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Effect of the host plant on some biological parameters of *Ceratitis capitata* (Diptera, Tephritidae) in the extreme south-eastern Algeria (Sahara)

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Abstract

This paper studies the effect of the plant support on the biological activity of *Ceratitis capitata*, as well as the estimated infestation rate of certain fruit trees (orange, mandarin, fig, apricot and pomegranate) in two regions of extreme south-eastern Algeria. The results show that the fruits most bitten by the Mediterranean fly are pomegranates with a number varying between 2 and 40 bites/fruit (9.2 ± 0.5 bites/fruit), while figs are the least bitten with a number varying between 1 and 4 bites/fruit (1.7 ± 0.1 bites/fruit). In terms of infestation, apricot (Rd = 93.3%) and pomegranate (Rd = 88.6%) are the trees most attacked by *Ceratitis capitata*, while orange is the least attacked (Rd = 42%). The study of some bio-ecological parameters of this bio-aggressor shows that the pupal period varies according to the type of host plant, between 6.9 ± 1.7 days (apricot) and 13.0 ± 1.8 days (mandarin), with zero emergence for orange tree. Pupae size varies very little between host plants, with 4.2 ± 0.2 mm for languor and 1.9 ± 0.0 mm for large diameter. The emergence rate also varies between crops (p = 0.038) from 33.8 ± 14.7% (apricot) to 63.4 ± 20.5% (mandarin). The same is true for adult longevity. The sex-ratio of *C. capitata* is higher for females on all host plants. Thus, this study shows that the infestation of *C. capitata* depends on the host plants, the pupal stage duration, the emergence rate and the longevity of adults (very long during the winter and decreased during the summer period).

Keywords: Mediterranean fly, fruit trees, infestation, bio-ecology, Algerian Sahara
Abbreviations: t. f_total number of examined fruits, a. f_Number of attacked fruits, R d (%)_Damage rate, SD_Standard deviation, NB_Number of bites, If_Ifoten station, T. O_Tin Ouaraghen station, Tegh_Tegherghart station, Ta. 1_Tazrouk 1
Ta. 2_Tazrouk 2, N_Number of fruits, Min_Minimum, Max_Maximum, SD_Standard deviation, L_Length, LD: Large diameter.

Introduction

The Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), or medfly, is a serious pest in most subtropical regions of the world. The female fly pierces the skin of the fruit and lays groups of eggs in the resulting pouch, causing economic damage. After hatching, the larvae consume the inner parts of the fruit. This damage further reduces the market value of the crop and may even render the fruit unfit for human consumption (Vail et al., 1976). It can infest 353 cultivated and non-cultivated species, including fruit species with successive maturities, such as citrus, apricots, peaches, pomegranates and figs (Liquido et al., 1991). It is a polyvoltine species that develops 6 generations per year in Algeria (Oukil, 1995). Its life cycle is highly variable for the same region and depends on climatic factors as well as the fruit species on which took place the laying (Ramade, 2003).
The biological properties and development time of fruit flies depend on the temperature, relative humidity of the environment and the hosts. For most of these species, the life cycle is similar and takes place without diapause according to the following scheme at 25 °C and 75%. Relative humidity: eggs deposited by females on the host plant hatch after 2-3 days. When the eggs hatch, 3 larval instars follow one another and last 5-15 days before hatching; after, they develop into pupae (8-12 days). Emerging adults can live for 40-90 days (Vayssières et al., 2008). On the other hand, Harris and Lee (1989) concluded that *Ceratitis capitata* (Wied) and *Dacus dorsalis* have a distribution and abundance that are directly affected by the removal of their favorite host fruits and indirectly by climatic factors.
This pest has been the subject of several studies: Liquido et al. (1991), Garcia and Ricalde (2013), De Pedro et al. (2013), Hafsi et al. (2015 a, b), Harbi et al. (2015), Hafsi et al. (2016), Rehman et al. (2018), Hafsi et al.(2019). Harbi et al.(2019) studied the parasitism of *Diachasmimorpha longicaudata* to Medfly. In Algeria and particularly in the northern region, the research of Ali Ahmed-Sadoudi (2007), Ali Ahmed-Sadoudi et al. (2010), Boudjelida and Soltani (2011), Metna et al. (2012), Laamari et al. (2015) focusses on the medfly as a new pest of apple in Algeria, Bachi and Ali Ahmed-Sadoudi (2017) and Settaoui et al. (2017) can be cited.
It should be mentioned that medfly adapts to the type of fruit, its fruiting period and the climate of the region to complete its annual cycle. Given the scarcity of such works in the south of the country, this paper aims to examine the

influence of the host plant on the biological properties, distribution and losses due to this species in the Saharan regions of Algeria.

Results

The results of the study of *Ceratitis capitata* in the extreme south-east of Algeria are divided into two parts, infestation and biological.

Infestation of Ceratitis capitata on some fruit trees

This section presents the results of *Ceratitis capitata* infestation rates on five fruit species (mandarin, orange, apricot, fig and pomegranate). The number of bites and damage rate are based on different plant species, study stations and the position of the fruit on the tree. According to the results, the apricot tree is the most attacked with a rate of 93.3%, followed by the pomegranate tree (R d = 88.7%; Table 1). On the other hand, the orange tree is the least attacked by *Ceratitis capitata* with a rate of 42%.

The fruit most bitten by the Mediterranean fly is the pomegranate with a number that varies between 2 and 40 bites/fruit (mean = 9.2 ± 0.5 bites/fruit; Figure 1). Whereas, the fig is the least bitten with a number that varies between 1 and 4 bites/fruit (mean = 1.7 ± 0.1 bites/fruit). Comparison of the number of bites per plant species shows a very highly significant difference (p = 0.000).

According to the results of each study station, the most bitten fruit is pomegranate with an average of 11.7± 2.2 bites/fruit in the Tazrouk 2 station. Whereas the fig tree in Tegherghart station is the least bitten (mean = 1.6 ± 0.1bites/fruit; Table 2). The results summarized in Table 2 indicate that the fig and apricot trees in Ifoten station and the pomegranate tree in Tazrouk 2 station have the highest damage rate with 93.3%. Whereas the orange tree in Tin Ouaraghen station is the least attacked (R d = 32%; Table 2). The number of bites show a very highly significant difference (p = 0.000) between the different stations.

Furthermore, according to the cardinal points, the fruits collected in the northern part of the orange tree are the most bitten by *Ceratitis capitata*, with a number that varies between 1 and 6 bites/fruit (mean = 3.5 ± 3.5 bites/fruit; Figure 2). Similarly, for the mandarin tree, the fruits exposed in the north (mean = 3.2 ± 2.2 bites/fruit) and in the center of the tree (mean = 3.3 ± 2.2 bites/fruit) are also the most bitten, with a variation of 1 and 6 bites/fruit. For the fig tree, the fruits collected from the eastern part are the most bitten with an average of 2.5 ± 0.9 bites/fruits.

The southern part of the tree has the most bitten fruits for the apricot tree (mean = 2.9 ± 1.0 bites/fruits), while the fruits collected from the northern part of the tree are the most pricked for the pomegranate tree (mean =13.1 ± 5.1 bites/fruit; Figure 2). The pomegranate culture shows an important variation in the number of bites per fruit especially in the southern part of the tree (min = 2; max = 40), which generates outliers in the distribution (Figure 2). It should be mentioned that *Ceratitis capitata* has no preference for the location of the fruit in the tree.

The percentage of damaged fruit shows the highest rate for fruits from the orange tree center with a rate of 80% in Ifoten station (Table 3), while fruits collected from the east part of the tree (Rd = 60%) are the most infested in the Tin Ouaraghen station. In the case of the mandarin tree, the fruits collected from the north (Rd = 100%) and west (Rd = 100%) parts of the tree are totally affected by this pest in the Ifoten station. The same damage rate (Rd = 100%) is observed for the fruits collected from the west part in Tin Ouaraghen station. For the fig tree, the fruits collected from the east (Rd = 100%) are the most attacked by *C. capitata* in the Ifoten station, however for the Tegherghart station, the figs from the north (Rd = 80%) and center (Rd = 80%) are the most attacked.

For the apricot tree, the fruits collected from the north (Rd = 100%), the east (Rd = 100%) and the center (Rd = 100%) are totally attacked. Whereas, the south (Rd = 93.3%) and east (Rd = 93.3%) parts are the most attacked for the pomegranates in Tazrouk 1 station. In Tazrouk 2 station, the fruits collected from the north (Rd = 100%), south (Rd = 100%) and east (Rd = 100%) parts are the most attacked (Table 3).

Some bioecological parameters of C. capitata according to the crops

The bio-ecological results of *C. capitata* are grouped according to several parameters.

Duration of the pupal stage

The pupal stage of *C. capitata* varies between 10 and 22 days (mean = 13.0 ± 1.8 days) for mandarin (Figure 3). The pomegranates pupae are relatively short with a pupation varying between 3 and 14 days (mean = 8.3 ± 2.1 days). The fig pupation varies between 2 and 12 days (mean = 7.8 ± 2.0 days). The shortest pupation is recorded for the apricot pupae, between 5 and 9 days (mean = 6.9 ± 1.6 days). These variations show a highly significant difference (p = 0.000), which implies that the host plant influences the pupation duration of this bio-aggressor. The same applies to fruit exposure (p = 0.01).

Morphometry of pupae

The length of the pupae from the mandarin varies between 4 and 4.5 mm (mean = 4.2 ± 0.2 mm; Table 4) and the large diameter varies between 1.9 and 2 mm (mean = 1.9 ± 0.0 mm). Pupae of other host plants have almost the same dimensions without significant difference (p = 0.42).

Emergence rate

Pupae derived from mandarin has a high emergence rate that can reach 100% (mean = 63.4 ± 20.5%; Figure 4), while the lowest values are recorded for apricots, between 13.3% and 50% (mean = 33.8 ± 14.7%). These results show a significant difference (p = 0.04) in the emergence rate of *Ceratitis capitata* according to the type of crop, contrary to the direction which has no influence on the emergence (p = 0.28).

Longevity of adults

C. capitata adults have a very variable lifespan (p = 0.000) depending on the type of crop. The highest longevity of adults is that of mandarin, which varies between 41 and 70 days (mean = 57.3 ± 12.3 days; Figure 5). The longevity rate is average for pomegranates (between 9 and 49 days; mean = 26.7 ± 13.1 days) and very short for figs (3 and 14 days; mean = 5.0 ± 2.8 days). It is important to note that the lifespan of males and females shows a significant difference (p = 0.016) for all crops. Thus, the longevity of adults varies according to seasons; it is very long during winter and it decreases during summer.

Adult lifespan for both sexes (p = 0.01) has a significant variation for all cultures. The same is true for the sexes

according to the host plant, with a very significant difference between females (p=0.000) and males (p=0.000). The longevity of the latter varies between 41 and 70 days (mean = 57.1 ± 12.9 days; Figure 6) for mandarin and it is almost the same for females (mean = 57.5 ± 13.3 days). For fig adults, males (mean = 4.5 ± 2.2 days) and females (mean = 5.5± 3.3 days) live between 3 and 14 days. For pomegranate adults, their lifespan is medium (males: mean = 35 ± 13.1 days; Figure 6) (females: mean = 24.7 ± 12.5 days).

Sex-ratio

Overall, females have a good sex-ratio for all host plants, except for mandarin in Ifoten station (Table 5). Rates vary for females between 54.8% for pomegranates in Tazrouk 2 station and 75.8% for figs in Teghergart station.

Relationship between infestation and fruit type

The attack rate is positively correlated with the number of bites (Figure 7). However, the latter is inversely correlated with the average number of bites/fruit. As the number of fruits increases, the average number of bites decreases, which suggests that this last variable is relatively stable (well-determined interval), unlike the number of bitten fruits, which increases with sample size.

The attack rate cloud projection on the main components 1 and 2 allows classifying the host plants of *Ceratitis capitata* into three groups (Figure 8). Group 1 is the winter fruit crop (oranges and mandarins); group 2 consists of summer fruit crops (figs and apricots) and group 3 consists of autumn fruit plants (pomegranate trees).

The distribution of modalities in the form of a parabola constitutes the Guttmann effect. Indeed, pomegranate trees on the right side of axis 1 are characterized by a high infestation rate, unlike orange and mandarin trees on the left side, which are lightly infested, thus constituting the limits of the infestation interval of *C. capitata* in the Algerian Sahara.

Discussion

This section discusses the results of the damage caused by *Ceratitis capitata*, as well as the study of some bio-ecological aspects in the extreme south-east of Algeria.

Infestation rate according to the type of fruit

The apricot tree (Rd= 93.3%) and the pomegranate tree (Rd = 88.7%) are the most attacked trees by *Ceratitis capitata*, while the orange tree is the least attacked (Rd = 42%). This result is also confirmed by several previous field observations. Ali Ahmed-Sadoudi et al. (2010) noted that the fruits of the two apricot varieties are the ones with higher rates of infestation (59.60% for variety Hatifcolomer and 57.7% for the variety Bulida). While, other studies have reported that *Citrus* is the most affected host crop by this pest (Menta et al., 2012; Bachi and Ali Ahmed-Sadoudi, 2017).

Regarding the number of bites per fruit, medfly behaves differently depending on the plant species (p = 0.000). The pomegranate tree displays the highest values (mean = 9.2 ± 0.5 bites/fruit), while the fig tree is the least bitten (mean= 1.7 ± 0.1 bites/fruit). This behavior can be explained by the influence of some factors such as the diameter of the fruit, where the fruits with the largest diameter were the most bitten, unlike those with the smallest diameter. This result is in good agreement with the work of Katsoyanos (1986), who reported that *C. capitata* prefers larger fruits. Furthermore, sugars and proteins from host fruits can also contribute to their infestations by this pest (Ali Ahmed-Sadoudi et al., 2007). In addition, half of the medfly's bites on citrus fruits are not intended for oviposition, but rather for feeding adults. Gilmour (1968) observed that this behavior allows adults to store citric acid that they use during winter as an energy source in the metabolism of the insect.

As for the location of the fruits on the tree, it has no influence on its infestation (p = 0.15), which may explain the strong proliferation of this pest in the various study stations. These results confirm those of Bachi (2018) who reported that there was no significant difference between the rates of bitten fruits for different exposures. Ali Ahmed-Sadoudi et al. (2010) reported that *C. capitata* prefers fruits that are located in the west. This result suggests that this part of the tree is very exposed to the sun and contains the most colorful fruits which attract more flies (Drummond et al., 1984; Affelah et al., 1997; Epsky and Heath, 1998).

Biological parameters of Ceratitis capitata

The duration of *Ceratitis capitata*'s pupal stage varies depending on the plant species (p = 0.0000). It varies between 6.9 ± 1.6 days (apricot) and 13.0 ± 1.8 days (mandarin). These variations show that the host plant and the weather conditions influence the pupation time of this bio-aggressor. These data confirm the results obtained by Ali Ahmed-Sadoudi et al. (2010), who reported that the longest pupation time is recorded in the genus *Citrus*, notably the orange tree Thomson (18.3 days), ordinary clementine (15.7 days) and clementine Monréal (16 days). For the fig tree, the results of this study (min = 2 days; max = 12 days) are in good agreement with those of Boller (1985) (9 and 10 days) and Ali Ahmed-Sadoudi et al. (2012) (10 to 12 days). Other studies have reported that at 26ºC, the pupal stage lasts between 10 and 11 days and if the conditions ae not favorable due to low temperatures, this stage can be extended by several days (Mavrikakis et al., 2000).

In addition, it can be noted that the pupation time is linked to the weather conditions and more precisely to the temperature. The pupae found in summer fruits (apricots and figs) emerge more quickly than those from winter fruits (oranges and mandarins). This period can reach up to 22 days for the mandarin, while no pupa has emerged for the orange tree. Menta et al. (2012) and Bachi and Ali Ahmed-Sadoudi (2017) reported that the number of pupae per fruit is low or even zero for the different varieties of the *Citrus* genus. In addition to the low temperatures prevailing during fruit maturity, other factors can contribute to stop the pupation, such as the oily texture of the skin and the moisture content of the fruits which increases during maturation (Delanoue and Soria, 1962). In addition, high densities negatively affect the viability of the larvae which turn into pupae (Debouzie, 1981).

The dimensions of the pupae according to the host plants show a certain stability (p = 0.4215). They are equal to 4.2 ± 0.2 mm for the languor and 1.9 ± 0.04 mm for the large diameter. Shoukry and Hafez (1979) noted that the length of pupae varies between 4 and 4.3 mm. The emergence rate of the medfly varies depending on the crop (p = 0.038) between 33.8 ± 14.7% (apricots) and 63.4 ± 20.5% (mandarins), but it does not depend very much on the position of the fruits (p = 0.284). Fellah and Dhouibi (1997) reported that the host plant can affect the rate of emergence by its nutritional characteristics, without

Table 1. Damage rate of *Ceratitis capitata* on different fruits

	Orange	Mandarin	Fig	Apricot	Pomegranate
Total number of examined fruits	50	50	150	75	150
Number of attacked fruits	21	38	125	70	133
Damage rate (%)	42	76	83.33	93.33	88.67

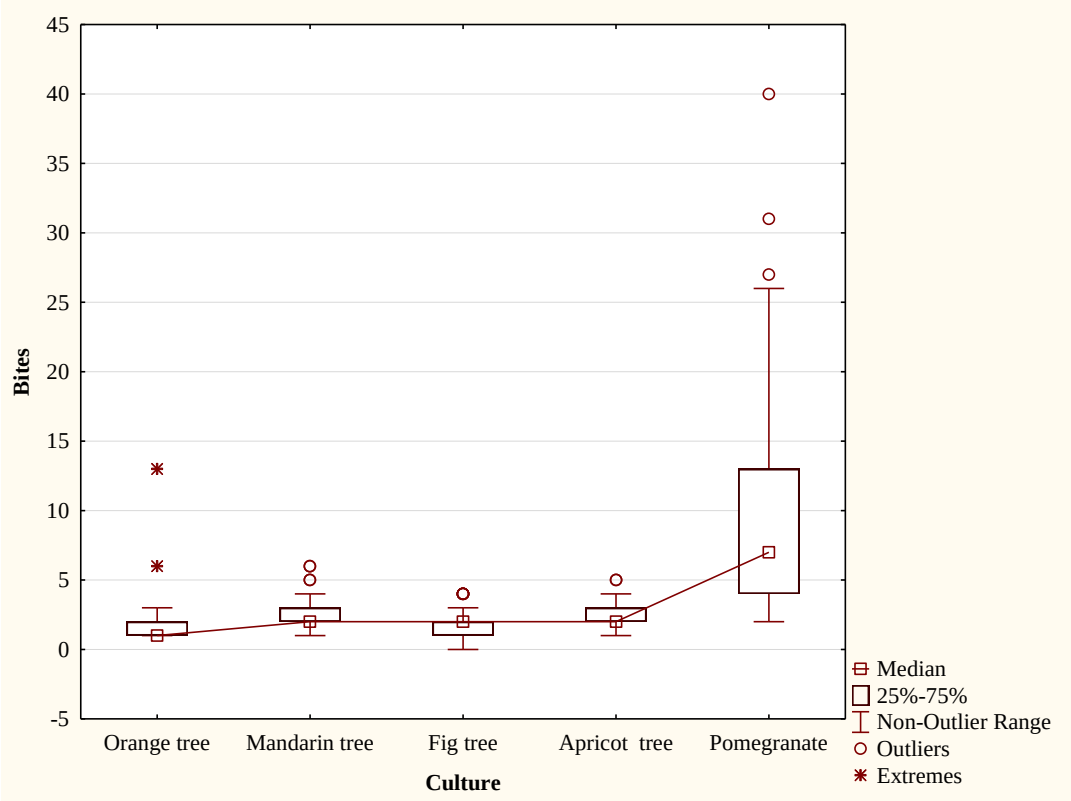

Fig 1. Number of *Ceratitis capitata*'s bites on different fruit trees

Table 2. Number of bites, number of attacked fruits and damage rate of *C. capitata* by type of fruit in the extreme south-east of Algeria

		Orange (N = 50)		Mandarin (N = 50)		Fig (N = 150)		Apricot (N =75)	Pomegranate (N = 150)	
Station		If. (N=25)	T.O. (N=25)	If. (N=25)	T.O. (N=25)	If. (N=75)	Tegh. (N=75)	If. (N=75)	Ta.1. (N=75)	Ta.2 (N=75)
Nbr. B.	Min.	1	1	1	1	1	1	1	2	2
	Max.	6	13	6	4	4	3	5	26	40
	Mean	2.22	2.71	2.92	2.15	1.84	1.62	2.56	6.58	11.73
	SD	1.43	4.33	0.90	0.55	0.23	0.09	0.17	1.33	2.26
Nbr. a. f.		13	8	20	18	70	55	70	63	70
Rd (%)		52	32	80	72	93.33	73.33	93.33	84	93.33
Student test		< 0,00 ***	0,10 NS	< 0,00 ***	< 0,00 ***	< 0,00 ***	< 0,00 ***	< 0,00 ***	< 0,00 ***	< 0,00 ***
Tukey's pairwise		0,515 NS		0,047 *		0,144 NS		-	< 0,000 ***	

SD: Standard deviation; Nbe. B.: Number of bites ; Nbr t. f.: Total number of examined fruits; Nbr. a. f: Number of attacked fruits; R d (%): Damage rate ; If.: Ifoten station; T. O. : Tin Ouaraghen station; Tegh. : Teghergart station; Ta. 1: Tazrouk 1 station; Ta. 2: Tazrouk 2 station; NS: not significant.

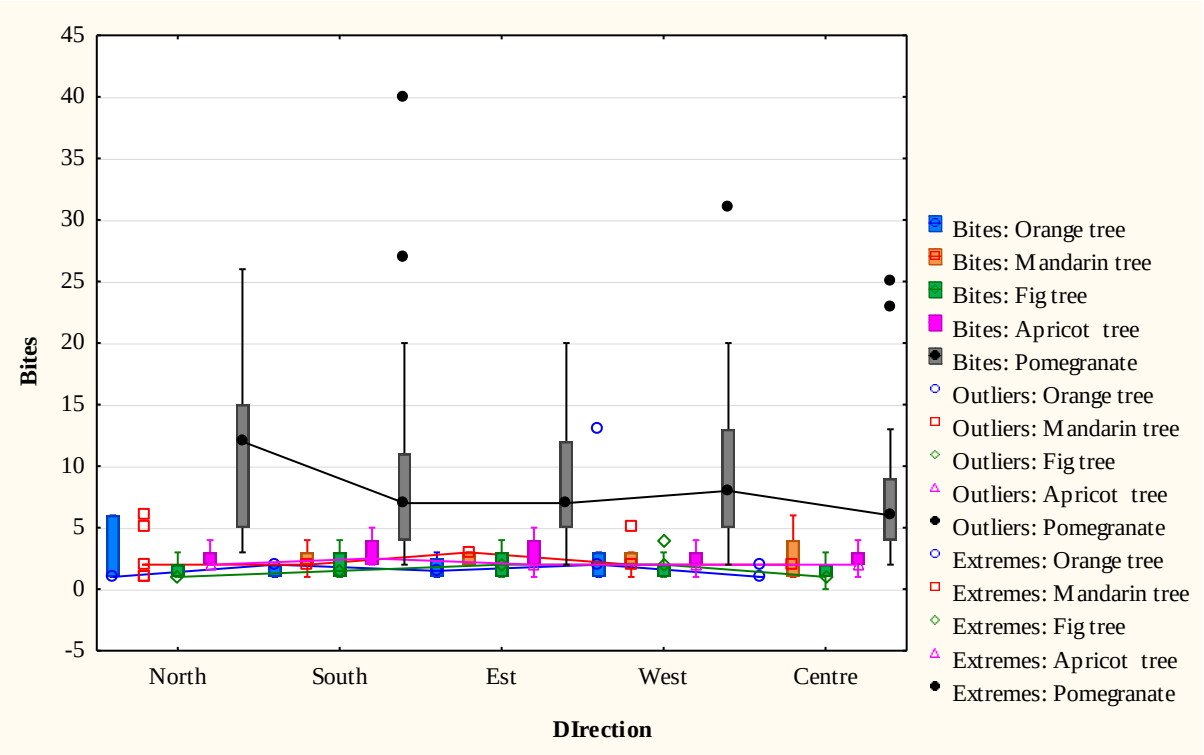

Fig 2. Number of *Ceratitis capitata*'s bites on different fruit crops according to the fruit position

Table 3. Number of bites, number of infested fruit and damage rate of *Ceratitis capitata* on fruit by direction and station

	Station		North	South	Est	west	Centre
Orange	Ifoten (N=25)	Nbr. a. f	2	3	1	3	4
		Rd (%)	40	60	20	60	80
	Tin Ouaraghen(N=25)	Nbr. a. f	1	0	3	2	2
		Rd (%)	20	0	60	40	40
Mandarin	Ifoten (N=25)	Nbr. a. f	5	3	3	5	4
		Rd (%)	100	60	60	100	80
	Tin Ouaraghen (N=25)	Nbr. a. f	4	3	3	5	3
		Rd (%)	80	60	60	100	60
Fig	Ifoten (N=75)	Nbr. a. f	14	13	15	14	14
		Rd (%)	93.33	86.67	100	93.33	93.33
	Tegherghart (N=75)	Nbr. a. f	12	9	11	11	12
		Rd (%)	80	60	73.33	73.33	80
Apricot	Ifoten (N=75)	Nbr. a. f	15	14	15	11	15
		Rd (%)	100	93.33	100	73.33	100
Pomegranate	Tazrouk 1 (N=75)	Nbr. a. f	12	14	14	13	10
		Rd (%)	80	93.33	93.33	86,67	66.67
	Tazrouk 2 (N=75)	Nbr. a. f	15	15	15	13	12
		Rd (%)	100	100	100	86.67	80

Nbr. a. f: Number of attacked fruits; Rd (%): Damage rate; N: Number of fruits

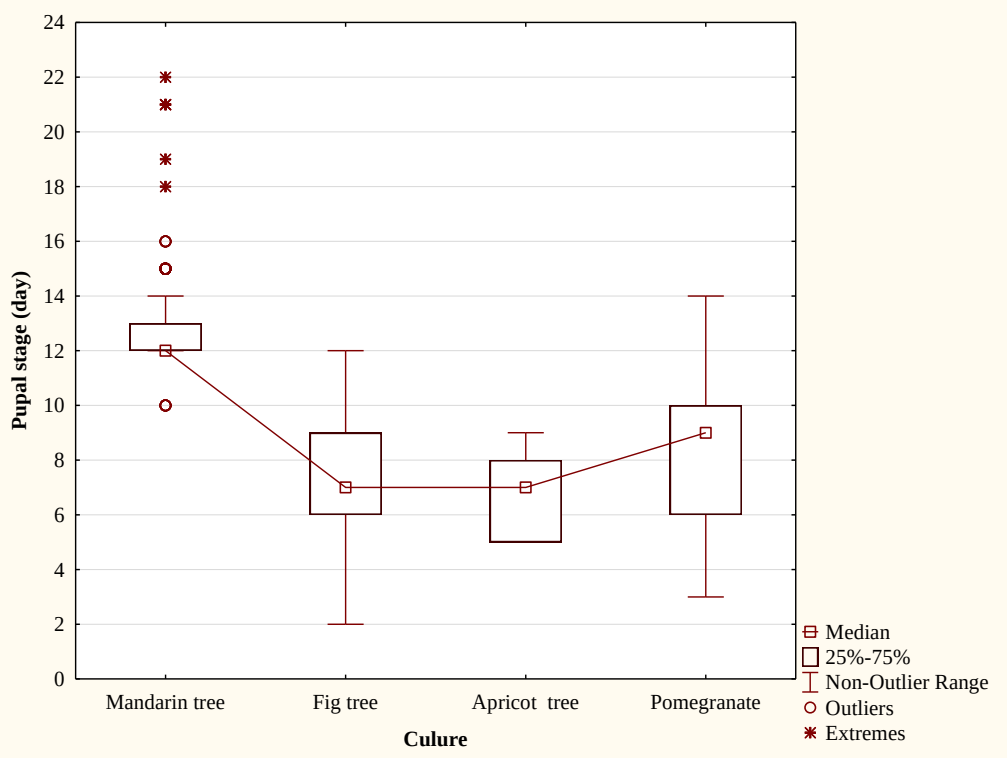

Fig 3. Variation in the pupal stage of *Ceratitis capitata* according to the host plant.

Table 4. Morphometry of *C. capitata*'s pupae based on the host plant.

	Mandarin		Fig		Apricot	
	L (mm)	L D (mm)	L (mm)	L D (mm)	L (mm)	L D (mm)
Min.	4	1,9	4	1	4	2
Max.	4.5	2	4.54	2	5	2
Mean	4.2	1.98	4.10	1.87	4.29	2
SD	0.18	0.04	0.20	0.28	0.41	0

Min.: Minimum; max.: Maximum; SD: Standard deviation ; L : Length; LD : Large diameter

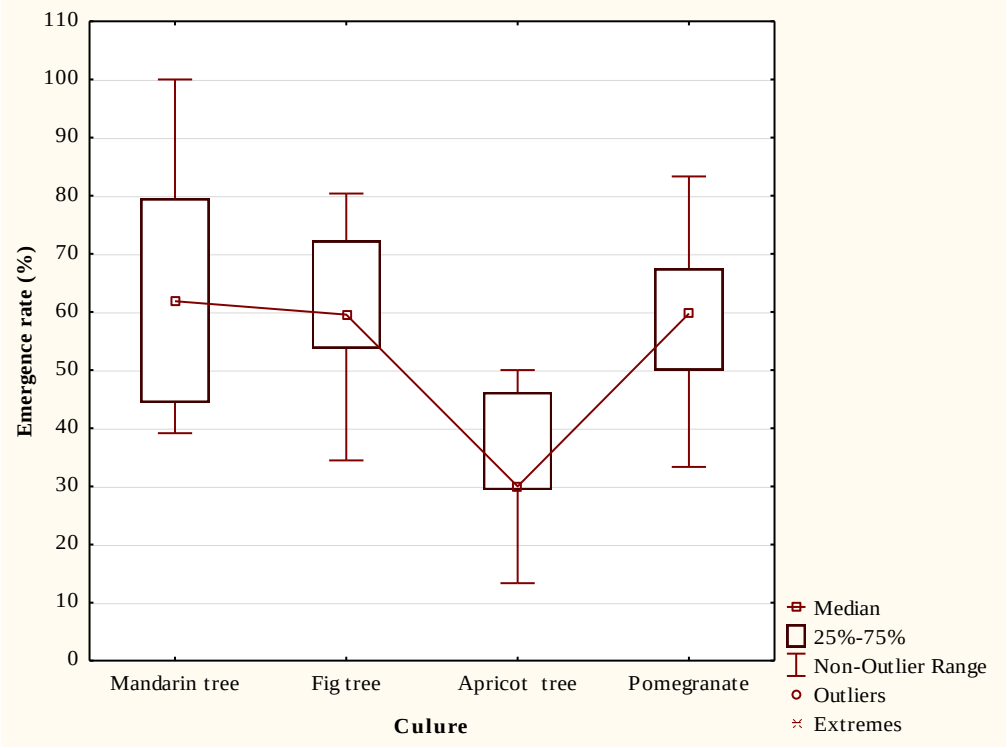

Fig 4. Emergence rate of *Ceratitis capitata's* pupae according to the host plant.

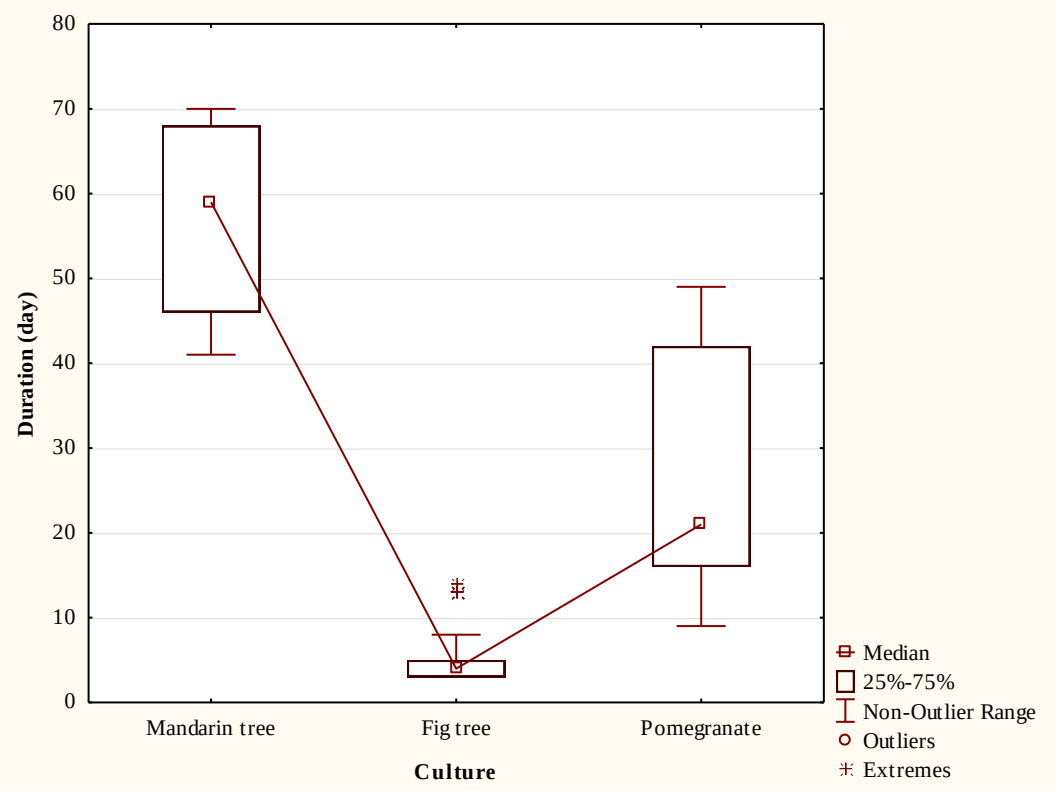

Fig 5. Variation in the longevity of *Ceratitis capitata* depending on the crop type.

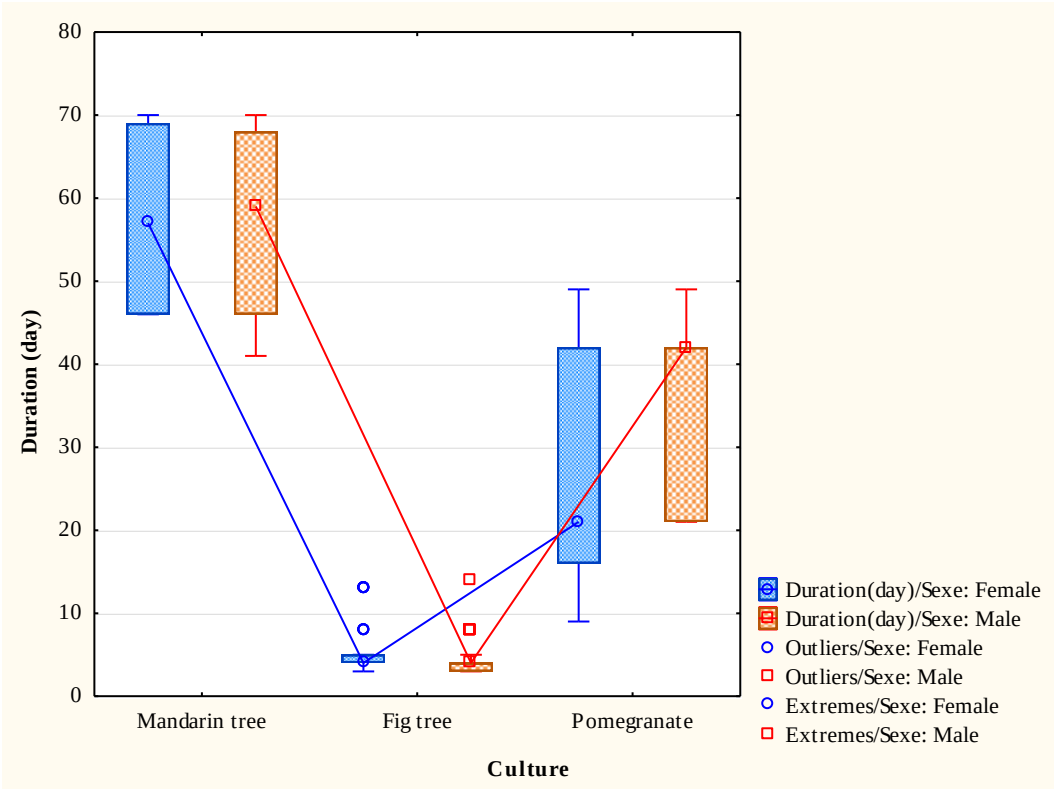

Fig 6. Longevity of *Ceratitis capitata* adults by crop type and sex.

Table 5. Sex-ratio for *Ceratitis capitata* by host plants and stations.

	Mandarin		Fig		Pomegranate	
	If.	T.O.	If.	Tegh.	Ta.1	Ta. 2
Number of males	86	16	69	37	8	28
Number of females	69	25	115	116	15	34
Sex-ratio (%)	44.52	60.98	62.50	75.82	65.22	54.84

If.: Ifoten station; T. O.: Tin Ouaraghen station; Tegh.: Tegherghart station; Ta. 1: Tazrouk 1 station; Ta. 2: Tazrouk 2 station.

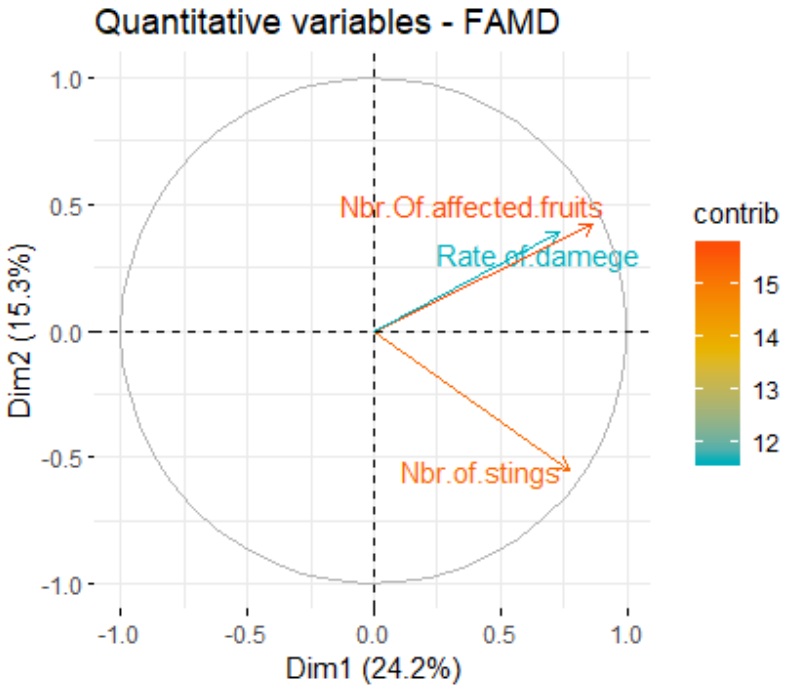

Fig 7. Correlation circle of the Factorial Analysis of Mixed Data (AFDM) applied to quantitative variables (Damage rate; Nbr of affected fruits Number of Fruits; Nbr of stings: number of bites).

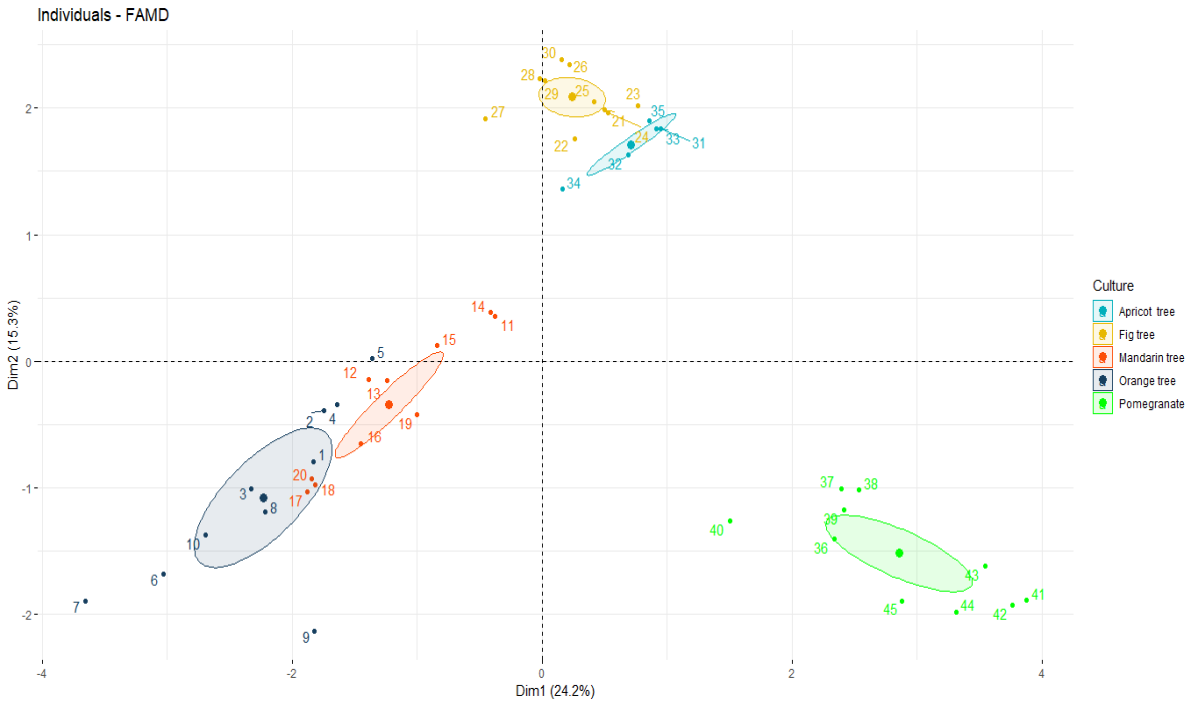

Fig 8. AFDM factorial map with axis 1 and 2 of attack rates of *Ceratitis capitata* according to plant support.

disturbing the pupae's sex-ratio, duration and period of emergence from its fruits. However, Ali Ahmed-Sadoudi et al. (2010**)** argued that peaches and apricots have the highest emergence rate. Hafsiet al. (2016) reported that larval survival rates differ significantly among the fruit species ($p < 0.001$) and among the tephritid species ($p < 0.001$). The interaction between tephritid and fruit species is also significant ($p < 0.001$).

The longevity of adults of *C. capitata* is variable ($p = 0.000$) among the host plant. It varies between 5.0 ± 2.8 days (figs) and 57.3 ± 12.3 days (mandarins). The longevity of adults varies according to seasons; it is very long during winter and it decreases during summer. The same applies for the lifespan of both sexes ($p = 0.0162$). Several authors have mentioned the influence of temperature on the longevity of adult flies (Shoukry and Hafez, 1979; Albajes and Santiago Alvarez, 1980). In addition, the authors have noted that the longevity of adults is related to temperature. The sex-ratio of *C. capitata* is higher for females on all host plants. This result is confirmed by the work of Bachi (2018). Ali-Ahmed et al. (2007) reported that for great depths of soil (10 to 20 cm), the sex-ratio is higher for females for all textures.

Materials and methods

Choice of the study stations

Two study stations were selected to carry out the experiments. The first one is Djanet (24°31' to 24°34' N; 9°27' to 9°29' E) located in the extreme south-east of Algeria. It is approximately 2200 km far from the capital Algiers and it is a Saharan region localized near Tassili n'Ajjer (1094 m altitude). It is limited by the Ahellakane massif in the north, the Erg Tihoudaine in the south-east, and the great Oued Tafessasset and the Afara gap in the south-west.

The second section selected is Tamanrasset (20°54' to 23°38' N.; 4°40' to 6°38' E.), located in the extreme south of the country, at 2000 km south far from the capital. Tamanrasset is located in the southern Sahara on an altitude of 1350 m (Seltzer, 1937). This region is characterized by an immense mountain system, limited in the north by the barren plain of the Tidikelt and in the south-east and west by the desert plateaus of the Ténéré and Tanezrouft (Blanguernon, 1955). The weather of these two regions is characterized by a dry period that spreads throughout all the year and belongs to the bioclimatic Saharan stage with a cool winter (2008 and 2018). Five stations atewere chosen in these regions, 3 in Djanet and 2 in Tamanrasset.

Plant materials

The choice of plant material was made according to the species most affected by the fly in the regions studied, which are: orange, mandarin, fig, apricot and pomegranate trees.

Sampling methods

The sampling was carried out during 2015 and 2016 and it concerns the maturity period of the fruits. Five trees were randomly selected and inspected; from each one, three fruits were collected from each direction (north, south, east, west and center) of the canopy, with a total of fifteen fruits per tree. The bites were counted per fruit in laboratory to estimate the damage rate of the fruit caused by the fly for each crop and for each direction. The damage rate is calculated based on the ratio between the number of attacked fruits and the total number of fruits examined expressed in percent. After having calculated the number of bites per fruit, all attacked fruits were deposited in sieves with plastic basins at the bottom that contain fine sand (2 cm of depth) to recuperate the pupae and to survey the following biological parameters:

Duration of the pupal stage

The collected pupae were separately deposited on Petri dishes until emergence to determine the pupal stage duration, which corresponds to the interval between the formation of pupae and the emergence of adults.

Emergence rate

The number of emerged pupae is calculated to evaluate the emergence rate, which corresponds to the ratio between the number of emerged pupae and the total number of pupae expressed in percentage.

Longevity of adults

Once emerged, the adults were put in plastic boxes containing a nutritious liquid (water + sugar) to calculate the longevity of males and females.

Sex-ratio

Adults were identified by their sex to calculate the sex-ratio, which was the percent ratio between the number of females and the total number of adults.

Statistical analyses

The data were analyzed by the ANOVA test, the Kruskall-Wallis and the Factor Analysis of Mixed Data (FAMD), using the Minitab software (version 17.1.0.0) and R (version R i386 3.5.2). All statistical analyses were realized with Minitab software (version 17.1.0.0) and R (version R i386 3.5.2).

Conclusion

This paper aimed to examine the influence of the host plant on the biological properties, distribution and damage caused by *Ceratitis capitata* in Saharan regions of Algeria. One of the objectives of this study is to provide more information in this field given the scarcity of works on this subject in southern Algeria. It can be noted that the infestation of *Ceratitis capitata* depends on the crop type, and it is very important for summer and autumn fruits (apricots, pomegranates and figs), unlike winter fruits (mandarins and orange). Furthermore, the infestation also depends on the pupal stage duration, emergence rate and the longevity of adults which vary according to the host plants and seasons. The longevity of adults is very long during the winter and it decreases during the summer period.

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