https://www.biodiversityjournal.com - Edizioni Danaus
Biodiversity Journal, 2024, 15 (2): 219–224 - **Monograph**
https://doi.org/10.31396/Biodiv.Jour.2024.15.2.219.224

Biodiversity Journal
ISSN 2039-0394 (Print Edition)
ISSN 2039-0408 (Online Edition)

Recent findings of alien insect in citrus and olive groves in the Mediterranean basin: new risks for integrated pest management (IPM)

Salvatore Bella

Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA). Centro di ricerca Olivicoltura, Frutticoltura e Agrumicoltura. Corso Savoia 190, 95024 Acireale (Catania), Italy

ABSTRACT Recently, the number of alien arthropods found in the Mediterranean basin has increased considerably. This phenomenon occurred especially in the milder climate areas of the southern sector. In this context, citrus and olive groves see their productions and even their existence at risk. In the last three decades, the increased number of allochthonous species introduced to Italy and potentially harmful to *Citrus* and *Olea* genera has alerted and worried farmers, especially for those species capable of transmitting diseases for which no phytosanitary remedies are yet known. The adoption of an integrated supra-regional surveillance and monitoring system is therefore essential. Here the focus is on some invasive alien insect species (phytophagous and predators) recently reported on the Italian territory on *Citrus* and *Olea* plant species.

KEY WORDS *Citrus*; *Olea*; agroecosystems; alien pests and predators; biological control.

Received 28.04.2024; accepted 02.06.2024; published online 30.06.2024
Proceedings of 6th International Congress on Biodiversity "*Biodiversity and the new scenarios on alien species, climate, environment and energy*" - Trapani (Italy, Sicily) 2–3 September 2022

INTRODUCTION

The accidental or deliberate introduction of organisms in areas outside their original range is a global phenomenon and this is considered as one of the main reasons for the biodiversity decline (Jucker et al., 2009). The recorded number of alien arthropod species introduced into the Mediterranean region has markedly increased over the last three decades (Roques et al., 2009). This number is growing rapidly, with records of new taxa being published regularly. The introduction of these non-native species, respectively in the adult, nymph and egg stages, can be unintentional (accidental) through the movement of goods and the transport of cultivated and ornamental plants, or planned (deliberate) with the aim of introducing natural enemies useful for biological and integrated pest management (IPM) in agrosystems. The spread of species potentially harmful to *Citrus* and *Olea* genera outside their native territories can furthermore cause economic losses through various pathways. Several of the introduced phytophagous are vectors for plant pathogens or can directly damage plants through their feeding activity or through egg laying in plant tissue. In Italy, there are currently around fifty arthropods that can live on citrus plants. Considering that approximately 80% of these species are of exotic origin, 44% of them were accidentally introduced from 1970 onwards, with a significant increase in the last three decades.

ALIEN INSECTS RECENTLY RECORDED IN CITRUS AND OLIVE GROVES IN THE MEDITERRANEAN BASIN

Citrus and olive trees have shown that can adapt to multiple environments and their cultivation is practiced from temperate Mediterranean climates to the hot-humid ones of the subtropics. Consequently, the arthropods associated with them, equally capable of great adaptation, have also spread, adapting to different climatic conditions. Over the last three decades, olive trees and especially citrus plants, more than other crops, have seen a continuous increase in invasive insect species, with notable economic repercussions due to the costs to be faced for their control and to limit production losses. An example is the Citrus leafminer moth, *Phyllocnistis citrella* Stainton, 1856 (Gracillariidae) on which a large group of indigenous and exotic antagonists have carried out significant control activity. Also interesting are the cases of the Woolly whitefly, *Aleurothrixus floccosus* (Maskell, 1896) and of the Citrus whitefly, *Dialeurodes citri* (Ashmead, 1885), against which the respective parasitoids *Cales noacki* Howard, 1907 and *Encarsia lahorensis* (Howard, 1911) (Hymenoptera Aphelinidae) were imported from the areas of origin, adapting to the environmental conditions of the agrosystems, guaranteeing an important control activity of the two aleyrodids. For other phytophages, however, there are no specific antagonists capable of effectively counteract their populations. This is the case of the two carpophagous fruit flies *Ceratitis capitata* (Wiedemann, 1824) and *Bactrocera oleae* (Rossi, 1790) (Diptera Tephritidae), respectively on *Citrus* and *Olea*, whose control continues to be a worldwide problem with no easy solution (Massimino Cocuzza & Rapisarda, 2017; Las Casas et al., 2022).

Below are reported (by taxonomic group) the main invasive exotic species (phytophagous and predators) recently established in Italian citrus and olive groves, and those present in the Mediterranean basin whose accidental introduction in Italy in the coming years is possible.

INVASIVE ALIEN PHYTOPHAGOUS

Thysanoptera Thripidae

These insects, both nymphs and adults, attack the small fruits immediately after the petals fall, and the alterations are highlighted by suberified areas especially around the peduncle. The alteration of the fruit is only of aesthetic nature, as the pulp is not compromised.

In the Mediterranean basin there are currently about ten species potentially harmful to citrus and olive plants. Of them, *Pezothrips kellyanus* (Bagnall, 1916), *Frankliniella occidentalis* (Pergande, 1895), *Heliothrips haemorrhoidalis* Bouché, 1833 and *Thrips major* Uzel, 1895 are widespread on Italian territory, while *Scirtothrips dorsalis* (Hood, 1919), *Scirtothrips aurantii* Faure, 1929 and *Thrips hawaiiensis* Morgan, 1913 are currently localized only in some areas of Spain and *Chaetanaphothrips orchidii* Moulton, 1907 in Turkey (Vono et al., 2022).

Hemiptera Cicadellidae

Some leafhoppers recently introduced in the Mediterranean area should be kept under observation as they attack *Citrus* and *Olea* species in their areas of origin. Among them, the Afrotropical *Penthimiola bella* (Stål, 1855) (reported in Israel, Lebanon, Morocco, Portugal and Spain) and the Oriental *Hishimonus diffractus* Dai, Fletcher et Zhang, 2013 (reported in France, Gibraltar, Madeira, Sicily, Spain and United Kingdom) (Fig. 1). The species of the latter genus are particularly feared, as they can transmit microorganisms capable of causing serious diseases and production

Figure 1. Adult of *Hishimonus diffractus* Dai, Fletcher et Zhang (Cicadellidae) (after Bella et al., 2022).

losses. *H. diffractus* has been found associated with *Jasminum* and *Olea* (Oleaceae), *Citrus* (Rutaceae), *Pittosporum* (Pittosporaceae), *Rubus* (Rosaceae), *Nerium* (Apocynaceae) and *Vitis* (Vitaceae) (Bella et al., 2022).

Hemiptera Aleyrodidae

Also known as "whiteflies", they are insects native to tropical and subtropical climate areas, among which some accidentally introduced species have adapted well to Mediterranean groves.

The involuntary introduction of some alien species into Italian citrus groves began in the 1970s with *Dialeurodes citri* (Ashmead, 1885), which was followed by *Aleurothrixus floccosus* (Maskell, 1896), *Parabemisia myricae* (Kuwana, 1927), *Paraleyrodes minei* Iaccarino, 1990 and recently *Aleurocanthus spiniferus* (Quaintance, 1903) (Fig. 2). The latter species was reported for the first time in the Euro-Mediterranean Region in the Lecce District (Apulia Region, southeaster Italy) in 2008. *Aleurocanthus spiniferus* is known to be polyphagous on wild or cultivated shrubs and trees, some of which with horticultural economic importance. Being a quarantine pest included in EPPO A2 list, phytosanitary containment measures are necessary to limit its spread (Porcelli, 2008).

Figure 2. Puparia of the polyphagous Orange spiny whitefly, *Aleurocanthus spiniferus* (Quaintance) (Aleyrodidae) on underside lemon leaves. Photo by S. Bella.

Hemiptera Aphididae

The Brown citrus aphid, *Aphis (Toxoptera) citricidus* (Kirkaldy, 1907), a species widely distributed in tropical and subtropical regions, has been present for over a decade only in Portugal and in the north-west Spain. The species is reported on approximately 70 host plants belonging mainly to the Rutaceae family (Massimino Cocuzza & Rapisarda, 2017). Direct damage is negligible, but the species is important above all for its high efficiency in the transmission of Citrus tristeza virus (CTV).

Hemiptera Liviidae, Triozidae

Only two species of psyllids are known to live on citrus plants: the Asian citrus psyllid, *Diaphorina citri* Kuwayama, 1908 (Liviidae), and the African citrus psyllid, *Trioza erytreae* (Del Guercio, 1918) (Triozidae). The presence of *D. citri* has been reported in Israel (2021) and Cyprus (2023), while that of *T. erytreae* in the western part of the Iberian Peninsula (since 2016). Both species are efficient vectors of Huanglongbing (HLB) or Citrus greening disease (caused by the Candidatus *Liberibacter asiaticus* and C. *L. africanus*), considered the most destructive disease of citrus plants. For this reason, both psyllids are quarantined in all Mediterranean citrus-growing regions (Sorrentino et al., 2021).

Hemiptera Coccidae, Diaspididae, Pseudococcidae

Among the numerous species, the Pyriform scale, *Protopulvinaria pyriformis* (Cockerell) (Coccidae) that seems to prefer lemon, the Citrus snow scale, *Unaspis citri* (Comstock) (Diaspididae) (present in Egypt and the Azores) regulated as quarantine pests in the EPPO A1 list, and the pseudococcid *Delottococcus aberiae* De Lotto (Spain) that was accidentally introduced from South Africa, are reported due to their invasiveness (Massimino Cocuzza & Rapisarda, 2017).

Lepidoptera Gracillariidae, Tortricidae

Among the species of Lepidoptera, the Citrus leafminer, *Phyllocnistis citrella* Stainton (Gracillariidae) (Fig. 3), native to South-East Asia, where it lives mainly on *Citrus*, *Murraya*, *Poncirus* and *Severina* (Rutaceae) genera, should be considered of phytosanitary importance. In Italy, this micromoth arrived in the first half of the 1990s and continues to cause damage, especially to young plants and in the nurseries. Furthermore, there is fear of the spread of the False codling moth, *Thaumatotibia leucotreta* (Meyrick) (Tortricidae), in the Mediterranean basin. It is widespread throughout sub-Saharan Africa, with a stable presence in Israel. The species has been intercepted several times on imported oranges and vegetables in various European countries, including Italy. The damage is caused by the larvae, which feed inside the fruit, favoring premature ripening and rotting caused by the development of secondary infections mediated by fungi and bacteria. It is included in the EU quarantine list A1 (Bella et al., 2024).

Figure 3. Alterations caused by the larvae of *Phyllocnistis citrella* Stainton (Gracillariidae) on citrus leaves. Photo by S. Bella.

INVASIVE ALIEN PREDATORS

In recent years, in the Mediterranean region, numerous alien predator species have also been reported. Invasive alien predators, it is scientifically verified, unfortunately occupy the territory and trophic niches of native useful species, causing the decline of their populations. Below, some recent examples which cause preoccupation due to their impacts on natural and cultivated environments.

Hemiptera Reduviidae

*Zelus renardii (*Kolenati) (Fig. 4) is an invasive alien species, native to North-Central America. Reported in Europe for the first time in 2010 from Greece, in a few years it has invaded almost all the Mediterranean regions. In Italy it was reported in 2013 in Latium and quickly spread also in Liguria, Apulia, Campania, Sardinia and Sicily. *Z. renardii* is a general feeder on a wide range of insects, including species of aphids and, unfortunately, its prey also includes useful arthropods (e.g. Coccinellidae). This well-known behavior indicates that this reduviid is not suitable for classical biological control. In fact, it is a harmful and potentially dangerous species for agroecosystems because it is extremely generalist and could represent a new threat for the indigenous species present in the newly invaded territories. The presence of this opportunistic predator has recently been reported in the olive and citrus groves of the Sicilian Ionian coast (Bella, 2020).

Coleoptera Coccinellidae

The Harlequin ladybird, *Harmonia axyridis* (Pallas) is a generalist predator, native to central-eastern Asia. In Western Europe, this predator was released as a biological control agent in 1995, against different species of aphids and scale insects and now is present in almost all of Europe (Brown et al., 2008). In Europe, it is suspected to cause the decline of native ladybirds through competition and predation. Kenis et al. (2020), in Switzerland, monitored the Harlequin ladybirds for 11 years and these surveys showed that, on broadleaved hedges, the coccinellid quickly became the most abundant species, representing 60-80% of all specimens collected in this habitat. The side effects of the use of

H. axyridis have a significative impact on biocenosis since it preys not only on aphids and scale insects but also on others useful insects, such as larvae of other native coccinellids, Neuroptera Lacewings, mites, eggs and larvae of Lepidoptera and Diptera.

The neotropical ladybird, *Delphastus catalinae* (Horn) has recently been observed in southern Italy and Sicily in some organic citrus groves (Bella et al., 2023). In its areas of origin, *D. catalinae* feeds on numerous species of whiteflies and field investigations are necessary to analyze its behavior in relation to indigenous predators active in the Mediterranean agrosystems.

During recent investigations on predators in some Sicilian citrus groves, the Oriental coccinellid *Serangium montazerii* Fürsch (Fig. 5) was found (Bella et al., 2021; Massimino Cocuzza et al., 2023). It is known to be a natural enemy of whiteflies and has been observed preying and feeding on *Aleurocanthus spiniferus* and could therefore play an important role in the biological control of the numerous alien species of Aleyrodidae established in the Mediterranean region.

New risks for integrated pest management

The natural self-regulation capacity of agroecosystems simplifies the management and control of organisms harmful to crops. However, the modern farmer must be able to correlate the different phases of agronomic management to ecological mechanisms of the orchard, and know the strategies to oppose phytophagous pests, in order to guarantee the stability of the agrosystems. These are fundamental aspects, because the exotic insects that invade the new environment often alter the biological balance. Especially in the citrus grove, adequate resilience is guaranteed both by indigenous entomophagy, who have adapted to the newly arrived species, and by antagonists (predators and parasitoids) of exotic origin deliberately introduced into the new environments to contain infestations of alien species. A modern strategy must have the objective of reducing phytophagous populations below the threshold of economic damage. With this aim, monitoring activities are advantageous to evaluate the real consistency of the phytophagous populations, the valorisation of the control activity of natural antagonists, the use of biostimulant substances with the aim of strengthening the natural defenses of plants, as well as active substances of natural origin with low environmental impact and also entomopathogenic microorganisms.

DISCUSSION AND CONCLUSIONS

The increase in the number of alien species in the Mediterranean region, potentially harmful to

Figure 4. The invasive alien species *Zelus renardii* (Kolenati) (Reduviidae). Photo by S. Bella.

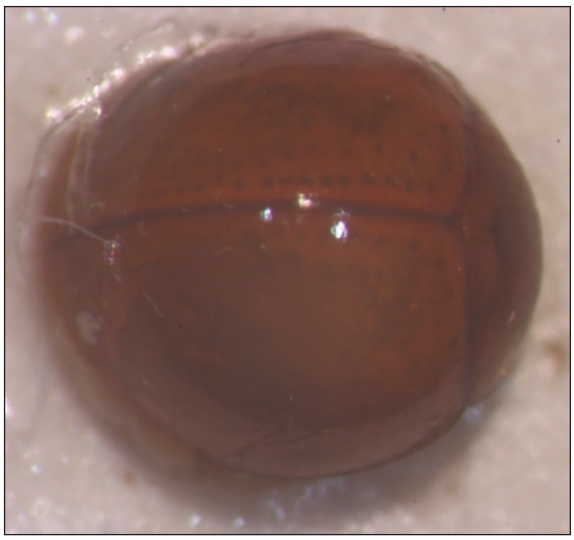

Figure 5. The Oriental coccinellid *Serangium montazerii* Fürsch (Coccinellidae). Photo by S. Bella.

the species of the *Citrus* and *Olea* genera must alert and worry farmers, especially for those capable of transmitting diseases for which no phytosanitary remedies are yet known. Many of the phytophagous species that live in the agroecosystems are characterized by cyclical population dynamics. These populations grow certain periods of the year favored by biotic factors (presence of sufficient pabulum, absence of antagonists) and abiotic factors (for example climate and humidity) and decrease when the latter vary. In addition to the aforementioned natural factors, those deriving from agricultural management must be considered, as they are able to influence the population dynamics of phytophagous insects as much as natural factors. Obviously also pesticide treatments, which can lead to a numerical reduction of natural antagonists and benefit phytophagous populations. The adoption of an integrated supra-regional surveillance and monitoring system is therefore essential. Integrated pest management (IPM) requires the implementation of all those practices and technical means useful for reducing the populations of phytophagous pests below the 'intervention thresholds' and for carrying out specific sampling, intervening with pesticides only after the exceeding of the economic thresholds has been ascertained.

REFERENCES

Bella S., 2020. The Nearctic bug *Zelus renardii* (Kolenati) (Hemiptera, Reduviidae) in Northern Italy and Sicily. Redia, 103: 87–88. https://doi.org/10.19263/REDIA-103.20.14

Bella S., Aguín-Pombo D., Aguiar A.M.F., Kunz G., Miralles-Núñez A., Foster S., Sánchez-García I., Wilson M.R. & D'Urso V., 2022. Discovery of *Hishimonus diffractus* Dai, Fletcher & Zhang, 2013 (Hemiptera: Auchenorrhyncha: Cicadellidae) in Europe, with remarks on previously recorded species of the genus. Zootaxa, 5159: 558–570. https://doi.org/10.11646/ZOOTAXA.5159.4.5

Bella S., Catania R. & Baviera C., 2021. First record of the genus *Serangium* Blackburn, 1889 (Coleoptera Coccinellidae) in Italy. Redia, 104: 185–191. https://doi.org/10.19263/REDIA-104.21.21

Bella Catania R. & Baviera C., 2023. First data on establishment and population trend of the neotropical *Delphastus catalinae* (Horn, 1895) (Coleoptera Coccinellidae) in Italy. Redia, 106: 69–74. https://doi.org/10.19263/REDIA-106.23.08

Bella S., Caruso P., Licciardello G. & Strano C., 2024. Gli alieni degli agrumi sono già tra noi? Creafuturo, 9. https://creafuturo.crea.gov.it/11601.

Brown P.M.J., Adriaens T., Bathon H., Cuppen J., Goldarazena A., Hägg T., Kenis M., Klausnitzer B. E. M., Kovar I., Loomans A. J. M., Majerus M. E. N., Nedved O., Pedersen J., Rabitsch W., Roy H.E., Ternois V., Zakharov I.A. & Roy D.B., 2008. *Harmonia axyridis* in Europe: spread and distribution of a non-native coccinellid. BioControl, 53: 5–21. https://doi.org/10.1007/s10526-007-9132-y

Jucker C., Barbagallo S., Roversi P.F. & Colombo M., 2009. Insetti esotici e tutela ambientale: morfologia, biologia, controllo e gestione. MiPAAF, Cermenate (CO), Italy, 416 pp.

Kenis M., Nacambo S., Van Vlaenderen J., Zindel R. & Eschen R., 2020. Long term monitoring in Switzerland reveals that *Adalia bipunctata* strongly declines in response to *Harmonia axyridis* invasion. https://doi.org/10.3390/insects11120883

Las Casas G., Ciaccia C., Iovino V., Ferlito F., Torrisi B., Lodolini E.M., Giuffrida A., Catania R., Nicolosi E. & Bella S., 2022. Effects of different inter-row soil management and intra-row living mulch on spontaneous flora, beneficial insects and growth of young olive trees in Southern Italy. Plants, 11: 545. https://doi.org/10.3390/plants11040545

Massimino Cocuzza G. E. & Rapisarda C., 2017. Integrated Pest Management in Citrus. In: Integrated Pest Management in Tropical Regions. CAB International, 246–269.

Massimino Cocuzza G. E., Jovičić I., Frisenna F., Tumminelli R. & Siscaro G., 2023. Discovery of *Serangium montazerii* Fürsch (Coleoptera, Coccinellidae) as a predator of *Aleurocanthus spiniferus* (Quaintance) (Hemiptera, Aleyrodidae) in Italy. EPPO Bulletin, 53: 1–11.

Porcelli F., 2008. First record of *Aleurocanthus spiniferus* (Homoptera: Aleyrodidae) in Apulia, Southern Italy. Bulletin OEPP/EPPO Bulletin, 38: 516–518.

Roques A., Rabitsch W., Rasplus J.Y., Lopez-Vaamonde C., Nentwig W. & Kenis M., 2009. Alien terrestrial invertebrates of Europe. In: DAISIE, editor. Handbook of alien species in Europe. Dordrecht: Springer, pp. 63–79.

Sorrentino G., Guardo M., Caruso M., Strano M.C., Allegra M., Di Silvestro S., Bella S., Catania R. & Russo G., 2021. Nuovi patogeni alieni. Certificazione volontaria da estendere in Europa. Rivista di frutticoltura e di ortofloricoltura, 1: 44–48.

Vono G., Bonsignore C.P. & Marullo R., 2022. A Comprehensive Thrips Species Assessment for Eco-Consistent Management of Infestations in Mediterranean *Citrus* Crops. Horticulturae, 8: 137. https://doi.org/10.3390/horticulturae8020137