollination. Unlike other oil crops, the oil palm is heavily dependent on pollinating insects, particularly beetles of the genus *Elaeidobius*, to ensure cross-fertilisation between male and female inflorescences (Genty et al. 1986).

These insects, which are dependent on the inflorescences, ensure good fruit set and have a direct influence on yield in terms of number of fruit clusters (Kehinde and Samways, 2014). Consequently, their population dynamics are a key determinant of production. However, pollinating insects live in an environment subject to significant anthropogenic pressures. Intensive farming practices, in particular the use of plant protection products, can affect beneficial biodiversity (Desneux et al. 2007). Indeed, although chemical treatments are used to control pests and maintain crop productivity, they often have collateral effects on non-target organisms, notably pollinators (Pisa et al. 2015).

The impacts may include a reduction in population numbers, behavioural disturbances, increased mortality or a decline in species diversity (Potts et al. 2019). In PALMCI's industrial plantations, and more specifically at the Blidouba site, the issue of the impact of chemical treatments on pollinating insects is of paramount importance. A significant decline in pollinator populations could compromise natural pollination, resulting in reduced production and increased reliance on artificial pollination methods, which are costly and labour-intensive (Li et al. 2019).

How, then, do the chemical treatments applied in industrial plantations affect the populations of oil palm pollinating insects, and what are the consequences for the productivity and sustainability of agroecosystems? To this end, the aim of this study is to assess the effect of chemical treatments on the population dynamics of oil palm pollinating insects in the Blidouba industrial plantation.

I. Material and methods

1. Experimental treatment setup

The design used was a completely randomised Fisher block design, with three (3) treatments and three (3) replicates. An 8-hectare plot was subdivided into 4 blocks, and each block was further subdivided into 3 sub-blocks. Each sub-block consisted of 20 trees, 6 of which were commercial trees. The trial was conducted on 11-year-old palm trees, i.e. those planted in 2015.

The various treatments were: Oxatop 50GR (Oxamyl), Karate® (5 EC containing 50 g/l lambda-cyhalothrin) and Evisect (500 g/kg thiocyclam hydrogen oxalate). These chemicals were applied at the standard rates using a motorised sprayer with a capacity of 16 litres: that is, 2.66 litres of water per tree per pass. Treatments such as 0.188 g/l of lambda-cyhalothrin and 0.94 g/l of thiocyclam hydrogen oxalate were applied at a rate of 2 capsules per 2.66 litres of water per tree per application. As for the oxamyl-based treatment, 10 g of granules were measured out and dissolved in 2.66 L of water, corresponding to a concentration of 0.188 g/l.

1.1- Observation

1.1.1- Prior to chemical treatments

❖ Female inflorescences

One month prior to the chemical treatments, daily samples were collected from the female inflorescences of oil palms in the 8-hectare plot treated with the three insecticides. To this end, the 8-hectare plot was subdivided into 5 sub-blocks, each containing 20 oil palms, arranged diagonally in accordance with the method described by Hala (2012). These sub-blocks constituted the replicates and were spaced approximately 15 metres apart. Every three days, four female inflorescences were identified in each sub-plot and protected on the first day of flowering with muslin for the three days that anthesis lasted. To identify them, the sub-plots were visited very early in the morning from 6.00 am onwards to expose the female inflorescences using a machete. Samples were thus taken at each stage of anthesis (early anthesis, full anthesis and late anthesis) using a hand-held vacuum cleaner to collect all insects landing on the muslin during the following time intervals:

- 9.00 am to 10.00 am: 10 minutes of data collection
- 11.00 am to 12.00 pm: 10 minutes of data collection
- 4.00 pm to 5.00 pm: 10 minutes of data collection

These data provided information on the abundance or frequency of visits by the various species to the female flowers prior to the chemical treatments.

❖ Male inflorescences

Every three days, on the day of collection from the female inflorescences, three male inflorescences at each stage of anthesis are identified. From each of these, four spikelets are carefully removed using secateurs and placed in a plastic bag. The insects living on these spikelets were then killed using an insecticide before being collected in labelled pill boxes containing 70 per cent alcohol. The data were used to determine the population of pollinating insects present prior to the chemical treatments.

1.1.2- Following chemical treatments (from the first day to the fourth day)

One day (24 hours) after treatment, a survey was carried out in each treated plot up to the fourth day (96 hours) after treatment on every productive tree in each block. This enabled the number of pollinating insects killed by these chemicals to be recorded.

To collect dead insects, a piece of muslin sewn into a bag shape was used to protect the male and female inflorescences. The muslin enabled the dead insects found on the inflorescences both male and female to be retained, whilst also allowing the number of pollinating insects visiting them to be observed. Using a handheld vacuum cleaner, pollinating insects visiting the female inflorescences were captured and placed into pill boxes containing 70 per cent diluted alcohol.

Checks to monitor the mortality of pollinating insects were carried out every morning from the first day after treatment until the fourth day. These involved counting the dead individuals, which were systematically removed from the bags. The dead insects were preserved in the laboratory for identification using a binocular magnifying glass. The mean cumulative mortality rates for pollinating insects for each treatment were calculated using the following formula:

$$Tmes = \frac{\sum \text{Dead pollinating insectsts in each treatment}}{\text{Number of individuals observed across all treatments}} \times 100$$

(Tmes: Estimated mortality rate)

1.1.3- One and two months after the chemical treatments

The observations were the same as those made one month before the treatments. The data obtained showed the recovery of pollinator populations on male flowers and those that had visited female flowers following the chemical treatments.

II- Results and discussion

1. Inventory

Sampling carried out before and after the chemical treatments identified 9 species of pollinating insects belonging to 3 families. These were the Curculionidae, Nitidulidae and Staphylinidae. The Curculionidae family comprised five species, namely: *Elaeidobius kamerunicus*, *Elaeidobius plagiatu*s, *Elaeidobius subvitu*atus, *Elaeidobius singu*laris; whilst the Nitidulidae family comprised two species, namely: *Atheta burgeoni* and *Grabrius* sp., whilst the Staphylinidae family comprised two species: *Microporum congolense* and *Microporum dispar* (Table 1).

Indeed, the predominance of Curculionidae, particularly species of the genus *Elaeidobius*, demonstrates their vital role in the pollination of the oil palm. The abundant presence of *Elaeidobius subvitu*atus and *Elaeidobius kamerunicus* reflects their strong adaptation to the inflorescences of the oil palm and their vital role in the pollination process. Recent studies on the ecosystem services provided by insects in tropical crops indicate that the conservation of beneficial insects remains essential for maintaining agricultural productivity, particularly in crops that rely primarily on plant–insect interactions.

(FAO. 2024) points out that pollinating insects play essential roles in the reproduction of many crops, whilst (Katumo et al. 2022) highlight the importance of preserving populations of specialised pollinators in tropical agroecosystems.

Table 1: List of pollinating insects surveyed

Orders	Genera	Species
Coléoptères	<i>Elaeidobius</i>	<i>Elaeidobius subvittatus</i>
		<i>Elaeidobius plagiatus</i>
		<i>Elaeidobius singularis</i> ,
		<i>Elaeidobius kamerunicus</i>
	<i>Microporum</i>	<i>Microporum dispar</i>
		<i>Microporum congolense</i>
	<i>Lithargus</i>	<i>Lithargus</i> sp
	<i>Gabrius</i>	<i>Gabrius</i> sp
	<i>Atheta</i>	<i>Atheta burgeoni</i>

1.1. Changes in the abundance of pollinator species before and after chemical treatments

❖ Male inflorescences 1 month before the chemical treatments

One month prior to the chemical treatments, the average abundances of each pollinator species varied. The species *Elaeidobius subvittatus* was the most abundant, with an average of (948.75 ± 574.6) individuals per spikelet). It was followed by *Atheta burgeoni* (218.61 ± 54.47) individuals per spikelet), *Elaeidobius kamerunicus* and *Elaeidobius singularis*, with averages of (94.4 ± 71.44) individuals per spikelet) and (91.4 ± 82.24) individuals per spikelet) respectively (Figure 1).

As for species such as *Elaeidobius plagiatus*, *Microporum dispar*, *Microporum congolense*, *Gabrius* sp and *Lithargus* sp, the respective average abundances recorded were: (66.66 ± 34.57) individuals/spikelet); (56.13 ± 39.97) individuals/spikelet); (59.73 ± 35.46) individuals/spikelet), (10.47 ± 8.13) individuals/spikelet) and (5.73 ± 3.76) individuals/spikelet) (Figure 1).

❖ Male inflorescences: 1, 2, 3 and 4 days after chemical treatments

Following the chemical treatments, the average abundances of each pollinator species fell sharply. The results obtained on the first, second and third days were very low.

Average abundances were less than one individual per spikelet (Figure 1). The averages recorded per species on the fourth day after the treatments were: *Elaeidobius subvittatus* (11.2 ± 7.45 individuals per spikelet) was the most abundant. The other species had an average abundance of fewer than 10 individuals per spikelet. Prior to chemical treatment, pollinator populations were relatively high on both male and female inflorescences. However, their abundance declined sharply from the first few days following the application of insecticides.

❖ Male inflorescences: 1 and 2 months after chemical treatments

One month after the chemical treatments, the abundance of each species began to increase, reaching the average level recorded one month previously. As for the abundance recorded two months after the chemical treatments, the species observed showed abundance levels identical to those recorded one month before the chemical treatments (Figure 1).

Before the chemical treatments, pollinator populations were relatively high on both male and female inflorescences. However, their numbers fell sharply from the very first days following the application of the insecticides. This decline could be explained by the direct toxicity of the active ingredients contained in each insecticide. It could also result from sublethal effects that reduce mobility and the ability to locate inflorescences. These results corroborate those of (Basu et al. 2024), which show that pesticides can have multiple effects on pollinating insects, ranging from direct mortality to behavioural disturbances. Furthermore, (Tosi and Nieh. 2021) added that chemical pesticides can alter insects' locomotor and cognitive abilities, thereby reducing their ecological performance.

Thus, two months after treatment, continued resilience of pollinator communities was observed. This recolonisation could be linked to the movement of individuals from nearby untreated plots, the reproduction of surviving individuals and the gradual return to normal conditions within the plantation. This strong recovery demonstrates a certain resilience in pollinator populations when they find suitable habitats. Research by (Albrecht et al. 2023) has shown that access to suitable habitats improves the recovery of pollinator populations following disturbance. Similarly, (Harrison et al. 2018) demonstrated that diversified agricultural landscapes facilitate the re-establishment of beneficial insects. According to (FAO. 2024), the importance of habitats as refuges supports the recovery of pollinators.

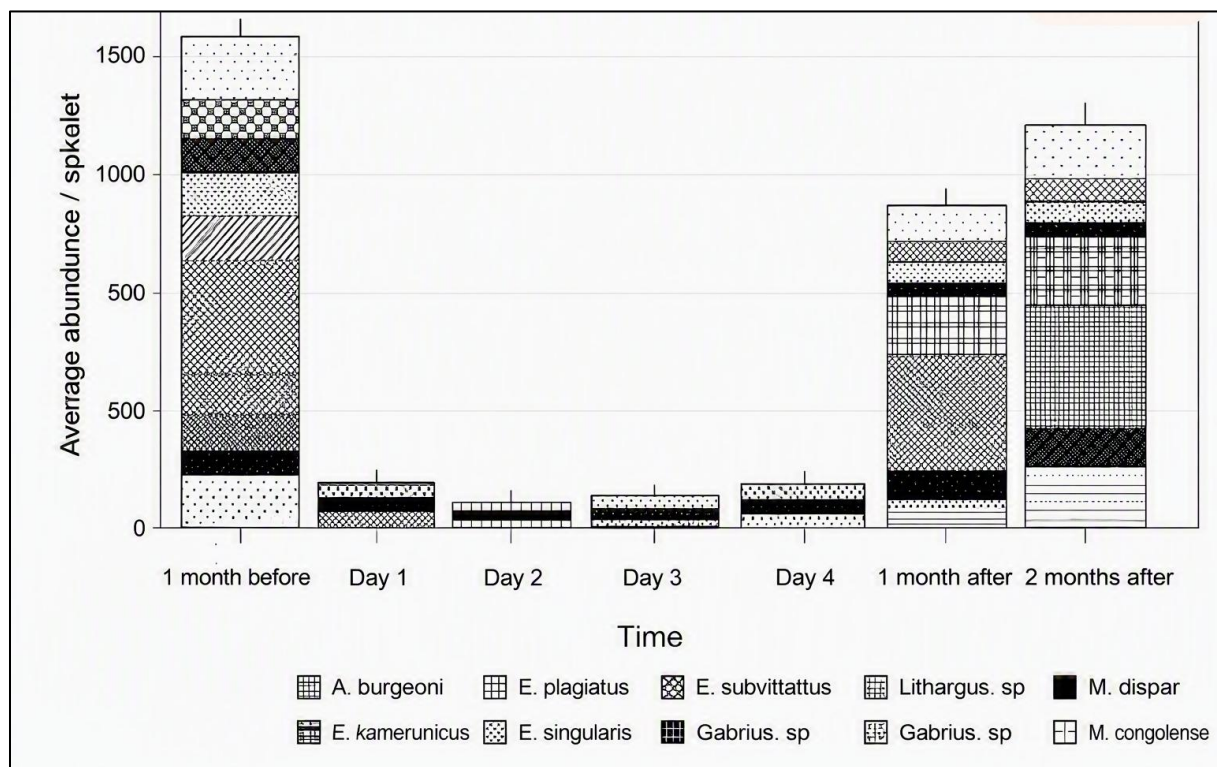


Figure 1: Changes in the population of pollinating insects on the male inflorescences of the oil palm before and after chemical treatments

1.2. Mortality rate by treatment

❖ Immediate effect (Day 1)

On the first day, following treatment, the insecticides EVISECT and OXATOP killed 5.463 ± 1.339 and 10.008 ± 5.909 pollinating insects per inflorescence respectively, representing mortality rates of 9.51 per cent and 17.4 %.

In contrast, the insecticide KARATE recorded the highest number of dead pollinators, namely 41.975 ± 9.581 individuals per inflorescence (Figure 2), representing a mortality rate of 73.1 %. According to the Kruskal-Wallis test (chi-squared = 30.853, df = 2, p-value = 1.997e-07), there is a significant difference between the mortality rates of these three insecticides.

❖ Early residual effect (Day 2)

On the second day following treatment, the number of individuals killed by the three insecticides fell significantly, indicating a gradual decline in their activity. However, KARATE maintained the number of dead insects at approximately 905 ± 192 individuals per inflorescence, representing a mortality rate of 68.1 %. It was followed by OXATOP, with approximately 245 ± 57.4 individuals per inflorescence

and a mortality rate of 18.4 %, and then by EVISECT, with approximately 179 ± 49.6 individuals per inflorescence, representing a mortality rate of 13.5 % (Figure 3).

This trend highlights KARATE's ability to maintain long-term residual efficacy, unlike the other two insecticides (EVISECT and OXATOP), Kruskal-Wallis chi-squared = 24.521, df = 2, p-value = 4.735e-06.

❖ Medium-term effect, on the third day of trapping (72 hours)

By the third day, the efficacy of the three insecticides had become very low. In contrast, the insecticide KARATE continued to maintain its insecticidal effect, with approximately 131 ± 35.9 individuals per inflorescence, representing a mortality rate of 75.8 %, whereas EVISECT and OXATOP recorded 16 ± 4.98 and 25.9 ± 6.70 individuals per inflorescence respectively, corresponding to mortality rates of 9.21 % and 14.9 %. A rapid decline in the insecticidal effect was observed with EVISECT and OXATOP (Figure 4). According to the Kruskal-Wallis test (chi-squared = 21.789, df = 2, p-value = 1.856e-05), a significant difference was observed between these three insecticides.

❖ Long-term effect, on the 4th day of trapping (96 hours)

Four days after treatment, the efficacy of the three insecticides had diminished further. KARATE still recorded the highest number of deaths, at approximately 60.9 ± 22.9 individuals per inflorescence, representing a mortality rate of 59.3 %. It is followed by OXATOP, with 34 ± 16.2 individuals per inflorescence, representing a mortality rate of 33.1 %, and by EVISECT, with 7.75 ± 1.97 individuals per inflorescence, representing a mortality rate of 7.55 %. These results demonstrate that, whilst the effect of EVISECT and OXATOP is rapid, it is not long-lasting (Figure 5). There is a significant difference in mortality between these three insecticides, as shown by the non-parametric Kruskal-Wallis test: chi-squared = 13.148, df = 2, p-value = 0.001396.

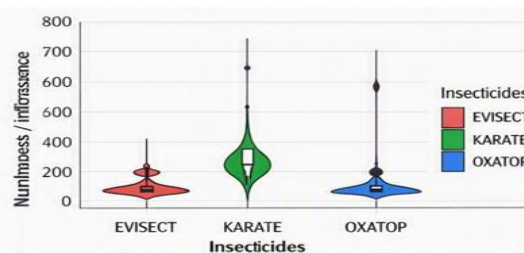


Figure 2 : Distribution of insects killed according to insecticide treatments on Day 1

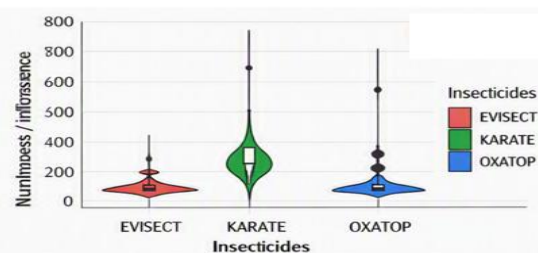


Figure 3 : Distribution of insects killed according to insecticide treatments on Day 2

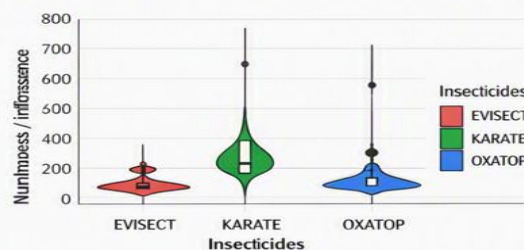


Figure 4 : Distribution of insects killed according to insecticide treatments on Day 3

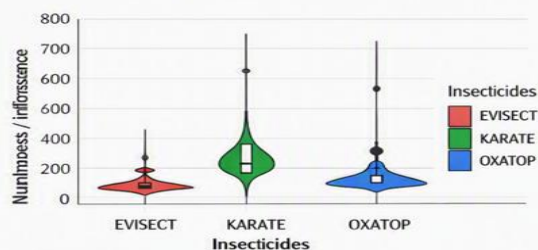


Figure 5 : Distribution of insects killed according to insecticide treatments on Day 4

1.4. Comparison of insecticides based on their toxic effect

❖ KARATE and EVISECT

The mean difference in mortality between KARATE and EVISECT was -4.59 ± -2.002 individuals per inflorescence, with an adjusted P-value ($P_a = 1.307e-05$) (Figure 6). These results indicate that the average mortality rate was significantly higher with the insecticide KARATE compared with EVISECT, according to DUNN's post-hoc test.

❖ OXATOP and EVISECT

The mean difference observed between OXATOP and EVISECT was 0.407 ± 0.0034 . The adjusted P-value was $P_a = 1$ (Figure 7). According to the Dunn post-hoc test, there is therefore no significant difference in mortality between the OXATOP and EVISECT treatments.

❖ OXATOP and KARATE

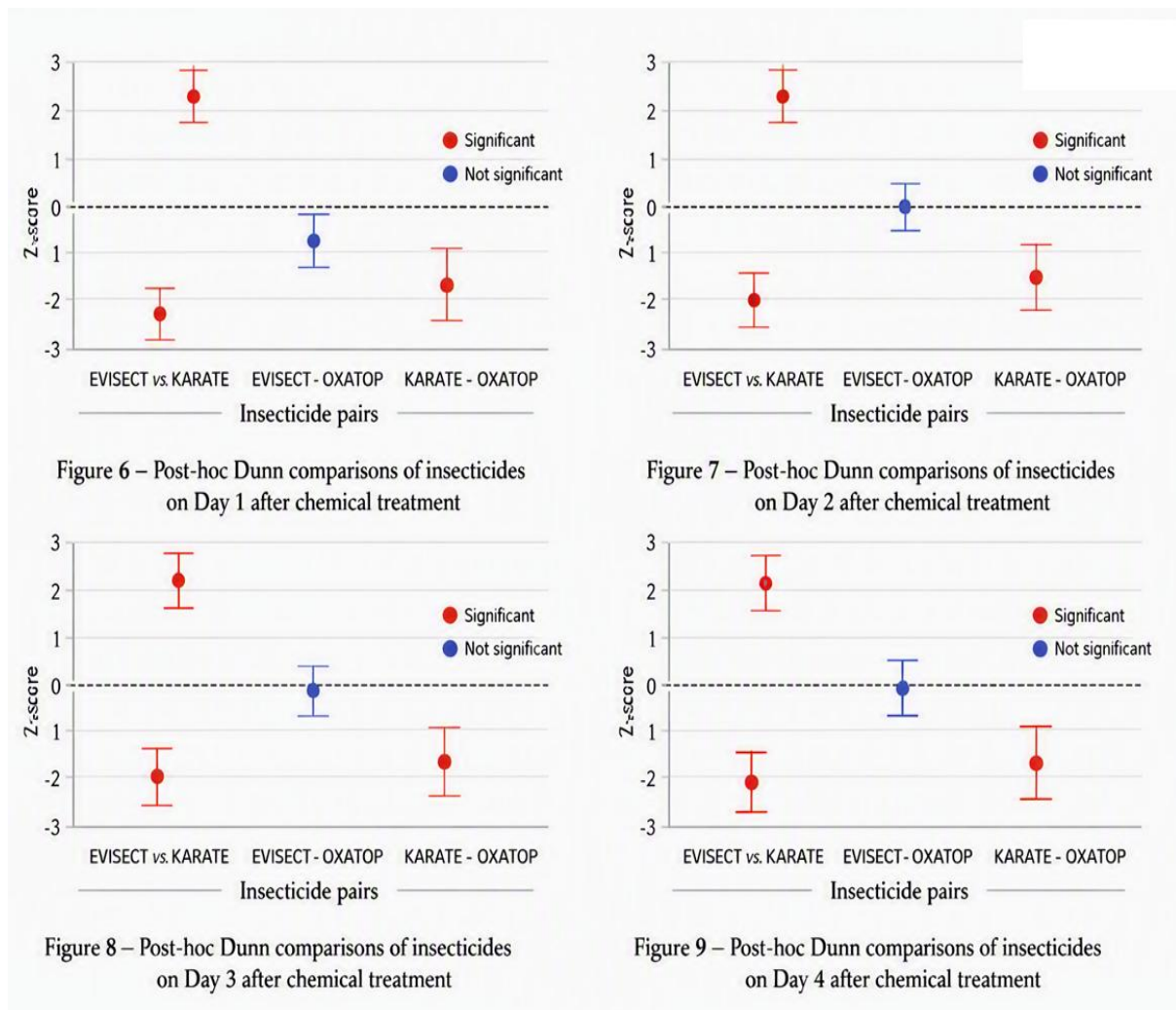
The mean rank between these two insecticides was 3.52 ± 1.08 . The adjusted p-value following the DUNN post-hoc test was $1.248581e-03$ (Figure 8). These results show that there is a statistically significant difference in mortality between the two insecticides.

Thus, this study revealed significant differences between the products tested. KARATE, whose active ingredient is lambda-cyhalothrin, resulted in the highest mortality rates during the observation period. This insecticidal effect could be explained by the neurotoxic action of pyrethroids, which affect the functioning of the insects' nervous system. Pyrethroids are most commonly used in agriculture but are highly toxic to several groups of non-target insects. The results obtained corroborate those of (Mata et al. 2024), which demonstrate a high sensitivity of beneficial insects to pyrethroids. Similarly, (Main et al. 2023) have shown that broad-spectrum insecticides can drastically reduce beneficial insect populations. Thus, (Basu et al. 2024) demonstrate that these insecticides place significant pressure on agricultural beneficial insects.

2. Assessment of the impact of chemical treatments on pollinator visit rates in treated plots

❖ Female inflorescences 1 month prior to chemical treatments

The average number of visits recorded on female inflorescences was high for certain species, such as *Elaeidobius subvittatus*, with an average of (263.27 ± 65.64) individuals/inflorescence). This species was followed by *Elaeidobius singularis* with (59.57 ± 10.08) individuals per inflorescence). The average number of visits by the other species was less than 10 individuals per inflorescence. (Figure 10).



❖ Female inflorescences 1, 2, 3 and 4 days after chemical treatments

Following the chemical treatments, the average number of visits by each pollinator species fell dramatically. The visitation figures recorded on the first, second and third days were very low. Average abundances were less than one individual per inflorescence, except for the species *Elaeidobius subvittatus* (21.3 ± 2.41 individuals per inflorescence), which was the most abundant (Figure 10).

❖ Female inflorescences 1 and 2 months after chemical treatments

One month after the chemical treatments, visits by each species to the female inflorescences are beginning to return to normal. Between one and two months after the chemical treatments, there is a clear and steady increase in the average number of visits by each pollinator species. This observation reflects a gradual recolonisation of the area by pollinating insects and a resumption of biological activity around the treated plants. Species of the genus *Elaeidobius*, in particular *Elaeidobius subvittatus*, show high activity, with an average of 211.15 ± 64.13 individuals per inflorescence one month after chemical treatment and 222.91 ± 64.69 individuals per inflorescence two months after chemical treatment.

In contrast, the other species show a much more moderate but constant abundance. Their activity increases gradually between the first and second months following chemical treatments (Figure 10). According to the findings, the decline in visits by beneficial insects to female inflorescences following chemical treatments may be linked not only to species mortality but also to behavioural changes caused by the insecticides. Indeed, certain chemical insecticides can impair insects' ability to locate floral resources, thereby reducing visits and altering their foraging behaviour. All these changes can reduce the effectiveness of pollination even when certain species survive exposure. These findings are consistent with those of (Knapp et al. 2023), who explained that insecticides can diminish the ecosystem service provided by pollinators. Basu et al. (2024) also show that the behavioural effects of insecticides are a major factor in the decline of natural pollination services. Finally, (FAO, 2024) recommends reducing the risks associated with insecticides in order to maintain agricultural ecosystem services.

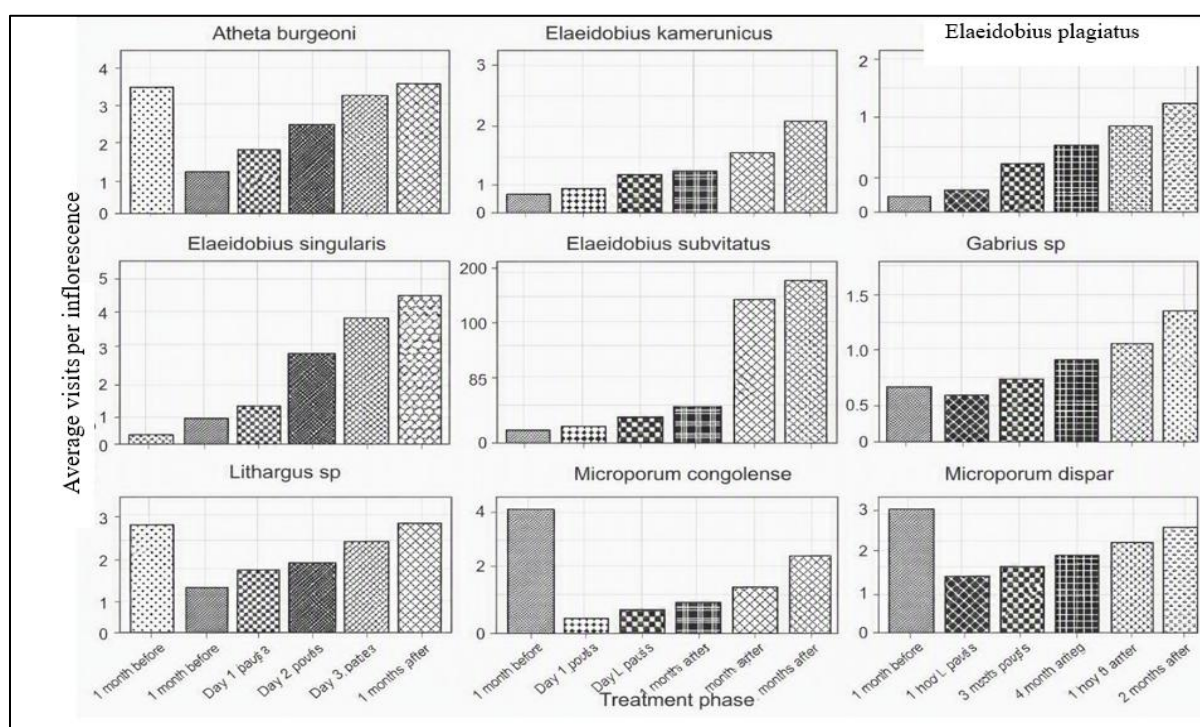


Figure 10: Changes in the average number of visits by oil palm pollinating insects to female inflorescences before and after chemical treatments

Conclusion

The assessment of the impact of chemical treatments on the pollinator insect population of the oil palm led to the collection of nine species from three families, with the Curculionidae being the most numerous specifically, species of the genus *Elaeidobius*. Prior to the application of chemical insecticides, the pollinator fauna exhibited relatively high abundance and very high average visitation rates to female inflorescences. The application of chemical insecticides led to a 52 % reduction in the abundance and visitation rates of pollinating insects between the first and fourth days following chemical treatment.

The three chemical insecticides tested had an insecticidal effect on the pollinator population, but this effect varied depending on the active ingredients contained in the three formulations.

The KARATE insecticide proved to be more harmful, with higher mortality rates at every level. In contrast, EVISECT and OXATOP exhibited fewer toxic effects. Despite these high initial mortality rates caused by the insecticides, a gradual recovery of the pollinator population was observed one to two months after the chemical treatments. These findings show that the chemical insecticides used in industrial oil palm plantations have a negative impact on pollinator populations.

❖ Conflict of interest

- There is no conflict of interest amongst those involved in the preparation of this manuscript
- This research did not receive any funding.

Bibliography

Albrecht M, Kleijn D, Williams NM (2023) Landscape-scale enhancement of pollinator communities and ecosystem services in agricultural systems. *Agriculture, Ecosystems & Environment*, 350 -108482.

Basu P, Ngo HT, Aizen MA., Garibaldi LA, Gemmill-Herren B, Imperatriz-Fonseca V, Klein AM, Potts SG, Seymour CL, & Vanbergen, A. J. (2024). Pesticide impacts on insect pollinators: Current knowledge and future research challenges, *Science of the Total Environment* 954-176656.

Desneux N, Decourtye A and Delpuech JM (2007) The sublethal effects of pesticides on beneficial arthropods. *Annual Review of Entomology*, 52:81-106.
<https://doi.org/10.1146/annurev.ento.52.110405.091440>

European Environment Agency (EEA). (2023). *How pesticides impact human health and ecosystems in Europe*. EEA Briefing No 06/2023. Copenhagen: European Environment Agency.
<https://doi.org/10.2800/760240> Consulté le 28 juillet 2026

Food and Agriculture Organization of the United Nations (FAO). (2024). *The state of food and agriculture 2024: Value-driven transformation of agrifood systems*. FAO.
<https://doi.org/10.4060/cd2616en> Consulté le 28 juillet 2026

- Genty P, Desmier de Chenon R, Morin JP (1986) *Les ravageurs du palmier à huile en Afrique occidentale*. Paris : Institut de Recherches pour les Huiles et Oléagineux (IRHO). ISBN : 2:85984-018
- Goulson D, Nicholls E, Botías C, Rotheray EL (2015) *Bee declines driven by combined stress from parasites, pesticides, and lack of flowers*. *Science*, 347: 6229 -1255957. <https://doi.org/10.1126/science.1255957>
- Harrison T, Gibbs J, Winfree R (2018) *Forest bees are replaced in agricultural and urban landscapes by native species with different phenologies and life-history traits*. *Global Change Biology*, 24(1): 287–296.
- Henry M, Béguin M, Requier F, Rollin O, Odoux JF, Aupinel P, Aptel J, Tchamitchian S, and Decourtye A (2012) A common pesticide decreases foraging success and survival in honey bees. *Science*, 336(6079): 348-350. <https://doi.org/10.1126/science.1215039>
- Katumo DM, Liang H, Ochola AC, Lv M, Wang Q.-F, Yang C.-F (2022). Pollinator diversity benefits natural and agricultural ecosystems, environmental health, and human welfare. *Plant Diversity*, 44(5): 429–435.
- Kehinde T, and Samways MJ (2014) Insect-flower interactions in oil palm plantations and the conservation of pollinators. *Journal of Insect Conservation*, 18(4): 711-721.
- Knapp JL, Nicholson CC, Jonsson O, de Miranda JR, and Rundlöf M (2023) Ecological traits interact with landscape context to determine bees' pesticide risk. *Nature Ecology & Evolution*, 7: 547–556. <https://doi.org/10.1038/s41559-023-01990-5>
- Li K, Tscharntke T, Saintes B, Buchori D, Grass I (2019) Critical factors limiting pollination success in oil palm: A review. *Agriculture, Ecosystems and Environment*, 280:18-27. <https://doi.org/10.1016/j.agee.2019.04.011>
- Main AR, Hladik ML, Webb EB, Goyne KW, and Mengel D (2020) Beyond neonicotinoids: Wild pollinators are exposed to a range of pesticides while foraging in agroecosystems. *Science of the Total Environment*, 742:140436.
- Mata L, Knapp RA, McDougall R, Overton K, Hoffmann AA, and Umina PA (2024) Acute toxicity effects of pesticides on beneficial organisms – Dispelling myths for a more sustainable use of chemicals in agricultural environments. *Science of the Total Environment*, 930 : 172521.

- OCDE/FAO. (2025). *Perspectives agricoles de l'OCDE et de la FAO 2025-2034*. Éditions OCDE, Paris/FAO, Rome. <https://doi.org/10.1787/af125b62-fr>. Consulté le 28 juillet 2026
- PALMCI. (2024). *Rapport RSE 2024 : Performance économique, sociale et environnementale*. Groupe SIFCA, Abidjan, Côte d'Ivoire. https://www.sifca.ci/wp-content/uploads/2025/09/RAPPORT-RSE-2024-PALMCI.pdf?utm_source=chatgpt.com Consulté le 28 juillet 2026
- Pisa LW, Amaral-Rogers V, Belzunces LP, Bonmatin JM, Downs CA, Goulson Kreutzweiser DP, Krupke C, Liess M., McField M, Morrissey CA, Noome DA, Settele J (2015) Effects of neonicotinoids and fipronil on non-target invertebrates. *Environmental Science and Pollution Research*, 22(1): 68–102. <https://doi.org/10.1007/s11356-014-3471-x>
- Potts SG, Imperatriz-Fonseca V, Ngo HT, Aizen MA, Biesmeijer JC, Breeze TD, Dicks LV, Garibaldi LA, Hill R, Settele J, Vanbergen AJ (2016) Safeguarding pollinators and their values to human well-being. *Nature*, 540: 220-229. <https://doi.org/10.1038/nature20588>
- Simon-Delso N, Stark JD, Van der Sluijs JP, Van Dyck H, Wiemers M (2015) Effects of neonicotinoids and fipronil on non-target invertebrates. *Environmental Science and Pollution Research*, 22: 68-102. <https://doi.org/10.1007/s11356-014-3471-x>
- Tosi, S., Nieh, J. C., Brandt, A., Colli, M., Fourrier, J., & Giffard, H. (2021). Long-term field-realistic exposure to a next-generation pesticide, flupyradifurone, impairs honey bee behaviour and survival. *Communications Biology*, 4 : 805. <https://doi.org/10.1038/s42003-021-02336->