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Population dynamics of aphids (Aphididae) on orange (*Citrus sinensis* 'Thomson Navel') and mandarin (*Citrus reticulata* 'Blanco')

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ABSTRACT

Citrus fruits represent one of the most important fruit productions worldwide. However, they suffer from a numerous constraints. Aphids are among the causes of the decline in the production of citrus. In this study, the diversity of citrus aphids and their seasonal occurrence were explored on orange and mandarin, during 2012 and 2013, in an orchard located in Skikda province (Algeria). In total, six different aphid species were found during two years. The most common species was *Aphis spiraecola* Patch, 1914. Climatic conditions had an important role in the infestation level by aphids. There were changes of aphid dynamics between the two years of the investigation. No aphids was recorded in six months in 2012 (January, June, July, August, September and December) and in three months in 2013 (January, February and August). Besides, the number of identified aphid species increased from two to five. On the other hand, the orange trees seemed to be the most infested host species.

Key words: Algeria, citrus aphids, *Citrus reticulata*, *Citrus sinensis*, climate change, population dynamics

IZVLEČEK

POPULACIJSKA DINAMIKA LISTNIH UŠI (Aphididae) NA POMARANČEVCU (*Citrus sinensis* 'Thomson Navel') IN MANDARINOVCU (*Citrus reticulata* 'Blanco')

Plodovi citrusov so med najvažnejšimi v svetovni proizvodnji sadja, a je njihova proizvodnja omejena zaradi številnih omejitev. Listne uši so eden izmed vzrokov upada njihove proizvodnje. V tej raziskavi sta bila preučevana raznolikost in sezonsko pojavljanje listnih uši, ki se pojavljajo na citrusih v sadovnjaku pomarančevcev in mandarinovcev v provinci Skikda (Algeria), v letih 2012 in 2013. Celukupno smo v dveh letih raziskave našli šest različnih vrst listnih uši. Najbolj pogosta je bila vrsta *Aphis spiraecola* Patch, 1914. Pri okužbi z listnimi ušmi so imele pomembno vlogo klimatske razmere. Dinamika njihovega pojavljanja se je med obema letoma raziskave spreminjala. Listnih uši nismo zabeležili v obdobju šestih mesecev v letu 2012 in treh mesecev v letu in 2013. Poleg tega se je število vrst v tem obdobju povečalo iz dveh na pet. Pomarančevci so se izkazali kot najbolj okužen gostitelj.

Ključne besede: Alžirija, listen uši na citrusih, *Citrus reticulata*, *Citrus sinensis*, podnebne spremembe, populacijska dinamika

1 INTRODUCTION

Citrus is an important fruit crop worldwide (Altaha *et al*., 2012). The citrus are cultivated from about 15° N to 35° S, between sea level and 1000 m, and are susceptible to frost unless the tree is dormant (Hill, 2008). They are grown in more than 100 countries all over the world, mainly in tropical and subtropical areas, where favorable soil and climatic conditions prevail. Citrus fruits are marketed mainly as fresh fruit or as processed juice (Peña *et al.*, 2007). The citrus industry is one of the main components of Mediterranean agriculture, helping to guarantee incomes in underprivileged

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rural zones. Furthermore, citrus fruits provide the main source of vitamin C in the Mediterranean Basin, contributing to the general nutritional supply (Dambier *et al.*, 2011). In Algeria, the citriculture has a strategic importance because it is a source to supply fresh fruits (Biche, 2012). However, it suffers since a few years from a considerable decline of the production and the quality of fruits. Among the causes of this decline, the pests such as the aphids keep a predominant place (Boulfekhar-Ramdani, 1998). The latter are serious pests of many agricultural crops. Therefore, a good understanding of their population dynamics is vitally important for crop protection (Kindlmann and Dixon, 2010). Little quantitative data are available on the population dynamics of citrus aphids because of sampling difficulties (Lapchin *et al.*, 1994). Although aphids are dangerous pests, little is known about the aphid fauna of Algeria (Laamari *et al.*, 2010).

In this study, we established an inventory of the aphid species present on different citrus trees in the Northeastern Algerian region of Skikda, based on the prospection work carried out during two years (2012 and 2013). This constitute a step towards exploring the diversity of the Algerian aphid fauna on citrus and their seasonal occurrence, and comparing the aphids associated with different citrus species in order to elaborate an appropriate control plan against these pests, and thus contributing to increase the production of citrus fruits.

2 MATERIALS AND METHODS

The orchard used in this study is located in the northeast of Algeria (Emjez Djich: Skikda) (36° 42’ N, 6° 47’ E), planted with approximately 15-year-old citrus trees. The experimental area consisted of different citrus species and varieties, among them, we studied two species: ‘Thomson Navel’ sweet orange (*Citrus sinensis* L.) and ‘Carval Hal’ mandarin (*C. reticulata* Blanco), all grafted on Troyer citrange (*C. sinensis* (L.) Osb. × *Poncirus trifoliata* Raf.) rootstock. The trees were planted in rows with 5 m between rows. Intrarow-tree spacing was also 5 m. From January 2012 to December 2013, samples were taken every month.

Orange and mandarin trees were almost under the same management regime. There were no other crops under the trees. In general, the orchard was cultivated with low pesticide application, and weeding was executed mechanically.

In 2012, five young citrus shoots from each variety were randomly collected.

Lapchin *et al.* (1994) mentioned that sampling methods used to study the population dynamics of citrus aphids are generally based on counting infested shoots. Several authors (Yokomi and Tang, 1996; Kavallieratos *et al.*, 2002; Boukhris-Bouhachem, 2011) have used young citrus shoots to study citrus aphid in different countries (Puerto Rico, Greece and Tunisia respectively).

In 2013, four leaves from each tree, and four trees from each variety were sampled. Thus, totally 32 leaves were examined for each sampling date.

Fadamiro *et al.* (2008) and Yoldaş *et al.* (2011) also sampled leaves of citrus to study aphids in the United States and Turkey respectively.

On each sampling date, all the aphids (nymphs and adults regardless of species) and aphid mummies were counted on one shoot (in 2012) and on one leaf (in 2013). Individuals of dipteran predators were counted visually in the field only as larvae. Aphids were transferred in tubes to be conserved in ethanol and then identified in the laboratory using identification key of Stoetzel (1994) and those of Blackman and Eastop (2000).

Statistical analysis was done by using aphid densities obtained during study (24 sampling months). Data were analyzed by one-way ANOVA. All the statistical procedures were performed using SPSS for Windows 10.0.5 (SPSS, Inc.). Figures were drawn using Microsoft Excel 2007.

3 RESULTS

The aim of this work was to obtain knowledge on population dynamics of aphids on two citrus species in Algeria (Mediterranean region). Thus, samples (shoots or leaves) were taken every month during two years to assess and identify aphids.

Six species of aphids in total were found on two citrus varieties in this study (Tables 1 and 2) including *Aphis spiraecola, A. gossypii, A. nerii, A. craccivora, Myzus persicae* and *Macrosiphum euphorbiae.* We identified four species on orange and four on mandarin.

3.1 Aphids and population dynamics

Table 1: Occurrence of aphid species in the studied orchard during 2012
+ rare species; +++ dominant species

	'Thomson Navel' sweet orange	'Carval Hal' mandarin
Aphis spiraecola (Patch, 1914)	+++	+++
Aphis craccivora (Koch, 1854)	+	

Table 2: Occurrence of aphid species in the studied orchard during 2013
+ rare species; +++ dominant species

	'Thomson Navel' sweet orange	'Carval Hal' mandarin
Aphis spiraecola (Patch, 1914)	+++	+++
Aphis gossypii (Glover, 1877)	+	+
Myzus persicae (Sulzer, 1776)		+
Macrosiphum euphorbiae (Thomas, 1878)	+	
Aphis nerii (Boyer De Fonscolombe, 1841)		+

The infestation of orange and mandarin trees by aphids varied markedly among sampling dates (Figures 1 and 2). In 2012, densities of aphids decreased to zero in six months (January, June, July, August, September and December). However, no aphids was noted in 2013 in three months only (January, February and August). We remark also that the highest levels of infestation were concentrated in autumn and spring. About 35 % and 43 % of the total infestations was recorded on April and November 2012 respectively. In 2013, the biggest proportion of infestation was in April with about 36 % of the total infestation, and in September with approximately 42 %.

3.2 Difference of infestation between citrus species

During the first year of the study, ANOVA showed significant difference among the aphids that infested citrus species in April (231,6 aphids/shoot on orange 15,6 aphids/shoot on mandarin, $F = 17{,}469$, $p = 0.003$) and in November (240,8 and 65,8 aphids/shoot on orange and mandarin respectively, $F = 5{,}907$, $p = 0.041$). During the second year, ANOVA revealed significant differences of the infestation degree between the examined citrus species in June (11,06 aphids/leaf on orange and 0,75 aphid/leaf on mandarin, $F = 4{,}395$, $p = 0.045$), September (107,31 and 19,88 aphids/leaf on orange and mandarin respectively, $F = 5{,}280$, $p = 0.029$) and October (11,06 on orange and 0,75 on mandarin, $F = 8{,}901$, $p = 0.006$). No significant difference was recorded between aphids found on different citrus species during the other months in both years of the study.

'Thomson Navel' orange trees seemed to be the most infested cultivar with a peak of approximately 241 aphids/shoot observed on November 2012 (Figure 1), and 107 aphids/leaf noted on September 2013 (Figure 2). On the other hand, 'Carval Hal' mandarin appears the least infested with maximal value of about 66

aphids/shoot on November 2012 and 33 aphids/leaf on April 2013. Besides, no aphid was recorded on mandarin in twelve months among 24 sampling dates.

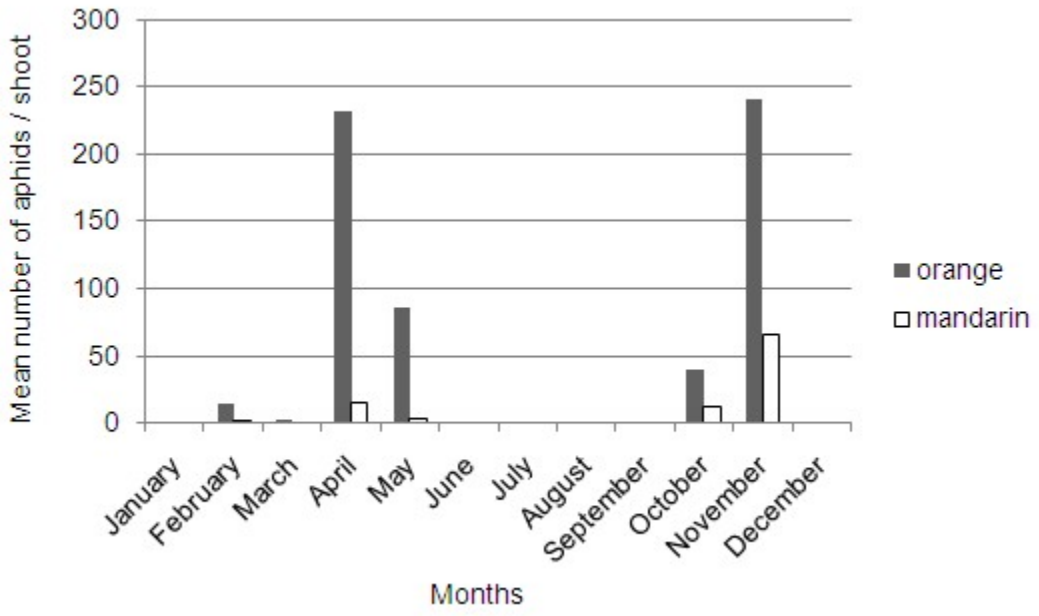

Figure 1: Seasonal abundances of aphids in the studied citrus orchard from January to December 2012. Values indicate mean number of aphids (nymphs + adults) of 5 shoots.

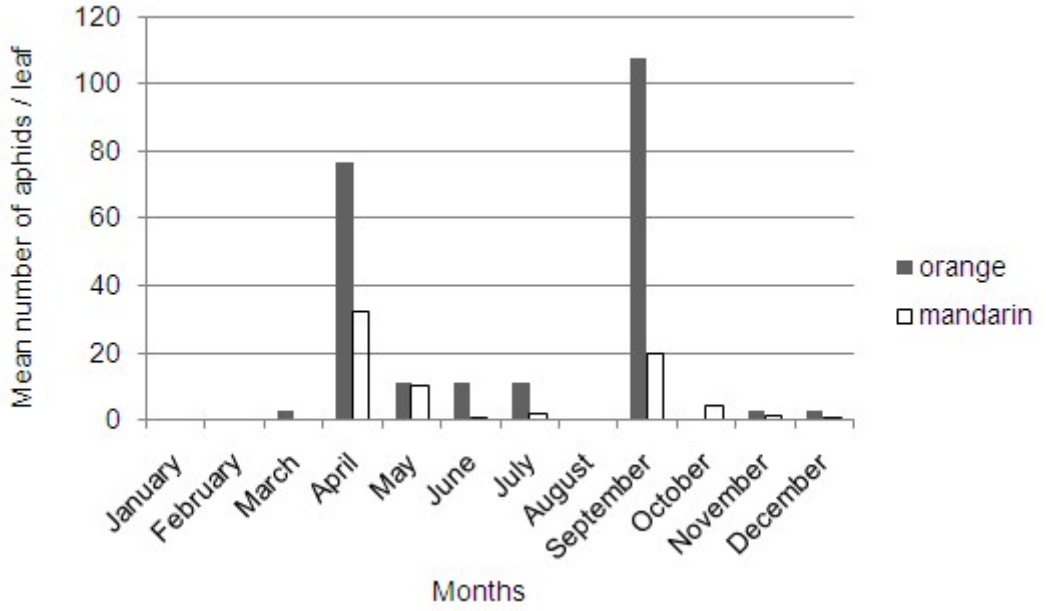

Figure 2: Seasonal abundances of aphids in the studied citrus orchard from January to December 2013. Values indicate mean number of aphids (nymphs + adults) of 16 leaves.

In general, on the two hosts, we noted a progressive increasing in the mean number of aphids until reaching a first peak in spring, and then decreasing until 0 in some months of summer. The infestation level increased once again to arrive to a second peak in the same year in autumn, and it reduced another time in winter.

3.3 Natural enemies of citrus aphids

Predators of citrus aphids found in this study were mainly larvae of syrphids. Its number was slightly higher than parasitoids, although it remains very limited (Tables 3 and 4). The distribution and abundance of predators varied among citrus species. The highest number was found on orange.

Concerning parasitoids, their number was much reduced. There were only two mummified individuals on mandarin (on February 2012) and three mummified aphids on orange (on May 2013).

Table 3: Number of predators of citrus aphids found on orange and mandarin trees in 2012. Values indicate total number of predators on 5 shoots.

	January	February	March	April	May	June	July	August	September	October	November	December
Orange	0	0	0	3	1	0	0	0	8	0	1	0
Mandarin	0	0	0	0	0	0	0	0	0	0	0	0

Table 4: Number of predators of citrus aphids found on orange and mandarin trees in 2013. Values indicate total number of predators on 16 leaves.

	January	February	March	April	May	June	July	August	September	October	November	December
Orange	0	0	0	2	5	0	0	0	0	0	0	0
Mandarin	0	0	0	0	0	0	0	0	2	2	0	0

4 DISCUSSION

4.1 Aphids and population dynamics

Six species of aphid was detected in this survey. There were five aphid species present as different degree vector of *Citrus tristeza virus* transmission: *Aphis spiraecola, A. gossypii, Myzus persicae, Toxoptera aurantii* Boyer de Fonscolombe, 1841 and *T. citricida* Kirkaldy, 1907. This latter is the most important, it is already present in certain countries of the Mediterranean region (Lebdi Grissa, 2010). However, in our study, it was not found.

We found four aphid species on 'Thomson Navel' sweet orange and four on 'Carvalhal' mandarin. Two among the identified aphids (*Aphis spiraecola* and *Aphis gossypii*) were present on the two citrus varieties. While *Aphis craccivora* and *Macrosiphum euphorbiae* were determined on orange only, *Myzus persicae* and *Aphis nerii* were observed on mandarin. Similarly, Ben Halima-Kamel and Ben Hamouda (2005) and Kavallieratos *et al.* (2007) mentioned differences between the species of aphids that infested orange, lemon, sour orange and clementine in Tunisia, and those attacking orange and mandarin in Greece respectively.

In this study, the aphids identified on orange were *Aphis spiraecola*, *A. gossypii, A. craccivora* and *Macrosiphum euphorbiae*. Four aphid species are found frequently on orange trees in the Mediterranean region, which are *Aphis spiraecola*, *A. gossypii, Toxoptera aurantii* and *Myzus persicae* (Loussert, 1989). Ben Halima-Kamel and Ben Hamouda (2005) found besides these species, *Aphis fabae* Scopoli, 1763 and *A. craccivora* Koch, 1854 on 'Maltaise' and 'Valencia' oranges in Tunisia. Nevertheless, Kamel (2010) identified only *A. gossypii* on both 'Baladi' and 'Navel' orange in Egypt; and Lopes *et al.* (2006) showed that seven species of aphids were found on orange in Portugal, among them *A. hederae* Kaltenbach, 1843, *A. solanella* Theobald, 1914 and *Anoecia haupti* Börner, 1950. Differences among these studies are due to environmental conditions and the effect of the host variety.

The most common species observed in this survey was *Aphis spiraecola*, and with lower importance *Aphis gossypii*. The hierarchy of the species is highly variable from country to country. *A. gossypii* is generally not the most abundant species (Lapchin *et al.*, 1994). Several studies showed that *A. spiraecola* and *A. gossypii* were among the most abundant species on citrus trees in Algeria (Franco *et al.*, 2006), in Morocco (Belati and Belabed, 2014), in Tunisia (Ben Halima-Kamel and Ben Hamouda, 2005; Lebda Grissa, 2010), in Italy (Yahiaoui *et al.*, 2009), in Spain (Marroquín *et al.*,

2004) and in the United States (Powel *et al.*, 2006; Fadamiro et *al.*, 2008). In contrast, *Toxoptera aurantii* and *T. citricida* were the major aphids of orange, mandarin, and other *Citrus* spp. in the southeast of Asia (Bayhan *et al.*, 2006).

On the other hand, the peak of infestation and number of auxiliaries were observed mainly in spring and in autumn. This coincides with moderate temperature and the production of new shoots appropriate for the reproduction of aphids and consequently the occurrence of predators and parasitoids. Many researches mentioned the peak of infestation by some aphids on citrus trees in spring (Saharaoui and Hemptinne, 2009; Kamel, 2010; Yoldaş *et al.*, 2011; Mostefaoui *et al.*, 2014). The within-year dynamics of aphids are largely determined by seasonal changes in host quality. Aphids do best when amino acids are actively translocated in the phloem. Thus on trees, the leaves are most suitable for aphids in spring and autumn (Kindlmann and Dixon, 2010).

The fluctuations of infestation during two years of study seem to be influenced by the changes of temperatures. Many authors mentioned the importance of temperature for the biology of aphids (Bayhan *et al.*, 2006; Dixon and Hopkins, 2010; Harrington and Clark, 2010; Gao *et al.*, 2013). Several generations follow each other during campaign in favorable conditions, elevated humidity and temperature between 20 and 25 °C; during big heats of summer, the infestations are less numerous (Bellabas, 2011). In addition, aphid reproduction and survival could be significantly reduced in summer if there are longer periods when temperature remains above the optimal threshold for aphid growth (Qureshi, 2010). Planet Earth has experienced many significant climatic changes. The increase in the concentration of greenhouse gases in the atmosphere induces an increase in temperature, which influences other climatic parameters (Ameixa, 2010). Benhamiche *et al.* (2014) cited some indicators of climate change in Algeria. Recent changes in climate, particularly warmer temperatures, have already begun to impact on biodiversity and ecosystems. Changes in species distributions, population sizes, the timing of reproduction and migration events, and in the frequency of pest and disease outbreaks have all been documented and linked to elevated temperatures (Bergant *et al.*, 2005; Roy and Majerus, 2010).

In this study, the number of identified aphid species increased from two in 2012 to five in 2013. Hullé *et al.* (2010) demonstrated that temperature changes had repercussions for aphid diversity and population dynamics. At a pan-European scale, the EXAMINE observation network has provided evidence for an increase in the number of aphid species present over the last 30 years and for earlier spring flights.

4.2 Difference of infestation between citrus species

A difference in infestation between the tested citrus species was noted, with the biggest number on orange. In the same way, Marroquín *et al.* (2004) found, in their study in Spain, that clementine was the most attacked host species, followed by lemon, sweet orange, grapefruit, and satsuma. Additionally, Kavallieratos *et al.* (2002) mentioned differences between the number of aphids that infested orange and tangerine trees in Greece.

Winged aphids visit many plants and the selection is realized based on many physical and chemical factors. This latter include stimulating or inhibiting substances such as essential nutrients (amino acids and sugars) which launch usually a behavior effect (Herrbach, 1985); and plant secondary metabolites that are involved in insect-host interactions mainly by chemical derived substances and volatile substances (Bhatia *et al.*, 2011).

4.3 Natural enemies of citrus aphids

Very limited number of predators and parasitoids were observed in this investigation. The predators found consisted of syrphid larvae. Some syrphids have larvae devour aphids (Sarthou and Speight, 2005; Biche, 2012). They feed on the aphid by piercing and sucking out the body contents, while holding the prey aloft (Sullivan, 2008).

Climate change can have diverse effects on natural enemies of pest species. The fitness of natural enemies can be altered in response to changes in herbivore quality and size induced by temperature and CO_2 effects on plants (Thomson *et al.*, 2010). Majority insect life history traits are linked to

temperature. All trophic levels stand to be affected by the increase in average global temperature: the herbivores, their natural enemies (parasitoids, predators and pathogens), and hyperparasitoids and tertiary predators (van Baaren *et al.*, 2010). Hotter, longer summers would imply extended periods of prey scarcity for aphid natural enemies and could further impede their ability to survive this difficult season (Qureshi, 2010).

In conclusion, this study showed differences between infestation of orange and mandarin trees by aphids in northeastern Algeria (Skikda). The 'Thomson Navel' orange was more infested than 'Carval Hal' mandarin. *Toxoptera citricida*, which is an effective vector of tristeza virus, was not identified; but four among the six aphid species identified are reported to transmit this quarantine virus. Comparing same periods of the two years of study, the degree of infestation changed. Thus, more concentration should be given to orange trees during all seasons, especially in spring and autumn, for best controlling aphid pests. On the other hand, a reduced level of parasitoids and predators were remarked, that cannot limit the proliferation of aphids. Therefore, new adapted auxiliaries should be researched and used, to contribute to the increasing of citrus production.

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6 REFERENCES

Al-taha H.A., Jasim A.M., Abbas M.F. 2012. Somatic embryogenesis and plantlet regeneration from nucleus tissues of Local orange (*Citrus sinensis* (L.) Osbeck). Acta agriculturae Slovenica, 99, 2: 185-189

Ameixa O.M.C.C. 2010. Aphids in a changing world. V: Aphid Biodiversity under Environmental Change: Patterns and Processes. P. Kindlmann, A.F.G. Dixon, Michaud J.P. (eds.). Dordrecht, Heidelberg, London, New York, Springer Science & Business Media: 21-40, doi: 10.1007/978-90-481-8601-3_2

Bayhan E., Lmez-Bayhan S.ö., Ulusoy M.R., Chi H. 2006. Effect of temperature on development, mortality, fecundity, and reproduction of *Aphis rumicis* L. (Homoptera: Aphididae) on broadleaf dock (*Rumex obtusifolius*) and Swiss chard (*Beta vulgaris vulgaris* var. *cida*). Journal of Pest Science, 79: 57-61, doi: 10.1007/s10340-005-0112-7

Belati F., Belabed A. 2014. Phytosanitary state of plant citrus in irrigated area of the lower Moulouya (Morroco Oriental). Nature & Technology, 10: 09-15

Bellabas A. 2011. Etude de base sur les agrumes en Algérie. Rome, Food and Agriculture Organisation: 45 str.

Ben Halima-Kamel M., Ben Hamouda M.H. 2005. A propos des pucerons des arbres fruitiers de Tunisie. Notes Fauniques de Gembloux, 58: 11-16

Benhamiche N., Madani K., Laignel B. 2014. Impact of climate changes on water resources in Algeria V: Vulnerability of Agriculture, Water and Fisheries to Climate Change: Toward Sustainable Adaptation Strategies. Behnassi M., Muteng'e M.S., Ramachandran G., Shelat K.N. (eds.). Dordrecht, Heidelberg, New York, London, Springer Science+Business Media: 193-205

Bergant K., Trdan S., Žnidarčič D., Črepinšek Z., Kajfež-Bogataj L. 2005. Impact of climate change on developmental dynamics of *Thrips tabaci* (Thysanoptera: Thripidae): can it be quantified?. Environmental entomology, 34, 4: 755-766, doi: 10.1603/0046-225X-34.4.755

Bhatia V., Uniyal P.L., Bhattacharya R. 2011. Aphid resistance in Brassica crops: challenges, biotechnological progress and emerging possibilities. Biotechnology Advances, 29: 879-888, doi: 10.1016/j.biotechadv.2011.07.005

Biche M. 2012. Les principaux insectes ravageurs des agrumes en Algérie et leurs ennemis naturels. Algeria, Food and Agriculture Organisation, 36 str.

Blackman R.L., Eastop V.F. 2000. Aphids on the world's crops: An identification and information guide. England, John Wiley & Sons, 466 str.

Boukhris-Bouhachem S. 2011. Aphid enemies reported from Tunisian citrus orchards. Tunisian Journal of Plant Protection, 6: 21-27

Boulfekhar-Ramdani H. 1998. Inventaire des acariens des citrus en Mitidja. Annales de l'Institut National Agronomique El Harrach, 19: 30-39

Dambier D., Benyahia H., Pensabene-Bellavia G., Kaçar Y.A., Froelicher Y., Belfalah Z., Lhou B., Handaji N., Printz B., Morillon R., Yesiloglu T., Navarro L., Ollitrault P. 2011. Somatic hybridization for citrus rootstock breeding: an effective tool to solve some important issues of the Mediterranean citrus industry. Plant Cell Reports, 30: 883-900, doi: 10.1007/s00299-010-1000-z

Dixon A.F.G., Hopkins G.W. 2010. Temperature, seasonal development and distribution of insects with particular reference to aphids. V: Aphid Biodiversity under Environmental Change: Patterns and Processes. P. Kindlmann, A.F.G. Dixon, Michaud J.P. (eds.). Dordrecht, Heidelberg, London, New York, Springer Science & Business Media: 129-147

Fadamiro H.Y., Xiao Y., Hargroder T., Nesbitt M., Umeh V., Childers C.C. 2008. Seasonal occurrence of key arthropod pests and associated natural enemies in Alabama Satsuma citrus. Environmental Entomology, 37, 2: 555-567, doi: 10.1093/ee/37.2.555

Franco J.C., Garcia-Marí F., Ramos A.P., Besri M. 2006. Survey on the situation of citrus pest management in Mediterranean countries. IOBC/WPRS Bulletin, 29, 3: 335-346

Gao G.-Z., Perkins L.E., Zalucki M.P., Lu Z.-Z., Ma J.-H. 2013. Effect of temperature on the biology of *Acyrthosiphon gossypii* Mordvilko (Homoptera: Aphididae) on cotton. Journal of Pest Science, 86: 167-172, doi: 10.1007/s10340-012-0470-x

Harrington R., Clark S. 2010. Trends in the timings of the start and end of annual flight periods. V: Aphid Biodiversity under Environmental Change: Patterns and Processes. P. Kindlmann, A.F.G. Dixon, Michaud J.P. (eds.). Dordrecht, Heidelberg, London, New York, Springer Science & Business Media: 41-54

Herrbach E. 1985. Rôle des sémiochimiques dans les relations pucerons-plantes: II- Les substances allélochimiques. Agronomie, 5, 4: 375-384, doi: 10.1051/agro:19850412

Hill D.S. 2008. Pests of crops in warmer climates and their control. Springer Science & Business Media: 704 str.

Hullé M., Cœur d'Acier A., Bankhead-Dronnet S., Harrington R. 2010. Aphids in the face of global changes. Comptes Rendus Biologies, 333: 497-503, doi: 10.1016/j.crvi.2010.03.005

Kamel A.S. 2010. Insects attack citrus trees in Al-Qalyubiyah Governorate, Egypt. Egyptian Academic Journal of Biological Sciences, 3, 2: 107-117

Kavallieratos N.G., Athanassiou C.G., Stathas G.J., Tomanović Ž. 2002. Aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) on citrus: seasonal abundance, association with the species of host plant, and sampling indices. Phytoparasitica, 30, 4: 365-377, doi: 10.1007/BF02979684

Kavallieratos N.G., Tomanović Ž., Sarlis G.P., Vayias B.J., Žikić V., Emmanouel N.E. 2007. Aphids (Hemiptera: Aphidoidea) on cultivated and self-sown plants in Greece. Biologia Bratislava, 62, 3: 335-344, doi: 10.2478/s11756-007-0056-x

Kindlmann P. and Dixon A.F.G. 2010. Modelling population dynamics of aphids and their natural enemies. V: Aphid Biodiversity under Environmental Change: Patterns and Processes. P. Kindlmann, A.F.G. Dixon, Michaud J.P. (eds.). Dordrecht, Heidelberg, London, New York, Springer Science & Business Media: 1-20.

Laamari M., Jousselin E., Cœur D'acier A. 2010. Assessment of aphid diversity (Hemiptera: Aphididae) in Algeria: a fourteen-year investigation. Faunistic Entomology, 62, 2: 73-87

Lapchin L., Guyot H., Brun P. 1994. Spatial and temporal heterogeneity in population dynamics of citrus aphids at a regional scale. Ecological Research, 9: 57-66, doi: 10.1007/BF02347242

Lebdi Grissa K. 2010. Etude de base sur les cultures d'agrumes et de tomates en Tunisie. Regional integrated pest management program in the Near East GTFS/REM/070/ITA. Food and Agriculture Organisation: 93 str.

Lopes D.J.H., Cabrera P.R., Pereira A., Figueiredo A., Santos A.M., Melo C., Silva L., Silva D., Filipes M.C., Mexia A.M.M. 2006. The Phytosanitary problems that affect orange groves on Terceira Island, Azores. IOBC/WPRS Bulletin, 29, 3: 17-28

Loussert R. 1989. Les Agrumes, Tome 2: Production. Paris, Technique et Documentation – Lavoisier: 158 str.

Marroquín C., Olmos A., Gorris M.T., Bertolini E., Martínez M.C., Carbonell E.A., de Mendoza A.H., Cambra M. 2004. Estimation of the number of aphids carrying *Citrus tristeza virus* that visit adult

citrus trees. Virus Research, 100: 101-108, doi: 10.1016/j.virusres.2003.12.018

Mostefaoui H., Allal-Benfekih L., Djazouli Z.-E., Petit D., Saladin G. 2014. Why the aphid *Aphis spiraecola* is more abundant on clementine tree than *Aphis gossypii*? Comptes Rendus Biologies, 337: 123-133, doi: 10.1016/j.crvi.2013.11.008

Peña L., Cervera M., Fagoaga C., Romero J., Juárez J., Pina J.A., Navarro L. 2007. Citrus. V: Biotechnology in Agriculture and Forestry. Pua E.C., Davey M.R. (eds.). Berlin, Heidelberg, Springer: 35-50

Powel C.A., Burton M.S., Pelosi R.R., P.A. Rundell, Ritenour M.A., Bullock R.C. 2006. Six-year evaluation of brown citrus and spirea aphid populations in a citrus grove and effects of insecticides on these populations. HortScience, 41, 3: 688-690

Qureshi J.A. 2010. Implications of climate change for *Toxoptera citricida* (Kirkaldy), a disease vector of citrus in Florida V: Aphid Biodiversity under Environmental Change: Patterns and Processes. P. Kindlmann, A.F.G. Dixon, Michaud J.P. (eds.). Dordrecht, Heidelberg, London, New York, Springer Science & Business Media: 91-106

Roy H.E., Majerus M.E.N. 2010. Coccinellids in a changing world. V: Aphid Biodiversity under Environmental Change: Patterns and Processes. P. Kindlmann, A.F.G. Dixon, Michaud J.P. (eds.). Dordrecht, Heidelberg, London, New York, Springer Science & Business Media: 149-170, doi: 10.1007/978-90-481-8601-3_9

Saharaoui L., Hemptinne J.-L. 2009. Dynamique des communautés des coccinelles (Coleoptera: Coccinellidae) sur agrumes et interactions avec leurs proies dans la région de Rouiba (Mitidja orientale) Algérie. Annales de la Société Entomologique de France, 45, 2: 245-259, doi: 10.1080/00379271.2009.10697604

Sarthou J.-P., Speight M.C.D. 2005. Les Diptères Syrphidés, peuple de tous les espaces. Insectes, 137, 2: 3-8

Stoetzel M.B. 1994. Aphids (Homoptera: Aphididae) of potential importance on *Citrus* in the United States with illustrated keys to species. Proceedings of the Entomological Society of Washington, 96, 1: 74-90

Sullivan D.J. 2008. Aphids (Hemiptera: Aphididae). V: Encyclopedia of Entomology. Capinera J.L. (eds.). Dordrecht, Heidelberg, Springer Science+Business Media: 191-215

Thomson L.J., Macfadyen S., Hoffmann A.A. 2010. Predicting the effects of climate change on natural enemies of agricultural pests. Biological Control, 52: 296-306, doi: 10.1016/j.biocontrol.2009.01.022

van Baaren J., Le Lann C., van Alphen J.J. 2010. Consequences of climate change for aphid-based multi-trophic systems. V: Aphid Biodiversity under Environmental Change: Patterns and Processes. P. Kindlmann, A.F.G. Dixon, Michaud J.P. (eds.). Dordrecht, Heidelberg, London, New York, Springer Science & Business Media: 55-68

Yahiaoui D., Addante R., Djelouah K., D'Onghia A.M. 2009. Preliminary monitoring of *Citrus tristeza virus* (CTV) vectors in Apulia region. Options Méditerranéennes, B 65: 173-175

Yokomi R.K., Tang Y.Q. 1996. A survey of parasitoids of Brown Citrus Aphid (Homoptera: Aphididae) in Puerto Rico. Biological Control, 6: 222-225, doi: 10.1006/bcon.1996.0027

Yoldaş Z., Güncan A., Koçlut T. 2011. Seasonal occurrence of aphids and their natural enemies in Satsuma mandarin orchards in Izmir, Turkey. Türkiye Entomoloji Dergisi, 35, 1: 59-74