

Ecology of Arachnida alien to Europe

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Abstract The ecology of selected species of spiders (Araneae), harvestmen (Opiliones), and the neglected tropical order Schizomida, alien to Europe, is discussed. Their geographic origins and pathways of introduction, by transportation with goods, are similar to other predatory terrestrial arthropods. Occurrence in buildings (synanthropy) is a prerequisite for range expansion in many arachnid species. Thelytokous parthenogenesis facilitated spread of a few spider, harvestman and schizomid species outside their native range. Both prey generalists and specialists (woodlice-eating *Dysdera crocata* and ant-eating *Zodarion rubidum*) are among species successfully expanding their range. Alien

arachnids include individual species belonging to many different families. We stress the absence of true invasiveness of alien arachnids in Europe. Some unusual adverse effects of alien arachnids were recorded, such as pollution of buildings and clogged car fuel system ventilation tubes. Frequency of painful biting and threat to native biota are low.

Keywords Invasive species · Neobiota · Non-indigenous species · Myrmecophagy · *Oecobius navus* · *Stenochrus portoricensis* · *Triaeris stenaspis* · *Zoropsis spinimana* · *Dicranopalpus ramosus* · *Leiobunum*

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Introduction

Most arachnids, except many mites (Acari), are predators and live in terrestrial habitats. Their predatory nature affects their potential to invade new regions. According to DAISIE (2009) there are 39 species of spiders (Araneae) identified as alien to Europe, as well as seven cryptogenic species, i.e., species of unknown origin (Carlton 1996). Moreover, DAISIE (2009) lists 42 European spider species which have become alien within Europe due to range expansion beyond their native region. Although these are usually viewed as alien by the public, they are considered as aliens by ecologists only if they were artificially introduced outside of their natural dispersal potential (Pyšek et al. 2008). Kobelt and Nentwig (2008) recorded 87 spider species unintentionally introduced to Europe. The Global Invasive Species Database (GISD) is more strict. It listed recently only two species of invasive spiders, both alien to North America: cryptogenic *Dysdera crocata* Koch and European *Linyphia triangularis* (Clerck) (ISSG 2011b).

DAISIE (2009) also identified 59 non-European plus five cryptogenic species of mites and ticks (Acari) alien to Europe, accompanied by three intra-European alien mites. An inventory of alien mites and ticks by Navajas et al. (2010) recognized 96 aliens to Europe plus five cryptogenic species. Altogether 23 of those species are predatory or parasitic. A North American list of invasive and exotic Arachnida (Invasive.org 2011) includes 31 species of ticks and mites. The GISD listed recently only two species of invasive mites, one phytophagous (*Raoiella indica* (Hirst)), and one parasitic (*Varroa destructor* Anderson and Trueman) (ISSG 2011b).

There is only one harvestman (Opiliones) species mentioned in the DAISIE (2009) inventory, moreover, it is only an intra-European alien. No species of any other arachnid order is recognized as alien to Europe or North America in the above-mentioned inventories and reviews.

We will focus here on the ecology of selected species of spiders (Araneae) and harvestmen (Opiliones) that are alien in Europe, and we also introduce the neglected tropical order Schizomida, which has established in European greenhouses. Acari are rather exceptional within the Arachnida due to being primarily non-predatory and having a small body size. Therefore, they are beyond the scope of this review.

Absence of invasiveness and rare deleterious effects

No alien arachnid species occurs within the list of the 100 most invasive alien species (*sensu* Pyšek et al. 2008, and Roy et al. 2011a), either in Europe (DAISIE 2009) or in the world (ISSG 2011a). There are economically important invasive species of mites, namely plant pests (spider mites, Tetranychidae) and bee parasites (*V. destructor*). However, no evidence is available for species from other arachnid orders alien to Europe of rapid range expansion or sudden population increases outside of the native range or of important damage to people or the environment. A number of non-indigenous species of arachnids recorded in central Europe are labelled as invasive simply because they are not native to the new country and habitat and they have become widespread.

Few alien spiders and harvestmen have the potential to cause damage to people or to represent a threat to biodiversity, which is by contrast common in other groups of predatory arthropods (see Haefliger et al. 2011). Harvestmen *Leiobunum* sp. is believed to displace native harvestmen (Wijnhoven et al. 2007). However, spiders may represent a specific type of threat that is rare or absent in other arthropods. Several spiders are of potential medical importance due to their venomous bites (Knoflach 2009). These include *Zoropsis spinimana* (Dufour) and *Cheiracanthium* spp., which are expanding their ranges within Europe from the Mediterranean. However, Vetter et al. (2006) mentions only five recorded bites by *Cheiracanthium* spp. between 1900 and 2006 for Europe and a review of international literature on confirmed bites revealed only a single bite by American *C. inclusum* (Hentz) with mild necrotic symptoms (Vetter et al. 2006). Theridiid spiders may inflict a painful bite, but except for the black widow (*Latrodectus* spp.), which is not invasive, they are not dangerous.

The Chilean recluse spider, *Loxosceles laeta* (Nicolet), is considered to be the most dangerous of introduced spiders. Its bite results in necrosis, and sometimes in severe systemic reactions including death. The spiders can survive a long time (often one month) without food or water (Lowrie 1980), a fact that has encouraged their spread all over the globe. In Europe it has been reported only from Finland. Two cases of skin necrosis arising after

supposed spider bites by *Loxosceles rufescens* (Dufour) were reported from France during the last decade (Pernet et al. 2010). This species of Mediterranean origin has expanded its range to a few temperate European countries and has been introduced to North America in the 1960s (Vetter et al. 2009).

The cosmopolitan alien *Oecobius navus* Blackwall and European range expanding mesh-web spider *Dictyna civica* (Lucas) cause problems of economic importance by reducing the aesthetic value of buildings. Their webs remain stuck to the facade of buildings, adhesive silk catches dust and debris, resulting in a patchy pattern that creates a dirty impression (Samu et al. 2004).

In March 2011, the Mazda company initiated a recall of 65,000 automobiles after silken retreats of black-footed yellow sac spider (*C. inclusum*) were found to have clogged fuel system ventilation tubes (NHTSA 2011). It is unclear why the spiders were drawn to build retreats inside this particular vehicle, but the problem appeared to be widespread, though rare, across the US (Hsu 2011).

Modes of expansion

The modes of range expansion in arachnids vary. Although arachnids are not active fliers some spiders and mites have evolved a very efficient means of transport. Small web-building spiders naturally spread by means of ballooning—flying in the wind using silk threads. By this means they can be transported hundreds of kilometres with the help of air currents (Bell et al. 2005). However, ballooning is not regularly used by large invasive species (Walter et al. 2005). Such species and non-ballooning species must have used other means, in particular human-mediated transfer (cf. Rabitsch 2011).

Alien arachnids have been mostly non-intentionally introduced as contaminants and stowaways. A number of arachnid species have been shipped to Europe as a result of global trade (Kobelt and Nentwig 2008). Thus, as with invasive beetles (cf. Evans 2011), humans are directly or indirectly responsible for most spider introductions. Potted plants and container shipments with manufactured goods are important modes of introduction for exotic arachnids (Kobelt and Nentwig 2008; Nentwig and Kobelt 2010).

Although spiders are considered important natural enemies of invertebrates (e.g. Birkhofer et al. 2008), their biocontrol potential is limited because great majority of species are polyphagous and have an insufficient numerical response to prey—are incapable to reproduce as quickly as their prey and have long development times (Riechert and Lockley 1984). Unlike some other predators and parasitoids (cf. Roy et al. 2011b) arachnids (again except mites, such as Phytoseiidae) are not being intentionally released as biological control agents.

Geographic origin

Thirty-three percent of alien spiders have an Asian origin (Nentwig and Kobelt 2010) compared to 28% of all predatory and parasitoid aliens (Roy et al. 2011b). About 20% come from North America (cf. 23%) and 20% from Africa (cf. 16%), thus arachnids alien to Europe seem to comprise a typical geographic composition of alien predators and parasitoids. However, Kobelt and Nentwig (2008) found the eastern Palaearctic and the Indomalayan regions provided a significantly higher number of introductions than expected, whereas the Nearctic, Neotropical, and Afrotropical regions provided a significantly lower number of introduced species than expected, based on trade volume, area size, and geographical distance. The origin of 15% of spiders alien to Europe is doubtful or unknown, comparable to the global proportion of cryptogenic alien predators and parasites in Europe (Roy et al. 2011b).

About 45% of alien spiders in Europe originate from temperate habitats and 55% from tropical habitats. Synanthropic species, i.e. house dwelling and greenhouse dwelling ones, are clearly shipped from climatically different regions. Many such species are constantly being transported to new regions, but only about twenty have established stable populations (Blick et al. 2006). These species cannot survive under natural conditions, especially the cool climate, of temperate zones. They are therefore closely associated with heated buildings. Accidental introductions of large mygalomorph spiders with banana or other fruit shipments have received a large amount of attention from the public, but these species have never established in European countries.

Thaler-Knoflach (2010) reports that of 87 spider species introduced to Europe, 71% were synanthropic. Several spider species (*Pholcus phalangioides* (Fuesslin), *Psilochorus simoni* (Berland), *Parasteatoda tabulata* (Levi), *P. tepidariorum* (Koch), *Steatoda grossa* (Koch), *S. triangulosa* (Walckenaer), *Dysdera crocata* and *Oecobius navus*) became cosmopolitan.

Taxonomic affiliation

Spiders alien to Europe belong to many diverse families, including species-poor ones. Among them, the Theridiidae is the best represented family (13 species according to Kobelt and Nentwig 2008), Pholcidae being the second (nine species). Alien species of both families typically inhabit human buildings (i.e., are synanthropic) and include cosmopolitan aliens. Generally, synanthropic species are much better represented than free-living ones among spiders alien to Europe (Kobelt and Nentwig 2008).

The families Sparassidae, Salticidae, Linyphiidae, and Oonopidae include each about five alien species. These are mainly single alien species from well represented families. There are few examples of two or more congeneric species expanding their ranges: cosmopolitan *Pholcus phalangioides* and European *P. opilionoides* (Schrank); cosmopolitan *Steatoda grossa*, *S. triangulosa* and European *S. castanea* (Clerck); cosmopolitan *Tegenaria domestica* (Clerck) and other four intra-European aliens of this genus.

Interestingly, there are no true alien orb-weaver spiders (Araneidae) in Europe. However, the intra-European alien araneid *Argiope bruennichi* (Scopoli) that has expanded over Europe partially by natural spread, partially by human aid (Borges and Wunderlich 2005; Nentwig et al. 2010) is very successful and attracts public attention due to the conspicuous colouration and decorative web structures.

The family Theridiidae includes significantly larger alien species than native European spiders of the same family. There is a similar trend towards larger body size for alien species compared to the native spiders for other families (Kobelt and Nentwig 2008).

It seems that more general biological characteristics of higher taxa (families and genera) do not provide much information with which to predict which arachnid species may become aliens or even

invasive. Except for a synanthropic way of life and large body size, the characters of individual species that enable them to move to and establish in new areas are rather specific. In the following section, we review the ecology of several selected arachnid species with diverse origins.

Cosmopolitan species

Dysdera crocata

Spiders of the genus *Dysdera* (Araneae: Dysderidae) are clumsy cursorial predators, foraging on the ground at night. During the day they shelter themselves in silken retreats under stones or in gravel covered with organic material (Cooke 1965a). *Dysdera* spiders are characterised by a long life (three years) and relatively low fecundity (60 eggs) (Cooke 1965a).

The majority of species of the genus are prey specialists among spiders, eating woodlice (Crustacea: Isopoda) (Bristowe 1958; Cooke 1965a, b, c; Hopkin and Martin 1985; Pollard et al. 1995; Raupach 2005; Řezáč et al. 2008b). Woodlice proliferate most in habitats rich in calcium, including the vicinity of human buildings. Because *Dysdera* tend to attach silken retreats to objects lying on the ground, which include shipped goods, such as stone, bricks or wood in semi-synanthropic habitats, these species are often accidentally transported.

Except for the cosmopolitan *Dysdera crocata*, all 240 species of the *Dysdera* genus are restricted to the Palearctic region. Most species are restricted to small areas in the western part of the Palearctic region, mainly in the Mediterranean (Deeleman-Reinhold and Deeleman 1988; Platnick 2011). Remarkably small distribution areas demonstrate the inability of *Dysdera* to disperse long distances naturally. Dispersal by ballooning has never been reported for *Dysdera* spiders (Bell et al. 2005; Řezáč et al. 2008a).

Dysdera crocata occurs only in relatively dry, synanthropic, or semi-synanthropic and adjacent habitats. It represents the most extensive case of range expansion among spiders. It has been introduced to synanthropic habitats of all continents except for Antarctica (Cooke 1967; Hutchinson and Cayouette 1993; Řezáč et al. 2008a). This species was described from Greece in 1838, but at that time it

had probably been already distributed by man all over the world. It is thus a typical cryptogenic species, but based on the distribution of its closest relatives, the autochthonous area of *D. crocata* is probably in the southern part of the Mediterranean, perhaps in northern Africa. The reason why only a single species of this genus has spread so widely is unknown. Expansion of this species to areas with endemic *Dysdera* species was expected to lead to their extinction (Cooke 1967; Macías-Hernández et al. 2008), but there is no evidence yet for such adverse effects.

Oecobius navus

There are 79 species of the genus *Oecobius* in the world (Platnick 2011). Two of these species have become cosmopolitan (*O. cellariorum* (Dugés) and *O. navus*) and two other species (*O. concinnus* Simon and *O. marathaus* Tikader) are pantropical. *Oecobius navus* has attained the largest distribution. It has spread from North Africa to other parts of the world mostly with a subtropical and tropical climate (Shear and Benoit 1974), namely South and North America (Santos and Gonzaga 2003), Australia (Voss et al. 2007), South Europe (Blick et al. 2004), and South Asia (Platnick 2011).

Spiders of this genus are tiny, building silken retreats with signal threads on a flat surface. *Oecobius navus* is frequently associated with urban areas, such as the walls of buildings (Voss et al. 2007). It lives in a tent-like web but does not use the web for prey capture. Instead, it only uses bands of silk to restrain prey (Hingston 1925). Available anecdotal data on its prey from Southern Europe and Australia suggests that the most common food items are ants (Glatz 1967; Voss et al. 2007). Myrmecophagy is further supported by laboratory observations where these spiders did not consume other arthropods but only ants (Glatz 1967).

Investigation of trophic niche in two distinct populations of *O. navus*, one in southern Europe (Portugal) and the other in South America (Uruguay) (Sentenská, unpublished) revealed local trophic specialisation and versatile capture strategies at different locations: the Uruguayan population is a myrmecophagous specialist, but the Portuguese population contradicted this view as this population captured mainly dipterans. In both locations *O. navus* spiders also captured members of other insect orders as prey,

though these orders were represented at a markedly lower frequency. The fundamental trophic niche of this species is wide suggesting that *O. navus* is a euryphagous predator, geographically variable, locally specialised on the most abundant prey.

In conclusion, affinity to building material has likely promoted the dispersal of cosmopolitan *Oecobius* spp. outside the native area. Predatory versatility and wide trophic range has probably enabled utilisation of a variety of local prey. Ants that are present in all kinds of terrestrial habitats and are often superabundant (Hölldobler and Wilson 1990) simply became often the prey of *O. navus* and other cosmopolitan *Oecobius* species (Glatz 1967). *Oecobius navus* is thus considered a facultative myrmecophage.

The high abundance of retreats on the wall facades might have negative aesthetic effects. Retreats remain stuck to the facade even after the death of spiders. Adhesive silk catches dust and debris turning the webs darker in comparison with the light colours of some facades. This results in a patchy pattern that creates a dirty impression.

Tropical arachnids in European greenhouses

Schizomida

The Schizomida are a small and neglected arachnid order, containing 258 species in 46 genera. There are many more species awaiting discovery (Harvey 2007). They are exclusively known from the tropical and subtropical regions, where they inhabit leaf litter, space under rocks and logs, caves (Rowland and Reddell 1980) and abandoned termite or ant nests (Reddell and Cokendolpher 1995). Their occurrence is limited mostly by availability of sufficient moisture (Vine et al. 1988). Some species have been accidentally introduced to greenhouses in the temperate zone, by being brought with plants or soil from their original habitat. Although these species have been introduced by human transport to a region which is not their native one and have established populations here, they should be considered as neobiota rather than invasive species. They are not able to survive outside the greenhouses and therefore cannot spread to natural habitats in the temperate zone.

Three schizomid species have been recorded in greenhouses in Europe. *Schizomus crassicaudatus*

(Cambridge) was imported to France from Sri Lanka, *Zomus bagnallii* (Jackson) was introduced to Great Britain from South-east Asia (Blick 2010). The third species, *Stenochrus portoricensis* Chamberlin naturally occurs in Mexico and the Caribbean (Rowland and Reddell 1980; Martín and Oromí 1984; Reddell and Cokendolpher 1995; Tourinho and Kury 1999), but has been introduced into many countries of South and North America and even to Europe. It has been reported from Spain (Canary Islands), Great Britain, Germany (Blick 2010) and the Czech Republic (Korenko et al. 2009a; Sentenská and Líznavá 2010). In its original region, it has been collected from termite and ant nests (Reddell and Cokendolpher 1995; Santos et al. 2008), even disturbed habitats (Tourinho and Kury 1999). In continental Europe, the species occurs only in heated greenhouses, but in the Canary Islands it has been found in caves and inside houses (Oromí and Martín 1992).

Although both sexes have been described in most schizomid species, only females have been found in many introduced populations (Rowland and Reddell 1980; Reddell and Cokendolpher 1995; Armas 2004), which suggests they can breed parthenogenetically (Reddell and Cokendolpher 1995). Parthenogenesis likely enables *S. portoricensis* to spread and provides a better chance to establish new populations. Development is very slow, it can take 2–3 years (Rowland 1972).

Schizomids are considered to be predators, but laboratory observations reveal preferences for freshly killed or maimed prey. They were also able to catch very small intact, live insects such as small termites, psocids and zorapterans (Brach 1976) which inhabit the litter too.

Triaeris stenaspis

The spider genus *Triaeris* contains 18 tiny cursorial species all occurring only in the tropics. Of these only a single species, *T. stenaspis* Simon has become resident in Europe. This species was first described from the Caribbean island of St. Vincent and it occurs from USA to Venezuela and in the West Indies (Platnick 2011). In Europe, the species has always been found inside heated greenhouses, in Great Britain, France, Finland, Slovakia, and the Czech Republic (Miller and Žitňanská 1976; Heimer and Nentwig 1991; Koponen 1997; Korenko et al. 2007).

Triaeris stenaspis passes through three juvenile instars, each lasting approximately a month. As the longevity of the adult stage is on average six months there should be approximately three overlapping generations per year. The species is eurychronous and females have iteroparous (multiple) reproduction. Eggs are laid in pairs. The lifetime fecundity of females is on average 27 eggs (Korenko et al. 2009b).

As only females of this species had been so far collected, Koponen (1997) suggested that it is parthenogenetic. Later, thelytokous parthenogenesis was proved in this species as all laboratory reared spiders developed into females and these, although kept isolated, laid fertile eggs (Korenko et al. 2009b). It is not known whether *T. stenaspis* is parthenogenetic also in its native range, in the Caribbean, as the male of this species has not been found yet (Platnick 2011), but as females of *T. stenaspis* possess fully developed copulatory organs (Korenko et al. 2007), this indicates that parthenogenesis might be only a recent apomorphy of populations expanding outside their native range.

There was a considerable genotypic variation found in life history traits (fecundity, fertility, longevity), comparable with traits found in sexually reproducing spider species (Korenko et al. 2009b). A single cost of parthenogenesis was recognised, i.e., low fertility amounting to 60%. This cost seems to be negligible in comparison with the benefits as this species of spider has produced viable populations over Europe.

Mediterranean arachnids alien to temperate Europe

Zodarion rubidum

Spiders of the subfamily Zodariinae are all considered stenophagous ant- or termite-eaters (Jocqué 1991). They are mainly distributed in Africa and in the Arabian Peninsula where, for example, representatives of the genus *Trygetus* specialise on *Monomorium* ants (Pekár et al. 2005a).

Zodarion spiders (Araneae: Zodariidae) are cursorial hunters with body size of about 5 mm. They occur mainly in the Mediterranean, where they likely originally diversified (Denis 1951). Most of the 130 species seem to have small distribution ranges, restricted to a few hundred square kilometres

(Bosmans 1994; 1997). Only a few species extended their range beyond the Mediterranean (Snazell and Bosmans 1998; Askins 1999; Řezáč 2002; Pekár et al. 2005b).

A single species, *Z. rubidum* Simon, that has been described from northern Spain, currently has a nearly pan-European distribution. It has also been introduced and is slowly spreading across North America (Vogel 1968; Cushing and Santangelo 2002; Paquin and Dupérré 2006).

The spread of this species in Europe and North America is suspected to be by means of trains, as it has been often found on railway lines or in ruderal habitats in close proximity to railways (Pekár 2002). *Zodarion* spiders shelter themselves and their eggs from predators in igloo-shaped retreats which they attach to a solid substrate, so *Z. rubidum* individuals could likely attach their retreats to shipped goods, such as stones, bricks, wood, cans, etc., and thus become transported. A second possible dispersal mode is by the back draught produced by the train's passage, as is the case for the seeds of invasive plants.

Erigone spiders infected by endosymbiotic bacteria of the genus *Rickettsia* have a higher tendency for long-distance movement (Goodacre et al. 2009). It was hypothesised that the dispersal of *Z. rubidum* might also be enhanced by their intracellular symbiotic bacteria, *Cardinium* sp. (Pekár and Šobotník 2007; 2008). These are known to modify their host's behaviour. Infected individuals could have higher propensity to move and climb, thus increasing their dispersal capacity.

Zodarion spiders are known to be ant-eating specialists as they catch no other prey but ants (Pekár 2004), sometimes only some genera or species of ants (Pekár et al. 2011). *Zodarion rubidum* populations might be locally specialised. In Belgium, this species was observed to prey mainly on *Formica* ants (Couvreur 1989), while in Slovakia it captured *Tetramorium* and *Lasius* ants (Pekár 2004). In North America this spider appears to catch *Lasius* ants (Cushing and Santangelo 2002). Several ant species, including those of the genus *Lasius*, are very common on the railway ballast across Europe (Collingwood 1979) helping establishment of *Z. rubidum* dispersing along railways.

Dispersal might be also enhanced by a specific reproductive strategy. Other *Zodarion* species deposit one or two successive egg sacs in their retreat and guard them until hatching. *Zodarion rubidum* females

produce several egg sacs that are singly deposited in retreats and females do not guard them (Pekár and Král 2001). Such iteroparous reproduction has likely enhanced the range expansion rate compared to congeneric species, although the absence of guarding may decrease the reproductive success.

Zoropsis spinimana

The Zoropsidae is a small family with less than 100 species world-wide (Platnick 2011). Of the 15 species of the genus *Zoropsis*, five occur in Europe. Only a single species of this genus, *Z. spinimana* (Dufour), has expanded its range recently.

Zoropsis spinimana is a large cursorial spider that originated in the Mediterranean (Thaler and Knoflach 1998), where it lives in woodland and stony areas. It also occurs in synanthropic habitats like walls and houses (Hansen 1988; Bellmann 1997; Thaler and Knoflach 1998). It was introduced into the USA in 1992 (Griswold and Ubick 2001; Vetter and Ubick 2008). In Europe, its northward expansion has been observed since the middle of the 1990s, when *Z. spinimana* was found in Austria (Thaler and Knoflach 1998) and Switzerland (Hänggi 2003). It is now found in Germany (Hänggi and Bolzern 2006), Belgium (Lambeets et al. 2007) and in the Netherlands (van Helsdingen 2007).

In all cases where *Z. spinimana* was found outside the area of origin, it was synanthropic, occurring in and around houses, garages or cellars (Griswold and Ubick 2001; Hänggi and Bolzern 2006; Kreuels 2007). The distribution pattern of *Z. spinimana* in Germany suggests that the species benefits from human-mediated transport along the river Rhine (Staudt 2010). This is a waterway of international importance and numerous motorways and railways run parallel with it. Additionally, climatic effects could support the expansion of *Z. spinimana*.

It is reported that *Z. spinimana* is an aggressive species able to inflict a painful bite when provoked (Kreuels 2007), though Griswold and Ubick (2001) consider *Z. spinimana* to be harmless to humans. Since it is a relatively large spider (body length of adults from 10 to 19 mm—Thaler and Knoflach 1998, up to 21 mm—Schmitt, pers. obs.) living close to humans, bites cannot be ruled out and the expansion thus increases medical concerns. However, these are probably of relatively minor importance.

Dicranopalpus ramosus

There are 12 species of harvestmen of the genus *Dicranopalpus* in the world (Hallan 2005), but only one of them has expanded its range from the Mediterranean to Western Europe. *Dicranopalpus ramosus* (Simon) was originally found in Morocco in 1904. It was reported from Portugal in 1948, from where it slowly spread northwards and eastwards (Rambla 1986). It was found in Great Britain in 1957 (Sankey and Storey 1969), in Spain in 1965, and in France in 1969 (Rambla 1986). In the Netherlands it appeared in 1993 (Noordijk et al. 2007), in Belgium (Slosse 1995) and Ireland (Cawley 1995) it was discovered in 1994, in Scotland in 2000 (Hillyard 2000) and in Germany in 2002 (Schmidt 2004). Its spread started earlier than the recent climate changes that have occurred. Harvestmen have limited natural dispersal abilities and substantial expansion must have been associated with human-mediated transportation.

Nowadays, *D. ramosus* is a common species. Originally, it was found mainly in the anthropogenic environment, i.e. urban parks and gardens on edge of vegetation along roads and hedgerows, and especially on buildings. Most observations in the Netherlands (71%) come from brick buildings (Noordijk et al. 2007). Gradually it has appeared in peripheral semi-natural environments and in smaller towns, where it has expanded into the surrounding habitats.

Cryptogenic species

There are more than 120 species of harvestmen of the genus *Leiobunum* in Asia, Europe, North Africa, and in Central and North America (Tourinho 2007). One *Leiobunum* species closely related to European and North American ones, whose identification has not been completed yet, probably arrived from overseas to Europe around 2000. It was probably shipped to the Netherlands on board a ship, as the first population was found in 2004 in Nijmegen on the River Waal (Wijnhoven et al. 2007). Then it spread across the Netherlands, in particular along the Waal. In Germany, it was found in 2006 and its spread continued along the river Rhine and into the northern plains, where it almost reached Denmark. In 2007, it was found in Switzerland and in Austria (Wijnhoven et al. 2007).

This species has been found on buildings, especially in the ruins of old factories, old buildings and cellars (Wijnhoven 2009). Expansion of harvestmen should not be constrained by prey availability as they are polyphagous predators. *Leiobunum* is omnivorous, feeding also on fruit (Acosta and Machado 2007). Finally, the expansion of some *Leiobunum* harvestmen could be facilitated by parthenogenesis (Tsurusaki 1986). *Leiobunum* sp. seems to displace other native harvestmen (Wijnhoven et al. 2007).

Conclusions

The reasons for the successful expansion and establishment of particular arachnid species are usually unknown. It might be a combination of several factors, such as occurrence in buildings (synanthropy), a body size larger than in relatives non-expanding their range, and species specific traits. The potential to invade new regions depends on the fact that most arachnids are predators and live in terrestrial habitats.

Thelytokous parthenogenesis seems to have facilitated spread of several spider, harvestman and schizomid species (*T. stenaspis*, *Leiobunum* sp. and *S. portoricensis* mentioned above) outside their native range. The Brazilian scorpion *Tityus stigmurus* (Thorell) (known as *T. serrulatus* Lutz and Mello) has invasive synanthropic parthenogenetic populations in contrast to sexual rural native populations (Lourenço and Cloudsley-Thompson 1999; Lourenço 2002). Parthenogenetic species can establish a new population in isolation and away from their sexual progenitors (Cuellar 1977; Lourenço 2008). Parthenogenetic animals have no mating costs and possess higher reproductive potential (White 1973). Therefore, parthenogenetic species or populations can be successful colonisers.

Iteroparous (multiple) reproduction might enhance range expansion of *Z. rubidum* in comparison with semelparous congeneric species, although the absence of guarding may decrease the reproductive success. Both prey generalists and specialists (woodlice-eating *D. crocata* and ant-eating *Z. rubidum*) are among species successfully expanding their range. The cosmopolitan *O. navus* is a euryphagous predator locally specialised on the most abundant prey.

Human activities are responsible for most of range expansion, including spread with goods on transportation such as ships and trains, offering suitable warm habitats and availability of food. An affinity for building material has likely promoted the dispersal of several species (*O. navus*, *Z. rubidum*, *D. ramosus*, *Leiobunum* sp). Climate warming likely enabled many species native or introduced to southern Europe to expand northward. Particularly in species that occur indoors, it is likely that release from natural enemies has helped their expansion (cf. Roy et al. 2011c).

Although some adverse effects of alien arachnids have been recorded, such as pollution of building facades, clogged car fuel system ventilation tubes, painful biting and threats to native biota, expansions have also provided scientists with easy access to a series of interesting organisms as models for research. Several spider species that expanded to densely populated areas and reached high population densities there became model species in research, for example the cellar spider *Pholcus phalangioides* in reproduction biology (e.g. Schafer et al. 2008) and the wasp spiders *Argiope* spp. in cognitive biology (Walter et al. 2008).

No arachnid species (excluding ticks and mites) in Europe can be clearly classified as invasive alien species, since they do not possess all key traits (being alien to Europe, rapid spreading, high abundance and deleterious effects) together. Control actions against most alien arachnids are not necessary.

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References

- Acosta LE, Machado G (2007) Diet and foraging. In: Pinto da Rocha R, Machado G, Giribet G (eds) Harvestmen. The biology of opiliones. Harvard University Press, Cambridge, pp 309–338
- Armas LF (2004) Arácnidos de República Dominicana. Palpigradi, Schizomida, Solifugae y Thelyphonida (Chelicerata: Arachnida). Rev Iber Aracnol 2:1–63
- Askins M (1999) *Zodarion fuscum* (Simon, 1870): A spider new to Britain. Newsl Br Arachnol Soc 86:11
- Bell JR, Bohan DA, Shaw EM, Weyman GS (2005) Ballooning dispersal using silk: world fauna, phylogenies, genetics and models. Bull Entomol Res 95:69–114
- Bellmann H (1997) Kosmos-Atlas Spinnentiere Europas. Franckh-Kosmos, Stuttgart
- Birkhofer K, Gavish-Regev E, Endlweber K, Lubin YD, von Berg K, Wise DH, Scheu S (2008) Cursorial spiders retard initial aphid population growth at low densities in winter wheat. Bull Entomol Res 98:249–255
- Blick T (2010) Zwerggeisselskorpione in Europa und auf den Kanarischen Inseln. <http://theoblick.homepage.t-online.de/Schizomida.pdf>. Accessed 20 December 2010
- Blick T, Bosmans R, Buchar J, Gajdoš P, Hänggi A, van Helsdingen P, Růžička V, Starega W, Thaler K (2004) Checkliste der Spinnen Mitteleuropas. Checklist of the spiders of Central Europe (Arachnida: Araneae). http://www.arages.de/checklist.html#2004_Araneae. Accessed 1 December 2010
- Blick T, Hänggi A, Wittenberg R (2006) Spiders and allies—Arachnida. In: Invasive alien species in Switzerland. Federal Office for the Environment FOEN, Switzerland, pp 101–112
- Borges PAV, Wunderlich J (2005) Araneae. In: Borges PAV, Cunha R, Gabriel R, Martins AF, Silva L, Vieira V (eds) A list of terrestrial fauna (Mollusca and Arthropoda) and flora (Bryophyta, Pteridophyta and Spermatophyta) from the Azores. Direcção Regional do Ambiente and Universidade dos Açores, Horta, Angra do Heroísmo and Ponta Delgada, pp 178–180
- Bosmans R (1994) Revision of the genus *Zodarion* Walckenaer, 1833 in the Iberian Peninsula and Balearic Islands (Araneae, Zodariidae). EOS 69:115–142
- Bosmans R (1997) Revision of the genus *Zodarion* Walckenaer, 1833, part II. Western and Central Europe, including Italy (Araneae: Zodariidae). Bull Br Arachnol Soc 10: 265–294
- Brach V (1976) Development of the whip scorpion *Schizomus floridanus*, with notes on behaviour and laboratory culture. Bull South Calif Acad Sci 74:270–274
- Bristowe WS (1958) The world of spiders. Collins, London
- Carlton JT (1996) Biological invasions and cryptogenic species. Ecology 77:1653–1655
- Cawley M (1995) *Dicranopalpus ramosus* (Simon) (Arachnida: Opiliones), new to Ireland. Irish Nat J 25:153
- Collingwood CA (1979) The Formicidae (Hymenoptera) of Fennoscandia and Denmark. Fauna Entomol Scand 8:1–174
- Cooke JAL (1965a) A contribution to the biology of the British spiders belonging to the genus *Dysdera*. Oikos 16:20–25
- Cooke JAL (1965b) Beobachtungen an der Spinnengattung *Dysdera*. Nat Mus 95:179–184
- Cooke JAL (1965c) Spider genus *Dysdera* (Araneae, Dysderidae). Nature 205:1027–1028
- Cooke JAL (1967) Factors affecting the distribution of some spiders of the genus *Dysdera* (Araneae, Dysderidae). Entomol Mon Mag 103:221–225
- Couvreux JM (1989) Quelques aspects de la biologie d'une araignée myrmécophage: *Zodarion rubidum* (Simon, 1914). MSc Thesis. Université libre de Bruxelles, Bruxelles

- Cuellar O (1977) Animal parthenogenesis. *Science* 197:837–843
- Cushing PE, Santangelo RG (2002) Notes on the natural history and hunting behavior of an ant eating zodariid spider (Arachnida, Araneae) in Colorado. *J Arachnol* 30:618–621
- DAISIE (2009) Handbook of alien species in Europe. Springer, Heidelberg, p 400
- Deeleman-Reinhold CL, Deeleman PR (1988) Revision des Dysderinae (Araneae, Dysderidae), les espèces méditerranéennes occidentales exceptées. *Tijdschr Entomol* 131: 141–269
- Denis J (1951) Essai biogéographique sur les araignées du genre *Zodarium* Walck. *Bull Soc Hist Nat Toulouse* 86:156–158
- Evans EW (2011) Invasive Coccinellidae and other predatory Coleoptera. *BioControl*. doi:10.1007/s10526-011-9374-6
- Glatz L (1967) Zur biologie und morphologie von *Oecobius annulipes* (Araneae: Oecobiidae). *Zoomorphology* 64: 185–214
- Goodacre SL, Martin OY, Bonte D, Hutchings L, Wooley C, Ibrahim K, Thomas CFG, Hewitt GM (2009) Microbial modification of host long-distance dispersal capacity. *BMC Biol* 7:32
- Griswold CE, Ubick D (2001) Zoropsidae: a spider family newly introduced in the USA (Araneae, Entelegynae, Lycosoidea). *J Arachnol* 29:111–113
- Haenfling B, Edwards F, Gherardi F (2011) Invasive alien crustaceans: dispersal, establishment, impact and control. *BioControl*. doi:10.1007/s10526-011-9380-8
- Hallan J (2005) Synopsis of the described opiliones of the world. *Biology Catalog*. Texas A & M University. <http://insects.tamu.edu/research/collection/hallan/acari/Family/Opiliones1.htm>. Accessed 7 December 2010
- Hänggi A (2003) Nachträge zum 'Katalog der schweizerischen Spinnen' 3. Neunachweise von 1999 bis 2002 und Nachweise synanthroper Spinnen. *Arachnol Mitt* 26:36–54
- Hänggi A, Bolzern A (2006) *Zoropsis spinimana* (Araneae: Zoropsidae) neu für Deutschland. *Arachnol Mitt* 32:8–10
- Hansen H (1988) Über die Arachniden-Fauna von urbanen Lebensräumen in Venedig (Arachnida: Pseudoscorpiones, Araneae). *Boll Mus Civ Stor Nat Venezia* 38:183–219
- Harvey MS (2007) The smaller arachnid orders: diversity, descriptions and distributions from Linnaeus to the present (1758–2007). *Zootaxa* 1668:363–380
- Heimer S, Nentwig W (1991) Spinnen mitteleuropas. Parey, Berlin and Hamburg, p 542
- Hillyard P (2000) *Dicranopalpus ramosus*. *Ocularium*. *Newsl Opiliones Rec Scheme* 3:2
- Hingston RWG (1925) Nature at the desert's edge, studies and observation in the Bagdad oasis. Witherby, London
- Hölldobler B, Wilson EO (1990) The ants. Harvard University Press, Cambridge
- Hopkin SP, Martin MH (1985) Assimilation of zinc, cadmium, lead, copper, and iron by the spider *Dysdera crocata*, a predator of woodlice. *Bull Environ Contam Toxicol* 34:183–187
- Hsu T (2011) Mazda recalls 65,000 cars for spider problem. *Los Angeles Times*. <http://www.latimes.com/business/lafi-mazda-spider-20110304,0,6199399.story>. Accessed 3 March 2011
- Hutchinson R, Cayouette V (1993) Note sur la répartition géographique et la biologie de *Dysdera crocata* C. L. Koch (Araneae: Dysderidae). *Pirata* 2:16–18
- Invasive.org (2011) Invasive and exotic Arachnids. <http://www.invasive.org/species/arachnids.cfm>. Accessed 30 March 2011
- ISSG (2011a) 100 of the world's worst invasive alien species. <http://www.issg.org/database/species/search.asp?st=100ss>. Accessed 17 April 2011
- ISSG (2011b) Global invasive species database: Arachnids. <http://www.issg.org/database/species/search.asp?sts=sss&st=sss&fr=1&Image1.x=26&Image1.y=12&sn=&rm=&hci=-1&ei=160&lang=EN>. Accessed 13 May 2011
- Jocqué R (1991) A generic revision of the spider family Zodariidae (Araneae). *Bull Am Mus Nat Hist* 201:1–160
- Knoflach B (2009) Das Dornfingersyndrom in Mitteleuropa. *Entomol Nachrichten Berichte* 53:69–73
- Kobelt M, Nentwig W (2008) Alien spider introductions to Europe supported by global trade. *Divers Distrib* 14:273–280
- Koponen S (1997) *Triaeris stenapsis* Simon (Araneae, Oonopidae) found in the botanical garden of the University of Turku, Finland. *Entomol Fennica* 8:7
- Korenko S, Řezáč M, Pekár S (2007) Spiders (Araneae) of the family Oonopidae in the Czech Republic. *Arachnologische Mitteilungen* 34:6–8
- Korenko S, Harvey M, Pekár S (2009a) *Stenochrus portoricensis* new to the Czech Republic (Schizomida, Hubardiidae). *Arachnol Mitt* 38:1–3
- Korenko S, Šmerda J, Pekár S (2009b) Life-history traits of the parthenogenetic oonopid spider, *Triaeris stenapsis* (Araneae: Oonopidae). *Eur J Entomol* 106:217–223
- Kreuels M (2007) Die Kräuseljagdspinne *Zoropsis spinimana*. *Pest Control* 36:16
- Lambeets K, Bosmans R, Bonte D (2007) Two exotic spider species (Araneae), *Zoropsis spinimana* (Zoropsidae) and *Saitis barbipes* (Salticidae), recently found in the inner city of Ghent (Belgium). *Nieuwsbr Belg Arachnol Ver* 22:55–60
- Lourenço WR (2002) Reproduction in scorpions, with special reference to parthenogenesis. In: Toft S, Scharff N (eds) *European arachnology 2000*. Aarhus University Press, Aarhus, pp 71–85
- Lourenço WR (2008) Parthenogenesis in scorpions: some history—new data. *J Venom Anim Toxins Trop Dis* 14:20
- Lourenço WR, Cloudsley-Thompson JL (1999) Discovery of a sexual population of *Tityus serrulatus*, one of the morphs within the complex *Tityus stigmurus* (Scorpiones, Buthidae). *J Arachnol* 27:154–158
- Lowrie DC (1980) Starvation longevity of *Loxosceles laeta* (Nicolet) (Araneae). *Entomol News* 91:130–132
- Macías-Hernández N, Oromí P, Arnedo MA (2008) Patterns of diversification on old volcanic islands as revealed by the woodlouse-hunter spider genus *Dysdera* (Araneae, Dysderidae) in the eastern Canary Islands. *Biol J Linn Soc* 94:589–615
- Martín JL, Oromí P (1984) Consideraciones sobre la presencia de *Schizomus portoricensis* Chamberlin 1922 (Arach. Schizomida) en cuevas de Tenerife (Islas Canarias). *Boletín Asoc Esp Entom* 8:265–270

- Miller F, Žitňanská O (1976) Einige bemerkenswerte Spinnen aus der Slowakei. *Biologia* 31:81–88
- Navajas M, Migeon A, Estrada-Peña A, Mailleux AC, Servigne P, Petanovid R (2010) Mites and ticks (Acari). *BioRisk* 4:149–192
- Nentwig W, Kobelt M (2010) Spiders (Araneae). *BioRisk* 4:131–147
- Nentwig W, Blick T, Gloor D, Hänggi A, Kropf C (2010) Spiders of Europe, Version 14. <http://www.araneae.unibe.ch>. Accessed 17 December 2010
- NHTSA (2011) National Highway Traffic Safety Administration Campaign ID #11V134000—Mazda recall notice. http://www-odi.nhtsa.dot.gov/recalls/results.cfm?rcl_id=11V134000&searchtype=quicksearch&summary=true&refurl=rss. Accessed 3 March 2011
- Noordijk J, Wijnhoven H, Cuppen J (2007) The distribution of the invasive harvestmen *Dicranopalpus ramosus* in the Netherlands (Arachnida: Opiliones). *Ned Meded* 26:65–69 (in Dutch)
- Oromí P, Martín JL (1992) The Canary Islands subterranean fauna characterization and composition. In: Camacho AI (ed) The natural history of biospeleology. CSIC, Madrid, pp 527–556
- Paquin P, Dupérré N (2006) The spiders of Québec: update, additions and corrections. *Zootaxa* 1133:1–37
- Pekár S (2002) *Zodarion rubidum* Simon, 1914: Railroad Riders? *News Br Arachnol Soc* 95:11–12
- Pekár S (2004) Predatory behavior of two European ant-eating spiders (Araneae, Zodariidae). *J Arachnol* 32:31–41
- Pekár S, Král J (2001) A comparative study of the biology and karyotypes of two central European zodariid spiders (Araneae, Zodariidae). *J Arachnol* 29:345–353
- Pekár S, Šobotník J (2007) Comparative study of the femoral organ in *Zodarion* spiders (Araneae: Zodariidae). *Arthropod Struct Dev* 36:105–112
- Pekár S, Šobotník J (2008) Erratum to “comparative study of the femoral organ in *Zodarion* spiders (Araneae: Zodariidae)”. *Arthropod Struct Dev* 37:93–94
- Pekár S, Král J, Lubin YD (2005a) Natural history and karyotype of some ant-eating zodariid spiders (Araneae, Zodariidae) from Israel. *J Arachnol* 33:50–62
- Pekár S, Král J, Malten A, Komposch C (2005b) Comparison of natural histories and karyotypes of two closely related ant-eating spiders, *Zodarion hamatum* and *Z. italicum* (Araneae, Zodariidae). *J Nat Hist* 39:1583–1596
- Pekár S, Bilde T, Martišová M (2011) Intersexual trophic niche partitioning in an ant-eating spider (Araneae: Zodariidae). *PLoS One* 6(1):e14603
- Pernet C, Dandurand M, Meunier L, Stoebner PE (2010) Necrotic arachnidism in the south of France: two clinical cases of loxoscelism. *Ann Dermatologie Venerologie* 137:808–812
- Platnick NI (2011) The world spider catalog, version 11.5. American Museum of Natural History. <http://research.amnh.org/entomology/spiders/catalog/index.html>. Accessed 5 March 2011
- Pollard SD, Jackson RR, van Olphen A, Robertson MV (1995) Does *Dysdera crocata* (Araneae: Dysderidae) prefer woodlice as prey? *Ethol Ecol Evol* 7:271–275
- Pyšek P, Hulme PE, Nentwig W (2008) Glossary of the main technical terms used in the handbook. In: DAISIE handbook of alien species in Europe. Springer, Dordrecht, pp 375–379
- Rabitsch W (2011) The hitchhiker's guide to alien ant invasions. *BioControl*. doi:10.1007/s10526-011-9370-x
- Rambla M (1986) Nuevos datos sobre *Dicranopalpus ramosus* (Simon, 1909) (Arachnida, Opiliones, Phalangiidae). In: Barrientos JA (ed) Actas X Congr Int Aracnol Jaca/España. Impreso por Imprenta Juvenil, Barcelona, pp 373–382
- Raupach MJ (2005) Die Bedeutung von Landasseln als Beutetiere für Insekten und andere Arthropoden. *Ent Heute* 17:3–12
- Reddell JR, Cokendolpher JC (1995) Catalogue, bibliography and generic revision of the order Schizomida (Arachnida). *Tex Mem Mus Speleol Monogr* 4:1–170
- Řezáč M (2002) *Sitticus distinguendus* and *Zodarion italicum*, two spider species recently found in Bohemia, Czech Republic (Araneae: Salticidae, Zodariidae). *Acta Univ Carol Biol* 45:295–298
- Řezáč M, Král J, Pekár S (2008a) The spider genus *Dysdera* (Araneae, Dysderidae) in central Europe: revision and natural history. *J Arachnol* 35:432–462
- Řezáč M, Pekár S, Lubin Y (2008b) How oniscophagous spiders overcome woodlouse armour. *J Zool* 275:64–71
- Riechert SE, Lockley TC (1984) Spiders as biological control agents. *Annu Rev Entomol* 29:299–320
- Rowland JM (1972) The brooding habits and early development of *Trithyreus pentapeltis* (Cook), (Arachnida: Schizomida). *Entomol News* 83:69–75
- Rowland JM, Reddell JR (1980) The order Schizomida (Arachnida) in the new world. III. Mexicanus and pecki group (Schizomidae, Schizomus). *J Arachnol* 8:1–34
- Roy HE, Ware RL, Lawson Handley L-J, De Clercq P, Wajnberg E (2011a) Alien arthropod predators and parasitoids: an ecological approach. *BioControl*. doi:10.1007/s10526-011-9388-0
- Roy HE, Roy DB, Roques A (2011b) Inventory of alien arthropod predators and parasitoids established in Europe. *BioControl*. doi:10.1007/s10526-011-9355-9
- Roy HE, Handley LJ, Schönrogge K, Poland RL, Purse BV (2011c) Can the enemy release hypothesis explain the success of invasive predators and parasitoids? *BioControl*. doi:10.1007/s10526-011-9349-7
- Samu F, Józsa Z, Csányi E (2004) Spider web contamination of house facades: habitat selection of spiders on urban wall surfaces. In: Samu F, Szinetár C (eds) European arachnology 2002. Plant Protection Institute and Berzsenyi College, Budapest, pp 351–356
- Sankey JHP, Storey MW (1969) *Dicranopalpus caudatus* Dresco (Arachnida, Opiliones), first records in Britain and France. *Entomol Mon Mag* 105:106–107
- Santos AJ, Gonzaga MO (2003) On the spider genus *Oecobius* Lucas, 1846 in South America (Araneae, Oecobiidae). *J Nat Hist* 37:239–252
- Santos AJ, Dias SC, Brescovit AD, Santos PA (2008) The arachnid order Schizomida in the Brazilian Atlantic forest: a new species of *Rowlandius* and new records of *Stenochrus portoricensis* (Schizomida: Hubbardiidae). *Zootaxa* 850:53–60
- Schafer MA, Misof B, Uhl G (2008) Effects of body size of both sexes and female mating history on male mating

- behaviour and paternity success in a spider. *Anim Behav* 76:75–86
- Schmidt C (2004) Der Weberknecht *Dicranopalpus ramosus* (Simon, 1909) (Arachnida, Opiliones, Phalangidae) neu für Deutschland. *Mitt AG Westfäl Entomol* 20:1–12
- Sentenská L, Líznavá E (2010) New arachnid order for the fauna of the Czech Republic. *Živa* 58:126–127 (in Czech)
- Shear W, Benoit PLG (1974) New species and new records in the genus *Oecobius* Lucas from Africa and nearby islands (Araneae: Oecobiidae: Oecobiinae). *Revue de Zoologie Africaine* 88:705–720
- Slosse W (1995) *Dicranopalpus ramosus* (Opiliones, Phalangidae), new harvestman for Belgian fauna. *Nieuwsbr Belg Arachnol Ver* 10:11–13 (in Dutch)
- Snazell R, Bosmans R (1998) *Zodarion vicinum* Denis, 1935: new to Britain. *Newsl Br Arachnol Soc* 81:8–10
- Staudt A (2010) Nachweiskarten der Spinnentiere Deutschlands (Arachnida: Araneae, Opiliones, Pseudoscorpiones), Version 26. <http://www.spiderling.de/arages>. Accessed 5 November 2010
- Thaler K, Knoflach B (1998) *Zoropsis spinimana* (Dufour), eine für Österreich neue Adventivart (Araneae, Zoropsidae). *Ber nat-med Verein Innsbruck* 85:173–185
- Thaler-Knoflach B (2010) Gebietsfremde Spinnen in Mitteleuropa. In: Rabitsch W (ed) *Aliens. Neobiota und Klimawandel—Eine verhängnisvolle Affäre, Katalog des Landesmuseums Niederösterreich N.F.* 485:80–91
- Tourinho ALM (2007) Sclerosomatidae Simon, 1879. In: Pinto da Rocha R, Machado G, Giribet G (eds) *Harvestmen—the biology of opiliones*. Harvard University Press, Cambridge, pp 127–131
- Tourinho AL, Kury AB (1999) The southernmost record of Schizomida in South America, first records of Schizomida for Rio de Janeiro and of *Stenochrus* Chamberlin, 1922 for Brazil (Arachnida, Schizomida, Hubbardiidae). *Bol Mus Nac Zool Rio* 405:1–6
- Tsurusaki N (1986) Parthenogenesis and geographic variation of sex ratio in two species of *Leiobunum* (Arachnida, Opiliones). *Zool Sci* 3:517–532
- van Helsdingen PJ (2007) From the outer front. *Nieuwsbrief SPINED* 23:36 (in Dutch)
- Vetter RS, Ubick D (2008) Pest notes: *Zoropsis spinimana*, a mediterranean spider in California. Oakland University of California Division of Agriculture and Natural Resources Publication 74143. <http://www.ipm.ucdavis.edu/PDF/PESTNOTES/pnzoropsis.pdf>. Accessed 25 January 2011
- Vetter RS, Isbister GK, Bush SP, Boutin LJ (2006) Verified bites by yellow sac spiders (genus *Cheiracanthium*) in the United States and Australia: where is the necrosis? *Am J Trop Med Hyg* 74:1043–1048
- Vetter RS, Hinkle NC, Ames LM (2009) Distribution of the brown recluse spider (Araneae: Sicariidae) in Georgia with comparison to poison center reports of envenomations. *J Med Entomol* 46:15–20
- Vine B, Knott B, Humphreys WF (1988) Observations on the environment and biology of *Schizomus vinei* (Chelicerata: Schizomida) from Cape Range, Western Australia. *Rec West Aust Mus* 14:21–34
- Vogel BR (1968) A zodariid spider from Pennsylvania (Araneida: Zodariidae). *J N Y Entomol Soc* 76:96–100
- Voss SC, Main BY, Dadour IR (2007) Habitat preferences of the urban wall spider *Oecobius navus* (Araneae, Oecobiidae). *Aust J Entomol* 46:261–268
- Walter A, Bliss P, Moritz RFA (2005) The wasp spider *Argiope bruennichi* (Arachnida, Araneidae): ballooning is not an obligate life history phase. *J Arachnol* 33:516–522
- Walter A, Elgar MA, Bliss P, Moritz RFA (2008) Wrap attack activates web-decorating behavior in *Argiope* spiders. *Behav Ecol* 19:799–804
- White MJD (1973) *Animal cytology and evolution*. Cambridge University Press, New York
- Wijnhoven H (2009) The Netherlands harvestmen (Opiliones). *Ned Faun Meded* 28:5–118 (in Dutch)
- Wijnhoven H, Schönhofer AL, Martens J (2007) An unidentified harvestman *Leiobunum* sp. alarmingly invading Europe (Arachnida: Opiliones). *Arachnol Mitt* 34:27–38

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