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Evaluation of *Frankliniella occidentalis* different body colours and their development in a pepper crop greenhouse in the Region of Moknine in Tunisia

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Abstract

Regular observations realized during 2009 in a pepper crop greenhouse in the region of Moknine in Tunisia permitted to distinguish different *Frankliniella occidentalis* (Pergande) (Thysanoptera Thripidae) body colours. Temporal evolution of these three forms was studied depending on thermal conditions of the greenhouse. Indeed, based on their body colour, three forms were found: dark, pale yellow and intermediate colour. In fact, the dark one was shown to be mostly abundant during winter and spring seasons reaching mean values during April over 1800 individuals per trap, and decreased lately approaching summer season reaching mean values about 1000 individuals per trap. However, the pale yellow one was completely absent during cold season, appeared in spring and early summer with very low values, and continued to increase gradually throughout the study period with temperature's increase till reaching mean values over 800 individuals per trap. Individuals having intermediate body colour were present all through the observations' time without showing too many variations and did not exceed 500 individuals per trap.

Key words: temperature, western flower thrips, dark, pale yellow and intermediate form.

Introduction

Originated from the west of USA, and particularly from California, *Frankliniella occidentalis* (Pergande) (Thysanoptera Thripidae) had spread, since 1970, over many countries in Asia, Africa, Central and South America, Europe and Oceania (Karnkowski and Trdan, 2002). However, this species is still considered as quarantine pest in Tunisia though its presence which is due to the possibility of virus transmissions (Belharrath *et al*., 1994).

Western flower thrips (WFT) *F. occidentalis* is known to be having morphological and phenotypical differences between individuals all through the year (Brødsgaard, 1989). Actually, *Frankliniella* spp. in general are variable in colour and structure and especially for the species *F. occidentalis* which identification is a bit hard due to its colour and size variability which has led to a large number of synonyms (Nakahara, 1997).

In fact, three different body colours have been identified for *F. occidentalis* (Brødsgaard, 1989) and classed in different forms according to Bryan and Smith (1956) who divided the colour forms of the adult females into pale ones (white or yellow), intermediate (with orange thorax and brown abdomen) and dark (dark throughout). Genetically, only diploid females express this phenotypic characteristic, while haploid males do not represent any colour change and are always pale yellow. On the other hand, inbred lines of the pale and dark forms were reared and the subsequent well-replicated crosses showed clearly that there was a simple mendelian genetic component of colour. In fact, dark and pale yellow forms are homozygous with a genotype described as DD for pale yellow ones and dd for dark ones, while the intermediate ones are heterozygous with a genotype described as Dd. Otherwise, Bryan and Smith (1956) mentioned that the possible effect of variation in temperature was not investigated on *F. occidentalis* and could have been confounded with genotype; the rearing temperature could well affect the adult colour and interact with genotype. In addition, there may be differential survival of colour forms with temperature. However, an effect of temperature on colour forms had been demonstrated on *Thrips tabaci* Lindeman by Loomans (1997) who found that pale females became darker in one generation when moved from 25 °C to 20 °C and lighter in one generation when moved back. In the other hand, the case of *T. tabaci* has led some authors, such as Bournier (1983), to conclude that on the field and during winter season dark coloured forms of this species were present, then with approaching of summer time, it is rather individuals of lighter colour that take place.

Kirk (2002) mentioned that in the case of *F. occidentalis*, the presence of dark forms in field populations in California and the virtual absence of dark forms in *F. occidentalis* in European greenhouses is, as yet, unexplained. However, Elimem and Chermiti (2009) mentioned that proportion and abundance of *F. occidentalis* vary with seasonal weather changing which means that it depends on temperature variations. In other way, as with any thrips species, such as *T. tabaci* or *F. occidentalis* (Bournier, 1983), the colour variability depended on the weather thermal changes occurring in the different seasons of the year (Bryan and Smith, 1956).

The temperature affects only the pre-imaginal stages which will be expressed on adults later (Fraval, 2006). These three body colours have different periods of appearance and frequency. In fact, in California, dark individuals were found in spring season, while the yellow ones have been reported during summer. Concerning the intermediate ones, they were found throughout all the year (Bryan and Smith, 1956; Brødsgaard, 1989). However, in Germany, the Netherland and Italy both yellow pale and intermediate forms were found, while dark one

was reported only once (Brødsgaard, 1989). In Tunisia, Elimem and Chermiti (2009) mentioned that on rose crop these three forms have been reported with a difference in appearance and abundance; in fact, during winter and early spring times, *F. occidentalis* population was dominated by individuals having dark body colour, while pale yellow ones appeared only when temperatures began to increase considerably to establish during summer time their domination on the WFT population. In the other hand, individuals with intermediate body colour were reported during all the year with no significant variation.

The aim of this study is to identify the different body colours of *F. occidentalis* and to evaluate their progression and abundance through the different year seasons in relation with temperature evolution using blue sticky traps in pepper crop greenhouse in Tunisia during 2009 in the reason to recognize the effect of this environmental parameter on morphological characteristics of this pest.

Materials and methods

Experimental site

The study was carried under a 520 m^2 pepper crop greenhouse in the region of Moknine (Governorate of Monastir, Center-east of Tunisia) during 2009's season. The greenhouse is formed by four rows that each of which is formed by two lines of pepper variety named "*Chargui"*. The inter-row distance is about 1 m. The culture was conducted without treatments in the reason to evaluate the growth and evolution of thrips forms throughout the study period.

Monitoring of environmental parameters

Climatic factors, temperature and relative humidity (RH), were monitored using a thermohygrograph with a weekly cycle that shows an average of both environmental parameters for each week, with maximum and minimum values.

Adults' trapping

In this study, only female adults were considered because they are the only individuals of *F. occidentalis* population which are affected by temperature; males have always the same body colour with no changes. Monitoring of different *F. occidentalis* forms was carried out by the use of ten blue sticky traps (Koppert®), weekly renewed, installed along the greenhouse and suspended at a height of 30 cm above pepper plants. The blue sticky traps used were 25 cm long and 10 cm wide. The installation of these traps started on February 12th 2009 till June 04th 2009.

Statistical analyses

The statistical analyses were done by the statistical software program SPSS 17 (Statistical Package for the Social Sciences version 17) (SPSS, 2008). This program was used for analysis of variance (ANOVA) and Duncan test to determine differences between different body colour forms.

Results and discussion

Identification of the different thrips forms

According to the identification keys of Brødsgaard (1989), Palmer *et al.* (1989), Karnkowski and Trdan (2002), and Steiner (2003), the different forms of thrips found on blue sticky traps belong to the same species which is *F. occidentalis*. However, the three body colours of the WFT encountered in the pepper crop greenhouse in the region of Moknine in 2009 have not been observed at the same periods or with the same densities throughout the study period.

Monitoring of climatic conditions of the experimental site

Climatic conditions' monitoring in the pepper crop greenhouse in the region of Moknine revealed a variation throughout the study period; during the early observation period till the March 26th 2009, the highest average temperature (figure 1) was of about 14.1 °C, while the lowest average which was about 11.7 °C was registered on March 12th 2009. Beyond this phase, the temperature tends to increase gradually over the next months to reach average values approaching to 25 °C reported on May 28th 2009.

Concerning RH (figure 2), mean values registered were highly elevated since the beginning of prospecting till April 02nd 2009, date from which R.H. tended to decrease progressively without reaching very low average values, knowing that lowest average was recorded on May 14th 2009 with 73.1%.

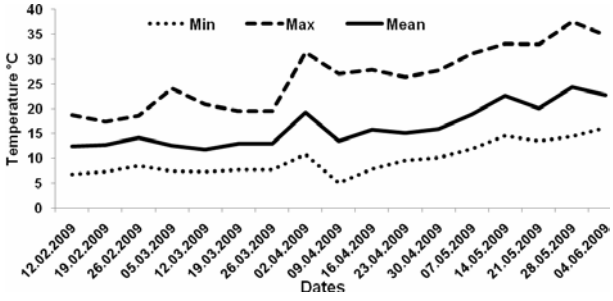

Figure 1. Temperature (min, max and average) in a pepper crop greenhouse in the region of Moknie (Monastir, Tunisia) in 2009.

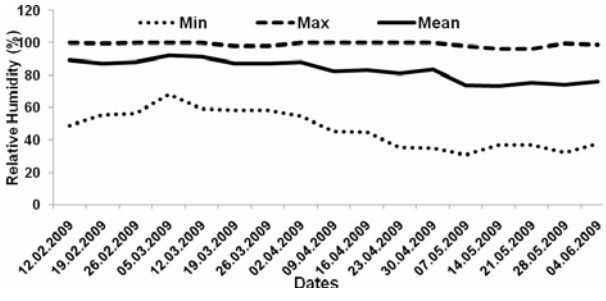

Figure 2. Relative humidity (min, max and average) in a pepper crop greenhouse in the region of Moknie (Monastir, Tunisia) in 2009.

Table 1. Temporal evolution of the photoperiod (in hours) during the different months of the study period (from February 2009 till June 2009) in the governorate of Monastir (NIMT, 2009).

Months	February	April	March	May	June
Photoperiod (Hours/month)	179	208	228	276	303

Figure 3. Dark body colour of *F. occidentalis* (dark throughout) (photo: Elimem 2009).
(In colour at www.bulletinofinsectology.org).

Figure 4. Intermediate body colour of *F. occidentalis* (with orange thorax and brown abdomen) (photo: Elimem 2009).
(In colour at www.bulletinofinsectology.org).

Figure 5. Pale yellow body colour of *F. occidentalis* (pale throughout) (photo: Elimem 2009).
(In colour at www.bulletinofinsectology.org).

Concerning photoperiod, data taken from the National Institute of Meteorology of Tunisia showed that this parameter, in the governorate of Monastir, never stopped to get longer till the end of the study (table 1).

Evaluation and evolution of different *F. occidentalis* body colours

Throughout the study period, three *F. occidentalis* body colour have been reported in the pepper crop greenhouse in the region of Moknine (figures 3, 4 and 5). However, they showed huge differences in period of appearance and even in their abundance and domination of the WFT total population. On the other hand, evolution of adults' number of *F. occidentalis* captured on blue sticky traps was marked with some variations all the way through the study period. In fact, evolution, development and even morphological and biological characteristics of this pest are strongly associated to climatic conditions such as temperature, RH and photoperiod which can have an effect on the development and proliferation of thrips population (Bournier, 1983; Loomans *et al*., 1995; Guérineau, 2003; Whittaker and Kirk, 2004; Chaisuekul and Riley, 2005; Fraval, 2006; Elimem and Chermiti, 2009).

According to the obtained results, the first body colour individuals that were frequent and abundant in the beginning of the observations were the dark ones (figures 6 and 7). During that period, environmental conditions were favorable for the appearance of this form and its population's domination where its percentage was around 70% of total female WFT population (figure 7). According to Brødsgaard (1989) and Bryan and Smith (1956), those individuals are known to be resistant to low temperatures which averages, during the first phase of observations, were comprised between 11 and 14 °C, with a maximum and minimum recorded of about 24.1 °C March 5th 2009 and 6.7 °C February 2009 respectively. In fact, these results concords with those of Bournier (1983) and Loomans (1997) on who found same results for *T. tabaci.* Mean numbers of this morph continued to increase progressively to reach an average of about 2329.5 individuals per trap on April 16th 2009 (figure 6) where mean temperature was 15.8 °C which is encouraging for the proliferation of the dark morph. However, beyond that date mean number of this form began to decline gradually and decreased to an average of about 1059.7 and 1028.5 respectively on May 28th and June 04th 2009. In fact, this decrease in *F. occidentalis* dark form is due to the photoperiod which had increase significantly during the month of April, May and June with high illumination hour's numbers respectively of around 228, 276 and 303 hours (table 1) and also to the temperature's rising during last phase of observations which was of about 22.5 °C and 24.3 °C respec-

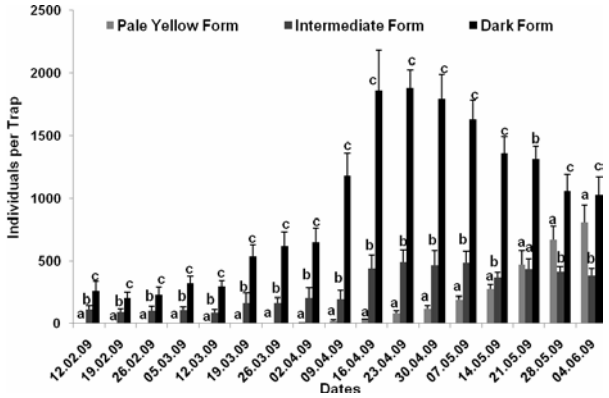

Figure 6. Evolution of the three body colours of *F. occidentalis* in the pepper crop greenhouse in the region of Moknine (Tunisia) in 2009. (Means followed by the same letter are not significantly different $\alpha = 0.05$).

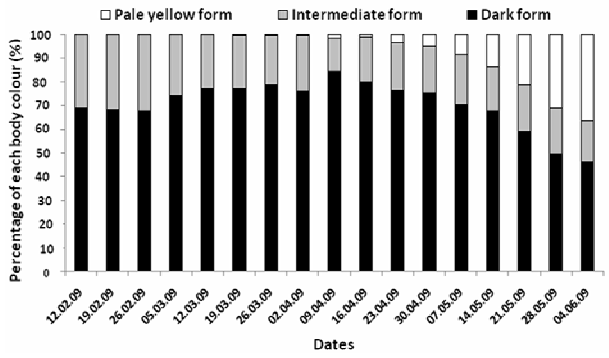

Figure 7. Evolution of the three body colours percentage of *F. occidentalis* compared with the total population in the pepper crop greenhouse in the region of Moknine (Tunisia) in 2009.

tively on May 14th and May 28th 2009 provoking thus such a decline of dark body individuals proving thus that this category cannot tolerate high temperatures. Similar results were found in Tunisia in a rose crop greenhouse where WFT population was conquered by especially by dark individuals with mean percentages around 60% during cold and spring seasons, and that these values begin to decline with the increase of temperature approaching hot season (Elimem and Chermiti, 2009). Bournier (1983) mentioned same evolution of dark body form which mean number decrease approaching hot season for *T. tabaci*.

Concerning the second colour body form that was reported with the dark one during first period of observations was the intermediate one with an average number of about 94.6 individuals per trap on February 19th 2009 (figure 6) and percentages around 30% of total female population (figure 7). In effect, it was present during all the study period without making big variations. However, its mean numbers tended to increase slightly with the temperatures' rising reaching thus an average of about 493 individuals per trap on April 23rd 2009. During the rest of the prospecting till the end, this form stood more or less constant with no big variations which was consistent with results mentioned by Bryan and Smith (1956), Brødsgaard (1989) and Elimem and Chermiti (2009) who reported that *F. occidentalis* morph with intermediate body colour was present all through the year with just some few and non-significant changes in its population density. Bournier (1983) reported also same results for this body colour for *T. tabaci*.

Concerning the pale yellow form, it was completely absent during the winter and spring season which is due to low temperatures that prevented its appearance and development. These individuals seem to be less resistant to low temperatures compared to the others (Bournier, 1983; Brødsgaard, 1989); this explains its absence during the beginning of this study. However, individuals with pale yellow body colour began to appear during the beginning of spring season on March 19th 2009 with a mean average of about 0.2 individuals per trap which is a very low value comparing with those of the other body colour forms. In a similar work, this form made its appearance during the same month (March) and with very low values (Elimem and Chermiti, 2009). In the other hand, pale yellow body colour individuals' number began to increase with temperatures rising during late spring and the beginning of summer where temperatures' values approach 22 to 24 °C. Density of this form increased gradually achieving thus high numbers of about 31.1% and 36.4% corresponding to 667.7 and 811.9 individuals per trap respectively on May 28th and June 04th 2009 (figures 6 and 7) while individuals with dark body colour were decreasing. Same results found for *T. tabaci* where dark body forms were replaced by yellow ones during spring and summer seasons (Bournier, 1983). In the other hand significant differences were reported between mean numbers of pale yellow form and both others except on May 25th 2009 where no significant differences where reported between the intermediate form and the pale yellow one. Brødsgaard (1989) and Elimem and Chermiti (2009) mentioned that when *F. occidentalis* population becomes very active during warm season, which is consistent with results found during this study where the WFT population reached high values of about 2455.2 female per trap on April 04th 2009 (figure 6), it is the pale yellow body coloured individuals that dominate the population rather than the others. In fact, and according to Brødsgaard (1989) and Bournier (1983), this form seems to be resistant to high temperatures especially during hot season, unlike the dark one, which explains its absence in the beginning of the study period and its gradual increase synchronized with going up of temperatures.

Moreover, figure 8 illustrates *F. occidentalis* three body colour forms evolution in relation with temperature. In fact, during temperatures comprised between 10 and 15 °C, the dark form is the most dominant while the pale one was completely absent proving thus that the dark body colour is resistant to low temperature. However, figure 8 shows that with temperature increase dark form begins to decline and the pale one starts its progressive evolution till values more or less high when

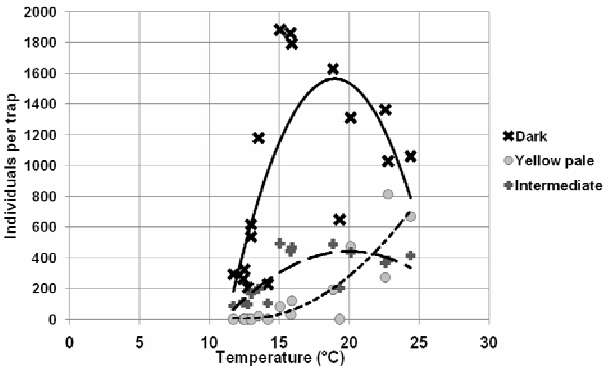

Figure 8. Correlation between different *F. occidentalis* body colour forms evolution and temperature.

temperatures approach 25 °C which confirms that the pale yellow body colour is resistant only to high temperatures. Concerning the intermediate body colour form, it has not shown a big variation all along temperature evolution.

Conclusions

Weekly observations of the WFT population during 2009 in a pepper crop greenhouse in the region of Moknine (Center-east of Tunisia) permitted to discriminate different body colours of *F. occidentalis*. Certainly, and based on their abdomen colour, the three forms were found: dark ones, pale yellow individuals and intermediate. These three forms were encountered during different periods with different frequencies and abundances. Actually, dark body colour form was shown to be mostly present during cold season and early spring, and then it becomes to decrease progressively as long as temperature increases. In the other hand, pale yellow body form was completely absent during winter, appeared in spring and early summer and then continued to increase gradually in relation with temperature increase. Third body colour was the intermediate one which was present throughout the study period without showing huge variations.

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