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## The distribution of meadow and steppe vipers (*Vipera graeca*, *V. renardi* and *V. ursinii*): a revision of the New Atlas of Amphibians and Reptiles of Europe

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In some cases, species' distributions have not been accurate and some geographical areas were not accounted for in the New Atlas of Amphibians and Reptiles of Europe (NA2RE), a project performed by the Mapping Committee of the Societas Europaea Herpetologica (SEH). The distribution of species within the *Vipera ursinii-renardi* group were presented jointly as a single taxon ("*Vipera ursinii/renardi*"), without differentiation between the meadow viper *V. ursinii*, the steppe viper *V. renardi*, and the recently described Greek meadow viper *Vipera graeca*. Here we present a revised 50×50 km resolution distribution map of this group with new records, eliminating putative or erroneous records and extinct populations. Additionally, we filled several spatial gaps in the distribution of *V. renardi* in Eastern Europe by incorporating recent regional overviews, previously considered ambiguous or inaccessible to most researchers, due to language barriers.

**Key words:** Biogeography, mapping, NA2RE, snake, threatened species, Viperidae.

The New Atlas of Amphibians and Reptiles of Europe (hereafter NA2RE; SILLERO *et al.*, 2014a,b) was created to present and provide accurate knowledge on the spatial distribution of amphibians and reptiles in Europe. It is the most comprehensive and up-to-date spatial database of

European herpetofauna. However, exact distributions of some species groups remain unresolved (but see WIELSTRA *et al.*, 2014). Species groups have often been the subject of continuous taxonomic studies and rearrangements; thus, species status of some lineages, borders of area, extent of

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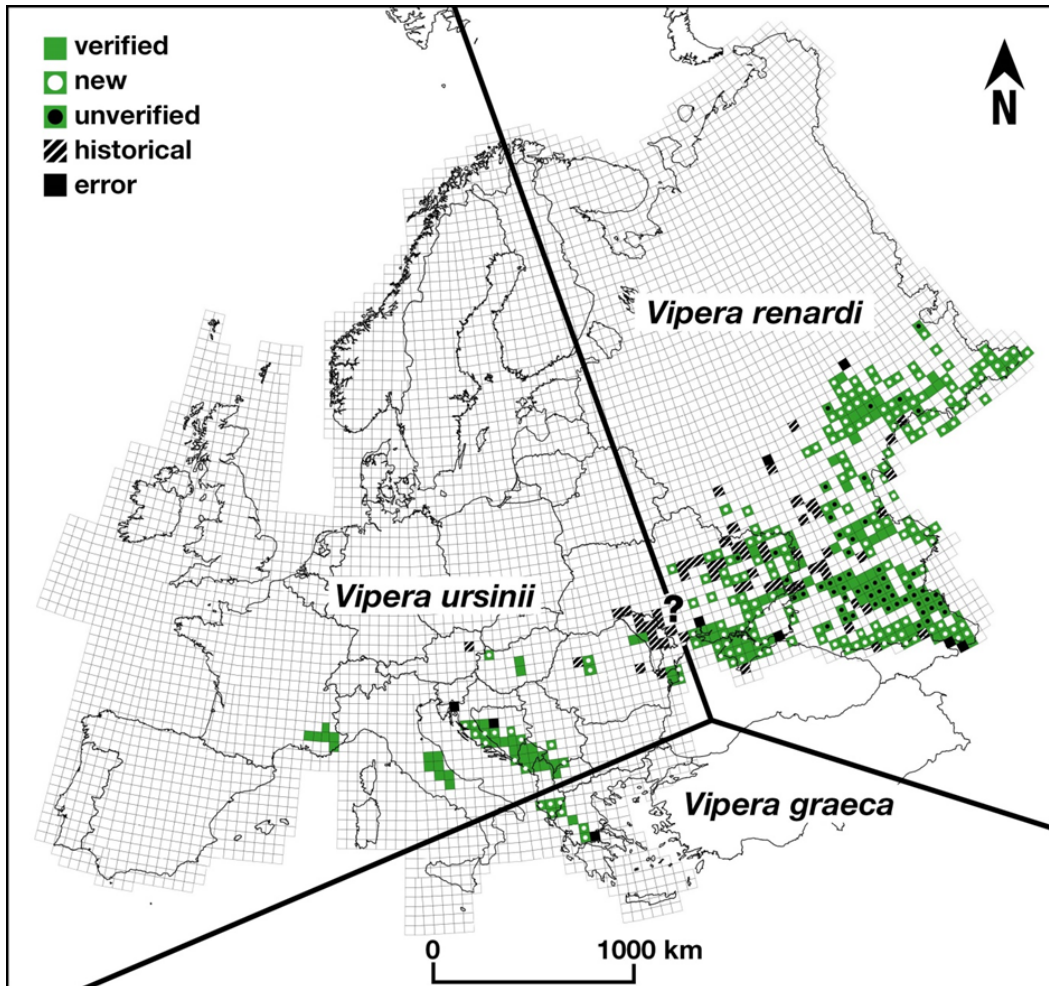
overlaps, and potential hybrid zones are often unknown or unrecognised (e.g. Gvoždík *et al.*, 2010).

The distribution of viper species of the *ursinii-renardi* group (sometimes referred as the *Acridophaga* subgenus), have been jointly presented as a single taxon in NA2RE “*Vipera ursinii/renardi*”, including records of both the meadow viper *V. ursinii* and steppe viper *V. renardi*. The latter was not accepted previously as a full species by the Societas Europaea Herpetologica (SEH) (footnote 9 on table 3 in SILLERO *et al.*, 2014a), despite that species delimitation between *V. ursinii* and *V. renardi* had been proved or discerned (NILSON & ANDRÉN, 2001; FERCHAUD *et al.*, 2012; GVOŽDÍK *et al.*, 2012). Further mitochondrial and nuclear DNA evidences also support the species status of these lineages (ZINENKO *et al.* 2015; MIZSEI *et al.*, 2017). A recent taxonomic change has also influenced the current known distribution of this group, as the Greek meadow viper *Vipera graeca*, a former subspecies of *V. ursinii*, was elevated to the species level (MIZSEI *et al.*, 2017). Additionally, most of the distribution within the former Soviet Union is poorly understood because of the lack of accessible observation records. In fact, *V. renardi*, which is more common in lowland steppes, is more widespread than previously depicted in the NA2RE (e.g. ZINENKO *et al.* 2015). Most published occurrence records are hard to find or overlooked, as they are often harboured in regional publications and written in local languages. Here, we have compiled these observations to update the map.

We revised the presence records of the group, differentiating *V. ursinii*, *V. renardi*

and *V. graeca* in the NA2RE data (Supplementary Material) cell by cell. We have (i) identified cells with species' presence (=1); (ii) confirmed species' presence with available data in published or unpublished sources; (iii) added new species' presence when we had available data for a cell previously showing species' absence (=0); (iv) deleted species' presence (1→0) when there was no evidence of presence (mainly by erroneous identification of species and locations); (v) changed status of cells to historical where there was no observations for the last 25 years, and provided the date of last observations; and finally (vi) we added a comment to each cell where changes were implemented. We determined the species according to recent molecular studies on meadow and steppe vipers (FERCHAUD *et al.*, 2012; ZINENKO *et al.*, 2015; MIZSEI *et al.*, 2017). Following the results of FERCHAUD *et al.* (2012) and ZINENKO *et al.* (2015), we treated *Vipera lotievi* (NILSON *et al.*, 1995) as *V. renardi* s.l. To revise the distribution we used literature sources (SUKHOV, 1928; BANNIKOV *et al.*, 1977; NILSON & ANDRÉN, 2001; VLASOV & VLASOVA, 2001; DOTSENKO, 2003; KRECSÁK *et al.*, 2003; FILIPPI & LUISELLI, 2004; FERRI & MARCONI, 2006; GHIRA, 2007; VEDMEDERJA *et al.*, 2007; ZINENKO & BAKIEV, 2007; FERRI & PELLEGRINI, 2008; SELIUNINA, 2008; KOTENKO & KUKUSHKIN, 2008; 2009; STRUGARIU *et al.*, 2011; ZAMFIRESCU *et al.*, 2012; COGĂLNICEANU *et al.*, 2013; DEBELO & CHIBILYOV, 2013; FROLOVA & KLIMOV, 2013; JELIĆ *et al.*, 2013; LYET *et al.*, 2013; BAKIEV *et al.*, 2015; PÉCHY *et al.*, 2015; TUPIKOV & ZINENKO, 2015; ZINENKO *et al.*, 2015; BAKIEV *et al.*, 2016; MIZSEI *et al.*, 2016); museum collections (The M. Shcherbak Zoological

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**Figure 1:** Revised distribution of meadow and steppe vipers in Europe.

Museum, National Museum of Natural History at the National Academy of Sciences of Ukraine, Kiev; The Museum of Nature at V. N. Karazin Kharkiv National University, Kharkiv, Ukraine); and records from our personal unpublished databases, and other unpublished sources (see acknowledgements). The date of each record was taken from the corresponding publication; in the case when no date was available in the text, we used the date of

the publication for which it was referenced in. All records before 1992 (from 25 years ago) were considered as “historical”. After that point, with the maximum pressure from agriculture on steppic habitats of *V. renardi* and *V. ursinii* in the former USSR countries, there was temporary relief for steppic habitats, and a shift in the way of their management. Simultaneously, national Red data books and sometimes local monitoring programs started to gather

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current data about local species in newly established independent countries.

We added seven cells to the distribution of *V. graeca* from new populations recently discovered (Fig. 1). Furthermore, only one cell was confirmed and another one was deleted because observations suggest presence only in the neighbouring cell. We validated the presence of *V. renardi* in 42 cells, added 173 new cells based on published (N = 144 cells), and unpublished observations of the authors (N = 29 cells), listed 69 as historical, and deleted 6 cells (erroneous species identification in the literature; specification and correction of geographic coordinates of localities), most of them located in the north-eastern edge of the species' distribution in Europe. However, we were unable to validate 56 cells where *V. renardi* is present in the NA2RE, but kept these cells as occupied in the database until these areas are further investigated. The distribution of *V. ursinii* (separated from the distribution of *V. graeca* and *V. renardi*) remained the same in most parts (33 cells), but we added 17 cells mainly in the Balkan Peninsula based on the comprehensive database of JELIĆ *et al.* (2013). We have changed the status of 17 cells to "historical", mostly in Bessarabia (Ukraine, Romania, and Republic of Moldova), the eastern edge of the species range (*V. ursinii* ssp. *moldavica*). Most likely, all populations have gone extinct in these areas due to habitat alteration by agriculture. Last recorded observations of meadow viper there belong to the 1970's, and only a few survived populations near Iasi and in the Danube Delta still existing (KRECSÁK *et al.*, 2003). There are no known overlaps among the geographic ranges of

the three species, thus, we consider them as allopatric; however, a contact zone may have historically existed between *V. renardi* and *V. u. moldavica* (see Fig. 1). Overall, we increased the known distribution of *V. graeca* by 87.5%, *V. renardi* by 63.8%, and *V. ursinii* by 34.0% in 50×50 km grid cells.

We assume that at this scale (50×50 km grids), further fieldwork may only slightly increase the currently known range of *V. graeca* and *V. ursinii*. However, it is possible to improve our knowledge of the distribution at finer scales, mostly in the reticulating mountain ranges in the Balkan Peninsula where these species live in isolated high alpine meadows that have been poorly explored. Due to the large distribution of *V. renardi* in Eastern Europe, which was mostly continuous in the past, there is potential for substantially extending the list of localities of these species and filling gaps in the known distribution, mostly in Southern Russia. Greater prevalence of "historical" observations (before 1992) in that region, indicates a need for contemporary surveys and consistent monitoring. Recent habitat loss, population size decrease, and population extinctions may be overlooked due to data deficiency. Northern isolated historical records in Russia may have resulted from range fluctuations in postglacial times (ZINENKO & BAKIEV, 2007), similarly to other reptile species in the region (MAROSI *et al.*, 2012); many of these populations are most likely to be extinct now.

All three species are threatened by past and ongoing habitat loss and fragmentation. IUCN Red List Category of *V. ursinii* is Vulnerable (VU) globally (JÖGER *et al.*, 2009), and *V. renardi* is VU in Europe re-

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gionally (COX & TEMPLE, 2009). *V. graeca* fulfils the criteria for the category of Endangered (EN) because the species' area of occupancy is less than 500 km<sup>2</sup>, the distribution is severely fragmented and there is ongoing habitat loss and degradation (MIZSEI *et al.* in press). Our updated maps increase vital information needed for the implementation of effective conservation of these species, by pinpointing the geographic areas to focus future conservation efforts on. Our results are integrated to NA2RE, the web-based spatial data infrastructure, underpinning the New Atlas of Amphibians and Reptiles of Europe (<http://na2re.ismai.pt>).

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