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Invasive Mantodea species in Europe

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Abstract

This paper summarizes the current knowledge about invasive praying mantids (Mantodea) in Europe. The continent has been spared invasive mantodeans for a long time, but reports on allochthonous populations increased recently. We differentiate between native species increasing their range, true neobiota and single specimens which failed to establish viable populations. The first group is represented by *Ameles spallanzania* (Rossi, 1792), *Mantis religiosa* Linnaeus, 1758, *Sphodromantis viridis vischeri* (Werner, 1933), and *Hierodula transcaucasica* Brunner von Wattenwyl, 1878. The latter is now established on the Balkan Peninsula. True neobiota are the Nearctic *Brunneria borealis* Scudder, 1896 in southern Spain, the afrotropical *Miomantis caffra* Saussure, 1871 and *M. paykullii* Stål, 1871 in Portugal, as well as *Tenodera sinensis* Saussure, 1871 in Germany. Single individuals or oothecae of the following species have also been recorded: *Iris oratoria* (Linnaeus, 1758), *Hymenopus coronatus* (Olivier, 1792), *Empusa pennata* (Thunberg, 1815), *Idolomantis diabolica* (Saussure, 1869), *Tenodera sinensis* Saussure, 1871, *Hierodula* sp., and *Stagmomantis carolina* (Johansson, 1763). The immigration pathways and potential risks for the native mantodean fauna are discussed.

Zusammenfassung

Diese Arbeit fasst die aktuellen Daten über die in Europa invasiv auftretenden Gottesanbeterinnen (Mantodea) zusammen. Nachdem der Kontinent lange Zeit vor gebietsfremden Arten verschont blieb, häufen sich in letzter Zeit die Nachweise allochthoner Populationen. Wir unterscheiden hierbei zwischen in Europa heimischen Arten, die ihr Areal ausdehnen und an Orten auftauchen, an denen diese noch nie vorkamen, eigentlichen Neobiota sowie Einzelindividuen, die keine Populationen etablieren konnten. Zur ersten Gruppe zählen *Ameles spallanzania* (Rossi, 1792), *Mantis religiosa* Linnaeus, 1758, *Sphodromantis viridis vischeri* (Werner, 1933) und *Hierodula transcaucasica* Brunner von Wattenwyl, 1878. Letztere ist mittlerweile auf der Balkanhalbinsel etabliert. Gebietsfremd sind oder waren die nearktische *Brunneria borealis* Scudder, 1896 in Südspanien, die afrotropischen *Miomantis caffra* Saussure, 1871 und *M. paykullii* Stål, 1871 in Portugal sowie *Tenodera sinensis* Saussure, 1871 in Deutschland. Zusätzlich wurden Einzelindividuen bzw. Ootheken der folgenden Arten festgestellt: *Iris oratoria* (Linnaeus, 1758), *Hymenopus coronatus* (Olivier, 1792), *Empusa pennata* (Thunberg, 1815), *Idolomantis diabolica* (Saussure, 1869), *Tenodera sinensis* Saussure, 1871, *Hierodula* sp. und *Stagmomantis carolina* (Johansson, 1763). Die möglichen Einwanderungs- und Besiedlungswege sowie der zu erwartende Einfluss auf die autochthone Mantodeenfauna Europas werden diskutiert.

Introduction

Invasive species are plant and animal taxa which have established populations outside their natural range with the aid of man. Today, they are the second most important threat to biodiversity after habitat destruction (VITOUSEK et al. 1996, 1997b, MCKINNEY & LOCKWOOD 1999). Various studies corroborate negative impacts of invasive species on autochthonous floras and faunas (e.g. VITOUSEK et al. 1996, HOWARTH 1991, CIVEYREL & SIMMBERLOFF 1996, VITOUSEK et al. 1997a, FRITTS & RODDA 1998, BOETTNER et al. 2000, LOWE et al. 2000, MACK et al. 2000, COURCHAMP et al. 2003, CLAVERO & GARCÍA-BERTHOU 2005). However, extensive empirical data are still lacking for the most part, preventing so far a thorough qualitative and quantitative evaluation of the ecological effects exerted by invasive organisms (PARKER et al. 1999). This is also the case for praying mantids (Mantodea) which are known to have become invasive in the Nearctic (GURNEY 1951, ANDERSON 2018), Hawaii (HOWARTH & MULL 1992), and New Zealand (RAMSAY 1984), causing negative effects on native mantodeans at least in the latter area (FEA et al. 2013).

Europe has long been spared invasive Mantodea species, but since a few years new records on Mantodea species found outside their range have increasingly surfaced. In this paper, we sum up the existing records and discuss the potential impacts.

Methods

We have screened our substantial literature and correspondence database for publications dealing with new findings of mantodeans on the European territory. As such, we consider continental Europe from the Iberian Peninsula to the Ural and Caucasus, respectively, including the Mediterranean islands, but excluding Macaronesia. In addition, we checked museum collections for unpublished records. We have considered every species recorded at new European localities outside its natural range. However, for sake of clarity, we distinguished naturally occurring species currently expanding their range from both invasive neobiota and single specimens failing to establish new populations. The former are included because their dispersal, while seemingly natural, is accelerated by man. The list of the latter is certainly not exhaustive, since not every specimen is reported to specialists, and data from countries outside Germany and Switzerland, where a dense information network on Mantodea exists, are often lacking.

Institutional abbreviations

CBOM collection Matthias Borer, Liestal, Switzerland

CSC collection Christian J. Schwarz, Bochum, Germany

FAWF Forschungsanstalt für Waldökologie und Forstwirtschaft, Trippstadt, Germany

GÖG Gruppe für ökologische Gutachten, Stuttgart, Germany

LUBW Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg, Karlsruhe, Germany

MNHN Museum National d'Histoire Naturelle, Paris, France

MZUF Natural History Museum of the University of Florence, Zoological Section "La Specola", Florence, Italy

NMB Naturhistorisches Museum Basel, Switzerland

NME Naturkundemuseum Erfurt, Germany

SMNK Staatliches Museum für Naturkunde Karlsruhe, Germany

SMNS Staatliches Museum für Naturkunde Stuttgart, Germany

SDEI Senckenberg Deutsches Entomologisches Institut, Müncheberg, Germany

Results

Our list contains four species native to Europe which considerably expanded their range, four neobiota, and seven species failing to establish populations. The details are given below.

Native species increasing their distributional range

Fam. Amelidae

Ameles spallanzania (ROSSI, 1792)

This Eumediterranean element has recently been found in Southern Tyrol at the towns of Meran and Branzoll (BALLINI & WILHALM 2014). This species has also been recorded from Germany in 2018:

- 01.VIII.2018, nymph in Graben-Neudorf (Baden-Württemberg) (S. Fallnich, pers. comm.).
- 30.IX.2018, adult male, Albertshofen, Lower Frankonia (Bavaria) (leg. M. Thomas, CSC).
- 13.X.2018, two males and two females (Fig. 1) in Graben-Neudorf (Baden-Württemberg) (one of the specimens probably identical with the nymph found on August 1, S. Fallnich pers. comm.).

Whether the Graben-Neudorf population survives the upcoming winter remains to be seen.

Fam. Mantidae

Mantis religiosa religiosa LINNAEUS, 1758

While native to the area, the European Mantis is increasingly expanding its range northward, having lately crossed 58° N in parts of Russia (BOLSHAKOV et al. 2010). It has recently colonized southern Latvia (around Daugavpils, about 55° N, PUPIŅŠ et al. 2012), and also expanded its range in Central European countries where it was rare before (EHRMANN 2011b, EHRMANN & REINHARDT 2011, SCHWARZ et al. 2017, ZIELIŃSKI et al. 2018). Outside the Old World it has been accidentally introduced to North America (SLINGERLAND 1900, BERG et al. 2011), where it succeeded in colonizing major parts of western and northeastern USA, and southern Canada (ANDERSON 2018).

Sphodromantis viridis vischeri (WERNER, 1933)

The westernmost subspecies of this southern Mediterranean mantis (ROY 2010) was initially restricted to the Spanish province of Andalucía around the cities of Malaga, Cadiz and Seville (BOLÍVAR 1897, KALTENBACH 1963). Since about 20 years, however, it is expanding its range westward towards Portugal (MARABUTO et al. 2014) and northeastward towards Barcelona (CJS & RE pers. obs.). It has also colonized the Balearic Islands (CANYELLES & ALOMAR 2006) and Sardinia (RUZZANTE & LEO 2012, BATTISTON et al. 2017). We can add the following unpublished records:

- Cala Ratjada, NE Mallorca, 15.IX.2005, leg. R. B. Boczki, juv. female (NMB).
- Hotel Es Talajal, Cala D'or/Cala Egos, SE Mallorca, Spain, 14.X.2006, female, photographic record G. Krumm.
- Llubi, NE Mallorca, 39.42°N 03.00°E, 07.X.2010, leg. X. Canyelles, male (SMNK, genitalia preparation Roy 4318).
- Paguera, Autovia de Poniente (Ma-1) crossing Calle de Pau Casals, SW Mallorca, Spain, X.2010, leg. ootheca M. Wittenhagen (SMNK-12136-12139).
- Sa Rapita, Mallorca, Spain, 13 m, 39°21'58.9"N 02°56'49.6"E, 25.VI.2016, leg. J. Zhang, male (CBOM).

Hierodula transcaucasica BRUNNER VON WATTENWYL, 1878

The westernmost species of this hyperdiverse Asian genus reaches the European territory in the Caucasus region (KALTENBACH 1963, BATTISTON & MASSA 2008). It remained known exclusively from that region until the species showed up at different localities on the Balkan Peninsula.

The first, long overlooked record seems to be a juvenile male collected between dunes and olive grove in Kalamaki, north of Matala, S Crete, Greece (35°01'27.4" N, 24°45'34.7" E, 10 m) on 08.-12.V.2008 by P. Schnitter (today NMB). However, it took five years until the occurrence of this species on the Balkan Peninsula became known to specialists due to the following records:

- an olive grove near the town of Katerini, Greece, at the western shore of the Aegean Sea (40°16'50.01" N, 22°30'21.02" E, Fig. 5) on 19.XI.2013 (male and female plus several egg cases, leg. H. Aberle, SMNK-12452, 12453), confirmed one year later (4 males, 4 females & 1 exuvia ex ovo, and 8 oothecae, 24.V.-08.VI.2014, leg. ootheca H. Aberle, SMNK-12454, 12455, 12600-12614) (Figs 2-3, 10-11), and the following years (5 oothecae, 03.-18.VI.2015, leg. H. Aberle, SMNK-12629-12633; 9 oothecae, 21.XI.2016, leg. H. Aberle, NMB; Fig. 4; 5 oothecae, 02.-12.XII.2017, leg. H. Aberle, 4 males & 2 females ex ovo, NMB); 3 oothecae, 24.V.-08.VI.2014, leg. H. Aberle, 2 males & 1 female ex ovo, and 09.-16.XI.2015, 2 females ex ovo, CBOM).
- the Island of Skopelos, Greece, in 2015 (Stiewe, pers. comm.); recently (VIII.2018) also recorded by CIANFERONI et al. (2018).
- Paralia Panteleimonos, Greece, 10.IX.2017, photographic records by V. Tosheva & Y. Mindilikova (communicated by F. Hamann & C. Hampl).
- Kouses on the Island of Crete in 2018 (VAN DER HEYDEN 2018a).

- Kozhuh Hill, Prov. Blagoewgrad, SW Bulgaria, N41.462081 E23.257745, VII.2018, juvenile (D. Berger pers. comm.).
- Ribnik, Prov. Blagoewgrad, in the alluvial zone of the Struma river, SW Bulgaria, N41.480292 E23.271881, 13.VII.2018, juvenile (C. Roesti, pers. comm.).
- Olympia vic. Zacharo/Elis, Greece (37°29.550' N, 021°37.059' E, 1 m), olive and eucalyptus grove along shore, 22.IX.2018, adult female, photographic record by Angela & Hans Mühle.
- Vloë, S Albania, 02.X.2018 (VAN DER HEYDEN 2018b).

Additional Greek and Macedonian records are provided by CIANFERONI et al. (2018). How the species might have reached Greece remains unknown. However, the occurrence at vastly different sites in Greece and neighboring countries raises the assumption that the species occured in Greece for some time and, once established, colonized additional habitats on the Balkan Peninsula and adjacent islands. Interestingly, there are no reports of this species from western Anatolia (EHRMANN 2011a), so we regard its presence west of the Aegean Sea to have been more likely aided by man (cargo and other means of adventive transport) than the result of natural dispersal.

Fig. 1:
Ameles spallanzania (ROSSI, 1792), female from Graben-Neudorf; Photo © S. Fallnich.

Fig. 2:
Hierodula transcaucasica BR. V. WATTENWYL, 1878 from Katerini, Greece: portrait of male, showing prosternal pattern; Photo © C. Barth.

Fig. 3 *Hierodula transcaucasica* BR. V. WATTENWYL, 1878 from Katerini, Greece: pair in copula; Photo © C. Barth.

Fig. 4:
Hierodula transcaucasica BR. V. WATTENWYL, 1878 from Katerini, Greece: oothecae.

Fig. 5:
Hierodula transcaucasica BR. V. WATTENWYL, 1878 from Katerini, Greece: habitat; Photo © H. Aberle.

Neobiota

Fam. Coptopterygidae

Brunneria borealis SCUDDER, 1896

Several species of this genus inhabit the grasslands of South America. Only one species has a disjunct distribution, *B. borealis*, which occurs in southeastern USA

(GURNEY 1951, ANDERSON 2018). On September 1, 15, and 27, 2016 three specimens were found in the Llobregat Delta, a Natura 2000 habitat, at the town Viladecans near Barcelona (FERNÁNDEZ & SANTAEUFEMIA 2016).

Fam. Miomantidae

Miomantis caffra SAUSSURE, 1871

This is the first Miomantis species to have become adventive, colonizing New Zealand at some point before 1984 (RAMSAY 1984). Originally, it inhabits southern Africa (EHRMANN 2002). On September 9, 20, 22, and 27, 2014, four male specimens were attracted to lights in the municipalities of Carcavelos and Oeiras, Portugal, confirming the existence of a viable population on the European continent (MARABUTO 2014). The species is also confirmed in Long Beach, California, since 2013 (ANDERSON 2018).

Miomantis paykullii STÅL, 1871

This Afrotropical species is found as far north as Egypt and Israel (EHRMANN 2002, Battiston et al. 2010), reaching the Mediterranean region through the Nile valley. On August 5 and 8, 2014, two males were recorded in Quarteira, Portugal (MARABUTO 2014).

Fam. Mantidae

Tenodera sinensis SAUSSURE, 1871

Originally from Eastern Asia, this large mantis is well-known for having successfully colonized large parts of eastern USA since its accidental introduction near Philadelphia in 1895 (GURNEY 1951, ANDERSON 2018). The competition with the likewise invasive species *T. angustipennis* SAUSSURE, 1869 and *Mantis religiosa* in the eastern USA has been thoroughly studied by L. Hurd and coworkers (PRETE et al. 1999, BERG et al. 2011). Where the three species co-occur, *M. religiosa* and *T. angustipennis* may be negatively affected. No established European populations of *T. sinensis* are known at the time of writing. However, several specimens were discovered since the mid-2000s in the Upper Rhine Valley:

- 11.IX.2004, adult female in Bad Bergzabern (Rhineland Palatine) (N. Weitzel, pers. comm.).
- 25.VIII.2005, juvenile female in Huttenheim (Baden-Württemberg) (W. Dietrich, pers. comm.).
- 27.IX.2005, adult female in Herxheimweyher (Rhineland Palatine) (M. Persohn, pers. comm.).
- 05.X.2005, adult male in Neustadt-Mußbach (Rhineland Palatine) (balcony on third floor, leg. fam. Wentnagel, SMNK-11084).
- 25.X.2005, adult female in Landau-Siebeldingen (Rhineland Palatine) (leg. B. Schaub, SMNK-11085) (NIEHUIS 2006, NIEHUIS et al. 2011) (Fig. 6).
- 29.X.2005, adult female in Huttenheim (possibly same specimen as seen on August 25) (W. Dietrich, pers. comm.).
- 02.XI.2005, adult female in Landau-Nussdorf (Rhineland-Palatine) (leg. S. Idelberger).

- 03.XI.2005, adult female in Landau-Arzheim (Rhineland Palatine) (leg. M. Niehuis) (IDELBERGER & NIEHUIS 2006, NIEHUIS et al. 2011).
- 29.IX.2006, adult female on road in Huttenheim (B. Kühn, pers. comm.).
- 23.X.2006, adult male on house in Huttenheim (leg. W. Dietrich & G. Reiss, SMNK-11083).
- 25.VIII.2008, juvenile male in Ketsch (Baden-Württemberg) (W. Sior, pers. comm.).
- 31.VIII.2008, adult male in Ketsch (possibly the same specimen as seen on August 25) (W. Sior, pers. comm.).
- 13.X.2008, adult female in Ketsch (W. Sior, pers. comm.).

These findings point to the existence of one or a few viable populations during at least that time. No specimens have been recorded in the area since 2008.

Another population has surfaced in a bonsai garden in Gera-Linda, Thuringia, Germany (50°58′5.06″ N, 12°8′6.16″ E, 230 m), on July 25, 2018, when a juvenile specimen fell off a walnut tree (U. Krötenheerdt & M. Keller, pers. comm.). At the time of writing, a total of 8 nymphs have been recorded, 7 of which were preserved when adult:

- 08.X.2018, male and female, leg. J., L. & U. Krötenheerdt, ded. M. Hartmann (NME) (male CSC, female NMB).
- 13.XI.2018, 4 females, leg. J., L. & U. Krötenheerdt (2 females CSC, 2 females NMB).
- 22.XI.2018, female, leg. J., L. & U. Krötenheerdt (NMB).

Fig. 6: Live aspect of *Tenodera sinensis* SAUSSURE, 1871 from Landau-Siebeldingen; Photo © B. Schaub.

Single findings

Fam. Tarachodidae

Iris oratoria (LINNAEUS, 1758)

This Mediterranean mantis also has a colonization history, having invaded California in 1933 (STROHECKER 1952, GURNEY 1955). Today, in the USA it is found as far east as western Texas (ANDERSON 2018). Its interactions with native *Stagmomantis* species have been studied by MAXWELL & EITAN (1998). A single female of this species has been found in Henschleben-Vehra, Thuringia, Germany (51°8'54.50" N, 10°59'17.05" E) on September 29, 2017 (HARTMANN et al. 2018). It was repeatedly seen until October 13, and also deposited an ootheca (Fig. 7). We received the ootheca one year later for study (to be deposited in the NMB) and it turned out it had successfully hatched. However, the long-term survival of this species north of the Alps is highly unlikely.

Fig. 7:
Iris oratoria (LINNAEUS, 1758) from Vehra, with ootheca; Photo © M. Schmeißer.

Fam. Hymenopodidae

Hymenopus coronatus (OLIVIER, 1792)

One adult female was found and photographed in an apple tree in Grünwinkel, Karlsruhe, Germany on August 11, 2018 (F. Theves, LUBW, pers. comm., adult female) (Fig. 8). We received the specimen and an ootheca it produced on 26.XI.2018 (NMB).

Fam. Empusidae

Empusa pennata (THUNBERG, 1815)

A juvenile male of this Western Mediterranean *Empusa* species was found and photographed on April 13, 2007 in a factory in Sprendlingen (Rhineland Palatine) (PFEIFER & EHRMANN 2011) (Fig. 9). It had been released before its status as non-native was confirmed by specialists.

Fig. 8:
Semi-portrait of *Hymenopus coronatus* (OLIVIER, 1792) perching in an apple tree in Karlsruhe; Photo: © P. Hartmann.

Fig. 9:
Male nymph of *Empusa pennata* (THUNBERG, 1815) from Sprendlingen; Photo: © B. Vogt-Gladigau.

Fig. 10:
Hierodula transcaucasica BR. V. WATTENWYL, 1878 from Katerini, Greece, male and female in dorsal view.

Fig. 11:
Hierodula transcaucasica BR. V. WATTENWYL, 1878 from Katerini, Greece, male and female in ventral view.

Idolomantis diabolica (SAUSSURE, 1869)

- Marburg a. d. Lahn, Hesse, Germany, 06.VIII.2010, leg. W. Kläs (Fig. 12).

Fam. Mantidae

Tenodera sinensis SAUSSURE, 1871

- Kavala, Greece, 14.VI.1982, leg. Epping (SMNS) (Fig. 13).

Fig. 12:
Idolomantis diabolica (SAUSSURE, 1869) from Marburg a. d. Lahn, Germany.

Fig. 13:
Tenodera sinensis SAUSSURE, 1871 from Kavala, Greece.

Hierodula sp.

- Leutkirch, Baden-Württemberg, Germany, at gasoline station (K. Wieder, pers. comm.).

CIANFERONI et al. (2018) mention (but do not reproduce) photographic records of unidentified *Hierodula* individuals from Italy (Lombardy & Emilia-Romagna). At least some of these specimens might represent additional records of *H. transcaucasica* Brunner von Wattenwyl, 1878 (see above).

Stagmomantis carolina (JOHANSSON, 1763)

In September 2000, an ootheca was found attached to the underside of a leaf of the parlour palm or "Chico", *Chamaedorea elegans.* Leaves of this palm are used in Europe for flower arrangements. The respective palm originated in Juan Aldama, Durango, Mexico (24.16°N 103.22°W), where it had been imported from by a Dutch plant trader.

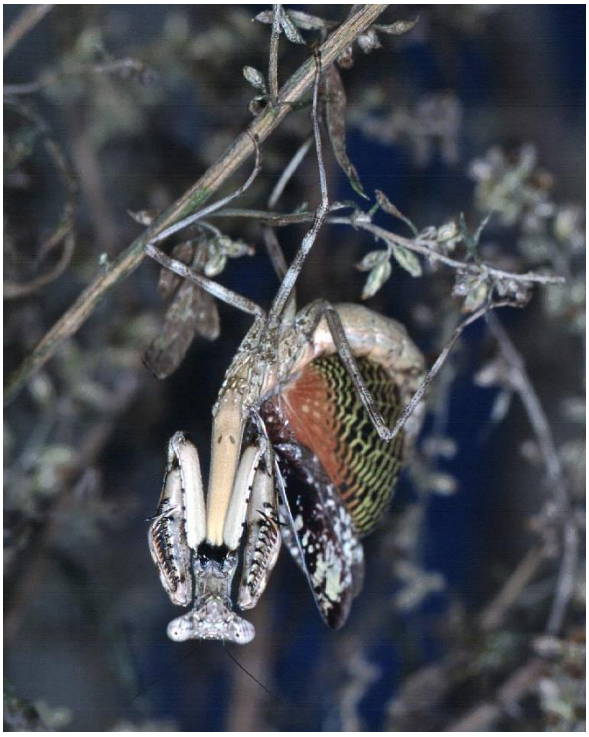

Fig. 14:
Displaying female of *Stagmomantis carolina* (JOHANSSON, 1763) from an ootheca transported from Mexico to Germany via a *Chamaedorea* palm.

From there, it arrived at a garden supplier in Heidelberg, Germany and was bought by I. Gutemann (Sandhausen), who found the ootheca. Eventually, 30 nymphs hatched. The species was later identified as *Stagmomantis carolina* (JOHANSSON, 1763) (Fig. 14), which is common in SE USA, Mexico and other parts of Central America. The original ootheca, all specimens which survived to adulthood, and their oothecae were preserved (five males, two females, one exuvia and 18 oothecae, SMNK-09895-09910). Even though the species did not become established in the wild, this example perfectly shows the novel dispersal opportunities provided by global trade.

Discussion

When discussing invasive species, three major issues need to be addressed: the immigration pathways, the risk of establishing viable populations, and the impacts on native fauna.

With respect to the first problem, natural dispersal is not always clearly separable from "unnatural", man-aided translocations. For example, when the habitat expands due to ecological changes (driven by a more suitable climate or new habitat availability) the species may colonize it by migration on foot and "on the wing", or by attaching to human transportation devices like cars or trains. The area where the organism drops off may be a place where the species would have eventually got to on its own at some point. Even dispersal along railways and highways is strictly speaking man-aided, since these structures are artificial habitat corridors in a landscape that initially provided at most stepping stone opportunities. The human aid, in these cases, is just acceleration of a natural phenomenon. Such is the case in *Ameles spallanzania*, *Mantis religiosa* and the Iberian spread of *Sphodromantis viridis*.

However, human transportation devices can take a species much further than it would be able to colonize on its own. Today, trains, planes, ships and even cars can travel across continents and bring a species to an ecologically suitable area which it would not have reached on its own due to biogeographic barriers. This is the case in true neobiota like *Brunneria borealis*, *Miomantis caffra*, *M. paykullii*, and *Tenodera sinensis*, but probably also in *Hierodula transcaucasica* and the island populations of *Sphodromantis viridis*. Adult females of the latter two species are fully winged and capable of flight, but the chances that they would cover such distances in flight are probably very low compared to transportation through cargo along these frequently used naval and plane routes.

Not every specimen transported this way is brought to a climatically suitable area. While they are capable of surviving during the warm months, they are not adapted to the harsh winter conditions. Such single records are the Palatinate *Empusa pennata* and the Thuringian *Iris oratoria* specimens, as well as the latter's putative offspring. The small population of the strictly Eumediterranean *Ameles spallanzania* recently found in Badenia will probably suffer the same fate.

Mantodeans are quite prone to this type of translocation due to the longevity of adult females, and their propensity of attaching their well-protected egg cases (oothecae) to hard, durable substrates like tires, tarps, wooden poles etc. (WERNER

1915, BERG et al. 2011, EHRMANN 2011b). For example, on October 10, 2006, J. Kemenes (Malsch) reported an ootheca of *Mantis religiosa* which had been deposited on a tire when he was on holiday in Hungary (vic. Pápa, Transdanubia). The ootheca safely made the trip back to southern Germany. Also, the *Stagmomantis carolina* ootheca transported from Mexico to Germany via plant material falls into this category. Often, females attracted to industry or parking lot lights stay in the area long enough to attach their ootheca to a piece of cargo which later leaves the area (CJS & RE pers. obs.). Such types of translocations probably occurred since ancient times, but the long durations of ancient travels prevented most of these adventives to produce viable populations. Since engine-driven travels are possible, the number of mantodean neobiota has rapidly increased (e.g. WERNER 1907, 1915, HOWARTH & MULL 1992, ANDERSON 2018).

Another factor that may contribute to the establishing of allochthonous mantodean populations is their popularity with insect breeders. However, in Central Europe at least, this seems to be less of an issue, since most hobbyists concentrate on exotic species. *T. sinensis* is somewhat of an exception due to its availability. The Upper Rhine population may have had such an origin (LECHNER 2007). Usually however, while single specimens may escape and survive the summer, their specific requirements prevent their long-term survival in temperate climates. The *Idolomantis diabolica* female found in Hesse and the *Hymenopus coronatus* female from Karlsruhe are such specimens. More problems are caused by "opportunistic insect lovers". These people, usually broadly interested in nature, often find mantises during their holidays. For educational purposes or out of own interest the mantis is brought back home. However, when interest in the specimen vanishes, it is often released because of a reluctance to kill it. *Mantis religiosa* is often involved in this type of translocation despite its conservation status, and at least some of the specimens which showed up in previous times at unusual locations might have represented such introductions (EHRMANN 2011b).

A whole different situation, however, is faced by Mediterranean countries. Their climate is suitable for mantodean establishment and reproduction, and most of the established allochthonous mantodeans (*Brunneria borealis*, *Miomantis caffra*, *M. paykullii*, *Hierodula transcaucasica*) occur there. It is, in fact, almost a surprise that the Chinese Mantis, *Tenodera sinensis*, has not yet set permanent foot on the European continent, considering its use in scientific laboratories, its ability to adapt to temperate climates, and the easily obtainable oothecae from the American market. This species has not yet managed to adapt to the Central European climate, since its early hatching (April-June) and late maturation (end of August to September) (PRETE et al. 1999) make it vulnerable to climatically unfavorable years. Even the most long-living population in one of the warmest regions of Germany survived only four years (according to our data). However, global change may eventually favor the species' survival at higher latitudes, so any voluntary release of this species for whatever reasons should be strictly avoided. Its establishment in more southerly regions seems to be only a matter of time.

The impacts of the new mantodeans on the native European fauna are hard to assess, as most populations are too recent to allow a thorough analysis. We can make some predictions, which can be tested when new data become available.

Competitive effects like resource depletion and intraguild predation are probably negligible. When compared to structurally comparable habitats in Africa and East Asia, Europe is depauperate in mantodeans due to past Ice Age oscillations. That is, there is no saturation point reached yet, providing empty niches for newcomers. Similar effects could be detected in the Nearctic after the introduction of three new mantodeans, *Mantis religiosa*, *Tenodera sinensis* and *T. angustipennis*. The addition of mantises to pristine habitats changed the biomass equilibrium to new values and affected abundances of certain taxa, but did not cause any extinction. Also, all three species could co-exist due to slight differences in their realized niches (reviewed in PRETE et al. 1999, see also BERG et al. 2011). As pointed out by KALTENBACH (1963) and BERG et al. (2011), realized niches of sympatric mantodeans are different enough to allow the coexistence of many syntopic Mantodea species, as evidenced, e.g. by African savannas.

Therefore, according to current data, we expect the invasive taxa to exert no severe competitive effects on native mantodeans. However, there is an interesting possibility that *Hierodula transcaucasica* and *Sphodromantis viridis* will eventually meet on a Mediterranean island or somewhere on the Balkan or Italian peninsula. The nominate subspecies of *Sph. viridis* occurs on Cyprus (KALTENBACH 1963, EHRMANN 2011a), so it is possible that this will be the first area colonized by both species, given that the spread of *H. transcaucasica* around the Aegean Sea continues. The genera *Sphodromantis* and *Hierodula* occupy similar arbusticolous to arboricolous niches in the Afrotropical and Oriental realms, respectively, overlapping in Iran. Should they ever coexist, it would be interesting to monitor the interactions of *H. transcaucasica* and *Sph. viridis*, in order to compare them with the results obtained for the graminicolous *Tenodera* species and *Mantis religiosa* in the USA.

Other than ecological effects are also known. In New Zealand, the males of the native *Orthodera novaezealandiae* (COLENSO, 1882) have been shown to react to the pheromones of females of the introduced (and more ferocious) *Miomantis caffra*, flying to their doom (FEA et al. 2013). Are such effects likely in Europe? While theoretically possible, we do not expect them to occur. This is because *O. novaezealandiae* has been the only native Mantodea species in New Zealand for a few million years at least, facing no sexual competition with other species. In such a case, it is reasonable to assume the species-specific component of the pheromone and/or of the detectors on the male antennae to have been lost or reduced over time, rendering the endemic species vulnerable towards any new mantodean in New Zealand, or at least towards groups initially not present in Australasia, like Miomantidae. Europe, while depauparate today, harbours ca. 30 native Mantodea species from five families, and was still much richer in the Tertiary. Many of those species still co-occur today in adjacent regions and share an evolutionary history of species-specific selection.

To sum up, we think that invasive mantodeans are not that much of a concern for local biodiversity as other invertebrates (e.g. the Argentine Ant, *Linepithema humile* MAYR, see LOWE et al. 2000). Nevertheless, we think that all biological invasions should be prevented by all means, and, once established despite all efforts, closely monitored. Non-native specimens should be collected when discovered,

and turned over to local natural history museums, so scientists can track the species' spread or demise over the years. Most importantly, we discourage any activity that tries to "enrich" local faunas by mindlessly releasing non-native biota.

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References

ANDERSON, K. (2018): Praying mantises of the United States and Canada. – Independently published; 291 p.

BALLINI, S. & WILHALM, T. (2014): *Ameles spallanzania* (Rossi, 1792) (Insecta, Mantidae, Amelinae): neu für die Region Trentino-Südtirol. – Gredleriana 14: 271-274.

BATTISTON, R. & MASSA, B. (2008): The Mantids of Caucasus (Insecta Mantodea). – Atti Acc. Rov. Agiati, a. 258, ser. VIII, vol. VIII B: 5-28.

BATTISTON, R., PICCIAU, L., FONTANA, P. & MARSHALL, J. (2010): Mantids of the Euro-Mediterranean Area. – World Biodiversity Assocation onlus, Verona, 239 p.

BATTISTON, R., ANDRIA, S. & RUZZANTE, G. (2017): The silent spreading of a giant mantis: a critical update on the distribution of *Sphodromantis viridis* (Forskål, 1775) in the Mediterranean islands (Mantodea: Mantidae). – Onychium 13: 25-30.

BERG, M., SCHWARZ, C.J. & MEHL, J.E. (2011): Die Gottesanbeterin, *Mantis religiosa.* – Die Neue Brehm-Bücherei 656, Westarp Wissenschaften, Hohenwarsleben; 521 p.

BOETTNER, G.H., ELKINTON, J.S. & BOETTNER, C.J. (2000): Effects of a Biological Control Introduction on Three Nontarget Native Species of Saturniid Moths. – Conserv. Biol. 14: 1798-1806.

BOLIVAR, I. (1897): Catálogo sinóptico de los Orthópteros de la fauna Ibérica. Fam. III. Mántidos. – Ann. Sci. Nat. 4: 132-135, 203-208.

BOLSHAKOV, L.V., SHCHERBAKOV, E.O., MAZUROV, S.G., ALEKSEEV, S.K., RYABOV, S.A. & RUCHIN, A.B. (2010): Northernmost records of praying mantis *Mantis religiosa* (Linnaeus, 1758) (Mantodea: Mantidae) in European Russia. – Eversmannia 23/24: 22-25.

CANYELLES, X. & ALOMAR, G. (2006): Sobre la presència de *Sphodromantis viridis* (Forskål, 1775) (Dictyoptera, Mantoidea) a Mallorca. – Boll. Soc. Hist. Nat. Balears 49: 83-87.

CIANFERONI, F., MOCHI, O. & CECCOLINI, F. (2018): New records of *Hierodula* Burmeister, 1838 (Mantodea: Mantidae) in Europe. – Rev. Gadit. Entomol. 9 (1): 299-308.

CIVEYREL, L. & SIMBERLOFF, D. (1996): A tale of two snails: is the cure worse than the disease? – Biodiv. Conserv. 5: 1231-1252.

CLAVERO, M. & GARCÍA-BERTHOU, E. (2005): Invasive species are a leading cause of animal extinctions. – Trends Ecol. Evol. 20: 110.

COURCHAMP, F., CHAPUIS, J.-L. & PASCAL, M. (2003): Mammal invaders on islands: impact, control and control impact. – Biol. Rev. 78: 347-383.

EHRMANN, R. (2002): Mantodea – Gottesanbeterinnen der Welt. – Natur und Tier -Verlag, Münster; 519 p.

EHRMANN, R. (2011a): Mantodea from Turkey and Cyprus (Dictyoptera: Mantodea). – Articulata 26 (1): 1-42.

EHRMANN, R. (2011b): *Mantis religiosa religiosa* Linné, 1758 in Deutschland und angrenzenden Ländern (Insecta: Mantodea). – Articulata 26 (2): 135-146.

EHRMANN, R. & REINHARDT, R. (2011): Beiträge zur Insektenfauna Sachsens, Band 9. Fauna der Fangschrecken (Mantodea) Sachsens. – Mitt. Sächs. Entomol. Suppl. 9: 82-96, 3 pl.

FEA, M.P., STANLEY, M.C. & HOLWELL, G.I. (2013): Fatal attraction: sexually cannibalistic invaders attract naïve native mantids. – Biol. Lett. 9: 20130746.

FERNÁNDEZ, D. & SANTAEUFEMIA, X. (2016): Primera cita a Europa d'un pregadéus d'origen americà, *Brunneria borealis* Scudder, 1896 (Insecta: Mantodea: Mantidae). –Butlletí ICHN 80: 141-144.

FRITTS, T.H. & RODDA, G.H. (1998): The Role of Introduced Species in the Degradation of Island Ecosystems: A Case History of Guam. – Annu. Rev. Ecol. Syst. 29: 113-140.

GURNEY, A.B. (1951): Praying mantis of the United States, native and introduced. – Annu. Rep. Smiths. Inst. f. 1950: 339-362, 9 pl.

GURNEY, A.B. (1955): Further notes on *Iris oratoria* in California (Mantodea). – Pan-Pac. Entomol. 31 (2): 67-72.

HARTMANN, M., KÖHLER, G. & EHRMANN, R. (2018): Die Europäische Gottesanbeterin, *Mantis religiosa religiosa* Linnaeus, 1758, und die Mittelmeer-Gottesanbeterin, *Iris oratoria* (Linnaeus, 1758) (Insecta: Mantodea, Mantidae et Tarachodidae), neu für Thüringen. – Mitteilungen des Thüringer Entomologenverbandes e.V. 25 (2): 38-47.

HOWARTH, F.G. (1991): Environmental impacts of classical biological control. – Annu. Rev. Entomol. 36: 485-509.

HOWARTH, F.G. & MULL, W.P. (1992): Hawaiian Insects and their kin. – University of Hawaii Press, Honolulu; 160 p.

IDELBERGER, S. & NIEHUIS, M. (2006): Gefräßige "Chinesen" aus dem amerikanischen Schmelztiegel. – Rheinpfalz 22.XI.2006.

KALTENBACH, A.P. (1963): Kritische Untersuchungen zur Systematik, Biologie und Verbreitung der europäischen Fangheuschrecken (Dictyoptera-Mantidea). – Zool. Jahrb. Syst. 90: 521-598.

LECHNER, F. (2007): Siegeszug des Liebhaber mordenden Insekts. – Bruchsaler Rundschau 62 (210): 15.

LOWE, S., BROWNE, M., BOUDJELAS, S. & DE POORTER, M. (2000): 100 of the World's Worst Invasive Alien Species. A selection from the Global Invasive Species Database. – Published by The Invasive Species Specialist Group (ISSG), a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN).

MACK, R.N., SIMBERLOFF, D., LONSDALE, M.L., EVANS, H., CLOUT, M. & BAZZAZ, F.A. (2000): Biotic Invasions: Causes, Epidemiology, Global Consequences, and Control. – Ecol. Appl. 10: 689-710.

MARABUTO, E. (2014): The Afrotropical *Miomantis caffra* Saussure 1871 and *M. paykullii* Stal 1871: first records of alien mantid species in Portugal and Europe, with an updated checklist of Mantodea in Portugal (Insecta: Mantodea). – Biodiv. Data J. 2: 34117. doi: 10.3897/BDJ.2.e4117.

MARABUTO, E, RODRIGUES, I & HENRIQUES, S (2014): *Sphodromantis viridis* (Forskål, 1775): New for Portugal and new records of the rare and small mantids *Apteromantis aptera* (Fuente, 1894) and *Perlamantis allibertii* Guérin-Méneville, 1843 in the country (Mantodea: Mantidae and Amorphoscelidae). – Biodiv. Data J. 2: e1037. doi: 10.3897/ BDJ.2.e1037.

MAXWELL, M.R. & EITAN, E. (1998): Range expansion of an introduced mantid *Iris oratoria* and niche overlap with a native mantid *Stagmomantis limbata* (Mantodea: Mantidae). – Ann. Entomol. Soc. America, 91 (4): 422-429.

MCKINNEY, M.L. & LOCKWOOD, J.L. (1999): Biotic homogenization: a few winners replacing many losers in the next mass extinction. – Trends Ecol. Evol. 14: 450-453.

NIEHUIS, M. (2006): Meldeaufruf: Gottesanbeterin (*Mantis/Tenodera*). – GNOR Info: 102.

NIEHUIS, M., EHRMANN, R. & PFEIFER, M.A. (2011): Chinesische Gottesanbeterin – *Tenodera sinensis* Saussure, 1871. In: PFEIFER, M.A., NIEHUIS, M., RENKER, C. (eds): Die Fang- und Heuschrecken in Rheinland-Pfalz. – Fauna und Flora in Rheinland-Pfalz, Beiheft 41: 156-160.

PARKER, I.M., SIMBERLOFF, D., LONSDALE, W.M., GOODELL, K., WONHAM, M., KAREIVA, P.M., WILLIAMSON, M.H., VON HOLLE, B., MOYLE, P.B., BYERS, J.E. & GOLDWASSER, L. (1999): Impact: toward a framework for understanding the ecological effects of invaders. – Biol. Inv. 1: 3-19.

PFEIFER, M.A. & EHRMANN, R. (2011): *Empusa* Illiger, 1798. – In: PFEIFER, M.A., NIEHUIS, M., RENKER, C. (eds): Die Fang- und Heuschrecken in Rheinland-Pfalz. – Fauna und Flora in Rheinland-Pfalz, Beiheft 41: 161-162.

PRETE, F.R., WELLS, H., WELLS, P.H. & HURD, L.E. (1999): The praying mantids. – University Press, Baltimore, 362 p.

PUPIŅŠ, M., KALNIŅŠ, M., PUPIŅA, A. & JAUNDALDERE, I. (2012): First records of European Mantid *Mantis religiosa* (Linnaeus, 1758) (Insecta: Dictyoptera, Mantidae) in Latvia. – Acta Biol. Univ. Daugavpil. 12 (2): 175-184.

RAMSAY, G.W. (1984): *Miomantis caffra*, a new mantid record (Mantodea: Mantidae) for New Zealand. – N. Zeal. Entomol. 8: 102-104.

ROY, R. (2010): Mises au point sur le genre *Sphodromantis* Stål, 1871 (Mantodea, Mantidae). – Bull. Soc. Entomol. France 115 (3): 345-366.

RUZZANTE, G. & LEO, P. (2012): Segnalazioni faunistiche n. 115-118. – Quad. Studi Nat. Romagna 35: 172-176.

SCHWARZ, C.J., KELLER, M. & BERGER, D. (2017): Neues zur Gottesanbeterin, *Mantis religiosa* Linnaeus, 1758 (Mantodea, Mantidae), dem Insekt des Jahres 2017. – Entomol. Nachr. Ber. 61 (1): 1-18.

SCUDDER, S.H. (1896): Index to the Mantidae of North America, north of Mexico. – Can. Entomol. 28: 207-215.

SLINGERLAND, M.V. (1900): A new beneficial insect in America. The common European praying mantis. – Bull. Cornell Univ. Agric. Exp. Stat., Entomol. Div. 185: 35-47.

STROHECKER, H.F. (1952): Two Palaeartic Orthoptera established in the United States. – Pan-Pac. Entomol. 28 (3): 138.

VAN DER HEYDEN, T. (2018a): An interesting finding of a mantis on Crete/Greece (Dictyoptera: Mantodea: Mantidae: Mantinae: Paramantini). – BVnPC 7 (99): 142-145.

VAN DER HEYDEN, T. (2018b): First record of *Hierodula transcaucasica* Brunner von Wattenwyl (Mantodea: Mantidae: Mantinae: Paramantini) in Albania. – Rev. Chilena Entomol. 44 (4): 407-409.

VITOUSEK, P.M., D'ANTONIO, C.M., LOOPE, L.L. & WESTBROOKS, R. (1996): Biological Invasions as Global Environmental Change. – Amer. Sci. 84: 468-478.

VITOUSEK, P.M., D'ANTONIO, C.M., LOOPE, L.L., REJMÁNEK, M. & WESTBROOKS, R. (1997a): Introduced species: a significant component of human-caused global change. – N. Zeal. J. Ecol. 21:1-16.

VITOUSEK, P.M., MOONEY, H.A., LUBCHENCO, J. & MELILLO, J.M. (1997b): Human Domination of Earth's Ecosystems. – Science 277: 494-499.

WERNER, F. (1915): Verschleppung von Fangheuschrecken (Mantodeen) durch den Schiffer-Verkehr. – Zeitschr. Wiss. Insektenbiol. 11 (3-4): 98-99.

WERNER, F. (1933): Neue Orthopteren im Naturhistorischen Museum zu Basel. II. Eine neue *Stagmatoptera*-Art: *Stagmatoptera vischeri*. – Verh. Naturf. Ges. Basel 43: 3.

ZIELIŃSKI, D., SCHWARZ, C.J. & EHRMANN, R. (2018): Evaluation of the expansion of *Mantis religiosa* (L.) in Poland based on a questionnaire survey. – Anim. Biodiv. Cons. 41: 275-280.