Aleurothrixus floccosus: an Invasive Pest Attacks Different Species of Citrus Trees in Alexandria Governorate, Egypt

Ahmed M. Soliman[1]

ABSTRACT

Since 2022, the woolly whitefly, *Aleurothrixus floccosus* (Maskell) (Hemiptera: Aleyrodidae) has been recorded as an invasive pest infesting different species of citrus trees which were peculiar and previously undetected. The infestations were observed on orange (*Citrus sinensis*), lemon (*C. limon*), grapefruit (*C. paradise*), mandarin (*C. reticulata*), and lime (*C. aurantiifolia*) in the campus of the Faculty of Agriculture (El-Shatby), Alexandria University, Egypt. *A. floccosus* arises frequently and causes a number of disorders; the leaves' lower surface was covered with a white mass of wax and an amount of honeydew,which served as a substrate for the black sooty mold growing. Following the initial observation, numerous reports of this particular insect emerged from different areas within the Alexandria governorate. However, no infestation with *A. floccosus* was noticed following a qualitative survey of various citrus varieties in some regions of Al Beheira governorate. These results highlight the need for further and intensive investigation and preventive. The morphological identification, damage symptoms and distribution of *A. floccosus* was reported in the present article.

Keywords: *Aleurothrixus floccosus*, woolly whitefly, citrus, Alexandria, Al Beheira, Egypt.

INTRODUCTION

Whiteflies, these visually small but extremely destructive agricultural pests, have severely damaged numerous crops across the globe. Direct damage by manipulating plants′ sap and through the growth of sooty mold on the secreted honeydew has a detrimental effect on the yield and quality of several field crops and vegetables.They are also of transmitting more than 100 viral diseases that can result in considerable losses for many economically significant crops (Brown *et al*., 1995 and Oliveira *et al*., 2001). The Egyptian agricultural system has at least 23 Aleyrodid pests (Abd-Rabou and Evans, 2020), three of which (*Bemisia tabaci*, *B. Argentifolii*, and *Trialeurodes ricini*) are known to be plant Geminivirus vectors (Idriss *et al*., 1997). *Aleurothrixus floccosus* was initially identified from *Citrus* spp. in Cuba (Maskell, 1896), and is native to the neotropical region wherever citrus is grown (Malumphy *et al*., 2015). The genus *Citrus* is believed to have originated in Southeast Asia, and become one of the most important fruit crops. To date, *Citrus* spp. are grown in more than 137 countries across six continents, particularly in the subtropical and tropical regions. Considering the expansion of citrus marketability, it generates over US$105 billion annually (Ismail and Zhang, 2004). According to the Central Agency for Public Mobilization and Statistics (CAPMAS), citrus exports from Egypt in 2018 accounted for 82% of all fruit exports (2.16 million tons). with a value of 14.24 billion pounds, which is equivalent to 70% of the fruit exports. As the second-largest exporter of fresh oranges, Egypt exports oranges to Netherlands, France, Germany, Russia, China, Saudi Arabia, Iraq, and UK. (United Nations Foreign Trade website). In Egypt, citrus trees are being attacked by 13 different insect species belonging to the eight families (Kamel, 2010) viz. *Aphis gossypii* (Aphididae); *Pulvenaria pisidi*, *Ceratoplastes floridensis*, *Ceratoplaste rusci*, and *Coccus hesperidum* L. (Coccidae); *Iceryae pruchsi* and *Iceryae seychelarum* (Margarodidae); *Palatoria zizphi* and *Aonidella orientali* (Diaspididae); *Pegomyia hyasayami* (Anthomyiidae); *Thrips* spp. (Thripidae); *Drosophila* spp. (Drosophilidae) and *Bemisia tabaci* (Aleyrodidae). Since the citriculture serves as a valuable source of foreign currency in Egypt and needs more sustainable and productive disease and pest management techniques, so, the aim of the current investigation is to provide a new data about the host range and the distribution of *A. floccosus*, which is a new pest threatening the citriculture in Egypt**.**

MATERIALS AND METHODS

Collecting insects:

Prior to collecting samples, the distinctive symptoms of the woolly whitefly, *A. floccosus* infestation on various citrus tree species from different locations within the Alexandria governorate were recorded. Specimens of *A. floccosus* were collected from heavily infested leaves of citrus, then they were packed in well ventilated bags and transported to the laboratory. Before preservation took place for identification, field characteristics like colour and shape of different life stages and the diagnostic or taxonomical characteristics, were recorded.

DOI: 10.21608/asejaiqjsae.2023.327455

[1] Department of Applied Entomology and Zoology, Faculty of Agriculture, (El-Shatby), Alexandria University, Egypt.

Received, October 20, 2023, Accepted November 26, 2023

Identification and Characterization of *A. floccosus*:

Pupae were processed and slides were prepared following Martin *et al*. (2000). Morphological and taxonomical characteristics were shown using a light stereoscope (Optika B-150, Optika Microscopes, Italy), identification was performed following the taxonomical key of the family Aleyrodidae (Abd-Rabou and Evans, 2020). Infested leaves that were collected from various citrus trees were sent to confirm the identification by the experts of The Survey and Identification Insects Research Department, Plant Protection Research Institute, Agriculture Research Center, Dokki, Giza, Egypt. The surface area of the pupae from different citrus species was measured and calculated as a mean of 25 replicas by a micrometer lens at 100 X as an ellipse using the formula used for the calculation of an oval-shaped surface area. The equation is $[(L \times W) \div 4] \pi$,

Where:

L = pupal length

W= pupal width.

$\pi = 3.14$

Host plants and distribution:

The woolly whitefly, *A. floccosus* had infested a variety of citrus trees grown in the campus of the Faculty of Agriculture (El-Shatby), Alexandria University (31°12'18" N, 29°55'11' E)., The varieties of citrus trees included orange (*Citrus sinensis*), lemon (*C. limon*) grapefruit (*C. paradise*), mandarin (*C. reticulata*), and lime (*C. aurantiifolia*). The occurrence of this pest on different host plants in gardens and orchards in various regions of Alexandria was investigated. A survey of some citrus-cultivated districts in Al Beheira governorate was conducted to find out more about the spread of this pest on several citrus species outside Alexandria governorate. The survey included the following districts: Al Noubareya (31°09'02" N, 29°51'45' E), Abu Al Matamir (30°54'47" N, 30°10'23' E), and Housh Eissa (30°55'19" N, 30°17'30' E).

RESULTS AND DISCUSSION

Identity and symptoms of *Aleurothrixus floccosus* on citrus plants:

synonyms:

Aleurothrixus floccosus (Maskell,1896).

Aleyrodes horridus (Hempel, 1899).

Aleyrodes howardi (Quaintance, 1907).

The pest was identified as the woolly whitefly, *A. floccosus* (Hemiptera: Aleyrodidae). The eggs, immature stages, and adults of *A. floccosus* are circumscribed on the lower surface of the leaves. In heavy infestations, the entire lower side of the leaves is frequently covered with a flocculent, white mass of wax, which along with the crystalized sugars that are produced during feeding, and the cast skins makes a crust or shelter for immature stages (Fig. 1, A). Similar to all other whitefly species, all postembryonic stages of the *A. floccosus* are obligated plant feeders, which obtains the plant juices and secrete honeydew, which serves as a substrate for black sooty mold to grow on the leaf surface (Fig. 1, B), decreasing the photosynthetic efficiency of the plant, resulting in discoloration affected fruit and reducing its size. As the damage intensity increases, the leaves rolled up (Fig. 1, C), become scorched, necrotic and then dropped (Kerns *et al*., 2021) and the host plant becomes weak and appears sick. Additionally, ants that tend the woolly whiteflies consume the honeydew as food, interrupting biological control agents (Gullan, 1997) .

Figure 1. Symptoms of *Aleurothrixus floccosus* on citrus trees. (A) flocculent, white wax beneath the leaves' surface, (B) black sooty mold growing, (C) the rolled-up leaves

Field characteristics of *Aleurothrixus floccosus*:

A. floccosus eggs are light brown, elongated, and laid in circle or semicircular patterns, attached to the underside of the newly, fully expanded leaves by a short pedicel (Fig. 2, A). The 1st instar, crawlers are mobile, aggregate close to the eggs and pierce the leaves with their stylets to feed (Kerns *et al*., 2021). Early-stage nymphs (2nd and 3rd instars) are oval-shaped, pale yellow or light brown, with a border of bright white wax. (Fig. 2, B), the 3rd is significantly bigger and often found in clusters covered by waxy flocculent secretions (Fig.2, C). The pupae are elongated and varying in colour from light-cream to light brown, sometimes dark brown to black (Fig. 2, D), which is suggesting a possible species complex, that demands further research (CABI, 2021). Adults of Aleyrodidae species have white wings held roof-like over their yellowish body (Arulappan *et al*., 2022), preferring to exist underneath the fresh, fully developed leaves for feeding and oviposition (Fig. 2, E).

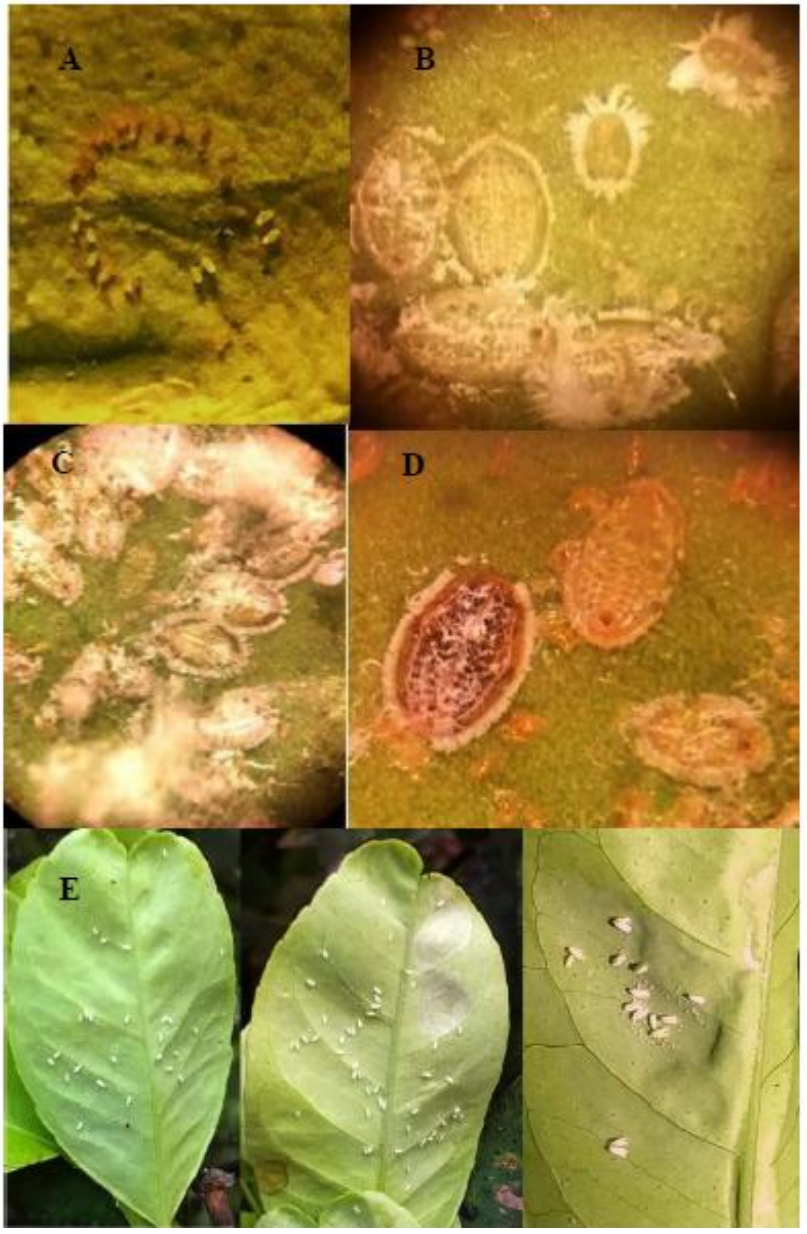

Figure 2. Field characteristics of *Aleurothrixus floccosus* on citrus. (A) eggs, (B) early-stage nymphs, (C) late-stage nymphs with waxy flocculent secretions, (D) pupae with different pupal pigmentation, (E) underside of leaf with adults

Diagnostic characteristics of *Aleurothrixus floccosus* pupae:

The surface area of the pupa from different citrus species was at the average of 0.37 ± 0.03 mm^2 with maximum length of 0.85 mm and maximum width of 0.57 mm (Fig. 3, A). The pupal margin has rough teeth (mt) and glands (gl) that are located at the base of each tooth. This gives the impression that the border has double rows of teeth (Fig. 3, B). Each side of the body has a continuous submarginal fold (smf) that starts over the mouthparts and ends in a straight line beneath the vasiform orifice (vo) (Fig. 3, A), a transverse line (tl) is extending almost to the submarginal fold. Submedial region with one pair of long dorsal setae (mts) arising from the metathoracic segment (Fig. 3, A and C). The eighth abdominal segment has one pair of long setae (8as) that emerge anterolateral to the vasiform orifice and typically extend behind the posterior margin (Fig. 3, D). The caudal setae (cs) are also long but slightly shorter than the 8th abdominal setae and that arise midway between the vasiform orifice and posterior margin of the body (Fig. 3, D). Vasiform orifice elevated, heart-shaped transverse, wider than long; operculum (op) is large, covering the entire vasiform orifice (Fig. 3, D).

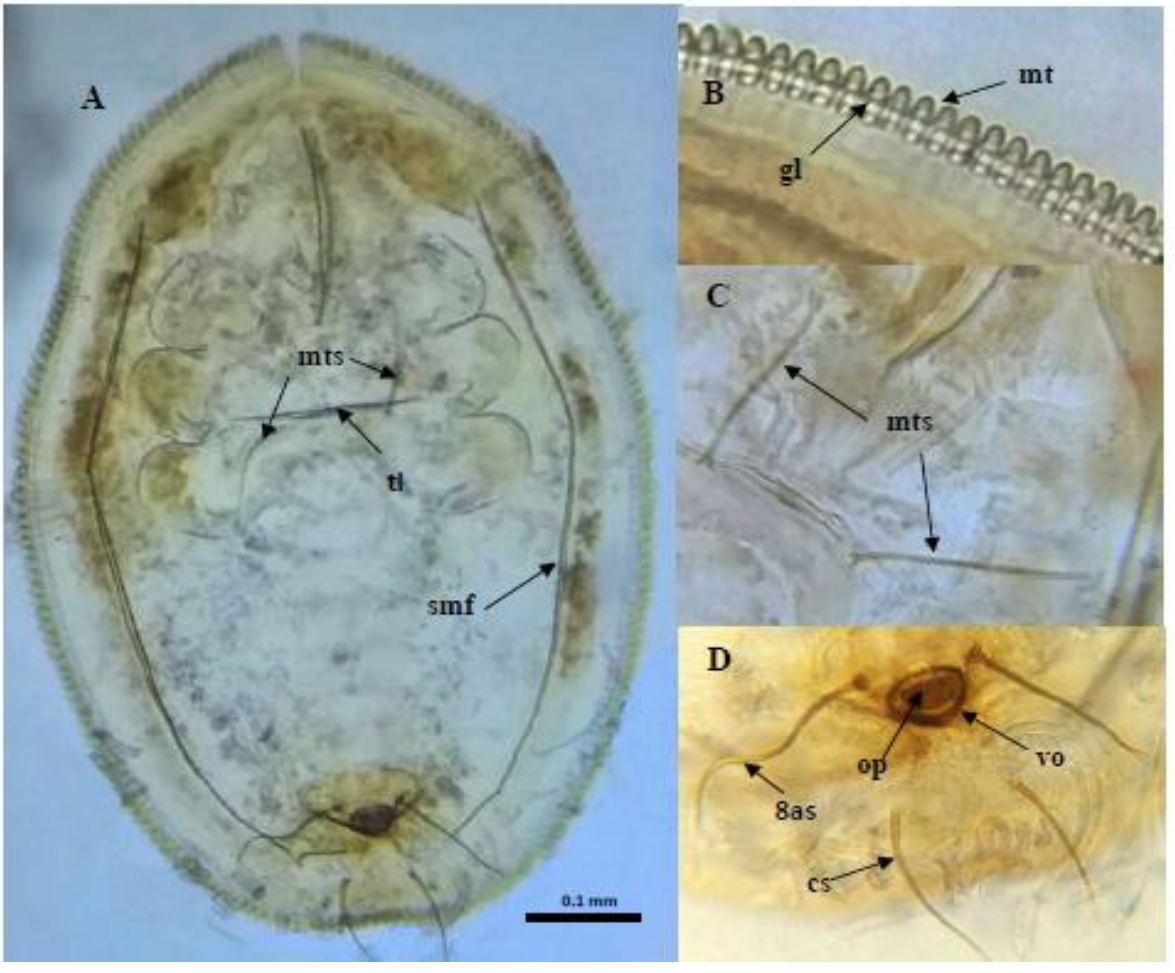

Figure 3. Diagnostic characteristics of *Aleurothrixus floccosus* pupa. (A) habitus, (B) magnified lateral margin, (C) magnified metathoracic segment, (D) magnified vasiform orifice
Eighth abdominal seta (8as), caudal seta (cs), gland (gl), marginal teeth (mt), metathoracic setae (mts), operculum (op), submarginal fold (smf), transverse line (tl), vasiform orifice (vo)

Distribution of *Aleurothrixus floccosus*:

Observations revealed that *A. floccosus* is distributed in most citrus-cultivated regions that were investigated within Alexandria governorate (Table 1).

Table 1. Distribution of *Aleurothrixus floccosus* on various *Citrus* spp. cultivations from different regions of Alexandria governorate, Egypt

Locality	Geographical coordinates	Host plant
The Faculty of Agriculture (El-Shatby)	31°12'18" N, 29°55'11' E	*C. sinensis* *C. limon* *C. paradise* *C. reticulata* *C. aurantiifolia*
Al-Manshiya	31°11'50" N, 29°53'34" E	*C. aurantiifolia*
Ras AL-Tin	31°12'19" N, 29°52'57" E	*C. reticulata* *C. aurantiifolia*
Smouha	31°12'23" N, 29°57'57" E	*C. reticulata*
Kafr Abdou	31°31'30" N, 29°57'21" E	*C. sinensis* *C. aurantiifolia*
Muharram Bek	31°11'25" N, 29°54'28" E	*C. sinensis* *C. reticulata*
Al Mamurah	31°17'26" N, 30°01'57' E	*C. sinensis* *C. reticulata* *C. aurantiifolia*

Significantly varying degrees of injury were demonstrated among different citrus-trees species (unpublished data). However, no injuries were observed in other areas on the outskirts of the governorate, such as El-Agamy or Al Dakhila, or even within the borders of Al Beheira governorate, such as Al Noubareya, Abu Al Matamir and Housh Eissa. The disappearance of this pest from those areas -specially districts of Al Beheira governorate- could be interpreted as a result of the follow-up control by the chemical pesticides for combating the traditional various citrus-pests such as thrips, mealybugs, and leafminers. This unintentionally process may prevent these trees from being infested by *A. floccosus*. This is unlike trees found in public parks, streets, or private property, which lacking the same level of the agricultural-fundamental treatments of fertilization, pruning or pests' control. In addition, the relative humidity of those areas is low compared to Alexandria governorate, which is remarkable with the high relative humidity, that provides suitable climatic conditions for the presence, reproduction, and significant outbreak of the insect.

Although *A. floccosus* whitefly was previously reported from Egypt (Vulić and Beltran., 1977; CABI, 2021), the authors built their information just based on the report of the German Ministry of Agriculture (Ministerio de Agricultura, 1971) [in German]). However, there is no available data regarding its host plants or distribution in Egypt (Abd-Rabou and Evans, 2020). Therefore, this is the first report of invading citrus trees by *A. floccosus* whitefly in Egypt. The first incidence of the woolly whitefly in the United States was in Florida in 1909, and it emerged on the west coast in 1960 (DeBach and Rose, 1976). *Aleurothrixus floccosus* is known to infest over 50 plant species from 31 families in Hawaii alone, demonstrating the broad spectrum of its host range; however, citrus is the most preferred host (Pauloson and Beardsley, 1986). The woolly whitefly was stablished in Africa and Europe in the late 1960s. It was identified for the first time in Morocco in 1973 (Abbassi and Onillon, 1973) and Kenya in 1990. In the late 1980s, reports of its presence from several eastern and southern African countries, including Rwanda, Burundi, Zambia, Uganda and Tanzania, followed by Malawi in 1994 (Legg *et al*., 2003) were received. Currently, it is widespread across the African continent. Mercado *et al*. (2014) reported that it spread in various biogeographic zones, including nearctic, neotropical, palearctic, arotropical, and Pacific islands. India reported it on guava (*Psidium guajava*) during 2019 (Sundararaj *et al*., 2020). In its report, CABI (2021) mentioned that, with the exception of Australia, *A. floccosus* is announced to be a cosmopolitan species.

CONCLUSION

Agriculture is threatened by *Aleurothrixus floccosus* as an invasive species due to its current, rapid regional expansion. It causes great ecological interference to the native ecosystem in its new habitat due to its exceptionally high capacity for reproduction, favorable environmental conditions, the presence of host plants, and the absence of natural enemies that would serve to control its populations. In the context of climate change and global warming, attacks by invasive insects have become widespread and have demanded the urgent development of management plans to control outbreaks of these invasive species in their new habitat.

REFERENCE

Abbassi, M., and J.C. Onillon. 1973. La mouche blanche floconneuse, *Aleurothrixus floccosus* Mask. ravageur dangereux pour lÕagrumiculture marocaine. Maroc Fruits 441:1-3. [In French].

Abd-Rabou, S. and G.A. Evans. 2020. The Whiteflies in Egypt (Hemiptera: Aleyrodidae). Acta Phytopathologica et Entomologica Hungarica 55 (1): 193–205. DOI: 10.1556/038.55.2020.014.

Arulappan, J., G.A. Evans, C. Mohan, M. Babu, A.K. Meerasahib, A. Muthu and V. Hegde. 2022. Morphological and molecular identification of the woolly whitefly, *Aleurothrixus floccosus* (Maskell). International Journal of Tropical Insect Science 42:2493-2500.

Brown, J.K., D.R. Frohlich and R.C. Rossell. 1995. The Sweet potato or silver leaf whiteflies biotypes of *Bemisia tabaci* a species complex?. Annual Review of Entomology 40: 511-534.

Central Agency for Public Mobilization and Statistics (CAPMAS), Egypt, 2018. Annual Bulletin of Production and Foreign Trade Movement, Cairo.

Centre for Agriculture and Bioscience International (CABI). (2021). https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.4538.

DeBach, P. and M. Rose. 1976. Biological control status of woolly whitefly. California Agriculture, 30: 4-7.

Gullan, P.J. 1997. Relationships with ants, pp. 351-373. In Y. Ben-Dov and C. J. Hodgson (eds.), World crop pests: soft scale insects, their biology, natural enemies and control. Elsevier Science, New York. Pp 439.

Idriss M., N. Abdallah, N. Aref, G. Haridy and M. Madkour. 1997. Biotypes of the castor bean whitefly *Trialeurodes ricini* (Misra) (Hom., Aleyrodidae) in Egypt: biochemical characterization and efficiency of geminivirus transmission. Journal of Applied Entomolgy, 121: 501-509

Ismail, M. and J. Zhang. 2004. Postharvest citrus diseases and their control. Outlooks Pest Management, 15: 29 -35.

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

Kerns D., G. Wright and J. Loghry. 2021.Wooly whiteflies (*Aleurothrixus floccosus*). University of Arizona cooperative extension. Citrus Arthropod Pest Management in Arizona. https:// cals. arizo na. edu/ crops/ citrus/ inse ts/ wooly whitefly.

Legg, J., D. Gerling and P. Neuenschwander. 2003. Biological control of whiteflies in sub-Saharan Africa, pp. 87-101. In P. Neuenschwander, C. Borgemeister and J. Langewald (eds.), Biological control in IPM systems in Africa, CABI Publishing, Boston, MA. Pp 414.

Malumphy, C., S. Radonjic, S. Hrncic, and M. Raicevic. 2015. New data on the whiteflies (Insecta: Hemiptera: Aleyrodidae) of Montenegro including three species new for the country. Acta Entomologica Serbica, 20:29–41.

Martin J.H., D. Mifsud, C. Rapisarda. 2000. The whiteflies (Hemiptera: Aleyrodidae) of the Europe and the Mediterranean Basin. Bulletin of Entomlogical Research, 90:407-448.

Maskell, W.M. 1896. Contributions towards a monograph of the Aleurodidae, a family of Hemiptera - Homoptera. Transactions and Proceedings of the New Zealand Institute, 28:411-449.

Mercado, V.T., E.S. Fernández and J.H. Giliomee. 2014. Life table parameters of the woolly whitefly *Aleurothrixus floccosus* (Hemiptera: Aleyrodidae) and its parasitoid *Cales noacki* (Hymenoptera: Aphelinidae) European Journal Entomology. 111(2): 251-256. Doi: 10.14411/eje.2014.020

Ministerio de Agricultura.1971. Dirección General de Agricultura: La mosca blanca des los cítricos. 1-29,

Oliveira, M.R.V., T.J. Henneberry, and P. Anderson. 2001. History, current status, and collaborative research projects for *Bemisia tabaci*. Crop Protection. 20: 709–723.

Pauloson, G.S. and J.W. Beardsley. 1986. Development, oviposition, and longevity of *Aleurothrixus floccosus* (Maskell) (Hemiptera: Aleyrodidae). Proceeding of Hawaiian Entomological. Society. 26: 97-99.

Sundararaj R., K. Selvaraj, C.M. Kalleshwaraswamy, M. Ranjithand B.V. Sumalatha. 202•. First record of the invasive woolly whitely, *Aleurothrixus floccosus* Maskell from India. Indian Journal of Entomology, 82(1):88-91.

United Nations Foreign Trade website www.trademap.org

Vulić, M. and J.L. Beltran. 1977. The whitefly *Aleurothrixus floccosus*, a serious pest of citrus crops. (Die Weisse Fliege *Aleurothrixus floccosus*, ein gefährlicher Schädling der Citrus-Kulturen.). Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz. 84:202–214. [In German].

الملخص العربي

الذبابة البيضاء الصوفية (Maskell) *Aleurothrixus floccosus* : آفة غازية تصيب أنواع مختلفة من أشجار الموالح في محافظة الإسكندرية بجمهورية مصر العربية

أحمد محمد سليمان

خلال عام ٢٠٢٢، تم تسجيل إصابة الذبابة البيضاء الصوفية *Aleurothrixus floccosus* لأنواع مختلفة من أشجار الموالح الموجودة في حرم كلية الزراعة (الشاطبي) – جامعة الإسكندرية بجمهورية مصر العربية. ظهرت الإصابة بشكل كتل بيضاء صوفية على أوراق أشجار البرتقال و الليمون الأضاليا والجريب فروت واليوسفي والليمون البنزهير. تتكاثر الذبابة البيضاء الصوفية بشكل سريع مسببةً العديد من أعراض الإصابة حيث ظهرت على شكل كتل بيضاء من الشمع تغطي السطح السفلي للأوراق بالإضافة للندوة العسلية التي ينمو عليها فطر العفن الأسود. عقب ذلك ظهرت هذه الحشرة في مناطق مختلفة داخل محافظة الإسكندرية. ومع ذلك، لم يتم ملاحظة أي إصابة بهذه الحشرة بعد إجراء حصر نوعي لأصناف مختلفة من الموالح في بعض مراكز محافظة البحيرة. وهذا يسلط الضوء على الحاجة إلى مزيد من الدراسات. في هذه الدراسة تم تعريف وتسجيل الذبابة البيضاء الصوفية *A. floccosus* لأول مرة على أشجار الموالح في مصر وأيضاً وصف أعراض الإصابة والضرر بالإضافة لتحديد بعض مناطق انتشار الحشرة بمحافظة الإسكندرية بجمهورية مصر العربية.

الكلمات المفتاحية: الذبابة البيضاء الصوفية، الموالح، الإسكندرية ، البحيرة، جمهورية مصر العربية.