Online ISSN: 2588-3526

Journal of Wildlife and Biodiversity

Volume 5 (4): 44-52 (2021) (**http://www.wildlife-biodiversity.com/**)

Research Article

Species distribution modeling and environmental suitability of the Southern crested newt, *Triturus karelinii* (Strauch, 1870) (Amphibia: Caudata) in Iran

Maryam Pourhallaji[1], Mohamad Dehdar Dargahi1[*], Haji Gholi Kami[2], Eskandar Rastegar Pouyani[3], Mahsa Hakimi Abed[4]

[1]Department of Environment, Lahijan Branch, Islamic Azad University, Lahijan, Iran
[2]Department of Biology, Faculty of Sciences, Golestan University, Gorgan, Iran.
[3]Department of Biology, Faculty of Sciences, Hakim Sabzevari University, Sabzevar, Iran.
[4]Department of Environment, Lahijan Branch, Islamic Azad University, Lahijan, Iran.
[*]Email: dehdardargahi@gmail.com

Received: 15 May 2021 / Revised: 14 July 2021 / Accepted: 17 July 2021 / Published online: 09 December 2021. Ministry of Sciences, Research, and Technology, Arak University, Iran.

How to cite: Pourhallaji, M., Dehdar Dargahi, M., Kami, H.G., Rastegar Pouyani, E. (2021). Species distribution modeling and environmental suitability of the Southern crested newt, *Triturus karelinii* (Strauch, 1870) (Amphibia: Caudata) in Iran. Journal of Wildlife and Biodiversity, 5(4), 44-52. **DOI: 10.22120/jwb.2021.530445.1228**

Abstract

The southern crested newt, *Triturus karelinii* (Strauch, 1870), is a newt endemic to the Ponto-Caspian region. We evaluate the potential distribution of this species and identify the most important environmental factors that determine the distribution of this species in Iran. Forty-four presence points and seven environmental variables were used to model the distribution range. Species distribution modeling was performed using the Maximum Entropy algorithm (MaxEnt). Precipitation of the warmest quarter, with 68.60% contribution, and altitude, with 13.70% contribution, were the most important factors determining the distribution of the species. According to our habitat suitability map, the Golestan, Mazandaran, Guilan, and Ardabil provinces are determined as possessing suitable habitat for the species, while the central and southern regions of Iran do not possess suitable habitats, associated with insufficient rainfall.

Keywords: Amphibia, biodiversity, climate change, MaxEnt, Northern Iran

Introduction

Global amphibian diversity includes 8,314 living species (the order Anura includes 7334 species, Caudata includes 766 species and Gymnophiona includes 214 species; Frost, 2021) and most of them are adapted to specific habitats, biomes, or climatic niches (Vitt & Caldwell, 2013). However, amphibian populations are declining worldwide, particularly during the last thirty years, mostly due to anthropogenic activity (Blaustein & Bancroft, 2007; Green et al., 2020). The Iranian amphibian community includes 14 frogs and toads (order Anura) and 7 newts and salamanders (order Caudata). In Iran, the order Caudata contains four genera (*Paradactylodon*, *Neurergus*, *Triturus* and *Salamandra*) (Hosseinian Yousefkhani et al., 2013; Safaei-Mahroo et al., 2015).

The genus *Triturus* Rafinesque, 1815 occurs in Europe and adjacent Asia and comprises the marbled and crested newts (Wielstra et al., 2019). *Triturus* newts differ in relative body proportions and can be arranged from a stocky to a slender built (Arntzen et al., 2007). The marbled newt group includes *T. marmoratus* (Latreille, 1800) and *T. pygmaeus* (Wolterstorff, 1905). The crested newt group includes *T. anatolicus* (Wielstra & Arntzen, 2016), *T. carnifex* (Laurenti, 1768), *T. cristatus* (Laurenti, 1768), *T. dobrogicus* (Kiritzescu, 1903), *T. ivanbureschi* (Arntzen & Wielstra, 2013), *T. karelinii* (Strauch, 1870) and *T. macedonicus* (Karaman, 1922).

Triturus karelinii (the southern crested newt) is a relatively terrestrial newt and endemic to the Pontocaspian region, present in three allopatric regions: Crimea, Caucasus, and Caspian region (Wielstra et al., 2019; Wielstra & Arntzen, 2020). According to Safaei-Mahroo et al., 2015 the distribution of *T. karelinii* in Iran includes the Mazandaran, Guilan, East Azarbaijan, and West Azarbaijan Provinces. This species lives in mountain forests, forest steppes, and mountain steppe sites. Habitat loss, deforestation, and water pollution appear to be the main factors that threaten this species and have caused the reduction and even extinction of some local populations in Crimea and the Caucasus (Bannikov et al., 1971; Baloutch & Kami, 1995).

Species distribution models are used to predict the geographical range of species for which occurrence data are present and species distribution models can predict the importance of particular environmental variables determining a species’ distribution (Raxworthy et al., 2003; Anderson & Martınez-Meyer, 2004; Pearson, 2007; Miller et al., 2009; Moor et al., 2015). Among the many methods of species distribution modeling, the Maximum Entropy algorithm (MaxEnt, Phillips, 2017) is one of the most popular tools for predicting the distribution range of species based on presence-only records (Pearson, 2007; Elith et al., 2011; Marcer et al., 2013; García-Holgado et al., 2015; Phillips et al., 2017). We used MaxEnt to model the distribution of *T. karelinii* in Iran to predict the most suitable habitats and determine which environmental factors might restrict its distribution.

Materials and methods

Forty-four occurrence records were obtained from our fieldwork and available literature sources (Kami, 1997; Naderi et al., 2013) and all available data resources in Global Biodiversity Information Facility “GBIF” (http://www.gbif.org), excluding obviously erroneous points (Appendix 1). A total of 20 variables including 19 bioclimatic variables and one altitude data layer with a resolution (30 arcseconds (~1 km)) for the selected period (1950-2000) were employed in this study (Table 1). Bioclimatic variables were downloaded from the WorldClim database (http://www.worldclim.org/current) (Hijmans et al., 2005) and altitude was obtained from DIVA-GIS (http://www.diva-gis.org). The distribution records and environmental variables were processed in Openmodeller v. 1.5.0 to calculate the Pearson correlation coefficient. Variables with a correlation of less than 0.7 were selected (Rissler et al., 2006) to run the species distribution model and predict the potential distribution (Hosseinian Yousefkhani et al., 2013).

The selected layers and distribution records were opened in MaxEnt 3.4.4 (Phillips et al., 2017). Ninety percent of the data were used as training samples and 10% as test samples to obtain the final model. The convergence threshold and a maximum number of iterations were 0.00001 and 500. The model was run with 15 replicates with cross-validate replicate type. The area under the receiver operating characteristic (ROC) curve (AUC) is used for evaluating the model performance. An AUC value over 0.9 indicates that the model is very good and a value of 0.5 refers to the model that is not better than the random model (Swets, 1988).

Table 1. The variables used for ecological niche modeling of *Triturus karelinii*

BIO1	Annual mean temperature
BIO2	Mean diurnal range [mean of monthly (max temp–min temp)]
BIO3	Isothermality (BIO2/BIO7) * (100)
BIO4	Temperature seasonality (standard deviation * 100)
BIO5	Max temperature of the warmest month
BIO6	Min temperature of the coldest month
BIO7	Temperature annual range (BIO5–BIO6)
BIO8	Mean temperature of wettest quarter
BIO9	Mean temperature of driest quarter
BI010	Mean temperature of warmest quarter
BIO11	Mean temperature of coldest quarter
BIO12	Annual precipitation
BIO13	Precipitation of wettest month
BIO14	Precipitation of driest month
BIO15	Precipitation seasonality (standard deviation/mean)
BIO16	Precipitation of wettest quarter
BIO17	Precipitation of driest quarter
BIO18	Precipitation of warmest quarter
BIO19	Precipitation of coldest quarter
Altitude	

Results

Considering the species' habitat and the Pearson correlation coefficient, six environmental variables were selected (Table 2). The variables with Pearson correlation values <0.75 included altitude, BIO1 (Annual Mean Temperature), BIO 3 (Isothermality), BIO6 (Min temperature of the coldest month), BIO 9 (Mean temperature of the driest quarter), BIO 15 (Precipitation seasonality) and BIO 18 (Precipitation of warmest quarter).

Table 2. The selected variables with their percent contribution.

Variable	Percent contribution
BIO1: Annual mean temperature	0.4572
BIO3: Isothermality (BIO2/BIO7) * (100)	7.0038
BIO6: Min temperature of the coldest month	9.017
BIO9: Mean temperature of driest quarter	0.0056
BIO15: Precipitation seasonality (coefficient of variation)	1.2005
BIO18: Precipitation of warmest quarter	68.6065
Altitude	13.7094

The average AUC value for the model was 0.963 (Fig.1). According to the predictive map, the distribution of *Triturus karelinii* covers northern Iran and is limited to the Golestan, Mazandaran, Guilan, and Ardabil Provinces. The central and southern regions of Iran are unsuitable for *Triturus karelinii* (Fig. 2).

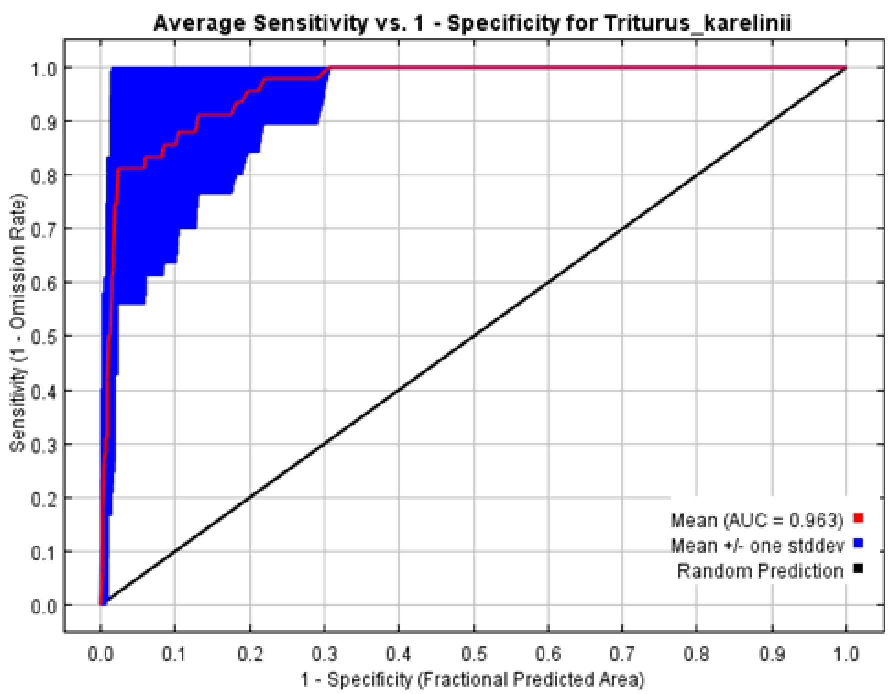

Figure 1. The receiver operating characteristic (ROC) curve and AUC of *Triturus karelinii* in Iran.

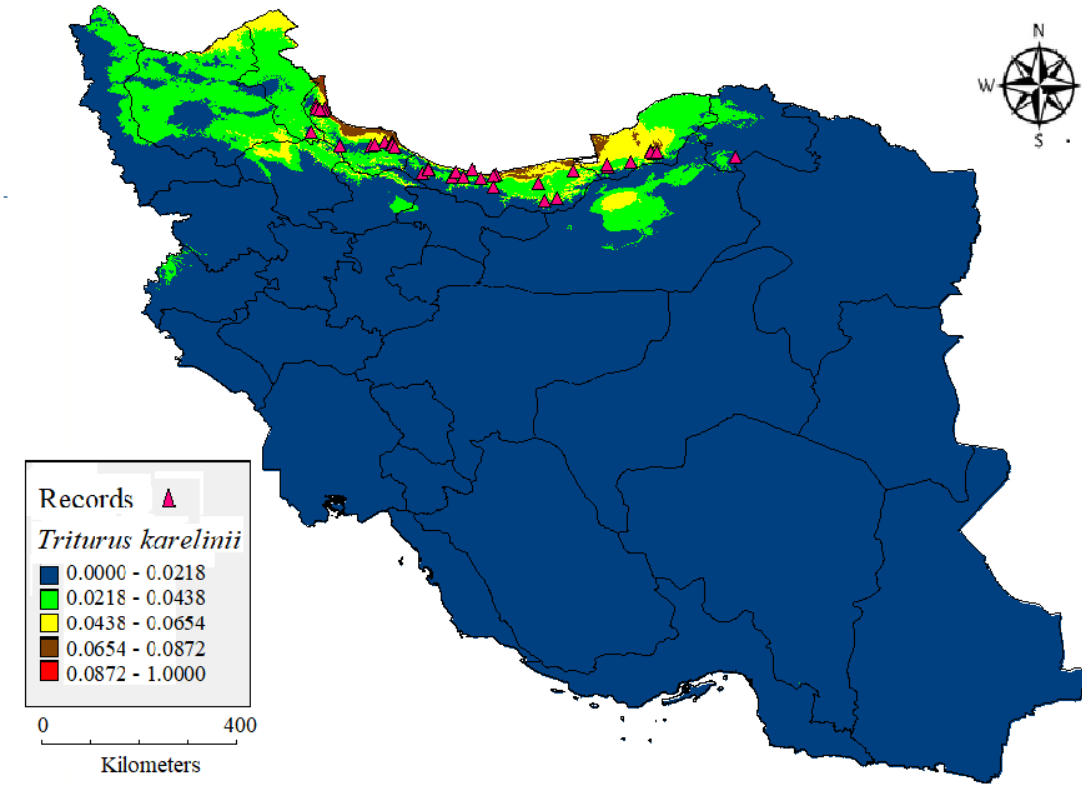

Figure 2. Potential distribution of *Triturus karelinii* in Iran. Pink triangles signify available records used in this study. Colors and numbers present predicting of occurrence (Appendix 1).

The percent contribution of variables showed that the variables bio 18 (precipitation of warmest quarter) and altitude have the greatest contribution to the species distribution model. The mean temperature of the driest quarter with 0.0056 contributions has the least effect on the model (Table 2). More than 100 mm of precipitation during the warmest quarter and an altitude below 1500 meters predicted the most suitable habitats (Figs. 3 and 4).

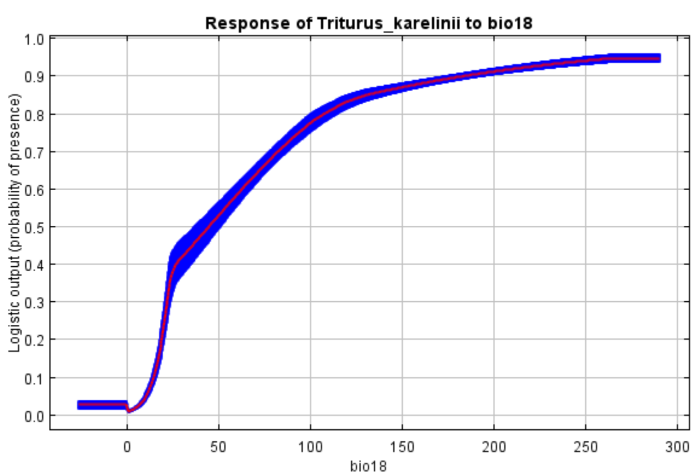

Figure 3. The response curves of Precipitation of warmest quarter (millimeter)

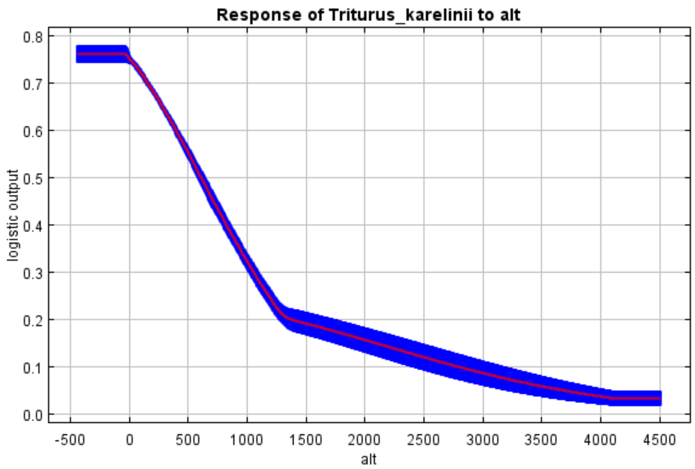

Figure 4. The response curves of Altitude (meter)

Figure 5. Habitat of *T. karelinii* in Lahijan (Guilan province), Iran (by Pourhalajii, 2021)

Discussion

Predictive distribution maps provide useful information for identifying suitable areas when distribution data for a species are limited. These maps help assess the conservation status and set up large-scale geographic management plans for target species or communities (Benito et al., 2013). Thus, species distribution models can be a key component in conservation plans for species, as it allows us to estimate and identify suitable habitat for the species based on abiotic factors (e.g. climate) (Nasrabadi et al., 2018).

We used the maximum entropy approach to model the distribution of a particular species, the southern crested newt *Triturus karelinii* because little has been done so far to identify the habitat preference, potential distribution, and important environmental factors for this species in Iran.
The average AUC value for the model was 0.963, demonstrating very good performance. The habitat suitability map shows that the Golestan, Mazandaran, Guilan, and Ardabil Provinces contain habitat for the species, whereas the central region of Iran is unsuitable given low precipitation. Thus it seems that the distribution of *T. karelinii* is practically restricted to the area north of the Alborz Mountains in Iran (Fig. 2). Our results emphasize the predictive model of Wielstra and Arntzen (2020), which considers the southern area of the Caspian Sea and the north of the Elburz Mountains have suitable climate conditions for this taxon.
Precipitation of the warmest quarter (Bio18), precipitation seasonality (Bio15), and altitude were the most important contributors to the habitat suitability of *T. karelinii*, when used independently, indicated by their high contribution (Table 2). Water availability is the most important variable that determines the distribution range of *T. karelinii*, more precisely the amount of moisture and rainfall in spring and summer which is the peak activity time. The suitable precipitation of the warmest quarter for *T. karelinii* was 100–300 mm, indicating that this species prefers a humid environment (Fig. 3). The predicted distribution and presence of this species decreases in altitude and the highest density is predicted in lowlands (Fig. 4), although we observed the species at an altitude of 2800 meters in Ardabil Province. Precipitation of the warmest quarter increases the vernation in the northern region of Iran and breeding populations of *T. karellini* are often found in water bodies in Hyrcanian forest and shrubs (Fig. 5). The protection of Hyrcanian forests in Iran and the biodiversity of its amphibians is an essential issue that should be given more attention.

References

Anderson, R. P., & Martınez-Meyer, E. (2004). Modeling species' geographic distributions for preliminary conservation assessments: an implementation with the spiny pocket mice (Heteromys) of Ecuador. Biological Conservation, 116(2), 167-179.

Arntzen, J. W., Themudo, G. E., & Wielstra, B. (2007). The phylogeny of crested newts (Triturus cristatus superspecies): nuclear and mitochondrial genetic characters suggest a hard polytomy, in line with the paleogeography of the center of origin. Contributions to Zoology, 76(4), 261-278.

Baloutch, M & ,.Kami, H. G. (1995). Amphibians of Iran. Tehran University Publishers.

Bannikov, A. G., Darevsky, I. S., & Rustamov, A. K. (1971). Zemnovodnye i Presmykayushchienya SSSR [Amphibians and Reptiles of the USSR]. Izdatelistvo Misl.

Benito, B. M., Cayuela, L., & Albuquerque, F. S. (2013). The impact of modeling choices in the predictive performance of richness maps derived from species-distribution models: Guidelines to build better diversity models. Methods in Ecology and Evolution, 4(4), 327-335.

Blaustein, A. R., & Bancroft, B. A. (2007). Amphibian Population Declines Evolutionary Considerations. BioScience, 57(5), 437-444. https://doi.org/10.1641/b570517

Elith, J., Phillips, S. J., Hastie, T., Dudík, M., Chee, Y. E., & Yates, C. J. (2011). A statistical explanation of MaxEnt for ecologists. Diversity and Distributions, 17(1), 43-57.

García-Holgado, A., García-Peñalvo, F. J., & Rodríguez-Conde, M. J. (2015). Definition of a technological ecosystem for scientific knowledge management in a Ph.D. Program. Proceedings of the 3rd International Conference on Technological Ecosystems for Enhancing Multiculturality,

Green, D. M., Lannoo, M. J., Lesbarrères, D., & Muths, E. (2020). Amphibian population declines 30 years of progress in confronting a complex problem. Herpetologica, 76(2), 97-100.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology: A Journal of the Royal Meteorological Society, 25(15), 1965-1978.

Hosseinian Yousefkhani, S. S., Ficetola, G. F., Rastegar Pouyani, N., Ananjeva, N. B., Rastegar Pouyani, E., & Masroor, R. (2013). Environmental suitability and distribution of the Caucasian Rock Agama, Paralaudakia Caucasia (Sauria: Agamidae) in western and central Asia.

Kami, H. G. (1997). Rediscovery of the southern crested newt, Triturus (cristatus) karelini (Salamandridae), from its easternmost locality in Iran. Zoology in the Middle East, 15 .۳۷-۴۰ ,(۱)

Marcer, A., Sáez, L., Molowny-Horas, R., Pons, X., & Pino, J. (2013). Using species distribution modeling to disentangle realized versus potential distributions for rare species conservation. Biological Conservation, 166, 221-230.

Miller, F. G., Colloca, L., & Kaptchuk, T. J. (2009). The placebo effect: illness and interpersonal healing. Perspectives in biology and medicine, 52(4), 518.

Moor, H., Hylander, K., & Norberg, J. (2015). Predicting climate change effects on wetland ecosystem services using species distribution modeling and plant functional traits. Ambio, 44(1), 113-126.

Naderi, G., Mohammadizadeh, M., Khalatbari, M., Ahadirad, R., Lahoot, M., & Kamran, M. (2013). New Record and Habitat Affinities of Southern Crested Newt Triturus karelini (Amphibians: Salamandridae) in Mazandaran Province, Iran. World Journal of Zoology, 8(2), 131-134.

Nasrabadi, R., Rastegar-Pouyani, N., Rastegar-Pouyani, E., Kami, H. G., Gharzi, A., & Yousefkhani, S. (2018). Distribution and Environmental Suitability of the European Glass Lizard Pseudopus apodus (Pallas, 1775) in the Iranian Plateau. Russian Journal of Herpetology, 25(1).

Pearson, R. G. (2007). Species distribution modeling for conservation educators and practitioners. Synthesis. American Museum of Natural History, 50, 54-89.

Phillips, S. J., Anderson, R. P., Dudík, M., Schapire, R. E., & Blair, M. E. (2017). Opening the black box: An open-source release of Maxent. Ecography, 40(7), 887-893.

Rancilhac, L., Irisarri, I., Angelini, C., Arntzen, J. W., Babik, W., Bossuyt, F., Künzel, S., Lüddecke, T., Pasmans, F., & Sanchez, E. (2021). Phylotranscriptomic evidence for pervasive ancient hybridization among Old World salamanders. Molecular Phylogenetics and Evolution, 155, 106967.

Raxworthy, C. J., Martinez-Meyer, E., Horning, N., Nussbaum, R. A., Schneider, G. E., Ortega-Huerta, M. A., & Peterson, A. T. (2003). Predicting distributions of known and unknown reptile species in Madagascar. Nature, 426(6968), 837-841.

Rissler, L. J., Hijmans, R. J., Graham, C. H., Moritz, C., & Wake, D. B. (2006). Phylogeographic lineages and species comparisons in conservation analyses: a case study of California herpetofauna. The American Naturalist, 167(5), 655-666.

Safaei-Mahroo, B., Ghaffari, H ,.Fahimi, H., Broomand, S., Yazdanian, M., Najafi-Majd, E., Hosseinian Yousefkhani, S. S., Rezazadeh, E., Hosseinzadeh, M. S., & Nasrabadi, R. (2015). The herpetofauna of Iran: checklist of taxonomy, distribution and conservation status. Asian Herpetological Research, 6(4), 257-290.

Swets, J. A. (1988). Measuring the accuracy of diagnostic systems. *Science*, *240*(4857), 1285-1293.

Vitt, L. J., & Caldwell, J. P. (2013). *Herpetology: an introductory biology of amphibians and reptiles*. Academic press.

Wielstra, B., & Arntzen, J. W. (2020). Genetic homogeneity in a Pontocaspian crested newt species (*Triturus karelinii*) suggests recent isolation of its three allopatric range sections. *Amphibia-Reptilia, 1*(aop), 1-9.

Wielstra, B., McCartney-Melstad, E., Arntzen, J., Butlin, R. K., & Shaffer, H. B. (2019). Phylogenomics of the adaptive radiation of *Triturus newts* supports gradual ecological niche expansion towards an incrementally aquatic lifestyle. *Molecular Phylogenetics and Evolution, 133*, 120-127.