Lepidoptera

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Lepidoptera
Chapter 11

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Abstract
We provide a comprehensive overview of those Lepidopteran invasions to Europe that result from increasing globalisation and also review expansion of species within Europe. A total of 97 non-native Lepidoptera species (about 1% of the known fauna), in 20 families and 11 superfamilies have established so far in...
Europe, of which 30 alone are Pyraloidea. In addition, 88 European species in 25 families have expanded their range within Europe and around 23% of these are of Mediterranean or Balkan origin, invading the north and west. Although a number of these alien species have been in Europe for hundreds of years, 74% have established during the 20th century and arrivals are accelerating, with an average of 1.9 alien Lepidoptera newly established per year between 2000–2007. For 78 aliens with a known area of origin, Asia has contributed 28.9%, Africa (including Macaronesian islands, Canaries, Madeira and Azores) 21.6%, North America 16.5%, Australasia 7.2% and the neotropics just 5.2%. The route for almost all aliens to Europe is via importation of plants or plant products. Most alien Lepidoptera established in Europe are also confined to man-made habitats, with 52.5% occurring in parks and gardens. We highlight four species in particular, Diaphania perspectalis, Cacyreus marshalli, Cameraria ohridella and Paysandisia archon, as the most important current economic threats.

**Keywords**
biological invasion, introduction, pest species, Europe, Lepidoptera, globalisation

11.1 Introduction

Apart from the undoubted impact of climate change, various other facets of human activity, including the increasingly efficient means of transport in the last century, increased trade and globalisation, are having a dramatic effect on the composition of European faunas. Lepidoptera, as a mostly alate and largely phytophagous insect group, are particularly affected, not only by increased transport of the invasive species, but by increased trade in plants and stored plant products. In addition, many species are spreading to hostplants not used in their area of origin.

Lists of naturalized non-native Lepidoptera are already available for a number of European countries (Agassiz 1996a, Essl and Rabitsch 2002, Geiter et al. 2001, Karsholt and Nielsen 1998, Kenis 2005, Šefrová and Laštůvka 2005). In addition, several detailed case studies have been published on the process of invasion to Europe of several non-native Lepidoptera species (Nash et al. 1995, Šefrová 2001, Šefrová 2002a, Šefrová 2002b, Šefrová and Laštůvka 2001, Whitebread 1990). The first list of terrestrial invertebrate species alien to and within Europe included 272 Lepidoptera species, of which 122 were alien to Europe, 139 alien to countries within Europe, and 11 of cryptogenic origin (DAISIE 2008). We substantially revise and update this list here, in the first comprehensive review of known naturalized non-native Lepidoptera known to Europe.

We divided species into two categories:

1. Naturalized exotic species (originating from a continent other than Europe) whose first introduction into Europe appears to be a direct or indirect (deliberate or accidental) result of human activity (Table 11.1). This includes now well known alien lepidoptera such as the Neotropical castniid moth *Paysandisia archon* (Burmeister,
or the South African lycaenid butterfly *Cacyreus marshalli* (Butler, 1898). We also considered in this category species of unknown origin (cryptogenics) such as the leaf-mining moth *Phyllonorycter platani* (Staudinger, 1870). It is worth noting that we also included here species introduced into confined environments like greenhouses which while not apparently spreading of their own accord, have been introduced with their hostplants, with the potential to spread due to horticultural trade. For instance, 11 species of aquatic Pyralidae have been introduced accidentally by man from Asia and North America into Europe, mostly as contaminants of plants. Current climate makes their establishment in the wild unlikely, but global warming could allow their establishment in the near future.

2. European species spreading throughout the continent as a result of human activity (Table 11.2). This category includes the invasive leaf-mining moth *Cameraria ohridella* Deschka and Dimić, 1986, now understood to be Balkan in origin (Valade et al. 2009). It is worth noticing that although many aliens are highly invasive our review also includes naturalised aliens that are not necessarily invasive such as the saturniid moth *Samia cynthia* (Drury, 1773).

We excluded all the following cases, here giving examples:

i) Species showing clear range expansions/contractions at a country level, which are known to follow global climate change trends (Warren et al. 2001). The butterfly *Colotis evagore* (Klug, 1829) in Spain (Fric, 2005), the processory pine moth *Thaumetopoea pityocampa* (Denis & Schiffermüller, 1775), in central Europe (Battisti et al. 2005) and several British butterfly species (Asher et al. 2001) are classical examples of this phenomenon. However, it must be noted that *T. pityocampa* has apparently been introduced through human activity from continental Italy to Sardinia (Luciano et al. 2007).

ii) Naturally-expanding species known as migrants which have established without clear human assistance, such as the choreutid *Tebenna micalis* (Mann, 1857) in Azores (Karsholt and Vieira 2005) and the geometrid *Peribatodes secundaria* (Denis & Schiffermüller, 1775) in Great Britain (Kimber, 2008) as well as rare vagrants that may or may not sporadically naturalize, such as *Acontia crocata* Guenée, 1852 in France (Letellier, 2004); *Pardasena virgulana* (Mabille, 1880) in Great Britain (Honey, 1994) and *Gelechia sabinellus* (Zeller, 1839), *Eccopsis effractella* Zeller, 1848 and *Zophodia grossulariella* (Hübner, 1809), all recently recorded from Great Britain (Agassiz 1978a, Agassiz 1996b, Roche 1982).

iii) New records of species probably overlooked in particular countries for which there is no clear evidence of range expansion. For instance, in Great Britain the presence of *Bucculatrix ulmifoliae* Hering, 1931 and *Ocnerostoma* spp. (Heath and Emmet 1996, Langmaid et al. 2007).

iv) Deliberate translocations of species between European countries, such as the introduction of the butterflies *Araschnia levana* (Linnaeus, 1758) (Frohawk, 1940), Ma-
culinea arion (Linnaeus, 1758) (Thomas et al. 2009) and Lycaena dispar (Haworth, 1803) (Ford, 1945) into Great Britain. These translocations result from solitary enthusiasts or are for conservation management purposes including the reintroduction of extinct species, but have nothing to do with our subject of biological invasion, essentially the aspects associated with increased globalisation.

v) Species once apparently established but now extinct (e.g. in Great Britain, the blastobasid Blastobasis phycidella (Zeller, 1839) and the oecophorid Eulemnsia woodiella (Curtis, 1830) (Emmet 1988, Koster and Sinev 2003)

vi) The large number of living display species (this is the case of butterfly houses), unless these species are either establishing in the wild, or there is evidence they have become greenhouse pests (we have no examples). Nevertheless, we highlight the risks involved in importation of butterflies for butterfly houses and for a new practice of wedding releases.

Finally, the introduction of exotic host plants by man has indirectly allowed several lepidopteran species to expand their distribution range. We consider as alien species Stigmella speciosa Frey, 1857, Caloptilia rufipennella (Hübner, 1796) and Phyllonorycter geniculella (Ragonot, 1874), all feeding on Acer pseudoplatanus in northern Europe; Stigmella suberivora (Stainton, 1869) feeding on Quercus ilex in Great Britain; Eupithecia phoeniceata (Rambur, 1834) feeding on Juniperus and various Cupressaceae in Belgium and Great Britain, Cydia grunertiana (Ratzeburg, 1868) in Belgium, Denmark and Sweden; C. illutana (Maslov, 1988) and C. pactolana (Zeller, 1840) feeding on Larix, the last two in Great Britain; Theria cupressata (Geyer, 1831), feeding on imported Abies in Sweden and Cupressaceae in Great Britain, and Lithophane leautieri (Boisduval, 1829) on Cupressaceae cultivars in Great Britain. Polychry sia moneta (Fabricius, 1787) started to spread as early as 1891 in Europe, possibly as a result of rise in popularity of ornamental hostplants such as Delphinium in gardens (Agassiz, 1996a). Other well known examples of species which have followed the invasion of their host plants are the milkweed butterflies, Danaus plexippus (Linnaeus, 1758) and Danaus chrysippus (Linnaeus, 1758). The larvae of both species feed on ornamental and invasive milkweeds (Apocynaceae) which have been introduced in some Macaronesian islands and the Iberian Peninsula (Baez, 1998).

We summarise the relative importance of naturalized alien invasives by family, in relation to their proportion in the relatively well known European fauna, finding great disparities in their prevalence.

11.2 Diversity of alien lepidopteran species

Lepidoptera is one of the largest insect orders, with around 175,000 described species in 128 families and 47 superfamilies (Kristensen and Skalski 1999, Mallet 2007). About 9,428 native species in 83 families and 31 superfamilies have been recorded in
A total of 97 non-native Lepidoptera species, in 20 families and 11 superfamilies have established so far in Europe (Table 11.1). Our analysis reveals that there is a significant correlation between the number of alien species and the number of native species per family (Spearman’s rho correlation: \( r = 0.48 \), \( P < 0.001 \)). In addition, 88 European species in 25 families have expanded their range within Europe and many of these are of Mediterranean origin, invading northern and western areas of Europe (Table 11.2).

The 20 families which contain alien species to Europe are: Pyralidae (30 species), Tortricidae (10), Gracillariidae (8), Tineidae (7), Noctuidae (6), Gelechiidae (6), Blastobasidae (5), Yponomeutidae (4), Oecophoridae (4), Cosmopterigidae (3), Saturniidae (3), Pterophoridae (2), Nymphalidae (2) and Bucculatricidae, Agonoxenidae, Lycaenidae, Geometridae, Arctiidae, Nolidae and the alien family Castniidae, each with one species (Table 11.1).

**Agonoxenidae**: Sixteen species of agonoxenids are native to Europe. The Asian species *Haplochrois theae* (Kusnezov, 1916) represents the only alien. During the 20th century this was a serious pest on tea plantations in Georgia and to a lesser degree, in the Krasnodar Territory of Russia (Sinev, 1994).

**Arctiidae**: One hundred and one species of arctids are native to Europe but only one species, the North American Fall Webworm, *Hyphantria cunea* (Drury, 1773), is alien to the region. The larvae are highly polyphagous, feeding on hundreds of different species of deciduous trees on which they form conspicuous webbed nests in late summer and autumn.

**Blastobasidae**: Only 41 species of native blastobasid moths have been recorded in Europe, a large evolutionary radiation of which 26 species occur in Madeira (Karsholt and Sinev 2004). However, the number of alien species in this family (five) is relatively high, mainly because the larvae feed usually on dead organic matter. Some species, such as *Blastobasis laticolella* (Rebel, 1940) are pests of stored foodstuffs. Interestingly, all alien Blastobasidae appear to have colonized continental Europe (mostly Great Britain and/or mainland Portugal) from Madeira, presumably with the import of ornamental plants. The common species *B. adustella* Walsingham, 1894 (originally described as a form of *B. lignea* Walsingham) (Sinev, 2007) is another example. However, *B. adustella* has widely been treated, erroneously, as a synonym of the Madeira endemic species *B. vittata* Wollaston, 1858. Although there are records attributed to *B. vittata* on the internet, including from the British Isles, there are no unambiguously identified instances of the introduction of this species outside Madeira at present.

**Bucculatricidae**: There are 53 native bucculatricids known in Europe. One macaronesian species, *Bucculatrix chrysanthemella* (Rebel, 1896), was recently introduced from the Canaries into Italy and France, where it seems to have established populations. This species has also recently been recorded from Finland, at which latitudes it seems unlikely to become established (Siloaho, 2008). *B. chrysanthemella* attacks Paris Daisy (*Argyranthemum frutescens*), an economically important ornamental crop in some parts of Europe.

**Castniidae**: This family has no native species in Europe. The majority of castniid moths are Neotropical, while some species are also found in Australia and South-east
Asia. The Neotropical *Paysandisia archon* is the only alien castniid known to occur in Europe and is currently spreading along the Mediterranean coast attacking a wide range of palm species. The castniid *Riechia acraeoides* (Guérin-Méneville, 1832) is one of numerous sporadic adventitvies included in the previous list (DAISIE 2008) that we discount here.

**Cosmopterigidae:** There are 79 species of cosmopterigids native to Europe, with three species considered as aliens. Two of these are African species that feed on *Acacia* in Malta. The larvae feed internally on the leaves, seeds and stems of their hostplants. There is no evidence that *Cosmopterix pulchrimella* Chambers, 1875, recently established in Cornwall, Great Britain, arrived there directly through human agency.

**Gelechiidae:** There are 697 species of gelechiids known to occur in Europe. The larvae of most species are concealed feeders on plant tissues, many of them feeding internally in seed heads and fruits, some mining and even producing galls. Six alien gelechiids are known from Europe, among them major agricultural pests such as the Tomato Leafminer *Tuta absoluta* (Meyrick, 1917), the cosmopolitan Angoumois Grain Moth *Sitotroga cerealella* (Olivier, 1789), which attacks stored whole cereal grains, and the Pink Bollworm *Pectinophora gossypiella* (Saunders, 1844), whose larvae bore into the flowers and seeds of cotton.

**Geometridae:** There are 1,024 species of geometrids native to Europe, but only one non-native species appears to have naturalized in Europe. This is *Pseudocoremia suavis* (Butler, 1879), an endemic geometrid to New Zealand (Berndt et al. 2004), which was recorded on five separate occasions in Cornwall in 2007 (James 2008, Skinner 2009), suggesting establishment in the wild. This species, polyphagous on various gymnosperms, represents a potential risk to European conifer forests.

**Gracillariidae:** There are 249 species of native gracillariids known in Europe and eight alien species have been recorded. Among these are pests of economic importance, such as the Citrus Leafminer *Phyllocnistis citrella* Stainton, 1856.

**Lycaenidae:** One hundred and thirty-six species of lycaenids are native to Europe. The South African *Cacyreus marshalli* is one of the few butterflies which are naturalised aliens in Europe (see also under Nymphalidae). This is a pest of cultivated *Pelargonium* plants, mainly in Mediterranean region but it was found to be breeding in Great Britain in 1997 (Lewes, East Sussex), where it became temporally established in greenhouses until May 1998 but was eradicated (Holloway, 1998).

**Noctuidae:** This is the most species-rich family of Lepidoptera in Europe, with over 1,435 native species. Six alien noctuids have been recorded so far, including some major agricultural pests such as *Chrysodeixis eriosoma* (Doubleday, 1843) and *Spodoptera litura* (Linnaeus, 1758). However, on a cautionary note, these genera are known to have strong migratory tendencies. Indeed we may never know, due to lack of sufficient historical records, when or whether certain noctuids arrived as invasives to Europe or by artificial agency. One good example of this is *Araeopteron ecphaea* (Hampson, 1914) (type locality Nigeria). It is also interesting to note the African and Austral-Oriental fern-feeding species *Callopistria maillardi* (Guenée, 1862) seems to have been accidentally imported with *Nephrolepis* ornamental ferns, but this species has five subspecies and the precise origin
of the introduced individuals is unknown. Some records of *Chrysodeixis acuta* (Walker, 1858) could also represent misidentifications of *C. chalcites* (Esper, 1789). Following our exclusion criteria, we have not included singleton records, for example of *Acontia crocata* Guenée, 1852, a specimen of which was collected in Irays (Deux-Sevres), France (Letellier, 2004), possibly resulting passively from a plant import from SE Asia (Hacker et al. 2008).

**Nolidae:** Thirty-five species of nolids are native to Europe, but only one exotic species has repeatedly been recorded within the region, the Spotted Bollworm, *Earias vittella* (Fabricius, 1794). The larva of this species feeds on several plants of the family Malvaceae, in particular Okra (*Abelmoschus esculentus*) pods, *Gossypium* (it is one of the most important pests of cotton) and *Hibiscus*. It has been found as a vagrant in Great Britain and seems to also be present in southern Spain (Nash, 2003). Its establishment needs to be confirmed.

**Nymphalidae:** There are 239 species of nymphalid butterflies native to Europe. Two non-native danaine species, the Monarch butterfly *Danaus plexippus* and the Plain Tiger *D. chrysippus* have established themselves in the Macaronesian islands and Iberian Peninsula. We have included both species despite them being well known migrants because their introduction and establishment in Europe has followed the invasion and establishment in Europe of their Apocynaceae host plants (*Asclepias curassavica*, of Neotropical origin and *Gomphocarpus fruticosus* of Afrotropical origin). Thus, the Monarch’s range has greatly expanded during the 19th and 20th centuries from North America and now encompasses numerous Atlantic, Pacific and Indian Ocean islands and Australia. A number of hypotheses have been developed to explain this great range expansion (Vane-Wright 1993).

**Oecophoridae:** There are 120 native species of oecophorids in Europe. Only four alien oecophorids are established in the region, three of which feed on dead plant material.

**Pterophoridae:** There are 166 native pterophorids known to Europe. Two species, *Megalorhipida leucodactylus* (Fabricius, 1794) and *Lantanophaga pusillidactylus* (Walker, 1864) are known to be alien to Europe. *M. leucodactylus* has a circum-tropical distribution and has established populations in Sicily (Bella and Ferrauo 2005) and Israel. It has also been recorded in Spain, but its presence there needs confirmation (Gielis, pers. comm.). The larvae feed on Amaranthaceae, Cucurbitaceae, Goodeniaceae, Leguminosae, Nyctaginaceae, Rosaceae and Asteraceae (Vargas, 2007). The Lantana Plume Moth *L. pusillidactylus* is also a pantropical species whose origin, as for *M. leucodactylus*, is not clear. This species has been introduced with its Verbenaceae hostplant (which is of neotropical origin), *Lantana camara*, into Spain, Portugal and southern Italy (Aguiar and Karsholt 2006, Bella and Marchese 2007, King 2000). The moth is used as the biocontrol agent against this plant, itself an invasive in many parts of the world.

**Pyraloidea (Pyralidae and Crambidae):** This superfamily has 898 native species known in Europe. Pyraloidea also has the highest number of species (30) alien to Europe. This is probably due to the high number of alien crambid pyrales that have larvae feeding on submerged and floating aquatic plants used in aquariums and ponds (11 species) as well as cosmopolitan pests that feed on stored products (seven species). These invasives include the North American wax moth *Vitula edmandsii* (Packard, 1865), whose larvae damage the combs of honeybee and bumblebee nests.
Saturniidae: Seven saturniids are native to Europe. Three Asian species have deliberately been introduced into Europe for silk production, but have naturalized from escapes. This family is also very popular among amateur breeders and sometimes there are reports of adult moths of a wide number of species in urban areas.

Tineidae: There are 262 species of native tineids in Europe and seven alien species have also been recorded to the region. At least five of these feed on stored products, cloths, and detritus, such as the Common Clothes Moth (Tineola bisselliella (Hummel, 1823)), whose larvae feed on clothing and natural fibres.

Tortricidae: About 977 species of tortrix moths have been recorded as native to Europe. Among the 10 alien species recorded to Europe, there are some economically important pests, in particular of apple trees, for example the oriental fruit moth (Gnapholita molesta (Busck, 1916)) and the light brown apple moth Epiphyas postvittana (Walker, 1863). Larvae of the latter species are not easily distinguished from the larvae of other tortricid leafrollers; only DNA-based testing appears to work reliably for identification. Interestingly, half of the tortricids recorded as alien to Europe (five out of 10 species) are specialists on Cedrus and have been introduced into southern France, where plantations of these trees are common.

Yponomeutidae: There are 113 species of ermine moths native to Europe, with four alien species having been recorded. The larvae tend to form communal webs, and some species are agricultural forestry pests, such as the Arborvitae Leafminer, Argyresthia thuiella (Packard, 1871) and Prays citri (Millière, 1873), a well-known Citrus pest in the Mediterranean region. Two North American leafminers of the genus Argyresthia attack Cupressaceae in Europe.

In our analysis, it is interesting that we found a similar number of alien species to Europe (Table 11.1) as species that have expanded their range within Europe due to human activity (Table 11.2). Indeed, there is a significant correlation between the number of alien species per family to Europe and the number of alien species per family within Europe (Spearman’s rho correlation: r= 0.39, P = 0.044). However, several families exhibit some species which have expanded their range within Europe, yet have very few or no recorded aliens to Europe. For instance, strikingly, Geometridae features only one species alien to Europe within a fauna of 1,024 species, a number of which are known migrants, whereas as many as 11 species have been recorded invading other countries within Europe (Table 11.2). The North American sternhine geometrid Iidea bonifata (Hulst, 1887) has been intercepted several times with imports of dried plant material but, as far as known, is not yet established in Europe (Martinez and Coutin 1985).

The absence of alien species within other species-rich families, such as Coleophoridae (533 spp.), Nymphalidae (239 spp.), Psychidae (231 spp.), Nepticulidae (242 spp.) and Sphingidae (39 spp.) is also notable. In spite of the known high mobility of the last family, several exotic species (i.e. the American Sphinx drupiferarum Smith, 1797, Agrius cingulatus (Fabricius, 1775) and the African Polyptychus trisecta (Aurivillius, 1901)) have been recorded (sometimes repeatedly) within the region, with no confirmed establishment (Marabuto 2006, Pittaway 1993, Waring et al. 2003).
11.3 Temporal trends

The precise date of arrival is not known for two species. An analysis of the 95 species for which the date of the first record in Europe is known shows that the arrival of alien Lepidoptera has dramatically accelerated during the second half of the 20th century (Figure 11.2). This trend is still increasing, with an average of 1.9 alien Lepidoptera newly established per year in Europe between 2000 and 2007 (Figure 11.2). This average is twice that during the period 1975 to 1999 (1.1 species per year). The same trend has been observed for all groups of alien terrestrial invertebrates analysed together (Roques et al. 2008). This temporal trend might be due to the acceleration of processes that happened in much wider time frames in the past, such as global climate change and human assisted transportation via the much faster and more efficient means of transport nowadays.

Alien species have historically been introduced for centuries, so it should not be considered that invasive species are necessarily a 20th century phenomenon, although the poor documentation of older cases inevitably also provides more scope for speculation. One such case is *Euclemensia woodiella*, belonging to a North American oecophorid lineage (Koster and Sinev 2003) found in numbers near Manchester in 1829 and not since. A much older potential example is the lasiocampid *Pachypasa otus* (Drury, 1773) with a scattered distribution in southern Italy, whose larva feeds mainly on *Cuypressus*, could even have been introduced by the Romans for “Coan” silk production, as it possibly represents the “Assyrian Bombyx” mentioned in Naturalis Historia by Plinus (Good, 1995).

11.4 Biogeographic patterns

For at least 19 alien species, the precise area of origin is not known and these we consider as cryptogenic. We have classified *Phyllonoryctery platani* (Gracillariidae) as cryptogenic because there are some doubts regarding its origin (Šefrová, 2001). Thus, *P. platani* is either of North American origin and was introduced to Europe with American *Platanus occidentalis*, or it originated in Southeastern Europe and Southwestern and Central Asia, on *Platanus orientalis*. We have included *C. ohridella* as alien within Europe (Table 11.2) since recent genetic studies suggest a Balkan origin as most likely (Valade et al. 2009).

An analysis of the 78 alien species for which the native area of origin is known, shows that Asia has contributed the most alien species with 28.9% (28 out of 97 species) (Figure 11.3). Africa (including Macaronesian islands, Canaries, Madeira and Azores) supplied 21.6% of alien species (21 out of 97 species) followed by North America with 16.5%, Australasia with 7.2%, and the Neotropics, surprisingly few with 5.2%.

Large differences exist among European countries in the number of alien Lepidoptera recorded per country (Figure 11.4). With 42 species, the United Kingdom is the
European country with the highest number of alien Lepidoptera, followed by France (mainland) with 41 and Spain (mainland) with 39 species. Both Moldavia and Luxembourg are the European countries with the lowest number (with one alien species each). These differences are very likely to result at least partly from variation in sampling effort and the availability of local taxonomic expertise, but the area and the geographical location of a country is also a very important factor, in this respect.

11.5 Main pathways and vectors to Europe

As far as we know, most Lepidoptera alien to Europe have been introduced accidentally (96.9%). A clear exception is some saturniid species that were imported from Asia into Europe for silk production in the nineteenth century, and subsequently became naturalized, including in urban areas. On the other hand, the Silkworm *Bombyx mori* Linnaeus, 1758. has not been included in the analysis, because although it is widespread in captivity throughout Europe, its flightlessness has prevented naturalisation.

The import of ornamental plants (particularly palms, geraniums and azaleas) is most likely responsible for the introduction of several species such as *Paysandisia archon*, *Cacyreus marshalli* and *Caloptilia azaleella*. Transport also plays an important role in the dispersal of some species, including ones alien within Europe. For instance, *Cameraria*
ohridella seems to feed almost exclusively on Aesculus hippocastanum trees planted in urban areas and parks. The main means of its spread is likely to be wind dispersal, but human assisted transportation played a major role in the long distance dispersal of this species (Gilbert et al. 2004). Since the advent of tropical butterfly houses in the 1980s, a potential new threat has emerged, the use of mass butterfly releases for weddings, a practice increasingly popular in countries such as Italy, where one of us (AZ) has recorded a number of exotic species flying freely in cities. Usually Monarch butterflies are used, but less scrupulous companies may be using a range of exotics, many of which are likely to find climate change and the availability of hostplants for some papilionid butterflies, such as Rutaceae planted in city gardens propitious for establishment of at least temporary populations.

11.6 Most invaded ecosystems and habitats

Most alien Lepidoptera are phytophagous (78.3%), whereas detritivores represent only 21.6% (Table 11.1). The majority of alien Lepidoptera established in Europe are confined to man-made habitats, and only a few species have become established in a more or less natural environment, mostly in woodlands. Examples of the latter include the
Figure 11.3. Regions of origin of the Lepidoptera species alien to Europe.

Figure 11.4. Colonization of continental European countries and main European islands by Lepidoptera species alien to Europe.
arctiid *Hyphantria cunea*, the gracillariid *Phyllonorycter issikii* in Central Europe and the saturniid *Antheraea yamamai* in the Balkans.

In Europe, most alien Lepidoptera species feed on their original hostplants. However, some species seem to have been able to switch to other hostplants that are often closely related. For instance, *Paysandisia archon* specializes on *Trithrinax campestris* (Arecaceae) and to a lesser extent on *Cocos yalai* in its native area (Argentina, Uruguay).

However, in Europe this moth has expanded its host range to many ornamental exotic palms (*Phoenix canariensis, Latania* sp.) as well as posing a threat to the native *Chamaerops humilis* (Montagud Alario 2004).

About 50.5% of alien Lepidoptera live indoors in domestic, industrial and other artificial habitats such as 16.5% in greenhouses (Figure 11.5). Six out of the nine species that feed on stored products show a cosmopolitan distribution. Parks and gardens host 52.6% of alien species, where they are frequently introduced with their native hostplant, while 25.8% have colonized agricultural land (Figure 11.5).

### 11.7 Ecological and economic impact

The impact of most alien Lepidoptera species has not been quantified in detail. However, negative economic impact has been recorded for 16 alien species. The Indian
Figure 11.6. Adult habitus of some lepidopteran species alien to Europe: a Argyresthia thuiella b Parectopa robiniella c Phyllonorycter issikii winter form d Phyllonorycter issikii summer form e Phyllonorycter leucographella f Phyllonorycter platanii g Phyllonorycter robiniella h Plodia interpunctella i Tineola bisselliella j Ephesia kuehniella k Hyphantria cunea male l Hyphantria cunea female (drawings by Aleš Laštůvka).
Figure 11.7. Adult habitus of some lepidopteran species alien in Europe: a Coleophora laricella b Coleophora spireellaea c Cameraria ohridella d Caloptilia roscipennella e Leucoptera malifoliella f Acalyptris platani g Stigmella aurella h Stigmella atricapitella i Stigmella centifoliella j Stigmella pyri k Stigmella speciosa l Stigmella suberivora m Argyresthia trifasciata; n Ectoedemia heringella. (drawings by Aleš Laštůvka).
Meal Moth *Plodia interpunctella* (Hübner, 1823) may severely affect grain and grain products, dried fruits and seeds in households and warehouses. The Common Clothes Moth *Tineola bisselliella* is another example of a major pest in houses where it feeds on clothes, carpets, rugs, and upholstered furniture. However, along with several other tineids, this species has become rare due to the increase in use of man-made fibres and the dry environment created by central heating (Kimber, 2008). The most serious alien lepidopteran pests in orchards in many parts of Europe include *Grapholita molesta*, *Hyphantria cunea* and *Prays citri*.

Some species can also cause aesthetic impact. Thus, species causing severe infestations can lead to almost complete defoliation of the hostplants. For instance, *C. ohridella* causes premature defoliation of the white-flowered horse-chestnut, *Aesculus hippocastanum*. The trees do not die but the aesthetic impact is so severe that in some countries, heavily infested trees have been felled and removed.
Little is known, however, about the ecological impact of alien Lepidoptera in natural areas of Europe (Kenis et al. 2009). Four alien Lepidoptera species seem to have a potentially important ecological impact: 1) the recently introduced pyralid *Diaphania perspectalis* that could represent a serious threat to topiary Box hedges and plants in nurseries, parks and gardens, and *Buxus* shrubs growing in the wild; 2) *C. ohridella*, that recent studies suggest could have a potential negative impact on native leafminers via apparent competition and could be adapting to *Acer* species in some areas (Péré et al. 2009); 3) the lycaenid *Cacyreus marshalli*, which threatens both native geraniums and *Geranium*-consuming lycaenids (Quacchia et al. 2008); 4) finally, as previously mentioned, *Paysandisia archon* represents a serious threat to the conservation of natural populations of *Chamaerops humilis*, the only native palm in Europe (Montagud Alario 2004, Sarto i Monteys 2002).

Lastly, we recommend that in order to guarantee the well being of natural ecosystems and also to keep track of future additions to the European alien Lepidoptera list, natural areas of special conservation concern like those under the Natura-2000 framework should be monitored more intensively and regularly for the early detection of potential threats, which according to our results are expected to increase.
Figure 11.10. Damage by alien lepidopteran larvae. a mines of *Parectopa robiiniella* on *Robinia* b 3rd instar larva of *Cameraria ohridella* extracted from its mine on *Aesculus* c damage of *Hyphantria cunea* on *Acer negundo* d mines of *Phyllonorycter issikii* on *Tilia* e mines of *Phyllonorycter platani* on *Platanus* (Credit: Hana Šefrová).

Acknowledgements

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References


Baldizzone G (2010) pers. comm. 11/02/10 to DCL.


Honey MR (1994) *Pardasena virgulana* (Mabille) (Lepidoptera: Noctuidae), a species not previously found in the wild in Britain. *British Journal of Entomology and Natural History* 7: 33–34.


Linnaeus C (1758) *Systema naturæ per regna tria naturæ, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*. Holmiae: Laurentii Salvii, 824 pp.


Mihelakis SE (1997) Phyllocnistis citrella Stainton, Gracillariidae, the new insect pest in our citrus groves. VI National Entomological Congress in Greece
Moffat CB (1897) Bupalus piniaria in Ireland. The Irish Naturalist 6: 283.


### Table 11.1.

List and characteristics of the lepidopteran species alien to Europe. 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 01/06/2009

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<tr>
<th>Family</th>
<th>Species</th>
<th>Status</th>
<th>Regime</th>
<th>Native range</th>
<th>1st record in Europe and country</th>
<th>Invaded countries</th>
<th>Alien Habitat</th>
<th>Hosts</th>
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<td></td>
<td><strong>Blastobasis decolorrella</strong> (Wollaston, 1858)</td>
<td>A</td>
<td>Detritivorous</td>
<td>Africa, Macaronesia (PT-MAD)</td>
<td>1946, PT</td>
<td>PT</td>
<td>F5, G5, I2, J1, J6</td>
<td>Wide variety of foodstuffs, including leaf-litter, vegetation, and stored products</td>
<td>Corley et al. (2006), Karsholt and Sinev (2004)</td>
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<td>Family</td>
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<td>Bucculatrix chrysanthemella (Rebel, 1896)</td>
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<td>Africa (Macaronesia)</td>
<td>2007, IT</td>
<td>FI, FR, IT</td>
<td>I2</td>
<td>Argyranthemum frutescens</td>
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<td>1935, IT</td>
<td>AL, BG, ES, GR, GR-CRE, IL, IT, IT-SIC</td>
<td>I1</td>
<td>Cotton</td>
<td>Karsholt and Nielsen (1986), Povolny (1996), Roll et al. (2007), Russo (1939)</td>
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<tr>
<td><em>Phthorimaea operculella</em> (Zeller, 1873)</td>
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<td>1899, MT</td>
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<td>I1, J1</td>
<td>Potato, tobacco and other Solanaceae, stored products and fields</td>
<td>Aastrup (1969), Bentinck (1963), Borg (1899), García Mercet (1926), Huemer and Rabitsch (2002), Janežič (1951), Karsholt and Sinev (2004), Mendes (1910), Petralia (1949), Roll et al. (2007), Stanov and Kaitazov (1962), Zagulajev (1982)</td>
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<td><em>Sitotroga cerealella</em> (Olivier, 1789)</td>
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<td>1790, DE?</td>
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<td>Stored products</td>
<td>Borg (1932), Dei (1871), Glavendečić et al. (2005), Hrubý (1964), Huemer and Rabitsch (2002), Ivinskas (1993), Janežič (1951), Karsholt and Nielsen (1976), Karsholt and Vícera (2005), Lindeman (1880), Mehl (1977), Ostrauskas and Táundryte (2004), Šefrová and Laštůvka (2005), Snellen (1898), Tschorbadjiew (1930)</td>
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*Phyllonorycter leucographella* *(Zeller, 1850)*
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<td>2002, DE</td>
<td>DE</td>
<td>Highly polyphagous, foliage and fruit of many field and vegetable crops, ornamentals and weeds: chickpeas, lucerne, maize, potato, sunflower, etc.</td>
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<td>Geiter et al. (2001)</td>
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<td>Asia-Tropical</td>
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<td>F5, F6, F8, I1, I2, J100</td>
<td>Highly polyphagous, crops and ornamentals</td>
<td>Seymour and Kilby (1978)</td>
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<td>Hodges, 1974</td>
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<td>I2</td>
<td>Withered leaves, leaf-litter</td>
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<td>1977, GB</td>
<td>GB, NL</td>
<td>J1, J100</td>
<td>Aquatic water plants</td>
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<td>Phytophagous</td>
<td>Asia</td>
<td>1949, ES</td>
<td>ES, FR, FR-COR, RU</td>
<td>I1</td>
<td>Rice (leaves, stems)</td>
<td>Feron (1973), Gerasimov (1949)</td>
</tr>
<tr>
<td></td>
<td><em>Corcyra cephalonica</em></td>
<td>C</td>
<td>Detritivorous</td>
<td>Cryptogenic (Tropical, subtropical, (type locality, Great Britain)</td>
<td>1866, GB</td>
<td>AT, BE, BG, CH, CZ, DE, DK, ES, FR, GB, GR, IT, IT-SIC, LV, PL, PT, PT-AZO, RO, SE, GB</td>
<td>J1</td>
<td>Stored grain (Poaceae: e.g. rice)</td>
<td>Drenske (1930), Goater (1986), Nuernberg and Rabitsch (2002), Janmoulle (1938), Karsholt and Vieira (2005), Palm (1986), Šefrová and Laštůvka (2005), Silvestri (1943)</td>
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<tr>
<td>Family Specie</td>
<td>Status</td>
<td>Regime</td>
<td>Native range</td>
<td>1st record in Europe and country</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Hosts</td>
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<tr>
<td><em>Elophila diffuali</em> (Snellen, 1880)</td>
<td>A</td>
<td>Phytophagous</td>
<td>Asia</td>
<td>1978, DK</td>
<td>CZ, DK, FI, GB, NL</td>
<td>J1, J100</td>
<td>Aquatic plants</td>
<td>Buhl et al. (1982), Goater et al. (2005)</td>
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</tr>
<tr>
<td><em>Elophila melagynalis</em> (Agassiz, 1878)</td>
<td>A</td>
<td>Phytophagous</td>
<td>Asia-Tropical</td>
<td>1978, GB</td>
<td>GB</td>
<td>J100, J1</td>
<td>Aquatic plants</td>
<td>Agassiz (1978b)</td>
<td></td>
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<tr>
<td><em>Ephestia elutella</em> (Hübner, 1796)</td>
<td>C</td>
<td>Detritivorous</td>
<td>Cryptogenic (type locality, Germany)</td>
<td>1796, DE</td>
<td>AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR GB, GR, GR-CRE, HU, IE, IS, IT, IT-SAR, IT-SIC, LT, LV, MK, MT, NL, NO, PL, PT, PT-AZO, PT-MAD, RO, RU, SE, SI, SK</td>
<td>J1</td>
<td>Stored nuts, dried fruits, grain, etc.</td>
<td>Abafi-Aigner et al. (1896), Aguiar and Karsholt (2006), Caruana Gatto (1905), De Séllys-Longchamps (1844), Filipjev (1932), Huemer and Rabitsch (2002), Karsholt and Vieira (2005), Kenis (2005), Mehl (1977), Petersen (1924), Reid (2008), Šefrová and Laštůvka (2005), Speiser (1903), Paoli (1922)</td>
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<td>Family</td>
<td>Species</td>
<td>Status</td>
<td>Regime</td>
<td>Native range</td>
<td>1st record in Europe and country</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
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<td><strong>Ephesia kuehniella</strong></td>
<td>C</td>
<td>Detritivorous</td>
<td>Cryptogenic (no type locality)</td>
<td>1879,?</td>
<td>AL, AT, BA, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, GR-CRE, HU, IE, IS, IT, IT-SAR, IT-SIC, IT, LV, ME, MT, NO, PL, PT, PT-AZO, PT-MAD, RO, RS, RU, SE, SI, SK</td>
<td>J1</td>
<td>Stored nuts, dried fruits, grain, etc.</td>
<td>Aguiar and Karsholt (2006), Bolle (1921), Borg (1932), De Crombrugghe (1906), Glavendekić et al. (2005), Goater (1986), Hrubý (1964), Huemer and Rabitsch (2002), Janežić (1951), Karsholt and Vieira (2005), Kenis (2005), Mehl (1977), Palm (1986), Šefrová and Laštůvka (2005), Zverezomb-Zubowsky (1918)</td>
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<td></td>
<td><strong>Paralipsa gularis</strong></td>
<td>A</td>
<td>Detritivorous</td>
<td>SE Asia (type locality: Japan)</td>
<td>1921</td>
<td>AT, BE, CH, CZ, DE, DK, FR, GB, HU, IT, IT-SIC, LV, NL, NO, SE</td>
<td>J1</td>
<td>Dry fruits, occasionally in imports of nuts for chocolate industry.</td>
<td>De Prins (1983), Giunchi (1957), Goater (1986), Huemer and Rabitsch (2002), Mariani (1941–1943), Mehl (1977), Palm (1986), Šefrová and Laštůvka (2005),</td>
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<td><strong>Family</strong></td>
<td><strong>Species</strong></td>
<td><strong>Status</strong></td>
<td><strong>Regime</strong></td>
<td><strong>Native range</strong></td>
<td><strong>1st record in Europe and country</strong></td>
<td><strong>Invaded countries</strong></td>
<td><strong>Alien Habitat</strong></td>
<td><strong>Hosts</strong></td>
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<tr>
<td><strong>Parapoynx bilinealis</strong> Snellen, 1876</td>
<td>A</td>
<td>Phytophagous</td>
<td>Asia-Tropical</td>
<td>1978, DK</td>
<td>DK, GB, SE</td>
<td>J100</td>
<td>Aquatic plants</td>
<td>Hancock (1984), Karsholt and Nielsen (1998)</td>
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<tr>
<td><strong>Parapoynx crisonalis</strong> (Walker, 1859)</td>
<td>A</td>
<td>Phytophagous</td>
<td>Asia-Tropical</td>
<td>1979, GB</td>
<td>GB</td>
<td>J100</td>
<td>Aquatic plants</td>
<td>Goater (1986)</td>
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<tr>
<td><strong>Parapoynx diminutalis</strong> Snellen, 1880</td>
<td>C</td>
<td>Phytophagous</td>
<td>Cryptogenic (Old world tropics: Asia and Africa)</td>
<td>1977, GB</td>
<td>AT, CZ, DK, FI, GB</td>
<td>J100</td>
<td>Nymphaea</td>
<td>Buhl et al. (1982), Goater (1986), Goater et al. (2005), Huemer and Rabitsch (2002)</td>
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<td><strong>Parapoynx fluctuosalis</strong> (Zeller, 1852)</td>
<td>C</td>
<td>Phytophagous</td>
<td>Cryptogenic (ES, Asia and Africa, type locality, Natal)</td>
<td>1979, GB</td>
<td>GB</td>
<td>J100</td>
<td>Aquatic plants</td>
<td>Goater (1986)</td>
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<tr>
<td><strong>Parapoynx obscuralis</strong> Grote 1881</td>
<td>A</td>
<td>Phytophagous</td>
<td>North America</td>
<td>1967, GB</td>
<td>GB</td>
<td>J100</td>
<td>Aquatic plants</td>
<td>Goater (1986)</td>
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<td><strong>Parapoynx polydectalis</strong> Walker, 1859</td>
<td>A</td>
<td>Phytophagous</td>
<td>Australasia</td>
<td>1979, GB</td>
<td>GB, NL</td>
<td>J100</td>
<td>Aquatic plants</td>
<td>Goater et al. (2005)</td>
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<tr>
<td><strong>Phycita diaphana</strong> (Staudinger, 1870)</td>
<td>C</td>
<td>Detritivorous</td>
<td>Cryptogenic (type locality: Spain, Malaga)</td>
<td>1870, ES, (2002, PT)</td>
<td>ES, GR, PT</td>
<td>I2, J6</td>
<td>Ricinus communis</td>
<td>Corley et al. (2000)</td>
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<td>Species</td>
<td>Status</td>
<td>Regime</td>
<td>Native range</td>
<td>1st record in Europe and country</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
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<td></td>
<td>Spoladea recurvalis (Fabricus, 1775)</td>
<td>A</td>
<td>Phytophagous</td>
<td>Tropics: Asia (type locality: India Orientali) South America and Africa</td>
<td>1968, NL (from Canaries)</td>
<td>BE, DK, IT, NL, PT-AZO, PT-MAD</td>
<td>I1, I2</td>
<td>Beta vulgaris, Trianthema postulacastrum, Chenopodium sp., Portulaca sp., Amanthus sp.</td>
<td>De Prins (2005), Karsholt and Vieira (2005), Nuss (2010)</td>
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<td>Family</td>
<td>Species</td>
<td>Status</td>
<td>Regime</td>
<td>Native range</td>
<td>1st record in Europe and country</td>
<td>Invaded countries</td>
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<td>(Guérin-Méneville, 1861)</td>
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<td>Samia cynthia</td>
<td>A</td>
<td>Phytophagous</td>
<td>Asia</td>
<td>1854, IT</td>
<td>AL, AT, CH, DE, ES, FR, HR, IT, SI</td>
<td>I2, X24</td>
<td><em>Ailanthus</em> and other deciduous trees</td>
<td>Huemer and Rabitsch (2002), Kenis (2005), Kollar (1854), Koster and Sinev (2003), Lepidopterologen Arbeitsgruppe (2000), Quajat (1904)</td>
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<td></td>
<td>(Drury, 1773)</td>
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<td>(Meyrick, 1893)</td>
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<td>(Bojer, 1856)</td>
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<td>Invaded countries</td>
<td>Alien Habitat</td>
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<td><strong>Tortricidae</strong></td>
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<tr>
<td><em>Clepsis peritana</em> (Clemens, 1860)</td>
<td>A</td>
<td>Phytophagous</td>
<td>North America</td>
<td>1979, DE</td>
<td>DE, DK, GB, PT-MAD</td>
<td>I1, I2, J100</td>
<td><em>Citrus, Euphorbia pulcherrima,</em> strawberries, and low herbaceous plants</td>
<td>Buhl et al. (1997), Hill et al. (2005)</td>
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<td><em>Cryptophlebia leucoptera</em> (Meyrick, 1927)</td>
<td>A</td>
<td>Phytophagous</td>
<td>Africa</td>
<td>1965, FI</td>
<td>IL, FI</td>
<td>I1, J100</td>
<td><em>Citrus, Macadamia terniflora, Ricinus communis,</em> cotton</td>
<td>Bradley (1959), Hamburger et al. (2000), Karvonen (1983)</td>
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<tr>
<td><em>Epichoristodes aceribella</em> (Walker, 1864)</td>
<td>A</td>
<td>Phytophagous</td>
<td>Africa</td>
<td>1960, DK</td>
<td>DK, ES, FR, GB, IT, IT-SAR, IT-SIC, NO, RS</td>
<td>I2</td>
<td>Polyphagous, especially <em>Dianthus</em></td>
<td>Costa Seglar and Vives Quadras (1976), Fjeldalen (1965), Glavendečkić et al. (2005), Thygesen et al. (1965), Zanget and Cavalloro (1971)</td>
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<tr>
<td>Family</td>
<td>Species</td>
<td>Status</td>
<td>Regime</td>
<td>Native range</td>
<td>1st record in Europe and country</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Hosts</td>
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<td><strong>Prays citri</strong> (Millière, 1873)</td>
<td>A Phytophagous</td>
<td>Asia</td>
<td>1877, IT</td>
<td>AL, DK, ES, FR, FR-COR, GR, GR-CRE, IL, IT, IT-SAR, IT-SIC, NL, PT, PT-AZO, PT-MAD</td>
<td>I2, J100</td>
<td>Citrus</td>
<td>Buhl et al. (2001), de Carvalho (1995), Franco et al. (2006), Karsholt and Vieira (2005), Liotta and Mineo (1963), Roll et al. (2007)</td>
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**Table 11.2.** List and characteristics of the lepidopteran species expanding within Europe (alien in Europe). Country codes abbreviations refer to ISO 3166 (see appendix I). Habitat abbreviations refer to EUNIS (see appendix II). Last update 01/06/2009.

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>Regime</th>
<th>Native range</th>
<th>Invaded countries</th>
<th>Alien Habitat</th>
<th>Hosts</th>
<th>Refs</th>
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<tbody>
<tr>
<td><strong>Arctiidae</strong></td>
<td><strong>Eilema caniola</strong></td>
<td>Phytophagous</td>
<td>Europe, W Asia &amp; N Africa</td>
<td>AT, BE, CH</td>
<td>B3</td>
<td>Algae and lichens</td>
<td>Fologne (1859), Huemer and Rabitsch (2002), Kenis (2005)</td>
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<tr>
<td></td>
<td>(Hübner, 1808)</td>
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<td></td>
<td><strong>Autostichidae</strong></td>
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<tr>
<td></td>
<td>Busck, 1915</td>
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<td></td>
<td><strong>Coleophoridae</strong></td>
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<td><strong>Coleophora coracipennella</strong></td>
<td>Phytophagous</td>
<td>W Europe</td>
<td>PT-MAD</td>
<td>I1, I2, X24</td>
<td>Malus</td>
<td>Aguiar and Karsholt (2006)</td>
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<td></td>
<td>(Hübner, 1796)</td>
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<td><strong>Coleophora laricella</strong></td>
<td>Phytophagous</td>
<td>European Alps</td>
<td>BE, DK, HR, EE, FI, GB, HR, IE, LT, LV, MK, NL, NO, RS, SE</td>
<td>G3</td>
<td>Larix</td>
<td>Bond et al. (2006), De Fré (1858)</td>
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<td><strong>Coleophora spiraeella</strong></td>
<td>Phytophagous</td>
<td>C Europe (incl. CZ, AU)</td>
<td>DE, HU, IT, LT, SE, SK</td>
<td>G, I2</td>
<td>Spiraea</td>
<td>Baldizzone (pers. comm.), Huemer and Rabitsch (2002), Reiprich and Janovský (1981)</td>
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<td></td>
<td>Rebel, 1916</td>
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<td></td>
<td><strong>Coleophora versurella</strong></td>
<td>Phytophagous</td>
<td>Europe</td>
<td>PT-AZO</td>
<td>E1</td>
<td>Atriplex, Chenopodium</td>
<td>Karsholt and Vieira (2005)</td>
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<td></td>
<td>Zeller, 1849</td>
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<td><strong>Epermenia aequidentellus</strong></td>
<td>Phytophagous</td>
<td>C &amp; S Europe</td>
<td>PT-AZO</td>
<td>U</td>
<td>Daucus carota</td>
<td>Karsholt and Vieira (2005)</td>
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<td>(Hoffmann, 1867)</td>
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<td><strong>Ethmia terminella</strong></td>
<td>Phytophagous</td>
<td>Europe to N Africa and Asia Minor</td>
<td>SE</td>
<td>B2</td>
<td>Echium vulgare</td>
<td>Svensson (1992)</td>
</tr>
<tr>
<td>Family</td>
<td>Species</td>
<td>Regime</td>
<td>Native range</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Hosts</td>
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<td><em>Arthrips rancidella</em></td>
<td>Phytophagous</td>
<td>Europe</td>
<td>GB</td>
<td>I2</td>
<td><em>Cotoneaster horizontalis</em></td>
<td>Chalmers-Hunt (1985)</td>
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<td>(Herrich-Schäffer, 1854)</td>
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<td></td>
<td><em>Chrysosia sexguatella</em></td>
<td>Phytophagous</td>
<td>Europe and/or N Africa</td>
<td>PT-AZO</td>
<td>D6</td>
<td><em>Chenopodium</em></td>
<td>Karsholt and Vieira (2005)</td>
</tr>
<tr>
<td>(Thunberg, 1794)</td>
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<td></td>
<td><em>Gelechia senticetella</em></td>
<td>Phytophagous</td>
<td>European Alps</td>
<td>BE, DK, GB, NL, BU</td>
<td>I2, G</td>
<td><em>Juniperus, Cupressus</em></td>
<td>De Prins (1989), van Nieukerken et al. (1993), Buhl et al. (2007)</td>
</tr>
<tr>
<td>(Staudinger, 1859)</td>
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<td></td>
<td><em>Platyedra subcinerea</em></td>
<td>Phytophagous</td>
<td>Europe</td>
<td>PT-AZO</td>
<td>I2</td>
<td><em>Malva sylvestris, seeds, flowers</em></td>
<td>Karsholt and Vieira (2005)</td>
</tr>
<tr>
<td>(Haworth, 1828)</td>
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<td><strong>Geometridae</strong></td>
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<td></td>
<td><em>Bupalus piniaria</em></td>
<td>Phytophagous</td>
<td>Europe</td>
<td>IE</td>
<td>G3</td>
<td><em>Pinus</em></td>
<td>Moffat (1897)</td>
</tr>
<tr>
<td>(Linnaeus, 1758)</td>
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<td></td>
<td><em>Eramis defoliaria</em></td>
<td>Phytophagous</td>
<td>Europe</td>
<td>IS</td>
<td>G1, I2</td>
<td>Polychagous (<em>Quercus, Betula, Ulmus, Acer, Tilia</em>)</td>
<td>Wolff (1971)</td>
</tr>
<tr>
<td>(Clerck, 1759)</td>
<td></td>
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<td></td>
<td><em>Eupithecia carpophagata</em></td>
<td>Phytophagous</td>
<td>Mediterranean</td>
<td>DE</td>
<td>E4</td>
<td><em>Silene (S. saxifraga, S. rupestris)</em></td>
<td>Geiter et al. (2001)</td>
</tr>
<tr>
<td>Staudinger, 1871</td>
<td></td>
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<td></td>
<td><em>Eupithecia indigata</em></td>
<td>Phytophagous</td>
<td>Europe from Urals W and S to Alps</td>
<td>IE</td>
<td>G3</td>
<td><em>Pinus sylvestris, Picea, Larix</em></td>
<td>Skou (1986)</td>
</tr>
<tr>
<td>(Hübner, 1813)</td>
<td></td>
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<td></td>
<td><em>Eupithecia phoeniceata</em></td>
<td>Phytophagous</td>
<td>Atlantic Europe</td>
<td>BE, GB</td>
<td>I2</td>
<td><em>Juniperus phoenicea</em></td>
<td>De Prins (2007)</td>
</tr>
<tr>
<td>(Rambur, 1834)</td>
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<td><em>Eurranthis plummistaria</em></td>
<td>Phytophagous</td>
<td>Mediterranean</td>
<td>DE</td>
<td>F6</td>
<td><em>Dorycnium</em></td>
<td>Geiter et al. (2001)</td>
</tr>
<tr>
<td>(De Villers, 1879)</td>
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<td>(Scopoli, 1763)</td>
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<td></td>
<td><em>Macaria liturata</em></td>
<td>Phytophagous</td>
<td>Europe to E Asia</td>
<td>IE</td>
<td>G3</td>
<td><em>Pinus sylvestris</em></td>
<td>Roques et al. (2006)</td>
</tr>
<tr>
<td>(Clerck, 1759)</td>
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<td>Family</td>
<td>Species</td>
<td>Regime</td>
<td>Native range</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Hosts</td>
<td>Refs</td>
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<tr>
<td><strong>Operophtera brumata</strong> (Linnaeus, 1758)</td>
<td>Phytophagous</td>
<td>Europe to Caucasus</td>
<td>IS</td>
<td>G</td>
<td>Deciduous trees</td>
<td>Peterson and Nilssen (2004)</td>
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<tr>
<td><strong>Peribatodes perversaria</strong> (Boisduval, 1840)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>DE</td>
<td>F4</td>
<td>Juniperus</td>
<td>Savela (2010)</td>
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<td><strong>Thera britannica</strong> (Turner, 1925)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>SE</td>
<td>G3</td>
<td>Abies, Pinus</td>
<td>Skou (1986), Svensson (1977)</td>
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<tr>
<td><strong>Gracillariidae</strong></td>
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<tr>
<td><strong>Caloptilia rufipennella</strong> (Hübner, 1796)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>LT, LV, NO, SE</td>
<td>I2, G3</td>
<td>Acer pseudoplatanus</td>
<td>Kimber (2008)</td>
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<td><strong>Caloptilia rocipennella</strong> (Hübner, 1796)</td>
<td>Phytophagous</td>
<td>Europe or SW Asia?</td>
<td>AT, BE, CH, CZ, DE, ES, FR, FR-COR, HU, IT, IT-SIC, MD, PL, RO, RU, UK</td>
<td>I2, G3</td>
<td>Juglans regia</td>
<td>Šefrová and Laštůvka (2005)</td>
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<tr>
<td><strong>Phyllonorycter geniculella</strong> (Ragonot, 1874)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>GB, LV, LT, SE</td>
<td>I2, G5</td>
<td>Acer pseudoplatanus</td>
<td>Emmet et al. (1985)</td>
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<tr>
<td><strong>Phyllonorycter joannis</strong> (Le Marchand, 1936)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>GB</td>
<td>I2, G5</td>
<td>Acer platanoides</td>
<td>Emmet et al. (1985)</td>
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<tr>
<td>Family</td>
<td>Species</td>
<td>Regime</td>
<td>Native range</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Hosts</td>
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<td>messaniella (Zeller,</td>
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<td>1846)</td>
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<td></td>
<td>Phyllonorycter strigulatella (Zeller, 1846)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>GB</td>
<td>G,J1, H1</td>
<td>Alnus incana</td>
<td>Hill et al. (2005)</td>
</tr>
<tr>
<td>(Linnaceus, 1758)</td>
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<tr>
<td>Lyonietaidae</td>
<td>Leucoptera malifoliella</td>
<td>Phytophagous</td>
<td>Mediterranean</td>
<td>PT-MAD</td>
<td>I1, G1, G2</td>
<td>Polyphagous, mostly Rosaceae (Malus, Pyrus, Sorbus, Crataegus, Prunus), Betula</td>
<td>Aguiar and Karsholt (2006)</td>
</tr>
<tr>
<td>(O. Costa, 1836)</td>
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<td>(Müller-Rutz, 1934)</td>
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<td></td>
<td>Ectoedemia heringella</td>
<td>Phytophagous</td>
<td>S. Europe (Adriatic)</td>
<td>GB</td>
<td>I2, G2</td>
<td>Quercus ilex leaf miner</td>
<td>Hill et al. (2005)</td>
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<tr>
<td>(Mariani, 1939)</td>
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<td></td>
<td>Stigmella atricapitella</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>PT-MAD, ES</td>
<td>G1,G4,X10</td>
<td>Quercus</td>
<td>Aguiar and Karsholt (2006)</td>
</tr>
<tr>
<td>(Haworth, 1828)</td>
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<tr>
<td></td>
<td>Stigmella aurella</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>PT-AZO</td>
<td>I1</td>
<td>Rubus</td>
<td>Karsholt and Vieira (2005)</td>
</tr>
<tr>
<td>(Fabricius, 1775)</td>
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<tr>
<td>(Zeller, 1848)</td>
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<tr>
<td>Family</td>
<td>Species</td>
<td>Regime</td>
<td>Native range</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Refs</td>
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<td></td>
<td><strong>Stigmella pyri</strong> (Glitz, 1865)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>SE</td>
<td>I1</td>
<td><em>Pyrus</em></td>
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<td></td>
<td><strong>Stigmella speciosa</strong> (Frey, 1857)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>DK, GB</td>
<td>G, I2</td>
<td><em>Acer pseudoplatanus</em></td>
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<tr>
<td></td>
<td><strong>Stigmella suberivora</strong> (Stainton, 1869)</td>
<td>Phytophagous</td>
<td>S Europe</td>
<td>GB</td>
<td>G3, G4</td>
<td><em>Quercus ilex</em></td>
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<tr>
<td><strong>Noctuidae</strong></td>
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<td></td>
<td><strong>Caradrina ingrata</strong> Staudinger, 1897</td>
<td>Phytophagous</td>
<td>E Mediterranean, N &amp; NE Africa</td>
<td>CH</td>
<td>I2, X11</td>
<td>Rezbanyai-Reser (1983)</td>
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<td></td>
<td><strong>Chrysodeixis chalcites</strong> (Esper, 1789)</td>
<td>Phytophagous</td>
<td>Mediterranean &amp;/or tropical Africa</td>
<td>CZ, PL, SE</td>
<td>J100, I1</td>
<td>Šefrová and Laštůvka (2005)</td>
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<td></td>
<td><strong>Euplexia lucipara</strong> (Linnaeus, 1758)</td>
<td>Phytophagous</td>
<td>Europe &amp; W Asia, N Africa</td>
<td>PT-AZO</td>
<td>G</td>
<td>Ferns</td>
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<td></td>
<td><strong>Lithophane leautieri</strong> (Boisduval, 1829)</td>
<td>Phytophagous</td>
<td>Mediterranean expanding to C Europe, N Africa</td>
<td>DK, GB, NL</td>
<td>I2</td>
<td><em>Chamaecyparis, Cupressocyparis</em></td>
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<tr>
<td></td>
<td><strong>Polychrysa moneta</strong> (Fabricius, 1787)</td>
<td>Phytophagous</td>
<td>C &amp; SE Europe to W Asia</td>
<td>BE, DK, DE, GB</td>
<td>I2</td>
<td><em>Delphinium</em></td>
<td></td>
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<tr>
<td></td>
<td><strong>Sesamia nonagrioides</strong> (Lefèbvre, 1827)</td>
<td>Phytophagous</td>
<td>S Europe, N, W, and SW Africa</td>
<td>PT-AZO, PT-MAD</td>
<td>I1</td>
<td>Corn, sugar cane</td>
<td></td>
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<tr>
<td></td>
<td><strong>Spodoptera littoralis</strong> (Boisduval, 1833)</td>
<td>Phytophagous</td>
<td>Subtropical Africa, Madagascar and S Europe</td>
<td>AL, CH, DE, DK, ES, ES-CAN, FR, FR-COR, GB, IT, IT-SIC, PT, PT-MAD</td>
<td>F5, F6, F8, I1, I2</td>
<td>Polyphagous (vegetables, flowers, fruit trees, introduced with <em>Chrysanthemum</em>)</td>
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<td><strong>Nolidae</strong></td>
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<td></td>
<td><strong>Polychrysa moneta</strong> (Fabricius, 1787)</td>
<td>Polyphagous</td>
<td>C &amp; SE Europe to W Asia</td>
<td>BE, DK, DE, GB</td>
<td>I2</td>
<td><em>Delphinium</em></td>
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<td></td>
<td><strong>Sesamia nonagrioides</strong> (Lefèbvre, 1827)</td>
<td>Polyphagous</td>
<td>S Europe, N, W, and SW Africa</td>
<td>PT-AZO, PT-MAD</td>
<td>I1</td>
<td>Corn, sugar cane</td>
<td></td>
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<tr>
<td>Family</td>
<td>Species</td>
<td>Regime</td>
<td>Native range</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Hosts</td>
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<tr>
<td>Lepidoptera</td>
<td>Earias vernana (Fabricius, 1787)</td>
<td>Phytophagous</td>
<td>C&amp;S Europe &amp; W Asia</td>
<td>SE</td>
<td>G, FA</td>
<td>Populus alba</td>
<td>Hyden et al. (2006)</td>
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<tr>
<td>Notodontidae</td>
<td>Thaumetopoea pityocampa (Denis &amp; Schiff., 1775)</td>
<td>Phytophagous</td>
<td>S Europe &amp; N Africa</td>
<td>IT-SAR</td>
<td>G 3</td>
<td>Pinus spp</td>
<td>Mendes (1905)</td>
</tr>
<tr>
<td>Oecophoridae</td>
<td>Endrosis sarcitrella (Linnaeus, 1758)</td>
<td>Detritivorous</td>
<td>Mediterranean?</td>
<td>AT, BE, BY, CH, CZ, DE, DK, EE, FI, GB, IS, LT, LV, NL, NO, PL, RO, SE, SK</td>
<td>J1, G</td>
<td>Carpets, corks of wine bottles, dried plant material, dried foodstuffs indoors. Occurs outdoors in dried bracket-fungi on trees</td>
<td>Abaﬁ-Aigner et al. (1896), Hrubý (1964), Martin (1991), Mehl (1977), Šefrová and Laštůvka (2005), Ulmer et al. (1918)</td>
</tr>
<tr>
<td></td>
<td>Hofmannophila pseudospretella (Stainton, 1849)</td>
<td>Detritivorous</td>
<td>Mediterranean?</td>
<td>AT, BE, BY, CH, CZ, DE, DK, EE, FI, GB, IS, IE, LT, LV, NL, NO, PL, PT, RO, SE, SK</td>
<td>J1, I2</td>
<td>Fabrics, including carpets, upholstery, leather and books, but more especially infesting dried foodstuffs</td>
<td>Amsel (1959), Hill et al. (2005), Hrubý (1964), Jürivete et al. (2000), Mehl (1977), Šefrová and Laštůvka (2005)</td>
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<tr>
<td>Plutellidae</td>
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<tr>
<td>Family Species</td>
<td>Regime</td>
<td>Native range</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Hosts</td>
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<tr>
<td><em>Emmelina monodactyla</em> (Linnaeus, 1758)</td>
<td>Phytophagous</td>
<td>Europe, Africa, Asia, and/or N America, Mexico</td>
<td>PT-AZO</td>
<td>E, F, I2</td>
<td>Bindweeds (<em>Convolvulus</em> and <em>Calystegia</em> spp.), occasionally Morning glory (<em>Ipomoea</em>), <em>Chenopodium</em> and <em>Arrilex</em></td>
<td>Karsholt and Vieira (2005)</td>
<td></td>
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<tr>
<td><em>Stenoptilia milleridactylus</em> (Bruand, 1861)</td>
<td>Phytophagous</td>
<td>Atlantic Europe</td>
<td>GB, IE</td>
<td>I2</td>
<td>Wild Mossy saxifrage (<em>Saxifraga hypnoides</em>)</td>
<td>Hill et al. (2005)</td>
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<tr>
<td><em>Apomyelois ceratoniae</em> (Zeller, 1839)</td>
<td>Detritivorous</td>
<td>Mediterranean?</td>
<td>AT, BE, CH, CZ, DE, DK, GB, HU, NL, NO, PL, RO, RU, SE, UK</td>
<td>J1</td>
<td>Stored products: dry fruits, dates, nuts, carob, pistachio</td>
<td>Palm (1986), Sterneck and Zimmermann (1933)</td>
<td></td>
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<tr>
<td>Family</td>
<td>Species</td>
<td>Regime</td>
<td>Native range</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Hosts</td>
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<td></td>
<td><em>Euclasta varii</em> (Popescu-Gorj &amp; Constantinescu, 1973)</td>
<td>Phytophagous</td>
<td>SW Europe (Spain)</td>
<td>MT</td>
<td>F6</td>
<td>Palm trees (<em>Phoenix canariensis</em> and <em>P. dactylifera</em>)</td>
<td>Sammut (2005)</td>
</tr>
<tr>
<td></td>
<td><em>Sclerocona acutellus</em> (Eversmann, 1842)</td>
<td>Phytophagous</td>
<td>S &amp; C Europe to Asia (apparently expanding to Siberia, China and E USA)</td>
<td>GB</td>
<td>B, E</td>
<td>Grass stems used for thatching</td>
<td>Wagner et al. (2003)</td>
</tr>
<tr>
<td>Saturniidae</td>
<td><em>Graellsia isabellae</em> Graells, 1849</td>
<td>Phytophagous</td>
<td>SW Europe (Spain, France)</td>
<td>CH</td>
<td>G3</td>
<td><em>Pinus sylvestris</em></td>
<td>Lepidopterologen Arbeitsgruppe (2000)</td>
</tr>
<tr>
<td>Sesidae</td>
<td><em>Pennisetia hylaeformis</em> (Laspeyres, 1801)</td>
<td>Phytophagous</td>
<td>Europe to W Asia</td>
<td>GB</td>
<td>I1, I2</td>
<td><em>Ribes</em></td>
<td>Reiprich (1980)</td>
</tr>
<tr>
<td></td>
<td><em>Synanthedon andrenaeformis</em> (Laspeyres, 1801)</td>
<td>Phytophagous</td>
<td>Europe &amp;/or Asia Minor to W Asia</td>
<td>SE</td>
<td>I2</td>
<td><em>Viburnum lantana</em></td>
<td>Torstenius and Lindmark (2000)</td>
</tr>
<tr>
<td></td>
<td><em>Synanthedon myopaeformis</em> (Borkhausen, 1789)</td>
<td>Phytophagous</td>
<td>SC Europe &amp;/or Asia Minor and Egypt</td>
<td>PT-MAD</td>
<td>I2</td>
<td><em>Malus</em></td>
<td>Aguiar and Karsholt (2006)</td>
</tr>
<tr>
<td>Family</td>
<td>Species</td>
<td>Regime</td>
<td>Native range</td>
<td>Invaded countries</td>
<td>Alien Habitat</td>
<td>Hosts</td>
<td>Refs</td>
</tr>
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<tr>
<td>Tortricidae</td>
<td>Acleris variegana (Denis &amp; Schiffermüller, 1775)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>PT-AZO</td>
<td>FB</td>
<td>Rosa</td>
<td>Karsholt and Vieira (2005)</td>
</tr>
<tr>
<td></td>
<td>Adoxophyes orana (Fischer von Rösslerstamm, 1834)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>GB</td>
<td>11, I2</td>
<td>Polyphagous, fruit trees (Prunus, Malus, Rosa) and deciduous (Ahus, Betula, Populus, Salix)</td>
<td>Bradley et al. (1973)</td>
</tr>
<tr>
<td>Family</td>
<td>Species</td>
<td>Genus (author, year)</td>
<td>Habitat</td>
<td>Hosts</td>
<td>Regime</td>
<td>Native range</td>
<td>Invaded countries</td>
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</tr>
<tr>
<td></td>
<td>Cydia illutana</td>
<td>Herrich-Schäffer, 1851</td>
<td>Phytophagous</td>
<td>on <em>Larix, Picea</em></td>
<td>Native</td>
<td>Europe</td>
<td>GB</td>
</tr>
<tr>
<td></td>
<td>Cydia milleniana</td>
<td>Adamczewski, 1967</td>
<td>Phytophagous</td>
<td>on <em>Larix</em></td>
<td>Native</td>
<td>Europe and Asia</td>
<td>GB</td>
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<tr>
<td></td>
<td>Cydia pactolana</td>
<td>Zeller, 1840</td>
<td>Phytophagous</td>
<td>on <em>Picea</em></td>
<td>Native</td>
<td>Europe</td>
<td>GB</td>
</tr>
<tr>
<td></td>
<td>Cydia pomonella</td>
<td>Linnaeus, 1758</td>
<td>Phytophagous</td>
<td>on <em>Malus</em></td>
<td>invasive</td>
<td>Europe, expanding to E USA</td>
<td>I1</td>
</tr>
<tr>
<td></td>
<td>Cydia splendana</td>
<td>Hübner, 1799</td>
<td>Phytophagous</td>
<td>on <em>Castanea, Quercus</em> but also <em>Fagus</em> and <em>Juglans</em>, fruit borer</td>
<td>Native</td>
<td>Europe</td>
<td>PT-AZO, PT-MAD</td>
</tr>
<tr>
<td></td>
<td>Notocelia rosaeflava</td>
<td>Doubleday, 1850</td>
<td>Phytophagous</td>
<td>on <em>Rosa</em></td>
<td>Native</td>
<td>Europe</td>
<td>NL</td>
</tr>
<tr>
<td></td>
<td>Polycottis rosae</td>
<td>Doubleday, 1850</td>
<td>Phytophagous</td>
<td>on <em>Rosa</em></td>
<td>Native</td>
<td>Europe</td>
<td>NL</td>
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<td><strong>Family</strong></td>
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</tr>
<tr>
<td>Rhopobota naevana</td>
<td>(Hübner, 1817)</td>
<td>Phytophagous</td>
<td>Europe</td>
<td>PT-AZO</td>
<td>I2</td>
<td>Holly (<em>Ilex aquifolium</em>) and blueberry (<em>Vaccinium myrtillus</em>)</td>
<td>Karsholt and Vieira (2005)</td>
</tr>
</tbody>
</table>

**Yponomeutidae**

<table>
<thead>
<tr>
<th><strong>Genus</strong></th>
<th><strong>Species</strong></th>
<th><strong>Regime</strong></th>
<th><strong>Native range</strong></th>
<th><strong>Invaded countries</strong></th>
<th><strong>Alien Habitat</strong></th>
<th><strong>Hosts</strong></th>
<th><strong>Refs</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Argyresthia</td>
<td>laevigatella</td>
<td>(Heydenreich, 1851)</td>
<td>Phytophagous</td>
<td>N or C Europe &amp;/or Japan</td>
<td>DK, FI, GB, HU, IE, LT, LV, NL, NO, SE</td>
<td>G3</td>
<td><em>Larix</em> shoots</td>
</tr>
<tr>
<td>Prays</td>
<td>oleae</td>
<td>(Bernard, 1788)</td>
<td>Phytophagous</td>
<td>Mediterranean</td>
<td>PT-AZO</td>
<td>I2, J100</td>
<td><em>Olea</em> (240) trees</td>
</tr>
<tr>
<td>Zelleria</td>
<td>oleastrella</td>
<td>(Millière, 1864)</td>
<td>Phytophagous</td>
<td>Mediterranean</td>
<td>GB, PT-MAD</td>
<td>I2, J100</td>
<td><em>Olea</em> (240) trees</td>
</tr>
</tbody>
</table>

**Zygaenidae**

<table>
<thead>
<tr>
<th><strong>Genus</strong></th>
<th><strong>Species</strong></th>
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