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Effect of Host Plant and Temperature on Biology and Population Growth of *Pterochloroides persicae* Cholodv (Hemiptera, Lachninae)

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ABSTRACT

This work aimed to study the population behaviour and distribution of brown peach aphid (*Pterochloroides persicae*) on different host trees. Five host plants were identified (peach, almond, plum, apricot and apple) and two behaviours were observed in which aphid could be maintained all-year round on peach in irrigated orchards and a sub-humid climate on four *Prunus* genus in dry fields and an arid climate. Population dynamics showed that aphids first appeared on roots and then moved up to cover the collar and the trunks where populations behaved differently. The effects of host and temperature on biotic potential were studied under controlled field conditions. Adults were reared individually at different temperatures (15, 20 and 25°C) on peach, almond, plum and apricot tree branches. 20°C is the best temperature for the reproductive potential of *P. persicae* and peach was the best host for *P. persicae* in terms of mass rearing.

Keywords: behaviour, host plants, temperature
Abbreviations: MRGR, mean relative growth rate; **T**, aphid-specific age

INTRODUCTION

The present investigation is an attempt to identify the preferential aphid host plant in different areas of Tunisia, to evaluate the adult behavior and to assess the effect of temperature on the biotic potential of this pest.

Pterochloroides persicae is one of the most important brunch cortex and trunk-feeding aphids in the *Prunaceous* genera in Tunisia (El-Trigui and El-Sherif 1989; Jerraya 2003). Feeding by this pest affects the quality of fruits (Stoetzel 1994; Rakshshani *et al.* 2005; Ateyyat and Abu-Darwish 2009). The brown peach aphid is considered to be one of the most widely distributed and economically important aphids attacking stone fruit trees such as peach, plum, apricot and almond (Darwich *et al.* 1989; Stoetzel and Miller 1998; Blackman and Eastop 2000; Ateyyat and Abu-Darwish 2009). It has been found in Europe, Asia and in some Mediterranean countries (Rakshshani *et al.* 2005). *P. persicae* was introduced to Tunisia in 1987 (El Trigui and El Sherif 1989). Limited information concerning its biology and ecology is available (Ben Halima-Kamel and Ben Hamouda 2004, 2005). The general biology of *P. persicae* was previously described (Darwich *et al.* 1989; Blackman and Eastop 1994, 2000; Ben Halima-Kamel and Ben Hamouda 2004, 2005, Rakshshani *et al.* 2005; Blackman and Eastop 2006). Aphid density, its critical infestation periods and economic threshold are still unknown. Moreover, little data is available about the adult's behavior and succession on Prunaceous host plants (Darwich *et al.* 1989; El Trigui *et al.* 1989; Kairo and Poswal 1995; Jerraya 2003).

MATERIALS AND METHODS

Area of study and determination of host plants

This study was performed at several sites in Tunisia containing wild or cultivated fruit trees (**Fig. 1**). Six sites are located in the North [Ariana (4), Beja (2), Jendouba (3), Elkef (6), Nabeul (5) and Bizerte (1)] with a sub-tropical climate; four on the coast [Sousse (8), Monastir (9), Mahdia (10) and Sfax (11)] and one in the center [Kairouan (7)] which is characterized by an arid climate. The distribution of *P. persicae* within infested trees was observed from March 2007 to November 2009. During that period, the studied sites were inspected weekly and both the presence and the absence (manifestation) of the pest were continuously recorded.

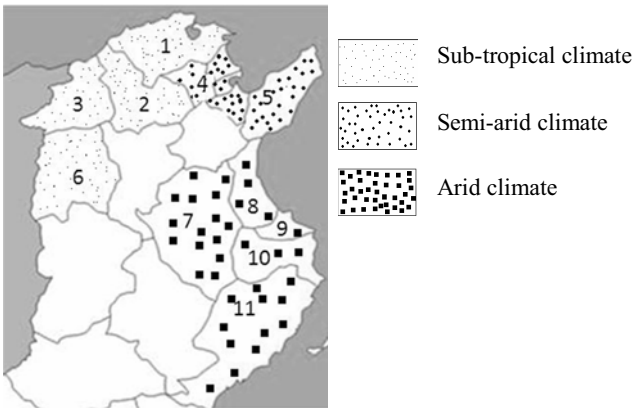

Fig. 1 Tunisia map representing areas of study. (1) Bizerte, (2) Beja, (3) Jendouba, (4) Ariana, (5) Nabeul, (6) Elkef, (7) Kairouan, (8) Sousse, (9) Monastir, (10) Mahdia, (11) Sfax.

Life cycle

The life cycle of *P. persicae* in Tunisia was conducted in three infested areas having different climates (**Table 1**). The date of infestation, the location of aphids on the trees and their succession were noted. In order to confirm the anholocycle (continuously partheno-

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Research Note

Table 1 Information about fields of studies and variety of fruit trees.

Field study	Climate	Number of trees	Variety	With or without irrigation
Sidi Thabet (**Fig. 1.6**)	Sub-tropical	5000 peach	Red Top (early variety), Pen Tao (late variety)	Irrigated
Chott Mariem	Arid	24 peach	Flord Start, Early May Crest and Seville	Dry
(**Fig. 1.8**)		8 apricot	-	
		16 plum	-	
		12 almond	Mazetto	
Jammel (**Fig. 1.9**)	Arid	260 peach	Spring Time, Spring Crest, May Gold and 344.15	Dry
		500 almond	Mazetto	
		56 plum	-	
		124 apricot	-	

genetic reproduction) of the pest in Mediterranean conditions, egg-laying was studied by covering previously infested peach trunks with muslin cloth immediately after the disappearance of all individuals over the period of one year (six covered branches were used per area (Jammel, Sidi Thabet and Chott-Mariem). Muslins traps were inspected weekly for potential hatching eggs.

Effect of temperature and host plants on biotic potential of *P. persicae*

To evaluate the influence of temperature and host plant on biotic potential of *P. persicae*, experiments were conducted under controlled and field conditions on different host plants, namely peach (*P. persica* var. 'Red Top', 'Pen Tao', 'Early May Crest' and 'Flordstar', almond (*P. dulcis* var. 'Mazetto'), apricot (*P. armeniaca* var. 'Wardi') and plum (*P. domestica* var. 'Black Diamond') by calculating mean relative growth rate (MRGR), which was calculated according to Fisher (1920) and Radford (1967), in Leather and Dixon (1984), using the formula:

$$MRGR = (Ln\ W1 - Ln\ W2)/(T2 - T1)$$

where W1 and W2 are the number of individuals at infestation and sampling and (T2-T1) is the period of development from infestation to sampling.

The specific age (T) was determined according to Ramade (2003) using the equation:

$$T = \log 2/(MRGR)$$

Assays under controlled conditions

Assays were conducted in rearing rooms with a 16-h photoperiod, 70% humidity (Daiqin and Robert 1996) and at different temperatures: 15, 20 and 25°C (Zamani *et al.* 2006). The experiment included four species of the *Prunus* genus: *Prunus persica* Batsh., *Prunus domestica* L., *Prunus dulcis* (Mill) and *Prunus armeniaca* L. Fragments from bottom part of trunks from all trees species were maintained on Knop's solution (Knop 1965) which was renewed daily. Apteral adult's aphids of the same age were individually inoculated (Dadd and Mittler 1965) and 30 adults per host plant were used for each experiment. The age of death and the number of produced progeny per day were recorded. Assays were continued until the death of adult mothers. A life table was established within the data collected depending on the aphid-specific age (T) and the MRGR at different temperatures.

In the field, at Chott-Mariem, peach, almond, apricot and plum trees were monitored. The number of infected trees was estimated and individual aphid numbers were recorded every 10 days up to the level of host tree, which permitted the density of infestation to be calculated. Similarly, in the laboratory, T and MRGR were estimated for each host plant.

Climate data was provided by the National Institute of Meteorology (**Table 2**).

Statistical analysis

Data were transformed using $\log_{10\ (x+1)}$ to normalize the distribution when necessary (Steel and Torries 1980). Statistical analysis was performed using SPSS (version 13.0.) and means were separated by Duncan's multiple range test (DMRT) at the 5% level.

RESULTS AND DISCUSSION

Host *P. persicae* trees

Table 3 shows that *P. persica*, *P. domestica*, *P. dulcis* and *P. armeniaca* constitute host plants of *P. persicae*, including *M. domestica*, as the occasional host. Results describing peach, almond, apricot, apple and plum as *P. persicae* host plants in different Tunisian areas were confirmed by other studies along the coast and in the south of Tunisia where Ben Halima Kamel and Ben Hamouda (2004, 2005), El-Trigui and El-Sherif (1989), and Atayyat and Abu-Darwich (2009) mentioned the occurrence of *P. persiace* on these species, except for apple (*Malus domestica*), which has been reported as a *P. persiace* host for the first time in this study. In other countries, other host plants have been mentioned such as *Prunus cerasiflora*, *Prunus divaricata* and *Prunus salicina* (Blackman and Eastop 1994, 2000; Rakhshani *et al.* 2005; Blackman and Eastop 2006), *Prunus avium*, *Citrus* sp., *Prunus cerasus* L., *Prunus spinosa* L., *Cydonia vulgaris* P. and *Malus pumila* M. (Stoetzel and Miller 1998).

Table 2 Minimum and maximum of temperatures in different areas of the Tunisian coast in the Tunisia, Sousse and Monastir (National Institute of Meteorology, Tunisia).

Month (2009)	Temperature	
	Minimum (°C)	Maximum (°C)
January	7.5	16.4
February	8.3	17.3
March	9.8	18.5
April	11.9	20.6
May	15.1	24.1
June	18.8	28
July	21.2	31.5
August	22.2	32
September	20.6	29.2
October	16.8	25.2
November	11.9	20.8
December	8.9	17.3

Table 3 Distribution of hosts trees of *P. persicae* in Tunisia areas and dates of the first infestation in 2008-2009.

Biotope		Hosts tree	Date of first infestation
Ariana (**Fig. 1.4**)	Sidi Thabet	Peach	September
Sousse (**Fig. 1.8**)	Chott Mariem	Peach	February until November
		Almond	December
		Plum	Mai and June
	Sahloul	Apple	June
Monastir (**Fig. 1.9**)	Elwerdanine	Peach	February
	Jammel	Almond	December
		Peach	February
		Apricot	June
		Plum	July and August
Mahdia (**Fig. 1.10**)	Sidi Alouane	Peach	Mars
	Rejich	Almond	February
Kairouan (**Fig. 1.7**)		Peach	April
Sfax (**Fig. 1.11**)		Peach	February

Fig. 2, 3 and 4 *P. persicae* on the roots, trunk and collar of peach, respectively.

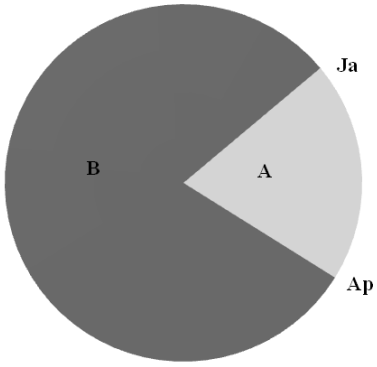

Fig. 5 Behavior of *P. persicae* in Sidi Thabet (sub-tropical climate). (A) Early variety, (B) Late variety, (Ja) January, (Ap) April.

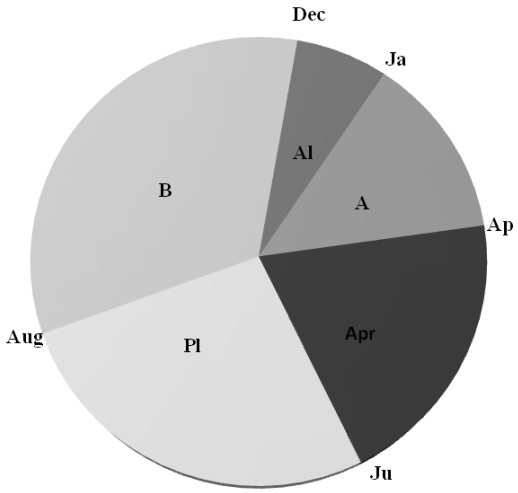

Fig. 6 Behaviour of *P. persicae* in Jammel. (A) Early peach, (Al) almond, (Apr) apricot, (B) late peach variety, (Pl) plum, (Dec) December, (Ja) January, (Ap) April, (Ju) July, (Au) August.

Further, Kairo and Poswal (1995) mentioned that the host range and pest status of *P. persicae* varied according to country and depending on the particular fruit species grown. The authors cited other host trees in different countries: *Prunus divaricarta* in Armenia, Georgia and Turkmenistan, *Prunus salicina* in Israel, *Prunus bokhriensis* in Pakistan, *Salix* sp. in Java and *Citrus sinensis* in Egypt. To our knowledge, there are no new reports of new hosts in any country between 2006 and 2011.

Annual cycle

The results obtained after weekly observations of muslin traps covering trunks of peach trees indicate that no eggs or larva were produced. This explains why *P. persicae* was reproduced just by parthenogenesis in Tunisia and confirms the holocycle of *P. persicae*.

The assessment of aphids in various areas covered by this survey and of different host plants showed that the dynamic of *P. persicae* can be explained by the effect of sap flow and the relation with plant phenology (**Figs. 2-4, 7**). Leaves of peach tree started to senesce at the end of autumn and the sap accumulated in roots where *P. percicae* was observed in November and December (**Figs. 2-7**). This aphid colonized the trunks after the appearance of leaves in January and February (**Figs. 5-7**) where it remained all-year round before returning to the collar (**Figs. 3-7**). This example of aphid movement was observed on peach in Sidi Thabet and Chott Mariem orchards.

The migration of aphids between different hosts plants (**Figs. 5, 6**) showed that they were related to the crop system. Indeed, two behaviors were observed. The first was observed in Sidi Thabet, in irrigated fields, where aphids achieved the totality of their life cycle on peach. Development begun on an early peach variety ('Red Top') and continued on the late variety ('Pen Tao') (**Fig. 6**). Also, the brown peach aphid was able to achieve its cycle on several hosts (peach, almond, apricot and plum). The second type of behavior was observed in non-irrigated fields in Chott Mariem and Jammel zones (**Fig. 8**). Thus, we can deduce

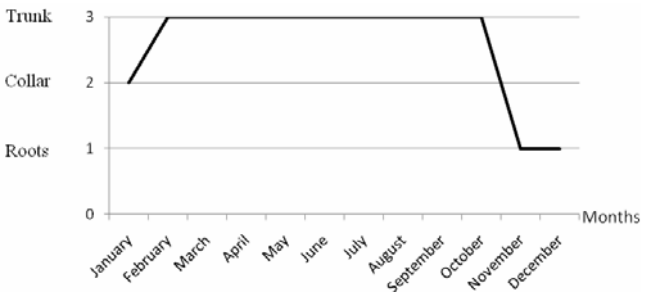

Fig. 7 *P. persicae* mobility mobility on peach tree in Chott Mariem and Sidi Thabet during 2009.

that peach, plum, almond, apricot and apple are important host plants of *P. persicae* in Tunisia. As for the biology and type of development, *P. persicae* reproduces only by parthenogenesis on different host plants and areas of Tunisia. Similarly, El-Trigui and El-Sherif (1989), Ben Halima Kamel and Mabrouk (1997) and Ben Halima Kamel and Ben Hamouda (2005) reported the anholocycly of *P. persicae* in Tunisia. This aphid can be reproduced by sexual means in other countries and in different climatic conditions. This hypothesis was proved in Syria and Lebanon where Kairo and Poswal (1995) mentioned that some oviparous females appear in late October and eggs are laid from October to mid-January. The masses of these eggs are shiny. Those authors also noticed that egg hatching began in mid-January and continued up to March when *P. persicae* females reached the adult stage in mid-April and the fondatrix generation was complete by early May. Similarly, Talhouk (1977) cited that *P. persicae* has the possibility to present a holocyclic or an anholocyclic life cycle depending on

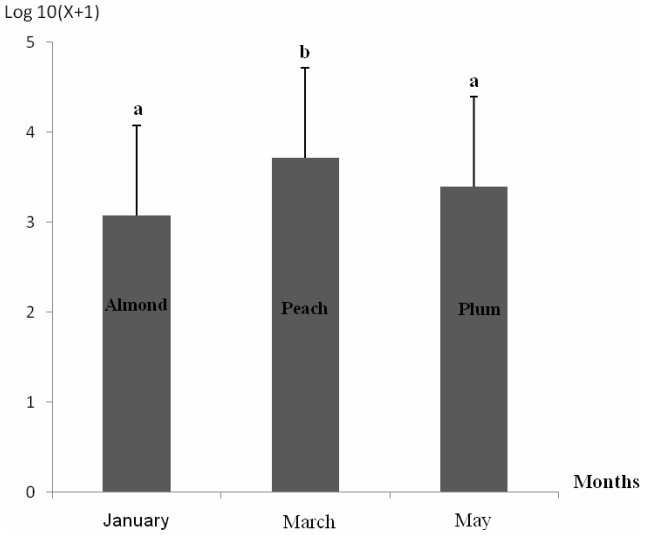

Fig. 8 ***P. persicae*** **on different hosts in Chott Mariem in 2009.** X = number of aphids.

environmental conditions; Talhouk observed an anholocyclic population in Syria and Lebanon in the warmer coastal areas and a holocyclic population in cold interior areas. Similar observations were reported by Blackman and Eastop (1994, 2000, 2006) and Rakhshani *et al*. (2005), who noted a holocyclic life cycle of *P. persicae* in colder areas of Romania, Italy and Greece.

However, aphid succession on different host trees and aphid behavior depends on cultural practices, particularly irrigation. In irrigated fields, populations were able to set all-year round on peach trees and could colonized its roots; thereafter, they moved to the collar and trunk following sap movement. The sap flow and its effect on the presence of insects were also noted by Thi Thuy *et al.* (2007) on *Macrosiphum euphorbiae* Thomas, Reynolds *et al.* (2007) on different insects, Miyasaka *et al*. (2007) on *Sipha flava* Forbes, Moravvej and Hatefi (2008) on *Acyrthosiphum pisum* Harris, and by Clark *et al.* (2009) and Pitman *et al.* (2010) on different species of aphids. In dry fields, the occurrence of aphid populations was recorded in several trees of different species of the *Prunus* genus. Different researchers suggested a second type of behavior in different countries (Darwich *et al.* 1989 in Egypt; El-Trigui *et al*. 1989, Ben Halima Kamel and Mabrouk 1997 and Ben Halima Kamel and Ben Hamouda 2005 in Tunisia; Rakhshani *et al*. 2005 in Iran). The presence of apteral individuals of *P. persicae* on roots is reported for the first time in this survey and indicates overwintering in this part under Tunisian conditions.

Effect of temperature and host plants on biotic potential of *P. persicae*

1. Under laboratory conditions

Table 4 illustrates that *P. persicae* development and reproduction were dependent on temperature and host plant. Regarding the temperature effects, our results showed that aphids reared on peach, almond, apricot and plum have a variable MRGR. Independent of the host plant, 20°C was most favorable to insect development. We also noticed, in some cases, that mass rearing was difficult to realize at 15 and 25°C on almond and at 15°C on apricot. In addition, the duration of a generation depended on temperature (**Table 4**). On peach, the duration at 15, 20 and 25°C was 39, 17.032 and 20 days, respectively, which indicates that *P. persicae* needs a short time to create a second generation at 20°C than at 15 and 25°C. Similar results were observed on plum and almond. Those results indicated that independent of the host plant, 20°C was the preferred temperature for *P. persicae* reproduction.

Table 4 MRGR and T at different temperatures and on *Prunuaceous* host tree fragments in rearing rooms.

Host trees	Temperature					
	15°C		20°C		25°C	
	MRGR	T	MRGR	T	MRGR	T
Peach	0.0152	20.39	0.0182	17.032	0.0155	20
Almond	0	0	0.0167	18.56	0	0
Plum	0.0115	26.95	0.0179	17.31	0.0126	24.60
Apricot	0	0	0.009	34.44	0.0105	29.52

MRGR: mean relative growth rate; T: aphid-specific age

Table 5 MRGR and T on *Prunuaceous* hosts trees in the fields in Chott Mariem.

Host trees	MRGR	T (days)
Peach	0.027	11.11
Almond	0.0192	15.62
Plum	0.022	13.63

MRGR: mean relative growth rate; T: aphid-specific age

Concerning the effects of host, MRGR varied from one host to another at the same temperature (**Table 4**). Our results proved that the duration of a generation depends on the host. Our observations indicate that *P. persicae* created the second generation after a shorter duration on peach than on almond, plum and apricot (**Table 4**). The study of temperature and host effect on aphid growth and reproduction illustrated the effect of host trees on MRGR under controlled condition and in fields where peach was the preferential host for this aphid. In addition, 20°C was the best temperature for the multiplication of *P. persicae* and temperatures above 25°C reduced the population. Other studies on the effect of temperature on this pest showed that the duration and severity of extremely low temperature during winter affects aphid survival (Walters and Dewar 1986; Harrington *et al*. 1990; Werker *et al.* 1998 in Cocu *et al*. 2005; Adler *et al*. 2007; Diffenbaugh *et al*. 2008). In the same context, other authors studied the effect of temperature on biology and population growth of species like *Aphis gossypii* Glover (Hemiptera, Aphididae) on cucumber under greenhouses (Zamani *et al*. 2006) and explained that the period of development of immature and the average longevity of adults varied between 8.56 days at 30°C and 17 days at 25°C. Those results demonstrated the influence of temperature on the growth of aphid species.

2. Under field conditions

The density of *P. persicae* under natural conditions in the Chott Mariem zone was significantly ($P < 0.05$) dependent on host plant and temperature (**Table 2**).

Aphids colonizing peach, almond and plum have variable density in relation to temperature (**Table 2**). Indeed, a high density of aphid on peach was observed in March when temperature was around 20°C (**Table 2**). Few individuals were observed in January and no colonies were found in May when the temperature was above 20°C. Independent of the host plant, temperatures near 20°C favored insect development the most. Nevertheless, the study showed that peach was the preferential host for insect production (**Table 5**).

Concerning the generation time, it was 11.11, 15.62 and 13.63 days, respectively on peach, almond and apricot which confirmed that under natural conditions, peach was the preferential host when the temperature was favorable. In the field, El Trigui *et al*. (1989) found that the *P. persicae* life cycle lasts 13 days in spring on plum and peach. In addition, Darwich *et al*. (1989) mentioned that in Egypt, under natural conditions, where the temperature fluctuated between 26.7 and 10.3°C, the development period of the four instars of *P. persicae* varied from 10 to 29 days. They indicated that the highest number of settled larvae was given by the apterous viviparae at the end of March and April and that females gave the highest number of progeny, reaching

an average of 26.9 larvae. In summer, the number of progeny began to decrease due to a slight increase in temperature. In this context, Avidov and Harpz (1969) in Kairo and Poswal (1995) indicated the effect of temperature on the development period. They recorded 15 days at 27°C which rose to 40 days at 14.5°C. Under natural conditions, Velmirovic (1977) in Kairo and Poswal (1995) recorded a development period of 20 days in March and 12 days in May and June.

CONCLUSION

Peach, almond, plum, apricot and apple are the host trees of *P. persicae* in Tunisia. Aphid was able to continue all-year round on peach in an irrigated orchard and in a sub-tropical climate, it can move from the roots and collar to trunks and can also change the host in a dry orchard and arid climate. Host and temperature were the principal factors affecting the aphid growth and development period during which peach was the preferential host and 20°C was the best temperature.

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