Reptiles and their conservation in south-west Ukraine

Oleksandra Oskyrko*[1,2,3], Roman Lysenko[4], Daryna Obikhod[4], Maksym Yakovliev[5,6] and Oleksandr Haidash[5,6]

Abstract Knowledge of the spatial distribution of reptiles is essential for decision-making in conservation under future climate change scenarios. We present a new compilation of reptile records for Odesa Oblast (i.e. province), south-west Ukraine. We compiled 662 records: 200 from our own research during 2012–2022, 362 from the published literature, 73 from public databases and 27 from museum collections. Fourteen native species of reptile (one species of Emydidae, four of Lacertidae, one of Anguidae, six of Colubridae and two of Viperidae) have been recorded in Odesa Oblast but the distribution of several are poorly known and/or records have rarely been published. We also report four introduced reptile species (one each of Emydidae, Gekkonidae, Lacertidae and Anguidae). We present the data in a grid of 462 10 × 10 km cells covering the oblast. In this compilation we did not record any new species, but our records include previously unreported localities for some species. Species richness was highest in the areas along the Black Sea, in protected areas. The main threats to the reptiles in Odesa Oblast are the alteration and degradation of habitats, military action, uncontrolled pressure from infrastructure projects and the presence of invasive species.

Keywords Europe, mapping, new records, occurrence, Odesa Oblast, protected areas, Reptilia, Ukraine

The supplementary material for this article is available at doi.org/10.1017/S0030605323001321

Introduction

The availability of reliable maps that depict the historical and current distribution of reptile species is important for conservation research (Sillero et al., 2014). Reptiles are a good model group for mapping studies because they are dependent on specific habitat types, have narrow ranges and are sensitivite to anthropogenic factors (Sinervo et al., 2010; Böhm et al., 2013). Many groups of reptiles are affected both directly and indirectly by anthropogenic impacts, particularly those that result in habitat loss and transformation (Wake & Vredenburg, 2008; Keinath et al., 2017).

Ukraine has relatively low levels of species richness compared to other European countries (Sillero et al., 2014), especially in the steppe zone (Tarashchuk, 1959). Odesa Oblast (i.e. province) is part of the Azov–Black Sea eco-corridor in the steppe zone, and this area is important for biodiversity conservation in Ukraine and Europe (Szczerbak, 1988; Kotenko, 2006). It is of particular relevance for local herpetofauna species that are protected at the national or international level (Akimov, 2009; IUCN, 2023). Records of these species are limited compared to other parts of the country, and much of the data are old or ambiguous, especially for rare species (Brauner, 1907; Volyansky, 1928; Kotenko & Tarashchuk, 1982; Tarashchuk, 1987; Szczerbak, 1988). In this area, reptiles face severe threats, including alteration and fragmentation of their native habitats, uncontrolled pressure from infrastructure projects, and pollution and climate change (Kotenko & Panchenko, 1992). In addition, warfare is currently having negative impacts on Ukraine's ecosystems (Vasyliuk, 2023). Fourteen native reptile species have been recorded in Odesa Oblast (Kotenko & Tarashchuk, 1982; Dotsenko & Radchenko, 2005) but only dubious records exist for some of these (Szczerbak, 1988; Tarashchuk, 1989; Kotenko, 1999). In addition, this area is a corridor for introduced species (Duz et al., 2012; Matvyeyev et al., 2013; Krasylenko & Kukushkin, 2017; Oskyrko et al., 2020, 2022a) and these need monitoring and management. Here we report the results of a comprehensive study of reptile distribution in this oblast.

Study area

Odesa Oblast lies in south-west Ukraine, bordering the Black Sea. In the south it borders Romania and in the west Moldova (Fig. 1). The 33,314 km² oblast comprises mostly hilly plains and flat steppes. It also includes an important historical region: Ukrainian Bessarabia. This area is bounded by two large rivers that are significant biogeographical barriers: the Dniester in the north and the Danube in the south. Odesa Oblast connects the eastern Carpathian and the European steppe areas. Most of the oblast lies in the Black Sea lowland, which gradually decreases in elevation towards the south-east (from 150–170 m to 10–20 m; Vermenich, 2010). The climate is moderately continental, with mild winters and little snow (−5.8 to −1.8 °C in

*Corresponding author, sashaoskirko@gmail.com
[1]Ukrainian Nature Conservation Group, Vasylkiv, Ukraine
[2]Institute of Zoology, Chinese Academy of Sciences, Beijing, China
[3]University of Chinese Academy of Sciences, Beijing, China
[4]Educational and Scientific Center, Institute of Biology and Medicine, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
[5]Danube Biosphere Reserve, National Academy of Sciences of Ukraine, Vilkove, Ukraine
[6]H.S. Skovoroda Kharkiv National Pedagogical University, Kharkiv, Ukraine

Received 2 March 2023. Revision requested 12 May 2023.
Accepted 21 August 2023. First published online 15 January 2024.

This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted re-use, distribution and reproduction, provided the original article is properly cited.

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press

FIG. 1 Odesa Oblast, Ukraine, indicating geographical areas and places mentioned in the text.

January) and hot, dry summers (21.0–22.9 °C in July). Total annual precipitation is 380–500 mm (Vishnevsky, 2009). There are 225 rivers in the oblast, of which the Danube and the Dniester are the most important. Odesa Oblast has 123 protected areas with a total area of 1,599 km² (Fig. 1). The largest are the Danube Biosphere Reserve, Tuzly Lagoons National Nature Park and Lower Dniester National Nature Park.

Methods

We compiled location data and created distribution maps for species based on four sources: our own data, museum collections (the National Museum of Natural History at the National Academy of Sciences of Ukraine in Kyiv), published data (Supplementary Material 1) and public databases (UkrBIN, 2017; GBIF, 2023). We compiled records for all of Odesa Oblast. From the public databases we only used records with accompanying photographs, to confirm species identification. We based species identification on Arnold & Ovenden (2002) and followed the taxonomy of Speybroeck et al. (2020). We did not consider subspecies, and therefore represent *Vipera berus nikolskii* as *Vipera ursinii* (Mizsei et al., 2018; Speybroeck et al., 2020).

We conducted herpetological field surveys across the whole area during April–September 2012–2022 (each survey lasted 3–7 days and was conducted by 3–5 people). We surveyed throughout the day (8–10 h of fieldwork) whenever weather conditions were suitable. These surveys were either transects of varying lengths or targeted species searches, covering all habitats. We employed the line transect method, recording and identifying all reptiles found c. 5 m either side (Lovich et al., 2012; McDiarmid et al., 2012). We collected data using dip-netting, netting, trawling of water bodies, stone-turning and other refugia searches as well as visual searches. We documented our observations with digital photographs of individuals, when possible, and of habitats. We released any captured animals at the capture site. In addition, we examined animals killed by people or vehicular traffic. We recorded geographical coordinates and altitudes for all observations using a GPS.

We collected data from the National Museum of Natural History at the National Academy of Sciences of Ukraine in Kyiv in 2021. We did not include published data with unspecified coordinates that could not be georeferenced to a specific locality. We manually georeferenced occurrences without geographical coordinates to the finest scale possible using the information provided by the source and Google Earth (2022). The accuracy of published localities was within 5 km, except for the data from Sillero et al. (2014), which were within 10–50 km. We recorded the geographical coordinates and altitudes of all visited localities as well as other relevant faunistic data. We created maps using *QGIS 3.30* (QGIS, 2022). The distribution data of individual species are presented in maps with a grid of 462 10 × 10 km cells. We categorized presence records as: new occupied cells based on our own records; unverified data from the literature, public databases and museum collections; previous records in cells confirmed by our new records; and historical records that have not been reconfirmed in the last 25 years. We calculated species richness of native reptiles per 10 × 10 km grid cell in *R 4.2.2* (R Core Team, 2022) using the *vegan* package (Oksanen et al., 2019). We obtained shapefiles for protected areas in Ukraine from UNEP-WCMC & IUCN (2023).

Results

We compiled 662 records of all 14 known native reptile species (200 from our survey data, 27 from museum collections, 362 from published literature and 73 from public databases; Table 1, Fig. 2). This represents 66.6% of the total number of known species in Ukraine. These records include one species of Anguidae (*Anguis colchica*), six of Colubridae (*Coronella austriaca*, *Dolichophis caspius*, *Elaphe sauromates*, *Natrix natrix*, *Natrix tessellata*, *Zamenis longissimus*), one of Emydidae (*Emys orbicularis*), four of Lacertidae (*Eremias arguta*, *Lacerta agilis*, *Lacerta viridis*, *Podarcis tauricus*) and two of Viperidae (*Vipera berus*, *Vipera ursinii*). We did not record any new species. In our

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press

TABLE 1 The 14 native reptile species recorded in Odesa Oblast, Ukraine (Fig. 1), with number of records (% of total), number of occupied 10 × 10 km grid cells (% of total), number of records in protected areas (% of total), inclusion in the Red Book of Ukraine (Akimov, 2009), IUCN Red List status and Plate reference.

Species (by Family)	Number of records (% of total)	Number of occupied grid cells (% of total)	Number of records in protected areas (% of total)	Red Book of Ukraine	IUCN Red List status[1]	Plate reference
Anguidae						
Eastern slowworm *Anguis colchica*	1 (0.1)	1 (0.2)	1 (100)	No	LC	
Colubridae						
Smooth snake *Coronella austriaca*	5 (0.7)	5 (1.0)	2 (40.0)	Yes	LC	
Caspian whipsnake *Dolichophis caspius*	120 (18.6)	59 (12.8)	41 (34.2)	Yes	LC	
Blotched snake *Elaphe sauromates*	47 (7.3)	22 (4.7)	19 (40.4)	Yes	LC	
Grass snake *Natrix natrix*	39 (6.0)	33 (7.1)	17 (43.6)	No	LC	1a
Dice snake *Natrix tessellata*	29 (4.5)	20 (4.3)	18 (62.1)	No	LC	
Aesculapian snake *Zamenis longissimus*	1 (0.1)	1 (0.2)	1 (100)	Yes	LC	
Emydidae						
European pond turtle *Emys orbicularis*	66 (10.3)	36 (7.8)	40 (60.6)	No	NT	1b
Lacertidae						
Steppe-runner *Eremias arguta*	40 (6.3)	21 (4.5)	11 (27.5)	No	LC	1c
Sand lizard *Lacerta agilis*	109 (16.9)	58 (12.5)	49 (45.0)	No	LC	1d
European green lizard *Lacerta viridis*	123 (19.0)	54 (11.7)	38 (30.9)	Yes	LC	1e
Balkan wall lizard *Podarcis tauricus*	58 (9.0)	31 (6.7)	18 (31.0)	No	LC	1f
Viperidae						
Common European viper *Vipera berus*	2 (0.3)	2 (0.4)	2 (100)	Yes	LC	
Meadow viper *Vipera ursinii*	6 (0.9)	6 (1.3)	4 (66.7)	Yes	VU	
Total	646 (100)	349 (75.2)	261 (40.4)			

[1]LC, Least Concern; NT, Near Threatened; VU, Vulnerable.

field surveys we were unable to confirm the occurrence of five of the 14 known species (*A. colchica*, *C. austriaca*, *Z. longissimus*, *V. berus*, *V. ursinii*).

Of the 462 10 × 10 km grid cells, we recorded reptiles in 349 (75.2%), of which there were 64 new grid cell records for eight native species. We found 261 records in protected areas (40.4% of all records; Table 1). *Emys orbicularis* is categorized as Near Threatened on the IUCN Red List (Tortoise & Freshwater Turtle Specialist Group, 1996) and *V. ursinii* as Vulnerable (Joger et al., 2009). Seven species (*L. viridis*, *C. austriaca*, *D. caspius*, *E. sauromates*, *Z. longissimus*, *V. berus*, *V. ursinii*) are listed in the Red Book of Ukraine (Akimov, 2009). *Emys orbicularis* had the most records in protected areas (60.6%). For three species found in protected areas (*A. colchica*, *Z. longissimus*, *V. berus*) there was only one record of each. Most data are concentrated in Ukrainian Bessarabia and near the city of Odesa, which served as the working base for most of the field trips. In addition, the number of species and records per grid cell were highest in these areas (Fig. 2). The maximum number of records in a single cell was 33 (for six species) between the villages of Mykolaivka and Kurortne in southern Odesa Oblast. The highest number of species (eight) was near Odesa and lakes Yalpuh and Kuhurlui (near the border with Romania).

We recorded eight species in grid cells in which they had not been reported previously (Fig. 3). Our new records confirm the occurrence of *E. arguta* in Odesa Oblast. In Ukraine, this species is limited to the steppe and forest–steppe zone, in habitats with sandy and sandy–shelly

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press

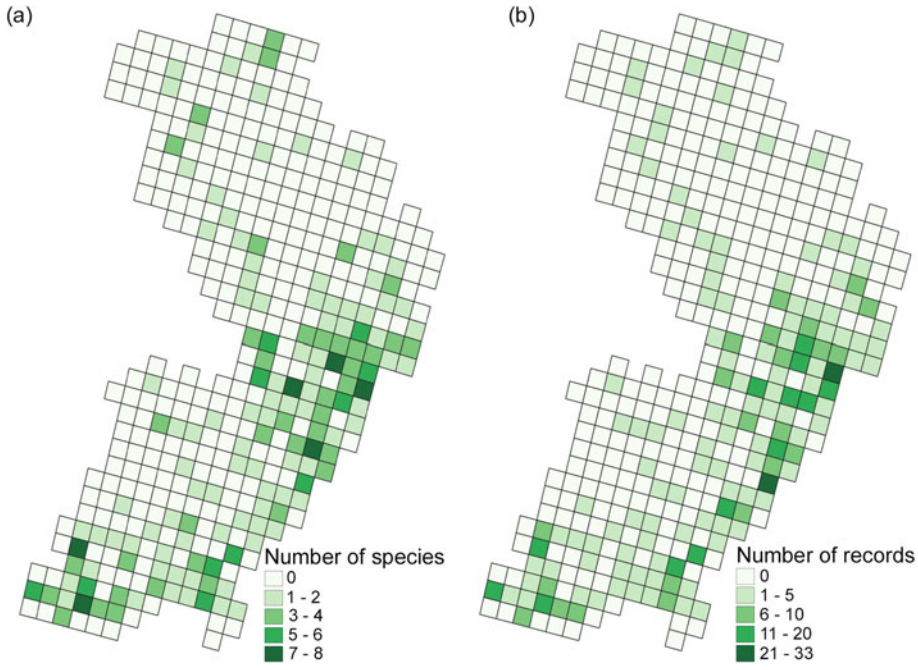

FIG. 2 (a) Number of reptile species and (b) number of records in 10 × 10 km grid cells across Odesa Oblast (Fig. 1).

soils and sparse psammophilous steppe and halophile herbaceous vegetation (Szczerbak, 1993; Plates 1c & 2a). With respect to both the per cent of the total of 654 records and of the 462 grid cells occupied, *D. caspius*, *L. agilis* and *L. viridis* were the commonest and most widely distributed species, respectively (Fig. 3, Table 1). *Dolichophis caspius* is widespread but probably occurs at a low density and hence is rarely observed; although there are records of this species in 59 grid cells, we confirmed its presence in only eight grid cells. We recorded the widespread and common *L. viridis* and *L. agilis* in 54 and 58 grid cells, respectively (Fig. 3).

The European pond turtle *E. orbicularis* was found along estuaries, lakes and large rivers such as the Danube and Dniester. Most of the populations of the lizards were syntopic. We did not find *A. colchica* in the published locality or in other parts of the oblast. We found a new record of *E. arguta* near the village of Pidhirne (46.261°N, 30.029°E). Some of our records for the other species of lizards are new localities but in areas where these lizards were previously known. We frequently recorded *N. natrix* and *N. tessellata* near large estuaries, lakes and large rivers, but these species have a scattered distribution. We found two new records of *E. sauromates*, near the village of Zelena Balka (45.927°N, 29.585°E) and Burnas estuary (45.858°N, 30.137°E). *Dolichophis caspius* was the most common snake, with a high number of observations per grid cell, and our findings confirm previous research on the species' range in Odesa Oblast (Tarashchuk, 2007; Sillero et al., 2014; Nekrasova et al., 2020).

We found 16 records of four introduced species of reptiles (seven from our survey data, eight from the published literature and one from a public database): *Trachemys scripta* (Emydidae), *Tenuidactylus bogdanovi* (Gekkonidae), *Podarcis muralis* (Lacertidae) and *Pseudopus apodus* (Anguidae) (Fig. 4). We found five new records for *T. scripta*, in artificial reservoirs in Odesa. We confirmed the published records for *T. bogdanovi* and *P. muralis* and did not observe any expansion of their range. Information about *P. apodus* has been published previously (Oskyrko et al., 2022a,b), and we did not find any new records of this species.

Discussion

Reptile distribution

There is less species distribution data available for Ukraine in general compared to other European countries (Sillero et al., 2014), which is typical of countries of the former USSR (Zizka et al., 2020), and much of the published research on the reptiles of Odesa Oblast dates from the Soviet era (e.g. Tarashchuk, 1959; Bannikov et al., 1971; Yablokov, 1976). Some of the records from that era do not contain location information (e.g. Tarashchuk, 1959; Kurylenko & Verves, 1999) and were therefore not included in our analysis. Our present compilation, however, is the most complete database to date of reptile occurrences in Odesa Oblast, although the distribution of five of the 14 species (*A. colchica*, *C. austriaca*, *Z. longissimus, V. berus*, *V. ursinii*) remains poorly known and we were unable to confirm their presence. Our survey efforts and those of earlier researchers were not evenly distributed across the oblast and this may partly explain why there are more records in some grid cells, especially near Odesa, for example (Figs 2 & 3).

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press

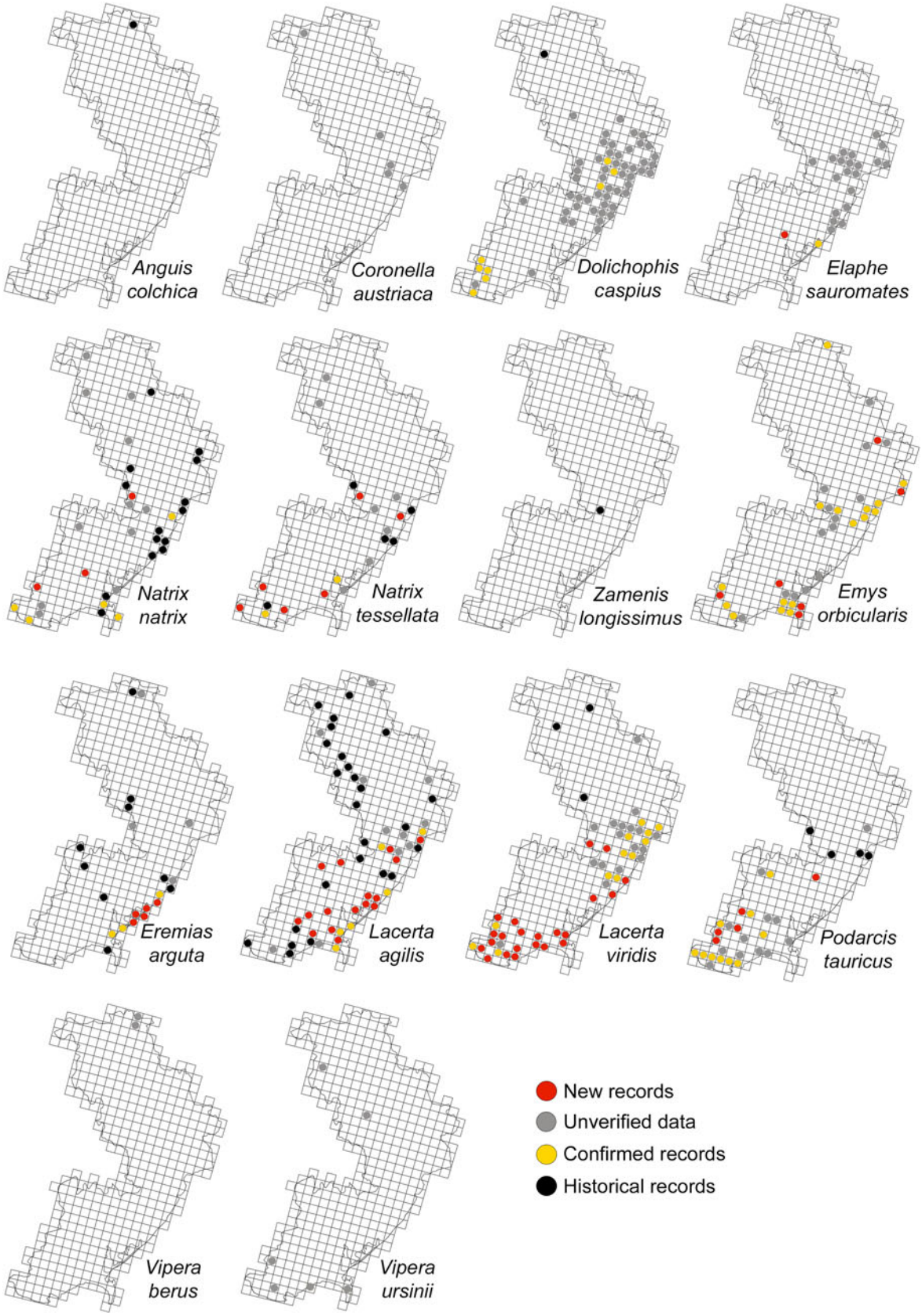

FIG. 3 The distribution of the 14 known native species of reptiles in Odesa Oblast, presented in 10 × 10 km grid cells. (Readers of the printed journal are referred to the online article for a colour version of this figure.)

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press

PLATE 1 Representative photographs of reptile species in Odesa Oblast, Ukraine (Fig. 1). (a) *Natrix natrix*, Lake Yalpuh; (b) *Emys orbicularis*, Lower Dniester National Nature Park; (c) *Eremias arguta*, Budak spit; (d) *Lacerta agilis*, juvenile, Myrne; (e) *Lacerta viridis*, Reni; (f) *Podarcis tauricus*, Lake Yalpuh. Photos: O. Oskyrko (a,b,d,f), R. Lysenko (c,e).

PLATE 2 Representative habitats of reptiles in Odesa Oblast. (a) Habitat of *Eremias arguta*, Budak spit; (b,c) habitat of *Lacerta agilis*, *Natrix natrix* and *Natrix tessellata*, Tuzly Lagoons National Nature Park; (d) habitat of *Lacerta agilis* near the village of Kurortne. Photos: R. Lysenko (a,d), O. Oskyrko (b,c).

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press

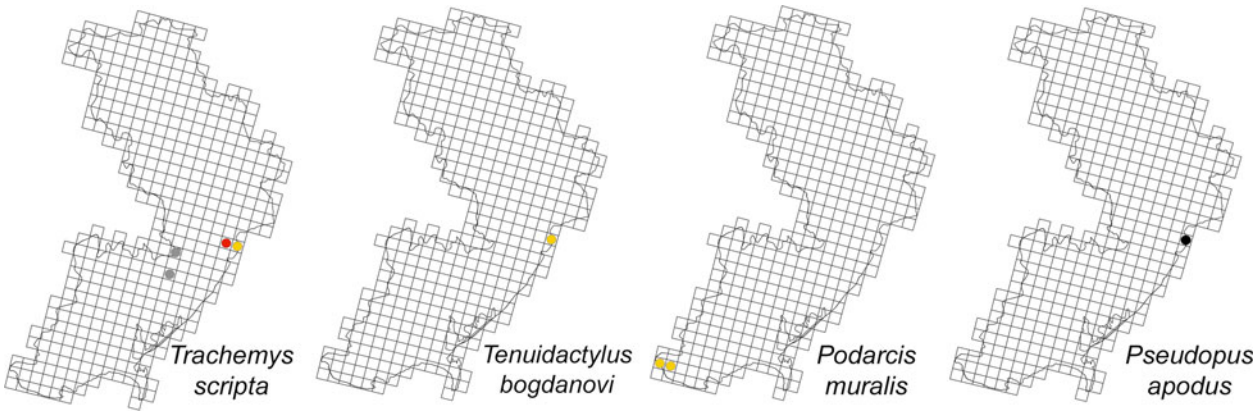

FIG. 4 The distribution of the four known introduced species of reptiles in Odesa Oblast, presented in 10 × 10 km grid cells. See Fig. 3 for key. (Readers of the printed journal are referred to the online article for a colour version of this figure.)

Anguis colchica was found in the 1990s in Savran Forest (Kotenko, 1990) but the species has not been recorded since then (Dotsenko & Radchenko, 2005). The rarity of records could be a result of the low detectability and secretive habits of this species. The earliest record of *C. austriaca* was in 1827 in Holodna Balka (Dotsenko & Radchenko, 2005) but some individuals were subsequently found in Odesa Oblast (Brauner, 1923; Volyansky, 1928; Tarashchuk, 1987; Dotsenko & Radchenko, 2005). The rarity of this species in the Oblast is probably because of habitat alteration by agriculture. *Zamenis longissimus* was recorded in 1985 (and there was an earlier record; Nikolsky, 1916) but has not been recorded since, despite intensive searches. We believe this species could still occur in Odesa Oblast as there are suitable habitats near the Dniester River. The earliest recorded observations for *V. ursinii* were in the 1920s (Brauner, 1923; Volyansky, 1928), and for *V. berus* in the 1990s (in Savran Forest; Kotenko, 1999), but we did not record either species. However, confirmation of the distribution of *V. ursinii* in this area was recently published (Mizsei et al., 2018). Both of these species are threatened by past and ongoing habitat loss and fragmentation. As these five species are rare, further surveys in their preferred habitats are required.

In the south, species richness was higher in the vicinity of the city of Odesa than in the northern part of the oblast. This could indicate synanthropy for some species and/or a result of the greater number of surveys in this area. Species richness was also high along the Black Sea coast (Fig. 2), perhaps as a result of the protected areas in this region (Fig. 1). Compared to the neighbouring Mykolaiv Oblast (935 records), Odesa Oblast has fewer reptile records (Oskyrko & Jablonski, 2021). This could be because of fewer surveys and/or fragmentation of habitats and uncontrolled pressure from infrastructure projects in Odesa Oblast (Kotenko & Panchenko, 1992).

Odesa Oblast has the highest number of introduced species of reptiles of all Ukrainian oblasts. We confirmed the presence of all except *P. apodus* (Fig. 4). *Pseudopus apodus* is included in the Red Book of Ukraine (only for the Crimea; Akimov, 2009) and is categorized as Least Concern on the IUCN Red List (Aghasyan et al., 2021). This species is distributed in the Western Palearctic from the Balkans through to Anatolia and Central Asia; in Ukraine it is native only in Crimea (Sindaco & Jeremcenko, 2008; Oskyrko et al., 2022a). We did not find increased ranges for *T. bogdanovi* and *P. muralis* compared to earlier studies (Matvyeyev et al., 2013; Krasylenko & Kukushkin, 2017; Oskyrko et al., 2020). These species are not included in the Red Book of Ukraine and are categorized as Least Concern on the IUCN Red List (Böhme et al., 2009; Nazarov, 2017). *Tenuidactylus bogdanovi* is native to Uzbekistan, southern Tajikistan, Kazakhstan and parts of Turkmenistan (Nazarov, 2017). These geckos in Ukraine comprise the only European population and were probably imported with cargo from Central Asia (Duz et al., 2012). *Podarcis muralis* is distributed from the Iberian Peninsula to Asia Minor, but is also native to extra-Mediterranean regions in eastern Central and Eastern Europe (Sindaco & Jeremenko, 2008; Schulte et al., 2012). These lizards were introduced into Ukraine via cargo boats on the Danube River from Romania (Oskyrko et al., 2020). We found new records of *T. scripta* near the city of Odesa. Its native range is central, southern and south-eastern USA and north-eastern Mexico (Semenov, 2010; Rhodin et al., 2021). There were numerous sightings of this species in various oblasts of Ukraine at the beginning of the 21st century (Kurtyak & Kurtyak, 2013; Kukushkin et al., 2017; Nekrasova et al., 2022) and in other European countries (Cadi & Joly, 2004; Pupins & Pupina, 2011; Kornilev et al., 2020; Rhodin et al., 2021). This species requires monitoring as it can be a threat to local biodiversity (Ficetola et al., 2012). The number of introduced species is increasing in Europe (Asztalos et al., 2021; van Doorn et al., 2021; Oskyrko et al., 2022b), and requires monitoring in Ukraine.

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press

Conservation

The main threats to reptiles in Europe are agriculture, residential/commercial development, competition for biological resources and habitat fragmentation (Visconti et al., 2018). The steppe biome, which has undergone significant anthropogenic transformation in south-west Ukraine (Kotenko & Panchenko, 1992), is particularly threatened (Wesche et al., 2016). Odesa Oblast contains c. 2.5 million ha of agricultural land, including 2 million ha of arable land and 80,000 ha of vineyards and orchards (Kotenko & Panchenko, 1992). In addition, there is significant tourism related to the Black Sea and the therapeutic mud of the region and its mineral waters (Kotenko, 1999). Tourism related activities can damage the natural steppe areas, which are amongst the largest in Europe (Kotenko, 1999; Kotenko & Panchenko, 1992). In addition, war has a significant destructive impact on nature (Daskin et al., 2015; Gaynor et al., 2016; Braga-Pereira et al., 2020), and the current war with Russia is affecting the steppe zone of Ukraine, including in Odesa Oblast (Vasyliuk, 2023). The most extensive of these negative consequences are fires caused by the firing of ammunition and explosions from mines, but also the explosions of other munitions and the destruction of military equipment, which together can cause long-term soil and surface water pollution.

Conservation of the remaining unique habitats of Odesa Oblast is important for its flora and fauna, including for its reptile species. In this context, distribution data is vital for informing conservation management decisions. The data we have compiled will inform investigations of population changes and modelling of the potential consequences of environmental and climate change. We recommend that future research on the reptiles of Odesa Oblast should focus on: (1) Surveys for the five previously recorded species that we were unable to confirm. (2) Further surveys in the north, which has been less surveyed than the south. (3) The expansion of existing or creation of new protected areas, as the habitats of Odesa Oblast face significant further losses and fragmentation. (4) Raising awareness of reptiles and involving local communities in their conservation, as these are essential to ensure the success of any conservation actions and to establish sustainable land use. (5) Further research in conjunction with local and governmental support for the development of species conservation programmes.

Author contributions Study design: OO; fieldwork and data collection: all authors; data analysis: OO; writing: all authors.

Acknowledgements We thank the administration and employees of Tuzly Lagoons National Nature Park and Danube Biosphere Reserve for supporting our research; the staff of the National Museum of Natural History at the National Academy of Sciences of Ukraine in Kyiv for help with museum collections; all the volunteers for their help with fieldwork and data collection; and the editor and reviewers for their valuable comments. This study was supported by a Rufford Small Grant 'Setting conservation priorities for reptiles and their habitats in the Ukrainian Bessarabia' (ID 34322-2).

Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards.

Data availability The data that support the findings of this study are available at doi.org/10.15468/uq7qrv.

References

Aghasyan, A., Avci, A., Tuniyev, B., Crnobrnja-Isailovic, J., Lymberakis, P., Andrén, C. et al. (2021) *Pseudopus apodus*. In *The IUCN Red List of Threatened Species* 2021. dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T157263A745759.en.

Akimov, I.A. (2009) *Red Data Book of Ukraine. Animals*. Global Consulting, Kyiv, Ukraine. [In Ukrainian]

Arnold, N. & Ovenden, D.W. (2002) *Reptiles and Amphibians of Europe*. Collins, London, UK.

Asztalos, M., Wielstra, B., Struijk, R.P., Ayaz, D. & Fritz, U. (2021) Aliens in the Netherlands: local genetic pollution of barred grass snakes (Squamata: Serpentes: Natricidae). *Salamandra*, 57, 174–179.

Bannikov, A.G., Darevsky, L.S. & Rustamov, A.K. (1971) *Amphibians and Reptiles of the USSR*. Mysl, Moscow, Russia. [In Russian]

Böhm, M., Collen, B., Baillie, J.E.M., Bowles, P., Chanson, J., Cox, N. et al. (2013) The conservation status of the world's reptiles. *Biological Conservation*, 157, 372–385.

Böhme, W., Pérez-Mellado, V., Cheylan, M., Nettmann, H.K., Krecsák, L., Sterijovski, B. et al. (2009) *Podarcis muralis*. In *The IUCN Red List of Threatened Species* 2009. dx.doi.org/10.2305/IUCN.UK.2009.RLTS.T61550A12514105.en.

Braga-Pereira, F., Peres, C.A., Campos-Silva, J.V., Santos, C.V. & Alves, R.R.N. (2020) Warfare-induced mammal population declines in southwestern Africa are mediated by species life history, habitat type and hunter preferences. *Scientific Reports*, 10, 15428.

Brauner, O.O. (1907) Years of Bessarabia. TR. Bessarabia. *Observation Naturalists*, 1, 1–6.

Brauner, O.O. (1923) *Agricultural Zoology*. State Publishing House of Ukraine, Odesa, Ukraine. [In Russian]

Cadi, A. & Joly, P. (2004) Impact of the introduction of the red-eared slider (*Trachemys scripta elegans*) on survival rates of the European pond turtle (*Emys orbicularis*). *Biodiversity & Conservation*, 13, 2511–2518.

Daskin, J.H., Stalmans, M. & Pringle, R.M. (2015) Ecological legacies of civil war: 35-year increase in savanna tree cover following wholesale large-mammal declines. *Journal of Ecology*, 104, 79–89.

Dotsenko, I.B. & Radchenko, V.I. (2005) The Herpetofauna of anthropogenous landscapes of Nikolayev and Odessa regions. *Proceedings of the Zoological Museum*, 37, 109–120. [In Russian, English summary]

Duz, S.L., Kukushkin, O.V. & Nazarov, R.A. (2012) A record of the Turkestan naked-toed gecko, *Tenuidactylus fedtschenkoi* (Sauria: Gekkonidae), in the south-western Ukraine. *Current Studies in Herpetology*, 12, 123–133.

Ficetola, G.F., Rödder, D. & Padoa-Schioppa, E. (2012) Slider terrapin (*Trachemys scripta*). In *Handbook of Global Freshwater Invasive species* (ed. R. Francis), pp. 331–339. Earthscan, Abingdon, UK.

Gaynor, K.M., Fiorella, K.J., Gregory, G.H., Kurz, D.J., Seto, K.L., Withey, L.S. & Brashares, J.S. (2016) War and wildlife:

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press

linking armed conflict to conservation. *Frontiers in Ecology and the Environment*, 14, 533–542.

GBIF (2023) *Global Biodiversity Information Facility*. gbif.org [accessed 13 January 2023].

Google Earth (2022) *Ukraine, 46.614051° N and 30.062325° E*. Google Earth Pro 7.3, Google, Mountain View, USA. google.nl/earth [accessed 6 April 2022].

IUCN (2023) *The IUCN Red List of Threatened Species 2022-2*. iucnredlist.org [accessed 1 March 2023].

Joger, U., Isailovic, J.C., Vogrin, M., Corti, C., Sterijovski, B., Westerström, A. et al. (2009) *Vipera ursinii*. In *The IUCN Red List of Threatened Species* 2009. dx.doi.org/10.2305/IUCN.UK.2009.RLTS.T22997A9406628.en.

Keinath, D.A., Doak, D.F., Hodges, K.E., Prugh, L.R., Fagan, W.F., Şekercioğlu, Ç.H. et al. (2017) A global analysis of traits predicting species sensitivity to habitat fragmentation. *Global Ecology and Biogeography*, 26, 115–127.

Kornilev, Y.V., Lukanov, S., Pulev, A., Slavchev, M., Andonov, K., Vacheva, E. et al. (2020) The alien pond slider *Trachemys scripta* (Thunberg in Schoepff, 1792) in Bulgaria: future prospects for an established and reproducing invasive species. *Acta Zoologica Bulgarica*, 72, 571–581.

Kotenko, T.I. (1986) *Eremias arguta deserti* (Reptilia: Sauria) in the Ukraine. In *Studies in Herpetology* (ed. Z. Rocek), pp. 479–482. Charles University, Prague, Czech Republic.

Kotenko, T.I. (1990) Reptiles. In *Animals of the Red Book* (eds A.P. Fedorenko, I.V. Rogatko, V.I. Lysenko, T.I. Kotenko & S.V. Volovnik), pp. 100–111. Harvest, Kyiv, Ukraine. [In Ukrainian]

Kotenko, T.I. (1999) Habitats of reptiles and other terrestrial vertebrates in the steppe zone. *Development of the Ecological Network of Ukraine*, 1, 80–83. [In Ukrainian]

Kotenko, T.I. (2006) The role of the Azov–Black Sea Ecological Corridor in the conservation of reptiles. *Scientific Bulletin of the Uzhgorod University (Ser. Biol.)*, 19, 20–54. [In Russian]

Kotenko, T.I. & Kukushkin, O.V. (2008) *Vipera renardi* (Christ.) – species of the Red Book of Ukraine. *Findings of the Red Book of Ukraine of Ukraine*, 1, 101–132. [In Ukrainian]

Kotenko, T.I. & Panchenko, N.S. (1992) Some problems of the protected area in the Odesa region of Ukraine. *Socio-Ecological and Economic-Legal Aspects of the Development of the Protected Area*, 1, 73–75. [In Ukrainian]

Kotenko, T.I. & Tarashchuk, S.V. (1982) New in the fauna of the USSR as a subspecies of lizard's lizard – *Lacerta agilis euxinica* Fuhn et Vancea, 1964 (Reptilia, Lacertidae). *Vestnik Zoology*, 6, 33–37. [In Ukrainian]

Krasylenko, Y.A. & Kukushkin, O.V. (2017) An update of thin-toed gecko *Tenuidactylus bogdanovi* (Reptilia, Gekkonidae) population status in Odessa city, Ukraine. *Zbirnik prac' Zoologicnogo muzeu*, 48, 3–12.

Kukushkin, O.V., Doronin, I.V., Tuniyev, B.S., Ananjeva, N.B. & Doronina, M.A. (2017) Introduction of amphibians and reptiles at the Caucasus and the Crimea: an overview and some actual data. *Current Studies in Herpetology*, 17, 157–197. [In Russian]

Kurtyak, F.F. & Kurtyak, M.F. (2013) Red-eared slider *Trachemys scripta elegans* (Wied, 1839) (Reptilia; Testudines), as an invasive threat in Transcarpathian region. *Scientific Bulletin of Uzhgorod University, Ser. Biology*, 34, 58–62. [In Ukrainian]

Kurylenko, V.G. & Verves, Y.A. (1999) *Amphibians and Reptiles of Ukraine*. Genesa, Kiev, Ukraine. [In Russian]

Lovich, R.E., Hayes, W.K., Mushinsky, H. & Rodda, G.H. (2012) Transect surveys, including line distance. In *Reptile Biodiversity, Standard Methods for Inventory and Monitoring* (eds R.W. McDiarmid, M.S. Foster & C. Guyerm), pp. 227–234. University of California Press, Berkeley, USA.

Matvyeyev, A.S., Kukushkin, O.V. & Sokolov, L.V. (2013) Common wall lizard, *Podarcis muralis* (Sauria: Lacertidae), as a new species in the fauna of Ukraine. *Proceedings of the Ukrainian Herpetological Society*, 4, 95–108. [In Russian, English summary]

McDiarmid, R.W., Foster, M.S., Guyer, C., Gibbons, J.W. & Chernoff, N. (eds) (2012) *Reptile Biodiversity: Standard Methods for Inventory and Monitoring*. University of California Press, Berkeley, USA.

Mizsei, E., Zinenko, O., Sillero, N., Ferri, V., Roussos, S.A. & Szabolcs, M. (2018) 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. Basic and Applied Herpetology*, 32, 77–83.

Nazarov, R. (2017) *Tenuidactylus bogdanovi*. In *The IUCN Red List of Threatened Species* 2017. dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T54573089A54573093.en

Nekrasova, O.D., Dyadchko, V.G. & Grandova, M.O. (2020) Red Book reptiles of Odesa region. In *Findings of species listed in the Red Book of Ukraine and International Agreements* (eds A.A. Kuzemko, S.S. Sadogurskaya, P.E. Goldin, V.V. Kavurka, Y.K. Kutsokon, O.D. Nekrasova et al.), pp. 337–338. I.I. Schmalhausen Institute of Zoology of National Academy of Sciences of Ukraine, Kyiv, Ukraine. [In Ukrainian]

Nekrasova, O., Tytar, V., Pupins, M. & Čeirāns, A. (2022) Range expansion of the alien red-eared slider *Trachemys scripta* (Thunberg in Schoepff, 1792) (Reptilia, Testudines) in Eastern Europe, with special reference to Latvia and Ukraine. *BioInvasions Records*, 11, 287–295.

Nikolsky, A.M. (1916) *Reptiles (Reptilia). T. II Ophidia. Fauna of Russia and Neighboring Countries*. Publishing House of the Imperial Academy of Sciences, Petrograd, Russia.

Oksanen, J., Blanchet, F.G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D. et al. (2019) *vegan: Community Ecology Package. R* package version 2.5-6. CRAN.R-project.org/package=vegan [accessed 10 June 2019].

Oskyrko, O. & Jablonski, D. (2021) The first comprehensive data on the distribution of reptiles within the Southern Bug eco-corridor, Ukraine. *Herpetozoa*, 34, 97–114.

Oskyrko, O., Laakkonen, H., Silva-Rocha, I., Jablonski, D., Marushchak, O., Uller, T. & Carretero, M. (2020) The possible origin of the common wall lizard, *Podarcis muralis* (Laurenti, 1768) in Ukraine. *Herpetozoa*, 33, 87–93.

Oskyrko, O., Lysenko, R. & Jablonski, D. (2022a) The sheltopusik (*Pseudopus apodus*) in southwestern Ukraine? Insights from the museum collection. *Evolutionary Systematics*, 6, 71–76.

Oskyrko, O., Sreelatha, L.B., Silva-Rocha I., Sos, T., Vlad, S.E., Cogălniceanu, D. et al. (2022b) Molecular analysis of recently introduced populations of the Italian wall lizard (*Podarcis siculus*). *Acta Herpetologica*, 17, 147–157.

Pupins, M. & Pupina, A. (2011) First records of 5 allochthonous species and subspecies of turtles (*Trachemys scripta troostii*, *Mauremys caspica*, *Mauremys rivulata*, *Pelodiscus sinensis*, *Testudo horsfieldii*) and new records of subspecies *Trachemys scripta elegans* in Latvia. *Management of Biological Invasions*, 2, 69–81.

QGIS (2022) *QGIS Geographic Information System, version 3.30*. Open Source Geospatial Foundation. qgis.org [accessed 29 September 2022].

R Core Team (2022) *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. R-project.org [accessed 19 September 2022].

Rhodin, A.G.J., Iverson, J.B., Bour, R., Fritz, U., Georges, A., Shaffer, H.B. et al. (2021) Turtles of the world: annotated checklist and atlas of taxonomy, synonymy, distribution, and conservation status (9th edition). In *Conservation Biology of Freshwater Turtles*

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press

and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group (eds A.G.J. Rhodin, J.B. Iverson, P.P. van Dijk, C.B. Stanford, E.V. Goode, K.A. Buhlmann & R.A. Mittermeier), pp. 1–472. Chelonian Research Monographs, Vermont, USA.

Schulte, U., Veith, M. & Hochkirch, A. (2012) Rapid genetic assimilation of native wall lizard populations (*Podarcis muralis*) through extensive hybridization with introduced lineages. *Molecular Ecology*, 21, 4313–4326.

Semenov, D.V. (2010) Slider turtle, *Trachemys scripta elegans*, as invasion threat (Reptilia; Testudines). *Russian Journal of Biological Invasions*, 1, 296–300.

Sillero, N., Campos, J., Bonardi, A., Corti, C., Creemers, R., Crochet, P.A. et al. (2014) Updated distribution and biogeography of amphibians and reptiles of Europe. *Amphibia–Reptilia*, 35, 1–31.

Sindaco, R. & Jeremcenko, V.K. (2008) *The Reptiles of the Western Palearctic. Volume 1*. Belvedere, Latina, Italy.

Sinervo, B., Méndez-de-la-Cruz, F., Miles, D.B., Heulin, B., Bastiaans, E., Villagrán-Santa Cruz, M. et al. (2010) Erosion of lizard diversity by climate change and altered thermal niches. *Science*, 328, 894–899.

Speybroeck, J., Beukema, W., Dufresnes, C., Fritz, U., Jablonski, D., Lymberakis, P. et al. (2020) Species list of the European herpetofauna – 2020 update by the taxonomic committee of the Societas Europaea Herpetologica. *Amphibia–Reptilia*, 41, 139–189.

Szczerbak, N.N. (1988) Zoogeographic division of the SSR. *Vestnik Zoology*, 3, 22–31. [In Russian]

Szczerbak, N.N. (1993) *Eremias arguta*. Naukova Dumka, Kiev, Ukraine. [In Russian]

Tarashchuk, V.I. (1959) Amphibians and reptiles. In *Fauna of Ukraine* (eds I.D. Bilanovskyi, M.A. Voinstvenskyi, V.G. Kasyanenko, O.P. Markevich & I.G. Pidoplichko), pp. 1–246. Academy of Sciences of Ukrainian SSR, Kyiv, Ukraine. [In Ukrainian]

Tarashchuk, S.V. (1987) *Herpetofauna of the north-western Black Sea region and its change under the influence of anthropic factors*. PhD thesis. I.I. Schmalhausen Institute of Zoology of National Academy of Sciences of Ukraine, Kyiv, Ukraine. [In Russian]

Tarashchuk, S.V. (1989) Sheltopusik (*Ophysaurus apodus*) from the Black Sea steppes. *Vestnik Zoologii*, 6, 66. [In Russian]

Tarashchuk, V.I. (2007) Conservation of biodiversity in the Primorisky steppe eco-corridor. In *Catalog of Species of Flora and Fauna that are Under Special Protection in Ukraine and are Vulnerable in the Implementation of Forestry Measures*. Veselyy Dolphin, Kyiv, Ukraine. [In Ukrainian]

Tortoise & Freshwater Turtle Specialist Group (1996) *Emys orbicularis* (errata version published in 2016). In *The IUCN Red List of Threatened Species* 1996. dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T7717A12844431.en.

UkrBIN (2017) *UkrBIN: Ukrainian Biodiversity Information Network*. ukrbin.com [accessed 22 June 2017].

UNEP-WCMC & IUCN (2023) *Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM)*. UNEP-WCMC and IUCN, Cambridge, UK. protectedplanet.net [accessed 31 July 2023].

van Doorn, L., Speybroeck, J., Brys, R., Halfmaerten, D., Neyrinck, S., Engelen, P. & Adriaens, T. (2021) Aesthetic aliens: invasion of the beauty rat snake, *Elaphe taeniura* Cope, 1861 in Belgium, Europe. *BioInvasions Records*, 10, 741–754.

Vasyliuk, O. (2023) Military combat impacts on ecosystem services in Ukraine. *Ukraine War Environmental Consequences Work Group*, 12, 10–14.

Vermenich, Y.V. (2010) Odesa Oblast. In *Encyclopedia of History of Ukraine* (ed. V.A. Smoly), pp. 537–728. Naykova Dumka, Kyiv, Ukraine. [In Ukrainian]

Visconti, P., Elias, V.V., Sousa, P.I., Fischer, M., Ali-Zade, V. & Baldi, A. et al. (2018) Status, trends and future dynamics of biodiversity and ecosystems underpinning nature's contributions to people. In *The IPBES Regional Assessment Report on Biodiversity and Ecosystem Services for Europe and Central Asia* (eds M. Rounsevell, M. Fischer, A. Torre-Marin Rando & A. Mader), pp. 187–384. IPBES, Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany.

Vishnevsky, V.I. (2009) *Odesa climate*. meteoprog.ua [accessed 19 September 2022].

Volyansky, B.E. (1928) Amphibians and reptiles on the outskirts of the Odesa (studies on sociology and economic significance). *Zapyski Natural and Mathematical Section of Odessa. Science Comrade*, 2, 75–109. [In Ukrainian]

Wake, D.B. & Vredenburg, V.T. (2008) Are we in the midst of the sixth mass extinction? A view from the world of amphibians. *Proceedings of the National Academy of Sciences of the United States of America*, 105, 11466–11473.

Wesche, K., Ambarli, D., Kamp, J., Török, P., Treiber, J. & Dengler, J. (2016) The Palearctic steppe biome: a new synthesis. *Biodiversity Conservation*, 25, 2197–2231.

Yablokov, A.V. (1976) *A Sand Lizard. Monographic Description of the Species*. Nauka, Moscow, Russia. [In Russian]

Zizka, A., Rydén, O., Edler, D., Klein, J., Aronsson, H., Perrigo, A. et al. (2020) Exploring the impact of political regimes on biodiversity. *University of Gothenburg, Varieties of Democracy Institute: Working Paper*, 98, 1–11.

https://doi.org/10.1017/S0030605323001321 Published online by Cambridge University Press