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The first record of the allochthonous *Hierodula tenuidentata* Saussure, 1869 (Insecta: Mantodea) in northwestern Romania

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Abstract. An imago, three nymphs and an ootheca of the alien mantid *Hierodula tenuidentata* were observed for the first time in northwestern Romania in 2022, and then in 2023 and 2024. This is the northernmost point where this species has been observed on the territory of Romania, suggesting a sequel in the extension of its range in the country.

Introduction

The genus *Hierodula* Burmeister, 1838 is the largest and one of the most widely distributed genera of mantids in the world, predominantly in the Australasian region (Leong 2009, Liu et al. 2020, Yamasaki et al. 2022). The giant Asian mantid *Hierodula tenuidentata* Saussure, 1869 (Mantodea, Mantidae, Hierodulinae), is distributed from Central Asia (Kazakhstan, Turkmenistan and Tajikistan) to Indonesia (Sunda Islands; Patel & Singh

2016). It is a large species (up to 70-80 mm in body length) and it was first recorded in Romania in 2019, probably as an example of transportation (Pintilioaie et al. 2021). Recently, it has been considered by some authors as synonym with *H. transcaucasica* Brunner von Wattenwyl, 1878, which was originally described for the northeast of Iran, therefore its entire native range goes westward to the Caucasus (Caesar et al. 2015, Patel & Singh 2016).

All the specimens and oothecas observed so far in Romania are from the east, south and southwest of the country, and the help of citizen science proved valuable through pictures posted on social media, like in other countries (Di Pietro & Battiston 2021, Kalaentzis et al. 2021, László et al. 2023, Pintilioaie et al. 2021). The first record of the species in Europe (Crimea) was in 1916, and it was rediscovered there only in 2016 (suggesting re-introduction rather than continuity of an established population), with recent expansion of range in Albania, Italy, Bulgaria, Greece, and Ukraine. Therefore, its presence in Romania was expected especially in the southern part, due to the suitable climatic conditions. Most of the recorded specimens in Europe were found in cities, in anthropogenic habitats (possibly due to moderate climate conditions and fewer predators), and its distribution in Romania is still punctiform, suggesting an aided dispersion (Pintilioaie et al. 2021).

The ootheca is variable in size, rounded, with almost straight proximal and distal edges, and the residual process is situated in the upper part of the distal end (Pintilioaie et al. 2021, Vasilev et al. 2023).

The presence of this alien species in Italy was first documented in 2016 (Battiston et al. 2019) and now it indicates a stable population (Battiston et al. 2018). It was found in the Greek islands for the first time in 2015 and then more precisely in 2018, in the mainland in 2013, and in Bulgaria in 2017 (possibly in 2016), partly as *H. transcaucasica*, expanding its range throughout the country (Cianferoni et al. 2018, Romanowski et al. 2019, Schwarz & Ehrmann 2018, Vasilev et al. 2023). In Crete it was found in 2008 and then in 2018 (as *H. transcaucasica*), and in 2021 it seemed to be established there

(Schwarz & Ehrmann 2018, van der Heyden & Schwarz 2021). It was found in Albania in 2018, in Serbia it was first identified in 2019 in photos posted on social media and then confirmed and collected in 2020, and it was found in Croatia in 2021 (Martinović et al. 2022, Schwarz & Ehrmann 2018, Vujić et al. 2021). Its recent spread in the Balkans, Central Europe, France and Spain was also documented, and it was first found in Hungary in 2019 and since then it was established there (László et al. 2023). Meanwhile, its range expanded in Asia as well (Liu et al. 2021, Mirzaee & Pashaie Rad 2017, Pahnwar et al. 2020 – in the last two as *H. transcaucasica*).

Other species in the genus were expanding their range in Europe and Asia recently, some identified with the help of citizen science (Battiston et al. 2020, Foo & Yeap 2021, Liu et al. 2020, Moulin 2020, Shim et al. 2021, Yadav et al. 2018, Yamasaki et al. 2022), while others are studied as potential biological control agents of pests (Raut et al. 2014).

Material and methods

On 5 August 2022 a last instar nymph of *H. tenuidentata* was observed in Oradea, near the Țării Crișurilor Museum. It was kept in a terrarium until moulting, and only the moult could be retrieved and preserved. On 29 September 2023 an imago was observed and collected in the same location, and an ootheca was observed on *Rosa sp.* near the same place and collected on 19 October 2023. The collected specimens were preserved and placed in the entomological collection of the Țării Crișurilor Museum. On 11 July 2024, two more nymphs were observed in the same place.

Results

The observed nymphs and the imago were females (Fatimah et al. 2016). The nymph observed in 2022 (Fig. 1) had a total body length of 45 mm and its pronotum was 20 mm long and maximum 5 mm wide. Its moult (Fig. 2) and the

imago and ootheca observed in 2023 (Fig. 3) were prepared and photographed as well.



Fig. 1. Habitus of the nymph observed in 2022.

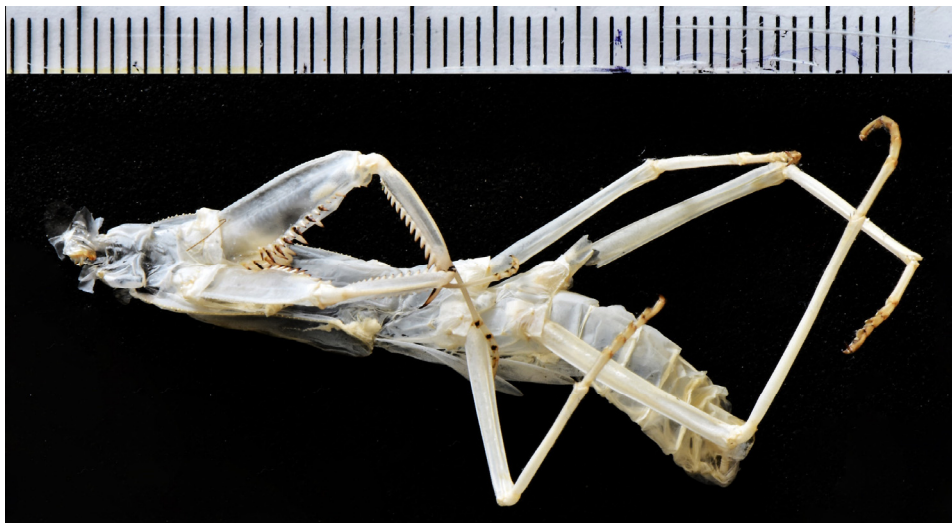


Fig. 2. The moult of the nymph from 2022 (photo Al. Szabó).



Fig. 3. Habitus of the imago and the ootheca observed in 2023 (photo E. Posmoşanu).

The specimens were identified based on the following morphological features (Battiston et al. 2019, 2020; Ghahari & El-Den Nasser 2014 – as *H. transcaucasica*; Pintilioaie et al. 2021; Romanowski et al. 2019 – as *H. transcaucasica*):

- whitish stigma on the forewings of the imago, compared to greenish like the rest of the tegmina in the similarly looking *Mantis religiosa* (Linnaeus, 1758) and *Iris oratoria* (Linnaeus, 1758);
- lack of a dark or white ringed dark spot on the fore coxae, as opposed to *M. religiosa* and *I. oratoria*;
- ovoidal shape of the pronotum, compared to spatulate in the allochthonous African species *Sphodromantis viridis* Forsskål, 1775;
- lack of conspicuous whitish plates at the base of the spines of inner margins of fore coxae, as in the other allochthonous species *H. patellifera* Serville, 1839;
- two small tubercles on the mesosternum (absent in *S. viridis*).

Discussion

The arrival of this species in Romania could have occurred by three hypothetical ways: deliberate or accidental releases from insect breeders (less likely), accidental introduction from Central Europe or South Europe, or by boats on the Black Sea. The recent records from more countries in a few years can be explained only as human introductions, deliberate or not, and then as natural spread from there. Thus, only genetic studies on the European populations of *H. tenuidentata* could point to their real origin (Pintilioaie et al. 2021). The sightings in Oradea documented by the present paper suggest a reproducing population and could be the result of the spread of the established populations in Hungary (László et al. 2023) or of northward expansion of the populations in south-western Romania. The expansion of this species all over Romania was to be expected, and the lack of data for central and north-western Romania does not mean absence.

The impact of this alien species on the indigenous fauna is unknown, since there was no evidence of invasive behavior so far, and an estimate of it may be too early due to its recent expansion and still punctiform distribution in Europe. Compared to the similar habitats in Africa and East Asia, Europe has fewer mantodeans due to the past Ice Age oscillations, so there are still empty ecological niches available for newcomer taxa (Moulin 2020, Schwarz & Ehrmann 2018).

An interesting observation is the non-specific pheromone attraction of males by females of another species, namely the widespread European *Mantis religiosa* males can be attracted by the pheromones of phylogenetically distant species and were observed arriving at cages with *Tenodera aridifolia sinensis* females, two species belonging to separate subfamilies (Lelito & Brown 2008). Similarly, males of *Orthodera novaezealandiae* (Colenso, 1882), a species native to New Zealand, react to the pheromones of females of the introduced *Miomantis caffra* Saussure, 1871 (Schwarz & Ehrmann 2018). Accordingly, cross-species reproductive behavior in *H. tenuidentata* and *H. transcaucasica* may include native species, as already observed (László et al. 2023). In *H. patellifera*, which is new to Europe as well (Battiston et al. 2020), the female can produce three oothecae after one mating and is not available for subsequent mating (Leong 2009), so the reproduction of *H. tenuidentata* may possibly interfere with the reproduction of native Mantidae species. Its impact on native mantids may be also positive if the parasitoids found in its oothecae in south-western Romania prove to be species-specific (Rădac & Háva 2021).

Furthermore, *M. religiosa* may be possibly predated by *H. tenuidentata*, both as nymphs or during sexual cannibalism, since the latter is more massive, even though it tends to be more arboreal (a tendency possibly reduced in urbanized habitats). The overlapping of the life cycles of *M. religiosa* and *H. tenuidentata* may suggest general competition between native and allochthonous mantids (Battiston et al. 2018, 2019, 2020, Di Pietro & Battiston 2021, Pintilioaie et al. 2021, Romanowski et al. 2019, Schwarz & Ehrmann 2018, Vujić et al. 2021).

The arrival of this species in Romania could have occurred by three hypothetical ways: deliberate or accidental releases from insect breeders,

accidental introduction from Central Europe or South Europe, or by boats on the Black Sea. The recent records from more countries in a few years can be explained only as human introductions, deliberate or not, and then as natural spread from there (Pintilioaie et al. 2021). Artificial light and climate anomalies may also have a role in facilitating the expansion of *H. tenuidentata* from Asia to Europe (Cianferoni et al. 2018). Moreover, this alien species is already established in northern Italy, as it can survive the harsh winters there, with persistent temperatures below 0 °C and extremes of -5 °C (Battiston et al. 2018, Di Pietro & Battiston 2021), and in Hungary as well (László et al. 2023). The northernmost observation in Europe was in Chernihiv, Ukraine (51.5°N, 31.2°E) (László et al. 2023), much further north than north-western Romania, and it may be an isolated occurrence. In most of its range it is found around urbanized areas, a fact possibly facilitated by the urban heat island effect (László et al. 2023), or a characteristic that may be due both to a distributional and a methodological bias (van der Heyden & Schwarz 2021). Its rapid, however non-contiguous dispersal in Europe in recent years seems to be facilitated involuntarily by human transportation activities (Battiston et al. 2018, László et al. 2023), since there were no reports of this species from western Anatolia (Schwarz & Ehrmann 2018).

The identity of *H. tenuidentata* and *H. transcaucasica* is still controversial, and the considerable morphological variability of the specimens from the former's native range (Central Asia) and both native and colonized European areas has led to suggestions of synonymy, though without a formal redescription. Several authors accepted the synonymy, while others continued to consider the two species as distinct or even considered all the European occurrences as *H. transcaucasica* (van der Heyden & Schwarz 2021). Yet the single objective morphological character useful to differentiate *H. tenuidentata* from *H. transcaucasica* is the presence of completely black discoidal spines on the fore femora in the first and of apically black spines in the latter, which is not a constant character however, and is not supported by the examination of male genitalia, and thus synonymy with *H. tenuidentata* comes as a natural

conclusion (Battiston et al. 2018), requiring a formal re-description. The genus seems to be paraphyletic, and a revision of the entire complex is needed (Schwarz & Roy 2019).

Further confusion can arise from another similar species, the East Asian congener *H. patellifera* (Audinet-Serville, 1838), which is allochthonous to Europe as well (in southern France and northern Italy). Therefore, to verify the synonymy, a proper investigation is needed on a considerable number of specimens from all over the range of *H. tenuidentata* and *H. transcaucasica* (van der Heyden & Schwarz 2021). Also, the validity of the many species in the genus needs verification and revision based on morphological characters, for future aid in identification, including of potential or real invasive species. For instance, *H. patellifera* (Serville, 1839), which is also expected to expand its European range, is easily recognizable based on the two to five whitish spines on its fore coxa (Battiston et al. 2020, Leong 2009, Oshima 2021).

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