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Population Trends of Woolly Apple Aphid, *Eriosoma lanigerum* and its Parasitoid, *Aphelinus mali* on two Apple Cultivars in Jordan

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ABSTRACT

The population trends of Woolly Apple Aphid (WAA), *Eriosoma lanigerum* Hausmann (Homoptera: Aphididae) and its parasitoid, *Aphelinus mali* Haldeman (Hymenoptera: Aphelinidae) were studied on two apple cultivars, Fuji and Golden Delicious during 2006-2007. Results indicated that even though both Fuji and Golden Delicious were grafted on the same rootstock, MM.106, but both of them showed variability in the populations of WAA. The edaphic populations of WAA recorded on Fuji during winter while roots of Golden Delicious did not sustain any form of WAA. Generally, aerial aphid colonies on both Fuji and Golden Delicious have been seen throughout the year except in severe winters from January to the end of March. Peak abundance of aerial populations on Fuji was 240 colonies per tree in November 2006 and 225 colonies per tree in August 2007. Peak abundance of arboreal populations in Golden Delicious was 43 colonies per tree in November 2006 and 33 colonies per tree in July 2007. Fuji sustained higher numbers of WAA than Golden Delicious throughout the years of study. The percentages of mummified WAA were very low (less than 10 %) during 2006-2007, but always higher on Fuji than on Golden Delicious.

Keywords: Population Trends, *Eriosoma lanigerum*, Fuji, *Aphelinus mali*, Golden Delicious.

INTRODUCTION

Woolly Apple Aphid (WAA), *Eriosoma lanigerum* Hausmann, is an important pest of apple orchards worldwide. It is native to eastern North America, where it used American elm (*Ulmus americanum* L.) as the primary host. This pest was spread to other growing regions throughout the globe beginning as early as the mid-1700s, before quarantine measures were conceived, let alone implemented (Beers *et al.*, 2006). It has become a more severe pest in apple production in Jordan in the past two decades (Ateyyat and Al-Antary, 2009). WAA infests both the aerial and edaphic (root) parts of the apple tree (Gurney, 1926; Lloyd, 1961). Its infestation reduces shoot growth and hence production capacity (Brown and Schmitt 1990; Brown *et al.*, 1995). Adult females over-wintering on the roots, continue to slowly develop and reproduce (Thwaite and Bower, 1983). Spring migration of crawlers from the roots into the tree is the major source of re-infestation each year (Hoyt and Madsen, 1960).

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Aphelinus mali (Hald) (Hymenoptera: Aphelinidae) is considered the most important natural enemy for WAA. This parasitoid parasitizes the aerial population of WAA (Mols and Boers, 1998; Mols *et al.*, 1996). Studies showed that *A. mali* parasitised all stages of *E. lanigerum* reared on potted apple plants, but preferred 3rd-instar nymphs and older hosts (Mueller *et al.*, 1992).

With attention to the importance of WAA in Jordan apple orchards, the population trends of WAA and its parasitoid, *Aphelinus mali* was studied on two apple cultivars of different characteristics, Fuji and Golden Delicious.

MATERIALS AND METHODS

This study was conducted at the Apple Genetic Complex in Ash-Shoubak Regional Center of Agriculture Research and Extension (about 1300 m above sea level and 220 Km south of Amman). All the trees at the experimental site were planted in 1992 and trained under the central-leader system to an average height of 3 m (range 2.5.–3.5 m), with a mean trunk diameter of approximately 30 cm. All trees were planted on Merton-Malling Series (MMS) 106 rootstock. Planting distances were a 5 by 5 m grid. The experiment was conducted on two cultivars of apple of different characteristics; Fuji and Golden Delicious (Table 1). Aerial colonies of woolly apple aphid were monitored every 2 weeks from the beginning of January 2006 to December 2007. Five trees were randomly chosen from each cultivar. The numbers of WAA colonies were counted on the trunk and 8 randomly chosen terminals of each tree (4 primary and 4 secondary scaffold limbs). For counting edaphic WAA colonies, five trees of each cultivar were uprooted once in December 2005, and soil was removed from the roots. As the roots were cleaned, aphid colonies were counted on the primary and secondary roots of the last 20 cm of basal growth. Also, the parasitism of WAA by *Aphelinus mali* was studied on both Fuji and Golden Delicious by choosing 5 trees of each cultivar monthly and cutting randomly five 10-cm secondary scaffold limbs from each tree. The percentage of mummified WAA on each tree was recorded, then the branch sections were placed in aerated 8-cm Petri dish that were held in an incubator at 25 ± 2 ˚C. The numbers of emerged adults of *A. mali* were recorded.

RESULTS

Populations of WAA on Fuji

Edaphic populations of WAA on Fuji were recorded from January to mid March of 2006 and from December 2006 to mid April 2007 when mean soil temperatures ranged from 8 to 13˚C (Figs. 1, 2). Upward movement of WAA on the trunk began in April 2006, when mean ambient temperature was above 10˚C. WAA populations increased on the trunk and reached a plateau (40 colonies per tree) in November 2006 after which downward movement began and populations disappeared in January 2007 (Fig. 2). In 2007, the populations of WAA reached a plateau (80 colonies per tree) on the trunk in August after which downward movement began and populations disappeared in December (Fig. 2). Aerial populations of WAA on primary and secondary scaffold limbs were recorded from April and disappeared in the last week of December in both years of study, 2006 and 2007 (Fig. 2). Populations of WAA reached a plateau on limbs (about 100 colonies on the primary scaffold limbs and 140 colonies on the secondary scaffold limbs) in November 2006 and in August 2007 (about 120 colonies on the primary scaffold limbs and 100 colonies on the secondary scaffold limbs) (Fig. 2).

Populations of WAA on Golden Delicious

WAA was not recorded on the roots of Golden

Delicious apple grafted on MM106 rootstock. Populations of WAA were recorded on the trunk throughout the year except from January to March 2006 and from January to April 2007 (Fig. 3). The highest populations on the trunk of Golden Delicious were recorded in July 2006 (32 colonies) and in August 2007 (22 colonies) (Fig. 3). In 2006, WAA appeared in April on the primary scaffold limbs and in June on the secondary scaffold limbs (Fig. 3). But in 2007, WAA appeared in May on both primary and secondary scaffold limbs (Fig. 3).

Populations of WAA on Fuji *vs* Golden Delicious

Generally, Fuji sustained a higher number of WAA colonies throughout the period of study. Complete absence of WAA colonies was detected on Golden Delicious from January to March 2006 and from January to April 2007 (Fig. 4) The highest total number of WAA populations on both edaphic and aerial parts of Fuji tree was recorded in November 2006 (278 colonies) and August 2007 (308 colonies) (Fig. 4). As a total number of WAA populations on both edaphic and aerial parts of Golden Delicious, two distinct peaks were recorded in 2006, one in July (67 colonies) and the other was in November (65 colonies), while in 2007 only one distinct peak was recorded in August (55 colonies) (Fig. 4).

Parasitism of WAA by *Aphelinus mali*

Parasitism was recorded on Fuji earlier than that recorded on Golden Delicious in both years of study, 2006 and 2007 (Fig. 5). Even though the percentages of mummified WAA were very low (less than 10%) during this period, the percentage was always higher on Fuji than on Golden Delicious (Fig. 5). The same was true for the number of emerged *A. mali* on both cultivars (Fig. 6).

DISCUSSION

The aphid *Eriosoma lanigerum* infests both the canopy and root system of *Malus* spp (Deng *et al.*, 1993). Root damage is usually more severe than stem damage and more difficult to control. Populations of *Eriosoma lanigerum* were studied in Ashoubak area on two apple cultivars grafted on MM.106. The first cultivar is Fuji that was recorded as highly susceptible cultivar to WAA, and the second was Golden Delicious that was recorded as resistant cultivar (Ateyyat and Al-Alntary, 2009). Even though both Fuji and Golden Delicious are grafted on the same rootstock, MM106, both of them showed variability in the populations of WAA particularly the edaphic populations of WAA that were recorded on Fuji during winter while roots of resistant Golden Delicious did not sustain any form of WAA.

Generally, aerial aphid colonies on both Fuji and Golden Delicious have been seen throughout the year except in severe winters from January to the end of March at 6.5 °C mean temperature (4.0 to 10.0 °C). During severe winters, WAA moved to roots of Fuji, at which the mean soil temperature was 10.33°C (8.0 to 13 °C). In a study conducted in India on Royal Delicious, Sushma-Bhardwaj *et al.* (1995) indicated that ambient temperature (>10.3°C) and soil temperature (>11.5°C) triggered the aphid movement toward aerial zone.

Variations in the timing of peak abundance of aerial populations of WAA in Fuji and Golden Delicious apples were recorded. Peak abundance of aerial populations on Fuji was 240 colonies per tree in November 2006 and 225 colonies per tree in August 2007. Peak abundance of aerial populations in Golden Delicious was 43 colonies per tree in November 2006 and 33 colonies per tree in July 2007. However, Fuji sustained higher numbers of WAA than Golden Delicious throughout the study. This agrees with Ateyyat and Al-Antary (2009) finding who approved that Fuji is more susceptible to WAA attack than Golden Delicious.

The incidence of *E. lanigerum* on 4 apple varieties

was determined in field trials in Meghalaya of India during 1977-78 (Sachan and Gangwar, 1989). The mentioned researchers indicated that no significant differences were observed with regard to the percentage infestation of plants or the average number of aerial colonies per plant, but highly significant differences were recorded between percentage infestation of branches. The highest infestation was recorded on Royal Delicious and the lowest on Golden Delicious.

Variations were obtained in the percentages of mummified WAA on Fuji and Golden Delicious. Even though the experiments were conducted on trees in which no spraying was allowed, the percentages of mummified WAA were very low (less than 10%) during 2006-2007, but always higher on Fuji compared with that recorded on Golden Delicious. The low percentage of parasitism could be due to the extensive use of pesticides by apple orchardists in the area that prevents the parasitoid to build up its population. The highest number of emerged *A. mali* was obtained from samples colleced from Fuji in November of both years of study. This is an expected result as Fuji sustained higher numbers of WAA compared with that sustained by Golden Delicious that provides the parasitoid a better chance for parasitism. Also, the high parasitism in November could be due to the fact that orchardists stop pesticide sprays during this period as they deal with harvesting fruits. However, the parasitism with *Aphelinus mali* is very weak and for this reason, more efforts are required to do mass rearing for this parasitoid to release it in the fields to suppress this insect.

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Table 1. Characteristics of Fuji and Golden Delicious

Cultivar	Parentage	Color	Season	Description
Golden Delicious	Grimes Golden X Golden Reinette ?	golden yellow, occasional russet patches	Late	Large, conic to round; smooth skin; crisp, clean juicy yellow flesh; sweet and mild flavor; famous variety from West Virginia, ca. 1912
Fuji	Ralls Janet x Delicious; Japan 1962	Yellowish green skin with an orangish red flush and darker stripes	Late	Tall, rectangular, medium size fruit. Darker blush on sun side. Crisp, juicy slightly subacid white flesh with outstanding texture. May require up to 200 days to mature. Good keeper

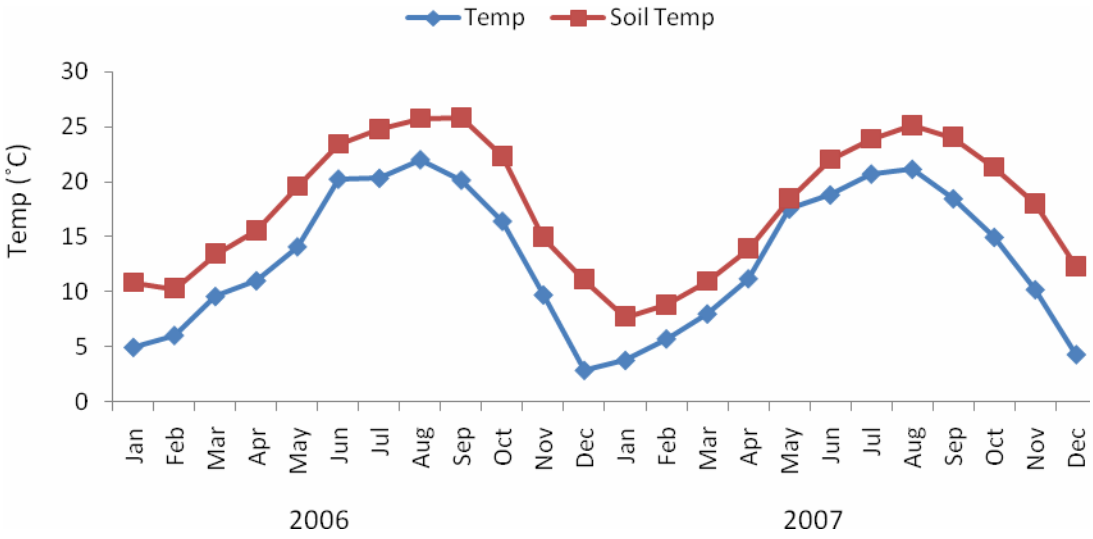

Fig. 1: Ambient and soil temperatures in Ash-Shoubak area during 2006-2007.

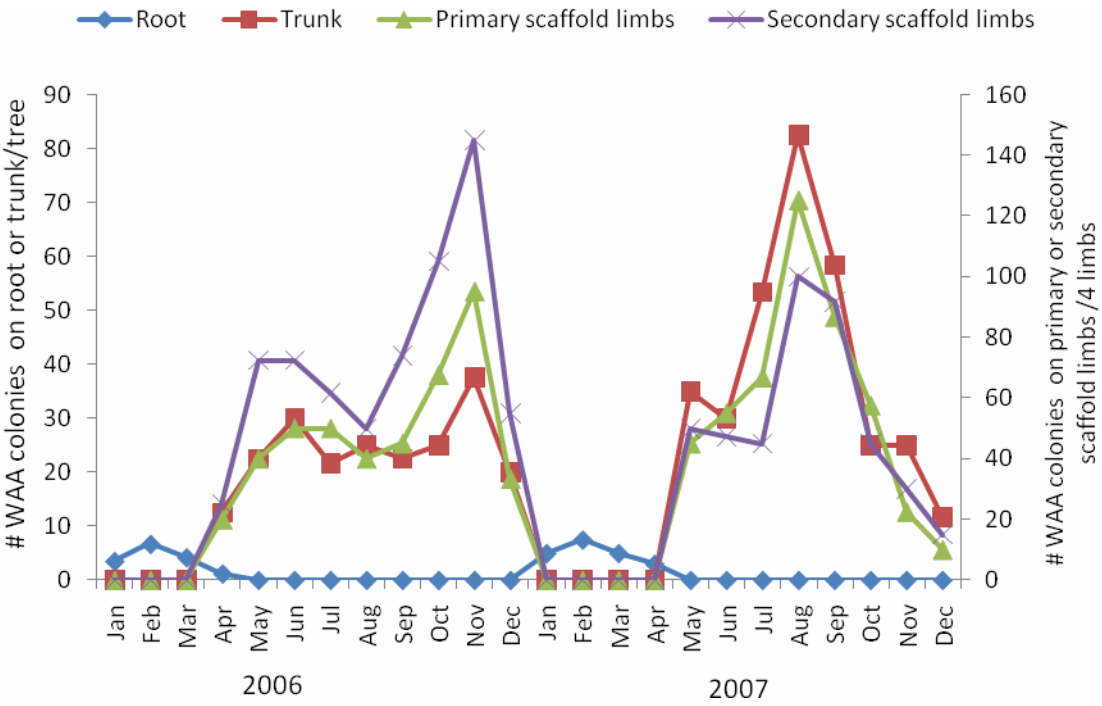

Fig. 2: Number of woolly apple aphid colonies on root, trunk, primary or secondary scaffold limbs of Fuji apple cultivar during 2006-2007.

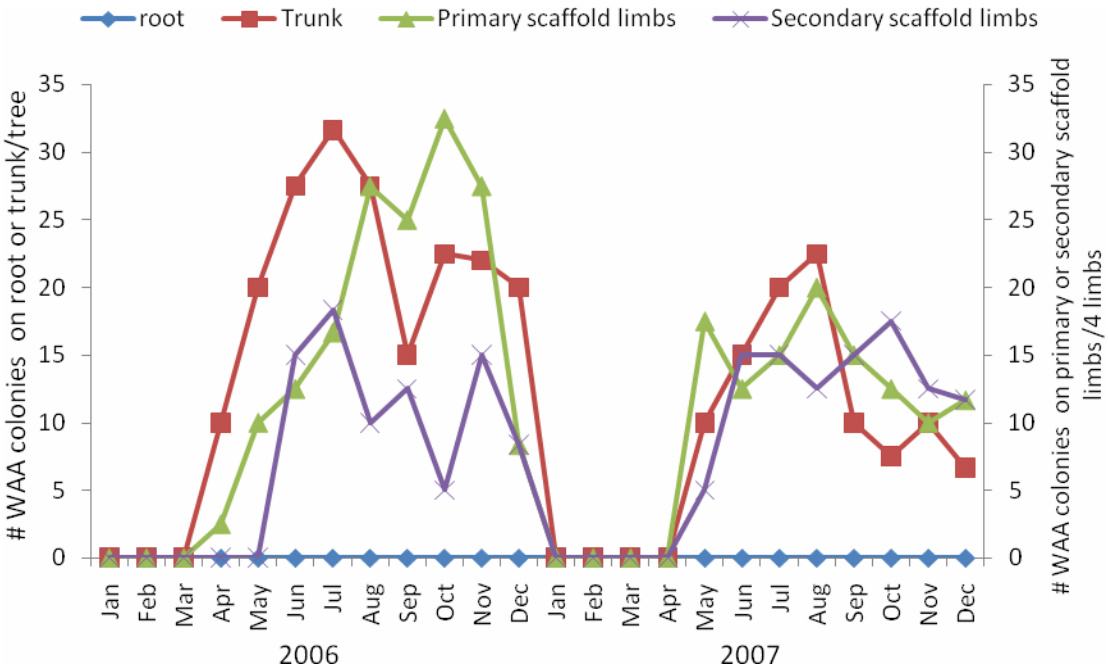

Fig. 3: Number of woolly apple aphid colonies on root, trunk, primary or secondary scaffold limbs of Golden Delicious apple cultivar during 2006-2007.

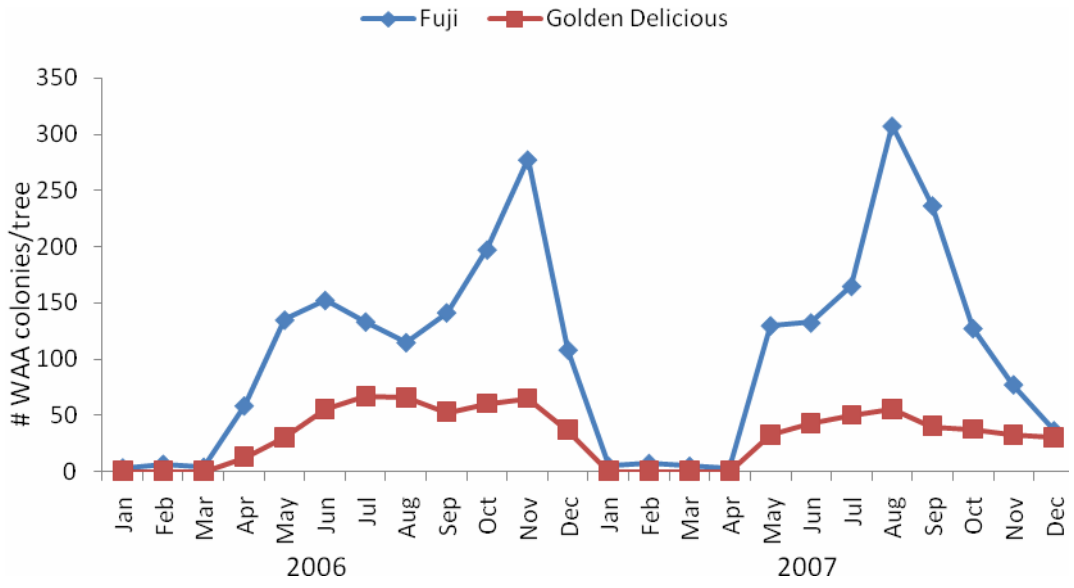

Fig. 4: Total number of woolly apple aphid colonies on both edaphic and aerial parts of the tree for Fuji and Golden Delicious apple cultivar during 2006-2007.

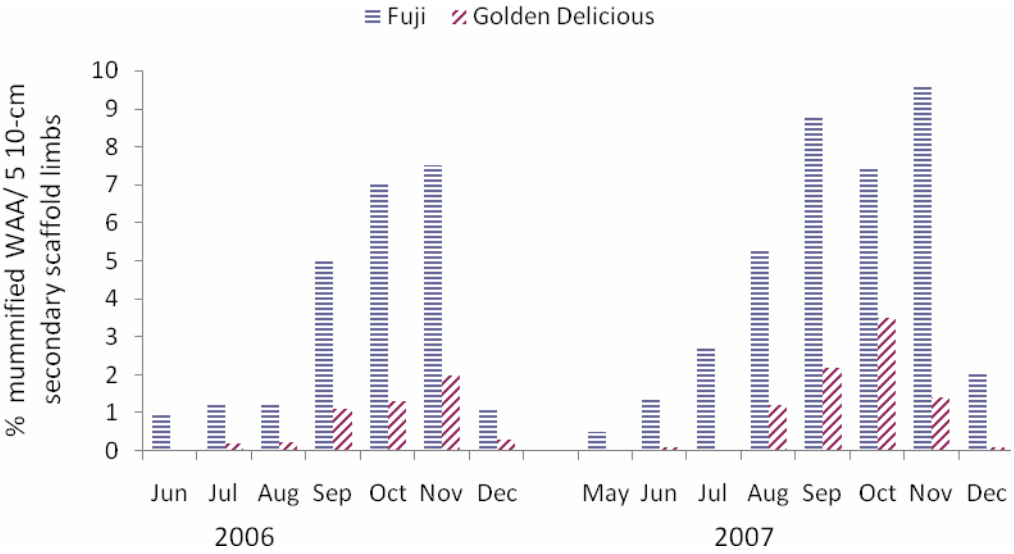

Fig. 5: Percentages of mummified WAA on Fuji and Golden Delicious apple cultivar during 2006-2007.

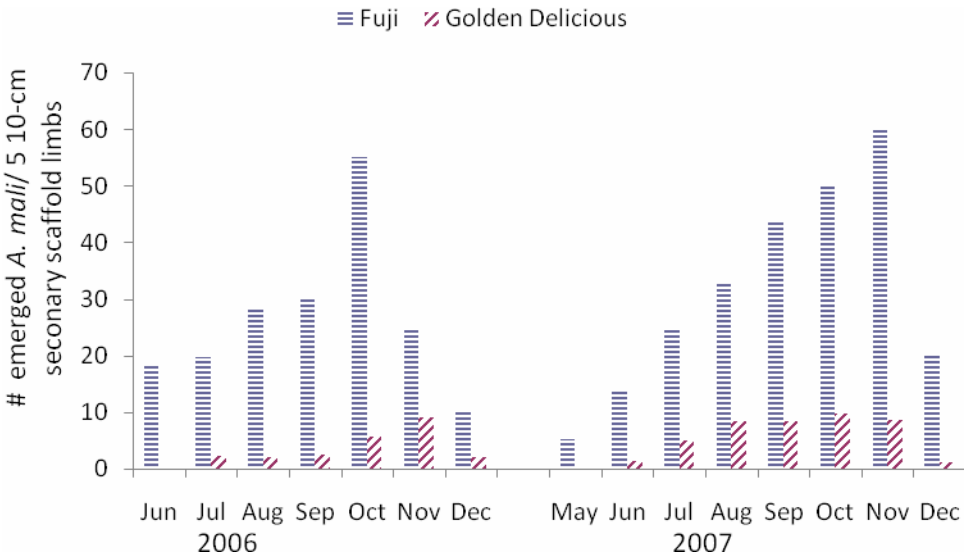

Fig. 6: Number of emerged *Aphelinus mali* from mummified WAA on Fuji and Golden Delicious apple cultivar during 2006-2007.

REFERENCES

Ateyyat, M.A. and Al-Antary, T.M. 2009. Susceptibility of nine apple cultivars to woolly apple aphid, *Eriosoma lanigerum* (Homoptera: Aphididae) in Jordan. ***Int. J. Pest Manage.*** 55/1: 79 -84.

Brown, M.W. and Schmitt, J.J. 1990. Growth reduction in nonbearing apple trees by woolly apple aphids (Homoptera: Aphididae) on roots. ***J. Econ. Entomol.*** 83: 1526-1530.

Brown, M.W., Schmitt, J.J., Ranger, S. and Hogmire, H.W. 1995. Yield reduction in apple by edaphic woolly apple aphid (Homoptera: Aphididae) populations. ***J. Econ. Entomol.*** 88: 127-133.

Beers, E.H., Cockfield, S.D. and Fazio, G. 2006. Biology and management of woolly apple aphid, Eriosoma lanigerum (Hausmann), in Washington state. Proceedings of the meeting at Lleida (Spain), 4 - 6 September.

Deng, J.Q., Rui, G.S., Guan, Y.T.., Yu Y.Q., Zhang, D., Hong J.Y., Deng, J.Q., Rui-G.S., Guan, Y.T., Yu Y.Q., Zhang, D.M. and Hong, JY.1993. The selection of an apple stock line, Siberian crabapple Jin 67, immune to the woolly apple aphid. ***Acta-Phytophylacica-Sinica*** 20/3: 217-222.

Gurney W.B. 1926. The woolly aphis parasite (*Aphelinus mali* Hald.). ***Agricultural Gazette of NSW*** 37: 620–623.

Hoyt, S.C. and Madsen, H.F. 1960. Dispersal behavior of the first instar nymphs of the woolly apple aphid. ***Hilgardia*** 30: 267-299.

Lloyd, N.C. 1961. The woolly apple aphid. ***Agricultural Gazette of NSW*** 72: 652–654.

Mols, P.J. and Boers, J.M. 1998. The characteristics of a better adapted strain of the parasitoid *Aphelinus mali* (Hald.) for the control of woolly apple aphid Eriosoma lanigerum (Hausmann) in the Netherlands. http://ishs.ethz-ch/5th_symposium/mols.html.

Mols, P.J., Polesny, F., Muller, W. and Olszak, R.W. 1996. Do natural enemies control woolly apple aphid? ***Bulletin-OILB-SROP***. 19/4: 203-207.

Muller, T.F., Blommers, L.H. and Mols, P.J. 1992. Woolly apple aphid (*Eriosoma lanigerum* Hausm., Hom., Aphidadae) parasitism by *Aphelinus mali* Hal. (Hym.: aphelinidae) in relation to host stage and host colony size, shape and location. ***J. Appl. Entomol.*** 114/2: 143-154.

Sachan, J.N. and Gangwar, S.K. 1989. Reaction of different varieties of apple to woolly aphid incidence. ***Indian J. Entomol.*** 49: 559-561.

Sushma, B., Chander, R.., Bhardwaj, S.P. and Bhardwaj, J.J. 1995. Movement of woolly apple aphid (*Eriosoma lanigerum*) (Homoptera: Pemphigidae) on apple (Malus pumila) plant in relation to weather parameters. ***Indian J. Agric. Sc.*** 65/3: 217-222.

Thwaite, W.G. and Bower, C.C. 1983. Woolly Aphid. Agfact H4. AE.3. NSW Agriculture, Orange, Australia.

التغيرات العددية لحشرة من التفاح القطني وعدوها الحيوي *Aphelinus mali* على صنفين من التفاح في الأردن

مازن عطيات[1] وتوفيق العنتري[2]

ملخـص

تمت في هذه الدراسة دراسةُ التغيرات العددية لكل من حشرة من التفاح القطني والمتطفل *Aphelinus mali* على صنفين من التفاح لهما صفات مختلفة في منطقة الشوبك خلال عامي 2006-2007. تمت هذه الدراسة على صنفين من التفاح، هما صنف فوجي وصنف جولدن دليشس، وكلاهما مطعمان على الأصل MM106. أظهرت النتائج أنه وبالرغم من أن كلا الصنفين مطعمان على نفس الأصل إلا أنهما أظهرا اختلافا في إعداد حشرة من التفاح القطني على الجذور؛ حيث لم يسجل أي تواجد للحشرة على جذور صنف جولدن دليشس. على نحو عام، شوهدت مستعمرات المن على كلا الصنفين على الأجزاء العلوية للنبات طوال العام باستثناء فترة الشتاء من كانون ثاني وحتى نهاية آذار. كان أكبر عدد لمستعمرات المن على الصنف فوجي (240 مستعمرة) للشجرة الواحدة على الأجزاء العلوية للنبات خلال شهر تشرين ثاني لعام 2006 و(225 مستعمرة) للشجرة الواحدة خلال شهر آب لعام 2007، بينما كان أعلى عدد من المستعمرات على الصنف جولدن ديلشس على الأجزاء العلوية للنبات (43 مستعمرة) للشجرة الواحدة خلال شهر تشرين ثاني لعام 2006 و(33 مستعمرة) خلال تموز لعام 2007. كانت أعداد المستعمرات على الصنف فوجي خلال سنوات الدراسة أكثر مما شوهدت على الصنف جولدن دلشس. وكانت نسبة حشرات المن القطني المتطفل عليها أقل من 10% خلال فترة الدراسة، وهي نسبة منخفضة جدا. وعلى نحو عام كانت نسبة التطفل على من التفاح القطني المتواجد على الصنف فوجي أكثر مما هو عليه في الصنف جولدن دلشس.

الكلمات الدالـة: التغيـرات العدديـة، مـن التفـاح القطنـي ,*Eriosoma lanigerum*، فـوجي، جولـدن دلـشس، *Aphelinus mali*.

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