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Population Dynamics of *Frankliniella occidentalis* Pergande (1895) (Thysanoptera: Thripidae) and Evaluation of its Different Ecotypes and their Evolution in a Rose (*Rosa hybrida*) Greenhouse in the Sahline Region, Tunisia

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ABSTRACT

Monitoring population dynamics of *Frankliniella occidentalis* Pergand (1895) (Thysanoptera; Thripidae) employing blue sticky traps and the weekly collection of flowers allowed the determination of the critical periods of insect population increase in Tunisia, namely spring and early summer. Indeed, the maximum *F. occidentalis* population was recorded during June, while the lowest number of thrips was observed during winter. On the other hand, the observations revealed that the number of males decreased gradually compared to females mainly in summer with a proportional decrease in the sex ratio. On the other hand, a study of the occurrence of natural enemies associated with Californian thrips led to the identification of a predatory bug *Orius insidiosus* Say (1832) (Heteroptera: Anthocorridae) which was frequently observed in the sampled flowers. This predator declined *F. occidentalis* population 5 weeks after its natural introduction and installation into the rose crop greenhouse. Moreover, regular prospecting realized on 2007 in rose crop greenhouses in the Sahline region in Tunisia permitted to distinguish different ecotypes of western flower thrips *Frankliniella occidentalis* Pergand (1895) (Thysanoptera, Thripidae). Indeed, based on their color, three ecotypes were found: dark, pale yellow and intermediate color. The temporal evolution of these three ecotypes was studied depending on environmental conditions. In fact, the dark ecotype was shown to be mostly abundant during winter and spring and to decrease in summer but did not disappear. However, the pale yellow ecotype was completely absent during the cold season, appeared in spring and summer and dominated the western flower thrips population. The ecotype of intermediate color was present throughout the year without showing too much variation.

Keywords: different ecotypes, *Orius insidiosus*, phenology, relative humidity, sex-ratio, temperature

INTRODUCTION

Rose is a shrub that may be encountered in several varieties with various characteristics (Perrin 2001). Several pest species may attack this shrub, including thrips. The most common thrips species is Western Flower Thrips (WFT) or the Californian thrips *Frankliniella occidentalis* Pergande (1895) (Brødsgaard 1989; Alford 1991). In Tunisia, *F. occidentalis* is still considered as quarantine pest (Belharrath *et al.* 1994). This species was first reported by Pergande in 1895 in California (USA) on apricot leaves and tomatoes, as well as flowers of various weeds (Kirk and Terry 2003). Originating from the western USA, *F. occidentalis* had spread, since 1970, over many countries in Asia, Africa, Central and South America, Europe and Oceania (Anonymous 2002).

F. occidentalis is the primary thrips species encountered by greenhouse producers and is extremely polyphagous attacking a wide range of host plants, more than 500 species, belonging to some 50 botanical families containing several cultivated and ornamental crops which include bean, pepper, lettuce, cucumber, melon, onion, tomato, strawberry, *Chrysanthemum*, orchids, rose (*Rosa* L. sp.), *Gypsophila* spp. etc (Yudin *et al.* 1986; González-Zamora and Garcia-Mari 2003; Cloyd 2009). On the other hand, *F. occidentalis* has been reported on weeds that served as alternative hosts in the absence of the primary host and during unfavorable conditions (Reddy and Wightman 1988). This pest reproduced in two ways: bisexual and parthenogenesis. In fact, if the egg is fertilized, progeny will be female and if not it will give a male (Bryan and Smith 1956). Development and biological cycle of this pest is often affected by environmental factors such as temperature, photoperiod and relative humidity (Bournier 1983, Brødsgaard 1989, Loomans and van Lenteren 1995; Guérineau 2003; Whittaker et Kirk 2004).

Moreover, *F. occidentalis* is a thrips species known to have three different colors: dark, pale yellow and an intermediate color (Brødsgaard 1989) classed in different ecotypes (Bournier 1983). As with any thrips species, the color variation depends on thermal changes occurring in different seasons of the year (Bryan and Smith 1956). Temperature affects only the pre-imaginal stages which will be expressed on adults later (Fraval 2006).

These three ecotypes have different periods of appearance and development. In fact, in California, dark individuals were found in spring while the yellow ones were reported during summer. Concerning the intermediate ecotype, it was found throughout the year (Bryan and Smith 1956; Brødsgaard 1989). Genetically, only diploid females express this phenotypic characteristic while haploid males do not represent any color change and are always pale yellow. On the other hand, dark and pale yellow ecotypes are homozygous while the intermediate ones are heterozygous (Bryan and Smith 1956).

Western Flower Thrips causes direct damage by feeding on plant leaves and flowers (Cloyd 2009). The impact of *F. occidentalis* on rose crop is observed especially on flowers which represented the commercially important organs. The damage results generally in yellow spots and distortions of the attacked organs, but the most important damage occurs

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on inflorescences (Brun *et al.* 2004). Due to feeding by larvae and adults, spots developed on petals are primarily white then brown; infected petals become dry and perforated in advanced stages (Alford 1991). When scares affect flower buds they may prevent them of fully deploying. Sepals, in case of attack, become crimped and slightly discolored (Alford 1991; Brun *et al.* 2004). In addition, *F. occidentalis* causes indirect damage by vectoring the tospoviruses such as the Tomato Spotted Wilt Virus (TSWV) and the Impatiens Necrotic Spot Wilt Virus (INSWV) that may affect a wide range of horticultural crops (Grasselly 1996; Cloyd 2009).

This pest can be controlled by employing insecticides belonging to many chemical families. Pesticides must be alternated to prevent resistance development (Grasselly *et al*. 1991). Successful pest biocontrol was achieved by using some beneficial insects to control the *F. occidentalis* population. The most predatory species used against this pest belong to the genus *Orius*. Some predatory mites such as *Neoseiulus cucumeris* and *Amblyseius cucumeris* are used to prevent evolution of the *F. occidentalis* population (Looman and van Lenteren 1995; Gélinas 2000; Pizzol *et al.* 2005). Some parasitoids are also used to control this thrips species. Loomans (2003) mentioned that the most studied genus of parasitoids employed against *F. occidentalis* is *Ceranisus* sp.

Blue sticky traps with attractive kairomones can be used in greenhouses to prevent proliferation of thrips population or to control it, and they can also attract males and females of many thrips pest. This control method can be employed regardless of the density of thrips in greenhouses (van Tol and de Kogel 2007; Broquier and Lacordaire 2008).

The aim of this study is to monitor the *Frankliniella occidentalis* population in a rose crop greenhouse depending on climatic conditions and phenology of the host plant, to evaluate the effect of the natural associated enemies on the WFT population and to identify the different ecotypes of *F. occidentalis* Pergand (1895) with the evaluation of their evolution and abundance over the seasons by use of blue sticky traps in a rose crop greenhouse.

MATERIALS AND METHODS

Experimental site

The study was carried under a 520 m² greenhouse of rose culture in the region of Sahline (at the center of Tunisia) during 2007 on two rose cultivars: *Rosa* hybrida cultivar 'First-red®' which has a red color, and *Rosa* hybrida cultivar 'Ociane®' with cream-white petals. Each cultuvar was cultivated in two rows in the greenhouse. The inter-row distance is about 1.5 m. The culture was conducted without treatment throughout the study period.

Monitoring environmental parameters

Climatic factors (temperature and relative humidity (RH)) were monitored weekly with a thermohygrograph.

Thrips identification

Identification of thrips individuals found on rose in the region of Sahline was made based on keys of Brødsgaard (1989), Palmer *et al.* (1989) and Anonymous (2002).

Adult trapping

Monitoring of *F. occidentalis* population was carried out by the use of five blue sticky traps (Koppert®) installed along the greenhouse between the two central rows of rose plants. The distance between each trap and the second one is about 10 m. The blue sticky traps used were 40 cm long and 21 cm wide. They were suspended at a height of 30 cm above rose plants. The installation of these blue sticky traps began on 1st March 2007 until 29th November 2007. Traps were renewed weekly. To monitor different ecotypes of the Western Flower Thrips only female adults were considered because they are the only individuals of *F. occidentalis* population affected by temperature.

Sampling of flowers

Monitoring of populations of thrips on rose started since 19th April 2007, a week after flowering, until 29th November 2007. The greenhouse was divided into four blocks and each block in nine sampling units consisting composed of 8 to 10 plants. Sampling units which are located on the greenhouse edges were not used. From each sampling unit, a rose plant was selected randomly and three flowers were collected from the different plant parts (apical, middle and basal).

Statistical analysis

The statistical analyses were done by the statistical software program SPSS 10 (Statistical Package for the Social Sciences version 10).

RESULTS AND DISCUSSION

Monitoring climatic conditions of the experimental site

During the beginning of the study and especially in March, the average temperature ranged between 15 and 18°C. Over the following months, the temperature increased gradually and achieved the highest average of about 29.69°C on the 28th June 2007. From September until the end of monitoring, the temperature tented to decrease continually to values close to 15°C (**Fig. 1**).

Concerning relative humidity (RH), the average values at the beginning of the study varied between 60 and 70%. These values remained more or less constant with some slight variations. However, the lowest mean RH of about 42.97% was recorded on 28th June 2007. During October and November, the average RH tented to increase to high values of about 70 and 75% near the maximum RH (**Fig. 2**).

Identification of thrips

The identification of the different forms of thrips found on blue sticky traps and in sampled flowers showed that they all belong to the same species which is *Frankliniella occidentalis* Pergand (1895) (Thysanoptera, Thripidae).

Abundance of *F. occidentalis* population based on rose phenology

The abundance and development stage of *F. occidentalis* in the rose crop greenhouse varied depending on the phonologic stage of the host plant (**Table 1**). In fact, during the period since the beginning of the study till mid-April, the number of adult thrips was relatively low due to the absence of flowers on the plant host. However, since the appearance of flowers, starting on 12th April 2007, the number of adults has considerably increased in traps. Petals were the preferential oviposition site, as reported by Gerin *et al.* (1999), which demonstrated that the number of individuals of *F. occidentalis* and its eggs laying activity is higher in flowering plants. On the other hand, *F. occidentalis* is a species developing on flowering plant hosts due to its pollen consumption (Anonymous 2002; González-Zamora and Garcia-Mari 2003). It is therefore clear that the phenological stage of the host plant plays a key role in the development and progression of *F. occidentalis* population.

Abundance of *F. occidentalis* depending on seasons of the year

The abundance and development of *F. occidentalis* are strongly associated with seasons and environmental conditions including temperature, relative humidity and photoperiod (Bournier 1983). In fact, in the present study, the

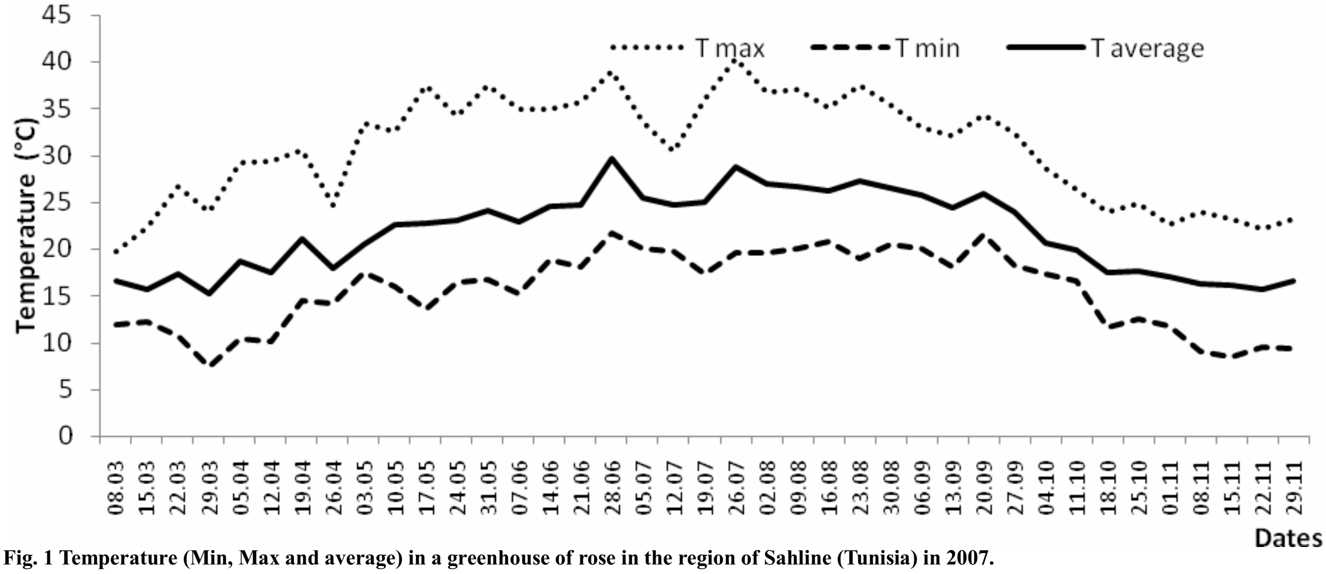

Fig. 1 Temperature (Min, Max and average) in a greenhouse of rose in the region of Sahline (Tunisia) in 2007.

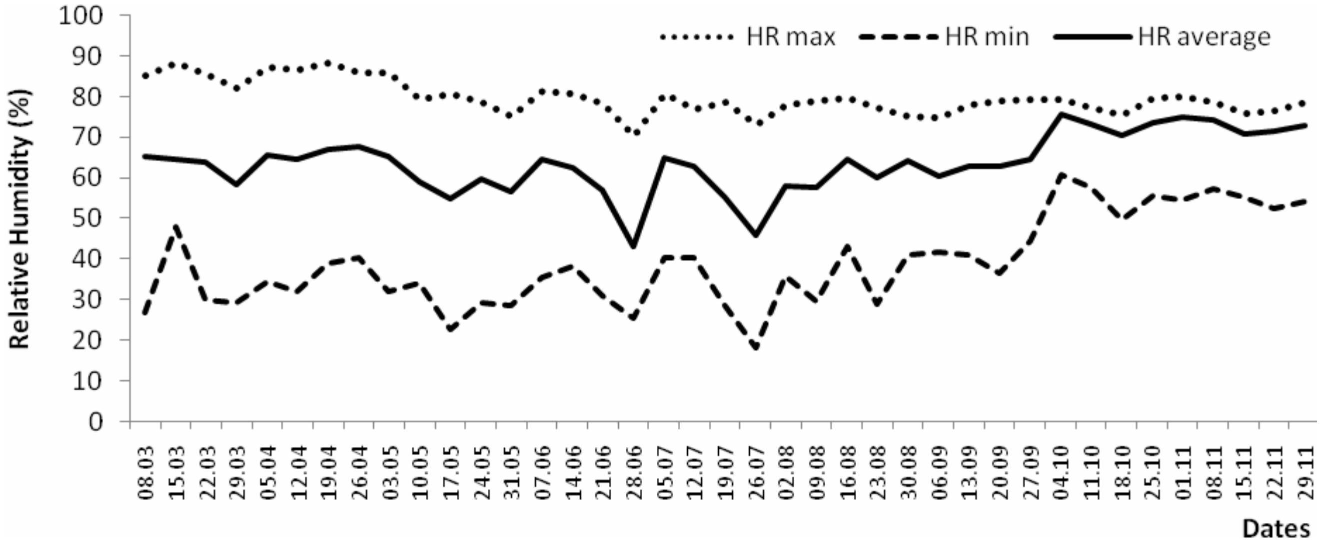

Fig. 2 Relative humidity (Min, Max and average) in the greenhouse of rose in the region of Sahline (Tunisia) in 2007.

Table 1 Influence of the phenological stage of rose plant on the development of the population of *F. occidentalis.*

Phenological stage of host plant (rose)	Dates	Means of thrips adults per trap
Absence of flowers	08.03.07	128.0 ± 40.669
	15.03.07	125.4 ± 46.138
	22.03.07	134.6 ± 25.175
	29.03.07	212.0 ± 17.175
	05.04.07	228.6 ± 41.367
	12.04.07	204.2 ± 32.337
Presence of flowers	19.04.07	411.4 ± 124.496
	26.04.07	640.6 ± 234.952
	03.05.07	804.6 ± 124.126
	10.05.07	1465.6 ± 454.183
	17.05.07	2072.2 ± 394.941
	24.05.07	2584.8 ± 383.655
	31.05.07	2525.0 ± 554.803
	07.06.07	3234.8 ± 396.549
	14.06.07	3461.2 ± 282.785
	21.06.07	3637.2 ± 288.063
	28.06.07	2394.6 ± 412.709

average temperatures recorded during the months of March and April were comprised between 15 and 17°C (**Fig. 1**), which was not conducive to pest development which, according to Bournier (1983), Brødsgaard (1989), Loomans and van Lenteren (1995) and Guérineau (2003), has a proper thermal preference for its development comprised between 25 and 30°C. Likewise, the average relative humidity was relatively high, of about 60-70% and the maxima varied between 80 and 90% (**Fig. 2**) which was able to limit the WFT development (**Fig. 3**) that grows better in low humidity and even below 50% (Guérineau 2003).

During April and May, the *F. occidentalis* population has increased due to the improvement of its biotic potential. Indeed, the duration of embryonic development, and the period of pre-eggs laying become shorter at 20°C (Loomans and van Lenteren 1995); this is consistent with the present

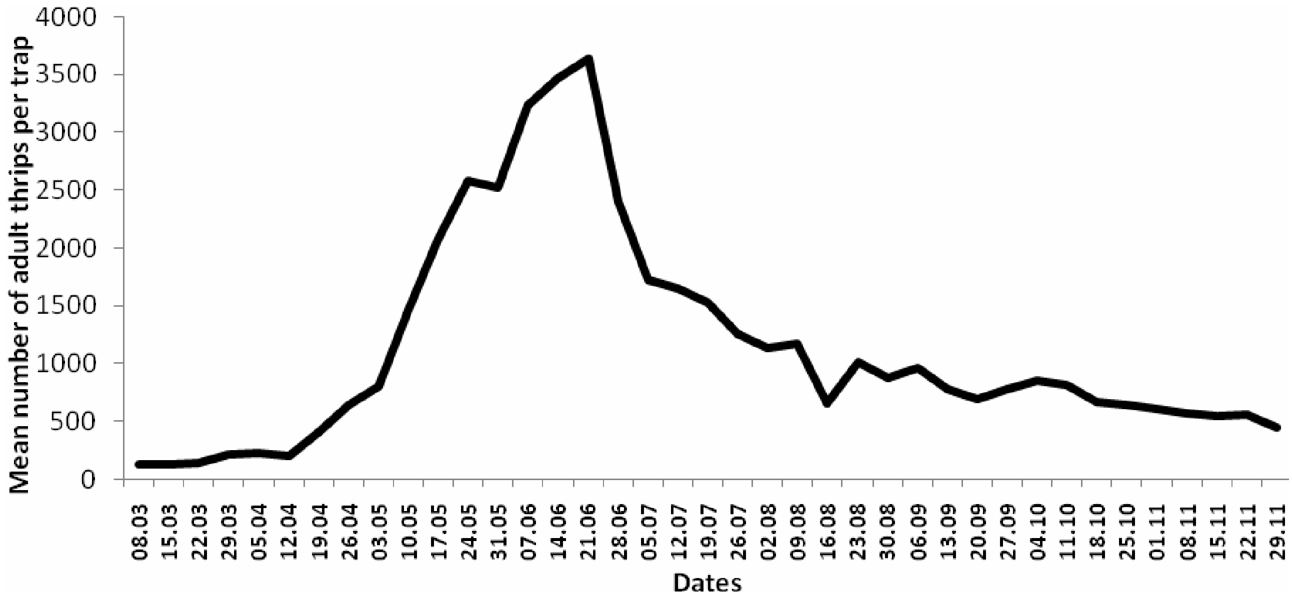

Fig. 3 Mean number of adults of *F. occidentalis* per trap in a greenhouse of rose crop in the region of Sahline (Tunisia) in 2007.

Table 2 Temporal evolution of the photoperiod (in hours) during the different months of the period of study (from March 2007 to November 2007) (*NIMT, 2007).

Months	March	April	May	June	July	August	Sept.	Oct.	Nov.
Photoperiod (Hours/month)	208	228	276	303	338	304	240	211	189

*NIMT: National Institute of Meteorology of Tunisia.

results recorded at temperatures comprised between 20 and 22°C in the rose crop greenhouse. Since the end of May and during the month of June, the *F. occidentalis* population rised rapidly (**Fig. 3**) and achieved a maximum average of about 3637.2 adults per trap in the 21st June 2007.

During this period, several parameters seemed to be involved in this population increase; the average temperature tended to increase to values close to 25°C and the atmosphere became dry with relative humidity values between 50 and 60%; these conditions were shown to promote *F. occidentalis* development (Brødsgaard 1989; Loomans and van Lenteren 1995; Guérineau 2003).

The third factor that reacted during the period of study was the photoperiod which is an essential ecological parameter for *F. occidentalis* and thrips pest development generally. Bournier (1983) and Loomans and van Lenteren (1995) mentioned that, besides the effect of photoperiod on morphological and phenotypic characteristics of thrips, the biotic potential increased with photoperiod extension, and the duration of embryonic development and post-embryonic stages became shorter. Whittaker and Kirk (2004) also reported that *F. occidentalis* fecundity of during a long photoperiod is more important than in short one. Indeed, during the late spring and early summer (from 3rd May 2007 to 21st June 2007), day length gets longer (**Table 2**) promoting the development and proliferation of the pest populations. Unlike the first observation period (March and April) when the short photoperiod slowed the growth of *F. occidentalis* population.

In autumn, from 11th October 2007 and till the end of prospecting, the temperature decline, the relative humidity increase and the short photoperiod provoked a continuous decline of *F. occidentalis* populations. Consequently, the pest dynamic seemed to be highly dependent on these three parameters.

Evolution of *F. occidentalis* population on rose

The evolution of the mean number of mobile forms (larvae and adults) of *F. occidentalis* on rose flowers started on 19th April 2007, one week after the appearance of flowers.

This sampling method revealed that growth of *F. occidentalis* population coincides with the presence of flowers on the plant host. Indeed, the number of individuals per flower progressively increased till the date of 24th May 2007 where it reached 7.88 individuals per flower (**Fig. 4**). Beyond that date, the population has increased sharply to a peak of 34.72 individuals per flower on 14th June 2007. This increase is a consequence of temperatures elevation to values between 23 and 24°C during the same period. The number of 35 thrips mobile forms per flower exceeds the damage threshold of rose crop based on 0.5 mobile forms per flower.

The comparative number of larvae (stages L1 and L2) and adult (**Fig. 5**) from 26th June 2007 showed a slightly increased number of adults per flower compared to that of larvae. Indeed, this date coincided with the greenhouse opening and the plastic film replacement which allowed introduction of adult thrips from outside to the greenhouse. Adults are able to migrate from one plant to another and even from one region to another as reported in Bournier (1983) study.

Determination of *F. occidentalis* sex-ratio

F. occidentalis reproduces into two ways; the bisexual reproduction which requires the omnipresence of male and female, and reproduction by arrhenotokous parthenogenesis (Bryan and Smith 1956). Monitoring *F. occidentalis* males and females evolution was made based on counting of both sexes captured in the blue sticky traps.

Evaluating *F. occidentalis* sex-ratio was calculated using the formula described by Ramade (2003) and Mateus *et al.* (2003) who mentioned that the sex-ratio is equal to the number of males compared to females: Sex ratio = number of males / number of females.

Throughout the study period, the number of females exceeded that of males with important differences. The difference between sexes was low in the early observations, but over time mean number of females exceeded highly the number of males (**Fig. 6**). This evolution of both sexes is expressed throughout the duration of observations by a masculinity rate lower than a femininity rate (**Fig. 7**), and a sex-ratio decline from the beginning of the study (**Fig. 8**) due to the increase of female number.

Several environmental factors have contributed to the

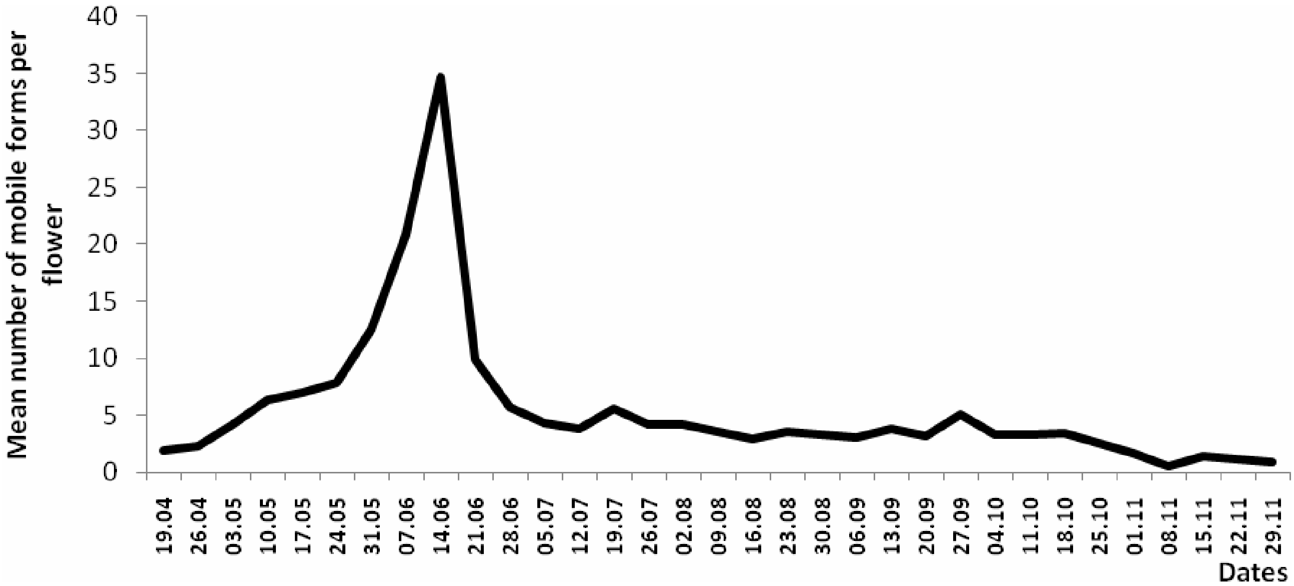

Fig. 4 Mean number of mobile forms of *F. occidentalis* per flower in a greenhouse of rose crop in the region of Sahline (Tunisia) in 2007.

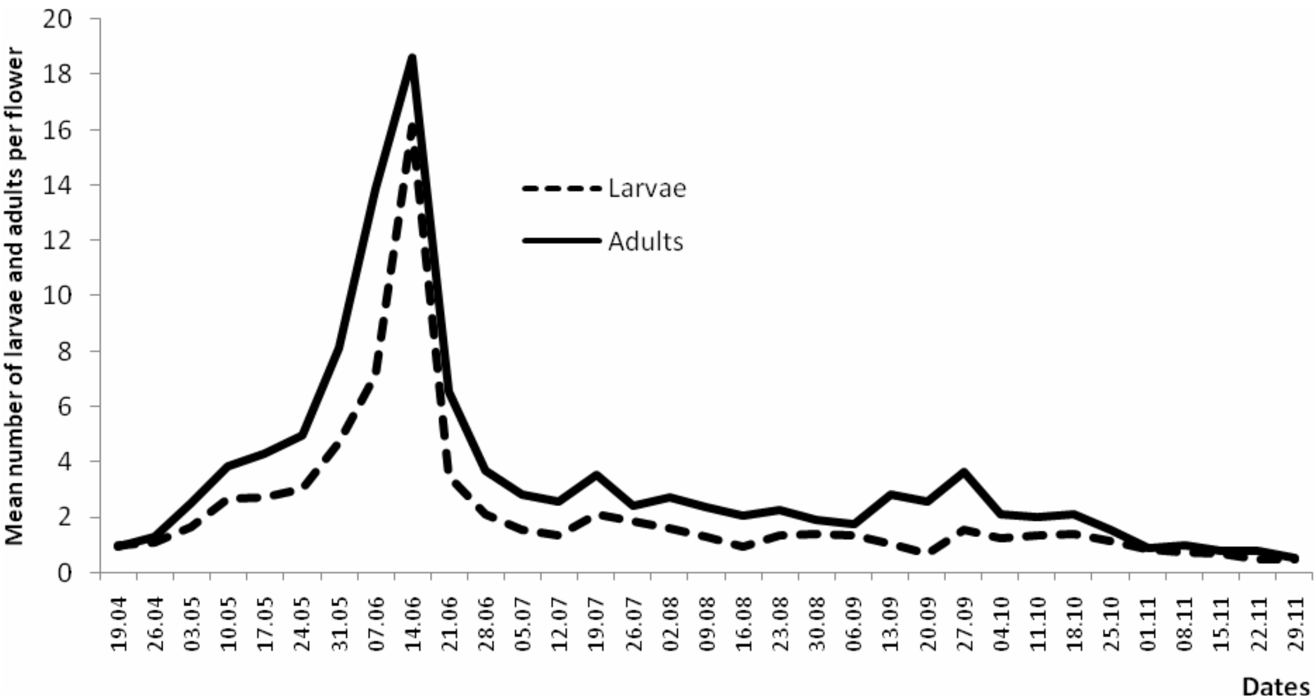

Fig. 5 Mean number of larvae and adults of *F. occidentalis* per flower in a greenhouse of rose crop in the region of Sahline (Tunisia) in 2007.

increase of sex-ratio and the rise of masculinity rate during the month of March till mid-April because of temperature decrease, the high relative humidity, the short photoperiod and the absence of flowers on the host plant. During these conditions, the dominating way of the Western Flower Thrips reproduction was the arrhenotokous parthenogenesis which generated males from unfertilized eggs. However, when these factors became favorable to pest development and proliferation with an average temperature about 25°C, a low relative humidity (**Fig. 2**), a prolonged photoperiod (**Table 2**) and the presence of flowers on the host plant, the population has increased with a femininity rate much higher compared to the masculinity rate. Thus, during the favorable conditions, the number of females from fertilized eggs became more important and induced regression of the sex-ratio to values so low as long as the number of females is much higher than males. This proves that the appropriate environmental factors promoted bisexual reproduction of this pest. On the other hand, these results are consistent with those of Steiner and Goodwin (2005) who mentioned that during the hot season *F. occidentalis* population is formed mainly by females. In addition, Fraval (2006) mentioned that generally thrips parthenogenesis reproduction, like is the case of *F. occidentalis*, is affected by external factors such as temperature, photoperiod or alimentation, these factors could react independently or in combination.

Effect of predation on the population of *F. occidentalis*

During the month of June, *F. occidentalis* population was reduced due to the action of a predatory bug found several times at the sampled flowers. According to Silveira *et al.* (2003), this bug is *Orius insidiosus* Say (1832) which belongs to the family of Anthocoridae. This species is capable of predation of several thrips species, including *F. occidentalis* (Loomans and van Lenteren 1995).

Monitoring the temporal evolution of the population of *O. insidiosus* (**Fig. 9**) revealed that the appearance of the predator in the flowers of rose was noted during the week of

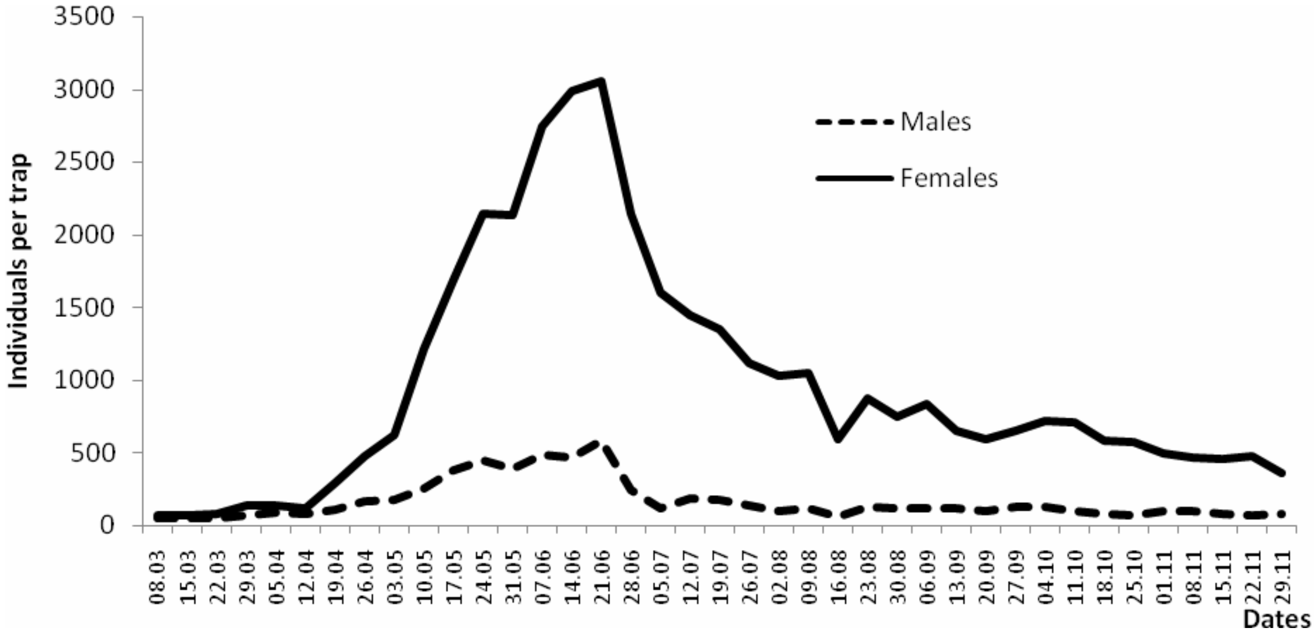

Fig. 6 Mean number of males and females of *F. occidentalis* per trap in a greenhouse of rose crop in the region of Sahline (Tunisia) in 2007.

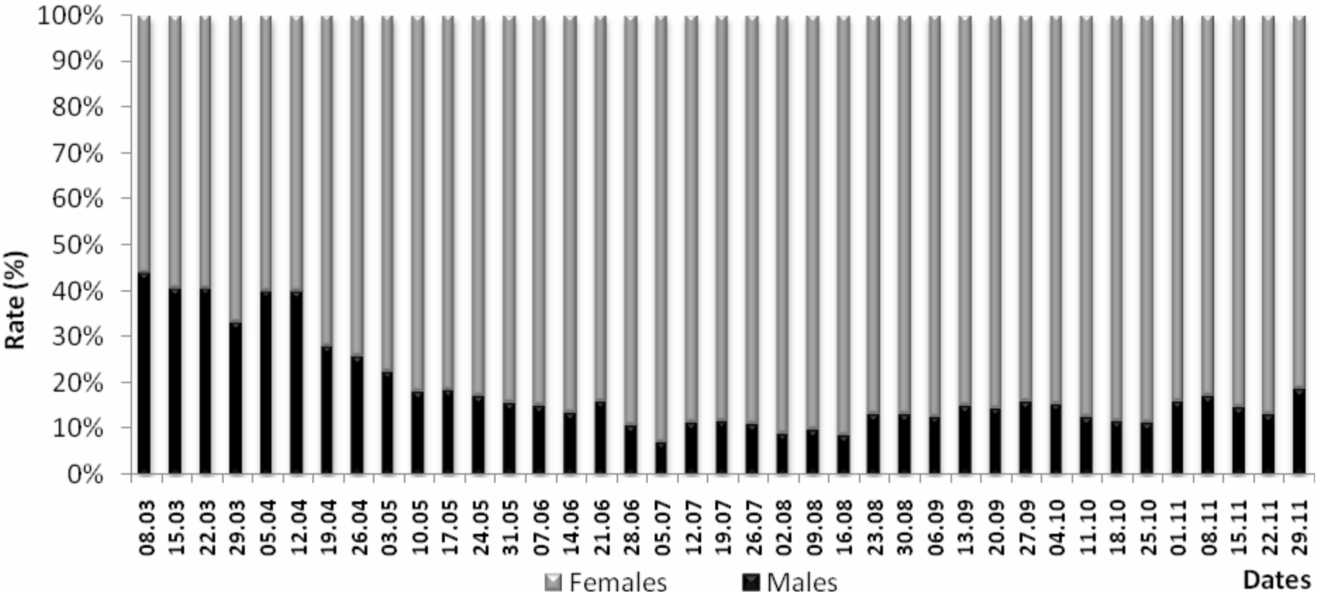

Fig. 7 Mean number of rates of males and females of *F. occidentalis* per trap in a greenhouse of rose crop in the region of Sahline (Tunisia) in 2007.

31st May 2007 with a low average of about 0.095 individuals per flower to reach a maximum of 2.4 individuals per flower in 21st June 2007. In fact, average temperatures in this period approached 24 to 25°C, while relative humidity decreased to values between 50 and 60%, these conditions are favorable to the development of the majority of *Orius* species including *O. insidiosus* which presents an adequate development at high temperatures and low relative humidity (Loomans and van Lenteren 1995; Guérineau 2003).

Monitoring the evolution of populations of *F. occidentalis* and its predator *O. insidiosus* on rose flowers (**Fig. 10**) showed that when the *F. occidentalis* population was maximum on 14th June 2007, that of *O. insidiosus* increased and achieved its peak on 21st June 2007, about 4 weeks after its natural introduction in the greenhouse. The maximum population of the predatory bug is accompanied by a remarkable decline of *F. occidentalis* populations in the flowers to 10 individuals per flower over a period of 4 weeks. These results revealed the effectiveness of this predator in the population of the Western Flower Thrips decrease. After 5 weeks, the population of *O. insidiosus* began to decrease, while that of thrips continued its decline without being able to resume its climb until the end of the prospecting period. In fact, this proved that even low numbers of the predator were able to stabilize thrips population.

The same phenomenon has been observed in blue sticky traps (**Fig. 11**). In effect, 5 weeks after the natural introduction of *O. insidiosus* in the rose crop greenhouse, the population of *F. occidentalis* regressed from an average of 3637.2 adults per trap, the week of 21st June 2007, to 1726 adults per trap the next week. This fall in *F. occidentalis* population was maintained until the end of the study period, reflecting the effectiveness of *O. insidiosus* against this thrips on this rose culture.

Evaluation of the progression of different *F. occidentalis* ecotypes

The appearance and the abundance of every *F. occidentalis* ecotype varied depending on temperature and season (**Figs. 12, 13**).

While monitoring WFT, the first ecotype that occurred

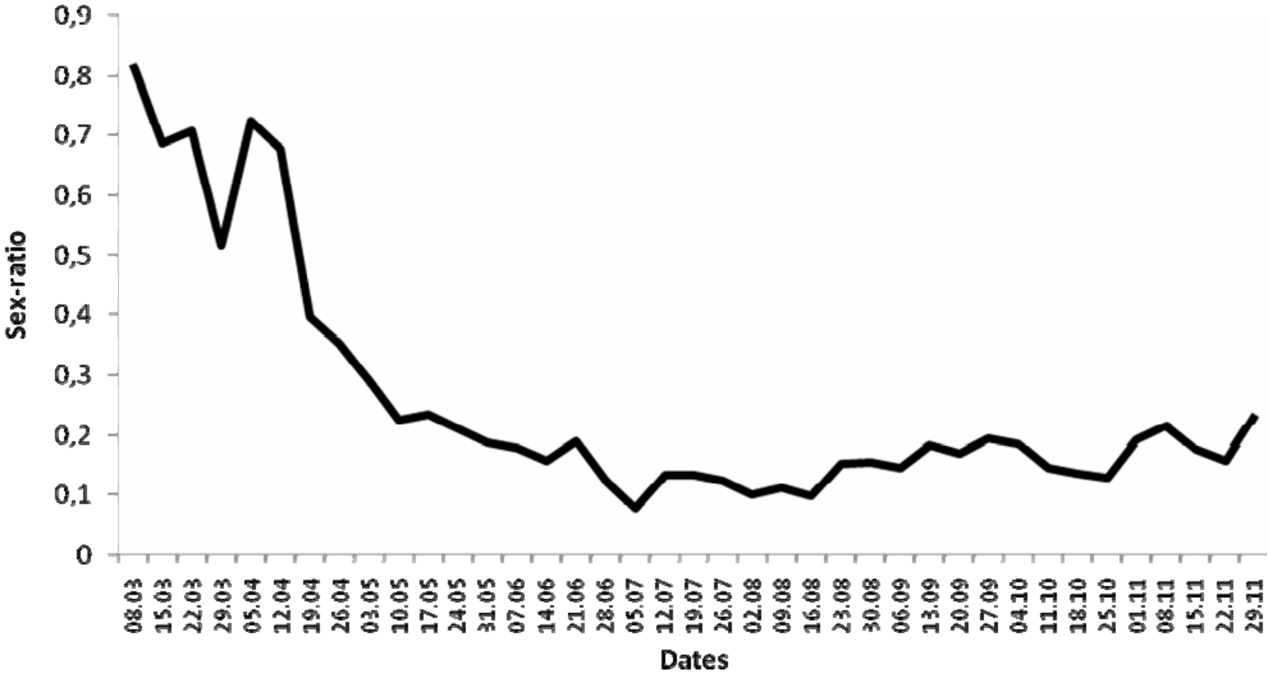

Fig. 8 Sex-ratio of *F. occidentalis* per trap in a greenhouse of rose crop in the region of Sahline (Tunisia) in 2007.

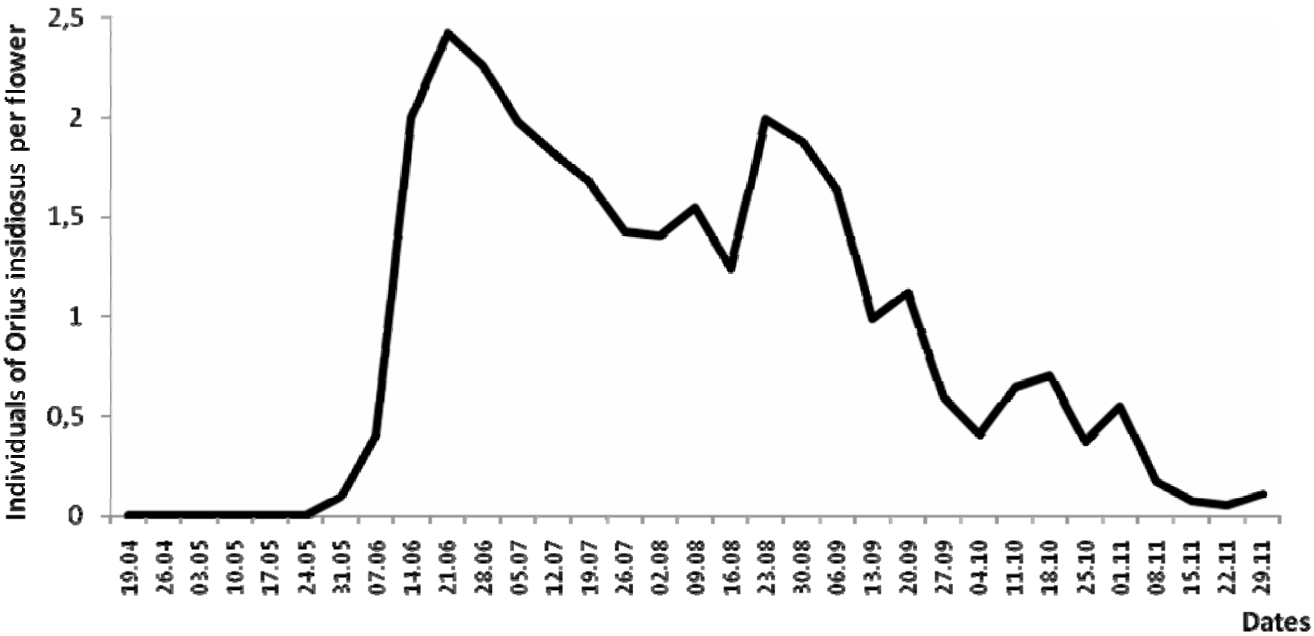

Fig. 9 Mean number of mobile forms (larvae and adults) of *O. insidiosus* per flower in a greenhouse of rose crop in the region of Sahline (Tunisia) in 2007.

with the highest density was the dark one. Indeed, this ecotype is known to be better at surviving wet weather and resistant to low temperatures (Brødsgaard 1989) that were at that time between 15 and 17°C. Nevertheless, once temperatures rose in spring, the density of this ecotype began to decline gradually and to decrease at extremely low rates and much lower than both other ecotypes. Therefore, it is likely that the dark ecotype does not tolerate temperatures of middle spring and summer. Moreover, this ecotype was known to disappear, usually in summer (Bournier 1983). However, this is not the case for this study, because the dark ecotype did not completely disappear during summer, but only few were observed. These results indicate that some individuals of this ecotype could tolerate high summer temperatures. On the other hand, in autumn, the decrease in temperature allowed the dark ecotype to restart its development and to reach the same level as both other ecotypes. However, Brødsgaard (1989) and Bryan and Smith (1956) mentioned that, under US conditions, the three ecotypes were reported at different times. Moreover, in the Netherlands, Germany and Italy, only two ecotypes were reported: the pale and the intermediate form. The dark form has only been found at one occasion in Denmark.

The second ecotype, with intermediate color, was present at low temperatures. However, its density tended to decrease as temperature increased without disappearing completely. During autumn, the fall in temperatures reinforced the development of this ecotype. These results are consistent with those of Bryan and Smith (1956) and Brødsgaard (1989) who reported that the *F. occidentalis* ecotype with intermediate color is present with few changes in its density and that it is a constant part of the WFT population throughout the year.

Concerning the pale yellow ecotype, it was completely absent during spring which is certainly due to low temperatures that prevented its appearance and development. This

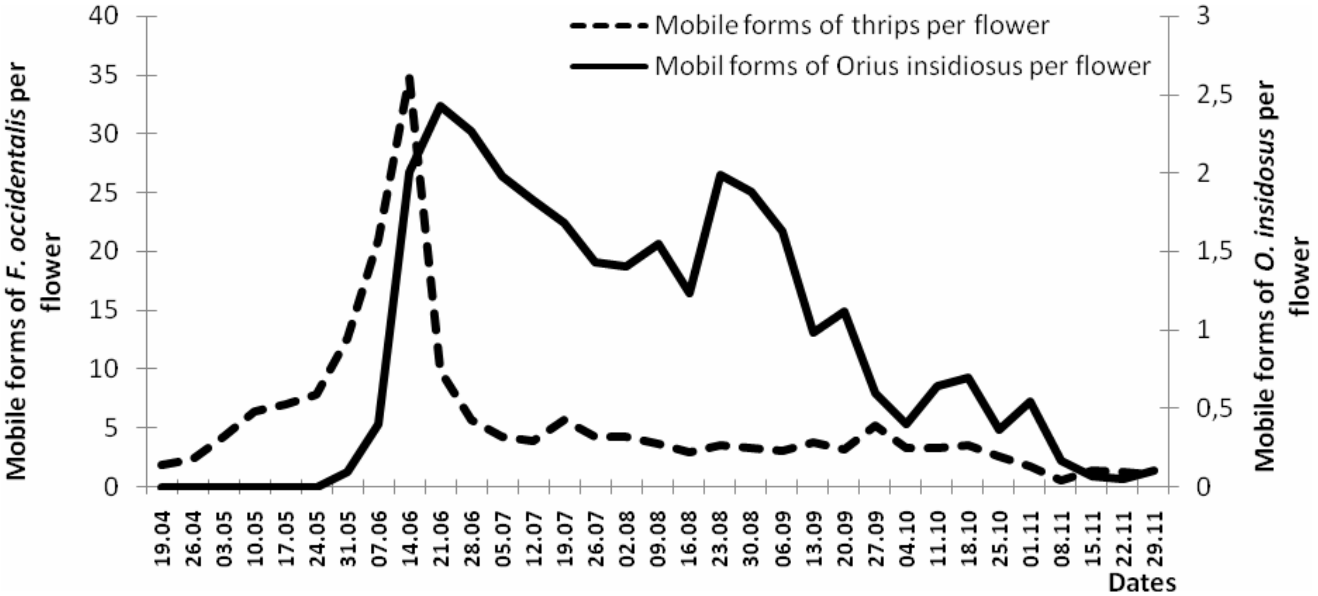

Fig. 10 Evolution of the populations of *F. occidentalis* and its predator *O. insidious* per flower in a greenhouse of rose crop in the region of Sahline (Tunisia) in 2007.

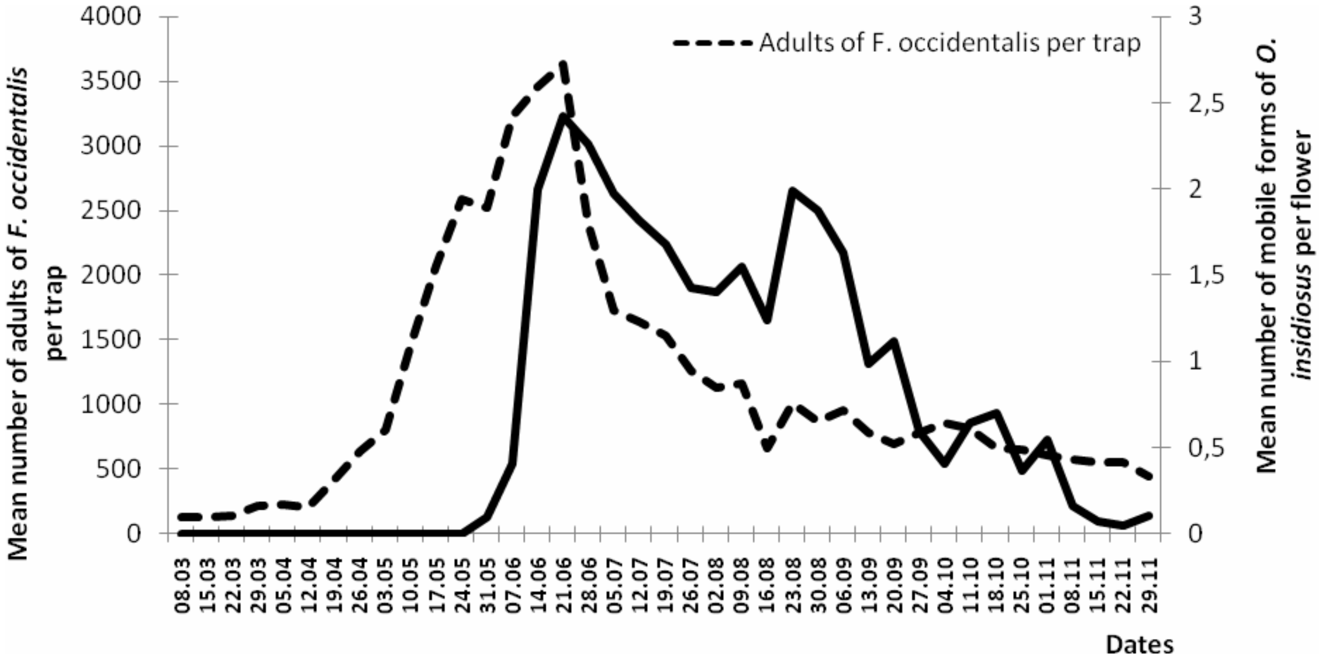

Fig. 11 Evolution of the populations of the adults of *F. occidentalis* per trap and its predator *O. insidious* per flower in a greenhouse of rose crop in the region of Sahline (Tunisia) in 2007.

ecotype seems to be less resistant to low temperatures compared to the two other ecotypes (Brødsgaard 1989); this explained its absence during the beginning of this study. However, with the succession of pest generations during spring and summer, we noted the emergence of pale yellow individuals with densities rising gradually to achieving elevated numbers highly significant compared to both other ecotypes. Thus, when the *F. occidentalis* population was very active during May, June and July, the pale yellow ecotype dominated. Similar results were also cited by Brødsgaard (1989) who mentioned that the pale yellow ecotype appears only in warm periods.

Furthermore, *F. occidentalis* was similar to that of *Thrips tabaci* Lindemann (1888) (Thysanoptera; Thripidae) cited by Bournier (1983) where generations occurring during summer were dominated by the pale yellow ecotype, and with some individuals of the intermediate ecotype.

CONCLUSIONS

These results revealed the evolution of *F. occidentalis* population in a rose crop greenhouse in Tunisia depending of the essential environmental conditions which allowed identifying critical periods of the increase and decrease of the pest population. Moreover, natural introduction of the predator bug *O. insidiosus* proved its effectiveness. This local Anthocorridae, showing a promising results in population regulation, could be used the Western Flower Thrips biological control. Moreover, the present results revealed the evolution of three ecotypes of *F. occidentalis* in a rose crop greenhouse in Tunisia. These findings should be confirmed via molecular tools to look for eventual differences between ecotypes' genomes and to explain the variable behavior in different environmental conditions. Furthermore, other studies could reveal if these ecotypes caused similar damage to rose or to other crops.

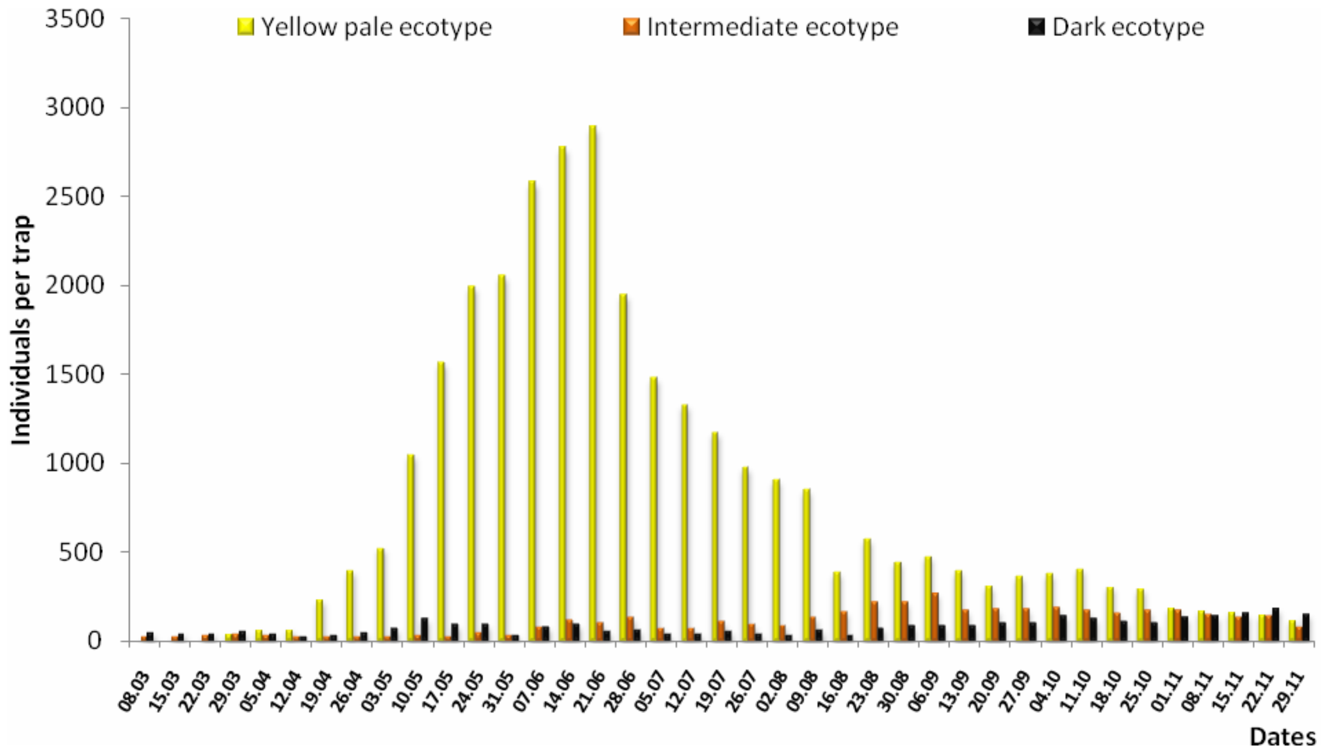

Fig. 12 Evolution of the three ecotypes of *Frankliniella occidentalis* in the rose greenhouse in the region of Sahline (Tunisia) in 2007.

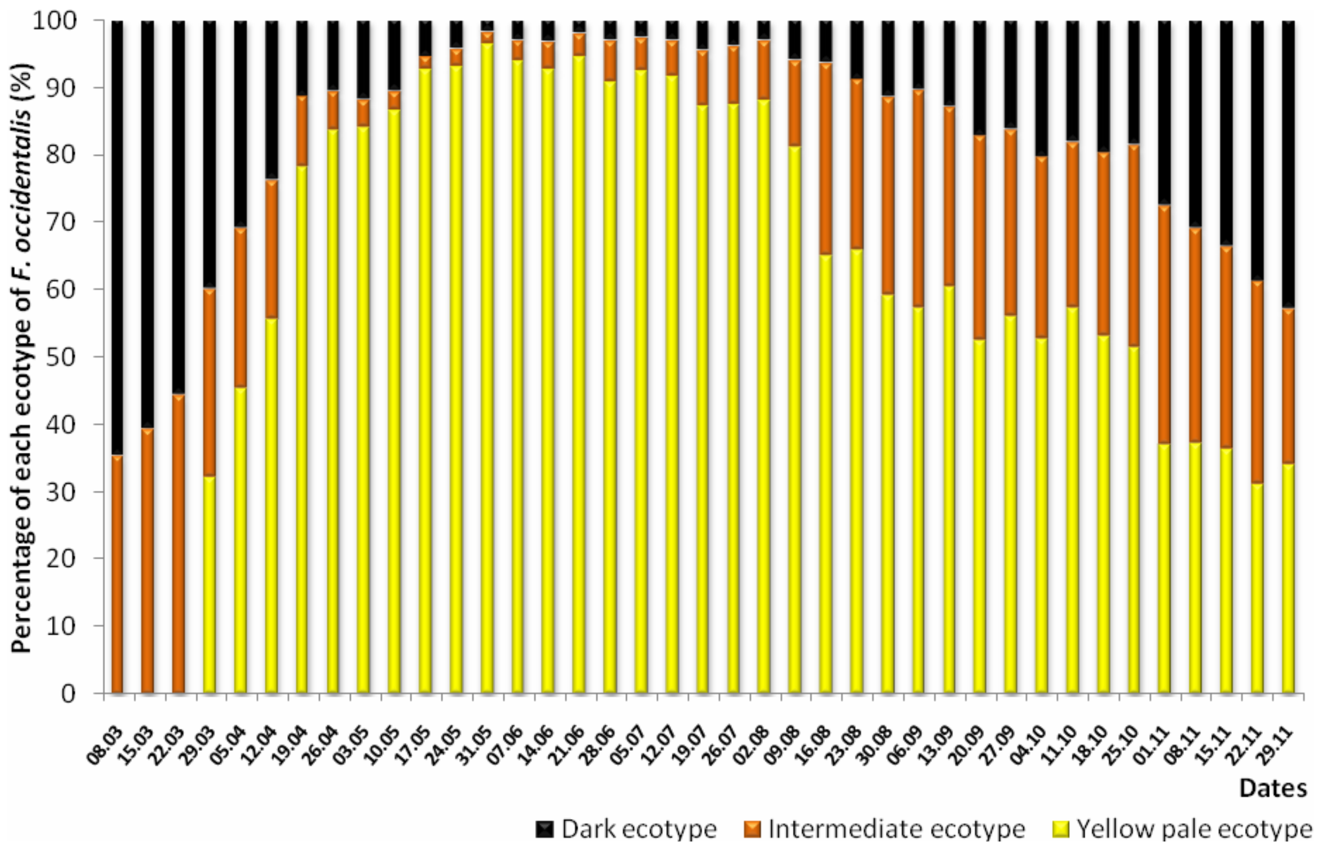

Fig. 13 Evolution of the percentage of the three ecotypes of *Frankliniella occidentalis* in the rose greenhouse in the region of Sahline (Tunisia) in 2007.

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