

AN OVERVIEW OF ALIEN DIPTERA IN SLOVENIA

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Abstract - The nonindigenous Diptera occurring in Slovenia are overviewed based on literature data. In total, 18 species belonging to eight Diptera families are alien to Slovenia. Most of the species originate from North America and continental Asia. The first record of an alien Diptera species (*Ceratitis capitata* (Wiedemann, 1824) (Diptera: Tephritidae)) was made in 1959, but the bulk of the species were recorded for the first time in the last two decennia. Most of the species were found in the pre-Alpine and sub-Mediterranean regions. The distribution and abundance of the alien Diptera are not fully known, as in most cases only the first observations were published. Most of the species are phytophagous and are known pests in agriculture and forestry. A list of expected nonindigenous Diptera species for Slovenia is given. It is suggested that a monitoring system should be developed in order to understand the population dynamics and the impact of the alien species on the ecosystem and economy.

KEY WORDS: nonindigenous species, Diptera, fauna, Slovenia

Izvleček – PREGLED TUJERODNIH DVOKRILCEV V SLOVENIJI

Na podlagi podatkov iz literature je pripravljen pregled dvokrilcev (Diptera), ki v Sloveniji niso domorodni. Skupno je v Sloveniji 18 tujih vrst, pripadajočih osmim družinam. Večina vrst izvira iz Severne Amerike in celinske Azije. Prvi podatek za tujo vrsto reda Diptera (*Ceratitis capitata* (Wiedemann, 1824) (Diptera: Tephritidae)) je iz leta 1959, toda večina vrst je bila prvič zabeležena v zadnjih dveh desetletjih. Največ vrst je bilo najdenih v predalpskem in submediteranskem območju. Razširjenost in pogostnost tujih dvokrilcev nista dobro znana, saj so bila v večini primerov objavljena le prva opazovanja. Večina vrst je rastlinojedih in so znani škodljivci v poljedelstvu in gozdarstvu. Predstavljen je seznam tujerodnih dvokrilcev, ki jih pričakujemo v Sloveniji. Priporočamo razvoj organiziranega spremljanja, da bi razumeli populacijsko dinamiko ter vpliv tujih vrst na ekosistem in ekonomijo.

KLJUČNE BESEDE: tujerodne vrste, Diptera, favna, Slovenija

Introduction

Diptera is one of the largest groups of insects in the world and comprises almost 125,000 species (Gullan & Cranston 2005). The species radiated in several directions and adopted different larval feeding strategies (parasitoids, detritivores, phytophages, etc) or differ in the degree of specialisation (Speight *et al.* 2008). The large larval functional diversity and the ability of adults to fly can make Diptera highly successful and therefore may survive in many habitats. They occupy many aquatic and terrestrial habitats. Additionally they have important negative and positive economical or health aspects (Speight *et al.* 2008). Many species are phytophagous and attack crops or are vectors of diseases. On the other hand, they can also operate as natural enemies of other economical pests (Speight *et al.* 2008). The ability to adapt to new environments and possible impact on economy and health makes this group potentially dangerous in the event of invading other continents.

In recent years, two seminal works have been published on alien invasive species in Europe (DAISIE 2009, Skuhrava *et al.* 2010). The consortium of DAISIE (2009) compiled a list of alien species in Europe, while Skuhrava and colleagues (2010) made an in depth review of alien Diptera in Europe. In total, 10,771 nonindigenous species were found in Europe (DAISIE 2009). Seven percent of the alien insects belong to the order of Diptera (Roques *et al.* 2009). In total, 129 alien Diptera were found in Europe, of which 98 species are alien to Europe and 31 species alien within Europe (Skuhrava *et al.* 2010). The greater part of the invasive Diptera are phytophages or detritivores (Skuhrava *et al.* 2010).

The research activity of Diptera is very low in Slovenia. There are many publications about economically harmful Diptera, especially for leafminers (Maček 1999) and gall forming Diptera (Janežič 1989a). Furthermore, there are people active on some taxonomical groups, e.g. Empididae (Horvat 1995), Syrphidae (De Groot & Govedič 2008) and Cecidomyiidae (Simova-Tošič *et al.* 1996). There are some notes about some selected species (De Groot *et al.* 2007, Seljak 2011). The work by Skuhrava and colleagues (2010) contains a list of alien species per countries, but recent new findings are not included. Furthermore, it only contains a list of species and is more focussed on the status of alien Diptera on the European scale than on a national scale. It lacks the status of the invasive species in Slovenia. There is a need to understand what are the knowledge gaps, potential risks and the potential new alien Diptera for Slovenia.

The aim of the article is to review the current status of the alien (invasive) Diptera species in Slovenia. The focus is on 1) the alien species, 2) the time of arrival, 3) origin of the alien species, 4) the distribution around and within Slovenia, 5) the abundance, 6) dispersion rate, 7) feeding mode, 8) vulnerable habitats and 9) potential new alien species. When possible, recommendations are made for further management of alien Diptera species and knowledge gaps are identified on the basis of this information.

Materials and methods

An extensive search was made in the literature and databases in order to get a good overview of alien Diptera species in Slovenia. In total, we found 18 species which are

alien for or within Europe. One species was excluded, because it is native in Slovenia (Skuhrava *et al.* 2010). Therefore, only the 17 introduced species were analysed.

The following data were found during the literature study: first year of occurrence, native range, occurrence in neighbouring countries, abundance, trend, distribution in Slovenia, habitat, vector of introduction and potential new alien species. Most of the data were found in the article by Skuhrava and colleagues (2010).

Results

Origin and arrival

In total, 19 species belonging to eight families which are alien for or within Europe were found in Slovenia (Table 1). One of these species, *Monarthropalpus flavus*, is considered native in Slovenia, but has been introduced in other parts of Europe.

The first alien species was *Ceratitis capitata*, recorded in 1959 (Fig. 1). Thereupon, four species were discovered for the first time by the end of the eighties (*Liriomyza trifolii* (1970), *Contarinia pisi* (1972), *Stenodiplosis panici* (1972), *Contarinia quinquenotata* (1979)), and then the bulk of species, which have been discovered in the last 20 years (*Rhagoletis complete* (1997), *Liriomyza huidobrensis* (1999), *Aedes albopictus* (2002), *Trichopoda pennipes* (2003), *Dasineura oxycoccana* (2004), *Obolodiplosis robiniae* (2004), *Rhagoletis cingulate* (2007), *Hermetia illucens* (2009), *Dasineura gleditchiae* (2010), *Drosophila suzukii* (2010), *Ophiomyia kwansonis* (2011)). In the last decade, nine new species have been added to the fauna of Slovenia.



Fig. 1: Number of first observations of nonindigenous Diptera species per year in Slovenia.

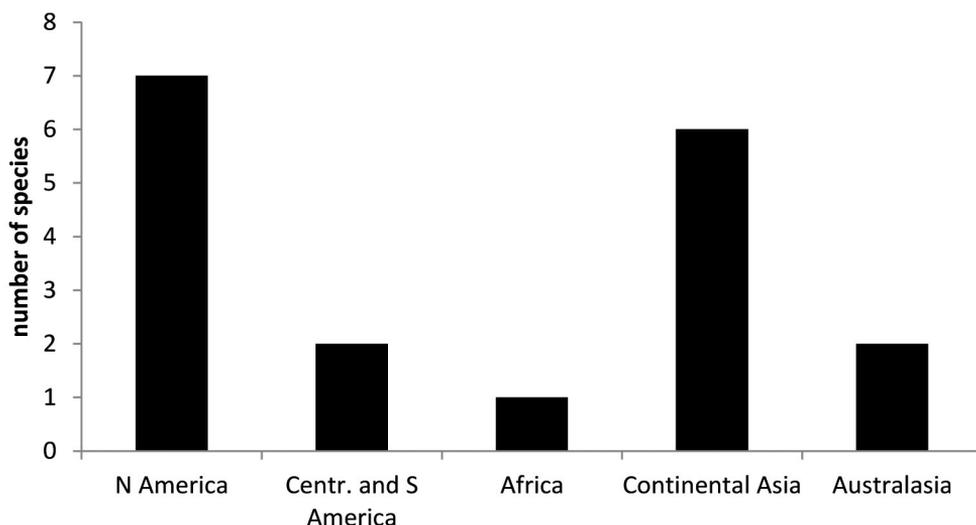


Fig. 2: Native range of the alien Diptera species in Slovenia.

Most of the species come from North America and Asia (Fig. 2). This is probably because these are continents with relatively similar climate. However, species from (sub)tropical countries were also found. All of these species were brought to Europe by (accidental) transport. Within Europe, the matter is more confusing: 11 of them were brought to Slovenia, five came by self-dispersal, while for two the way of introduction remains unknown. Species were observed in Slovenia 6-94 years after their introduction into Europe with the median arrival time at 14 years. The record of *Liriomyza trifolii* was made in 1970 (Maček 1999), six years before the known initial introduction in France (Skuhrava *et al.* 2010). However, the relatively late arrival time can be attributed to an increase of people interested in Diptera.

Distribution and status

Almost all of the species are known to occur also in the countries around Slovenia (Table 1). Countries with the most species also occurring in Slovenia are Austria (12), followed by Italy and Croatia (both 11) and Hungary (7). Only *Stenodiplosis panici* has not been found in the surrounding countries (Skuhrava *et al.* 2010).

Within Slovenia, the highest number of alien Diptera species were found in the pre-Alpine region (11), followed by the sub-Mediterranean region (9), the sub-Pannonian region (6), the Dinaric region (4), the pre-Dinaric region (4) and the Alpine region (3) (Table 1). For three species, no literature was available. *Liriomyza huidobrensis* was found in 1999 in a few glasshouses, but was eradicated (EPPO 2000). Therefore no distribution could have been determined.

Table 1: Distribution of alien species around and within Slovenia. Countries around Slovenia: Italy (I), Croatia (C), Hungary (H) and Austria (A). Biogeographic regions within Slovenia: Alpine region (AL), pre-Alpine region (PA), Dinaric Alps (DN), pre-Dinaric region (PD), sub-Pannonian region (SP), sub-Mediterranean region (SM). * indicates the species, which are considered native to Slovenia, but have been introduced in other European countries. The data on the presence in countries around Slovenia are based on Skuhrava *et al.* (2010).

Family	Species	Presence in countries around Slovenia	Presence in Slovenia	Literature used for the presence of the species in Slovenia
Agromyzidae	<i>Liriomyza huidobrensis</i> (Blanchard, 1926)	I, A, H, C	eradicated	EPPO 2000, Seljak 2003
	<i>Liriomyza trifolii</i> (Burgess, 1880)	I, A, C	AL, PA, PD, SM, SP	Maček 1999, EPPO 2000, Seljak 2003
	<i>Opomyia kwansonis</i> (Sasakawa 1961)		DN, PA, PD	Jurc <i>et al.</i> 2012
Cecidomyiidae	<i>Contarinia pisi</i> (Winnertz, 1854)	A, H	PA, SP	Janežič 1972, 1984, Simova-Tošič <i>et al.</i> 1996
	<i>Contarinia quinquenotata</i> (Hardy)	A, H	AL, DN, PA, PD, SP	Janežič 1979, 1980, 1982, 1984, 1988, 1989b, 1990
	<i>Dasineura gleditchiae</i> (Osten Sacken, 1866)	I, A, H, C	PA, SP	Jurc & Jurc 2010
	<i>Dasineura oxycoccana</i> (Johnson, 1899)	I, C	PA	EPPO 2006
	<i>Monarthropalpus flavus</i> (Schrank, 1776)*	A, H, C	DN, PA, PD, SM, SP	Janežič 1972, Simova-Tošič <i>et al.</i> 1996
	<i>Obolodiplosis robiniae</i> (Haldeman, 1847)	I, A, H, C	SM	EPPO 2008
	<i>Stenodiplosis panici</i> Rohd.	none	unknown	Janežič 1972
Culicidae	<i>Aedes albopictus</i> (Skuse, 1895)	I, C	DN, PA, SM	Kalan <i>et al.</i> 2011
	<i>Drosophila suzukii</i> (Matsumura, 1931)	I, A	PA, SM	Seljak 2011
Phoridae	<i>Dohnniphora cornuta</i> (Bigot, 1857)	A	unknown	Skuhrava <i>et al.</i> 2010
	<i>Megaselia gregaria</i> (Wood, 1910)	none	unknown	Skuhrava <i>et al.</i> 2010
Stratiomyidae	<i>Hermetia illucens</i> (Linnaeus, 1758)	I, C	PA, SM	de Groot & Veenliet 2011
Tachinidae	<i>Trichopoda pennipes</i> (Fabricius, 1781)	I	SM	de Groot <i>et al.</i> 2008
Tephritidae	<i>Ceratitits capitata</i> (Wiedemann, 1824)	I, A, C	SM	Peyrek 1960
	<i>Rhagoletis cingulata</i> (Loew, 1862)	A, H, C	SP	EPPO 2007
	<i>Rhagoletis completa</i> Cresson, 1929	I, A, C	AL, PA, SM, SP	Seljak 1999, Miklavc <i>et al.</i> 2009, Solar <i>et al.</i> 2007

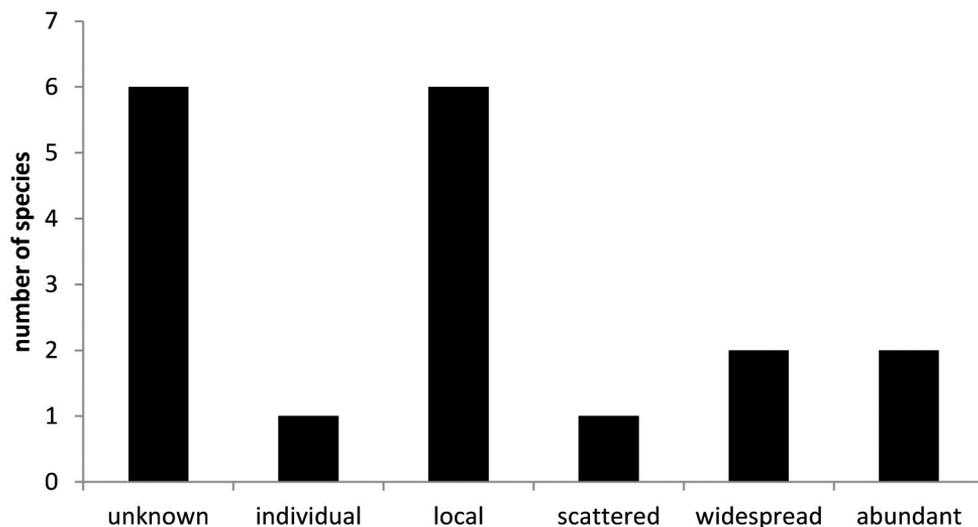


Fig. 3: Abundance of alien Diptera in Slovenia.

Most of the species only occur locally, while some are widespread or abundant (Fig. 3). The abundance in Slovenia could not have been determined for almost one third of the species.

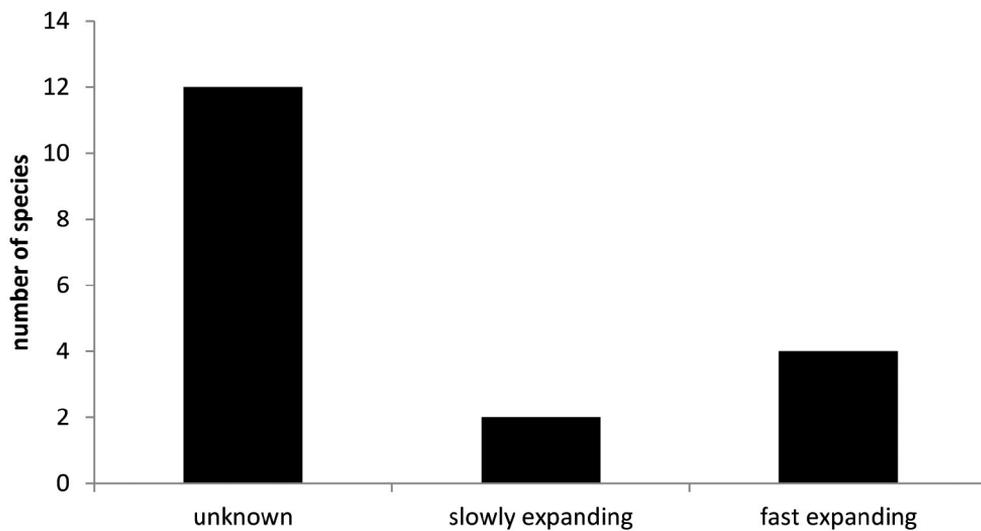


Fig. 4: Dispersion of alien Diptera in Slovenia.

At the moment, the expansion rate can be estimated for only six species (Fig. 4). Only four species are expanding rapidly, while two species are expanding slowly. For the other species, no information on their expansion rate is at hand. This is because for most of them only an article about the first observation has been written so far.

Habitat and impact

The nonindigenous species recorded in Slovenia have the following feeding modes: phytophagous (12), detritivorous (4) and parasitic/predator (2). Most of the phytophagous species are monophagous or feed on several species of the same family (8). Only three species are polyphagous. The detritivorous species feed on compost, mushrooms or are saprophagous. The two species, which are parasitic, feed on human blood (tiger mosquito) or on two bug species (*Trichopoda pennipes*).

Most of the alien species are occurring in human dominated land, like agriculture, waste deposits, buildings or parks and gardens. Only two species populate more natural ecosystem, like forest woodland as habitat.

Although many species have been found in Slovenia, several species are still expected to be found here. In total, 27 potential alien species have been identified. Italy has had the highest number of species (22), followed by Hungary (10).

Table 2: Alien Diptera species occurring in the surrounding countries, but could be present in Slovenia as well. * *Liriomyza huidobrensis* was already found in Slovenia, but has become extinct. The data on foreign species are based on Skuhrava *et al.* (2010).

Species	Italy	Austria	Hungary	Croatia
<i>Athrerigona soccata</i> Rondani, 1871	x		x	
<i>Braula schmitzi</i> Oroso Pal, 1939	x			
<i>Cerodontha unisetiorbita</i> Zlobin, 1993	x			
<i>Chymomyza amoena</i> (Loew, 1862)	x		x	
<i>Chymomyza procnemoides</i> Wheeler, 1952			x	
<i>Contarinia citri</i> Barnes, 1944	x			
<i>Contarinia lentis</i> Aczel, 1944			x	
<i>Crataerina melbae</i> (Rondani, 1879)	x			
<i>Dasineura abietiperda</i> (Henschel, 1880)	x			
<i>Desmometopa microps</i> Lamb, 1914			x	
<i>Drosophila melanogaster</i> Meigen, 1830	x			
<i>Drosophila tsigana</i> Burla & Gloor, 1952	x		x	
<i>Feltiella acarisuga</i> (Vallot, 1827)	x	x		
<i>Hydrotaea aenescens</i> (Wiedemann, 1830)	x	x		
<i>Janetiella siskiyou</i> Felt, 1917	x			
<i>Leucostoma edentata</i> Kluger, 1978	x			
<i>Liriomyza huidobrensis</i> (Blanchard, 1926)*	x	x	x	x
<i>Megaselia scalaris</i> (Loew, 1866)	x			
<i>Ochleroratus atropalpus</i> (Coquillett, 1902)	x			
<i>Orseolia cynodontis</i> Kieffer & Massalongo, 1902	x		x	
<i>Pelomyia occidentalis</i> Williston, 1893			x	
<i>Scaptomyza adusta</i> (Loew, 1862)	x			
<i>Stenodiplosis sorghicola</i> (Coquillett, 1899)	x			
<i>Thoracochaeta johnsoni</i> (Spuler, 1925)	x			
<i>Trachyopella straminea</i> Rohaček & Marshall, 1986			x	
<i>Zaprionus indianus</i> Gupta, 1970	x			
<i>Zeuxia zejana</i> Kolomiets, 1971	x			

Discussion and conclusions

The review of data has given us much new information on the nonindigenous Diptera in Slovenia. At the moment, records for 18 alien species are at hand for Slovenia. Most of them have come here in the last two decennia. They occur mainly in the pre-Alpine and Mediterranean regions. The abundance and dispersal rate are known only for a few species. Furthermore, most of the species occur in urban or agricultural areas. Although this is a relative high number of alien species, there are 27 potential new ones in the countries around Slovenia.

One of the main sequels of this survey is the lack of knowledge about a species after its first observation. Authors are mainly publishing the first observation, but there is no monitoring system that would result in a better information about the species distribution and abundance in Slovenia. One of the bright exceptions is the work carried out on the Tiger Mosquito (*Aedes albopictus*), where the species' distribution in the sub-Mediterranean part of Slovenia was surveyed (Kalan et al. 2011). However, there is still a need for an inventory of this species in other parts of Slovenia, and a monitoring system. Therefore, there is a need to work on a monitoring system of the invasive species to get a better insight into their distribution and impact on the environment.

The great problem, however, is the lack of Diptera experts in our country. As already mentioned in the introduction, only a few people are working on Diptera in Slovenia. These experts do not have the time or financial framework to develop a monitoring system for these groups. Additionally, some small Diptera families are simply neglected,

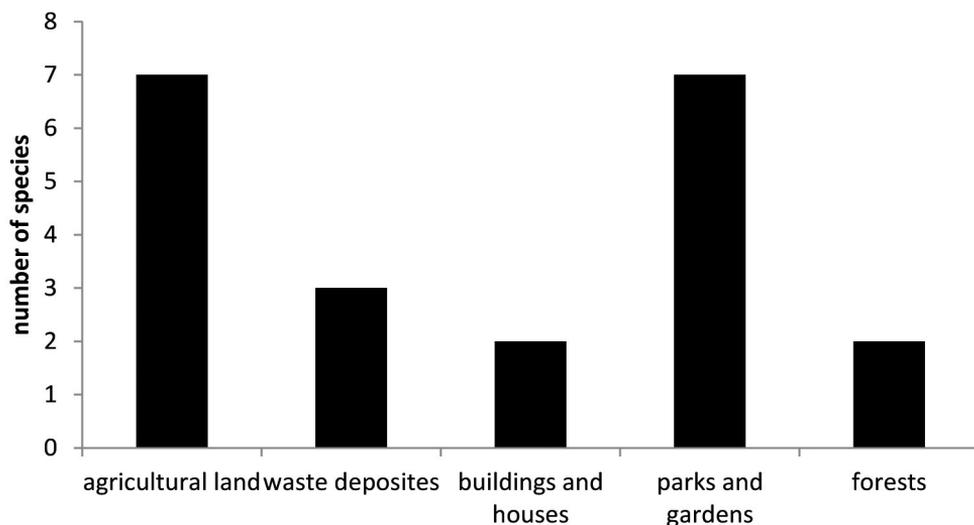


Fig. 5: Habitats occupied by the invasive Diptera species in Slovenia.

as no knowledge is available about them. It is therefore quite possible that some species stated as potential for Slovenia have actually been amongst us for some years.

Effects of the alien species vary from the species to the ecosystem levels. Most of the alien species depend on one host or a small range of them. This could be a problem for the particular host, when the population of the alien species increases. In the case of plant hosts, phytophagous species can make the plants less resistant to other phytophagous species, pathogens or unfavourable weather events. On the other hand, not only native plants are infested. *Obolodiplosis robiniae* feeds on the Black Locust Tree (*Robinia pseudacacia*) (Skuhrava et al. 2010). In the case of the parasitoid *T. pennipes*, the species only parasitized 10-30% of the local population of the Southern Green Stink Bug (*Nezara viridula* L.) (M. de Groot, unpublished data). Being parasitized, females were still able to produce eggs, so the fertility was not affected (Harris & Todd 1982). So at the moment the host species do not seem to have a problem. Regarding habitat problems, only two of the species can be regarded as problematic for the more natural habitats like forests. The other species prefer urban areas, parks and gardens, or agricultural land (Skuhrava et al. 2010).

Nonindigenous species can cause economical as well as health problems. Most of the species are phytophagous and have crops as host plants. Regarding health problems, the Tiger Mosquito can transmit diseases like dengue. In 2007, there was an outbreak of the chikungunya virus in Ravenna, in which 250 people fell ill, one of them even fatally. This virus has not yet been found in Slovenia. This means that control methods should be developed to suppress populations of nonindigenous species causing economical and health problems.

In conclusion, many alien Diptera species already occur in the territory of Slovenia and we expect more species to be added to the invasive fauna list of Slovenia. There is a need for a sophisticated monitoring system and inventory of the present species and species potentially occurring in Slovenia. In the future we expect that damage caused by alien Diptera will increase, especially if considering the environment and climate change.

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