RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
54 (1) 201-209, 2022
http://doi.org/10.54910/sabrao2022.54.1.19
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

PEST SPECIES COMPOSITION OF FRAGRANT TREES IN THE PARKS AND GARDENS OF YEREVAN CITY, ARMENIA

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SUMMARY

Several fragrant tree species, i.e., *Aesculus hippocastanum*, *Magnolia brooklynensis* 'Yellow Bird,' *Catalpa bignonioides*, and *Prunus serrulata* were previously registered in the database. *A. hippocastanum*, *Ailanthus altíssima*, *C. bignonioides*, and *Robinia pseudoacacia* were found to be the most common and important species in the parks and gardens of Yerevan, Armenia. These species were found in almost all of the studied gardens. The present study aimed to investigate the species composition of the pests of fragrant trees in different landscaped areas of Yerevan, Armenia, during 2020–2021. This study found 48 species of pests of fragrant trees in various parks and gardens. The species belonged to three taxonomic classes, 11 orders, and 33 families. These pest species significantly suppressed the growth and development of fragrant trees, and in some cases, even caused the trees to dry out. In the early spring, the pest species *Parthenolecanium corni* Bouche., *Euproctis chrysorrhoea*, *Aphis laburni* Kalt., *Myzus cerasi*, *Panonychus ulmi*, *Tetranychus urticae*, and *Schizotetranychus pruni* were observed on fragrant plants. Notably, this study revealed six species of fragrant tree pests, of which four, i.e., *Dasineura gleditchiae*, *Halyomorpha halys*, *Trioza neglecta*, and *Calophya rhois*, were found for the first time in the fauna of Armenia, and two, i.e., *Obolodiplosis robiniae* and *Euura tibialis*, were found previously in Tavush Region, Dilijan, Armenia.

Keywords: Fragrant trees, pests species composition, harmful insects, mites and nematodes, Yerevan, Armenia

Key findings: The present work found 48 species of fragrant tree pests belonging to three classes, 11 orders, and 33 families in the various parks and gardens of Yerevan, Armenia. Four species of pests were found for the first time under the physical–geographical conditions of Armenia. The findings of this study can serve as a baseline for implementing effective plant protection measures in the parks and gardens of Yerevan City, Armenia.

Communicating Editor: Prof. Dr. Clara R. Azzam
Manuscript received: November 23, 2021; Accepted: February 18, 2022.

INTRODUCTION

Ornamental fragrant trees remain one of the permanent assets with a pivotal role in the development and improvement of green belts and parks. Trees are important components of the green zones with various parks and gardens in Yerevan City, Armenia. These trees protect against dust and smoke and shield against noise (Hession, 2007). Moreover, they have great aesthetic value. Fragrant trees, being nectar sources, also attract a large number of insect pollinators to parks and gardens, thus contributing to the biological

To cite this manuscript: Babayan AH (2022). Pest species composition of fragrant trees in the parks and gardens of Yerevan City, Armenia. *SABRAO J. Breed. Genet.* 54(1): 201-209. http://doi.org/10.54910/sabrao2022.54.1.19

processes of other plant species. Overall, 41 parks exist in different parts of Yerevan. In recent years, approximately 18 000 trees, including fragrant trees, have been planted in various gardens. During 2020, the best types of trees were selected and imported from the Netherlands, i.e., *Prunus serrulata* 'Royal Burgundy,' *Sakura serrulata*, *Cotinus coggygria* 'Royal Purple,' *Hippomarathrum* species, *Acer platanoides*, *Crataegus medium,* and *Crassula ovata*. These trees have adapted to the climatic conditions of our capital.

Climate change in the present era, urbanization, and the introduction of new fragrant tree species (magnolia and cherry blossom [*P. serrulata*]) into green areas may also invite new species of pests to which local trees may not be adapted. Considering this situation, taking care of the fragrant trees in the green zones of Yerevan is entirely needed. The integrated biological control of various pests, the timely identification of various diseases and pests, the determination of species and the seasonal changes in the intensity and degree of infestations, and the study of various parasites and predators are important for the best management of green areas (Ter-Grigoryan *et al.*, 2014; Lestari *et al*., 2015; Evtushenko and Shamanskaya, 2019).

Various studies on garden and park pests, including fragrant tree pests, have been carried out under different agroclimatic conditions, and some best measures for future management have been recommended (Savkovskiy, 1990; Frago *et al.*, 2010; Berim, 2015; Friedli *et al.*, 2020). Numerous studies on the different pests and diseases of ornamental plants in Yerevan and other cities were also conducted during the 1960s and 1990s (Mirzoyan, 1977; Harutyunyan 1979, 1985), and as a result, more than 800 species of pests (nematodes, mites, and insects) were identified. Over the years, researchers have performed various studies to identify the characteristics, bioecological features, and distribution of fragrant tree species, their harmful insects, and their chemical and biological control measures. However, in recent years, very few studies have been carried out on these topics (Harutyunyan, 2014; Kalashyan *et al.*, 2019).

Targeted studies have found that ornamental trees and shrubs are mainly affected by the larvae of four species of Gracillariinae, i.e., two Orniginae species and two Phyllocnistinae species. The insect species *Phyllocnistis saligna*, *Gracillaria syringella*, *Parectopa robiniella*, *Callisto denticulella*, and *Parornix petiolella* were found to be the most harmful species in the green areas (Sautkin and Evdoshenko, 2013).

Specialized phytophages of *Robinia pseudoacacia* were long absent from the secondary domain. This situation changed in 1825 when the specialized phytophage *Euura tibialis* Newman was first mentioned in Europe. Other species of Hymenoptera-Tenthredinidae were found in 1837. At the end of the 20th century, several North American monophages penetrated Europe. Various types of insects were identified and studied from time to time, i.e., *Phyllonorycter robiniella* (Clemens, 1859) (Lepidoptera: Gracillariidae), *P. robiniella* (Clemens, 1863) (Lepidoptera: Gracillariidae), and *Obolodiplosis robiniae* (Haldeman, 1847) (Diptera: Cecidomyiidae) and its specialized parasite *Platygaster robiniae* Buhl and Duso, 2008 (Hymenoptera: Platygastridae) (Whitebread, 1989; Brguinot, 2010; Maslyakov and Izhevskiy, 2011).

Four new species of foreign phytophagous insects were registered in Dilijan, Armenia. These species included *O. robiniae* (Haldeman, 1847) (Diptera: Cecidomyiidae) and *E. tibialis* (Newman, 1837) (Hymenoptera) and were recorded for the first time in Armenia (Gubin, 2021). During 2016 and 2017, *Halyomorpha halys* damaged up to 50% of the mandarin crop in some parts of Abkhazia and Georgia. In 2017, this pest was observed in Krasnodar and some other areas of Krasnodar Territory, Russia. Therefore, the marble mound has spread at the speed of 100–150 km per year; in the next few years, it can inhabit the entire North Caucasus, Rostov, and Volgograd Regions in Russia, as well as neighboring countries, including Armenia (Neimorovets, 2018).

Dasineura gleditchiae, one of the pests of Gladiciaceae, is native to North America. This pest was first discovered in Europe in 1975; it mainly affects young trees and leads to a gradual reduction in the crown density of plants (Struchaev, 2011; Sinchuk and Kolbas, 2018). Damage by the beetle *Megabruchidius dorsalis* was observed on gladiolus seeds near *Gleditsia triacanthos* gledichia (15.3%), on Caspian *Gleditsia caspica* (17.4%), and on *Gutierrezia texana* (6.3%) (Belitskaya, 2018). *Cotinus* trees can be damaged by *Cactopinus rhois*, which causes wrinkling, followed by browning and drying (Vasilyev, 1987). *Catalpa* plants are frequently damaged by *Pseudococcus*, Japanese beetle, and aphids (Carolyn, 2005).

MATERIALS AND METHODS

This study was carried out on fragrant tree pests in different landscaping areas of Yerevan, Armenia, during 2020–2021. In early spring, hunting and gluing straps were wrapped around the trunks of the examined trees, and light traps were used to study the pests growing in the soil. The pests were collected by mechanically shaking the trees with the help of an entomological canopy. Pests in the early stages of development (caterpillar and pupal stages) were transferred to the Entomology Laboratory of Biology and Hydroecology of the National Academy of Sciences and raised to adulthood, after which their species composition was determined. Collected material was fixed in 70% ethyl alcohol or stored on cotton pads. The species of the collected pests were identified with the help of professional determinants (Treyvas, 2007). Surveys in different parks and gardens were conducted regularly and once every 5–10 days.

Mites were collected together with leaves and placed in plastic bags. The samples were labeled in accordance with the place of collection, the type of plant, the time of collection, and the nature of the damage. Mites were collected from leaves with a damp brush, after which they were examined with a magnifying glass 10 times. Collected lice were taken to the laboratory of the Scientific Center of Zoology and Hydroecology (Yerevan, Armenia) for specimen preparation and species determination (Bondarenko *et al.*, 1980).

For the detection of phytonematodes, vegetative soil samples were taken during the vegetation period. The samples were taken from the upper mineral horizon in the gardens and parks via the route method in the case of agrocenosis and in the soil loam in the horizontal soil layers in the case of biocenosis. Each soil sample, which had a volume of 0.5–1.0 kg, was selected from the perimeter of the tree (rhizosphere) with vertical soil with the following horizontal layers. Soil samples were taken at the depths of 10–20 and 20–40 cm, transferred into plastic bags, labeled, and analyzed in the laboratory. The weight of each sample analyzed in the laboratory was 100 g. Live nematodes were separated from the soil through the Berman method and the soil washing method (Matveeva *et al.*, 2018). Determinants were used to identify various nematodes (Gooday 1959; Kiryanova and Krall, 1969; Taylor and Brown, 1997).

RESULTS AND DISCUSSION

Artificial conditions for the growth of fragrant plants in the green areas of Yerevan, Armenia, are very different from natural conditions. Plantings in these areas have weakened given their high susceptibility to various pests under the influence of various unfavorable factors that are inherent in cities. The phytomonitoring of parks and urban green areas on the basis of information about phytopathogens and phytophagous tree pests is necessary for the development of strategic directions for the conservation of green spaces in urban agglomerations (Baris, 2005; Seraya *et al*., 2019). Most pests of trees are insects, mites, and nematodes that disrupt normal growth and development and decrease decorative value. In the many years of research conducted on the parks and gardens of Yerevan, Armenia, we collected 48 species of phytophagous pests of fragrant trees (Table 1).

Data analysis revealed that the pests were most diverse in acacia and tilia trees, which were each infested with 10 species of pests (Table 1). Nine species of phytophagous pests and approximately seven and six species of *Crataegus* and *Padus*, respectively, were found in *Elaeagnus*. Five species of pests were observed in *Aesculus* and *Sorbus* trees. However, only three species were found in *Catalpa* and *P. serrulata*, and approximately two phytophages were discovered in magnolia, *Sophora*, *Cercis*, and *Cotinus*. These tree species may be harmed by a small number of pest species because they are not commonly found in gardens in Yerevan. Several species of fragrant trees, such as *Albizia*, *Ailanthus*, and *Koelreuteria*, have no pests. The resistance of trees to insects is largely dependent on the degree of the activation of defense reactions (Berlinger, 2008; Goggin *et al.*, 2015; Mitchell *et al.*, 2016). Plants resist pests by producing secondary metabolites, including terpenes, phenols, and nitrogen- and sulfur-containing compounds, that either kill pests or hamper their development. The response to the complex effects of environmental factors is mainly reflected by the indicators of the vital state of woody plants. These plants have been found to exhibit unequal resilience under urban anthropogenic pressures (War *et al.,* 2012; Rowen and Kaplan, 2016).

Among the pests, aphids (*Aphis laburni* and *Myzus cerasi*) were the most common. During spring, these pests started to damage

Table 1. Phytophagous pests of fragrant tree species in Yerevan, Armenia.

Class	Order	Family	Species	Food specialization	Fragrant tree species harmed
Chromadorea	Tylenchida	Criconematidae	*Mesocriconema xenoplax* Raski, 1952	Polyphagous	Acacia
	Rhabditida	Hoplolaimidae	*Helicotylenchus dihystera* Cobb, 1893 Sher, 1966	Polyphagous	Acacia, Magnolia
	Tylenchida	Heteroderidae	*Meloidogyne arenaria* Neal, 1889	Polyphagous	Catalpa
Arachnoidea	Acariformes	Tetranychidae	*Panonychus ulmi* Koch 1836	Polyphagous	Cherry blossom
			Tetranychus urticae C.L. Koch, 1836	Polyphagous	Cercis, Tilia, Crataegus, Aesculus
			Schizotetranychus pruni Oudemans, 1931	Polyphagous	Padus, Crataegus, Tilia
		Eriophyidae	*Eriophyes tiliae var. Leiosoma* Nal 1982	Monophagous	Tilia
Insect	*Homoptera*	Aphididae	*Myzus cerasi* Fabricius, 1775	Oligophagus	Cherry blossom, Padus
			Aphis craccivora C.L.Koch, 1854	Polyphagous	Acacia
			Siphonaphis padi Linnaeus, 1758	Polyphagous	Padus
			Aphis pomi De Geer, 1773	Oligophagus	Sorbus, Crataegus
			Capitophorus hippophaes Walker, 1852	Oligophagus	Elaeagnus
			Aphis gossypii Glover, 1877	Polyphagous	Catalpa
		Cicadellidae	*Cicadella viridis* Linnaeus, 1758	Polyphagous	Cherry blossom, Magnolia, Crataegus, Padus
		Cercopidae	*Cercopis vulnerata* Rossi, 1807	Polyphagous	Acacia
		□Issidae	*Agalmatium flavescens* Olivier, 1791	Polyphagous	Elaeagnus, Sophora
		Coccidae	*Parthenolecanium corni* Bouche., 1844	Polyphagous	Acacia, Gleditsia, Sophora, Koelreuteria
	Hemiptera	Pentatomidae	*Halyomorpha halys* Stål, 1855	Polyphagous	Cercis, Sophora
			Palomena prasina Linnaeus, 1761	Polyphagous	Crataegus
			Dolycoris baccarum Linnaeus, 1758	Polyphagous	Crataegus
			Rhaphigaster nebulosa Poda, 1761	Polyphagous	Aesculus, Crataegus
		Coreidae	*Gonocerus acuteangulatus* Goeze, 1778	Polyphagous	Crataegus
		Calophyidae	*Calophya rhois* Löw, 1877	Monophagous	Cotinus
		Triozidae	*Trioza neglecta* Loginova, 1978	Monophagous	Elaeagnus
		Tingidae	*Stephanitis pyri* Fabricius, 1775	Polyphagous	Sorbus
	Coleoptera	Curculionidae	*Phyllobius pyri* Linnaeus, 1758	Polyphagous	Tilia, Padus
		Attelabidae	*Byctiscus betulae* Linnaeus, 1758	Polyphagous	Sorbus, Aesculus, Tilia
		Chrysomelidae	*Xanthogaleruca luteola* Statius Müller, 1766	Oligophagus	Catalpa, Acacia, Tilia
		Scarabaeidae	*Amphimallon solstitialis* Linnaeus, 1758	Polyphagous	Gleditsia, Acacia
			Oxythyrea cinctella Schaum, 1841	Polyphagous	Padus
			Cetonia aurata Linnaeus, 1758	Polyphagous	Acacia, Elaeagnus
		Buprestidae	*Capnodis cariosa* Pallas, 1776	Polyphagous	Cotinus
		Cerambycidae	*Chlorophorus varius* O.F. Müller, 1766	Polyphagous	Acacia, Elaeagnus
			Phymatodes variabilis Linnaeus, 1761	Polyphagous	Aesculus
	Lepitoptera	Pyralidae	*Etiella zinckenella* Treitschke, 1832	Oligophagus	Acacia
		Sphingidae	*Deilephila hippophaeae* Esper, 1789	Oligophagus	Elaeagnus
		Lymantridae	*Euproctis chrysorrhoea* Linnaeus, 1758	Polyphagous	Tilia, Acacia
			Lymantria dispar Linnaeus, 1758	Polyphagous	Elaeagnus, Tilia
		Geometridae	*Biston strataria* Hufnagel, 1767	Polyphagous	Tilia
			Lycia hirtaria Clerck, 1759	Polyphagous	Tilia
		Yponomeutidae	*Yponomeuta padellus* Linnaeus, 1758	Polyphagous	Sorbus
		Noctuidae	*Cosmia trapezina* Linnaeus, 1758	Polyphagous	Tilia, Elaeagnus
		Gelechiidae	*Recurvaria nanella* Denis & Schiffermüller, 1775	Polyphagous	Sorbus
		Tortricidae	*Archips crataegana* Hubner, 1796-1799	Polyphagous	Crataegus, Padus
	Dipthera	Cecidomyiidae	*Obolodiplosis robiniae* Haldeman, 1847	Monophagous	Acacia
			Dasineura gleditchiae Osten Sacken, 1866	Monophagous	Gleditsia
	Hymenoptera	Tenthredinidae	*Euura tibialis* Newman, 1837	Monophagous	Acacia
	Orthoptera	Gryllotalpidae	*Gryllotapla Gryllotalpa* Linnaeus, 1758	Polyphagous	Acacia, Gleditsia

trees in gardens when the temperatures reached 15 °C–18 °C. The harmfulness of aphids was observed in almost all of the gardens and parks. The presence of *Parthenolecanium corni* has been reported in several orchards (Oak Garden, Komitas Park, Botanical Gardens, and other green areas in Yerevan City, Armenia), where *R. pseudoacacia* and *Gleditsia* grow. *C. rhois* and *Psylla pyri* were also quite widespread. Notably, in this research, six species of fragrant trees pests were identified, four of which were mentioned for the first time in the fauna of Armenia. These insect species were *D. gleditchiae*, *H. halys*, *Trioza neglecta*, and *C. rhois*. Two, namely, *O. robiniae* and *E. tibialis*, were found and are known to be present in Tavush Region, Dilijan, Armenia, before the present study. The pests are distributed through natural and anthropogenic processes, with the globalization of markets for plants and plant products providing a significant contribution to their dissemination in recent decades (Woolhouse *et al.,* 2002; Anderson *et al.,* 2004). The penetration of the first detected pest species into the territory of Armenia likely occurred with infected planting material. This pathway for insect pest introduction is one of the main reasons for the recent rapid spread of phytopathogens to new host plants (Bergsma-Viami *et al*., 2015; Wang *et al*., 2015; Daughtrey and Buitenhuis, 2020).

In this work, the insect species *H. halys* was found in *Cercis siliquastrum* trees in Komitas Park and in *Styphnolóbium japónicum* trees in Vahan Zatikyan Park, Armenia. However, this pest was encountered in small quantities. *C. rhois* is well distributed on *C. coggygria* trees and is found in Nansen and Tsitsernakaberd Parks and different botanical gardens. *T. neglecta* was observed in *Elaeagnus angustifolia* trees in Shahumyan Park. However, this pest is monophagous and damages only the mentioned tree species. *O. robiniae* was found in pseudoacacia trees in a New Garden park in Avan Administrative District. Overall, the heaviest infection was observed in young trees. In the botanical gardens, *D. gleditchiae* was observed in *G. triacanthos* trees with significant damage (30%–35%) from April to July. *E. tibialis* is an oligophage pest and is found in the parks of Avan and Davitashen Administrative Districts, Armenia. It is also found on various *Robinia* tree species, wherein the larvae feed on host tissues (Hargrove, 1986; Liston, 2011).

The present observations also identified that the intensity of infection was higher in the wet areas of the gardens because insect pests most actively fed at temperatures of approximately 30 °C. The physiological processes of most pest species are particularly sensitive to temperature (Thomas *et al*., 2004; Juroszek *et al*., 2020). In general, all important stages in the life cycle of insect pests (survival, reproduction, and spread) are directly influenced by temperature, relative humidity, light quality or quantity, or any combination of these factors (Regniere, 1983). Rising temperatures affect the rate of reproduction and development of insect pests (Bale *et al*., 2002), the introduction of invasive species (Dukes and Mooney, 1999), and the extinction of insects (Thomas *et al*., 2004). According to the present findings, the insect species *E. tibialis* has not yet become widespread in the parks and gardens of Yerevan, Armenia. This North American species is a Palearctic species and is distributed mainly at northern latitudes (GBIF Backbone Taxonomy, 2021). However, its discovery in the urban green spaces of Donbass has been reported (Martynov *et al*., 2020).

Among the fragrant tree pests, four species (8%) belonged to the class *Arachnoidea*, three nematode species (6%) belonged to class Chromadorea, and 41 species (86%) belonged to class Insecta (Figure 1). The recorded pests belonged to 11 orders and 33 families, among which Homoptera and Lepidoptera were represented by 10 species each (21% each). Orthoptera and Hymenoptera were represented by one species each (Figure 2).

In accordance with the types of nutrition, 36 (76%) of all pest species were polyphagous. Oligophages and monophagous pests were represented by six species each (24%). Therefore, the majority of the detected pests species were polyphagous (Figure 3). Most of the recorded pest species, i.e., *S. pyri*, *T. neglecta*, *G. acuteangulatus*, and *A. craccivora*, feed mainly on leaves and annual shoots. However, the remaining pest species, i.e., *P. variabilis*, *G.gryllotalpa*, and *C. cariosa*, damage shrubs and perennial branches. Heavy feeding by these pests weakens the growth and resistance of fragrant trees and makes the plants vulnerable to secondary pests. At the same time, the decorative appearances of these trees deteriorate. In cases of heavy infection, some insects can even cause the partial or complete drying of trees. Therefore, identifying the effective means of control and taking measures to combat the spread of pests and diseases throughout the city are very necessary.

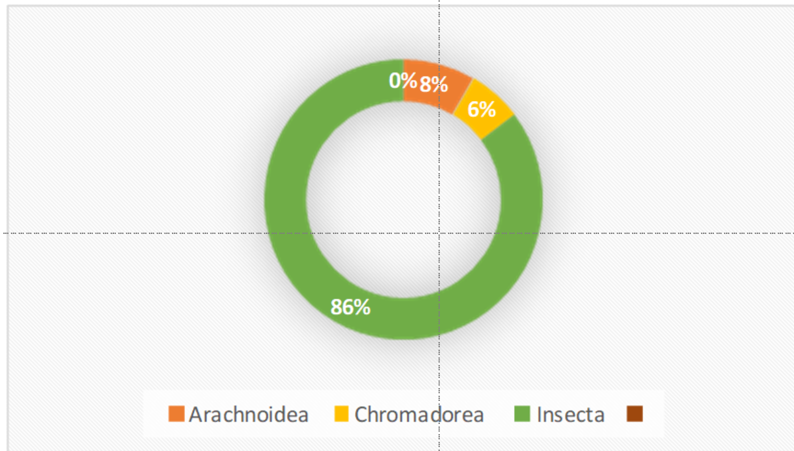

Figure 1. Class affiliations of phytophages in Yerevan, Armenia.

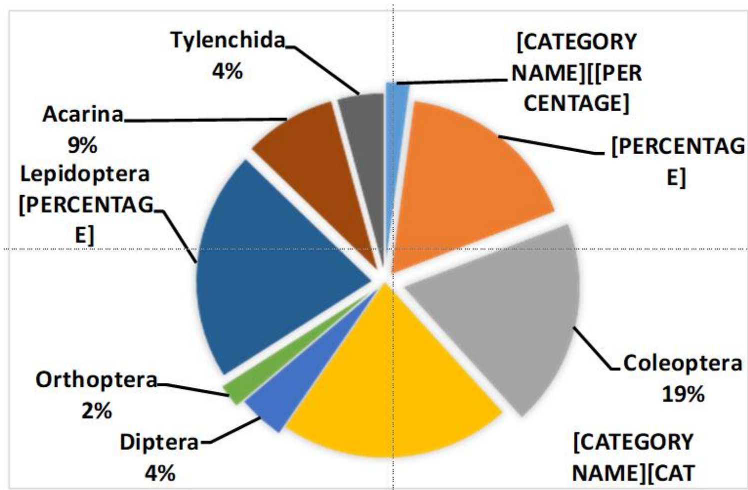

Figure 2. Order affiliations of phytophages in Yerevan, Armenia.

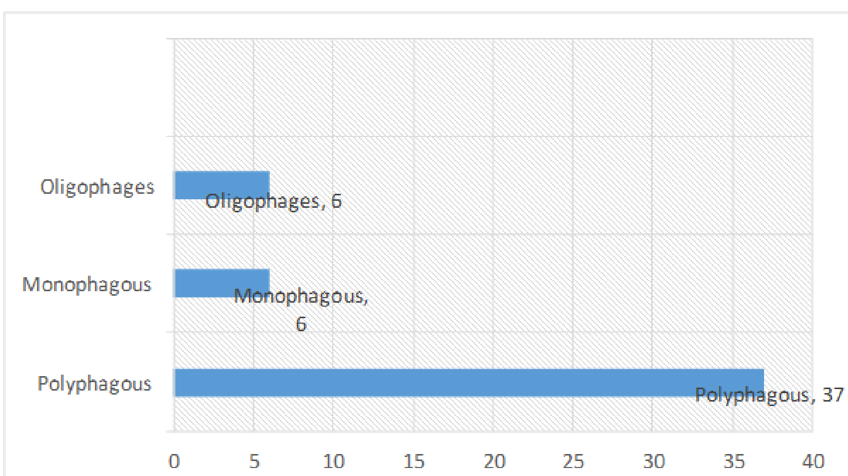

Figure 3. Feeding specialization classification of pests in Yerevan, Armenia.

The best available pest management practices include early warning systems, good diagnostic tools, and effective treatments (Thomas *et al.*, 2017; Munkvold and Gullino, 2020), along with appropriate sampling and monitoring. Other best available practices include the introduction of plant health practices and integrated plant protection systems, the application of strict hygiene measures, and the use of biological tree protection products (Munkvold, 2009). Other measures for effective pest control in gardens, such as observing a strict irrigation regime, avoiding waterlogging and drying out, using healthy planting material, and stimulating the development of entomophages, can be taken in addition to the strategies above.

CONCLUSIONS

This work revealed that various fragrant tree species, i.e., *A. hippocastanum*, *Magnolia brooklynensis* 'Yellow Bird', *C. bignonioides*, and *P. serrulata*, were registered in the parks and gardens of Yerevan, Armenia. *A. hippocastanum*, *Ailanthus altíssima*, *C. bignonioides*, and *R. pseudoacacia* were the most common species. Overall, 48 pest species of fragrant trees were found in the parks and gardens of Yerevan, Armenia. These pests included nematodes, mites, and insects belonging to three classes, 11 orders, and 33 families. Four types of pests were found for the first time under the physical-geographical conditions of Armenia, whereas two species were previously known only from Tavush, Dilijan Region, Armenia.

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