



Alien Terrestrial Invertebrates in North Macedonia: Overview, New Contributions and Insights into the Country's Efforts

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Abstract: Many introduced terrestrial invertebrate species pose significant ecological, economic and health challenges worldwide. North Macedonia, due to its geographic position and diverse ecosystems, is vulnerable to their introduction and establishment. This study aims to expand previous research regarding introduced terrestrial invertebrate species in North Macedonia by reviewing literature data, identifying new introduced species and addressing efforts to overcome this problem. Original data collected between 2022 and 2024, combined with a comprehensive review of existing literature, expanded the national list of alien invertebrates to at least 133 species. The paper also highlights policy frameworks, scientific research initiatives taken so far and regional cooperation efforts aimed at preventing introductions of alien species.

Key words: introduced species, new records, North Macedonia, terrestrial arthropods

Introduction

An alien species (also called an introduced, non-native, non-indigenous, foreign, new or exotic species, allochthonous) is a species, subspecies or lower taxon of animal, plant, fungus or other organism that has been transported by human activities, either intentionally or accidentally, outside of its natural (past or present) geographic range (Secretariat of the Convention on Biological Diversity, 2002). It includes any part of such species (e.g. seeds, eggs, gametes or propagules), as well as any hybrids, varieties or breeds that might survive and subsequently reproduce in the new environment (CBD 2002, Eu-

ropean Commission n.d.). Therefore, the identification and monitoring of introduced and invasive species have become critical components of ecological and biodiversity management worldwide.

According to the International Union for Conservation of Nature (IUCN), introduced alien species are considered the fifth most severe threat to amphibians, the fourth to reptiles, the third to birds and mammals and the second to freshwater fish species (Vié et al. 2009). They are threatening the biodiversity of terrestrial invertebrates as well, but due to a lack of data for many insect and invertebrate species, their negative impact is often overlooked (Cardoso et al. 2020). The very central location within the Balkans,

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its geomorphology and diverse climate result in a variety of habitats and ecosystems from wetlands, forests, grasslands to mountains, which, while supporting exceptionally high biodiversity, make North Macedonia particularly vulnerable to the introduction of non-native species. On the other hand, it is precisely the geographical position of North Macedonia, which offers opportunities for intensive trade, tourism and transport, that increases the country's exposure to the introduction of alien species. The intensive movement of people and goods and its proximity to major transport routes creates conditions for the introduction of species that could cause disruption to biodiversity and the stability of ecosystems. Hence, in order to prevent and possibly reduce negative impacts, it is of high importance to study, monitor and manage the introduction of alien species.

Previous studies of species introduction in North Macedonia have highlighted the presence of 129 alien terrestrial invertebrate species (Atanasov 1959, Tomov et al. 2009, Hristovski et al. 2015, Kulijer 2016, Postolovski & Lazarevska 2010, Postolovski et al. 2011, Lazarevska et al. 2017, Stojkoska & Stefanovska 2017, Cvetkovska-Gjorgjievska et al. 2019), emphasising the need for a better knowledge of their pathways of distribution. Considering previous data, this study aims to continue the research of introduced terrestrial invertebrate species in North Macedonia. It focuses on new records of four introduced species in North Macedonia, reviewing literature data about alien species, as well as addressing management efforts taken on the national and international levels. In order to prevent introductions, control introduced species and lessen their effects, the paper also discusses the existing policy frameworks, scientific research activities thus far and regional cooperation efforts.

Materials and Methods

The presented data include new records of introduced species in North Macedonia, collected during targeted field trips conducted by the authors across various locations and dates detailed below. The specimens were sampled manually or recorded via direct field observations in the period 2022–2024, and are stored in the collection of the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences (IBER, BAS). Additionally, this study summarises the existing literature on introduced species in the country, covering published records from 1951 up to 2025, and provides insights into the mitigation initiatives and measures that North Macedonia is implementing to address the introduction of non-native species.

Results

New contributions

We recorded three species of land gastropods (*Rumina decollata*, *Oxychilus cyprius*, *Boettgerilla pallens*) and one species of mantis (*Hierodula tenuidentata*) on the territory of North Macedonia. Further, we reviewed data on previous records, origin and possible routes of introduction into North Macedonia (Fig. 1). These findings are important because they expand the known alien invertebrate fauna of the country and point to previously under-reported taxonomic groups in monitoring efforts.

Rumina decollata (Linnaeus, 1758) (Gastropoda, Achatinidae)

Records: Skopje City, settlement Hrom, backyard of a warehouse, among plants, 250 m a.s.l., N42.004086° E021.368827°, 04.05.2023, 12 adult alive specimens and 2 adult shells, leg. Z. Nastov.

Origin: *Rumina decollata* (Fig. 2a) is native to the Western Mediterranean Region, including the Western Balkan Peninsula (Prévot et al. 2014).

Comments: The species is introduced in many parts of the world, including North and South America and South Asia (Prévot et al. 2014). Although Prévot et al. (2014) noted the species for the Western Balkans, so far it has not been reported from North Macedonia (Bank & Neubert 2017). In suitable habitats, *R. decollata* is known to be a successful coloniser due to its ability to self-fertilise and its omnivorous diet including both plants and invertebrates, such as other snails, slugs, worms (Selander & Ochman 1983), and could cause negative impact on native snail fauna (Bar-Zeev & Mienis 2007).

Oxychilus cyprius (L. Pfeiffer, 1847) (Gastropoda, Oxychilidae)

Records: Skopje City, backyard, among plants and in soil, 254 m a.s.l., N41.995683° E021.415746°, 17.06.2023, 1 adult shell, 1 alive sub-adult and 3 alive juveniles, leg. I. Dedov.

Origin: *Oxychilus cyprius* (Fig. 2b) occurs in Albania, Croatia, Greece, Cyprus, as well as in Asia Minor. According to Riedel (1983), in the north-western and south-eastern parts of its distribution range (e.g. caves near Dubrovnik, Croatia, caves near Naousa, Greece and the region of Antakya, Turkey) the species occurs in natural habitats, while in the middle of its distribution area (Southern Greece, Crete, Aegean Islands, Western Asia Minor) it is exclusively synanthropic. Riedel (1983) notes that such a phenomenon can not be explained, but *O. cyprius* shows a tendency towards synanthropy throughout its entire distribution range.

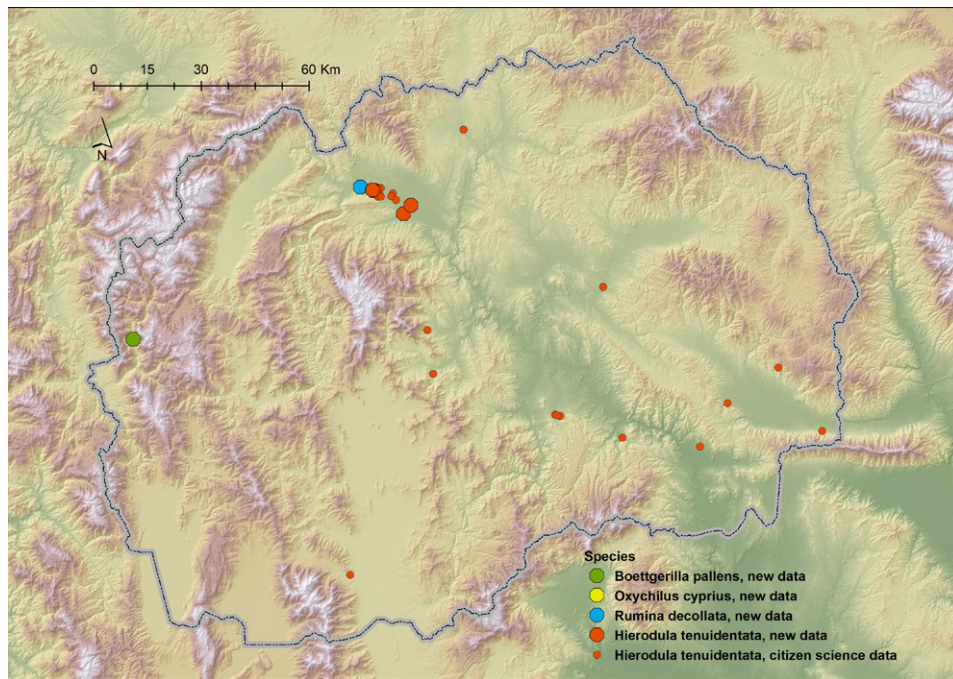


Fig. 1. Distribution map of newly recorded alien species in North Macedonia

Comments: *O. cyprus* has not been found in other localities of North Macedonia to date, but its finding in the City of Skopje is not surprising, since the species has a tendency towards synanthropy (Riedel 1983). It is likely that the species has inhabited various small suitable habitats in Skopje for a long time, possibly having been introduced there or being a remnant of a larger natural population in the region.

Boettgerilla pallens Simroth, 1912 (Gastropoda, Boettgeriidae)

Records: Radika River Valley, St. Jovan Bigorski Monastery, riparian vegetation, under stones, 669 m a.s.l., N41.62180° E020.60633°, 17.07.2024, 2 adult alive specimens, leg. I. Dedov. Slugs were treated following the recommendations of Nitz et al. (2009).

Origin: *Boettgerilla pallens* (Fig. 2c) is a Caucasian species, widespread in South-Eastern Europe and is rapidly invading the south-western part of the continent (Kerney & Cameron 1996, Reise et al. 2000, Šatkauskienė 2001, Margry 2014). On the Balkan Peninsula, the species is known from Bulgaria (Dedov et al. 2015, Georgiev et al. 2020), Greek mainland (Bank & Neubert, 2017) and Serbia (Dedov et al. 2025). In this paper, we present the first record of the species in North Macedonia.

Comments: *B. pallens* is distributed throughout most of Europe, including the Balkans: Bulgaria, Greece, Serbia and Turkey (Reise et al. 2000, Dedov et al. 2015, Bank & Neubert, 2017). According

to Reise et al. (2000), the human factor is a key to the spread of *B. pallens* in Europe. Previous surveys in North Macedonia, including the area of the 2024 record, did not report specimens.

Hierodula tenuidentata Saussure, 1869 (Insecta, Mantodea, Mantidae)

Records: Skopje City, Centre municipality, obs. S. Hristovski, 41.997098, 21.409416, 18.09.2022, 1 adult male; Skopje City, spring 2022, ootheca, obs. D. Chobanov; Skopje City, Centre municipality, obs. S. Hristovski, 41.995492, 21.415588, 17.08.2022, 1 adult male; Skopje City, Drachevo, obs. A. Cvetkovska-Gjorgjievska, 41.936922, 21.513989, summer 2024; Skopje City, Dolno Lisiche, obs. A. Cvetkovska-Gjorgjievska, 41.958014, 21.538179, summer 2024.

Origin: The giant Asian mantis *Hierodula tenuidentata* (Fig. 3) is distributed from Crimea in the West to India, Nepal and Malay Archipelago in the East. Recently, it has been spreading fast westwards reaching Italy and Spain to the West and Moldova, Hungary and Austria to the North (Battiston et al. 2018, Van der Heyden 2021, Zaharov & Romanovich 2021, Vujić & Ivković 2023, Oswald & Kölz 2025).

Comments: This species was first mentioned as possibly spreading out of its native range in eastern Turkey since the 1970s (Ehrmann 2011) and in southern Ukraine (Pushkar & Kavurka 2016), while soon afterwards almost simultaneously being



Fig. 2. New records of introduced gastropod species in North Macedonia: A) *Rumina decollata* (Linnaeus, 1758), B) *Oxychilus cyprius* (L. Pfeiffer, 1847), C) *Boettgerilla pallens* Simroth, 1912



Fig. 3. New records of introduced mantid species in North Macedonia: *Hierodula tenuidentata* Saussure, 1869

reported from Albania, Bulgaria, Greece and some Greek islands, Italy and North Macedonia (Battiston et al. 2018, Cianferoni et al. 2018, Schwarz & Ehrmann 2018, Van der Heyden 2018, Romanowski et al. 2019) either as *Hierodula* sp., *H. transcaucasica* Brunner von Wattenwyl, 1878 or *H. tenuidentata*. Cianferoni et al. (2018) and Vujić & Ivković (2023) have reported single records for North Macedonia. So far *H. tenuidentata* has been confirmed in Gevgelija City, Municipality Karaorman, N41.140362° E022.495796°, 28.09.2018, 1 specimen, photo by “ouranimalsweb” (IN) (Cianferoni et al. 2018) and in the city Sveti Nikole, Mečkuevci, N41.922570° E022.073040°, 23.07.2022, 1 nymph, leg. S. Ivković (Vujić & Ivković 2023). In the most complete overview of the range of this species in South-Eastern Europe, Vujić & Ivković (2023) show a high concentration of records in Bulgaria and the southern Balkan coastline, while the records in North Macedonia remain scarce. The species has been observed mostly in lowland habitats and is a large opportunistic carnivore. Field observations indicate that *H. tenuidentata* inhabits shrubs and trees, while the four native mantid species are mostly found in grass or low bushes (Battiston et al. 2018; own field observations).

Overview of known alien species in North Macedonia

The level of research regarding presence and distribution of alien species in North Macedonia is far from satisfactory. The review of literature data (around 36 scientific papers and online databases) covering a period of 74 years (1951-2025), suggests the presence of 129 non-indigenous species. Most of them belong to the orders Coleoptera (42 species, 12 families), Hemiptera (35 species, 15 families) and Lepidoptera (20 species, 11 families) (Tables 1, 2). However, our results indicate that other taxonomic groups, such as Gastropoda and Mantodea, are represented among newly introduced species.

The total confirmed number of alien invertebrates (including the four species reported in this paper) is at least 133, though this number is likely an underestimate due to insufficient research and reporting. As shown in Fig. 4, the introduction of alien invertebrates into North Macedonia follows a positive trend, probably driven by globalisation, tourism, trade, land-use changes, forest alteration and climate change. If this trend of introduction and establishment continues, measures should be taken to avoid or minimise their negative impact on biodiversity, socio-economic and ecosystem processes.

Table 1. Number of alien invertebrate species (belonging to different family) in North Macedonia for the period 1951-2025

Order/family	no. recorded alien species	Order/family	no. recorded alien species
Clitellata	1	Culicidae	1
Lumbricidae	1	Hemiptera	35
Gastropoda	3	Anthororidae	1
Arionidae	1	Aphididae	18
Helicidae	2	Cimicidae	1
Acarina	6	Cixiidae	1
Eriophyidae	3	Coccidae	3
Ixodidae	1	Coreidae	1
Tetranychidae	2	Diaspididae	1
Araneae	8	Dictyopharidae	1
Gnaphosidae	1	Margarodidae	1
Pholcidae	3	Membracidae	1
Tetragnathidae	1	Nabidae	1
Theridiidae	3	Oxycarenidae	1
Myriapoda	1	Pentatomidae	1
Paradoxosomatidae	1	Phylloxeridae	1
Zygentoma	1	Tingidae	2
Lepismatidae	1	Hymenoptera	7
Blattodea	1	Aphelinidae	2
Blattellidae	1	Encyrtidae	2
Coleoptera	42	Formicidae	3
Anobiidae	8	Lepidoptera	20
Anthicidae	1	Arctiidae	1
Cerambycidae	2	Coleophoridae	1
Chrysomelidae	7	Crambidae	1
Coccinellidae	1	Erebidae	1
Cryptophagidae	1	Gelechiidae	3
Dermestidae	4	Gracillariidae	3
Histeridae	1	Noctuidae	2
Latridiidae	7	Pyralidae	4
Mycetophagidae	1	Saturniidae	1
Nitidulidae	8	Tineidae	1
Staphylinidae	1	Tortricidae	2
Diptera	3	Thysanoptera	1
Agromyzidae	1	Thripidae	1
Cecidomyiidae	1		

Discussion

Most research on alien fauna was conducted during 2007, as part of the international project “Non-indigenous insects and their threat to biodiversity and economy in the Balkans” which lists 302 alien insects established in Albania, Bulgaria and the Re-

public of Macedonia (Tomov et al. 2009) (Table 2). Unfortunately, before and after 2007, there are no national or international projects concerning alien invertebrate species. The only exception is the project concerning Asian tiger mosquito (*Aedes albopictus* Skuse, 1894) (Stefkov et al. 2010) and the East and South European Network for Invasive Alien

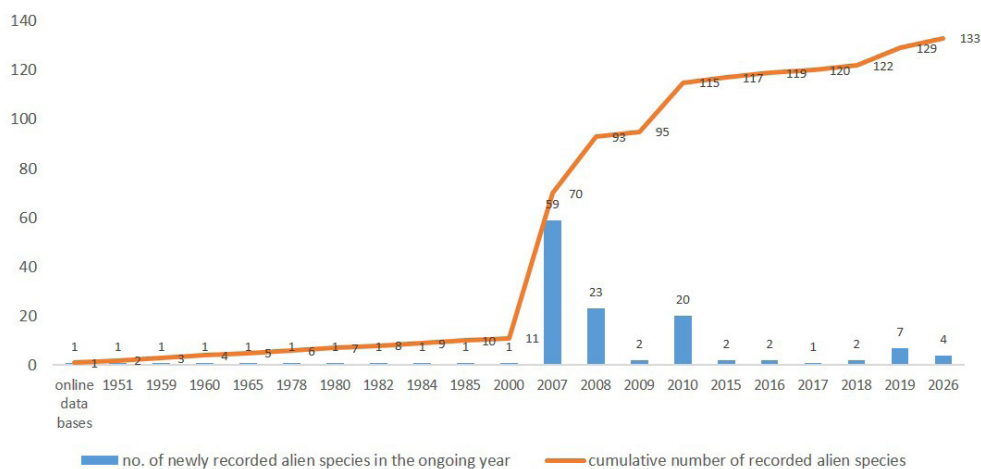


Fig. 4. Number of newly recorded vs. cumulative number of alien species in North Macedonia, by year

Species (ESENIA 2011). Most scientific publications have been authored by foreign researchers and have focused primarily on Lepidoptera, Coleoptera and Hemiptera (Table 2). This reveals a research gap in groups like terrestrial molluscs and predatory insects, now partially addressed by the present study.

Aphids (Hemiptera, Aphididae) have the highest number of non-native species (18 species) in North Macedonia and probably their introduction will continue, mainly with the import of horticulture (Tables 1, 2). Several global and regional instruments (databases, organisations and networks) provide frameworks for addressing invasive alien species: EASIN – European Alien Species Information Network, DAISIE (Delivering Alien Invasive Species Inventories for Europe), IUCN/SSC, Invasive Species Specialist Group (ISSG), NOBANIS – European Network on Invasive Species, GBIF – Global Biodiversity Information Facility, ESENIA – East and South European Network for Invasive Alien Species, CABI – Invasive Species Compendium, EPPO – Global Database and Neobiota – The European Group on Biological Invasions. North Macedonia has aligned its policies with the European Union (EU) regulations on introduced species through the adoption of laws on Nature Protection (2004), has adopted a National Biodiversity Strategy (2018–2025) and it is party to relevant conventions (CBD, Bern Convention). In 2022, North Macedonia became a member of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). This membership confirms the country's commitment to global efforts to conserve biodiversity and ecosystem services, as well as to actively participate in the development of policies for environmental protection and climate change (IPBES 2019). However, the country still lacks a centralised online database for

alien invertebrates and has limited cross-border control mechanisms, with the partial exception of its cooperation with Bulgaria under the INTERREG VI-A IPA programme (2021–2027).

Conclusion

Our research highlights the recent introductions of four non-native terrestrial invertebrate species in North Macedonia (*Rumina decollata*, *Oxychilus cyprinus*, *Boettgerilla pallens* and *Hierodula tenuidentata*). The documented number of newly recorded introduced species in North Macedonia likely under-represents the actual diversity and extent of alien species currently established within the country. Although North Macedonia has implemented measures both nationally and internationally by aligning its policies with European Union standards on introduced and invasive species, the absence of an official database and the lack of cross-border control limit the ability to adequately address this threat. To overcome this problem, we need to learn from the experience and follow the practices of other countries. International experiences and practices that can be applied in North Macedonia include increased scientific research and public awareness, appropriate legal regulations, updated national strategies, preparation of red lists of introduced species, increased border controls, etc. Public awareness, facilitated by scientific research, is fundamental for preventing the spread of introduced and invasive species and has fortunately increased. Effective border control is among the first tools for prevention, and in order to achieve it, it is crucial to make changes and additions to the legal regulations, to implement preventive measures and, at the same time, to strengthen the cooperation with neighbouring countries.

Table 2. List of alien species in North Macedonia according to literature data

Year of first record	Group	Family	Taxon	Reference
2024	Mantodea	Mantidae	<i>Hierodula tenuidentata</i> Saussure, 1869	This paper
2024	Gastropoda	Boettgerillidae	<i>Boettgerilla pallens</i> Simroth, 1912	This paper
2023	Gastropoda	Oxychilidae	<i>Oxychilus cyprius</i> (L. Pfeiffer, 1847)	This paper
2023	Gastropoda	Achatinidae	<i>Rumina decollata</i> (Linnaeus, 1758)	This paper
2019	Coleoptera	Dermestidae	<i>Trogoderma variabile</i> Ballion, 1878	Cvetkovska-Gjorgievska et al. (2019)
2019	Gastropoda	Arionidae	<i>Arion vulgaris</i> Moquin-Tandon, 1855	Cvetkovska-Gjorgievska et al. (2019)
2019	Gastropoda	Helicidae	<i>Cornu aspersum</i> (Müller, 1774)	Cvetkovska-Gjorgievska et al. (2019)
2019	Hemiptera	Coccidae	<i>Ceroplastes japonicus</i> Green, 1921	Cvetkovska-Gjorgievska et al. (2019)
2019	Hemiptera	Oxycarenidae	<i>Oxycarenus lavaterae</i> (Fabricius, 1787)	Cvetkovska-Gjorgievska et al. (2019)
2019	Hemiptera	Tingidae	<i>Corythucha ciliata</i> (Say, 1832)	Cvetkovska-Gjorgievska et al. (2019)
2019	Lepidoptera	Gelechiidae	<i>Tuta absoluta</i> (Meyrick, 1917)	Cvetkovska-Gjorgievska et al. (2019)
2018	Acarina	Eriophyidae	<i>Aceria kuko</i> (Kishida, 1927)	Traževski et al. (2018); EPPO
2018	Hemiptera	Dictyopharidae	<i>Dictyophara europaea</i> (Linnaeus, 1767)	Krstic et al. (2018)
2017	Gastropoda	Helicidae	<i>Arianta arbustorum</i> (Linnaeus, 1758)	Stojkoska & Stefanovska (2017)
2016	Hemiptera	Coreidae	<i>Leptoglossus occidentalis</i> Heidemann, 1910	Kulijer et al. (2016); EPPO (2018); Cvetkovska-Gjorgievska et al. (2019)
2016	Coleoptera	Coccinellidae	<i>Harmonia axyridis</i> (Pallas, 1773)	Kulijer et al. (2016); Cvetkovska-Gjorgievska et al. (2019); Global Register of Introduced and Invasive Species- Macedonia
2015	Lepidoptera	Crambidae	<i>Cydalima perspectalis</i> (Walker, 1859)	Načeski et al. (2018)
2015	Hemiptera	Cixiidae	<i>Hyalesthes obsoletus</i> Signoret, 1865	Atanasova et al. (2015)
2010	Acarina	Tetranychidae	<i>Eotetranychus weldoni</i> (Ewing, 1913)	Navajas et al. (2010); Hristovski et al. (2015); NBSAP 2018
2010	Acarina	Tetranychidae	<i>Panonychus citri</i> (McGregor, 1916)	Navajas et al. (2010); Hristovski et al. (2015); NBSAP 2018
2010	Acarina	Eriophyidae	<i>Eriophyes pyri</i> (H.A.Pagenstecher, 1857)	Navajas et al. (2010); Hristovski et al. (2015); NBSAP 2018
2010	Acarina	Eriophyidae	<i>Reckella celtis</i> Bagdasarjan, 1975	Navajas et al. (2010); Hristovski et al. (2015)
2010	Acarina	Ixodidae	<i>Hyalomma scupense</i> Schulze, 1919	Navajas et al. (2010); Hristovski et al. (2015); NBSAP 2018
2010	Araneae	Tetragnathidae	<i>Tetragnatha shoshone</i> Levi, 1981	Nentwig & Kobelt (2010); Hristovski et al. (2015)
2010	Araneae	Gnaphosidae	<i>Sosticus loricatus</i> (L.Koch, 1866)	Nentwig & Kobelt (2010); Hristovski et al. (2015); NBSAP 2018
2010	Araneae	Pholcidae	<i>Pholcus opilionoides</i> (Schrank, 1781)	Nentwig & Kobelt (2010); Hristovski et al. (2015); NBSAP 2018
2010	Araneae	Pholcidae	<i>Pholcus phalangioides</i> (Fuesslin, 1775)	Nentwig & Kobelt (2010); Hristovski et al. (2015)

Table 2. Continuation.

Year of first record	Group	Family	Taxon	Reference
2010	Araneae	Pholcidae	<i>Spermophora senoculata</i> (Dugès, 1836)	Nentwig & Kobelt (2010); Hristovski et al. (2015); NBSAP 2018
2010	Araneae	Theridiidae	<i>Steatoda grossa</i> (C.L. Koch, 1838)	Nentwig & Kobelt (2010); Hristovski et al. (2015); NBSAP 2018
2010	Araneae	Theridiidae	<i>Steatoda triangulosa</i> (Walckenaer, 1802)	Nentwig & Kobelt (2010); Hristovski et al. (2015)
2010	Araneae	Theridiidae	<i>Achaearanea tepidariorum</i> (C.L. Koch, 1841)	Nentwig & Kobelt (2010); Hristovski et al. (2015); NBSAP 2018
2010	Myriapoda	Paradoxosomatidae	<i>Oxidus gracilis</i> (C.L. Koch, 1847)	Stoev et al. (2010); Hristovski et al. (2015); NBSAP 2018
2010	Diptera	Cecidomyiidae	<i>Obolodiplosis robiniae</i> (Haldeman, 1847)	Glavendekić et al. (2010); Hristovski et al. (2015)
2010	Lepidoptera	Saturniidae	<i>Antheraea yamamai</i> Guérin-Méneville, 1861	Lopez-Vaamonde (2010); Hristovski et al. (2015); NBSAP 2018
2010	Lepidoptera	Coleophoridae	<i>Coleophora laricella</i> (Hübner, 1817)	Lopez-Vaamonde (2010); Hristovski et al. (2015); NBSAP 2018
2010	Lepidoptera	Gracillariidae	<i>Phyllonorycter platani</i> (Staudinger, 1870)	Lopez-Vaamonde et al. (2010); Hristovski et al. (2015); NBSAP 2018
2010	Lepidoptera	Tortricidae	<i>Lobesia botrana</i> (Denis & Schiffermüller, 1775)	Sullivan & Molet (2007); FAEU (2007)
2010	Hemiptera	Membracidae	<i>Stictocephala bisonia</i> Kopp & Yonke, 1977	Tomov et al. (2009); Mifsud et al. (2010); Hristovski et al. (2015); FAEU (2007); NBSAP 2018
2009	Coleoptera	Chrysomelidae	<i>Epitrix hirtipennis</i> (Melsheimer, 1847)	Tomov et al. (2009); Beenen & Roques (2010); Hristovski et al. (2015); NBSAP 2018
2009	Diptera	Agromyzidae	<i>Liriomyza trifolii</i> (Burgess, 1880)	Tomov et al. (2009)
2008	Lepidoptera	Pyrilidae	<i>Cadra figulilella</i> (Gregson, 1871)	Tomov et al. (2009); Lopez-Vaamonde et al. (2010); Hristovski et al. (2015); DAISIE, 2008; NBSAP 2018
2008	Coleoptera	Anobiidae	<i>Pinus fur</i> (Linnaeus, 1758)	Tomov et al. (2009); DAISIE, 2008
2008	Coleoptera	Anthicidae	<i>Omonadus floralis</i> (Linnaeus, 1758)	Tomov et al. (2009); DAISIE, 2008
2008	Coleoptera	Cerambycidae	<i>Neoclytus acuminatus</i> (Fabricius, 1775)	Tomov et al. (2009); DAISIE, 2008
2008	Coleoptera	Chrysomelidae	<i>Acanthoscelides pallidipennis</i> (Motschulsky, 1874)	Tomov et al. (2009); DAISIE, 2008; Beenen & Roques (2010); Hristovski et al. (2015); Cvetkovska-Gjorgjievska et al. (2019)
2008	Coleoptera	Cryptophagidae	<i>Caenoscelis subdeplanata</i> Brisout de Barneville, 1882	Tomov et al. (2009); DAISIE, 2008
2008	Hemiptera	Aphididae	<i>Acyrtosiphon caraganae</i> (Cholodkovsky, 1908)	Tomov et al. (2009); DAISIE, 2008; Coeur d'acier et al. (2010); Hristovski et al. (2015); NBSAP 2018

Table 2. Continuation.

Year of first record	Group	Family	Taxon	Reference
2008	Hemiptera	Aphididae	<i>Aphis gossypii</i> Glover, 1877	Tomov et al. (2009); DAISIE, 2008; Coeur d'acier et al. (2010); Hristovski et al. (2015); NBSAP 2018
2008	Hemiptera	Aphididae	<i>Aphis spiraeophaga</i> F.P. Müller, 1961	Tomov et al. (2009); DAISIE, 2008; Coeur d'acier et al. (2010); Hristovski et al. (2015); NBSAP 2018
2008	Hemiptera	Aphididae	<i>Chromaphis juglandicola</i> (Kaltenbach, 1843)	Tomov et al. (2009); DAISIE, 2008; Coeur d'acier et al. (2010); Hristovski et al. (2015); NBSAP 2018
2008	Hemiptera	Aphididae	<i>Myzus varians</i> Davidson, 1912	Tomov et al. (2009); DAISIE, 2008; Coeur d'acier et al. (2010); Hristovski et al. (2015); NBSAP 2018
2008	Hemiptera	Aphididae	<i>Panaphis juglandis</i> (Goeze, 1778)	Tomov et al. (2009); DAISIE, 2008
2008	Hemiptera	Aphididae	<i>Rhodobium porosum</i> (Sanderson, 1900)	Tomov et al. (2009); DAISIE, 2008
2008	Hemiptera	Aphididae	<i>Rhopalosiphum maidis</i> (Fitch, 1856)	Tomov et al. (2009); DAISIE, 2008
2008	Hemiptera	Aphididae	<i>Uroleucon erigeronense</i> (Thomas, 1878)	Tomov et al. (2009); DAISIE, 2008
2008	Hemiptera	Anthocoridae	<i>Lyctocoris campestris</i> (Fabricius, 1794)	Tomov et al. (2009); DAISIE, 2008
2008	Hemiptera	Tingidae	<i>Stephanitis oberti</i> (Kolenati, 1856)	Tomov et al. (2009); DAISIE, 2008
2008	Hymenoptera	Aphelinidae	<i>Encarsia berlessei</i> (Howard, 1906)	Tomov et al. (2009); DAISIE, 2008
2008	Hymenoptera	Aphelinidae	<i>Encarsia perniciosi</i> (Tower, 1913)	Tomov et al. (2009); DAISIE, 2008
2008	Hymenoptera	Encyrtidae	<i>Anicetus annulatus</i> Timberlake, 1919	Tomov et al. (2009); DAISIE, 2008
2008	Hymenoptera	Encyrtidae	<i>Ooencyrtus kuvanae</i> (Howard, 1910)	Tomov et al. (2009); DAISIE, 2008
2008	Hymenoptera	Formicidae	<i>Hypoponera punctatissima</i> (Roger, 1859)	Tomov et al. (2009); DAISIE, 2008
2008	Hymenoptera	Formicidae	<i>Paratrechina vividula</i> (Nylander, 1846)	Tomov et al. (2009); DAISIE, 2008
2007	Thysanoptera	Thripidae	<i>Frankliniella occidentalis</i> (Pergande, 1895)	Tomov et al. (2009); FAEU (2007); CABI (2014); Cvetkovska-Gjorgievska et al. (2019)
2007	Zygentoma	Lepismatidae	<i>Lepisma saccharinum</i> Linnaeus, 1758	Tomov et al. (2009); FAEU (2007)
2007	Diptera	Culicidae	<i>Aedes albopictus</i> (Skuse, 1894)	Sokolovska et al. (2007); Cvetkovikj et al. (2020)
2007	Blattodea	Blattellidae	<i>Blattella germanica</i> (Linnaeus, 1767)	Tomov et al. (2009); FAEU (2007); Hristovski et al. (2015)
2007	Coleoptera	Anobiidae	<i>Epauloeus unicolor</i> (Piller & Mitterpacher, 1783)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Anobiidae	<i>Gibbium psyllioides</i> (Czenpinski, 1778)	Tomov et al. (2009); FAEU (2007)

Table 2. Continuation.

Year of first record	Group	Family	Taxon	Reference
2007	Coleoptera	Anobiidae	<i>Niptus hololeucus</i> (Faldermann, 1835)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Anobiidae	<i>Pinus bicinctus</i> Sturm, 1837	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Anobiidae	<i>Pinus latro</i> Fabricius, 1775	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Anobiidae	<i>Pinus tectus</i> Boieldieu, 1856	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Anobiidae	<i>Stegobium paniceum</i> (Linnaeus, 1758)	Tomov et al. (2009); FAEU (2007); Cvetkovska-Gjorgjievska et al. (2019)
2007	Coleoptera	Cerambycidae	<i>Monochamus galloprovincialis</i> (Olivier, 1795)	CABI (2007); Nacheski & Papazova-Anakieva (2014)
2007	Coleoptera	Chrysomelidae	<i>Acanthoscelides obtectus</i> (Say, 1831)	Tomov et al. (2009)/FAEU (2007); Beenen & Roques (2010); Hristovski et al. (2015); Cvetkovska-Gjorgjievska et al. (2019); NBSAP 2018
2007	Coleoptera	Chrysomelidae	<i>Bruchus pisorum</i> Linnaeus, 1758	Tomov et al. (2009)/FAEU (2007); Beenen & Roques (2010); Hristovski et al. (2015); NBSAP 2018
2007	Coleoptera	Chrysomelidae	<i>Bruchus rufimanus</i> Boheman, 1833	Tomov et al. (2009); FAEU (2007); Beenen & Roques (2010); Hristovski et al. (2015)
2007	Coleoptera	Chrysomelidae	<i>Callosobruchus chinensis</i> (Linnaeus, 1758)	Tomov et al. (2009); FAEU (2007); Beenen & Roques (2010); Hristovski et al. (2015); NBSAP 2018
2007	Coleoptera	Dermestidae	<i>Attagenus unicolor</i> (Brahm, 1790)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Dermestidae	<i>Dermestes frischii</i> Kugelmann, 1792	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Dermestidae	<i>Trogoderma glabrum</i> (Herbst, 1783)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Histeridae	<i>Carcinops pumilio</i> (Erichson, 1834)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Latridiidae	<i>Cartodere nodifer</i> (Westwood, 1839)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Latridiidae	<i>Corticaria elongata</i> (Gyllenhal, 1827)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Latridiidae	<i>Corticaria ferruginea</i> Marsham, 1802	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Latridiidae	<i>Corticaria fulva</i> (Comolli, 1837)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Latridiidae	<i>Corticaria serrata</i> (Paykull, 1798)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Latridiidae	<i>Dienerella filum</i> (Aubé, 1850)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Latridiidae	<i>Latridius minutus</i> (Linnaeus, 1767)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Mycetophagidae	<i>Typhaea stercorea</i> (Linnaeus, 1758)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Nitidulidae	<i>Carpophilus hemipterus</i> (Linnaeus, 1758)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Nitidulidae	<i>Carpophilus marginellus</i> Motschulsky, 1858	Tomov et al. (2009); FAEU (2007)

Table 2. Continuation.

Year of first record	Group	Family	Taxon	Reference
2007	Coleoptera	Nitidulidae	<i>Carpophilus mutilatus</i> Erichson, 1843	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Nitidulidae	<i>Carpophilus nepos</i> Dobson, 1956	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Nitidulidae	<i>Carpophilus tersus</i> Wollaston, 1865	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Nitidulidae	<i>Epurea luteola</i> Erichson, 1843	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Nitidulidae	<i>Glischrochilus quadrisignatus</i> (Say, 1835)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Nitidulidae	<i>Urophorus humeralis</i> (Fabricius, 1798)	Tomov et al. (2009); FAEU (2007)
2007	Coleoptera	Staphylinidae	<i>Philonthus rectangulus</i> Sharp, 1874	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Aphididae	<i>Appendiseta robiniae</i> (Gillette, 1907)	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Aphididae	<i>Brachycaudus rumexicolens</i> (Patch, 1917)	Tomov et al. (2009); FAEU (2007); Coeur d'acier et al. (2010); Hristovski et al. (2015); NBSAP 2018
2007	Hemiptera	Aphididae	<i>Chaetosiphon fragaefolii</i> (Cockerell, 1901)	Tomov et al. (2009); FAEU (2007); Coeur d'acier et al. (2010); Hristovski et al. (2015); NBSAP 2018
2007	Hemiptera	Aphididae	<i>Macrosiphoniella sanborni</i> (Gillette, 1908)	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Aphididae	<i>Macrosiphum euphorbiae</i> (Thomas, 1878)	Tomov et al. (2009); FAEU (2007); Coeur d'acier et al. (2010); Hristovski et al. (2015); NBSAP 2018
2007	Hemiptera	Aphididae	<i>Myzus persicae</i> (Sulzer, 1776)	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Aphididae	<i>Nearctaphis bakeri</i> (Cowen, 1895)	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Aphididae	<i>Rhopalosiphum insertum</i> (Walker, 1849)	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Coccidae	<i>Coccus hesperidum</i> Linnaeus, 1758	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Coccidae	<i>Saissetia oleae</i> (Olivier, 1791)	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Margarodidae	<i>Icerya purchasi</i> Maskell, 1879	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Cimicidae	<i>Cimex lectularius</i> Linnaeus, 1758	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Nabidae	<i>Nabis capsiformis</i> Germar, 1838	Tomov et al. (2009); FAEU (2007)
2007	Hemiptera	Pentatomidae	<i>Nezara viridula</i> (Linnaeus, 1758)	Tomov et al. (2009); FAEU (2007)
2007	Hymenoptera	Formicidae	<i>Monomorium pharaonis</i> (Linnaeus, 1758)	Tomov et al. (2009); FAEU (2007)
2007	Lepidoptera	Gelechiidae	<i>Phthorimaea operculella</i> (Zeller, 1873)	Tomov et al. (2009); Lopez-Vaamonde et al. (2010); Hristovski et al. 2015; FAEU (2007); NBSAP 2018

Table 2. Continuation.

Year of first record	Group	Family	Taxon	Reference
2007	Lepidoptera	Gelechiidae	<i>Sitotroga cerealella</i> (Olivier, 1789)	Lopez-Vaamonde et al. (2010); Hristovski et al. (2015); Tomov et al. (2009); FAEU (2007); NBSAP 2018
2007	Lepidoptera	Noctuidae	<i>Helicoverpa armigera</i> (Hübner, 1808)	Tomov et al. (2009); FAEU (2007); EPPO
2007	Lepidoptera	Pyrilidae	<i>Plodia interpunctella</i> (Hübner, 1813)	Tomov et al. (2009); Lopez-Vaamonde et al. (2010); Hristovski et al. (2015); FAEU (2007); NBSAP 2018
2007	Lepidoptera	Pyrilidae	<i>Pyrallis farinalis</i> Linnaeus, 1758	Tomov et al. (2009); FAEU (2007)
2007	Lepidoptera	Tineidae	<i>Monopis crocipitella</i> (Clemens, 1859)	Tomov et al. (2009); FAEU (2007)
2007	Lepidoptera	Tortricidae	<i>Grapholita molesta</i> (Busck, 1916)	Tomov et al. (2009); Lopez-Vaamonde et al. (2010); Hristovski et al. (2015); FAEU (2007); NBSAP 2018
2000	Lepidoptera	Noctuidae	<i>Mythimna languida</i> Walker, 1858	Rezbanyai-Reser & Hausmann (2000); Tomov et al. (2009)
1985	Lepidoptera	Gracillariidae	<i>Cameraria ohridella</i> Deschka & Dimić, 1986	Simova-Tosic & Filev (1985); Tomov et al. (2009) EPPO
1984	Lepidoptera	Gracillariidae	<i>Parectopa robinella</i> Clemens, 1863	Maceljiski & Igre (1984); Tomov et al. (2009); Lopez-Vaamonde et al. (2010); Hristovski et al. (2015); NBSAP 2018
1982	Hemiptera	Phylloxeridae	<i>Daktulosphaira vitifoliae</i> (Fitch, 1855)	Galet (1982); EPPO
1980	Lepidoptera	Aretiidae	<i>Hyphantria cunea</i> (Drury, 1773)	Serafimovski et al. (1980); Tomov et al. (2009); Lopez-Vaamonde et al. (2010); Hristovski et al. (2015);
1978	Lepidoptera	Erebidae	<i>Euproctis chrysorrhoea</i> Linnaeus, 1758	CABI Pest map 362 (1978)
1965	Hemiptera	Aphididae	<i>Myzus ascalonicus</i> Doncaster, 1946	Todorovski et al. (1965); Tomov et al. (2009)
1960	Lepidoptera	Pyrilidae	<i>Ephestia elutella</i> (Hübner, 1796)	Todorovski (1960); Tomov et al. (2009); Lopez-Vaamonde et al. (2010); Hristovski et al. (2015); NBSAP 2018
1959	Hemiptera	Diaspididae	<i>Pseudaulacaspis pentagona</i> (Targioni Tozzetti, 1886)	Atanasov, P. (1959); Tomov et al. (2009); Cvetkovska-Gjorgjievska et al. (2019)
1951	Coleoptera	Chrysomelidae	<i>Leptinotarsa decemlineata</i> (Say, 1824)	Atanackovich (1951); Tomov et al. (2009); Beenen & Roques (2010); Hristovski et al. (2015); NBSAP 2018
online data-base	Clitellata	Lumbricidae	<i>Lumbricus rubellus</i> Hoffmeister, 1843	Global Register of Introduced and Invasive Species- Macedonia

Notes: Years without reported records are not shown as separate rows, but are included in the dataset and considered in the analysis of temporal trends.

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