

# Evaluation of the expansion of *Mantis religiosa* (L.) in Poland based on a questionnaire survey

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Zieliński, D., Schwarz, C. J., Ehrmann, R., 2018. Evaluation of the expansion of *Mantis religiosa* (L.) in Poland based on a questionnaire survey. *Animal Biodiversity and Conservation*, 41.2: 275–280, Doi: <https://doi.org/10.32800/abc.2018.41.0275>

## Abstract

*Evaluation of the expansion of Mantis religiosa (L.) in Poland based on a questionnaire survey.* *Mantis religiosa* (L.) is the only species of praying mantis in Poland. The main habitat where its occurrence is permanent and confirmed is the Sandomierska Basin (SE Poland). Numerous reports suggest a significant dispersion of these insects in Poland. Therefore, we decided to use and collect information to update the knowledge about the spread of the praying mantis in Poland. With the use of Google Maps, we created a map on which respondents were asked to select the location where they encountered a *M. religiosa* specimen in Poland in recent years (2013–2016). In total, we obtained 159 locations for the European mantis. These findings show the significant spread of this species in all directions from its main habitat in Sandomierska Basin. However, there is a need for more studies on this topic, especially to confirm the existence of reproductive populations in the provided locations and to confirm the existence of two different *M. religiosa* lineages in Poland.

Key words: Praying mantis, *Mantis religiosa*, Poland, Distribution, Questionnaire survey

## Resumen

*Evaluación de la expansión de Mantis religiosa (L.) en Polonia basada en una encuesta.* *Mantis religiosa* (L.) es la única especie de mantis religiosa en Polonia. El hábitat principal en el que se ha confirmado su presencia permanente es la cuenca de Sandomierska (SE de Polonia). Numerosos informes sugieren una dispersión significativa de estos insectos en Polonia. Por lo tanto, decidimos utilizar y recopilar información para actualizar el conocimiento sobre la propagación de *M. religiosa* en Polonia. Con el uso de Google Maps, se creó un mapa sobre el que se pidió a los encuestados que seleccionaran el lugar donde hubieran encontrado un espécimen de mantis en Polonia en los últimos años (2013–2016). En total, se obtuvieron 159 lugares para la mantis europea. Estos resultados muestran la dispersión significativa de esta especie en todas las direcciones desde su hábitat principal en la cuenca de Sandomierska. Sin embargo, es necesario realizar más estudios sobre este tema, especialmente para confirmar la existencia de poblaciones reproductivas en las localizaciones proporcionadas y de dos diferentes linajes de *M. religiosa* en Polonia.

Palabras clave: Mantis, *Mantis religiosa*, Polonia, Distribución, Encuesta mediante cuestionario

Received: 11 VIII 17; Conditional acceptance: 17 X 17; Final acceptance: 13 XII 17

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## Introduction

Polish fauna contains only one species of praying mantis, the European Mantis, *Mantis religiosa* (L.). The 'European' mantis is distributed throughout most of the Old World. Besides Europe, it occurs in Africa, Asia, and most of the Sunda archipelago, crossing 55° N in parts of Russia (Bolshakov et al., 2010). Older records of the species occurring in Australia, Bolivia, and the Caribbean, carried over in the literature for more than a century have been shown by Berg et al. (2011) to be erroneous. However, *M. religiosa* was introduced in Rochester, New York in 1899 (Berg et al., 2011), and the species is widely distributed across North America today (Gurney, 1950; Cannings, 2007; Berg et al., 2011).

The species has also recently shown a significant northward spread in several European countries, such as Germany (Berg et al., 2008, 2011; Stärz et al., 2010; Ehrmann, 2011; Landeck et al., 2013; Linn and Griebeler, 2015; Schwarz et al., 2017), France (Voisin, 2003), the Czech Republic (Piszkiwicz et al., 2000; Hanac and Hudeček, 2001; Tichá, 2005; Janšta et al., 2008; Gruchala, 2010; Holuša et al., 2012; Chobot, 2016), Slovakia (Kočárek et al., 1999; Krištín et al., 2004; Krištín and Hruz, 2005; Fedor, 2007; Fedor et al., 2010), Latvia (Pupiņš et al., 2012), Russia (Bolshakov et al., 2010; Shcherbakov and Savitsky, 2015), Ukraine (Nagy et al., 2011), Croatia (Romanowski and Romanowski, 2014), Hungary (Nagy and Sziráki, 2002; Nagy and Kisfali, 2007) and Poland (Sępioł, 2005; Buczyńska et al., 2006; Liana, 2007; Bonk and Kajzer, 2009; Bonk et al., 2011; Ćwik et al., 2012; Kozina, 2015; Błoński, 2015; Zieliński and Łazarecki, in press).

Historically, the Polish population has been assigned to its own subspecies, *Mantis religiosa polonica* Bazyluk, 1960, due to differences in morphology and postembryonic development from southern and central European nominative populations (Bazyluk, 1960). Its subspecific status, however, has not been universally accepted (see Berg et al., 2011; Schwarz et al., 2017 for a review).

*M. religiosa* is protected by national law in Poland (Ordinance of the Minister of the Environment of 16 December 2016 on protection of endangered species. Dz. U. from 2016 pos. 2183). Its main area of occurrence is located in the Sandomierska Basin macro-region (SE Poland), especially the Sandomierskie Forest, Janowskie Forests and Lipskie Forest in the southeastern part of Poland (Liana, 2007). However, there are many reports about new sites in other parts of country (Bonk and Kajzer, 2009; Bonk et al., 2011; Ćwik et al., 2012; Kozina, 2015; Zieliński, 2016). Moreover, every year during summer, in early August, accidental findings of praying mantises in different parts of Poland are published on Polish websites. During this time, *M. religiosa* undergoes its final molt, after which the specimens gain the ability to fly. Volant specimens are attracted by light and often show up inside houses or apartments. Usually, people do not know what kind of insect they are faced with; therefore, the encounter is an interesting event worth posting online (Zieliński et al., 2017).

The aim of this study was to use the knowledge of Polish people about the occurrence of the praying mantis to compile an online distribution map and to evaluate its expansion in Poland.

## Material and methods

We created an editable map of Poland using Google Maps® software. Respondents were asked to pinpoint the location where they found a *M. religiosa* specimen in Poland in recent years (2013–2016). To achieve this, we sent links to the map via social networking sites and online forums about wildlife and nature to people agreeing to assist in data collecting. Volunteers were also asked to provide information about the mantis they have encountered, with regard to stage (nymph, adult or ootheca), color (green or brown), sex (male or female), and location. Based on the information provided, the distributional records were plotted onto a UTM grid. To emphasize the different metapopulations of *M. religiosa* in different parts of Poland, their anticipated occurrence was drawn as ellipses. The ellipses were made according to the possible spread of the species on the basis of data provided by respondents and scientific data.

## Results and discussion

Based on the replies from 283 respondents, 159 locations of the European Mantis in Poland were obtained (fig. 1). *M. religiosa* is a protected species by national law in Poland as well as in Belgium, Germany, Luxembourg, Switzerland, Austria, the Czech Republic, Slovakia, and Hungary (Berg et al., 2011; Schwarz et al., 2017). However, due to its extensive range and higher abundances in climatically more favorable regions, it is listed in the IUCN Red List of Threatened Species in the 'Least Concern' category (Battiston, 2016). Additionally, in Poland this species is listed in the 'Red List of Threatened and Endangered Animals' (Głowaciński, 1992a; 2002) and in two editions of the 'Polish Red Book of Animals' (Głowaciński, 1992b; Głowaciński and Nowacki, 2004), initially with the status CR (critically endangered), later reduced to EN (species of very high risk).

Despite having been considered endangered or critically endangered at the northern edge of its distribution for the best part of last century, its recent rapid spread in North America and Central Europe shows that the species is actually a good disperser, able to rapidly invade new localities when environmental conditions are favorable (Pupiņš et al., 2012; Schwarz et al., 2017). Perhaps, if the current expansive trend continues, the conservation status of this species in the Polish law will have to be reconsidered.

The main sources of information about the recent distribution of *Mantis religiosa* in Poland are the paper of Liana (2007) and several smaller papers and popular articles (e.g. Bonk and Kajzer, 2009; Królik, 2010; Bonk et al., 2011; Kozina, 2015; Kozina and Łopucki, 2016) which reported findings of single mantises in

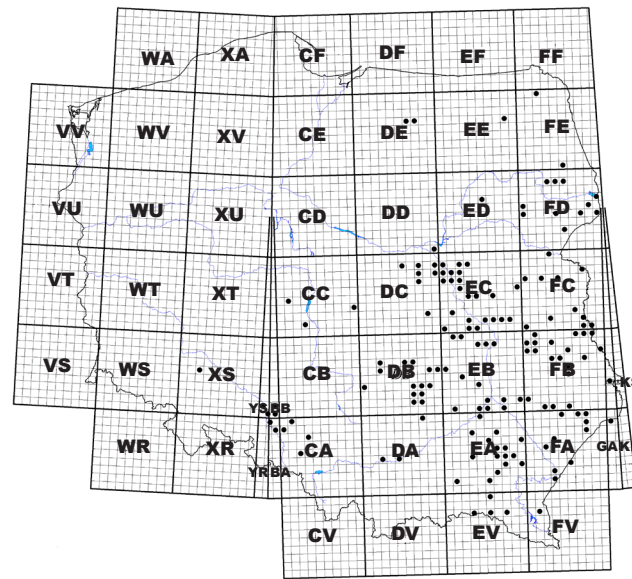


Fig. 1. Map of Poland showing Polish volunteers' pinned locations of *Mantis religiosa* encounters on a UTM grid of 10 x 10 km squares (created with GNOMON 3.1).

Fig. 1. Mapa de Polonia en el que se muestran los lugares en los que los voluntarios polacos indicaron haber encontrado un espécimen de *Mantis religiosa* en una cuadrícula UTM de 10 x 10 km (creado con GNOMON 3.1).

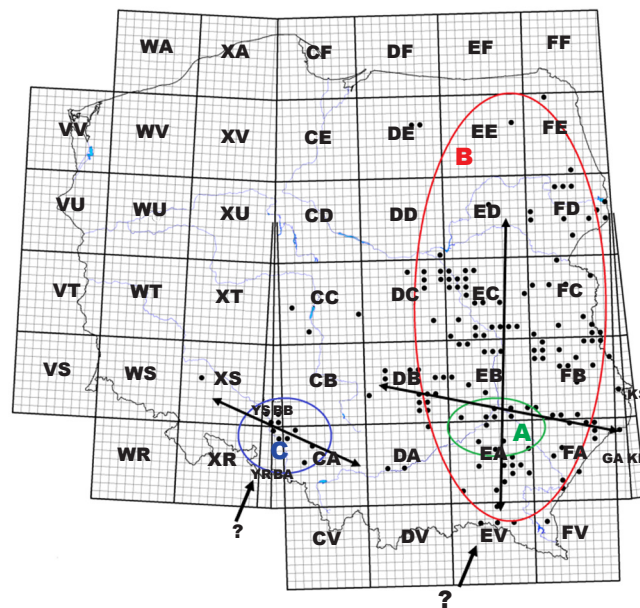


Fig. 2. Current expansion of *Mantis religiosa* in Poland and possible migration paths: A, long-term occurrence according to Liana (2007); B, possible expansion of populations originating from the population in circle A; C, new populations of *Mantis religiosa* probably not related to the populations from circle A.

Fig. 2. Expansión actual de *Mantis religiosa* en Polonia y posibles rutas migratorias: A, presencia durante un largo período de tiempo según Liana (2007); B, posible expansión de las poblaciones originarias de la población contenida en el círculo A; C, nuevas poblaciones de *Mantis religiosa* que probablemente no guardan relación con las poblaciones del círculo A.

different parts of the country. This indicates a significant spread of the European mantis in Poland. This study underscores this. Liana (2002) designates the Sandomierskie Forests, the Janowskie Forests and the Lipskie Forests, which are located in southeast Poland in the Sandomierska Basin macro-region, as the northern boundary of occurrence of these insects. In the mentioned 'forests' ('Puszcza' in Polish), the occurrence of this insect is permanent, confirmed and documented back to the early 1920s (Liana, 2007). In the 18th century, it even occurred as far north as Warsaw (Berg et al., 2011). We have found that today *M. religiosa* is widely distributed north of the boundary mentioned by Liana (2002). The subsequent study of Liana (2007) confirmed the presence of *M. religiosa* in the following regions of Poland: the Sandomierska Basin, the Lubelska Upland, the Małopolska Upland and the Carpathians. Since Liana (2007) summarized entomological data until 2006, a great recent range expansion of *M. religiosa* in Poland becomes obvious. This research corroborates the data of Liana (2007), but enumerates many more regions in which mantises were encountered (fig. 1). Based on these data, several conclusions about the significant spread of this species in all directions from their distributional core can be drawn (fig. 2). We consider these new distributional localities to be indeed new and not just overlooked older populations for the following reasons. First, in Central Europe, including Poland, orthopterans are a well-researched group because of their suitability for habitat quality assessment, and as such are frequently monitored. *Mantis religiosa* is also monitored in such studies (e.g. Liana, 2002; Nagy and Sziráki, 2002; Krištín et al. 2004; Krištín and Hruz, 2005; Nagy and Kisfali, 2007; Nagy et al., 2011; Holuša et al., 2012), and would have been recorded earlier if previously present. Second, the current spread observed in Poland is paralleled by that in neighboring countries (see above). And third, the species would have been previously encountered by laypersons if present in a certain location, even if abundances were lower and encounters rare. Previous records from most of the new localities, many of which are outside the known historical range of the species, are unknown.

The historical occurrence of *M. religiosa* in the Sandomierz Basin is not surprising as the warm climate of the region supports thermophilic taxa like mantises (Walther et al., 2009; Linn and Griebeler, 2016). However, the new reports of mantises in the southern parts of the country are intriguing. Liana (2007) had already mentioned the presence of two metapopulations in Poland, 'the Sandomierz' and 'the Carpathian'. In 1960 Bazyluk reported the subspecies *Mantis religiosa polonica* for the Sandomierz Basin population. But he also included the Ukrainian and northeast Austrian populations into *M. r. polonica*. Several authors were skeptical about the distinctive status of *M. r. polonica*, most notably A. Kaltenbach (1963 in Kočárek et al., 2005), suggesting that the Sandomierz population was only an ecological form characteristic for the northern edge of the range of this species (see also Berg et al., 2011). Królik (2010)

compared his specimens from UTM YS01 with the description of *M. r. polonica* given by Bazyluk (1960), and found them to be incompatible. He concluded that the specimens he found in Opole were *M. r. religiosa*, which now occurs abundantly in the Czech Republic (Chobot, 2016) and Slovakia (Fedor et al., 2010). Therefore, the specimens from southern Poland are representatives of morphologically typical *M. r. religiosa* which may have migrated through the Moravian Gate from Czech Moravia. They would thus represent a subspecies previously not recorded in Poland (fig. 2). Our own results confirm the occurrence of *M. religiosa* at UTM YS01 indicated by Królik (2010), supplemented by additional populations in the nearest area to the south (UTM BA98, UTM BA89, UTM CA08, UTM CA19).

New genetic data do not support the existence of more than one subspecies in Europe. Linn and Griebeler (2015) showed differences between the populations of western and eastern parts of Germany, using four mitochondrial markers. They detected a threefold origin of German haplogroups, two originating from France, and the other from the Czech Republic. In a more extensive study, Vitáček (2016) showed that European populations represent three distinct lineages derived from Pleistocene refugia in S Europe: an Eastern lineage derived from the Black Sea refuge, a Western lineage derived from a Franco-Iberian refuge, and a central lineage which found refuge in southern Italy and the Adriatic region. The Central European (E Germany, Czech Republic, Poland, Slovakia, Austria, S Switzerland) populations all derive from an eastern branch of the central lineage. Vitáček's (2016) data also show that the Sandomierz population has an impoverished haplotype set and clusters deeply nested among *M. r. religiosa* central lineage populations. This means that this population does not represent an entity worth of subspecific rank. Consequently, Schwarz et al. (2017) recently synonymized *M. r. polonica* Bazyluk, 1960 with *M. r. religiosa* Linnaeus, 1758.

## Conclusions

The widescale spreading of *Mantis religiosa* in Europe is a natural consequence of global warming and improved conservation measures (Walther et al., 2009; Linn and Griebeler, 2015; Schwarz et al., 2017). Even though the European mantis is the most common and widespread Mantodea species in the world, and despite being the subject of many different studies since historical times, there are many aspects of its biology and distribution which still need to be addressed, in addition to potential threats. The new localities of the European Mantis in Poland obtained through the present study show its recent rapid spread across the country. These data cannot yet be considered as confirmed sites of vital *M. religiosa* populations because they are based on anonymous responses, not on thorough entomological studies. Nevertheless, they are a serious signal for entomologists to undertake studies to confirm these

locations and update the data on the prevalence of the European Mantis in Poland. Moreover, there is a need for a refinement of genetic data in order to track the colonization pathways of *M. religiosa* in Poland and other European countries.

### Acknowledgements

We would like to thank all the respondents who provided data about their encounters with praying mantises in Poland. We also thank Paweł Buczyński (Department of Zoology, Maria Curie Skłodowska University in Lublin) for helping create the UTM map with the localities.

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