Diptera. Chapter 10

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Diptera
Chapter 10

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Abstract

Of the 19,400 native species and 125 families forming the European diptera fauna, 98 species (less than 0.5%) in 22 families are alien *to* Europe. These aliens constitute 66 species (18 families) of the suborder Brachycera and 32 species (4 families) of the suborder Nematocera. By family in this category, there are 23 Cecidomyiidae species, 18 Drosophilidae, nine Phoridae, eight Tachinidae and seven Culicidae. Another 32 fly species belonging to five families are considered to be alien *in* Europe. These invasives native to other European countries are composed of 14 species of Cecidomyiidae, seven Syrphidae, five Culicidae and three species each of Anthomyiidae and Tephritidae. The date of the first record in Europe is known for 84 alien species. Arrivals of alien species of Diptera have accelerated rapidly since the second half of the 20th century. North America appears to be the dominant contributor of the alien flies. The majority of alien Diptera were introduced into or within Europe unintentionally, with only three predators released intentionally for biological control. Alien Diptera are predominantly phytophagous (35.6%), while a lesser portion are zoophagous (28.6%) or detrivorous /mycetophagous (29.6%). Ecological impacts on native fauna and flora have not been documented for any of the alien species established in Europe. However, 14 alien species have economic impacts on crops.

Keywords

alien, Europe, Diptera

10.1 Introduction

Diptera is one of the largest insect orders, with a worldwide distribution. The order includes 172 to 179 families (depending on authors) with about 132,000 species described which probably underestimates the actual fauna by at least a half. About 19,400 native species and 125 families have been recorded in Europe (Fauna Europaea). The alien entomofauna is comparatively very limited with only 98 species observed to date, i.e. less than 0.5% of the total dipteran fauna in Europe.

Commonly called true flies, mosquitoes, midges, deer- and horseflies and houseflies feature among the most familiar Diptera. Flies are not only abundant in popular perception but also have particular veterinary and medical importance for vectoring diseases and as pests of agriculture, forestry and husbandry. However, some species are useful to man as parasitoids and predators of insect pests and as plant pollinators. Generally, adults are minute to small, soft-bodied insects with a highly mobile head, large compound eyes, antennae of variable size and structure, and sucking mouthparts. They have only one pair of functional wings, the second pair being changed into small head-like bodies called halteres. Legs are usually long, with five-segmented tarsi. Adults are usually very active and are found in all major habitats. They are often associated with flowers and with decaying organic matter, but females of some groups are blood-sucking. Larvae are eruciform and legless in most species. They develop mainly in moist or wet habitats such as soil, mud, decaying organic matter, and in plant or animal tissues. Only a small proportion of larvae is truly aquatic. The majority are liquid-feeders or microphagous.

10.2. Taxonomy of the Diptera species alien *to* Europe

The 98 species of Diptera alien *to* Europe belong to 22 different families (Table 10.1), which all have native representatives. A larger number of aliens belong to the suborder Brachycera (66 species and 18 families) than to the suborder Nematocera (32 species and 4 families). However, this apparently large diversity is confusing. More than 40% of the alien species are either midges (Cecidomyiidae- 23 species) or fruit flies and their relatives (Drosophilidae- 18 species). The other 20 families show less than 10 species each (Figure 10.1). The arrival of these alien species has largely modified the composition of some families such as Braulidae and Drosophilidae where at present aliens respectively account for 33.3% and 14.8% of the total fauna observed in Europe. However, the native entomofauna includes 103 additional families for which no alien species has yet been recorded in Europe, especially for some ecologically and economically- important groups such as Chironomidae, Syrphidae, Asilidae, Tipulidae and Anthomyiidae. The alien dipterans belong to the following families:

Suborder Brachycera

Agromyzidae. All species in the family are phytophagous, including a number of serious pests of cultivated plants. Larvae live in plant tissues, usually forming characteristic galleries as mines. Most larvae live in the parenchyma of leaves, or mine stems, few attack fruits and seeds. The majority of the species are monophagous, some of them are widely polyphagous, attacking different plants of several families. To date, only five alien species have been observed in Europe relatively to 903 recorded native species (Fauna Europaea). However, the alien fauna includes three species of *Liriomyza* (*L. chinensis, L. huidobrensis* - see factsheet 14.23*,* and *L. trifolii*) which are highly damaging to vegetable crops (Arzone 1979, Martinez 1982, Trouvé et al. 1991).

Braulidae. Larvae live as commensals within cells of honey-bee nests (*Apis* species). They feed on pollen, honey and organic debris. Adults are "food-parasites" of adult bees, attaching themselves to the body of the queen or rarely to a worker. They feed on liquids from the mouth of the bees. There is only one genus present in Europe, *Braula,* which includes one alien species, *B. schmitzi* (Dobson 1999), and two native species.

*Calliphorida*e. This is a key family for human health. Adults are potential vectors of bacteria, viruses, protozoaires and helminthes because they actively search for and sit on feces, fresh and cooked meat, fish, dairy products, and wounds. Larvae are parasitoids or predators of living snails, or feed on blood of nestling birds. A few species are obligate producers of *myiasis* in various animals. Only one alien species, *Chrysomya albiceps* (Mercier 1927), has been observed in Europe compared to 112 native species.

Canacidae (=Tethinidae). Most species are strictly associated with salty habitats (*halobionts*), e.g. coastal salt marshes, seashore wrack, sandy beaches, shores of inland salt lakes, alkaline springs etc, and only a few species are also known from habitats that are apparently without increased salinity (forests, meadows, deserts). Some species have been reared from deposits of seaweed. There is only one alien species, *Pelomyia occidentalis* (Irwin et al. 2001), compared to a total of 39 native species.

Ceratopogonidae. Biting adults of this family are potential vectors of major animal diseases. In particular, *Culicoides* species transmit bluetongue orbivirus between ruminant hosts. A species of Afro-Asian origin, *C. imicola* Kieffer, has been considered as the main agent of the recent outbreaks of bluetongue disease in Europe although some native species could also be involved (e.g., *C. pulicarius* L. and *C. newsteadi* Austen complexes (Purse et al. 2007)). However, it seems that the most likely mode of incursion of *C. imicola* in Europe was via passive transport on the wind as aerial plankton" (Mellor et al. 2008, Purse et al. 2007). Thus, this species was not considered in this chapter.

Dolichopodidae. Adults and larvae of most species are predaceous and feed on soft-bodied invertebrates. They occupy all terrestrial habitats from coastal beaches to high elevations, but they generally prefer humid areas. Larvae are mostly found in moist soils or in the litter layer while a few others depend on sap runs and tree rot holes for their development. There is only one alien species, *Micropygus vagans* (Chandler 2004), in comparison to 790 native species in Europe.

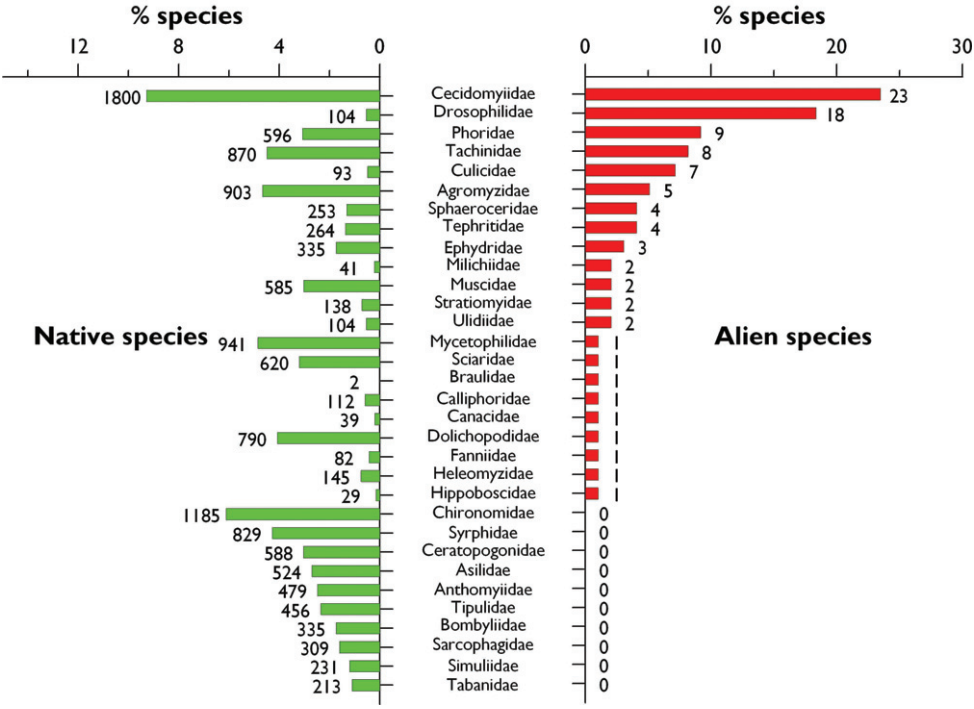

Figure 10.1. Relative importance of the families of Diptera in the alien and native entomofauna in Europe. Families are presented in a decreasing order based on the number of alien species. Species alien *to* Europe include cryptogenic species. Only the most important families of native species (> 50 spp.) have been considered. The number over each bar indicates the number of species observed per family.

Drosophilidae. Species in this family show very diverse biological habits. The larvae of most species develop in fermenting substrates, but some mine living plants. Some species are used as important laboratory animals. Drosophilids occur in all terrestrial habitats, from lowlands up to alpine meadows. They may be found near the habitats of their insect hosts or preys (mealybugs, bees, wood-boring beetles), around toadstools (Polyporales) and in the flower heads of thistles. Aliens include 18 species in the genera *Drosophila* (8 species) (Bächli et al. 2002, Grassi et al. 2009), *Chymomyza* (4 species) (Band 1994, Carles-Tolra and Andersen 2002, Perju 1959, Trent Band et al. 2005), *Zaprionus* (3 species) (Chassagnard and Kraaijeveld 1991, Monclus 1976, Tsacas et al. 1977), *Scaptomyza* (2 species) (Nicoli Aldini 2005, Nicoli Aldini and Baviera 2002) and *Dettopsomyia* (1 species) (Prevosti 1976) compared to 104 native species.

Ephydridae. Adults are usually associated with moist substrates, especially shores, marshes and wet meadows. Some develop in decomposing matter or excrement, other are leaf miners or parasitoids. Aquatic and semiaquatic habitats are typical of the family. A total of 335 native species occur in Europe with only three alien species - in the genera *Elephantinosoma, Placopsidella* and *Psilopa* (Gatt and Ebejer 2003).

Fanniidae. Species inhabit forests, rarely open landscape and wetlands. Larvae are generally saprophagous and mostly feed on decaying organic matter as human or animal faeces, decaying material in gardens, and rotting leaf litter. Some species have been reared from fungi, others occur in bird nests, burrows of vertebrates, and nests of social Hymenoptera. There is only one alien species, *Fannia pusio* (Carles-Tolra and Andersen 2002), compared to 82 native species.

Heleomyzidae. Larvae develop in sporocarps of fungi or live in association with mycelia in forest soil, some are necrophagous or saprophagous. There is only one alien species, *Prosopantrum flavifrons* (Ismay and Smith 1994) compared to 145 native species

Hippoboscidae. Adults are bloodsucking ectoparasites of birds and mammals. Females of all species are macrolarviparous, i.e. retaining the larva in the uterus to the end of the third instar. There is only one alien species, *Crataerina melbae* (Popov 1995), compared to 29 native species.

Milichiidae. Larvae are saprophagous and develop in decaying vegetation, wood detritus, in nests of birds, ants (myrmecophilous species) and of other social insects, but also in excrements, carrion, dead insects and snails. Adults of some species are commensals or *kleptoparasites* of predatory insects and spiders. There are two alien species, in the genus *Desmometopa* (Roháček (2006b)), compared to 41 native species.

Muscidae. Larvae develop in various kinds of decaying organic matter, often showing facultative or even obligatory carnivorous behaviour. Larvae of some species appear to be predaceous during their entire larval life. Adults feed on nectar or plant sap, sometimes also on decaying liquids and some species are predaceous. Some species are adapted to anthropogenically-altered ecosystems. Blood-sucking species are of medical and veterinary importance, being vectors of some diseases. There are two alien species, the sorghum pest *Athrerigona soccata* (Vercambre et al. 2000), and a predator of house flies, *Hydrotaea aenescens* (Rozkošný 2006, Saccà 1964), compared to 585 native species.

Phoridae. Adults are found in all types of terrestrial habitats, particularly in forests and meadows but also in steppe-like and xerothermic sites. Food preferences of larvae appear to be remarkably different. Most species are *polysaprophagous* with different degrees of specialisation. Parasitic species are often found in the nests of ants and termites. Some fungus breeders feed on the fungi but others are obligate predators or parasitoids of other fungus feeders such as larval Sciaridae. There are nine alien species in the genera *Megaselia* (three species) (Campobasso et al. 2004, Disney 2008, Disney and Durska 1999), *Chonocephalus* (two species) (Disney 1980, Disney 2002), *Dohrniphora* (two species) (Disney 2002, Disney 2004), *Hypocerides* (one species) (Disney 2004), and *Puliciphora* (one species) (Disney 1983) in comparison to a total of 596 native species.

Sphaeroceridae. Larvae and adults are saprophagous. Larvae develop in diverse organic matter and feed as saprophages on microorganisms destroying rotting plants, dung, carrion or fungi and also on the decomposed liquid substances. Adults occur in all habitats that contain the breeding media of the larvae, preferably in damp places. A few polyphagous species are *synanthropic*, living near human habitats. Many copro-

phagous species develop in dung heaps near stables or in pastures. There are four alien species, belonging to the genera *Thoracochaeta* (two species feeding on seaweeds) (Roháček and Marshall 2000), *Coproica* (one species) (Carles-Tolra and Andersen 2002), and *Trachyopella* (one species) (Roháček (2006a)), in comparison to a total of 253 native species.

Stratiomyidae. Terrestrial and aquatic larvae of this family live as scavengers. Adults feed on nectar of flowers, exploiting a wide range of flowering plants, especially umbels alongside water margins but also in open sunny places. There are two alien species, the scavenger *Hermetia illucens* (Venturi 1956), which has been used to control house fly, and a soldier fly, *Exaireta spinigera* (Lapeyre and Dauphin 2008), compared to a total of 138 native species.

Tachinidae. Larvae live as endoparasitoids of arthropod larvae. Many species are parasitoids of important pests of agricultural crops and forest trees and are regarded as economically beneficial. Aliens include 8 species of different genera (*Blepharipa, Catharosia, Clytiomya, Phasia, Leucostoma, Sturmia, Trichopoda* and *Zeuxia*) (Carles-Tolra and Andersen 2002, Cerretti 2001, Clemons 2001, Colazza et al. 1996, Vaňhara et al. Tschorsnig 2006) in comparison to a total of ca. 870 native species.

Tephritidae. So called "fruit flies" because larvae of most species inhabit the fruits or other seed-bearing organs of flowering plants. Larvae are phytophagous, some being leaf miners and stem-borers and others developing in roots. Many species are associated with Asteraceae. Adults feed on pollen and nectar. Some species are pests but others are used as biological control agents of weeds. Aliens include 4 species in the genus *Rhagoletis* (3 species) (Duso 1991, Lampe et al. 2005, Merz 1991) and the major fruit pest *Ceratitis capitata* (see factsheet 14.28) in comparison to a total of 264 native species.

Ulidiidae. The biology and immature stages are largely unknown. Adults occur in dry, sunny habitats, such as steppe meadows, and thin steppe forests. Larvae are mostly saprophagous and develop in rotting matter, under bark or in dung but a few seem to be phytophagous. Adults live in marshland habitats, woodland areas, sandy, salty or steppe meadows. They are often observed on flowers, shrub leaves, tree trunks, and on excrement and manure heaps. There are only two aliens, compared to a total of 106 native species, *Euxesta pechumani*, living on carrion and dung (Delage 1969) and *Euxesta notata* living on bulbs (such as onions) and sometimes considered as a pest (Martinez, unpublished).

Suborder Nematocera

Cecidomyiidae. Larvae of gall midges are either phytophagous, zoophagous or mycophagous. Phytophagous species cause galls on various parts of their host plants (hence the common name "gall midges") but some larvae live free in flower heads or in the stems without making galls, or in conifer cones, or are associated with cambium layers of various trees. Some gall-causing species are serious pests of cultivated plants and forest trees. The zoophagous larvae are predators of the larvae of other gall

midges, aphids, mites, coccids, and other arthropods and some of them are used for biological control of pests. Larvae of several species are endoparasites of aphids, psyllids and tingids. This is the dominant group of aliens in Diptera with 23 species (see Table 10.1 for references) but altogether 1800 native midge species are known to occur in Europe.

Culicidae. Larvae develop in water. Females of most species are haematophagous and feed by sucking the blood of vertebrates, whereas males may feed on flower nectar. Adults may transmit various disease pathogens, viz. viruses, malaria and filarioses. Most Culicidae are distributed in tropical and subtropical areas of the world. Whereas the European native fauna only includes 93 species within this family, seven alien species have established in Europe: two species belonging to the genus *Aedes* (the Asian tiger mosquito, *A. albopictus*- see factsheet 14.27, and the Asian rock pool mosquito, *A. japonicus* (Schaffner et al. 2009)); three Asian species of the genus *Culex* (Adhami 1987, Ramos et al. 1998, Samanidou and Harbach 2003) and two species of *Ochlerotatus* (Romi et al. 1999, Schaffner et al. 2001). *Aedes aegypti*, the vector of yellow fever which has been present in Europe for a long time, now seems to be extinct; no exotic species of *Anopheles* has yet established (Schaffner et al. 2001).

Mycetophilidae. Larvae are mycophagous, feeding on the mycelia or fruit bodies of various fungi or myxomycetes. Adults fly in the undergrowth of forests, on meadows and steppe habitats. There is only one alien species, *Leia arsona* (Halstead 2004) compared to a total of ca. 950 native species.

Sciaridae. Larvae are mostly free living in the upper soil layer of nearly all terrestrial habitats. Some species develop inside plant stems, leaves or decaying wood. They feed on fungal mycelia or decomposing plant tissue. There is only one alien species, *Bradysia difformis* (White et al. 2000), compared to a total of 629 native species.

10. 3. Temporal trends of introduction in Europe of alien Diptera

The date of the first record in Europe is more or less precisely known for 84 (ie., 86%) of the alien species of Diptera, whilst it remains unknown for the other 14 species (Table 10.1). Considering, cautiously, this first record in Europe as a proxy, the arrival of alien dipterans showed a significant, exponential acceleration since the second half of the 20th century (Figure 10.2). The mean number of new records per year increased from 0.25 during 1900–1950 to 2.2 during 2000–2008. In parallel, an increasing diversification of the dipteran families involved in the arrivals was observed.

Only a few aliens, mostly Cecidomyiidae, were newly recorded during the 19th century. Probably originating from the subtropics, the midge *Feltiella acarisuga* was first found and described in France in 1827 (Vallot 1827) . It was subsequently discovered in several other European countries to be finally introduced intentionnally in a large part of the world as a biological control agent for red spider mites in greenhouses. Four more alien dipterans, of which three midges and one fruit fly, were subsequently recorded during the second half of the 19th century, each showing different patterns of

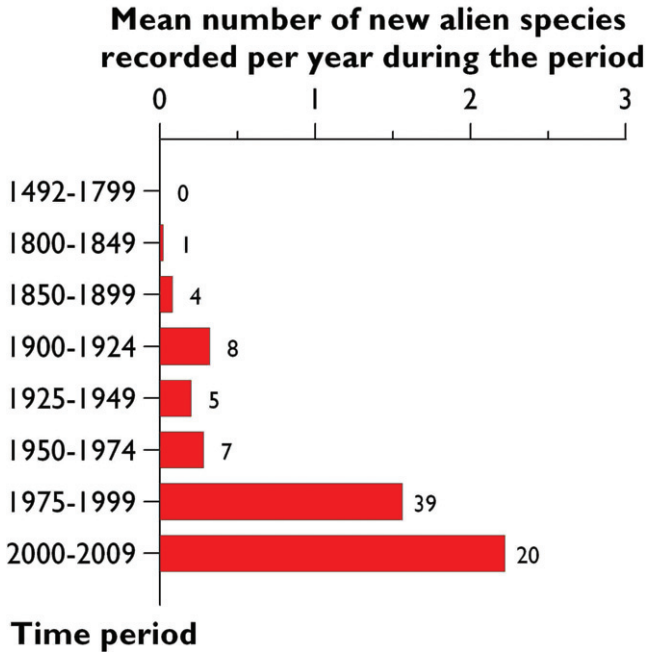

Figure 10.2. Temporal changes in the mean number of records per year of dipteran species alien *to* Europe from 1800 to 2009. The number over each bar indicates the absolute number of species newly recorded per time period.

expansion in Europe. *Contarinia quinquenota* (Cecidomyiidae), developing in flower buds of *Hemerocallis fulva* (Liliaceae), was first found in Austria in 1885 (Löw 1888 and subsequently in 11 other countries. *Clinodiplosis cattleyae* (Cecidomyiidae), which forms conspicuous swellings on the aerial roots of *Cattleya* species (Orchidaceae), was first observed in England in 1885 but later only in France (Molliard 1902). *Orseolia cynodontis* (Cecidomyiidae) was first observed in 1892 in Italy (Massalongo 1892) and then in three other countries. The fruit fly *Ceratitis capitata* (Tephritidae) was discovered in Italy in 1873 and subsequently in 15 other European countries.

The first half of the 20th century saw the arrival of 13 more alien dipterans of which six are Cecidomyiidae, five Drosophilidae, one Calliphoridae and one Stratiomyidae. Two of these species have not shown any expansion in Europe. A cecidomyiid from tropical Asia, *Procontarinia matteiana*, was only first observed in 1906 within the Botanical Garden of Palermo (Sicily), galling leafs of a plant imported from India, *Mangifera indica* (Anacardiaceae) (Kieffer and Cecconi 1906). According to recent information, the host plant has subsequently died out; this alien midge may be considered as extinct in Europe. Discovered in England in 1913, a North American midge, *Rhopalomyia grossulariae*, causing galls on *Ribes grossularia* (Grossulariaceae), has not been found anywhere else since that time (Theobald 1913). On the contrary, an other North American midge, *Janetiella siskiyou* (=*Craneiobia lawsonianae*), which develops in cones of *Chamaecyperis lawsoniana* (Cupressaceae), was first observed in the Netherlands

in 1931 (Meijere 1935) and subsequently in 10 further countries. A gall midge of Asian origin, *Rhopalomyia chrysanthemi*, damaging leaves of cultivated *Chrysanthemum* (Asteraceae), was observed in France and Denmark in 1935 (Bovien 1935) and subsequently found in greenhouses of eight more countries. An other Asian midge, *Stenodiplosis panici*, developing in inflorencesces of *Panicum miliaceum* (Poaceae), was discovered in southern Russia in 1926 (Dombrovskaja 1936) and then in four other countries. The African predatory midge, *Dicrodiplosis pseudococci,* attacking the scale *Planococcus citri* (Pseudococcidae) was found in Italy in 1914 (Felt 1914) and then in Spain. Five *Drosophila* species of unknown origin were first found in Great Britain in 1900 and then in several countries of northern and central Europe. The cryptogenic *Chrysomyia albiceps* (Calliphoridae) was recorded in 1927 in France (Mercier 1927) and later expanded to most of southwestern and central Europe. Finally, a Stratiomyidae, *Hermetia illucens*, was first discovered in Malta in 1936 but subsequently spread to 6 more countries (Venturi 1956).

The second half of the 20th century consisted of two distinct periods of invasion of alien dipteran species. From 1950 to 1974, only seven new alien species (i.e. 0.2 species per year on the average) were recorded. They belong to families Cecidomyiidae (*Contarinia citri* (Genduso 1963) and *Stenodiplosis sorghicola* (Starostin et al. 1987), both of African origin), Dolichopodidae (*Micropygus vagans* found in Great Britain in 1970 (Chandler 2004)), Muscidae (a north American predator of house fly, *Hydrotaea aenesecens* (Saccà 1964)), and Sciaridae (*Bradysia difformis* recorded from Great Britain in 1965 (White et al. 2000) and subsequently found in Northern Europe). In contrast, a total of 39 alien species were subsequently observed in Europe from 1975 to 1999 (i.e. 1.6 species per year on the average). These later invasions involved a much larger number of dipteran families than previously. By order of importance, families include Drosophilidae (eight species), Cecidomyiidae (six species), Culicidae (six species among which the tiger mosquito, *Aedes albopictus,* arrived in 1979 in Albania (Adhami 1987)), Phoridae (five species, including the mushroom pest *Megaselia tamilnaduensis* in 1999 (Disney and Durska 1999), Tachinidae (three species), Tephritidae (three species of *Rhagoletis* fruit pests), Agromyzidae (three species among which the crop pests *Liriomyza trifolii* in 1979 (Aguilar & Martínez 1979) and *L. huidobrensis* in 1989 (Trouvé et al. 1991)), and one species in the families Braulidae, Heleomyzidae, Hippoboscidae, Muscidae, and Mycetophilidae. Since 2000, alien dipterans were observed in Europe at a proportionally higher rate, with 20 species newly recorded from 2000 to 2009, i.e. an average of 2.2 species per year. In addition to families already represented by alien species such as Phoridae (four species) (Disney 2002, Disney 2004), Cecidomyiidae (four species among which the quickly spreading *Obolodiplosis robiniae* galling *Robinia pseudoacacia* (Duso C and Skuhrava 2003) - see factsheet 14.26) (Calvo et al. 2006, Gagné 2004, Harris and Goffau 2003), Drosophilidae (three species), Agromyzidae (two species) (Bella et al 2007, Süss 2001), Culicidae (Schaffner et al. 2003), Stratiomyidae (Lapeyre and Dauphin 2008) and Ulidiidae (one species each) (Martinez, unpublished), representatives of two new families were observed: Ephydridae shore flies (three species mostly linked to poultry dung) (Gatt and Ebejer 2003) and Canacidae (one species) (Irwin et al. 2001).

10. 4. Biogeographic patterns of the dipteran species alien to Europe

10.4.1. Origin of alien species

A region, or more simply a continent, of origin could be traced for only 78 of the 98 dipteran species alien *to* Europe, i.e. in ca. 80% of the species. However, in a number of cases, the origin of the dipteran species could only be assumed from that of its host. Several species of Cecidomyiidae illustrate the difficulties and uncertainties in assigning origins. Some species were found and described for the first time in Europe but it is likely that they are non-native and introduced together with their host. For example, the Asian origin of a gall midge *Procontarinia matteiana,* first described in Sicily (Kieffer and Cecconi 1906), and the African origin of *Orseolia cynodontis,* another gall maker on *Cynodon dactylon* (Poaceae), first discovered at Verona (Italy) (Massalongo 1892), were assumed from the source of their host plants, imported from India and North Africa, respectively. Similarly, that of *Dicrodiplosis pseudococci*, a predator midge of a scale, *Planococcus citri* (Pseudococcidae), also discovered in Sicily (Felt 1914), was assumed from the subtropical and tropical origin of its insect prey. The cases of *Rhopalomyia grossulariae* and *Dasineura gibsoni* are even more complex. The larvae of *Rhopalomyia grossulariae* which develop in enlarged, deformed leaf buds of *Ribes uva-crispa* (Grossulariaceae) were first discovered in Ohio (USA) and were later found in Great Britain (Theobald 1913); specimens of *Dasineura gibsoni* were described developing in flower heads of *Cirsium arvense* (Asteraceae) in Ottawa, Canada (Gagné 1989), before being also found in Great Britain (Harris 1976). Both species were thus considered to be native of the Nearctic, and then introduced to Europe. However, both host plants are not Nearctic species but *archaeophytes* of Eurasian origin. Therefore, *R. grossulariae* as well as *D. gibsoni* might also be of such origin. However, neither larvae nor adults of these two species have been discovered in continental Europe until now. Further genetic studies may contribute to tracking the exact origin of such species.

In contrast to the general trend observed for arthropods and insects, North America appears to be the dominant contributor of the alien dipteran fauna, with almost one-third of the species originating from this continent, far beyond Asia whilst a significant percentage of species came from Africa (Figure 10.3).

The 30 alien species originating from North America consists of Cecidomyiidae (10 species), Drosophilidae (6 species), Sphaeroceridae (3 species), Tephritidae (3 species; the fruit fly pests *Rhagoletis completa*, *R. cingulata* and *R. indifferens*), Ulidiidae (2 species), and Agromyzidae, Canacidae, Culicidae, Muscidae, Stratiomyidae, and Tachinidae (one species each). The insects originate from various part of this large continent; for example *Janetiella siskiyou* (Gagné 1972) and *Resseliella conicola* (Gagné 1989, Skuhrava et al. 2006) developing in cones of *Abies* and other conifers (Pinaceae) from the northwestern region whereas *Obolodiplosis robiniae* and *Dasineura gleditchiae* (Gagné 1989) developing in leaflet galls on *Gleditsia triacanthos* (Fabaceae) arrived from the northeast.

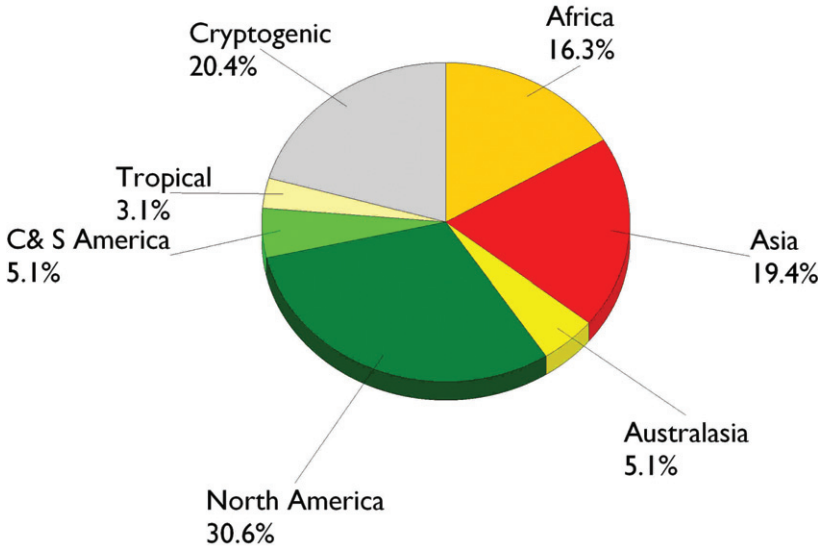

Figure 10.3. Origin of the 98 species of Diptera alien *to* Europe.

The 19 dipteran species coming from Asia consists of six species of Cecidomyiidae, five species of Culicidae, two species of Agromyzidae, Phoridae and Tachinidae, and one species of Drosophilidae and Ephydridae. Most species originate from the temperate, eastern Asia such as *Contarinia quinquenotata* damaging flower buds of *Hemerocallis fulva* (Liliaceae), *Epidiplosis filifera*, a predator of the coccid scale *Ceratoplates floridensis* on citrus fruits (Nijveldt 1965), and probably *Rhopalomyia chrysanthemi* (Cecidomyiidae) (Barnes 1948) whilst *Cerodontha unisetiorbita* (Agromyzidae) (Süss 2001), *Aedes japonicus* (Culicidae) (Schaffner et al. 2009) and *Drosophila curvispina* (Drosophilidae) (Bächli et al. 2002) originate from Japan. However, tropical Asia, mainly India, has also contributed to the alien entomofauna, having supplied *Aedes albopictus* (Eritja et al. 2005), *Culex tritaebiorhynchus* (Samanidou and Harbach 2003), *C. vishnui* (Culicidae) (Adhami 1987), *Placopsidella phaenota* (Ephydridae) (Gatt and Ebejer 2003), *Procontarinia matteiana* (Kieffer and Cecconi 1906), *Horidiplosis ficifolii* (Cecidomyiidae), causing leaf galls on *Ficus benjamina* (Moraceae) (Harris and Goffau 2003), and *Megaselia tamilnaduensis* (Phoridae) (Disney and Durska 1999). A few species came from Middle East (*Leucostoma edentata;* Tachinidae) (Chassagnard and Kraaijeveld 1991) and Western Asia (*Ochlerotatus subdiversus*; Culicidae) (Schaffner et al. 2001).

The 16 species coming from Africa consist of Cecidomyiidae (five species), Drosophilidae (three *Zaprionus* species), Phoridae (three species), Ephydriidae (two species), and one species of Tephritidae (*Ceratitis capitata*), Culicidae and Mycetophilidae. In addition to the species mentionned above (*D. pseudococci* and *O. cynodontis),* midges include *Stenodiplosis sorghicola* associated with *Sorghum* (Poaceae), and *Contarinia citri* developing in flower buds of *Citrus* sp. (Rutaceae), which probably originates from Mauritius. The Phoridae species came from tropical Africa.

Five alien dipteran species of different families are known to originate from Central and South America. They include *Clinodiplosis cattleyae* (Cecidomyiidae) from Brazil (Gagné 1994), *Liriomyza huidobrensis* (Agromyzidae) from South America (Trouvé et al. 1991) before having been introduced in Central America, Asia and Africa, *Fannia pusio* (Fanniidae) (Hill et al. 2005), *Prosopantrum flavifrons* (Heleomyzidae) (Ismay and Smith 1994), and the recently- arrived, *Phytoliriomyza jacarandae* (Agromyzidae) (Bella et al 2007).

Another 5 dipteran species originate from Australasia, viz. *Micropygus vagans* (Dolichopodidae) from New Zealand (Chandler 2004), *Megaselia gregaria* (Phoridae) from Tasmania (Disney 2002), *Coproica rufifrons* (Sphaeroceridae) from Papua-New Guinea (Carles-Tolra and Andersen 2002), *Exaireta spinigera* (Stratiomyidae) from Australia (Lapeyre and Dauphin 2008), and *Dohrniphora cornuta* (Phoridae) from Australasia (Disney 2002).

Three other dipteran species are only known to originate from the tropical and subtropical parts of the world. They include *Dettopsomyia nigrovittata* (Drosophilidae), which has been found only once in Canary islands (Prevosti 1976), *Puliciphora borinquenensis* (Phoridae), found only once in Great Britain (Disney 1983) and *Megaselia scalaris* (Phoridae), a saprophagous species which may be dangerous to human health and has largely spread in western and central Europe (Disney 2008).

10.4.2. Distribution of alien species in Europe

Alien dipteran species and families are not evenly distributed throughout Europe. Large differences exist between countries in the number of alien species present within each territory (Figure 10.4). As for the other arthropod groups, it may reflect differences in sampling intensity and in the number of local taxonomists specialized in these families.

The number of alien dipterans is significantly and positively correlated with the country surface area (after log-transformation; P= 0.0282). Indeed, Great Britain hosts the largest number of aliens (36 species of 11 families), followed by continental Spain (33 species; 17 families), continental France (29 species; 13 families) and continental Italy (28 species; 11 families). However, the family diversity is similar in three countries of Central Europe of much smaller size, the Czech Republic, Switzerland, and Slovakia which host each 11 families of alien dipterans for ca. 20 species. Although the western and southern countries seem to host more aliens (Figure 10. 4), the number of species per country relatively to their size is not correlated with longitude (P= 0.4106) nor with latitude (P= 0.3896). The European islands host proportionally more alien dipterans than continental countries relatively to their size (Kruskall- Wallis test on the number of aliens per km^2; P=0.0098). Thus, 14 alien species of 10 families were found in the small island of Malta occupying 316 km^2 in the Mediterranean Sea.

Most alien dipterans still have a very restricted distribution. More than 30% of the species (30 species) have been observed in only one country such as *Culex deserticola* (Culicidae) and *Dohrniphora papuana* (Phoridae) as yet only recorded from Spain

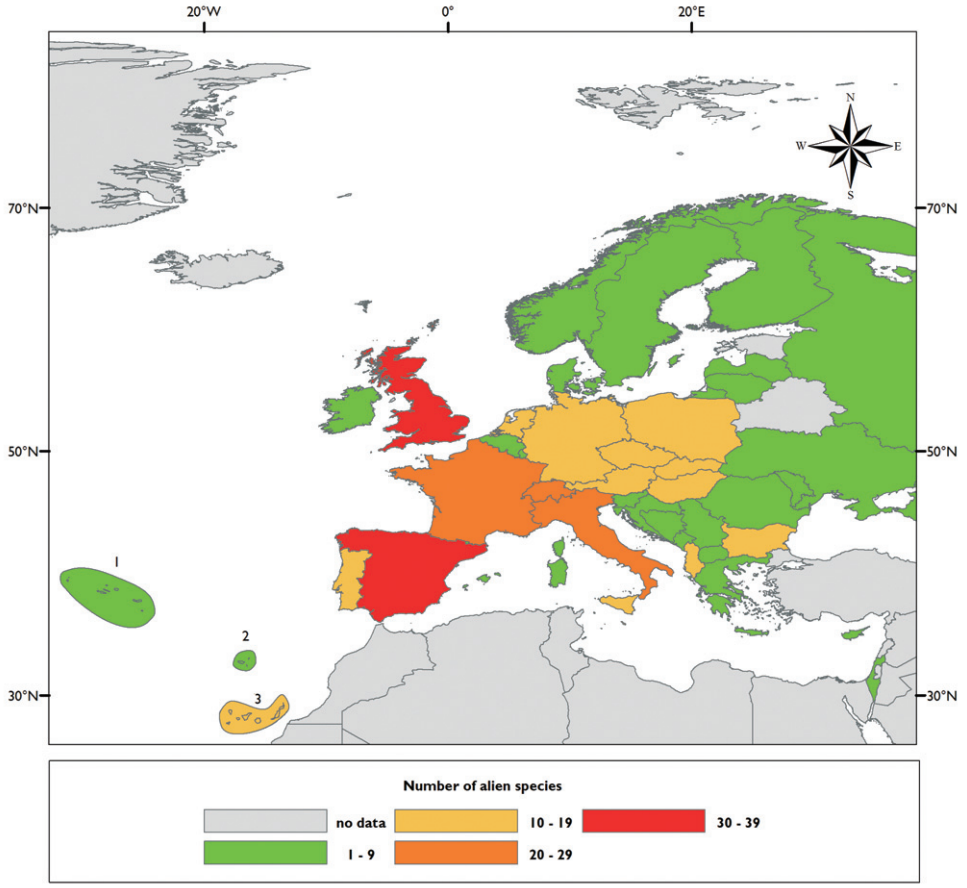

Figure 10.4. Comparative colonization of continental European countries and islands by dipteran species alien *to* Europe. Archipelago: **1** Azores **2** Madeira **3** Canary islands.

(Disney 2004, Eritja et al. 2000, Ramos et al. 1998), *Chymomyza wirthi* (Drosophilidae) in Great Britain (Gibbs 1994), *Placopsidella phaenota* (Ephydridae) in Malta (Gatt and Ebejer 2003), and *Exaireta spinigera* (Stratiomyidae) in France (Lapeyre and Dauphin 2008). Another 17 species are present in only two, often nearby, countries such as *Cerodontha unisetiorbita* (Agromyzidae) found in Italy and Albania (Süss 2001), *Drosophila suzukii* (Drosophilidae) in Spain and Italy (EPPO 2010) and *Culex tritaeniorhynchus* (Culicidae) in Albania (Adhami 1987) and Greece (Samanidou and Harbach 2003). No alien Diptera is present in more than 24 of the 65 countries and large islands of Europe. Only 9 species have been introduced or have expanded in 15 countries or more. Most are plant pests such as the agromyzid leaf miners *Liriomyza huidobrensis* (24 countries) (EPPO 2006, Fauna Europaea) and *L. trifolii* (22 countries) (Fauna Europaea), a midge *Obolodiplosis robiniae* (20 countries) (Glavendekić et al. 2009), and a fruit fly *Ceratitis capitata* (20 countries) (Fauna Europaea). The Tiger mosquito, *Aedes albopictus*, and the predator midge, *Feltiella acarisuga* are also

present in 13 and 21 countries, respectively. In most cases, it is not known whether the species has expanded naturally once established in a country or if the extended distribution corresponds to repeated introductions from abroad. However, very patchy distributions probably result from independent introductions. Thus, *Hypocerides nearcticus* (Phoridae) was found in Spain and Sweden (Disney 2004), and *Coprorica rufifrons* (Sphaeroceridae) in Malta and in the Canary islands (Carles-Tolra and Andersen 2002). In contrast, the occurence of an alien species within a whole geographic region is likely to proceed, at least partly, from natural dispersion such as for *Pelomyia occidentalis* (Canacidae) which is currently present throughout Central Europe (Czech Republic, Germany, Hungary, Poland and Slovakia) (Roháček (2006a), Roháček (2006c)). Some other species are known to combine both methods of dispersal. *Aedes albopictus* was introduced independently by human activity in Albania, France, Italy, Netherlands but probably spread naturally along the Adriatic coast (see map on factsheet 14.27). The honeylocust gall midge, *Obolodiplosis robiniae,* also spread very rapidly throughout Europe (Glavendekić et al. 2009). Four years after its discovery in Italy in 2003, it occupied a large area from southern England in the west to eastern Ukraine in the east and from northern Germany to southern Italy (see map on factsheet 14.26).

Dipterans alien *in* Europe, i.e. originating from one part of Europe and introduced through human activity in an other part, are a matter of debate because it is often difficult to discriminate between a natural expansion, an introduction, or simply a lack of previous information regarding the actual species‘ native range. Table 10.2 present some of these species. They include species of Mediterranean origin, likely to have been introduced with their Mediterranean hosts in more northern countries, for example *Monarthropalpus flavus,* a gall-maker of common box (*Buxus sempervirens*) in Central-European countries. In addition, the date of first record is likely to differ largely from the date of arrival for a few species specifically associated with *archaeophyte* plants. For instance, two gall midges, *Contarinia pisi* and *C. lentis,* specifically galling plants in the family Fabaceae, *Pisum sativum* and *Lens culinaris* respectively, have been recorded in Europe only rather recently, although their host plants have been introduced for cultivation since the prehistoric times, probably from the Mediterranean region or the Middle East. Other species followed their host plant introduced from continental Europe to islands on which the plant was absent. Dipterans specifically related to larch such as several species of *Strobilomyia* larch cone flies (Anthomyiidae) (Ackland 1965; Roques, unpubl.) and a larch gall midge, *Dasineura kellneri* (Hill et al. 2005) or to spruce (a spruce cone gall midge, *Kaltenbachiola strobi*) (Hill et al. 2005) are thus considered to be alien *in* Great Britain.

10.5. Main pathways of introduction to Europe of alien dipteran species

Intentional introductions represent a much smaller proportion of alien arrivals in Diptera than the average in arthropods in general (3.1% vs. 10%). Only three dipteran

predators of different families were introduced intentionally for biological control and have subsequently become established. Two of them, *Hydrotaea aenescens* (Muscidae) and *Hermetia illucens* (Stratiomyidae), were released from North America to control houses flies in poultry farms and stables (Saccà 1964). The third species, *Feltiella acarisuga* (Cecidomyiidae), is a cryptogenic species of cosmopolitan distribution preying exclusively on tetranychid red spider mites. Larvae and adults were found in several countries of Europe, in northern Africa, Asia, North America, Australia and New Zealand. It has been intentionally released, mostly in glasshouses, in Italy, Denmark and Poland, to protect crops.

Similarly, as for the other taxa, trying to identify pathways for the remaining 97% of accidental introductions is not a straightforward task. In a number of cases, it however could be inferred from the species biology, for that of the plant/animal host or from repeated interceptions with merchandise at borders. Thus, eggs and larvae of the Asian tiger mosquito, *Aedes albopictus,* and those of the Asian rock pool mosquito*, A. japonicus*, have been shown to be imported as stowaway through the trade of second-hand tyres (Reiter 1998, Schaffner et al. 2009). Larvae of *A. albopictus* were also found inside bags watering "lucky bamboos" (*Dracaena senderiana*) for horticultural markets. Larvae, such as these of *Liriomyza* spp., that are leaf-miners of vegetable crops, are regularly intercepted at borders along with agriculture imports, as well as fruits infested by larvae of *Ceratitis capitata* and *Rhagoletis* spp.

More generally, pathways can be hypothesized for about a half of the 95 alien Diptera which were accidentally introduced. Horticultural and ornamental trade is probably the most significant pathway, with a total of 30 species more or less closely associated. *Horidiplosis ficifolii,* a midge causing leaf galls on *Ficus benjamina* (Moraceae) was probably imported with infected fig plants in containers from South-eastern Asia (Taiwan) as well as the midge *Asphondylia buddleia*, developing in swollen aborted flowers of *Buddleia racemosa* (Scrophulariaceae), from El Salvador to southern France (Beguinot 1999). A similar process is likely to have occurred for the agromyzids *Cerodontha unisetiorbita* with *Phyllostachys* bamboos imported from south Asia (Süss 2001), and *Phytoliriomyza jacarandae* developing on ornamental blue Jacaranda trees (*Jacaranda mimosifolia*) introduced to Sicily and mainland Italy (Bella et al. 2007). Some other gall midges are assumed to have been transported to Europe with seedlings of plants for planting as very small larvae hidden in undeveloped plant organs, as for example *Obolodiplosis robiniae, Dasineura gleditchiae, Dasineura oxycoccana* and *Prodiplosis vaccinii,* the two last species developing in bud galls of cultivated species of *Vaccinium* (Ericaceae) in North America (Gagné 1989). Orchid trade was probably responsible for the transport of the midge *Clinodiplosis cattleyae* whereas cone and seed trade can be assumed as the vector of a seed midge, *Janetiella siskiyou*, infesting *Chamaecyprais lawsonniana* (A. Murr.) Parl. and a cone midge, *Resseliella conicola* on *Picea sitchensis* (Bong.) Carrière.

Comparatively few species (10) have larvae that appear to be associated with the trade of vegetable crops (the agromyzids *L. huidobrensis* and *L. trifolii* with a large number of different crops; *L. chinensis* with *Allium;* the cecidomyiids *Stenodiplosis pa-*

nici with *Panicum* and *S. sorghicola* with *Sorghum)* and fruit crops (the midge *Contarinia citri* with *Citrus,* and the tephritids *Ceratitis capitata, Rhagoletis completa, R. cingulata* and *R. indifferens*). The movement of stored products seems responsible for the introduction of another 10 species, mostly drosophilds but also several species associated with the mushroom trade such as the phorids *Megaselia tamilnaduensis* (Disney and Durska 1999) and *M. scalaris* (Disney 2008) and the mycetophilid *Leia arsona* (Halstead 2004). Movement of compost is the problable pathway for two species of Stratiomyidae, *Exaireta spinigera* (Lapeyre and Dauphin 2008) and *Hermetia illuscens* (Venturi 1956). Finally, three species are associated with animal husbandry such as *Crataerina melbae* (Hippoboscidae) (Popov 1995) and *Chonocephalus depressus* (Phoridae) (Disney 2002).

10.6. Ecosystems and habitats invaded in Europe by alien dipteran species

Alien dipterans predominantly exhibit phytophagous habits (35 species- 35.6%). However, zoophagous and detrivorous/mycetophagous species each represent nearly one-third of aliens (28.6% and 29.6%, respectively) whilst the feeding habits remains unknown for ca. 2% of the species. Leaves constitute the most important feeding niche for the alien phytophagous species (24 species), far beyond fruits (10 species including cones and seeds). Leaves are exploited by "true" leaf miners (agromyzids and cecidomyids) and by gall-makers (cecidomyids) but not by external feeders.

About 85 % of the alien Diptera seem to have firmly established in their new European environment and its habitats. However, there is little evidence of the establishment status of the 15 % remaining species which have been recorded only once or twice. Nearly 65% (64.1%) of the alien Dipteran species established in Europe are only present in man-made habitats, essentially around and in buildings, in agricultural lands, parks and gardens and glasshouses (Figure 10.5). This proportion is not significantly different from the average value observed for all arthropods. In addition, 16 of the 35 phytophagous aliens (45.7%) remain strictly related to their original, exotic plants used as ornamentals at the vicinity of human habitations such as *Cerodontha unisetiorbita* on bamboo, *Dasineura gleditchiae* on *Gleditsia*, *Asphondylia buddleia* on *Buddleia*, *Obolodiplosis robiniae* on honey locust *Robinia pseudoacacia*. Woodlands and forests have been colonized by a few alien species (11.7 %). The remaining species occur quite equally in diverse natural and semi-natural habitats, viz. in coastal areas, inland surface waters, mires and bogs, grasslands, and heathlands.

10.7. Ecological and economic impact of alien dipteran species

Like most insects, alien dipteran species are better known for their economic and sanitary impact than for their ecological impact. Indeed, ecological impacts on native fauna and flora are not documented at all for any of the species established in Europe. Nega-

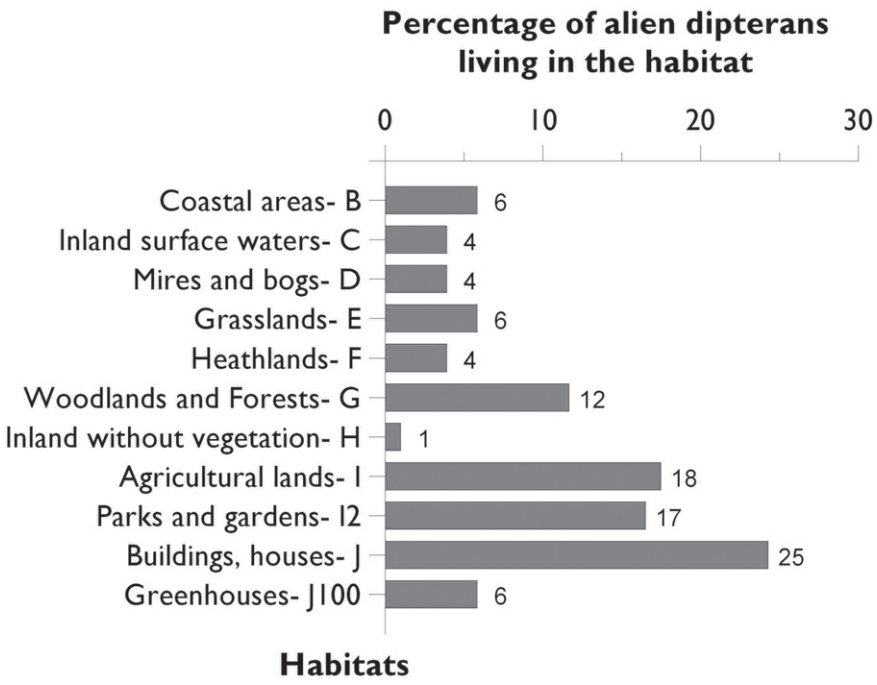

Figure 10.5. Main European habitats colonized by the established alien species of Diptera. The number over each bar indicates the absolute number of alien dipterans recorded per habitat. Note that a species may have colonized several habitats.

tive economic impacts on crops have been recorded for a total of 14 species. They include the agromyzid leaf miners *Liriomyza trifolii* and, more especially, *L huidobrensis*, whose larvae mine a wide range of vegetables and ornamental plants in glasshouses in a large part of Europe but also outdoors in the Mediterranean basin (see factsheet 14.23, 14.24). Of economic importance are also the tephritid fruit flies. *Ceratitis capitata* damage fruits of many host plants and has a large impact on fruit crops, especially citrus fruits and peach, all over the Mediterranean basin but also in some countries of central Europe (see factsheet 14.28). Other fruit fllies in the genus *Rhagoletis*, affect cherry (*R. cingulata* and *R. indifferens*) (Lampe et al. 2005, Merz 1991) and walnut crops (*R. completa*) (Duso 1991, Merz 1991) in Western Europe. The recently introduced *Drosophila suzukii* is also a fruit pest (EPPO 2010). Some mycetophagous species have a local impact on cultivated mushrooms (*Megaselia tamilnaduensis, Megaselia gregaria, and Bradysia difformis*) (Disney 2008, Disney and Durska 1999, White et al. 2000). Two other species of midges, *Stenodiplosis panici* and *Stenodiplosis sorghicola* developing in inflorescences of *Panicum* and *Sorghum,* respectively, may become economic pests in the future if the development conditions become more suitable for outbreaks.

Positive impacts are considered for the 3 dipteran species deliberately introduced to Europe for biological control of house flies and tetranychid mites (see 10.5). However, their possible ecological impact on the native, non-target fauna is not documented.

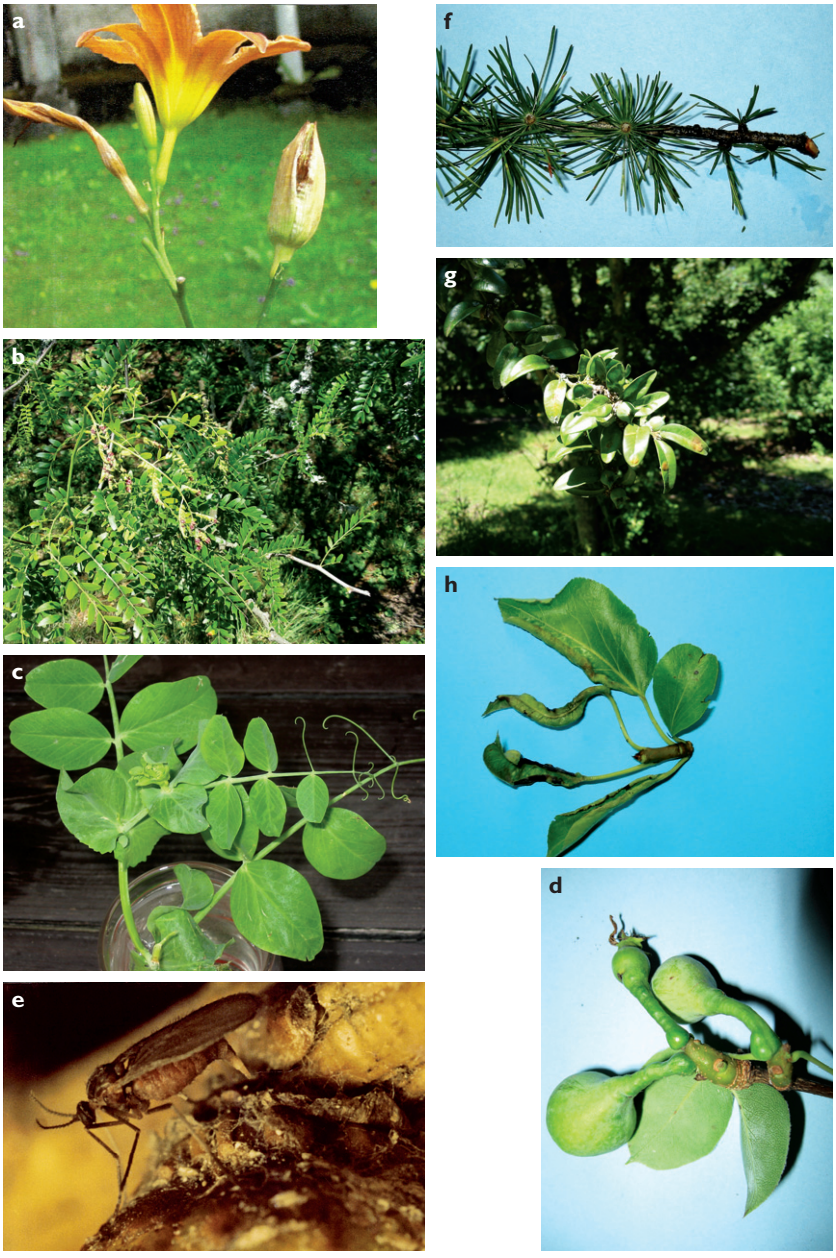

Figure 10.6. Some alien midges and their damage. **a** Unopened and swollen flower bud (right) of *Hemerocallis fulva* caused by larvae of *Contarinia quinquenotata* **b** leaflets of *Gleditsia triacanthos* changed into galls by larvae of *Dasineura gleditchiae* **c** Leaf bud gall on *Pisum sativum* caused by larvae of *Contarinia pisi* **d** Fruits of *Pyrus communis* heavily deformed by larvae of *Contarinia pyrivora* **e** female of *Dasineura kellneri* sitting on the bud of *Larix decidua* and laying eggs **f** Swollen buds of *Larix decidua* capped with resin caused by larvae of *Dasineura kellneri* **g** Galls in form of indistinct shallow blisters apparent on both sides of the leaf of *Buxus sempervirens*, caused by larvae of *Monarthropalpus flavus* **h** Rolled leaf margins of *Pyrus communis* caused by galls of *Dasineura pyri*.

Some other alien predators which have been accidentally introduced such as *Dicrodiplosis pseudococci* and *Epidiplosis filifera*, may be used for biological control of coccids in the future.

A total of 7 alien dipterans may have a sanitary impact on human and animal health. Six of the 7 introduced species of mosquitoes in the family Culicidae are capable of transmitting diseases through female bites (Taylor et al. 2006). The most important one, *Aedes albopictus,* is now established along the Mediterranean coast from south eastern France to northern Greece and is the vector of Chykungunya disease as well as many arboviruses, avian plasmodia and dog heartworm filariasis (see factsheet 14.27). Other alien culicids may be vectors of the West Nile virus (*Aedes japonicus* (Schaffner et al. 2009), *Culex tritaeniorhynchus, C. vishnui, O. atropalpus*), Japanese encephalitis (*A. japonicus, C. tritaeniorhynchus*) and Sindbis virus (*C. tritaeniorhynchus*). In addition, a detrivorous phorid, the scuttle fly *Megaselia scalaris*, may be a cause of allergies whilst it is reported in tropical areas to cause wound and intestinal myiasis in humans (Disney 2008).

Besides their measurable economic impact, some other alien dipterans may have an aesthetic impact because their oubreaks drastically changes the foliage of ornamental species in town parks and private gardens, even if the damage occurs on exotic, introduced trees. Such aesthetic impact has been observed for three midges at least, *Dasineura gleditchiae* causing galls on leaflets of *Gleditsia triacanthos* (Dini-Papanastasi and Skarmoutsos 2001), *Obolodiplosis robiniae* causing galls on leaf margins of *Robinia pseudoacacia* (Glavendekić et al. 2009, Skuhravá et al. 2007), and *Contarinia quinquenotata* preventing flowering of *Hemerocallis fulva* in gardens (Halstead and Harris 1990).

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Table 10.1. Diptera species alien *to* Europe. List and characteristics. Status: **A**: Alien *to* Europe; **C**: cryptogenic species. Country codes abbreviations refer to ISO 3166 (see Appendix I). Habitat abbreviations refer to EUNIS (see Appendix II). Last update 05/02/2010.

Family *Species*	Status	Regime	Native range	1st record in Europe and country	Invaded countries and islands	Habitat*	Hosts	References
Agromyzidae								
Cerodontha unisetiorbita Zlobin, 1993	A	Phyto-phagous	Asia	2001, IT	AL, IT	I2	Bamboos	Süss (2001)
Liriomyza chinensis Kato, 1949	A	Phyto-phagous	Asia	1982, FR	FR	I1	*Allium* spp.	Martinez (1982)
Liriomyza huidobrensis (Blanchard, 1926)	A	Phyto-phagous	C. & S. America	1989, FR	AL, AT, BE, BG, CH, CY, CZ, ES, ES-CAN, FR, GR, GR-CRE, HU, HR, IL, IT, IT-SIC, MT, NL, PL, NO, PL, PT, RS	I1, I2, J100	Polyphagous leaf miner	Beschovski and Karadjova (1996), Carles-Tolra and Andersen (2002), Cerný (2006), Cerný and Vála (2006), EPPO (2006), Gederaas et al. (red.) (2007), Glavendekić et al. (2007), Roll et al. (2007), Süss (1991), Trouvé et al. (1991)
Liriomyza trifolii (Burgess, 1880)	A	Phyto-phagous	North America	1976, FR	AL, AT, BA, BE, CH, CY, ES, ES-CAN, FR, GR, HR, IT, IT-SAR, IT-SIC, IL, MT, NL, NO, PT, RO, RS, RU	I1	Polyphagous leaf miner	Aguilar & Martínez (1979), Arzone (1979), Carles-Tolra and Andersen (2002), Cerný and Vála (2006), EPPO (2006), Gederaas et al. (red.) (2007), Glavendekić et al. (2007), Máca (2006), Roll et al. (2007)
Phytoliriomyza jacarandae Steyskal & Spencer, 1978	A	Phyto-phagous	South America	2006, IT-SIC	IT-SIC, IT	I2	*Jacaranda mimosifolia*	Bella et al (2007)

Family *Species*	Status	Regime	Native range	1st record in Europe and country	Invaded countries and islands	Habitat*	Hosts	References
Braulidae								
Braula schmitzi Orosi Pal, 1939	C	Parasitic/ Predator	Cryptogenic	1998, GB	BG, ES, FR, GB, GR, IT, PT	E, J	Bees	Carles-Tolra and Andersen (2002), Dobson (1999)
Calliphoridae								
Chrysomyia albiceps (Wiedemann, 1819)	C	Parasitic/ Predator	Cryptogenic	1927, FR	AT, BG, CH, ES, ES-BAL, ES-CAN, FR, HR, MT, PT-MAD, PT-AZO, SK	E	Cadavers	Carles-Tolra and Andersen (2002), Fauna Europaea, Kubík (2006), Mercier (1927)
Canacidae (=Tethinidae)								
Pelomyia occidentalis Williston, 1893	A	?	North America	2001	CZ, DE, HU, PL, SK	U	unknown	Irwin et al. (2001), Roháček (2006a), Roháček (2006c)
Cecidomyiidae								
Asphondylia buddleia Felt, 1935	A	Phyto-phagous	North America	1999, FR	FR	I2	*Buddleia racemosa*	Beguinot (1999), Gagné (1989), Skuhravá et al. (2005)
Clinodiplosis cattleyae (Molliard, 1903)	A	Phyto-phagous	C. & S. America	1885, GB	FR, GB	J, J100	*Cattleia* and other Orchidaceae	Barnes (1948), Gagné (1994), Molliard (1902), Skuhravá et al. (2005)
Contarinia citri Barnes, 1944	A	Phyto-phagous	Africa	1957, CY	AL, CY, IL, IT, IT-SIC	I	*Citrus* spp.	Genduso (1963), Georghiou (1977), Sinacori and Mineo (1997), Skuhravá and Skuhravý (2004a)
Contarinia quinquenotata (F. Löw, 1888)	A	Phyto-phagous	Asia (Temperate)	1885, AT	AT, BG, CZ, DE, F- COR, GB, HU, LV, NL, NO, PL, SE	I2, J6	*Hemerocallis fulva*	Balas (1943), Dittrich (1913), Docters van Leeuwen (1957), Halstead and Harris (1990), Löw (1888), Miller (1956), Prell (1916), Skuhravá (1975), Skuhravá and Skuhravý (in prep.), Skuhravá et al. (1991), Spungis (1988), Wahlgren (1944)

Family *Species*	**Status**	**Regime**	**Native range**	**1st record in Europe and country**	**Invaded countries and islands**	**Habitat***	**Hosts**	**References**
Dasineura gibsoni Felt, 1911	A	Phyto-phagous	North America	1976, GB	GB,	F4, I	*Cirsium*	Gagné (1989), Harris (1976)
Dasineura gleditchiae (Osten Sacken, 1866)	A	Phyto-phagous	North America	1975, NL	AL, AT, BG, CH, CZ, DE, DK, ES, FR, FR-COR, GB, GR,HU, IT, LU, NL, PL, RS, SK	I2	*Gleditchia triacanthos*	Bolchi Serini and Volonté (1985), Dauphin (1991), Dimitrova and Pencheva (2004), Dini-Papanastasi and Skarmoutsos (2001), EPPO (2008), Estal et al. (1998), Halstead (2004), Hrubík (1999), Labanowski and Soika (1997), Lambinon et al. (2001), Meyer and Jaschhof (1999), Nijveldt (1980), Simova-Tošić (2008), Simova-Tošić et al. (2000), Skuhravá (2004), Skuhravá M (Unpublished), Skuhrava et al. (2006), Steyrer et al. (2002)
Dasineura oxycoccana (Smith, 1890)	A	Phyto-phagous	North America	1997, IT	AL, FR, IT, SI	FB	*Vaccinium* spp.	Bosio et al. (1998), Gagné (1989), Seljak (2004)
Dicrodiplosis pseudococci (Felt, 1914)	A	Predator	Africa	1914, IT-SIC	ES, IT-SIC	I	Scale, *Planococcus citri*	Carles-Tolra and Andersen (2002), Felt (1914), Solinas (1971)
Epidiplosis filifera (Nijveldt, 1965)	A	Predator	Eastern Asia	1965, IL	GB, IL, LV, PT-MAD	U	Scale (*Ceratoplates floridensis*)	Harris (2004), Nijveldt (1965), Skuhravá (2008), Skuhravá et al. (2006), Spungis (2003)
Feltiella acarisuga (Vallot, 1827)	C	Predator	Cryptogenic	1827, ?	AL, AT, BE, CH, CZ, DE, DK, ES, FI, FR, GB, IE, IT, IT-SIC, LT, LV, NL, NO, PL, RU, SE	I, J100	Mites (Tetra-nychidae)	EPPO (2002), Fiedler (2005), Kahrer and Skuhravá (2000), Mamaev and Krivosheina (1965), Meijere (1939), Roberti (1955), Skuhrava et al. (2006), Spungis (2003), Vacante and Firullo (1985), Vallot (1827), Vimmer (1931)

Family *Species*	**Status**	**Regime**	**Native range**	**1st record in Europe and country**	**Invaded countries and islands**	**Habitat***	**Hosts**	**References**
Horidiplosis ficifolii Harris, (2003	A	Phyto-phagous	Asia (Tropical)	2001, NL?	DK, GB, IT-SIC, NL	X24	*Ficus benjamina*	Harris and Goffau (2003), Skuhrava et al. (2007), Suma et al. (2007)
Janetiella siskiyou Felt, 1917	A	Phyto-phagous	North America	1931, NL	AL, CZ, DE, DK, FR, GB, IT, NL, PL, SK	I2	*Chamae-cyparis lawsoniana*	Coutin (1976), Gagné (1972), Harris (2004), Juhásová and Hrubík (1984), Kapuscinski (1948), Meijere (1935), Skuhravá (1979), Skuhrava et al. (2006), Stelter (1978)
Lestodiplosis aonidiellae Harris, 1968	A	Predator	Africa	1999, IT-SIC	IT-SIC	J100	Scale (*Aonidiella aurantii*)	Siscaro et al. (1999), Skuhrava et al. (2007)
Obolodiplosis robiniae (Haldeman, 1847)	A	Phyto-phagous	North America	2003, IT	AL, AT, BA, CH, CZ, DE, FR, FR-COR, GB, GR-ION, HR, HU, IT, MK, NL, PL, RS, SI, SK, UA	G, I2, H1	*Robinia pseudoacacia*	Bathon (2007), Berest and Titar (2007), Csóka (2006), Duso C et al. (2005), Duso C and Skuhrava (2003), Glavendekić et al. (2009), Laguerre and Dauphin (2007), Roskam et al. (2008), Simova-Tošić and Skuhravá (1995), Skuhravá M (Unpublished), Skuhravá and Skuhravý (2004b), Skuhravá (2007), Skuhrava et al. (2008), Wehrmaker (2007), Wermelinger and Skuhravá (2007), Zúbrik et al. (2007)
Orseolia cynodontis Kieffer & Massalongo, 1902	A	Phyto-phagous	Africa	1892, IT	FR, HU, IT, RO	E1	*Cynodon dactylon*	Houard (1902), Massalongo (1892), Moesz (1938), Roman and Ionescu (1967), Skuhrava et al. (1972)
Procontarinia matteiana Kieffer & Cecconi, 1906	A	Phyto-phagous	Asia (Tropical)	1906, IT-SIC	IT-SIC	I2	*Mangifera indica*	Kieffer and Cecconi (1906), Skuhrava et al. (2007)

Family *Species*	Status	Regime	Native range	1st record in Europe and country	Invaded countries and islands	Habitat*	Hosts	References
Prodiplosis vaccinii (Felt, 1926)	A	Phyto-phagous	North America	2001, ES	ES	I2	V*accinium* spp.	Calvo et al. (2006), Skuhravá et al. (2006)
Prodiplosis violicola (Coquillett, 1900)	A	Phyto-phagous	North America	2004, NL/ SE	NL, SE	I	*Viola* spp.	Gagné (2004)
Resseliella conicola (Foote, 1956)	A	Phyto-phagous	North America	1999, DK	DK	I2	*Picea sitchensis*	Skuhrava et al. (2006)
Rhopalomyia chrysanthemi (Ahlberg, 1939)	A	Phyto-phagous	Asia (Temperate)	1935, FR	BE, CH, DE, DK, FI, FR, GB, NO, PL, SE	X24, I2	*Chrysan-themum* (cultivated)	Barnes (1948), Behr (1949), Blauvelt (1939), Bovien (1935), Gjaerum (1949), Häflinger (1945), Skuhrava et al. (2006), Suire (1935), Szadziewski (1991), Vappula (1965), Wahlgren (1951)
Rhopalomyia grossulariae Felt, 1911	A	Phyto-phagous	North America	1913, GB	GB,	G1	*Ribes grossularia*	Barnes (1948), Theobald (1913)
Stenodiplosis panici Plotnikov, 1926	A	Phyto-phagous	Asia (Temperate)	1926, RU	BG, RS, RU, SI, UA	I	*Panicum* spp.	Dombrovskaja (1936), Janežič (1972), Krištal (1959), Martinovic and Bjegovic (1949), Simova-Tošić et al. (1996), Simova-Tošić et al. (2000), Skuhravá et al. (1991)
Stenodiplosis sorghicola (Coquillett, 1899)	A	Phyto-phagous	Africa	1964, IT	FR, GR, IT, RU	I	*Sorghum* spp.	Coutin (1969), Mariani and Beccari (1964), Skuhravá et al. (2005), Starostin et al. (1987)
Culicidae								
Aedes albopictus (Skuse, 1894)	A	Parasitic/ Predator	Asia (Tropical)	1979, AL	AL, CH, ES, FR, GR, GR-ION, HR, IL, IT, IT-SIC, ME, RS, SI	J6	Humans (biting)	Adhami and Murati (1987), Dalla Pozza and Majori (1992), Eritja et al. (2005), Klobučar et al. (2006), Patsoula et al. (2006), Reiter (1998), Romi (1995), Romi et al. (1999), Sabatini et al. (1990), Šuligoj (2005), Urbanelli et al. (2000)

Family *Species*	**Status**	**Regime**	**Native range**	**1st record in Europe and country**	**Invaded countries and islands**	**Habitat***	**Hosts**	**References**
Aedes japonicus (Theobald, 1901)	A	Parasitic/ Predator	Asia (Temperate)	2000, FR	BE, CH, DE, FR	J6	Humans (biting)	Andreadis et al. (2001), Schaffner et al. (2003), Schaffner et al. (2009)
Culex deserticola Kirkpatrick, 1925	A	Parasitic/ Predator	Africa	1993, ES	ES	C1, D	Wild rabbits	Eritja et al. (2000), Ramos et al. (1998)
Culex tritaeniorhynchus Giles, 1901	A	Parasitic/ Predator	Asia (Tropical)	1987, AL	AL, GR	D6, C1	Humans (biting)	Adhami (1987), Samanidou and Harbach (2003)
Culex vishnui (Theobald, 1901)	A	Parasitic/ Predator	Asia (Tropical)	1987, AL	AL	C1, D	Humans (biting)	Adhami (1987)
Ochleroratus atropalpus (Coquillett, 1902)	A	Parasitic/ Predator	North America	1996, IT	IT	J6	Humans (biting)	Romi et al. (1999)
Ochleroratus subdiversus (Martini, 1926)	A	Parasitic/ Predator	Asia (Temperate)	1987, RS	RS	D	Humans (biting)	Bozicic (1987), Schaffner et al. (2001)
Dolichopodidae								
Micropygus vagans Parent, 1933	A	Parasitic/ Predator	Australasia	1970, IE	GB, IE	G, I2	Broadleaved woodlands	Chandler (2004)
Drosophilidae								
Chymomyza amoena (Loew, 1862)	A	Phyto-phagous, Detri-vorous	North America	1975, CZ	AT, CH, CZ, DE, ES, FR, GB, HU, LT, MO, NL, RO, RS, RU, SK,	G, I2, J1	Apple, fruits, nuts	Clemons (2009), Máca (2006), Máca (2006), Pakalniškis et al. (2006), Trent Band et al. (2005)
Chymomyza procnemis (Williston, 1896)	A	Detri-vorous	North America	2000, ES-CAN	ES-CAN	?	Unknown	Carles-Tolra and Andersen (2002)
Chymomyza procnemoides Wheeler, 1952	A	Detri-vorous	North America	1992, HU	HU	G	Unknown	Band (1994), Perju (1959)
Chymomyza wirthi Wheeler, 1954	A	Detri-vorous	North America	1994, GB	GB	B	Unknown	Gibbs (1994)

Family *Species*	Status	Regime	Native range	1st record in Europe and country	Invaded countries and islands	Habitat*	Hosts	References
Dettopsomyia nigrovittata (Malloch, 1924)	A	Detri-vorous	Tropical Subtropical	<1976, ES-CAN	ES-CAN		Unknown	Carles-Tolra and Andersen (2002), Prevosti (1976)
Drosophila curvispina Watabe & Toda, 1984	A	Detri-vorous	Asia	2002, CH	CH	G	Fungi (forest floor)	Bächli et al. (2002)
Drosophila busckii Coquillett, 1901	C	Detri-vorous	Cryptogenic	1900, GB	CZ, GB, LT, SK	G	Unknown	Hill et al. (2005), Máca (2006), Máca (2006), Pakalniškis et al. (2006)
Drosophila hydei Sturtevant, 1921	C	Detri-vorous	Cryptogenic	1900, GB	CZ, ES, ES-BAL, GB, LT, PT, PT-AZO, PT-MAD, SK	G	Unknown	Carles-Tolra and Andersen (2002), Hill et al. (2005), Máca (2006), Pakalniškis et al. (2006)
Drosophila immigrans Sturtevant, 1921	C	Detri-vorous	Cryptogenic	1900, GB	CZ, ES, ES-CAN, GB, LT, PT, PT-AZO, PT-MAD, SK	G	Fruits	Carles-Tolra and Andersen (2002), Hill et al. (2005), Máca (2006), Pakalniškis et al. (2006)
Drosophila repleta Wollaston, 1858	C	Detri-vorous	Cryptogenic	1900, GB	CZ, ES, ES-BAL, ES-CAN, GB, LT, PT, PT-AZO, PT-MAD, SK	G	Unknown	Carles-Tolra and Andersen (2002), Hill et al. (2005), Máca (2006), Pakalniškis et al. (2006)
Drosophila melanogaster Meigen, 1830	C	Detri-vorous	Cryptogenic	1900, GB	CZ, GB, IT, LT, PT, SK	G	Unknown	Bächli (2004), Hill et al. (2005), Máca (2006), Pakalniškis et al. (2006)
Drosophila suzukii (Matsamura, 1931)	C	Phyto-phagous	Cryptogenic	2009, IT	IT, SP	G	Fruits	EPPO (2010), Grassi et al. (2009)
Drosophila tsigana Burla & Gloor, 1952	C	Detri-vorous	Cryptogenic	?	AT, FR, HU, PT	G	Leaf miner	Fauna Europaea
Scaptomyza adusta (Loew, 1862)	A	Phyto-phagous	North America	1996	IT, GR, MT, ES-CAN, PT-AZO	I, J	Vegetables (Leaf miner)	Nicoli Aldini (2005), Nicoli Aldini and Baviera (2002)

Family *Species*	Status	Regime	Native range	1st record in Europe and country	Invaded countries and islands	Habitat*	Hosts	References
Scaptomyza vittata (Coquillett, 1895)	A	Phyto-phagous	North America	?	GB, SP- CAN	J100, I	Fruits	Carles-Tolra and Andersen (2002), Roll et al. (2007)
Zaprionus ghesquierei Collart, 1937	A	Phyto-phagous	Africa	1991, CY	CY		Fruits	Chassagnard and Kraaijeveld (1991)
Zaprionus indianus Gupta, 1970	A	Phyto-phagous	Africa	1976, ES-CAN	AT, ES-CAN, IL, IT		Fruits	Carles-Tolra and Andersen (2002), Monclus (1976), Roll et al. (2007)
Zaprionus tuberculatus Malloch, 1932	A	Phyto-phagous	Africa	1977, ES-CAN	CY, ES-CAN, IL, MT		Fruits	Carles-Tolra and Andersen (2002), Roll et al. (2007), Tsacas et al. (1977)
Ephydridae								
Elephantinosoma chnumi Becker, 1903	A	Parasitic/ Predator	Africa	2003, MT	MT	B	Shore fly	Gatt and Ebejer (2003)
Placopsidella phaenota Mathis, 1986	A	Parasitic/ Predator	Asia	2003, MT	MT	B	Shore fly	Gatt and Ebejer (2003)
Psilopa fratella (Becker, 1903)	A	Parasitic/ Predator	Africa	2002, ES-CAN	ES-CAN, MT	B	Shore fly	Carles-Tolra and Andersen (2002), Gatt and Ebejer (2003)
Fanniidae								
Fannia pusio (Wiedemann, 1830)	A	Detri-vorous	C. & S. America	?	ES, FR, MT	J	Poultry dung	Carles-Tolra and Andersen (2002)
Heleomyzidae								
Prosopantrum flavifrons Tonnoir & Malloch, 1927	A	Detri-vorous	C. & S. America	1991, GB	GB	J		Ismay and Smith (1994)
Hippoboscidae								
Crataerina melbae (Rondani, 1879)	A	Parasitic/ Predator	Cryptogenic	1990, DE	BG, CH, DE, ES, IT	J	Haemato-phagous on birds	Carles-Tolra and Andersen (2002), Popov (1995)
Milichiidae								
Desmometopa microps Lamb, 1914	A	Parasitic/ Predator	Cryptogenic	?	CZ, SK, HU	J	Adults attack bees	Roháček (2006a), Roháček (2006b)

Family *Species*	**Status**	**Regime**	**Native range**	**1st record in Europe and country**	**Invaded countries and islands**	**Habitat***	**Hosts**	**References**
Desmometopa varipalpis Malloch, 1927	A	Detri-vorous	Cryptogenic	?	FR, G, ES, CH	J	Biofilters, sewage filters, decaying vegetables and fruits	Carles-Tolra and Andersen (2002), Roháček (2006b)
Muscidae								
Athrerigona soccata Rondani, 1871	C	Phyto-phagous	Cryptogenic	1998, FR	FR, GR, HU, IT, IT-SIC,	I1	Sorghum	Vercambre et al.(2000)
Hydrotaea aenescens (Wiedemann, 1830)	A	Parasitic/ Predator	North America	1964, IT	AT, CH, CZ, DE, ES, ES-CAN, FR, GB, IE, IT, IT-SAR, MT, PT, PT-AZO, SK	E, J	Predator of house fly	Carles-Tolra and Andersen (2002), Gregor and Rozkošný (2006), Rozkošný (2006), Saccà (1964)
Mycetophilidae								
Leia arsona Hutson, 1978	A	Detri-vorous	Africa	1978, GB	CH, ES-CAN, GB, MT, NL, PT-AZO, PT-MAD	I, J	Fungus gnat	Carles-Tolra and Andersen (2002), Halstead (2004)
Phoridae								
Chonocephalus depressus Meijere, 1912	A	Detri-vorous	Asia (Temperate)	2002, MT	MT	J	Ripe fruits	Disney (2002)
Chonocephalus heymonsi Stobbe, 1913	A	Detri-vorous	Africa	1981, GB	GB,	J100	Ripe fruits	Disney (1980), Disney (2002)
Dohrniphora cornuta (Bigor in de la Sagra, 1857)	A	Detri-vorous	Australasia	1997	AT, BG, BE, CY, CZ, DE, ES, ES-CAN, FR, GB, NL, PL, PT, PT-AZO, PT-MAD, SI, SK,	J	sapro-phagous	Beschovski and Langourov (1997), Carles-Tolra and Andersen (2002), Disney (1991), Disney (2002), Mocek (2006)

Family *Species*	**Status**	**Regime**	**Native range**	**1st record in Europe and country**	**Invaded countries and islands**	**Habitat***	**Hosts**	**References**
Dohrniphora papuana Brues, 1905	A	Detri-vorous	Africa	2004, ES	ES	J6		Disney (2004)
Hypocerides nearcticus (Borgmeier, 1966)	A	Detri-vorous	Africa	2004, ES	ES, SE	U		Disney (2004)
Megaselia gregaria (Wood, 1910)	A	Detri-vorous	Australasia	2003	CZ, DE, DK, GB, NO, PL, PT, SE, SI, SK	J6, J1	Mushroom house	Carles-Tolra and Andersen (2002), Disney (2002), Mocek (2006)
Megaselia scalaris (Loew, 1866)	A	Detri-vorous, facul-tative predator/ parasite	Tropical, Subtropical	1994, ES	BE, BG, CH, DE, DK, ES, ES-CAN, FR, GB, IT, NL, PT-MAD	J6, J1	Decaying material, cadavers, myasis agent	Bourel et al (2004), Campobasso et al. (2004), Carles-Tolra and Andersen (2002), Dewaele et al. (2000), Disney (1994), Disney (2002), Disney (2008), Haenni Pers. comm. (2009), Langourov (2004), McCrae (1967), Miller (1979), Zwart et al. (2005)
Megaselia tamilnaduensis Disney in Mohan, Mohan & Disney, 1996	A	Detri-vorous	Asia (Tropical)	1999, PL	CH, PL	J	Cultivated oyster mushrooms (*Pleurotus*)	Disney and Durska (1999)
Puliciphora borinquenensis Wheeler, 1900	A	Detri-vorous	Tropical, Subtropical	1983, GB	GB	J		Disney (1983)
Sciaridae								
Bradysia difformis Frey, 1948	C	Detri-vorous	Cryptogenic	1965, GB	ES, ES-CAN, GB, NO, SE, SK	J100, J1	Mushrooms; ornamentals in nurseries	Carles-Tolra and Andersen (2002), Heller and Menzel (2006), Hellqvist (1994), White et al. (2000)
Sphaeroceridae								
Coproica rufifrons Hayashi, 1991	A	Detri-vorous	Australasia	?	ES-CAN, MT	U	Animal dung; leaf litter	Carles-Tolra and Andersen (2002)

Family *Species*	**Status**	**Regime**	**Native range**	**1st record in Europe and country**	**Invaded countries and islands**	**Habitat***	**Hosts**	**References**
Thoracochaeta johnsoni (Spuler, 1925)	A	Detri-vorous	North America	1999, GB	GB, IT	B	Seaweed	Roháček and Marshall (2000)
Thoracochaeta seticosta (Spuler, 1925)	A	Detri-vorous	North America	1999, GB	DK, GB, NO, SE	B	Seaweed	Roháček and Marshall (2000)
Trachyopella straminea Roháček & Marshall, 1986	A	Detri-vorous	North America	?	AD, CY, CZ, ES, ES-CAN, GR-CRE, HU, MT, SK	U	Sapro-phagous	Carles-Tolra and Andersen (2002), Roháček (2006a)
Stratiomyidae								
Exaireta spinigera (Wiedemann, 1830)	A	Detri-vorous	Australasia	2008, FR	FR	I	Compost, houses	Lapeyre and Dauphin (2008)
Hermetia illucens (Linnaeus, 1758)	A	Detri-vorous	North America	1936	CH, ES, ES-BAL, ES-CAN, FR, IT, MT, PT	J6	compost heaps, poutry, bee hives; used for control of house flies	Carles-Tolra and Andersen (2002), Venturi (1956)
Tachinidae								
Blepharipa schineri (Mesnil, 1939)	C	Parasitic/ Predator	Cryptogenic	?	AD, CZ, ES, GB, SK	?	Unknown	Carles-Tolra and Andersen (2002), Vaňhara et al. Tschorsnig (2006)
Catharosia pygmaea (Fallén, 1815)	C	Parasitic/ Predator	Cryptogenic	?	AD, ES, GB, PT	?	Unknown	Carles-Tolra and Andersen (2002)
Clytiomya continua (Panzer, 1789)	C	Parasitic/ Predator	Cryptogenic	?	ES, GB	?	Unknown	Carles-Tolra and Andersen (2002)
Phasia barbifrons (Girschner, 1887)	C	Parasitic/ Predator	Cryptogenic	2001, GB	GB	?	Unknown	Clemons (2001)
Leucostoma edentata Kluger, 1978	A	Parasitic/ Predator	Asia	1995, IT	IT	?		Cerretti (2001)

Family *Species*	**Status**	**Regime**	**Native range**	**1st record in Europe and country**	**Invaded countries and islands**	**Habitat***	**Hosts**	**References**
Sturmia bella (Meigen, 1824)	C	Parasitic/ Predator	Cryptogenic	?	ES, GB	I2, E5, FA	Danaid butterflies (*Ideopsis, Parantica*)	Carles-Tolra and Andersen (2002)
Trichopoda pennipes (Fabricius, 1781)	A	Parasitic/ Predator	North America	1989	AL, ES, FR, IT, IT-SIC	I	Squash bug; southern green stinkbug	Carles-Tolra and Andersen (2002), Colazza et al. (1996)
Zeuxia zejana Kolomiets, 1971	A	Parasitic/ Predator	Asia	1995, IT	IT	?	Unknown	Cerretti (2001)
Tephritidae								
Ceratitis capitata (Wiedemann, 1824)	A	Phyto-phagous	Africa	1873, IT	AL, AT, BG, CH, CZ, ES, ES-BAL, ES-CAN, FR, G, IL, IT, IT-SAR, IT-SIC, ME, PT, PT-AZO, PT-MAD, SI, SR	I	Fruits (poly-phagous)	Carles-Tolra and Andersen (2002), Kinkorová (2006), Peyrek (1960)
Rhagoletis cingulata Loew, 1862	A	Phyto-phagous	North America	1993, DE	DE, HU, NL, SI	G, I2	*Prunus* fruits (wild *P. avium, P. padus, P. serotina*)	van Aartsen (2001), EPPO (2007), Lampe et al. (2005), Szeőke (2006)
Rhagoletis completa Cresson, 1929	A	Phyto-phagous	North America	1991, IT	AL, CH, DE, FR, HR, IT, SI	I2	*Juglans* fruits	Duso (1991), EPPO (2004), Merz (1991), Seljak and Zežlina (1999)
Rhagoletis indifferens Curran, 1932	A	Phyto-phagous	North America	1983, CH	CH	I2	*Prunus* fruits (cultivated).	Merz (1991)

Family *Species*	**Status**	**Regime**	**Native range**	**1st record in Europe and country**	**Invaded countries and islands**	**Habitat***	**Hosts**	**References**
Ulidiidae								
Euxesta notata (Wiedemann, 1830)	A	Detri-vorous, Phyto-phagous ?	North America	2009	FR	?	?	Martinez (Unpublished)
Euxesta pechumani Curran, 1938	A	Detri-vorous	North America	1969, FR	BG, CH, ES, FR, SK	E, I	Carrion; dung	Carles-Tolra and Andersen (2002), Delage (1969), Fauna Europaea, Roháček (2006d)

Table 10.2. Diptera species alien *in* Europe. List and characteristics. Country codes abbreviations refer to ISO 3166 (see Appendix I). Habitat abbreviations refer to EUNIS (see Appendix II). Last update 05/02/2010.

Family *Species*	Regime	Native range	Invaded countries and islands	Habitat*	Hosts	References
Anthomyiidae						
Strobilomyia infrequens (Ackland, 1965)	Phyto-phagous	Alps	BE, DK, GB, NL	G	*Larix* spp.	Ackland (1965), Roques (Unpublished)
Strobilomyia laricicola (Karl, 1928)	Phyto-phagous	Alps	BE, GB, DK, NL	G	*Larix* spp.	Ackland (1965), Roques (Unpublished)
Strobilomyia melania (Ackland, 1965)	Phyto-phagous	Alps	BE, DK, NL, GB	G	*Larix* spp.	Ackland (1965), Roques (Unpublished)
Cecidomyiidae						
Aphidoletes abietis (Kieffer, 1896)	Predator	Central, South Europe	GB, LV, RU (?)	I, J100	*Adelges abietis* (Adelgidae)	Harris (1976), Mamaev and Krivosheina (1965), Pakalniškis et al. (2006)
Asphondylia borzi (Stefani, 1898)	Phyto-phagous	Medi-terranean	GB	I	*Rhamnus alaternus*	Harris (1976), Hill et al. (2005)
Contarinia lentis Aczél, 1944	Phyto-phagous	Eastern Medi-terranean	BG, CZ, FR, HU, SK	I	*Lens culinaris*	Aczél (1944), Baudyš (1947), Coutin (1965), Skuhravá (1989), Skuhravá et al. (1991)
Contarinia pisi (Loew, 1850)	Phyto-phagous	Western Asia	AL, AT, BE, BG, CH, CZ, DE, DK, FI, FR, GB, HU, LT, LV, NL, NO, PL, RO, RS, RU, SE, SI, UA	I	*Pisum sativum*	Ambrus (1958), Buhr (1939), Forsius (1922), Kieffer (1898), Krištal (1947), Kutter and Winterhalter (1933), Loew (1850), Mamaeva (1969), Meijere (1911), Pakalniškis et al. (2006), Perju (1959), Pileckis and Vengeliauskaite (1977), Schøyen (1926), Simova-Tošić et al. (1996), Simova-Tošić et al. (2000), Skuhravá and Skuhravý (1960), Skuhravá and Skuhravý (2009), Skuhravá et al. (2005), Skuhravá et al. (1991), Skuhrava et al. (2006), Spungis (1977), Theobald (1911), Tullgren (1917)

Family *Species*	Regime	Native range	Invaded countries and islands	Habitat*	Hosts	References
Contarinia pyrivora (Riley, 1886)	Phyto-phagous	Central, eastern Europe, southwest Asia	DK, GB, LV, NO, SE	I	*Pyrus communis*	Harris (1976), Máca (2006), Skuhravá and Skuhravý (in prep.), Skuhrava et al. (2006), Spungis (1977), Wahlgren (1944)
Dasineura abietiperda (Henschel, 1880)	Phyto-phagous	North-east Europe	GB, IT	G3	*Picea abies*	Harris (1976), Hill et al. (2005)
Dasineura kellneri (Henschel, 1875)	Phyto-phagous	Central Europe, Alps, Carpa-thians	GB	G3	*Larix decidua*	Harris (1976), Hill et al. (2005)
Dasineura pyri (Bouché, 1847)	Phyto-phagous	Central, eastern Europe, southwest Asia	DK, FI, GB, NO, SE	I	*Pyrus communis*	Forsius (1922), Harris (1976), Hill et al. (2005), Skuhrava et al. (2006), Wahlgren (1944)
Dasineura rhododendri (Kieffer, 1909)	Phyto-phagous	Central, south Europe, mountains	GB	I	*Rhodo-dendron ferrugineum*	Chandler (Ed) 1 (1998), Harris (1976)
Kaltenbachiola strobi (Winnertz, 1853)	Phyto-phagous	North-east Europe	GB, NL	G3	*Picea abies*	Harris (1976), Hill et al. (2005), Roques (Unpublished)
Monarthropalpus flavus (Schrank, 1776)	Phyto-phagous	Western Asia, southern Europe, Medi-terranean	AT, CH, CZ, DE, GB, HU, NL, PL, RO, SE, UA	I	*Buxus sempervirens*	Ambrus (1958), Docters van Leeuwen (1957), Harris (1976), Meyer and Jaschhof (1999), Ryberg (1941), Skuhravá and Skuhravý (1960), Skuhravá and Skuhravý (2009), Skuhrava et al. (1972), Skuhrava et al. (2008), Wahlgren (1944)
Phyllodiplosis cocciferae (Tavares, 1901)	Phyto-phagous	Medi-terranean	GB	I	*Quercus ilex*	Chandler (Ed) 1 (1998), Harris (1976)

Family *Species*	Regime	Native range	Invaded countries and islands	Habitat*	Hosts	References
Resseliella lavandulae (Barnes, 1953)	Phyto-phagous	Medi-terranean	DE	I	*Lavandula angustifolia*	Meyer and Jaschhof (1999)
Resseliella skuhravyorum Skrzypczynska, 1975	Phyto-phagous	Central Europe, Alps, Carpa-thians	BE, DK, GB, NL	G3	*Larix decidua*	Roques (Unpublished), Skrzypczynska et al. (1993), Skuhrava et al. (2006)
Culicidae						
*Aedes vexa*ns (Meigen, 1830)	Parasitic/ Predator	Conti-nental Europe	GB	C1, D	Human (biting)	Taylor et al. (2006)
Aedes cinereus (Meigen 1818)	Parasitic/ Predator	Conti-nental Europe	GB	D, J	Human (biting), dog	Taylor et al. (2006)
Culex territans Walker, 1856	Parasitic/ Predator	Eastern Europe	GB	D, J	Human (biting), dog	Taylor et al. (2006)
Culex pipiens molestus L., 1758	Parasitic/ Predator	Conti-nental Europe	GB	D, J	Human (biting), hot-blooded animals	Taylor et al. (2006)
Syrphidae						
Chamaesyrphus caledonicus Collin, 1940	Parasitic/ Predator	Conti-nental Europe	GB	G3	Aphids larval predator (pine forests)	Sivell and Phillips (1999)

Family *Species*	**Regime**	**Native range**	**Invaded countries and islands**	**Habitat***	**Hosts**	**References**
Dasysyrphus friuliensis (van der Goot, 1960)	Parasitic/ Predator	Conti-nental Europe	GB	G3	Aphid larval predator (spruce forests); Pollinator *Ranunculus* and Umbelli-ferae (Adult)	Stubbs and Falk (2002)
Didea intermedia Loew, 1854	Parasitic/ Predator	Conti-nental Europe	GB	G3	Aphid larval predator (*Schizo-lachnus pineti*; pine forests)	Stubbs and Falk (2002)
Eriozona erratica (Linnaeus, 1758)	Parasitic/ Predator	Conti-nental Europe	GB	G3	Aphid larval predator (forests)	Ball and Morris (2000)
Eriozona syrphoides (FallÚn, 1817)	Parasitic/ Predator	Conti-nental Europe	GB	G3	Aphid larval predator (spruce and pine forests-larva); Pollinator of Hogweed (*Heracleum sphon-dylium*) (adult)	Ball and Morris (2000)

Family *Species*	Regime	Native range	Invaded countries and islands	Habitat*	Hosts	References
Merodon equestris (Fabricius, 1794)	Parasitic/ Predator	Continental Europe	GB	I2, G1	Narcissus and bluebell bulbs	Hill et al. (2005)
Parasyrphus malinellus (Collin, 1952)	Parasitic/ Predator	Continental Europe	GB	G3	Aphid larval predator	Ball and Morris (2000)
Tephritidae						
Bactrocera (Daculus) oleae (Rossi, 1790)	Phytophagous	Mediterranean	CH	I	*Olea*	Neuenschwander (1984)
Tephritis praecox (Loew, 1844)	Phytophagous	Continental Europe	GB, NL		*Calendula arvensis* (flower heads)	Jones (2004), Kabos and van Aartsen (1984)
Terellia fuscicornis (Loew, 1844)	Phytophagous	Mediterranean	GB	I2	Artichoke (flower head)	Whittington (2002)