# TERRESTRIAL SNAILS OF PONTIC–CASPIAN STEPPE REGION AS A CASE STUDY OF SPECIES DISTRIBUTION MODELLING (SDMS)

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## SUMMARY

In this work we considered xerophilous terrestrial snails (*Brephulopsis cylindrica*, *Xeropicta derbentina*) distribution in Pontic-Caspian region by means of species distribution modelling (SDM). Predictors used described major climatic conditions relevant to biota as well as elevation. Overall predictions suggest similar distribution areas except for *X. derbentina* has a larger one comprising dryer areas.

***Keywords:*** SDM, ecological modelling, land snails, invasive species, *Xeropicta*, *Brephulopsis.*

Species distribution models (SDMs, aka ecological niche models) is a major tool for computational ecology. They have gained vast popularity among botanists, zoologists, evolutionary biologists as well as environmentalists, epidemiologists etc. SDMs have proven to be useful for prediction of species distribution areas as they connect observed localities to their relevant environmental conditions, i.e. covariates. Theoretical basis underlying SDM practice is Hutchinson's definition of ecological niche. In this concept, niche exists both in a geographical space and a multidimensional space of ecological factors; there is a two-way correspondence between them [1]. SDMs are based on machine learning; hence, their practitioner should be aware of all the general recommendations in the field. For example, ecological covariates often are correlated and/or contain a little information if taken together. This machine learning problem is referred to as the multicollinearity problem. Accordingly, proper modelling would require data optimization prior to it [2].

SDMs are applicable to past and future environmental conditions as well. This is evidently beneficial under possible climate change and biosphere transformation in general. Due to these changes, many species are spreading to the north. This causes transformation of invaded ecosystems, loss of native species, dissemination of parasitic and infectious diseases, and affects the economy in a number of ways. Invasive species management and control mainly aimed to predict redistribution of species outside their native range. Our research focuses on mollusc invasions. This group of animals has long been known for representatives invading various ecosystems around the world. Terrestrial snails in the Ponto-Caspian and the Black Sea regions are interesting because they are currently spreading to regions north of their natural range [3-6]. In this regard, it is especially important to understand their ecological characteristics within natural range. First of all, it is necessary to identify the distribution patterns of such species, which may help to assess their invasive potential. SDMs are widely used to investigate these aspects of invasions [7-8].

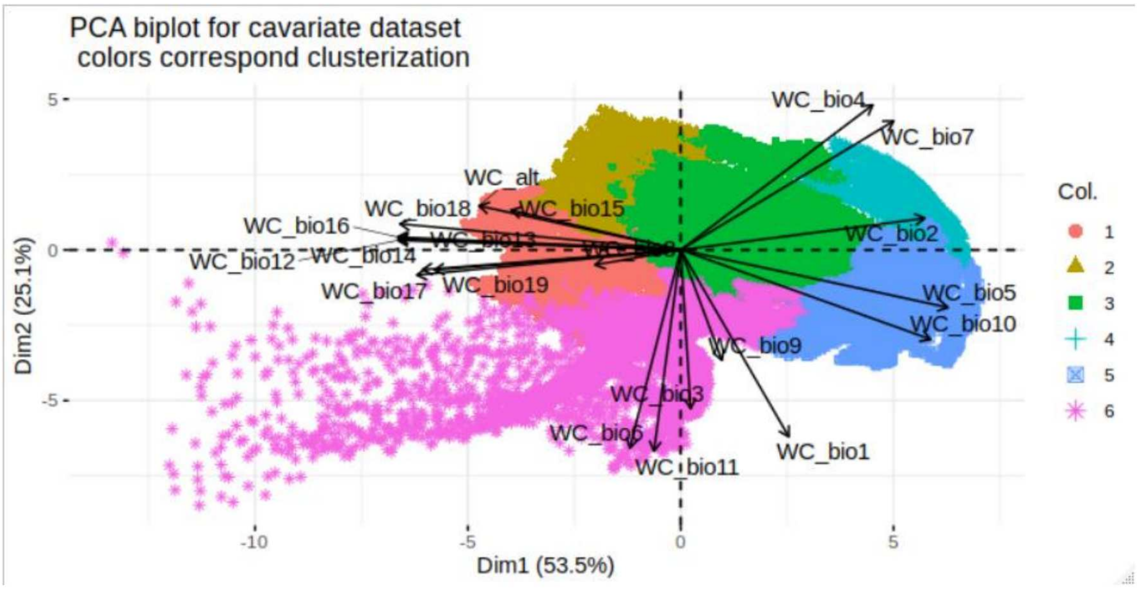


**Fig. 1.** PCA biplot.

Here we consider xerophilous terrestrial snails *Xeropicta derbentina* Krynicky, 1836 (Gastropoda, Hygromiidae) and *Brephulopsis cylindrica* Menke, 1828 (Gastropoda, Enidae). These species native to Ponto-Caspian region and Black sea region, mainly aridic habitats (steppes). *X. derbentina* and *B. cylindrica* have many adaptations to arid environments. At present, they are successfully settling in new territories. In particular, their populations were found acrossUkraine, Belarus, and in Russia as north as the Belgorod region [5, 9-12].

Data used comprises observed species localities and environmental covariates. Molluscs observations were taken from GBIF database (www.gbif.org), literary sources [5, 10] and our observations. Environmental predictors came from WorldClim database (www.worldclim.org). Prior to t species distribution modelling itself we have done exploratory data analysis. As for localities used, given the characteristic of the region very steep ecological gradient, especially in Crimea, we did not perform spatial thinning. This data preparation step usually allows to evade overcrowded observations due to sampling bias. In this case, many adjacent occurrences that differ significantly by ecological conditions would be lost.

As for the initial predictor variables dataset, principal component analysis (PCA) depicted two first principal components accounting for most variance (Fig. 1). Each point here represents one location and its environmental conditions; each arrow represents a certain covariate. Valuable predictors would have longer arrows and no overlaps with others. The plot and correlation calculated (Fig. 2) suggest that we should retain only certain predictors, for example, the only certain variables. Accordingly, we selected 9 variables as follows:

1. ALT = altitude
2. BIO1 = Annual Mean Temperature
3. BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
4. BIO6 = Min Temperature of Coldest Month
5. BIO7 = Temperature Annual Range (BIO5-BIO6)
6. BIO10 = Mean Temperature of Warmest Quarter
7. BIO16 = Precipitation of Wettest Quarter
8. BIO17 = Precipitation of Driest Quarter
9. BIO18 = Precipitation of Warmest Quarter

After that both the initial and the new reduced dataset of 9 covariates were clustered using hierarchical Ward's method. The two dendrograms (Fig. 3) are very similar as evidenced by the tanglegram presented. This pointed that the multidimensional data structure was mostly preserved through the data reduction step.

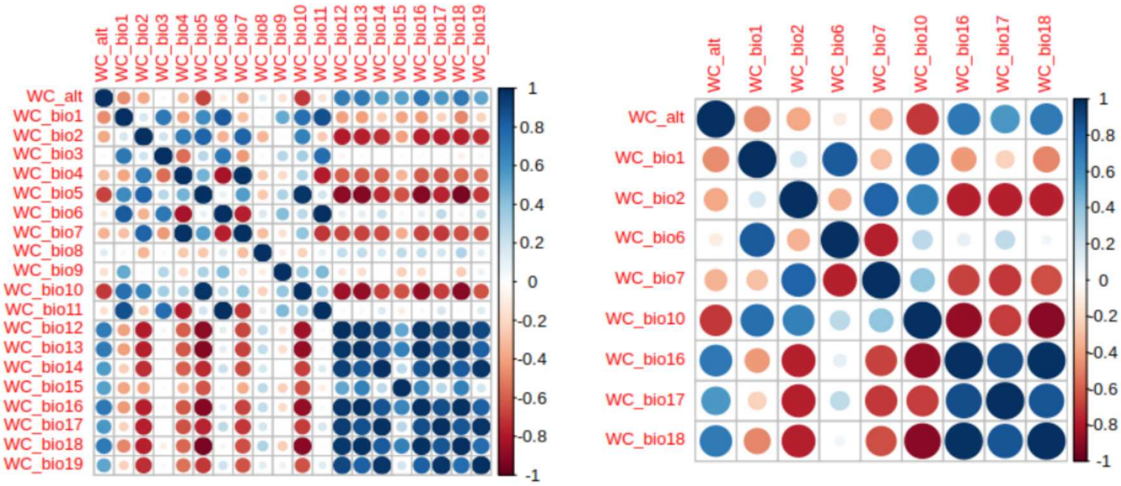


**Fig. 2.** Pearson correlation coefficient calculated and visualised for the initial dataset (left) vs. the reduced one (right).

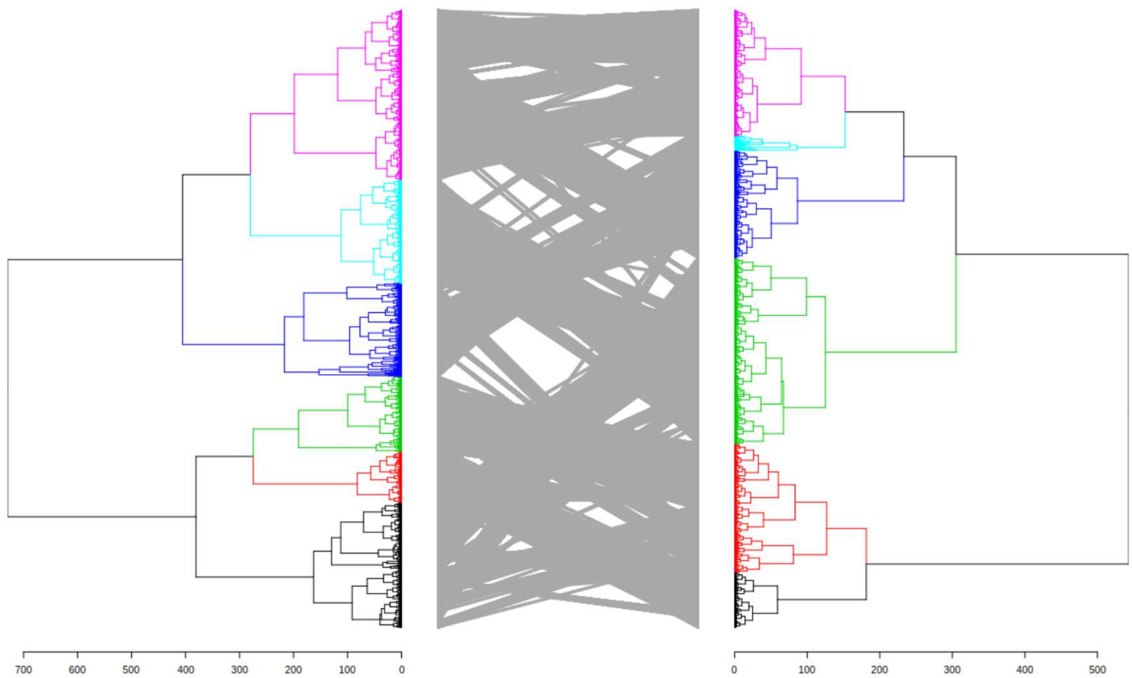


**Fig. 3.** Ward's hierarchical clusterization of the initial dataset (20 variables) aligned against the reduced one (9 variables). Grey lines connect the same localities.

Total number of observations equalled 113 for *X. derbentina* and 93 for *B. cylindrica* (Fig. 4). Occurrences at global scale that falls outside of the study region were not considered as there are quite isolated population (e.g. in Eastern Europe) and to characterize Pontic-Caspian population in a specific manner.

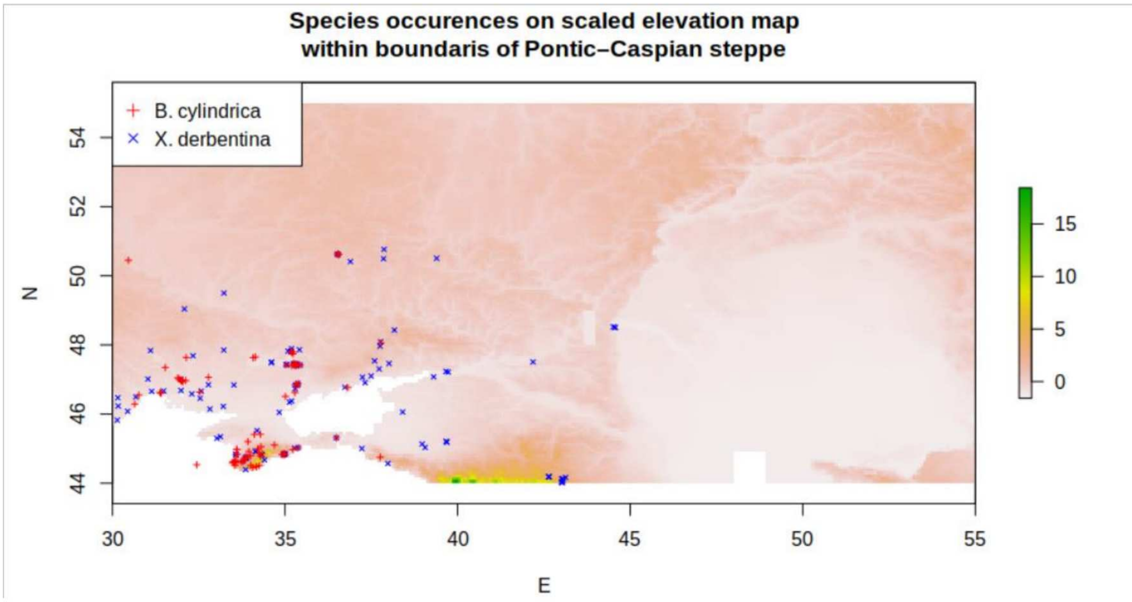


**Fig 4.** Observed localities for species of interest (44N to 55N, 30E to 55E)

Initial localities data were split into training (30%) and testing datasets. Next, models based on random forest classifiers were trained (10 repetition i.e. models for each species). High performance of the models was evidenced by ROC-curve; two best-performing models were used further.

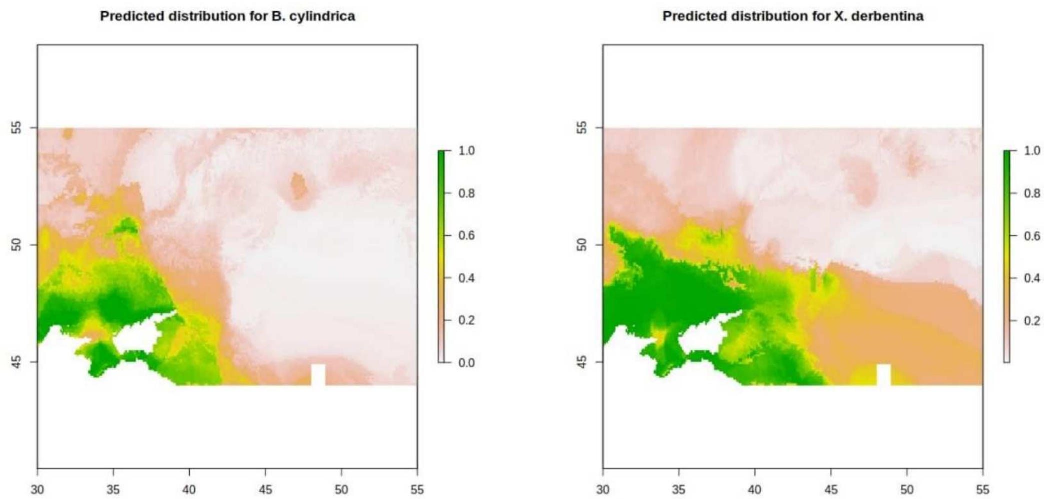


**Fig. 5.** Predicted distribution areas for *B. cylindrica* (left) and *X. derbentina* (right).
Distribution areas predicted imply that *B. cylindrica* have a smaller distribution (Fig. 5). The putative areal is mostly similar to the one of *X. derbentina*; however, the second comprises larger territory to the west.

It should be noted that *B. cylindrica* is the Crimean endemic and its spreading outside the peninsula has been noted only in last decades. *X. derbentina*, however, is native for the entire Black Sea region and the Caucasus. In other words, *X. derbentina* has a wider primary range than *B. cylindrica*. This may be an "advantage" in the expansion to the new territory. Climate change trends may create relevant conditions for xerophilous species in new territories, as confirmed by the SDM. In this regard, *B. cylindrica and X. derbentina*, native to the Ponto-Caspian region, has a high probability of invading new territories.

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