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Myriapods (Myriapoda)
Chapter 7.2

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Abstract
Alien myriapods in Europe have never been subject to a comprehensive review. Currently, 40 species belonging to 23 families and 11 orders can be regarded as alien to Europe, which accounts approximately for about 1.8% of all species known on the continent. Millipedes (Class Diplopoda) are represented by 20 alien species, followed by centipedes (Class Chilopoda) with 16, symphylans with 3 and pauropods with only 1. In addition there are numerous cases of continental species introduced to the Atlantic and Mediterranean islands or others of southern origin transported and established in North European cities. The earliest record of an alien myriapod dates back to 1836, although the introduction of some species into Europe could have begun already in historical times with an increase in trade between ancient Greeks and Romans with cities in the Near East and North Africa. In post-medieval times this process should have intensified with the trade between Europe and some tropical countries, especially after the discoveries of the Americas and Australia. The largest number of alien myriapods (25, excl. intercepted) has been recorded from Great Britain, followed by Germany with 12, France with 11 and Denmark with 10 species. In general, northern and economically more developed countries with high levels of imports and numerous busy sea ports are richer in alien species. The various alien myriapods have different origins, but most of them show tropical or subtropical links (28 species, 70%). Eight of them (20%) are widespread in the Tropical and Subtropical belts, eleven (circa 28%) are of Asian origin, seven show links with South and Central America, and one each originates from North America, North Africa, Australasia, and islands in...
the Indian Ocean. Ten myriapods are of unknown origin (cryptogenic). Only 12 species (ca. 30%) of all have established in the wild in Europe. At the present time alien myriapods do not cause serious threats to the European economy and there is insufficient data on their impact on native fauna and flora.

Keywords
Diplopoda, Chilopoda, Symphyla, Pauropoda, Europe, alien, invasions, intercepted species, biogeographical patterns

7.2.1. Introduction

Myriapods are terrestrial wingless arthropods with elongated bodies composed of more or less similar segments, most of which bear one or two pairs of legs. Four classes are recognised: Pauropoda, Symphyla, Chilopoda and Diplopoda. Approximately 15 000 species from nearly 160 families are currently known in the world. The Diplopoda is by far the most diverse group, comprising roughly 11 000 species (Adis and Harvey 2000). A total of 2,245 myriapod species or subspecies from 15 orders and 70 families are currently known in Europe (http://www.faunaeur.org/statistics.php), of which 1,529 are Diplopoda, 481 Chilopoda, 41 Symphyla and 125 Pauropoda. All members of the class Diplopoda (millipedes) have two pairs of legs per diplosegment for most segments. Several morphotypes have been recognised, i.e. juloid, polydesmoid, polyxenoid, platydesmoid and glomeroid (Kime and Golovatch 2000), of which the former two are especially rich in species both in Europe and worldwide. Most of the species are cylindrical or flattened dorsally, often with prominent lateral projections, generally medium- to large-sized (up to 8–9 cm in the genera Pachyiulus and Eurygyrus). Some species of the order Glomerida, or pill millipedes, are oniscomorph, capable of rolling up into a tight ball. Members of the order Polyxenida, or “dwarf millipedes”, are minute in size and with peculiar hairs along the body arranged in groups and tufts like small pin-cushions or brushes. The number of legs varies between species, often (especially in juloids) even individually, the record being 375 pairs in the North American siphonophoridan species Illacme plenipes Cook & Loomis, 1928 (Marek and Bond 2006).

Species of the class Chilopoda (centipedes) have an elongated flattened trunk and bear one pair of legs per segment, with a total number ranging between 15 and 191 pairs. Centipede body length varies from a few millimeters in some species of genus Lithobius (Monotarsobius) to approximately 30 cm in the Neotropical species Scolopendra gigantea (Minelli and Golovatch 2001). All centipedes have a pair of poison claws, or forcipules, which represent modified first body appendages. About 3,500 valid species and subspecies from 5 orders and 22 families are known in the world (Minelli 2006, Edgecombe and Giribet 2007). The other two myriapod classes – Symphyla and Pauropoda – consist of very small species, with body length of 2–8 and 0.5–1.9 mm respectively, both still remaining very poorly studied. The number of described symphylans and pauropods in the world is roughly estimated to about 200 and 700, respectively (Adis and Harvey 2000).
Most millipedes, as well as all pauropods and symphylans, are phytophages, detritivores or sapro- phages. A few millipedes can be regarded as omnivores, e.g. Blaniulus guttulatus (Fabricius, 1798), Uroblaniulus canadensis (Newport, 1844), or even predators, like Apfelbeckia insculpta (L. Koch, 1867), Callipus foetidissimus (Savi, 1819), and Abacion magnum (Loomis, 1843), which have been observed feeding on earthworms, flies and spiders (Hoffman and Payne 1969, Golovatch 2009). Other species feed on their own exuvia or fecal pellets (Minelli and Golovatch 2001).

Centipedes are mostly predatory, feeding on different available prey items in the soil (earthworms, enchytraeids, snails, slugs, small insects – both larvae and adults – and other arthropods). More details on the biology and ecology of millipedes, centipedes and the two other, smaller myriapod classes can be found in Hopkin and Read (1992), Lewis (1981), and Verhoeff (1933, 1934).

Little information is as yet available on the non-indigenous myriapods in Europe (DAISIE 2009, Roques et al. 2009). The most recent overview of alien organisms in Europe (see DAISIE 2009, p. 225) lists two centipedes (Lamyctes emarginatus, Lamyctes caeculus) and three millipedes (Oxidus gracilis, Eurygyrus ochraceus, Sechellobolus dictyonotus = Paraspirobolus lucifugus) as alien to Europe. Some papers have been, however, published on the ecology, morphology and post-embryonic development of several alien centipedes (Andersson 1984, 2006, Bocher and Enghoff 1984, 1975a, Negrea 1989) and millipedes (Enghoff 1975b, 1978, 1987, Golovatch et al. 2000, et al. 2002). Lists of alien species have been published for a few countries only, such as Germany (Kinzelbach et al. 2001), Austria (Gruber 2002, Gruber and Christian 2002), the Czech Republic (Šefrová and Laštůvka 2005), Switzerland (Wittenberg 2005), Italy (Zapparoli and Minelli 2005) and Great Britain (Barber 2009a, b). Increasing attention has been paid in the last decades to species which have accidentally arrived in Europe (see Barber 2009a, BBC News 2005, Christian and Szeptycki 2004, Gregory and Jones 1999, Lewis 1988, Lewis and Rundle 1988 for centipedes and Andersson and Enghoff 2007, Enghoff 2008a and Read 2008 for millipedes).

### 7.2.2. Taxonomy of the myriapod species alien to Europe

Altogether, 40 species belonging to 23 families and 11 orders can be regarded as alien to Europe (Table 7.2.1). This accounts approximately for about 1.8% of all myriapods known on the continent. Millipedes are represented by 20 alien species, followed by centipedes with 16, symphylans with 3 and pauropods with only 1. The relative proportion of alien species is highest in Symphyla (7.3%) and Chilopoda (3.3%), and the lowest in Pauropoda (0.8%) and Diplopoda (1.3%). The centipede family Henicopidae is the richest in alien species (5 species), followed by Scutigerellidae, Mecistocephalidae, Scolopendridae, Paradoxosomatidae and Pyrgodesmidae, each with three species. The remaining 17 families are represented by only one or two species each (Figure 7.2.1).
Striking is the absence of alien species in Europe of the species-rich order Spirostreptida since spirostreptidans, for instance *Hypocambala anguina* (Attems, 1900) and *Glyphiulus granulatus* Gervais, 1847, are quite widespread in the tropical countries and show a clear tendency to anthropochorism (Jeekel 1963, Shelley 1998).

Several myriapods have been intercepted at their arrival in Europe from consignments from other countries but have never managed to establish themselves. Barber (2009a) provided a list of centipede species captured and registered by the Central Science Laboratory (now FERA) in the UK when imported with exotic plants, fruits and luggage (Table 7.2.2). Two of them, *Lithobius forficatus* and *L. peregrinus*, are European natives which have long been introduced to Australia and New Zealand, so their interception in Great Britain is a clear case of re-introduction.

A similar list for intercepted millipedes examined by the Central Science Laboratories between 1975 and 2006 (S. Reid *pers. comm.*) is more substantial with some 85 entries over this period of time (Table 7.2.2). Of these 36 were records of *Oxidus gracilis* from a wide range of different parts of the world (W & S. Europe, Canary Islands, Israel, N., C. and S. America, Australia, China, Japan, Malaysia, Singapore, India, Nepal, N., W. and S. Africa and Madagascar). Other types found included members of the Polydesmida (dalodesmids, paradoxomatids, polydesmids), Spirosteptida (from Australia, New Zealand and Africa), Julidae and Blaniulidae. Amongst species from the latter two families were the NW European *Blaniulus guttulatus* and *Cylindroiulus*. 

Figure 7.2.1. Relative importance of each family in the alien (right side) and native (left side) myriapod fauna in Europe. Number near the bar indicates the number of species. Families are listed in a decreasing order based on the number of alien or, in alternative, native species.
londinensis (both from Australia) and Ommatoiulus moreletii (originating in the Iberian
Peninsula, introduced to Australia in 1953 and now a pest species there; in this list
reported from both that country (tree fern) and South Africa (melon fruit)).

Man-aided introductions of species from one part of Europe to another have played
a prominent role. One of the most common synanthropic centipedes in North Europe
is the Mediterranean “house centipede” Scutigera coleoptrata (Linnaeus, 1758). It has
been introduced to a number of North European cities, e.g., Copenhagen, Edinburgh,
Aberdeen, Leiden, etc., where it survives only in buildings. The earliest record in the
British Isles of this species is perhaps that by Gibson-Carmichael (1883) who recorded
it from a paperworks near Aberdeen. It could have been established there already for 25
years and arrived in bundles of rags from South Europe (Barber 2009a); at the present
time it is sporadically reported from inside buildings in various parts of Britain and
seems to be common in houses in St. Peter Port (Guernsey) and St. Helier (Jersey) in
the Channel Islands from where it has also been reported from outdoor sites. Other
cases of south or central European species being introduced to northern countries that
perhaps still survive only in buildings, hothouses, gardens or similar man-made habi-
tats are: Tuoba poseidonis (Verhoeff, 1901) in Finland, Dicellophilus carniolensis (C.L.
Koch, 1847), Lithobius lucifugus L. Koch, 1862, Lithobius peregrinus Latzel, 1880, Ha-
plopodoiulus spathifer (Brölemann, 1897) and Cylindroiulus salicivorus Verhoeff, 1908
in Great Britain, Cylindroiulus vulnerarius (Berlese, 1888) in Sweden, Pachyiulus varius
(Fabricius, 1781) in Norway, etc. (Barber 1995, Barber and Eason 1986, Barber and

Even within the same geographic area some indigenous species occur at localities
that are not part of their primary distribution area, most probably as a consequence
of accidental anthropogenic introductions. Examples are the records from Italy of
Lithobius infossus Silvestri, 1894 near Padua (Minelli 1991), of L. peregrinus Latzel,
1880 in northeastern and central Italy (Minelli 1991, Zapparoli 1989, Zapparoli
2006), of Pleuroliothobius patriarchalis (Berlese, 1894) in the Egadi, Pontine and Cam-
pania islands (Zapparoli and Minelli 1993), and of Scolopendra cingulata near Milan
(Manfredi 1930).

Island invasions by continental species is another phenomenon worth mention-
ing. Eason in a study on the Icelandic fauna, concluded that most centipede and
millipede species probably arrived by human transport (Eason 1970). Examples of
recent introductions to Iceland are Geophilus truncorum Bergsøe & Meinert, 1866,
Polydesmus inconstans Latzel, 1884, and Brachydodesmus superus Latzel, 1884, which “…
have only been found on Heimaey, one of the Vestman Islands, which supports a
town and where casual introduction by human transport is likely: they have probably
been introduced quite recently and the two millipedes seem still to be confined to
the outskirts of the town”. Regarding the other two possibly allochthonous species,
Lithobius forficatus (Linnaeus, 1758), and Lithobius erythrocephalus C.L. Koch, 1847,
Eason wrote, “these two species may be confined to the south owing to the relatively
warm and humid southern climate, but their restricted distribution might also be
explained by their having been introduced by Norse settlers ...”. The first Norse set-
tlements on Iceland were established in the ninth century A.D., so this must have happened after that time.

According to Enghoff (2008b), of the 21 species of centipedes recorded in Madeira 17 are introduced and 2 are probably introduced. High rates of introduction are also known for the Azores and Canary Islands (Borges and Enghoff 2005, Zapparoli and Oromi 2004) (Table 7.2.3). All symphylans on the Canary Islands have been considered as possibly introduced. Likewise, only two of 21 millipede species are considered native on the Azores (Enghoff and Borges 2005).

The geophilomorph centipede *Nyctunguis persimilis* Attems, 1932 was originally described from Turkey and has not been found there since in spite of the active work of the second author who has published several papers on the Turkish centipede fauna during the last 20 years. Taking into account that the species was recently found in synanthropic habitats in the outskirts of Vienna (Christian 1996) and that all other congeners occur in the Nearctic region, it is very likely that the type locality (the surroundings of Ankara, Turkey) is erroneous and the material was actually mislabeled (Zapparoli 1999).

*Mecistocephalus maxillaris* (Gervais, 1837), one of the first alien centipedes to be recorded in Europe, is another poorly known species. It was described from the gardens of the Muséum National d'Histoire Naturelle, Paris, and subsequently recorded from numerous places around the world. However, most of the records were certainly based on misidentifications with the morphologically similar *M. guildingii* or *M. punctifrons* actually being involved (Bonato et al. 2009). According to Bonato et al. (2009), most of the records in Europe e.g., those from Germany, Great Britain, France (not the type specimen but material taken subsequently from a greenhouse in the Paris Museum, cf. Brolemann 1930) and Portugal (Madeira), are referable to *M. guildingii*, while those from the Netherlands and Denmark require further clarification.

The actual taxonomic status and native range of *Ghiyaroviella cf. valiachmedovi* remains uncertain. The same applies to the millipede *Chondrodesmus cf. riparius* which shows some differences from the original description by Carl (1914) and its identity cannot be clarified without a comprehensive review of the entire genus (Enghoff 2008a).

### 7.2.3. Temporal trends in the introduction of alien myriapod species to Europe

Introductions of alien myriapods into Europe probably began several centuries ago, even though a precise arrival date is hard to determine. Only 10 out of 40 species were recorded for the first time in Europe in the 19th century while most of the records date from the 20th (26 species) and 21st centuries (4 records).

Gervais was virtually the first person to record alien myriapods in Europe (Gervais 1836, 1837). He described the tropical millipede *Iulus lucifugus* (now *Paraspirobolus lucifugus*) and the geophilomorph centipede *Mecistocephalus maxillaris* from greenhouses of the Paris Museum. The means of arrival of both species remains obscure but
must be linked to the establishment of the greenhouses and the planting of tropical flowers, perhaps already by the end of the 18th century. *P. lucifugus* has been subsequently recorded in intervals of around 60–70 years from greenhouses near Hamburg (Latzel 1895), Hortus Botanicus Amsterdam (Jeekel 1977), a greenhouse in Copenhagen (Enghoff 1975b), and more recently from the Tropical Biome at the Eden project (Lee 2006). This can hardly be regarded as reflecting the actual course of colonization but rather the date of investigation and the level of effort involved in each case.

The only alien millipede that has invaded some natural ecosystems in Europe and acclimatized is the East Asian species *Oxidus gracilis*. Perhaps the earliest records of this species in Europe are those of Tömösváry (1879) from the Margaret Island in Danube, Hungary, and of Latzel (1884) from greenhouses in Zeist, Utrecht, and Amsterdam in the Netherlands. Subsequently it was also found in Edinburgh in 1898 and in Kew Gardens in Great Britain (Evans 1900, Pocock 1902). In Finland the species was first recorded in 1900, but since the sample already contained several specimens the species must have arrived there at least two years earlier (Palmén 1949). The mechanism of dispersal of the species within Europe is certainly related to the trading and growing of tropical plants in the greenhouses as in some places this process must have happened more than once. According to Palmén (1949), the population of *O. gracilis* in the greenhouses of Hanko, South Finland went extinct during the period 1939–1943 when they were not kept warm. In 1946 a single female was found in a greenhouse with plants imported from Belgium, in 1947 its numbers increased considerably and the next year it was already very abundant in the whole greenhouse complex.

Golovatch (2008) suggested that the intense trade ties between the ancient town of Khersonesos in the Crimea and the town of Pergam (= Bergama), a major centre of red ceramics production of the time in present-day Turkey, as possible pathways for the introduction of *Eurygyrus ochraceus* in the Ukraine. He also pointed out that the Bulgarian population near Varna may owe its origin to the very active commerce in Roman times between Bergama and the colonies in Moesia (= currently northern Bulgaria and southern Romania), including Odessos (= Varna). The area and trade connections were already quite developed by the mid-4th century B.C. or even earlier, under ancient Greeks, so this introduction must have happened around that time.

Members of the genus *Lamyctes* are represented in Europe only by parthenogenetic populations. Males of *L. emarginatus* are known only from Macaronesia, New Zealand, Tasmania and Hawaii (see also Attems (1935) and Zapparoli (2002) for the record of a single male from Greece), while males of *L. coeculus* are only known from a greenhouse in Italy and from Cuba (Enghoff 1975a). Taking into account that the entire family Henicopidae is predominantly distributed in the Southern Hemisphere, and presuming that the regions where males are being found are the native areas of the species, *L. emarginatus* could have been introduced to Europe from one of the above regions, most likely from Australia or New Zealand. The earliest confirmed record is from Denmark in 1868 (see Meinert 1868). *Lamyctes coeculus* was first found in a greenhouse in Italy at the end of 19th century (Brölemann 1889), but its presence in the area would have been older. It has been recently found in Great Britain (Barber 2009b).
The earliest records of *Cylindroiulus truncorum* in Europe date from the 1920’s and, according to Schubart (1925), the Central European populations are probably of relatively recent origin. In Finland it was first reported in 1945 and in the following three years its numbers increased considerably. It is completely lacking in older collections (Palmén 1949).

One of the recent introductions is the large Neotropical millipede *Chondrodesmus* cf. *riparius* which was first recorded in 2000 in a flowerpot in the telephone office of Umeå University, northern Sweden. It was found again elsewhere in Sweden in 2006 and, later, in January 2007, it was also recorded in a flowerpot with a palm (*Phoenix robbelini*) in an office in Copenhagen and in a flowerpot in Bonn (Enghoff 2008a). There are further records of the species from flowerpots in Germany and also a recent one in Norway (Göran Andersson in litt.), so it seems that the species is dispersing well with palm pots.

The study of the invertebrate fauna of Kew Gardens, Great Britain began already at the beginning of 20th century with papers by Pocock (1902, 1906) and continues today (Blower and Rundle 1980, 1986, Read 2008). Some of the species recorded by Pocock such as *Scolopendra morsitans*, *Trigonius corallinus* and *Asiomorpha coarctata* have not been re-found since then and most likely could not become established in Kew Gardens. At the same time *Paraspirobolus lucifugus*, *Amphitomeus attemsi*, *Cylindrodesmus hirsutus*, *Rhinotus purpureus* and *Pseudospirobolellus avernus*, species not previously known from Britain have been recorded recently in the Tropical Biome at the Eden project in Cornwall (Read 2008, Barber 2009b, Barber et al. 2010).

### 7.2.4. Biogeographic patterns of the myriapod species alien to Europe

Records of exotic species are not evenly distributed in Europe but this is mainly due to the different levels of investigation of this area. The highest number of species (25) has been recorded from Great Britain, followed by Germany with 12, France with 11 and Denmark with 10 alien myriapods (Figure 7.2.2). In general, northern and economically more developed countries with high levels of imports and numerous busy sea ports are richer in alien species. These countries also, in general, have poorer native faunas meaning that a small number of aliens can constitute a large percentage of the fauna. Several species are hitherto known in Europe from a single country only, e.g. *Prosopodesmus panporus*, *Pseudospirobolellus avernus*, *Tygarrup javanicus* and *Cryptops doriae*, which implies recent introductions or poor dispersal abilities. Others, such as *Eurygyrus ochraceus*, *Paraspirobolus lucifugus* and *Lamyctes coeculus*, have a larger but yet fairly restricted distribution limited to two or more countries. The most widespread species are the parthenogenetic centipede *Lamyctes emarginatus*, whose range in Europe spreads from the Urals to Iceland [outdoor species], and the bisexual millipede *Oxidus gracilis*, reported from 33 countries, including several Mediterranean islands.
The various alien myriapods have different origins, but most of them show tropical or subtropical links (28 species, 70%). Eight of them (20%) are widespread in the Tropical and Subtropical belts, very often introduced by human agency to islands and synanthropic areas on continents. Their native range cannot so far be determined with certainty (Figure 7.2.3). Eleven (circa 28%) alien myriapods are of Asian origin, the majority (10 species) having their native range in East or Southeast Asia, and only one from West Asia, namely Anatolia. *Cylindroiulus truncorum* is perhaps the only North African myriapod introduced to Europe just as *Brachyiulus pusillus* (Leach, 1814) so far is the only European julid introduced to North Africa (Akkari et al. 2009). The only species that seems to be an Australasian native (Australia and New Zealand) is *Lamyctes emarginatus*. Among henicopids, *Rhodobius lagoi* and *Ghilaroviella* cf. *valischmedovi* are of particular interest being members of monotypic genera and the only representatives in Europe of the subfamily Anopsobiidae which comprises chiefly species with Gondwanan distribution patterns. Besides *Rhodobius*, four other monotypic genera represent the subfamily in the Northern Hemisphere, occurring in Vietnam, Japan, Kazakhstan, and Tajikistan (Edgecombe 2003, Farzalieva et al. 2004). Of Central or South American origin are seven species (circa 18%), and one each from North America and islands in Indian Ocean. The sole record of the pantropical geophilomorph centipede *Orphnaeus brevilabiatus* in Europe comes from Bohuslän, a Swedish province in the northern part of the W coast, where the animal was collected in the 19th century (Andersson et al. 2005).

Ten centipedes and millipedes have been considered as cryptogenic (= species of unknown origin which cannot be ascribed as being native or alien). Some of them such as the geophilid *Arenophilus peregrinus* and the schendylid *Nyctunguis persimilis*, which have only been reported from the Isles of Scilly, Great Britain and Austria respectively (Barber 2008, Christian 1996) whereas all the other species of these genera live in North America, are of likely Nearctic origins. Another suspected introduction of uncertain origin is *Nothogeophilus turki* which has hitherto been known only from Scilly and the Isle of Wight, Great Britain (Lewis et al. 1988) and represents a monotypic genus. However, we cannot completely exclude the possibility that some cryptogenic species suspected to be alien are actually native to Europe. Support for this notion we find in the scolopendromorph centipede *Theatops erythrocephalus* C.L. Koch, 1847, which occurs in various natural habitats (including caves) in the Pyrenees and the western part of the Balkans (with a gap between these geographic areas), while all its other four congeners occur in North America (Minelli 2006).

Unknown also is the origin of the symphylid *Hanseniella oligomacrochaeta* described from a hothouse in the Botanical Garden in Berlin; according to Scheller (2002), all species in the genus *Hanseniella* have tropical-subtropical distributions. The haplodesmid *Prosopodesmus panporus* is only known from the Royal Botanic Gardens in Kew, England, while its other described congener, *P. jacobsoni* Silvestri, 1910, is pantropical (Golovatch et al. 2009). Likewise, it is uncertain whether *Napocodesmus endogeus*, a millipede described solely from females collected in the garden of Cluj University, is a European native or not. According to Tabacaru et al. (2003), the generic allocation
of the second species described in the genus, *N. fl  orentzae* Tabacaru, 1975, hitherto known from Romania and Moldova, is not certain and since there are no other records of *N. endogeus* in nature it might be an introduced species.

### 7.2.5. Pathways for the introduction of alien myriapod species in Europe

All of the alien myriapods have most probably been accidentally introduced to Europe with plant material in relation to human activities and trade between Europe and other continents such as Asia, Australasia and the Americas. This process must have begun with an increase in trade between ancient Greek and Romans with cities in Asia Minor and North Africa and should have intensified in post-medieval times with the trade between Europe and some East Asiatic countries (e.g. Japan, China) and the geographic discoveries of the Americas and, later, of Australia. This process is still going on with
the trade of tropical flowers and other plants and their cultivation in houses and green-
houses or with the importing of goods from tropical countries. Even large species could
be transported this way, as is the recent case of the discovery of the largest centipede
*Scolopendra gigantea*, found in 2005 in a house in London, which is thought to have
arrived with a cargo of electrical goods or fruit (BBC News 2005). Pocock (1906) sug-
gested the possible countries whence a variety of alien species found in Kew Gardens
were introduced with their host plants: India (*Scolopendra morsitans, Mecistocephalus
guildingii*), Sri Lanka (*Chondromorpha kelaarti*), Barbados (*Anadenobolus monilicornis*),
Saint Vincent Island (*A. vincenti*).

The distribution of the alien diplopods in Europe shows that all the species living
here in greenhouses are much more widespread compared to e.g. the restricted outdoor
species *Eurygyrus ochraceus*. It is also likely that the obligate thelytokous parthenogen-
esis (= sexual reproduction giving rise to females only) shown in continental Europe
by several of the exotic millipedes and at least one of the centipedes has facilitated
their survival during transport and their establishment on the continent. However,
bisexual populations are known from the Azores and the Canary Islands for *Lamyctes
emarginatus* (Enghoff 1975a). Species from other centipede orders, such as the mecis-
tocephalid *Tygarrup javanicus* also presumably reproduce by parthenogenesis since so
far only females have been found in the hothouse at the Eden project, in Great Britain
(Barber 2009b).

The number of exotic diplopods in Europe is far smaller (3–4 times) than
that of European species introduced to other continents. Apparently, this could
mean that the arrival and, especially, becoming resident in Europe is much more
difficult than the converse process. The asymmetry has probably nothing to do
with quarantine controls at European borders. Instead, it may be due to specific
ecological and biological patterns exhibited by the successful invaders. Many of
the alien millipedes and centipedes which have successfully invaded Europe be-

![Figure 7.2.3. Geographic origin of the myriapod species alien to Europe (in percent).](attachment:image.png)
long to genera moderately rich to rich in species, such as *Poratia, Chondrodesmus, Lamyctes, Cryptops*, etc. A pertinent question arises as to why often only one species succeeds in establishing populations on foreign continents, sometimes becoming quite widespread to even cosmopolitan, whereas its rather numerous congeners fail to do so. Specific adaptive ecological patterns may be an issue, but, as noticed

**Figure 7.2.4.** *Scolopendra gigantea* Linnaeus, 1758 [Chilopoda: Scolopendromorpha: Scolopendridae] caught in 2005 in apartment in London, perhaps arrived with a cargo of electric goods or fruit. Source: BBC News: http://news.bbc.co.uk/go/em/fr/-/1/hi/england/london/4201634.stm

**Figure 7.2.5.** *Tygarrup javanicus* Attems, 1929 [Chilopoda: Geophilomorpha: Mecistocephalidae]. United Kingdom: Eden Project, Cornwall. Credit: Anthony Barber.
above, obligate or opportunist parthenogenesis is probably a major trait favoring dispersal at least because a single founder juvenile or female is sufficient to arrive at destination and found a population. It has to be noted that the successful myriapod invaders tend to be among the smallest species, thus being more easily transported, better fitted to find a suitable microhabitat, and sometimes requiring a shorter time and even a smaller number of developmental stages to reach maturity (Golovatch 2009).
Figure 7.2.8. *Chondrodesmus cf. riparius* Carl, 1914 [Diplopoda: Polydesmida: Chelodesmidae]. Denmark: Copenhagen. Credit: Gert Brovad.

Figure 7.2.9. *Oxidus gracilis* (C.L. Koch, 1847) [Diplopoda: Polydesmida: Paradoxosomatidae]. Italy: Porto Badino (Borgo Hermada – Terracina). Credit: Massimiliano Di Giovanni.
Another possible pathway of the introduction of exotic myriapods to Europe is their intentional import as ‘pets’, and their further escape from pet keepers. Large *Scolopendra* spp., as well as some large and colorful millipedes of the orders Spirobolida, Spirostreptida and Sphaerotheriida are quite popular pet animals subjected to trade in pet shops. Although there are many guides and internet resources available for keeping and caring for exotic species, there is no reliable information about the importance of the ‘pet’ trade for the introduction of alien myriapods to Europe. However, the establishment of pet myriapods in the wild is in most cases very unlikely.

### 7.2.6. The most invaded ecosystems and habitats

Man-made artificial environments (pastures and cultivated lands, greenhouses, urban and suburban areas) constitute the main habitat types hosting alien myriapods (Table 7.2.1). Species of tropical and subtropical origin are likely to be restricted to greenhouses or equivalent artificially warmed habitats. Some of them, in the summer season in the southern countries perhaps could survive also outdoors in close proximity to the hothouses. However, 11 species have been reported from natural habitats in Europe, where they most likely were able to establish viable populations. So far the alien species of symphylans and pauropods are unknown in natural areas, which is not the case with several species of the other two myriapod classes. The millipede *Oxidus gracilis*, which is bisexual everywhere and is naturalized in several areas in Europe and in the Caucasus, has been found in forests close to suburban and urban areas (Tömösváry 1879), in woodlands of *Robinia pseudoacacia* in the Kanev Nature Reserve, Ukraine.
(Chorny and Golovatch 1993) and records from caves also exist (Strasser 1974, Vicente and Enghoff 1999). On the Canary Islands the species is quite widespread invading various, mostly dry and warm, habitats (Arndt et al. 2008). According to Palmén (1949), *O. gracilis* dies when subjected for 2 hours to a temperature of minus 4°C. This means that in North Europe the species can survive only in hothouse conditions.

*Cylindroiulus truncorum* mainly inhabits synanthropic habitats: greenhouses, gardens, parks, woodpiles, school grounds, cemeteries, spoil heaps, horticultural nurseries (Kime 2004, Korsós and Enghoff 1990).

*Eurygyrus ochraceus* occurs in the Crimea only in a patch of semi-natural xerophytic vegetation ca. 1 km long and 100–300 m wide along a watershed. It was reported to be rather common, although not too abundant on the site and is definitely an anthropochores (Golovatch 2008).

*Lamyctes emarginatus* shows remarkable plasticity regarding the surrounding environment, although in the British Isles there is preponderance of rural records in comparison with (sub)urban ones. In artificial habitats it has been reported from gardens, roads, roadside verges, hedges, embankments, crops of *Zea mays* and *Medicago sativa*, even in human rubbish (Eason 1964, Minelli and Iovane 1987, Barber and Keay 1988). In natural habitats it lives in various woods (deciduous or mixed coniferous/deciduous) and has also been recorded from open and coastal areas (Barber and Keay 1988, Zerm 1997, Zapparoli 2006). According to Andersson (2006), it predominates in open and disturbed areas with sparse vegetation. A great many of these localities

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**Figure 7.2.11.** *Trigoniulus corallinus* (Gervais, 1847) [Diplopoda: Spirobolida: Trigoniulidae]. Taiwan. Credit: Zoltán Korsós.
are associated with lake shores, river gravels or river banks. *L. emarginatus* shows clear preferences for temporarily flooded sites, no matter for how long the inundation lasts. Its appearance as a pioneer species on mine sites may indicate that the species shows preference to disturbed habitats (Zerm 1997). In close proximity to water pools the species abundance can reach 95% of all centipedes (Minoranskii 1977).

Two of the (presumed) alien geophilomorphs, *Arenophilus peregrinus* and *Nothogeophilus turki*, have been recorded in coastal areas, where they occur under stones and in soil close to rocky sea cliffs with sparse vegetation although *A. peregrinus* has been found inland in Cornwall in woodland and one of the Isle of Wight records for *Nothogeophilus turki* was from an area of demolished buildings with copious rubbish on the ground although no more than 5 m from the tidal river (A.N. Keay pers. comm.).

Considerable fluctuation in the abundance of some alien species have been observed by Barber (2009b) in the tropical hothouse of the Eden Project. *P. lucifugus* which was not found in 2003/4, was rather restricted in its occurrence in 2005, had become abundant throughout by 2009. Likewise, *C. doriae* which has been relatively uncommon and limited in occurrence in 2005 was the dominant species there in 2009. Conversely, *T. javanicus*, which had been abundant in 2005, was difficult to find in 2009 (Barber 2009b).

### 7.2.7. Ecological and economic impact

Alien myriapods are unlikely to pose major threats to native biodiversity and ecosystems. The number of species established in the wild being very limited (12 species, ca 30%) for the moment (Table 7.2.1). Diplopods are detritivorous animals, consuming 10–15% of the leaf litter in temperate forest and as thus contribute significantly to soil formation processes through the fragmentation of leaves which stimulates microbial activity. They may thus indirectly influence the fluxes of nutrients (Hopkin and Read 1992). Nevertheless, some alien diplopods could be harmful to cultivated plants, especially in the artificial habitats where temperature and humidity conditions allow species establishment and expansion. Invasive soil invertebrates may also have an impact on the structure and function of natural ecosystems. They can change soil carbon, nitrogen and phosphorus pools and can considerably affect the distribution and function of roots and microorganisms (Arndt and Perner 2008). In addition, mass occurrences and swarming, which have been observed in several countries in Europe, may have negative ecological and economic impact although the causes still remain obscure (Sahli 1996, Voigtländer 2005). An example of a plant-damaging alien myriapod is *Oxidus gracilis*, which is regarded as a pest in several European countries. This species is very common in greenhouses where its density may exceed 2500 ind./m². It is known for attacking vegetable and fruit crops such as sugar beet, potatoes, strawberries, cucumbers, orchard fruits, roots of wheat, and flowers in outdoor cultivated areas. Furthermore, several thousand *O. gracilis* were once found after rain in a house in Lenoir City, Tennessee, USA, with most of the city infested during the same outbreak (Hopkin and Read 1992). As a curiosity, one might also mention the report
by the classical writer Theophrastus, according to whom an army of millipedes once overran Rhoeteum in the present province of Çanakkale (northwestern Turkey) and drove its human inhabitants into the sea (Sharples 1994, Enghoff and Kebapçı 2008).

Several plants can withstand the attacks of symphylans but they may cause severe damage to growing crops both in fields and greenhouses (Scheller 2002). Arndt and Perner (2008) recently carried out a study on the impact of invasive ground-dwelling predatory species, including alien centipedes, in the native laurel forest habitat in the Canary Islands. They found that centipedes in laurel forests seem to be much more variable than carnivorous ground beetles since the 14 recorded species include representatives of three orders with very different characters. They tentatively recognised four functional groups of centipedes: a micro-cephalic schendylid type, (ii) a geophilid type with medium head size and extreme body length, (iii) a scolopendromorph type, and (iv) a macro-cephalic lithobiomorph type. These groups suggest patterns of invasion similar to the coleopteran predators: autochthonous and introduced species of the same size class and group are mutually exclusive (Arndt 2006).

The potential role of tropical giant millipedes and centipedes (*Scolopendra* spp.) kept as pets has been little analyzed as a source of health problems in relation to their defensive fluids or their bites which can cause pathological reactions if exposed to skin, mouth/throat or eyes (Rein 2002).

**Acknowledgements**

We thank Helen Read (Farnham Common, UK), John Lewis (Taunton, UK), Greg Edgecombe (London, UK) and Zoltán Korsós (Budapest, Hungary) for their helpful comments and shared literature as a result of which the manuscript was able to be significantly improved. John Lewis and Göran Andersson shared unpublished information on the presence of alien myriapods in UK and Norway, respectively. Darren Mann (Oxford, UK) provided a copy of Pocock’s report on Kew species and the paper by Clarke. We are grateful to Zoltán Korsós, Gert Brovad (Copenhagen, Denmark), Massimiliano Di Giovanni (Roma, Italy) and Massimo Vollaro (Viterbo, Italy) for providing photographs of some of the alien species.

**References**


Gervais P (1837) Études pour servir à l’histoire naturelle des Myriapodes. *Annales des Sciences naturelles, Zoologie (2e série), 7: 35–60, Pl. IV.*


Verhoeff KW (1933) Symphyla (Bronn’s Klassen und Ordungen Tierreiches 5(2), 3, 1). Leipzig: de Gruyter, 1–120.


Table 7.2.1. List and main characteristics of the myriapod 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). Only selected references are given. Last update 10/03/2010.

<table>
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<th>Invaded countries</th>
<th>Habitat</th>
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<td>J1</td>
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<td></td>
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<td>(Pocock, 1895)</td>
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<td>J100 Pocock (1906)</td>
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Table 7.2.2 List of myriapod species intercepted in Great Britain (Barber 2009a, Clarke 1938, John Lewis, pers. comm., Sharon Reid (FERA), pers. comm.)

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<td>Dicksonia (Australia or New Zealand, 2008)</td>
</tr>
<tr>
<td><strong>Order Geophilomorpha</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>?Zelanion (= Steneuryton) sp.</td>
<td>Australia, New Zealand, Hawaii</td>
<td>Dicksonia (Australia, 2005)</td>
</tr>
<tr>
<td><strong>Order Scolopendromorpha</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scolopendra cingulata Laterille, 1829</td>
<td>Mediterranean region</td>
<td>With luggage (Spain, 2003), potatoes (Greece, 1975), Turkey (2004), Palestine (pre-1992)</td>
</tr>
<tr>
<td>Scolopendra dalmatica C.L. Koch, 1847</td>
<td>Balkan peninsula</td>
<td>Found in fruit &amp; vegetable warehouse on Isle of Wight (1983)</td>
</tr>
<tr>
<td>Scolopendra subspinipes subspinipes Leach, 1815</td>
<td>Asia, Africa, C. &amp; S. America</td>
<td>Trachycarpus wagnerianus (South Korea, 2006), bananas (Jamaica, 1938)</td>
</tr>
<tr>
<td><strong>Order Lithobiomorpha</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lithobius forficatus (Linneaus, 1758)</td>
<td>Europe</td>
<td>Dicksonia (Australia, 2004)</td>
</tr>
<tr>
<td>Lithobius peregrinus Latzel, 1880</td>
<td>Europe, Caucasus</td>
<td>Dicksonia (New Zealand, 2004)</td>
</tr>
<tr>
<td><strong>Class Diplopoda</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order Polydesmida</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polydesmida gen. spp.</td>
<td></td>
<td>Dracaena fragans (Belgium, 1979)</td>
</tr>
<tr>
<td>?Mestosoma sp.</td>
<td>Bromeliad (Ecuador, 1982)</td>
<td></td>
</tr>
<tr>
<td>Akamptogonus novanae (Humbert &amp; Saussure, 1869)</td>
<td>? Australia</td>
<td>Dicksonia (New Zealand, 2004)</td>
</tr>
<tr>
<td>Habrodesmus fals Cook, 1896</td>
<td>West Africa</td>
<td>Tete leaves (Nigeria, 1981)</td>
</tr>
<tr>
<td>Habrodesmus sp.</td>
<td></td>
<td>Orchid (Malawi, 1982)</td>
</tr>
<tr>
<td>?Oxidus gracilis</td>
<td>?East Asia</td>
<td>Zelkova (Netherlands, 1995)</td>
</tr>
</tbody>
</table>
Table 7.2.3. Relative importance of the non-native species in the myriapod fauna of the Macaronesian islands. The numbers of introduced species correspond to the total non-native species of both exotic and continental European origin (cf., Arndt et al. 2008, Baéz and Oromí 2004, Borges, 2008a,b, Borges and Enghoff 2005, Enghoff 2008b, Enghoff and Borges 2005, Zapparoli and Oromi 2004), some numbers updated according to recent records. * 7 certainly native, 6 probably native, 20 possibly native, ** all probably introduced; *** all possibly native.

<table>
<thead>
<tr>
<th>Species</th>
<th>Native Range</th>
<th>Found in/ Country of dispatch/ Year of Interception</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polydesmidae</td>
<td></td>
<td>Dicksonia (Australia, 2005; New Zealand, 2004), Orchid (Malaysia, 1983), Wild Plant (South Africa, 1983)</td>
</tr>
<tr>
<td>Polydesmus sp.</td>
<td></td>
<td>Miscanthus (Dominica, 2000), Orchid (Australia, 1985)</td>
</tr>
<tr>
<td>Order Spirostreptida</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spirostreptida</td>
<td></td>
<td>Cyathea (New Zealand, 2005), Dicksonia (Australia, 2004–2008), Dracaena (Rwanda, 1980)</td>
</tr>
<tr>
<td>Spirostreptus sp.</td>
<td></td>
<td>Fig (Ivory Coast, 1983)</td>
</tr>
<tr>
<td>Plusioglyphius sp.</td>
<td></td>
<td>Orchids &amp; Rhododendrons (Borneo, 1979)</td>
</tr>
<tr>
<td>Order Julida</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blaniulidae</td>
<td></td>
<td>Echinodorus (Singapore, 2008), Orchid (Brazil, 2003)</td>
</tr>
<tr>
<td>Blaniulus guttulatus (Fabricus, 1798)</td>
<td>Europe</td>
<td>Orchid (Australia, 1985)</td>
</tr>
<tr>
<td>Blaniulus sp.</td>
<td>Unknown (South Africa, 1999)</td>
<td></td>
</tr>
<tr>
<td>Cylindroiulus londinensis (Leach, 1814)</td>
<td>Europe</td>
<td>Phoenix dactylifera (Italy, 2004)</td>
</tr>
<tr>
<td>Cylindroiulus sp.</td>
<td></td>
<td>Dicksonia (New Zealand, 2004)</td>
</tr>
<tr>
<td>Ommatoiulus moreletii (Lucas, 1860)</td>
<td>Iberian peninsula</td>
<td>Dicksonia (Australia, 2006), melon fruit (South Africa, 1983)</td>
</tr>
<tr>
<td>Ommatoiulus oxyppus (Brandt, 1841)</td>
<td>Italy</td>
<td>Vitis sp. (Italy, 1979)</td>
</tr>
<tr>
<td>Ophyiulus targioni Silvestri, 1898</td>
<td>Italy</td>
<td>Unknown (New Zealand, 1982)</td>
</tr>
</tbody>
</table>