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Article

Population dynamics and trophic interactions between *Oligonychus afrasiaticus* (Acari: Tetranychidae) and its predator *Stethorus punctillum* (Coleoptera: Coccinellidae) on date palms in the north-eastern Algerian Sahara

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ABSTRACT

Drought is causing Algerian palm groves to suffer an increase in date palm acariasis, which is caused by the mite *Oligonychus afrasiaticus* (McGregor, 1939). This mite feeds on the fruit's epidermal cell, giving it a rough appearance and making it unfit for consumption. The study was carried out in the Souf region, north of the Grand Erg Oriental in Algeria over 12 months from July 2020 to June 2021. Our study aimed to determine the infestation of the date dust mite *O. afrasiaticus*, and to understand the population dynamics of this mite and its predator *Stethorus punctillum* (Weise, 1891) in the Deglet Nour and Ghars varieties, within different types of palm groves (El Bayadha 33° 19' 40" N, 6° 55' 33" E, Oued Alanda 33° 17' 25" N, 6° 46' 39" E and Sandarous 33° 13' 18" N, 6° 58' 40" E). Two sampling methods were used, direct collection of dates using the date branch sampling method and the date palm branch striking method. The result showed that the beginning of *O. afrasiaticus* infestation of dates coincided with the green phenological stage of dates (Kimri) and ended with the beginning of the Bser stage (Khalal). Our results showed that the Ghout palm grove was the least affected by this pest compared with the other groves. Dates of the Deglet Nour variety have the highest infestation rates compared with the Ghars variety. We also observed that the ladybird, *S. punctillum*, acts as a key predator of the date palm spider mite highlighting a significant trophic interaction between the two species. Our results showed that the population dynamics of these acarophagous insects vary according to the degree of presence of their trophic preferences and the ecological factors of the biotope.

KEYWORDS: Deglet Nour, El Oued, Ghars, Ghout, *Phoenix dactylifera.*

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INTRODUCTION

The date palm (*Phoenix dactylifera* L.) has long been one of the most important fruit crops in arid

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regions, particularly in North Africa. Moreover, the fruit of this tree has played an important role in the economy, society and environment of these countries (Chao and Krueger 2007; Dakhia *et al.* 2013; Mohammed *et al.* 2023). In Algeria, date palms are crucial to the agricultural sector, particularly in the southern oases (Idder-Ighili *et al.* 2013). With over 16.8 million date palms, national production reached 1,188,803 tonnes in 2022, of which the Deglet Nour variety accounted for 52.86% (628,409.3 tonnes) (DAS 2023). In the Oued Souf region, 1,542,522 date palms produce 73,395 tonnes of Deglet Nour, 28,453 tonnes of Ghars, and 20,472 tonnes of dry dates (DAS 2023). However, this production can be reduced by various bio-aggressors (Gaid et *al.* 2024), including the date palm moth *Ectomyelois ceratoniae* (Zeller) (Idder-Ighili *et al.* 2015), the bostrychid beetle *Apate monachus* Fabricius (El-Shafie 2012a), *Oryctes agamemnon* Burmeister (Chouia *et al.* 2018), the date palm scale *Parlatoria blanchardi* (Targioni- Tozetti) (Idder-Ighili *et al.* 2015), and the date dust mite *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae) (Idder and Pintureau 2008).

The date dust mite, *O. afrasiaticus*, is a major pest of date fruits in Algeria (Zaid *et al.* 1999; Idder and Pintureau 2008). It infests developing fruits, causing irreversible damage that reduces growth and renders them unfit for consumption (Idder-Ighili *et al.* 2013; Alatawi 2020; Ben Chaaban and Chermiti 2009; Mohammed *et al.* 2023).

Several studies on *O. afrasiaticus* have been conducted in date palm-growing regions, underscoring its economic and ecological significance. In Tunisia, Ben Chaabane and Chermiti (2009) studied the influence of fruit characteristics on its population dynamics, while El-Shafie (2022) reviewed its biology, ecology, and management. Chaker *et al.* (2020) highlighted control challenges. In Saudi Arabia, Mirza *et al.* (2021) documented its phenology and adaptation to local climates, and in Iran, Yadegar *et al.* (2022) linked physicochemical fruit properties to cultivar susceptibility. Research in Algeria (Guessoum *et al.* 2016) and Biskra (Nia *et al.* 2024) further emphasized the need for sustainable control strategies to manage this pest effectively.

Several natural enemies of *O. afrasiaticus* exist, with the acariphagous ladybird *Stethorus punctillum* being particularly significant; although polyphagous, *S. punctillum* primarily preys on *Tetranychus* mites (Kasap and Aktuğ 2003; Abad-Moyano *et al.* 2006). In Algeria, Idder and Pintureau (2008) first highlighted its role in controlling *O. afrasiaticus*, while Saharaoui *et al.* (2010) confirmed its ecological importance in Biskra date palm groves. Babaz *et al.* (2021) further demonstrated its voracity under laboratory conditions in the M'zab region, reinforcing its potential as a biological control agent.

Our study region, located in the oases of Oued Souf, features two date palm production systems: the traditional Ghout system, which relies on small family farms and sand-dug basins to access the water table, and the modern system, which employs techniques like drip irrigation to optimize production (Remini and Souaci 2019).

Our research work aims to determine the infestation of the date dust mite *O. afrasiaticus,* as well as to understand the population dynamics of this mite and its predator *S. punctillum,* along with their trophic interactions in the oases of the north-eastern Algerian Sahara. It also aims to analyze the factors influencing the population fluctuations of these two species. This research was carried out on two varieties of date palms in three different types of oases over 12 months, from July 2020 to June 2021.

MATERIALS AND METHODS

Study area

This study was carried out in three sites selected according to the type of oasis landscape in the El Oued region (Table 1). Two of these sites are modern palm groves with well-aligned date palms and drip irrigation systems. The first is at El Bayadha, while the second is in a dune environment (Erg) at Oued Alanda. The third site is a traditional Ghout palm grove at Sandarous (Fig. 1). It is the result of a technique invented hundreds of years ago by the farmers of the Saharan region of El Oued

(Fig. 2). This technique, called Ghout, is a self-irrigation system. It consists of a large funnel dug 12 meters deep over an area of 1 to 1.5 hectares, with palm trees planted three meters from the water table (Remini and Souaci 2019).

Table 1. Characteristics of the study palm groves.

Palm Grove	Geographical coordinates	Age of the palm grove (year)	Characteristic of biotope	Number of palms	Distance between palms (m)
El Bayadha	33° 19' 40" N 6° 55' 33" E	25	Irrigated production system	142	8
Erg	33° 17' 25" N 6° 46' 39" E	22	Irrigated production system	137	8
Ghout	33° 13' 18" N 6° 58' 40" E	47	Self-irrigated production system	80	12

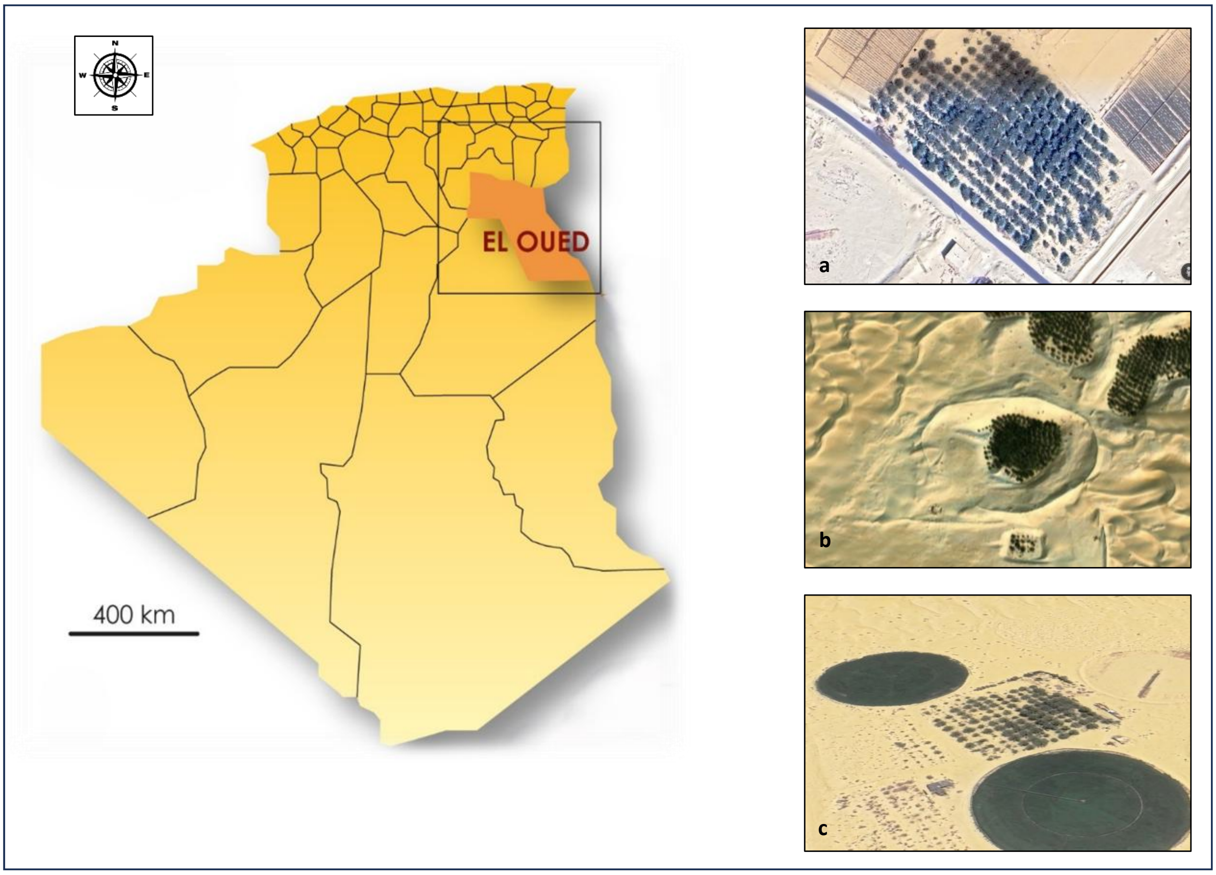

Figure 1. Geographic situation of study area and distribution of sampling sites – **a.** El Bayadha; **b.** Erg; **c.** Ghout.

Sampling of O. afrasiaticus *and its natural predator,* S. punctillum *in date fruits*

The sampling was conducted from July 2020 to June 2021, with biweekly visits to each site. To ensure statistical representativeness, five infested date palms were selected per palm grove. From each palm, three date bunches were collected, and from each bunch, three strands were randomly chosen. Seven dates were sampled per strand, resulting in a total of 630 dates per outing per palm grove (315 per variety Deglet Nour and Ghars) (Tliba 2016).

Sampling was carried out up to the beginning of the Bser (Khalal) stage, when no other stage of the date dust mite could be observed.

The dates were placed in kraft paper bags in a refrigerator at −8 °C to prevent mite activity before being counted *O. afrasiaticus* and its natural predator, *S. punctillum* under a stereoscope, were counted in three parts of the date: the apical part (L1), the middle part (L2) and the terminal part (L3). This protocol was adapted from previous studies on mite population dynamics in date palm groves (Ben Chaabane and Chermiti 2010; Tliba 2016).

Figure 2. Photographs showing the study palm groves – **a.** El Bayadha; **b.** Erg; **c.** Ghout.

Sampling of natural predator S. punctillum *in folioles*

To determine the seasonal changes in the population of the predatory ladybird, we carried out an inventory of these beetles in the palm grove over year.

Sampling was carried out monthly in the palm groves using the "hit and count" method, which involves placing a sheet under the palm tree and shaking it vigorously in all directions with a stick (Sahraoui *et al*. 2010). The sampled animals were then collected in Petri dishes.

Data analysis

The population dynamics of the date dust mite, *O. afrasiaticus*, and its predator, *S. punctillum*, were analyzed using a generalized linear model (GLM). The model incorporated several factors, including palm grove type (El Bayadha, Ghout and Erg), developmental stages of the mite and its predator, date variety (Deglet Nour and Ghras), and fruit infestation level (L1, L2 and L3).

To better understand the influence of different factors, phenological stages of dates and environmental parameters, simple (bivariate) correlations and multiple partial regressions were used to analyze the trophic interactions between the population of *O. afrasiaticus* and its predator *S. punctillum*.

The model used is presented below:

Abundance of *O. afrasiaticus* = β0 + β1 (Abundance of *S. punctillum*) + β2 (Temperature) + β3 (Humidity) + β4 (Phenological stage) + β5 (Variety) + β6 (Time) + β7 (Station) + ϵ

Where:

- β0 is the intercept,
- β1, β2, β3, β4, β5, β6, β7 are the regression coefficients associated with each independent variable,
- ϵ is the error term of the model.

The analyses were carried out using Minitab 21 statistical software, following the methods described by Legendre (2000).

RESULTS

Population dynamics and infestation levels of the date dust mite O.afrasiaticus

The results below show the degree of dust mite infestation in the palm groves studied (El Bayadha, Erg, and Ghout) for two date varieties: Deglet Nour (DN) and Ghars (GH).

The results presented in the graph below (Fig. 3), show that there are significant variations in the number of palm trees infested by the date dust mite depending on the palm grove and the variety.

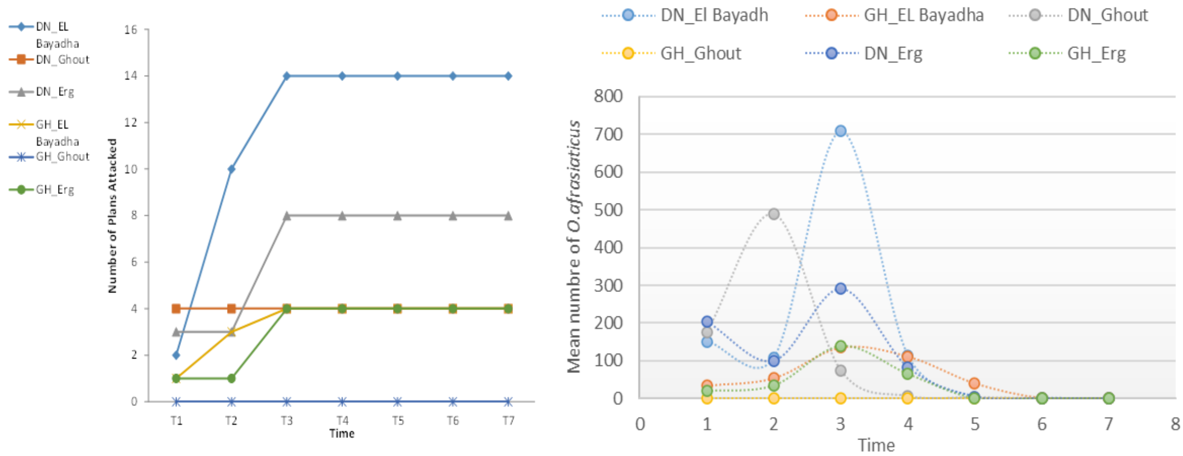

Figure 3. Temporal infestation of *Oligonychus afrasiaticus* in palm trees.

The results showed that in the El Bayadha palm grove, the Deglet Nour variety has the highest number of affected trees, i.e. 14 plants with a total of 700 individuals/dates, at the end of July (T3) and remaining constant until the beginning of September (T7). This indicates a rapid and severe infection. It then stabilized at a high level relatively early in the observation period. Still in the same palm grove, but this time with the Ghars variety, it should be noted that the number of infested date palms gradually increased to 4 plants (136 individuals/dates) from the end of July (T3), before stabilizing at the beginning of September (T7). In the Erg palm grove, the number of date palms attacked by the Deglet Nour variety increased to 8 plants at the end of July (T3) i.e. a total of 292 individuals/dates, then remained constant until the beginning of September (T7). For the Ghars variety, the average number of the mite i.e. 139 individuals/dates, increased slightly from around 4 plants at the end of July (T3) and remained stable until the beginning of September (T7). At the Ghout palm grove, the Deglet Nour variety showed a slight increase in the number of palm trees attacked, reaching around 4 plants from the beginning of July (T1). Infestation peaked in mid-July (T2) with 488 mites/dates, remaining stable until early September (T7). On the other hand, for the Ghars variety, no attacked palms were observed (Fig. 3).

The results in the graphs suggest that infestation starts earlier in the Ghout palm grove than in the other groves. It should also be noted that the Deglet Nour and Ghars varieties in the Ghout palm grove are the least affected by infestations of *O. afrasiaticus*.

An analysis of the spatial distribution of the mite as a function of different factors was then provided using a general linear model (GLM) (Fig. 4) .The factors taken into account were the time, the development cycle of the mite, the position of the damage on the fruit, the palm groves studied, and the type of variety. The results show that all factors, except for the type of the palm grove, have a considerable effect on mite abundance ($p < 0.05$).

The distribution of mite abundance varied significantly according to time ($F = 11.50$, $p = 0.000$), development stage ($F = 6.24$, $p = 0.000$), the position of fruit infestation ($F = 24.15$, $p = 0.000$), and palm variety ($F = 23.14$, $p = 0.000$).

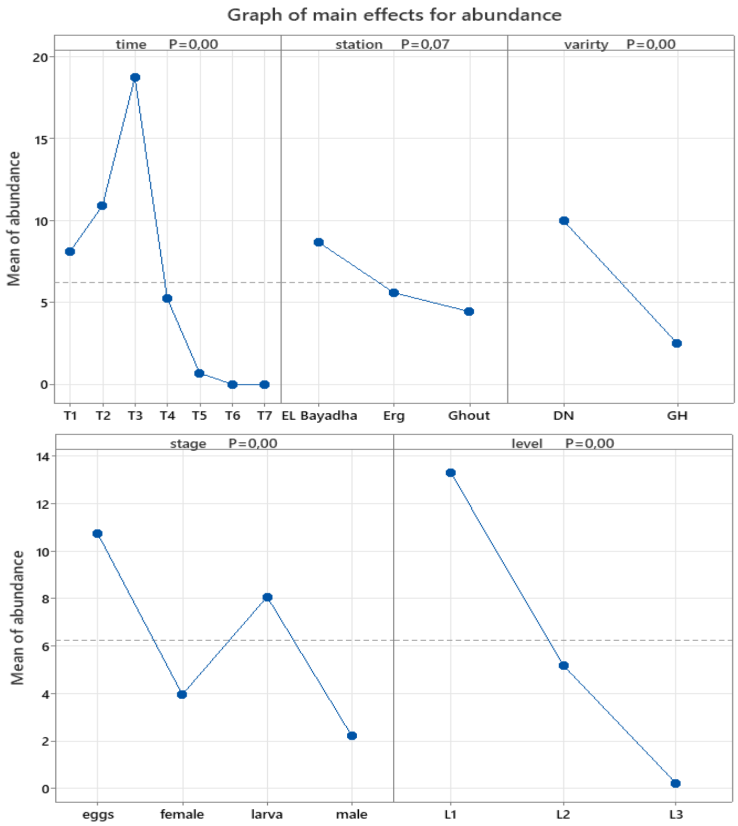

Figure 4. Generalized linear model (GLM) showing the abundance of the date mite *O. afrasiaticus* according to different factors (time, station, mite life stage, cultivar, and fruit infestation level).

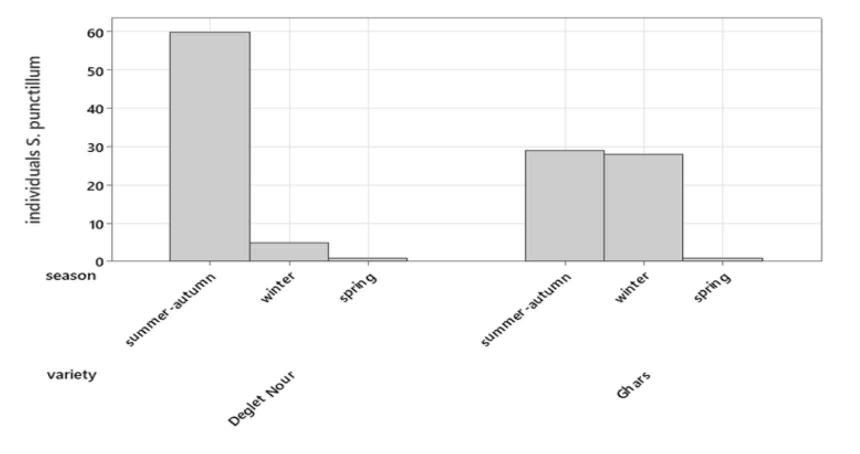

Figure 5. Seasonal distribution of *S. punctillum* in the study palm groves.

Population dynamics of S. punctillum *in palm groves and on dates*

Temporal variations in the predatory ladybird *S. punctillum* are shown in Figure 5. The abundance of *S. punctillum* on date palms of both varieties was very high during the summer and autumn periods, with an effective 60 individuals for Deglet Nour and 30 individuals for Ghars. On the other hand, during the cold period, there was a clear difference between the two varieties. We can see that on Deglet Nour the population of the predator decreases during the winter and spring. For the Ghars date palm, the decrease is less significant during the winter, i.e. 27 individuals, however it becomes more pronounced during the spring period.

A general linear model (GLM) statistical analysis was carried out to study the distribution of *S. punctillum* in the following areas.

The results obtained revealed that the abundance of this predator varied significantly over time ($F = 4.97$; $p < 0.001$). It has been reported that the highest density of this predator is recorded between July and August, the peak of which is marked in mid-August (T5). This peak corresponded to temperatures of 30.1 °C, 29.9 °C, and 26.9 °C and humidities of 44%, 43%, and 40% respectively in the Erg, El Bayadha, and Ghout palm groves. Thereafter, the abundance gradually decreases to reach a minimum at the beginning of September (T7), when the temperature can drop to its lowest point of 25.8 °C in the Ghout palm grove.

Even though the stage of development seems to influence the abundance of *S. punctillum*, statistically, we notice that it is not significant ($F = 1.57$; $p = 0.179$). However, it should be noted that larval stage 1 presents a significant correlation with a p-value = 0.019, indicating that there is a high predominance of first-stage larvae compared to the other stages (Fig. 6).

The results obtained also show that the distribution of individuals of this acarophagous varied significantly with the level of the fruit ($F = 5.78$; $p = 0.003$), with the apical level of the date (L1) being characterized by a significant correlation with the abundance of the predator (p-value = 0.043); this indicates that this level is presented by an intense activity of ladybirds compared with the other levels.

In addition, it is important to note that the distribution of *S. punctillum* varies significantly between the two date palm varieties Deglet Nour and Ghars ($F = 15.75$, $p < 0.001$). It can be observed that the Deglet Nour variety harbors a high density of this *Stehthorus* compared with the Ghars variety. Our results also suggest that the studied palm groves have a very significant impact on the distribution of this predator ($F = 29.35$; $p < 0.001$), with the El Bayadha palm grove appearing to be more abundant than the Erg and Ghout palm groves.

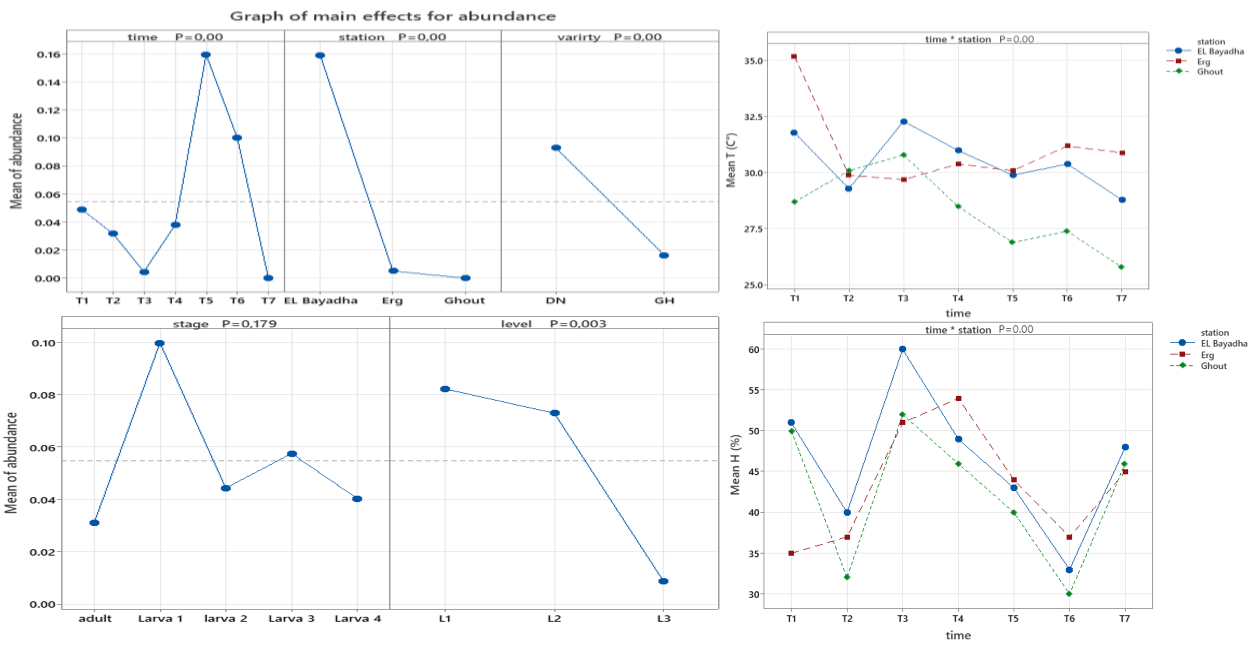

Figure 6. Generalized linear model (GLM) showing the abundance of *S. punctillum* according to different factors (time, temperature, humidity, station, life stage, cultivar, and fruit level.

Impact of phenology, time and ecological conditions on trophic interactions between mites and predators

The Spearman correlation table (Table 2) reveals complex trophic relationships between *O. afrasiaticus* and *S. punctillum*, influenced by temporal, phenological, and environmental factors. Over time, there is a strong and highly significant positive correlation with Kimri and Khalal phenological stages (r = 0.773, p < 0.001), as well as a strong and highly significant negative correlation with the abundance of *O.afrasiaticus* (r = −0.649, p < 0.001). Furthermore, the advanced phenological stages of the date fruit are associated with a decrease in the abundance of the date palm mite (r = −0.714, p < 0.001), and their predator shows a moderate negative correlation (r = −0.370, p < 0.016). We also note that the abundance of *S. punctillum* is higher under warmer conditions (r = 0.377, p = 0.014), which could reflect a numerical response of the predator to prey availability (r = 0.347, p = 0.024). In addition, climatic factors play a key role in the population dynamics of *O.afrasiaticus*, which are more abundant under warmer (r = 0.350, p = 0.023) and more humid conditions (r = 0.377, p = 0.029).

Table 2. Spearman's correlation coefficients between variables (Station, time, variety, abundance of *O. afrasiaticus* and *S. punctillum* (A.), temperature, humidity and phenological stage) during July to September 2020.

Variable		Station	Time	Variety	A. *O. afrasiaticus*	A. *S. punctillum*	T (°C)	H (%)	Phenological stage
Station	r	1.00	0.00	0.00	−0.092	−0.444***	0.053	−0.13	0.126
	p	-	1.00	1.00	0.562	0.003	0.739	0.411	0.426
Time	r	0.00	1.00	0.00	−0.649***	−0.339*	−0.287	−0.165	0.773***
	p	1.00	-	1.00	< 0.001	0.028	0.065	0.295	< 0.001
Variety	r	0.00	0.00	1.00	−0.352*	−0.218	0.00	0.00	0.155
	p	1.00	1.00	-	0.022	0.165	1.00	1.00	0.329
A. *O. afrasiaticus*	r	−0.092	−0.649***	−0.352*	1.00	0.347*	0.350*	0.337*	−0.714***
	p	0.562	< 0.001	0.022	-	0.024	0.023	0.029	< 0.001
A. *S. punctillum*	r	−0.444***	−0.339*	−0.218	0.347*	1.00	0.377*	−0.038	−0.370*
	p	0.003	0.028	0.165	0.024	-	0.014	0.812	0.016
T (°C)	r	0.053	−0.287	0.00	0.350*	0.377*	1.00	0.174	−0.238
	p	0.739	0.065	1.00	0.023	0.014	-	0.27	0.128
H (%)	r	−0.13	−0.165	0.00	0.337*	−0.038	0.174	1.00	−0.294
	p	0.411	0.295	1.00	0.029	0.812	0.27	-	0.059
Phenological stage	r	0.126	0.773***	0.155	−0.714***	−0.370*	−0.238	−0.294	1.00
	p	0.426	< 0.001	0.329	< 0.001	0.016	0.128	0.059	-

* significant (p ≤ 0.05), ** highly significant (p ≤ 0.01), *** very highly significant (p ≤ 0.001)

The following is an analysis of the regression model to determine the effect of environmental and biological variables on the abundance of *O. afrasiaticus* and its predator *S. punctillum.*

Table 3. Regression coefficients for the effects of environmental and biological variables on the abundance of *O. afrasiaticus* and its predator *S. punctillum* during July to September 2020.

Term	Coeff.	Std. Error	t-value	p-value	95% Confidence Interval
Intercept	−201	365	−0.55	0.586	[−920, 518]
Station	−31.7	25.6	−1.24	0.224	[−83.5, 20.1]
Time	−18.8	17.0	−1.11	0.277	[−53.2, 15.6]
Variety	−103.2	38.8	−2.66	0.012*	[−181.8, −24.6]
Abundance *S. punctillum*	−11.69	8.89	−1.32	0.197	[−29.7, 6.32]
T (°C)	14.7	11.0	1.34	0.190	[−7.5, 36.9]
H (%)	3.06	2.63	1.16	0.253	[−2.27, 8.39]
Phenological stage	1.9	74.8	0.03	0.980	[−148.7, 152.5]

* significant (p ≤ 0.05), ** highly significant (p ≤ 0.01), *** very highly significant (p ≤ 0.001)

The statistical analysis showed that the overall regression model is significant ($p = 0.014$) and explained a non-negligible portion of the observed variability in the abundance of the mite. Furthermore, the date variety (Deglet Nour and Ghars) had a significant negative effect on the abundance of *O. afrasiaticus* (Coefficient = –103.2, $p = 0.012$), which could reflect its key role in complex trophic interactions (Table 3).

DISCUSSION

Population dynamics and infestation levels of the date dust mite O. afrasiaticus

Infestation of dates by *O. afrasiaticus* begins in July, coinciding with the Kimri stage, and peaks at the end of the month. A strong positive correlation between mite abundance and the Kimri and Khalal stages ($r = 0.773$, $p < 0.001$) confirms that *O. afrasiaticus* is highly adapted to exploit immature dates. This is synchronized with the Kimri stage, characterized by high nutrient content and a texture favorable for mite feeding (Palevsky *et al.* 2003, 2004; Ben Chaaban *et al.* 2012). In contrast, mite abundance significantly decreases during advanced phenological stages ($r = -0.714$, $p < 0.001$), as date maturation reduces their attractiveness or accessibility. This decline is attributed to changes in the chemical composition and texture of the dates, making them less suitable for mite feeding and reproduction (Saito 1979; Palevsky *et al.* 2003, 2004; Mirza *et al.* 2018).

Climatic conditions, particularly temperature and humidity, play a crucial role in the population dynamics of *O. afrasiaticus*. The results indicate that the mite is more abundant under warmer ($r = 0.350$, $p = 0.023$) and more humid conditions ($r = 0.377$, $p = 0.029$), with temperatures ranging between 28.5 and 35.2 °C and relative humidity from 32 to 60%. This preference aligns with Ben Chaaban *et al.* (2012), who observed high mite densities in July and August at around 32 °C. Babaz *et al.* (2021) further demonstrated in laboratory studies that under constant conditions of 31.65 °C and 28.9% relative humidity, mite populations peaked at 3,390 mites per 100 dates.

All developmental stages of *O. afrasiaticus* are present, with a high density of eggs and larvae, reflecting the mite's high fecundity. El-Shafie (2022) highlights its significant reproductive capacity, while André (1932) notes that a single female can lay 50–60 eggs, and sometimes up to 100, during a short period from June to August. The low presence of females on fruits can be attributed to their feeding behavior. Mirza *et al.* (2018) demonstrated that females spend most of their time foraging for food under webs, on leaves, and fruits, rather than solely laying eggs on fruits.

Regarding mite distribution on dates, the results revealed a clear preference for the apical and medial parts of the fruit, with fewer mites on the terminal part. Mirza *et al.* (2018) explained this behavior, noting that *O. afrasiaticus* tends to feed and weave webs primarily at the base of the dates. Coudin and Galvez (1976) further suggest that females seek surfaces with relief, which provide anchor points for web construction.

Varietal vulnerability analysis revealed that Deglet Nour palm trees host significantly higher mite abundance than Ghars palm trees (Coefficient = −103.2, $p = 0.012$). The maximum abundance of *O. afrasiaticus* reached 708 individuals per date on Deglet Nour, compared to only 139 on Ghars. Consequently, 14 Deglet Nour palm trees were infested, versus only 4 Ghars palm trees. This abundance exceeds the findings of Idder and Pintureau (2008), who reported 422.2 ± 87.2 mites on 90–130 Deglet Nour dates during the development stage.

This result aligns with Ben Chaabane and Chermiti (2009), who found that susceptibility to *O. afrasiaticus* colonization in Bessr, Deglet Nour, and Alig cultivars is linked to the chemical composition of the fluids ingested by mites. They highlighted that sugar content (glucose, fructose, and sucrose) is crucial for mite colonization on Deglet Nour and Bessr varieties, suggesting sugar levels could act as a resistance factor. Kumbasli (2005) also emphasized that sugars are essential nutrients for bio-aggressors, serving as a primary energy source and having a strong phagostimulant effect (Albert and Parisella 1988, cited by Kumbasli 2005). Derridj and Wu (1995) added that sugars stimulate oviposition in piercing-sucking insects, which prefer sugar-rich substrates. Conversely, Yadegar *et al.* (2022) found no significant correlation between mite infestation and the chemical characteristics of date fruits but observed significant correlations with kernel weight, fruit length, and number of strands.

After analyzing the evolution of mite populations on the two cultivars, the results also reveal slight variations in bio-aggressor abundance across the three studied palm groves, though these differences were not statistically significant. However, the landscape type of the palm groves significantly impacts *O. afrasiaticus* outbreaks. This was confirmed by Szilvasi *et al.* (1998) and Georget *et al.* (1999), who observed that palm groves exposed to sun and wind facilitated mite dispersal. Similarly, studies by Margolies and Kennedy (1985), Li and Margolies (1993), and Oku *et al.* (2002) indicate that female mite densities increase with reduced humidity, which favors their spread.

In this context, the Ghout palm groves are the least affected by *O. afrasiaticus*. Although infestation begins earlier in Ghout (early July), it remains less severe, with only 4 Deglet Nour palm trees infested, compared to higher infestation levels in El Bayadha and Erg. This difference may be attributed to Ghout's cooler microclimate, which limits pest proliferation. Additionally, the Ghout oasis system is a unique phoenicultural landscape in Algeria's Oued Souf region developed by Sufi farmers in the fifteenth century. It is characterized by the presence of a palm grove close to the water table, which allows the palms to irrigate themselves. This system produces dates with a sufficient and stable sugar concentration (FAO 2011).

Population dynamics of S. punctillum *in palm groves and on dates*

Rott and Ponsonby (2000) and El-Shafie (2022) report that all species of the genus *Stethorus* are exclusive predators of spider mites. Saharaoui *et al.* (2010) highlight that *S. punctillum* is an effective biological control agent against the date palm spider mite, *O. afrasiaticus*, due to its remarkable ecological plasticity, enabling it to adapt to various agroecosystems in Algeria.

Our results indicate that the distribution of *S. punctillum* is shaped by prey availability, spatial behavior, and microclimatic conditions. The predator is most abundant in palm groves during summer, coinciding with peak *O. afrasiaticus* populations. Notably, *S. punctillum* larvae are predominantly found in the apical part (L1) of the fruit ($F = 5.78$, $p = 0.003$; $p = 0.043$ for L1 correlation), particularly in the Deglet Nour variety. This distribution aligns with the predator's active search for its prey, which tends to cluster in the peduncular zone of the date for shelter and feeding (Coudin and Galvez 1976). This niche overlap reflects an optimal foraging strategy, where *S. punctillum* targets prey-aggregated zones to maximize energy intake (Latifian 2012). In contrast, lower predator activity at medial and terminal levels (L2/L3) may result from reduced prey accessibility or microclimatic stressors. These findings are consistent with previous studies by Saharaoui (1987) and Sahraoui *et al.* (2010), who reported intense predatory activity from mid-May to August, a period marked by significant mite infestations. Furthermore, Idder-Ighili *et al.* (2013) observed that *S. punctillum* is capable of devouring between 75 and 100 individuals of *O. afrasiaticus* within 24 hours, highlighting its efficiency as a biological control agent.

It should be noted that the predatory efficiency of *S. punctillum* is highly dependent on temperature. We observed an increase in the number of predators at temperatures between 25 and 30 °C. Our results confirm those of Saharaoui *et al*. (2010) who reported that moderate temperatures, particularly around 28 °C, are highly favorable for optimal predatory activity and population growth, suggesting the existence of an optimal range for this activity. Similarly, Rott and Ponsonby (2000) reported a reduction in efficiency at temperatures above 30 °C. Furthermore, the correlation between relative humidity (RH) and *S. punctillum* abundance was not significant ($r = -0.038$, $p = 0.812$). This aligns with Rott and Ponsonby (2000), who found that increasing relative humidity did not significantly enhance predatory activity.

The abundance of *S. punctillum* showed a significant numerical response to prey availability (r = 0.347, p = 0.024), particularly during the Kimri stage, despite a moderate negative correlation with this stage (r = −0.370, p < 0.016). These findings align with Saharaoui *et al.* (2010), who observed limited *S. punctillum* populations due to low prey (*O. afrasiaticus*) abundance. This underscores the strong influence of prey availability on *S. punctillum* population dynamics. The decline in *S. punctillum* populations over time can be attributed to the absence of its preferred prey, the date palm mite. Our results indicate that *S. punctillum* feeds on all mobile stages of its prey but shows a clear preference for adult mites. This aligns with Latifian (2012), who found that both larval and adult *S. punctillum* preferentially target adult *O. afrasiaticus*, even when mite larvae are present. Idder and Pintureau (2008) highlighted the potential of *S. punctillum* to significantly reduce *O. afrasiaticus* infestations in date palm ecosystems, particularly on heavily infested trees, achieving a 26% reduction in infestation rates in a palm grove in Ouargla.

Trophic preferences may vary among species. For instance, Colburn and Asquith (1971) found that *S. punctum*, a related species, primarily feeds on eggs of the European red mite, *Panonychus ulmi* (Koch), in apple orchards. Similarly, Houck (1991) observed that *S. punctum* females prefer eggs and active stages of *Tetranychus urticae*. Sabelis (1992) suggests that generalist predators, like those in the genus *Stethorus*, select prey based on relative size, often overlooking smaller mite larvae in favor of larger, more nutritious adult stages.

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پویایی جمعیت و تعاملات تغذیه‌ای بین *Oligonychus afrasiaticus* (Acari: Tetranychidae) و شکارگر آن *Stethorus punctillum* (Coleoptera: Coccinellidae) در نخل خرما در شمال شرقی صحرای الجزایر

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چکیده

خشکسالی باعث می‌شود که نخلستان‌های الجزایر دچار افزایش آلودگی نخل خرما به هرنای *Oligonychus afrasiaticus* (McGregor, 1939) شوند. این کنه از سلول اپیدرمی میوه تغذیه می‌کند و ظاهری زبر به آن می‌دهد و آن را برای مصرف نامناسب می‌کند. این مطالعه در منطقه صوف، در شمال گراند ارگ اورینتال در الجزایر انجام شد. مدت بررسی بیش از ۱۲ ماه از ژوئیه ۲۰۲۰ تا ژوئن ۲۰۲۱ بود. هدف مطالعه تعیین آلودگی کنه گرد و غبار خرما *O. afrasiaticus*، و درک پویایی جمعیت این کنه و شکارگر آن *Stethorus punctillum* (Weise, 1891) در رقم‌های دگلت نور و غرس در انواع مختلف نخلستان‌ها (البایادها °۳۳ '۱۹ "٤۰ شمالی، °٦ '٥٥ "۳۳ شرقی، اوئد آلاندا °۳۳ '۱۷ "۲٥ شمالی، °٦ '٤٦ "۳۹ شرقی و سانداروس °۳۳ '۱۳ "۱۸ شمالی، °٦ '٥٨ "٤۰ شرقی) بود. از دو روش نمونه برداری، جمع‌آوری مستقیم خرما به روش نمونه‌گیری شاخه خرما و روش ضربه زدن به شاخه خرما استفاده شد. نتایج نشان داد که آغاز آلودگی خرما به *O. afrasiaticus* با مرحلهٔ فنولوژی سبز خرما (کیمری) همزمان بوده و با شروع مرحله بسر (Khalal) به پایان می‌رسد. نتایج نشان داد که نخلستان غوط در مقایسه با سایر نخلستان ها کمترین آسیب را از این آفت دیده است. خرمای رقم دگلت نور در مقایسه با رقم غرس بیشترین میزان آلودگی را داشت. همچنین مشاهده شد که کفشدوزک *S. punctillum* به عنوان شکارگری کلیدی کنه تارتن خرما عمل می‌کند و تعامل تغذیه‌ای زیادی بین این دو گونه را برجسته می‌کند. نتایج نشان داد که پویایی جمعیت این حشرات کنه‌خوار با توجه به درجهٔ ترجیحات تغذیه‌ای آنها و عوامل اکولوژیکی بیوتوپ متفاوت است.

واژگان کلیدی: دگلت نور، ال اوید، غرس، غوط، *Phoenix dactylifera*.

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