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Evaluation of the impact of olive fruit fly (*Bactrocera oleae* [Gmelin, 1790], Diptera: Tephritidae) infestation on olive grove in Biskra (Algeria)

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Evaluation of the impact of olive fruit fly (*Bactrocera oleae* [Gmelin, 1790], Diptera: Tephritidae) infestation on olive grove in Biskra (Algeria)

Abstract: Olive cultivation is important for Algeria's economy and ecology. In recent years, production in the Biskra region has expanded significantly, with an increase in both cultivated area and yield, particularly through olive varieties well adapted to local conditions. The olive tree (*Olea europaea* L.) is a key species for maintaining the Algerian ecosystem and achieving sustainable food security. Its integrity and abundance can affect other organisms that depend on it as a natural resource. However, both the consumption and processing of olives are threatened by *Bactrocera oleae* (Gmelin, 1790), the olive fruit fly, which is considered one of the most important pests of olives. It can cause significant yield losses and reduce olive oil quality. Our study focused on examining several aspects of the damage caused by the olive fly. We analysed infestation levels over three harvest seasons and confirmed that olive fly attacks are closely linked to climatic conditions, the geographical orientation of trees, and the phenology of their host, the olive tree. Our findings on the impact of *Bactrocera oleae* on olive production and food safety are essential for implementing effective control and management strategies in olive groves.

Key words: olive trees, *Bactrocera oleae*, damage, control, infestation.

Ocena vpliva napada oljčne muhe (*Bactrocera oleae* [Gmelin, 1790], Diptera: Tephritidae) v oljčnem nasadu v Biskri (Alžirija)

Izvleček: Pridelava oljk je pomembna za alžirsko gospodarstvo in ekologijo, zato se je v zadnjih letih v regiji Biskra njena pridelava močno razširila, saj so se povečale tako površine, kot pridelava sort, ki se dobro prilagajajo lokalnim razmeram. Oljka (*Olea europaea* L.) je ključna vrsta za ohranjanje alžirskega ekosistema in doseganje trajnostne prehranske varnosti; njena celovitost in številčnost lahko vplivata na druge organizme, ki so odvisni od nje kot naravnega vira, vendar sta tako uživanje kot predelava oljk izpostavljena škodljivcu, oljčni muhi (*Bactrocera oleae* [Gmelin, 1790]), ki velja za enega najpomembnejših škodljivcev oljk, ki lahko povzroči velike izgube pridelka in vpliva na zmanjšanje kakovosti oljčnega olja. Naša študija se je osredotočila na prikaz nekaterih vidikov škode, ki jo povzroči oljčna muha. Analizirali smo stopnjo napadenosti oljk v treh sezonah obiranja. Potrdili smo, da je napad z oljčno muho tesno povezan s podnebnimi razmerami, geografsko orientacijo dreves in fenologijo njihovega gostitelja, oljke. Naša študija o pomenu oljčne muhe na pridelavo oljk in varnost hrane je bistvena za izvajanje ustreznih ukrepov za njeno zatiranje v oljčnih nasadih.

Ključne besede: oljka, *Bactrocera oleae*, škoda, zatiranje, napad.

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1 INTRODUCTION

The olive tree (*Olea europaea* L., family: Oleaceae) is one of the oldest cultivated species in the Mediterranean Basin. It is deeply integrated into the region's landscape, culture, and economy, offering significant nutritional and socio-economic value. Originally native to Asia Minor, the species spread throughout the Mediterranean region via trade and conquests (Fraga et al., 2020). Well adapted to the region's climatic and soil conditions, the olive tree is highly resilient and capable of producing fruit even under suboptimal conditions such as poor soils and irregular irrigation. Algeria, like many Mediterranean countries, offers favourable ecological conditions for olive cultivation. The crop is primarily grown in the northern part of the country, particularly in mountainous regions, which account for nearly 80 % of the national olive orchards. The provinces of Tizi-Ouzou, Bejaia, and Bouira, located in Greater Kabylie, are especially noted for their production of olive oil (Lamani & Ilbert, 2016). Although traditionally concentrated in these areas, olive cultivation is steadily expanding across the country (Lachibi, 2023). Among the several factors limiting olive productivity, phytosanitary issues, especially insect pests, remain the most significant. The olive fruit fly (*Bactrocera oleae* [Gmelin, 1790]) is widely recognised as the most destructive pest of olive trees in the Mediterranean Basin (Chiboub Fellah, 2021). Belonging to the order Diptera and the family Tephritidae, this species shares the group with other fruit-damaging pests, such as the cherry fruit fly *Rhagoletis cerasi* [Linnaeus, 1758], the Mediterranean fruit fly *Ceratitis capitata* [Wiedemann, 1824], and the walnut blight fly *Rhagoletis completa* [Cresson, 1929] (Scolari et al., 2021). The damage caused by *B. oleae* is both quantitative and qualitative. In olives intended for oil production, larvae feed on the pulp, reducing oil yield and accelerating fruit drop, in addition to the deterioration in oil quality due to infestation includes increased acidity and oxidation. In table olives, even minor oviposition punctures are sufficient to render the fruit commercially unacceptable (Malheiro et al., 2015). The overall impact of olive fly infestation can be considerable. Annual losses due to olive pests in general are estimated at over 30 %, with *B. oleae* accounting for up to 15 % (Bueno & Jones, 2002). Despite research across several Algerian regions (M'sila, Tizi-Ouzou, Batna, and Tlemcen) documenting key aspects of *B. oleae* infestation, including infestation rates, temporal population dynamics, trap efficiency, soil pupation behaviour, and the influence of orchard orientation, no effective or environmentally sustainable control strategy has yet been established. The pest continues to inflict considerable damage on olive production, with infestation patterns varying according to region, season, and microclimatic conditions. The absence of integrated, eco-friendly management solutions remains a major challenge for Algerian olive growers, underscoring the urgent need for cost-effective, sustainable, and regionally adaptable control methods that reduce dependence on chemical insecticides (Bemmerzouk, 2020).

Within this context, the present study focuses on the Chemlal olive variety, one of the most extensively cultivated in Algeria. Renowned for its oil yield and late maturation, 'Chemlal' is grown in both traditional and modern orchards. The objective of this study is to assess the infestation rate of *B. oleae* by identifying and quantifying oviposition punctures, pupae, and larval exit holes across three consecutive harvest seasons.

2 MATERIALS AND METHODS

2.1 PRESENTATION OF THE STUDY SITE

The study was conducted in an irrigated olive orchard located in the El Outaya region of Biskra, Algeria (Figure 1), at a latitude of 34°56'00"N and a longitude of 5°39'29"E, at an altitude of 700 metres. The orchard covers an area of approximately 0.35 hectares and is planted with the Chemlal olive variety. The trees, around 16 years old, are spaced 4 × 4 metres apart, with a total of approximately 100 trees. No phytosanitary treatments were applied during the study period, and the soil was managed through surface ploughing.

2.2 DESCRIPTION OF THE CHEMLAL OLIVE VARIETY

Chemlal, also known as Achamlal, Achamli, or Achemlal, is the most widely cultivated olive variety in Al-

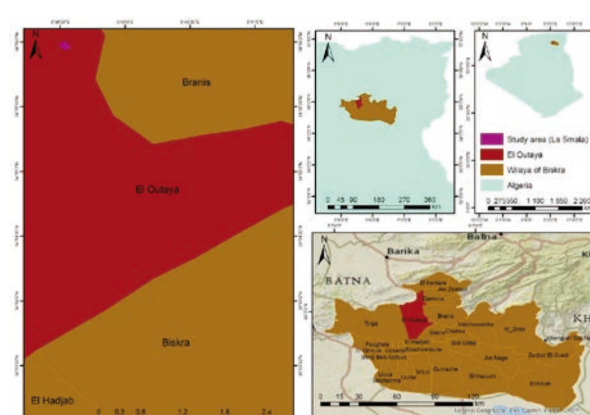

Figure 1: Chemlal Olive Orchard Location – El-Outaya, Biskra.

geria, accounting for approximately 40 % of the national olive orchard. It is predominantly found in the Kabylie region, stretching from Mount Zekkar in the west to the Bibans in the east. This hardy and late-maturing variety is particularly well-suited to Mediterranean and mountainous climatic conditions. Its fruit is small (about 2.5 g) and ovoid in shape, used exclusively for oil production, with an oil yield ranging between 18 % and 22 %. The extracted oil is of excellent quality, valued for its fruity flavour and nutritional properties. 'Chemlal' is self-incompatible and thus requires the presence of pollinating varieties, such as 'Azeradj', to ensure good fruit set. It is often grown in association with other local varieties to optimise pollination and improve yields. This variety is characterised by high productivity and minimal alternation, offering stable yields from year to year. However, it has a low rooting rate, which complicates its propagation. Most trees are grafted onto wild olive (oleaster) rootstocks, a common practice aimed at enhancing resistance and adaptability to Algerian soils. Although this variety is vigorous and upright in habit, it remains susceptible to diseases, particularly olive knot disease, caused by the bacterium *Pseudomonas savastanoi* (Tabti, 2009). Often confused with the Tunisian 'Chemlali', the Algerian 'Chemlal' remains a key reference for high-quality olive oil production and is considered one of the most prized varieties in the country.

2.3 SAMPLING PROCEDURE

Sampling was conducted five times per month, from October, to the end of January, over three consecutive olive harvest seasons (2021–2022, 2022–2023, and 2023–2024). During each visit, a single olive tree was randomly selected from the entire orchard, which had not been divided into blocks.

From the selected tree, a total of 100 olives were collected, 25 from each of the four cardinal directions (east, west, north, and south), either directly from the tree or from the ground. The olives were placed in paper bags and transported to the laboratory, where they were examined for signs of *Bactrocera oleae* infestation by counting both oviposition punctures and larval exit holes on the fruit surface.

2.4 OLIVE DISSECTION

A total of 2000 olives were dissected each year, at a rate of 100 olives per sampling visit, totalling 500 olives per month. Upon arrival at the laboratory, each olive was dissected to detect the presence of *B. oleae* larvae at various developmental stages, as well as pupae (Figure 2).

2.5 DAMAGE ASSESSMENT

2.5.1 Exit Holes

Olives considered "attacked" typically displayed an exit hole made by the fly. These holes are approximately 2 mm in diameter and are relatively easy to identify. If the translucent pericarp is still intact, the pupa is likely

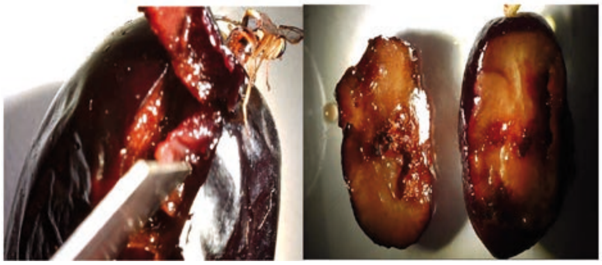

Figure 2: Dissection of an olive showing a gallery formed by *B. oleae* larvae (Original photo, 2023).

Figure 3: Larvae emerging from exit holes, along with several collected pupae (Original photo, 2023).

Figure 4: Female *B. oleae* on the olive; larvae and pupae visible on the right (Original photo, 2023).

still inside. If the hole is open, the adult fly has already emerged and may be pupating in the soil or flying in the orchard (Figure 3).

2.5.2 Egg-laying stings (Oviposition marks)

Oviposition punctures caused by *B. oleae* appear as small brown spots, approximately 0.5 mm in diameter, and are typically triangular or oval in shape. These marks may result from successful egg-laying, failed attempts, or aborted eggs, particularly during periods of high temperature. Females may also create punctures to hydrate or test fruit suitability (Figure 4).

To confirm the presence of an egg or larva, the skin beneath the puncture is carefully lifted with a scalpel and examined under a magnifying lens for signs of an egg or larval gallery. Newly emerged maggots are extremely small and often difficult to detect (Achouche, 2021).

2.5.3 Attack rate

The attack rate (%) was calculated using the formula proposed by Ouédraogo (2011):

Attack Rate (%) = (Number of attacked fruits × 100) / Total number of fruits sampled.

While some authors, such as Helvaci et al. (2018), define the attack rate as a ratio between attacked and healthy fruits, the present study adopted the standard percentage method based on the total number of sampled fruits.

2.6 STATISTICAL ANALYSIS

The data were subjected to statistical analysis using Analysis of Variance (ANOVA) to evaluate the effects of cardinal orientation and harvest season on olive infestation rates. All statistical calculations were performed using Microsoft Excel 2019.

3 RESULTS

3.1 INFESTATION LEVELS OVER OLIVE HARVEST SEASONS

The data presented in Table 1 reveal significant differences in *Bactrocera oleae* infestation levels across three consecutive olive harvest seasons.

During the first season, a total of 160 olives out of 2,000 were infested, resulting in an infestation rate of 8.00 %, while the proportion of healthy olives stood at 92.00 %.

In the second season, the infestation increased markedly, with 416 infested olives, corresponding to an infestation rate of 20.80 %. Consequently, the percentage of healthy olives declined to 79.20 %, indicating a period of higher pest pressure.

By contrast, the third season recorded the lowest infestation rate, with only 80 olives affected (4.00 %) and a significantly higher percentage of healthy fruit (96.00 %).

Table 1: Number of healthy and infested olives in the sampled olive grove.

Harvest Season	Infested olives	Infestation rate (%)	Healthy olives	Healthy olive rate (%)
1st olive harvest season	160	8.00	1840	92.00
2nd olive harvest season	416	20.80	1584	79.20
3rd olive harvest season	80	4.00	1920	96.00

3.2 ANALYSIS OF VARIANCE (ANOVA): SINGLE FACTOR

An analysis of variance (ANOVA) was conducted to assess whether the level of *Bactrocera oleae* infestation varied significantly across the three olive harvest seasons.

The summary statistics for each group (season) show clear differences in infestation means, with the second season exhibiting the highest average infestation (104 olives), followed by the first season (40 olives) and the third season (20 olives). Variance was also highest in the second season, indicating greater variability in infestation intensity.

The corresponding p-value of 0.0525 is marginally above the conventional significance threshold of 0.05 (Table 2). While this result does not meet the strict criterion for statistical significance at the 95 % confidence level, it nonetheless suggests a borderline effect of harvest season on infestation rate.

3.3 INFESTATION AND HEALTH RATES BY CARDINAL ORIENTATION

The distribution of *Bactrocera oleae* infestation and healthy olive percentages was analyzed across four cardinal directions (East, West, North, and South) over three consecutive olive harvest seasons. The results demonstrate clear spatial patterns in the intensity of infestation and the proportion of healthy fruits, reflecting both pest

Table 2: Results of analysis of variance of *Bactrocera oleae* infestation rate in olives by harvest seasons.

SUMMARY						
Groups	Count	Sum		Average		Variance
1st olive harvest season	4	160		40		666
2nd olive harvest season	4	416		104		4789.333
3rd olive harvest season	4	80		20		98
ANOVA						
Source of variation	SS	df	MS	F	P-value	F crit
Between groups	15402.67	2	7701.333	4.160384	0.052546	4.256495
Within groups	16660	9	1851.111			
Total	32062.67	11				

preference and the possible influence of microclimatic conditions on olive fruit fly (Figure 5).

During the first season, infestation rates were relatively low across all orientations, ranging from 1.70 % in the South to 2.40 % in the North. Correspondingly, the proportion of healthy olives remained high, exceeding 22 % in all directions. The North and East exposures recorded slightly higher infestation rates (2.40 % and 2.10 %, respectively), suggesting marginally greater vulnerability on these sides, possibly due to differences in sunlight exposure or humidity retention. However, the variation was minimal, indicating generally low pest pressure during this season.

A significant increase in infestation was observed in the second season, with rates more than doubling in all directions compared to the previous year. The East side again exhibited the highest infestation rate (5.50 %), followed closely by the South (5.30 %) and North (5.20 %) orientations. The West side, although still affected, had a comparatively lower rate of 4.80 %.

The third season showed a return to lower infestation rates, consistent with the broader trend of reduced olive fly activity. The East and North sides recorded slightly higher infestation levels (1.45 % and 1.00 %, respectively), while the West and South had the lowest rates (0.85 % and 0.70 %, respectively).

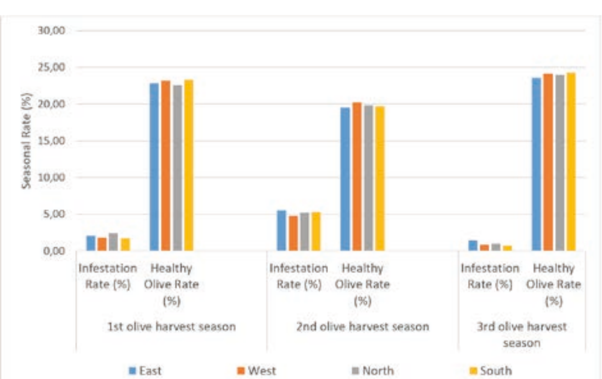

Figure 5: Infestation and healthy olive rates (%) by cardinal orientation over three olive harvest seasons.

3.4 INFESTATION DYNAMICS BY CARDINAL ORIENTATION

The spatial distribution of *B. oleae* infestation within olive trees was assessed by recording the number of infested olives from four cardinal directions (East, West, North, and South) over three successive olive harvest seasons (2021–2024). The data demonstrate clear variation in infestation intensity depending on the tree orientation, suggesting that microclimatic differences may influence olive fly behaviour and oviposition preference (Figure 6).

During the first season, the infestation progressed gradually across all four orientations. The North and East exposures consistently recorded higher numbers of infested olives, with peak values of 19 and 17, respectively, in January. The West and South sides showed slightly

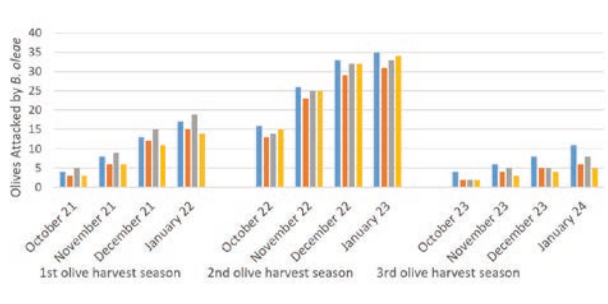

Figure 6: Monthly number of infested olives by orientation (east, west, north, south) across three olive harvest seasons

lower infestation levels, peaking at 15 and 14, respectively.

The second season exhibited a marked increase in infestation across all directions, with the East and South orientations being the most affected. The number of infested olives reached 35 in the East and 34 in the South by January, followed closely by 33 in the North and 31 in the West. This season displayed the highest infestation levels overall, and the relatively uniform distribution across all sides of the tree suggests a widespread and intense olive fly pressure. However, the East side consistently showed the highest infestation counts across all months.

In the third season, the overall infestation levels were considerably lower across all directions. The East again recorded the highest cumulative number of infested olives (29 in total from October to January), followed by the North (20), West (17), and South (14). Despite the reduced overall infestation, the trend of higher attack levels in the East and North directions persisted.

The directional distribution of *B. oleae* infestation reveals a consistent preference for the East and North sides of olive trees, particularly in the peak infestation months of December and January. This pattern is evident across all three seasons, regardless of overall infestation intensity.

3.5 MONTHLY INFESTATION DYNAMICS IN RELATION TO CLIMATIC CONDITIONS

The monitoring of *Bactrocera oleae* infestation over three consecutive olive harvest seasons (2021–2024) revealed significant variation in the monthly number of infested olives. This variation appears to be closely associated with a range of climatic parameters, including temperature (maximum, minimum, and average), rainfall, relative humidity, wind speed, and wind temperature. The analysis of these relationships provides insights into the influence of environmental factors on the seasonal dynamics of olive fly infestation in Biskra's climatic context (Figure 7).

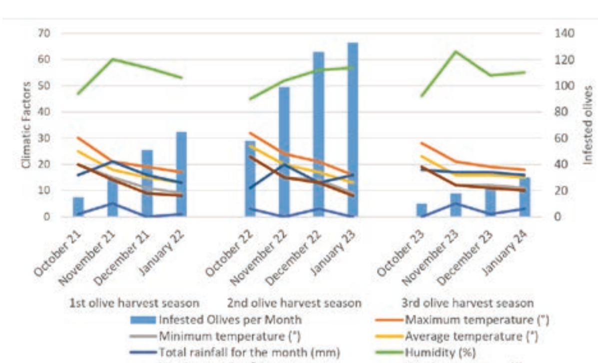

Figure 7: Monthly number of infested olives in relation to climatic conditions.

During the first season, the number of infested olives rose steadily from 15 in October to 65 in January, indicating a gradual increase in pest pressure as the season progressed. This rise in infestation coincided with a consistent decrease in average temperature, from 25 °C in October to 13 °C in January. Despite low rainfall (a maximum of 5 mm in November) and relatively moderate humidity (ranging from 47 % to 60 %), the olive fly population appears to have developed steadily. The moderate wind speeds (13–21 km h^{-1}) and mild wind temperatures (8–20 °C) likely did not exert significant constraints on fly activity.

The second season recorded the highest levels of infestation, with numbers increasing from 58 in October to 133 in January. Climatic conditions during this period were particularly conducive to olive fly development. The average temperatures remained relatively high in October (27 °C) and November (20 °C), gradually decreasing to 13 °C by January. These conditions fall within the optimal thermal range for *B. oleae* development and activity. Furthermore, the season was marked by very low rainfall and stable humidity levels (45–57 %), which may have favoured adult fly longevity and larval development. The consistent rise in infestation under these conditions suggests that warmer autumn temperatures, coupled with stable humidity and limited rainfall, contribute significantly to olive fly population growth.

In contrast, the third season exhibited substantially lower infestation levels, starting with 10 infested olives in October and reaching only 30 by January. Although average temperatures were only slightly lower compared to the previous season (23 °C in October to 15 °C in January), this modest decline may have been sufficient to reduce fly activity and development. Additionally, relative humidity was slightly higher in some months (peaking at 63 % in November), which, together with cooler conditions and slightly increased rainfall in December and January, may have contributed to suppressing fly reproduction. These findings suggest that even subtle shifts in temperature and humidity can influence pest population dynamics under arid conditions.

4 DISCUSSION

The Chemlal olive cultivar, known for its small, elongated fruits and high oil yield, is widely grown in Algeria, particularly in mountainous and semi-arid regions such as Biskra. Due to their biochemical composition and limited size, 'Chemlal' olives are generally considered less susceptible to *Bactrocera oleae* infestation compared to table varieties with larger fruit (Mraicha & Ksantini, 2011). However, our study demonstrates that, under certain climatic conditions, even oil varieties such as Chemlal can be subject to significant levels of attack. Our findings confirm that olive fly damage is most intense during the autumn months, particularly in December, which coincides with the local harvest period. Although the present investigation was limited to autumn and early winter, it is supported by our previous research on the Chemlal variety, which spanned all seasons and focused on the use of attractant traps for the management of *B. oleae*. That earlier study provided complementary evidence, confirming that olive fly damage is most severe during the autumn months, particularly in December, which coincides with the local harvest period (Gacem et al., 2024). Attack rates in the studied orchard ranged from 4 % to 20.8 %, with peak infestation aligning with the period of commercial fruit maturity. This agrees with earlier research by Louskas et al. (1980), who reported that *B. oleae* populations fluctuate throughout the year, often causing substantial quantitative losses, particularly in late-harvested oil varieties. Rojnić et al. (2015) recommend early harvesting and prompt processing as effective strategies to reduce damage. The optimum harvest window should be locally defined, considering pest dynamics, oil content, and fruit ripeness. The infestation rates recorded in our study are lower than those reported in some other Algerian regions. For instance, Bouzina (2017) reported infestation rates exceeding 78 % in olives collected directly from trees and more than 85 % in fallen fruit in the M'sila region, where this study was carried out in 'Chemlal' orchard. The grove is composed of approximately 200 trees planted in a regular quadrat design, with a few apricot, pomegranate, and fig trees interspersed. Notably, no phytosanitary treatments are applied in this orchard, which makes it representative of many traditional groves in the region and provides a realistic context for evaluating natural infestation dynamics of *B. oleae*. In Northern Cyprus, Helvaci et al. (2018) noted rates ranging from 2 % to 83.2 %, highlighting the pest's broad variability across Mediterranean environments, while Louskas et al. (1980) reported an abrupt increase in attacks in untreated Greek groves from mid-September onward, peaking at over 80 % by harvest. Our results highlight a clear seasonal variability in olive fly infestation, with the second season recording the highest impact, most likely due to more favourable environmental conditions that supported the development and activity of the pest. In contrast, the third season showed a markedly lower infestation rate, suggesting a reduction in pest pressure that may be linked to less favourable climatic conditions or the influence of natural suppression mechanisms. This overall pattern underscores the strong role of microclimatic exposure in shaping fly activity and distribution within the orchard, with sunnier orientations appearing to provide more suitable conditions for adult behaviour.

Mohamed & Djeddi (2015) found that in M'sila, the western and southern orientations of olive trees had the highest infestation rates. Although some studies, such as Zerkhefaoui (1998) and Gaouar & Debouzie (1991), reported no significant differences among the cardinal directions, this spatial heterogeneity may be linked to sunlight exposure, which influences fruit ripeness and visual attractiveness to female flies (Jerraya et al., 1986). Fruits that are more colourful or mature are often more susceptible to infestation. According to AFIDOL (2014), acceptable infestation thresholds for oil olives are 2 % in July, increasing monthly to 8 % in October. Our second-season results exceeded these thresholds, indicating the need for preventive control measures. High infestation rates, particularly when untreated, result in premature fruit drop, compromised oil quality due to increased acidity, and in severe cases, complete crop loss (Nestel et al., 2016; AFIDOL, 2020). Climatic conditions during the 2021–2024 seasons likely favoured *B. oleae* development in Biskra. Our results contrast with those from Kabylia, where Kherroubi (2016) observed higher infestation rates at elevated altitudes. Chabane (2016) and Abidi (2010), however, offered contradictory findings on the role of altitude in Tizi-Ouzou, suggesting that other local factors such as microclimate and cultivar susceptibility play a role. Belhocine (2003) and Gaouar (1996) found that groves at lower altitudes in Tlemcen were more infested, while Nebri and Zidane (2016) observed that infestation density is inversely proportional to crop size rather than to the adult fly population in tree canopies. These findings underscore that infestation levels depend on a combination of population pressure, climatic factors, fruit availability, and varietal characteristics. The reproductive behaviour of *B. oleae* also influences infestation patterns. Females typically lay a single egg per fruit, but multiple females may target the same olive. Eggs are highly vulnerable during the first 24 hours of incubation, with high mortality likely linked to fruit chemistry (Gomina, 2015). According to Arambourg (1986), infestation-induced weakening of fruit attachment can lead to up to 40 % reduction in detachment resistance. The female fly often selects fruits based on colour and maturity, with yellow-red olives preferred over green or black ones. Mraicha & Ksantini (2011) found that the largest-fruited varieties, such as Meski and Manzanilla, had the highest infestation rates. 'Chemlal', with its small fruit (approximately 7 mm in diameter), is less receptive, though still vulnerable under conducive environmental conditions. Pruning, while beneficial for aeration, can unintentionally increase fruit size and susceptibility if not balanced properly (Belguerri, 2016). Likewise, soil surface ploughing and the absence of phytosanitary treatment may have contributed to the pest pressure observed in our study site.

5 CONCLUSIONS

This study confirms that *Bactrocera oleae* can inflict economically and agronomically significant damage on the Chemlal olive variety in the Biskra region. While overall infestation levels were moderate, they exceeded commonly accepted thresholds of harmfulness during the second harvest season, thereby posing a substantial risk to both the yield and quality of olive oil production. The findings highlight that several factors influenced the variability in infestation rates, including climatic conditions, tree orientation, fruit maturity, and the absence of phytosanitary interventions. Notably, the timing of harvest emerged as a critical factor, as delayed harvesting, which is frequent in the region, was associated with higher infestation levels. This delay heightens the vulnerability of olives to fly attacks and contributes to reduced oil quality, particularly through increased acidity and premature fruit drop. Our results clearly demonstrate that early harvesting is an effective strategy for mitigating *B. oleae* damage. Advancing the harvest date, ideally before infestation peaks, can significantly limit the impact of the olive fly on both yield and oil quality. As such, it is strongly recommended that the optimal harvest window be locally defined, based on real-time monitoring of pest activity and fruit ripening stages. Over the three seasons studied, *B. oleae* infestation generally increased during the cooler months (November to January), with peaks occurring at average temperatures between 16 and 20 °C, which likely represent optimal conditions for oviposition and larval development. Nevertheless, other factors also influenced this pattern. The second season, marked by warm autumns and mild winters, was particularly favourable for fly proliferation. In contrast, although the third season was similarly cool, higher humidity levels combined with occasional rainfall may have disrupted adult activity and reduced larval survival, resulting in lower overall infestation. These findings suggest that temperature alone does not fully explain population dynamics. Rainfall did not appear to exert a direct influence, as precipitation remained consistently low throughout the study. However, extended periods of dryness, coupled with high temperatures, may exacerbate stress on olive trees, increasing their susceptibility to infestation. Wind speed and wind temperature showed moderate variability between seasons but lacked a clear correlation with infestation patterns, suggesting a more limited role in pest dynamics under the conditions observed.

In conclusion, to safeguard both the economic viability and environmental sustainability of olive cultivation in arid regions such as Biskra, it is imperative that producers adopt a combination of timely harvesting and ecologically sound pest management strategies, particularly for vulnerable and economically valuable cultivars like Chemlal.

Data availability statement

All data generated and analysed during this study are original and are fully included in this article.

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