

GIS MODELING AND STUDY OF THE INFLUENCE OF INVASIVE MAMMALIAN SPECIES' DISTRIBUTION ON EUROPEAN POND TURTLE

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Introduction. European pond turtle *Emys orbicularis* (Linnaeus, 1758) is a reptile species that requires special protection under a number of international agreements. This species is listed in Resolution 6 and Appendix II of the Bern Convention (1979) and has “Near Threatened” (NT) status in IUCN. Recently, pond turtle have faced many enemies in its natural habitat. For example, in addition to the aboriginal predators such as the grey wolf *Canis lupus* (Linnaeus, 1758) and the red fox *Vulpes vulpes* (Linnaeus, 1758), the turtles also suffer from the presence of invasive raccoon dog *Nyctereutes procyonoides* (Gray, 1834), golden jackal *Canis aureus* (Linnaeus 1758), raccoon *Procyon lotor* (Linnaeus, 1758), and stray dogs. The influence of invasive predators can be especially dangerous for pond turtles' small populations of on the border of the *E. orbicularis* range: *N. procyonoides* is widely distributed in Latvia, while *C. aureus* was registered here only in several recent years. Such invasive species as raccoon dog and golden jackal often live in the neighborhood with turtles occupying territories with light soils, sometimes near arid areas along small waterbodies, where turtles breed. Golden jackal has been actively migrating north for at least the last 20 years and is now known in most of Eastern Europe, including Estonia. This social predator is omnivorous, consuming wide range of food items from fruits and insects to small vertebrates (including pond turtles). Being widely introduced in the former Soviet Union as a fur animal in 1950s *N. procyonoides* has become now widely distributed invasive species in European Union as well. It is known that raccoon dog is a more environmentally flexible species than jackal. Its number in Ukraine has increased significantly in the past decades; in Latvia it is known since 1943 and ~15 000 individuals were registered in 2006. For example, in Belarus (Polissia), about 40 % of all turtles' clutches are excavated and eaten by foxes, raccoon dogs, wolves, stray dogs, and other predators in the very first days of incubation (Drobenkov, 2012). Therefore, the purpose of our study was to identify what factors influence the dispersal of the invasive predator *N. procyonoides* and its potential feeding object – *E. orbicularis* with the help of GIS modeling.

Materials and methods. With a ecological niche modeling technique and Species distribution modelling (SDM) has been used to determine potential range distribution of invasive species in new environments (MaxEnt with 25 replicates, DivaGis (Bioclim)). Bioclimatic variables from the CliMond dataset (35 variables, Kriticos et al., 2014; <https://www.climond.org/>) were used. Our occurrence data consisted of 1525 and 3560 georeferenced points for *N. procyonoides* and *E. orbicularis*, respectively. For analysis, GBIF data (<http://www.gbif.org>), literature (Kauhala & Kowalczyk, 2011 etc.) and modern original record points from Ukraine (Nekrasova O.), Latvia (Pupins M.) were used.

Results. As a result of our investigations in southern Ukraine, it was found out that about a half of all turtles' clutches suffered from predators – 25 excavated nests (eaten) and 5 turtles' remnants (some identified as females) were found in the Volyzhin Les arid areas (Black Sea region, Kinburn Spit, 2019) and 1 excavated nest with eaten 8 eggs was found for the first time in Southeastern Latvia (2019, unpublished observation, Silene Nature park, Natura 2000). In addition 2 excavated nests (a total amount of approximately 32 eggs' remnants) of *E. orbicularis* were registered on the river edge on the Sobachyj island in Kaniv Nature Reserve (Cherkas'ka oblast', Ukraine, 2012). And such finds were not rare, as the habitats of invasive predators and native species, go their food resources were changed with climate change. Using DivaGis we

found that the bioclimatic factors of the sites of *N. procyonoides* (70 %) have a wider range: Annual Mean Temperature (b1) from +1 to +14 °C (limit -3.1 – +18 °C), Annual Precipitation (b12) – 400–1600 mm (limit 173–2783 mm). Important factors that affect its distribution are – b14 (Precipitation of Driest Month), to a small extent – b4 (Temperature Seasonality (standard deviation * 100) and b6 (Minimal Temperature of Coldest Month) (Maxent). The turtle were more vulnerable, especially in the north of the range and were limited by temperature factors (70 %): b1 – 6–17 °C (limit +2 - +19.6 °C), b12 – 300–1200 mm (limit 153–2231 mm). Its distribution is also affected by the factors: b19 Precipitation of Coldest Quarter, b23 Radiation seasonality (C of V), b6 Minimal Temperature of the Coldest Week (°C), respectively. These two species have very similar living conditions in the north of their natural range. So, when comparing SDM models (Maxent) and when constructing a regression, the correlation coefficient was 0.5 in Latvia reliably.

Conclusion. The active advance to the north of new invasive mammalian predator species that are resistant to cold climates may affect the number of turtles in small northern populations. In the Baltic countries, where recent discoveries of turtles have been noted, it is important to minimize the impact of invasive predator species to ensure the protection of aboriginal biota.

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