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Extending the known vertical distribution for the highly adaptive *Triturus macedonicus* (Karaman, 1922)

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Abstract

Current knowledge of the vertical distribution of *Triturus macedonicus* places the species at altitudes up to 2140 m. Herein, we report its presence in the alpine lake Gistova at 2360 m on Mt. Grammos, Greece, thus extending the highest altitudinal point for the species, as well as for the *Triturus* genus. This record showcases the adaptive capacity of the Macedonian newt, which allows it to occupy markedly different environments. More populations may exist at similar or even higher altitudes and their discovery could positively impact conservation efforts.

Key Words

adaptability, alpine, Gistova, Grammos, Macedonian newt, plasticity, vertical distribution

Introduction

Triturus macedonicus (Karaman, 1922) is a newt species endemic to the Balkan Peninsula that belongs to the wider *Triturus cristatus* complex (Wielstra and Arntzen 2016; Wielstra et al. 2019) and its distribution spans through seven countries in the southern part of the European continent: Bosnia & Herzegovina, Montenegro, Serbia, Albania, North Macedonia, Greece (Wielstra and Arntzen 2011) and Bulgaria (Naumov and Tzankov 2008). Previously referred to as *Triturus carnifex macedonicus* and later raised to species level as *Triturus macedonicus* (Arntzen et al. 2007), the Macedonian newt has distinct morphological features from the other *Triturus* species (Arntzen and Wallis 1999; Arntzen 2003; Wielstra et al. 2013). Records to date have placed its vertical distribution at elevations up to 1900 m (Speybroeck et al. 2016), 2000 m (Valakos et al. 2008) and 2140 m on Mt. Smolikas, Greece (Denoël 2004). In the current work, we provide evidence for the presence of *Triturus macedonicus* in Lake Gistova (Fig. 1), the highest alpine lake in Greece at an altitude of 2360 m a.s.l. on Mt. Grammos (Kastoria Prefecture, Greece, 40°21.905'N, 20°47.419'E) (Fig. 2), thus extending the known altitudinal point for the species; as well as for the *Triturus* genus, under which the closely-related species often demonstrate parapatric distributions (Wielstra et al. 2014; Wielstra and Arntzen 2020). In parallel, we confirmed the presence of *Triturus macedonicus* at sea level within the estuaries of the River Pineios (Larissa Prefecture, Greece, 39°52.947'N, 22°43.096'E) at the southern limit of the genus' distribution in Europe (Fig. 3).

There has been only one targeted survey in Lake Gistova, where researchers collected hundreds of alpine newts (*Ichthyosaura alpestris*) for sampling purposes (Papaioannou et al. 2015), but did not record the Macedonian newt. Earlier bibliographical knowledge highlights the presence of *T. macedonicus* on Mt. Grammos when placing a limit on its altitudinal distribution at 1950 m (Sotiropoulos et al. 1995). The question arises whether the present record is a novel discovery of a pre-existing

Figure 1. *Triturus macedonicus* male in the alpine Lake Gistova.

Figure 2. Alpine lake Gistova, Kastoria, Greece.

population or if a lower population has shifted its dispersal upwards and only recently started occupying this alpine lake. Interestingly, *Triturus* species have been shown to be directly affected by increased temperature (Walther et al. 2002). Studies have also underlined that climate warming has forced a variety of amphibian taxa (Hickling et al. 2006; Chen et al. 2011) including newts of the *Triturus* genus (Tiberti et al. 2021), to shift their distribution towards higher elevations.

Whichever the case may be, the highlight of this record is the impressive adaptive capability of the Macedonian newt, spanning 2360 m of vertical distribution within various environmental conditions. Between sea-level wetlands that suffer scorching summer temperatures and almost permanently frozen alpine lakes, the Macedonian newt can effectively adapt to an impressive range of heterogeneous and even microclimatically fluctuating ecological niches. This is a critical determinant of species

Figure 3. *Triturus macedonicus* female at Pineios Delta, Greece.

survival and an undeniable advantage especially under unstable climatic conditions that can affect hydrological regimens in the Mediterranean Basin (Escoriza and Ben Hassine 2023), including Greece (Panagoulia and Dimou 1995). A recent study conducted by Degani and Meerson (2024) on the newt species *Ommatotriton vittatus*, showed extensive gene expression shifts and transcriptomic remodelling between terrestrial and aquatic stages in a population occupying an extreme habitat, confirming that phenotypic plasticity is the unsurpassed tool that allows amphibians to re-adjust to rapid environmental shifts (Diamond and Martin 2016). Considering the flexible responses that *T. macedonicus* also seems to possess, it may be another great candidate to investigate transcriptomic remodelling in populations occupying the two extreme habitats of its vertical range. Furthering our understanding of these mechanisms can have important implications for conservation and site preservation, because they may act as a buffer against serious threats under climate change (Urban et al. 2014).

Another significant implication of the current work is the possibility of more isolated populations of the Macedonian newt or even other species of the genus existing at higher altitudes. Subject to the available datasets, species distribution modelling approaches can be employed to facilitate the discovery of new populations within their range. A course of action that becomes more imperative after taking into consideration the direct threats through an ever-changing habitat (e.g. climate change, overgrazing, bioaccumulation of agricultural chemicals) and the status of the species. *T. macedonicus* is designated as "Vulnerable" (VU) by IUCN due to a multitude of factors, including aquatic habitat loss (Romano et al. 2009) and is also included in Annex II of the Directive 92/43/EEC which dictates the establishment of special conservation areas (Danelis et al. 2023). A better understanding of its distribution throughout its range would assist in more efficient conservation actions.

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References

Arntzen JW (2003) *Triturus cristatus* Superspezies-Kammolch-Artenkreis. Handbuch Der Reptilien Und Amphibien Europas, 421–514.

Arntzen JW, Espregueira Themudo G, 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 centre of origin. Contributions to Zoology 76(4): 261–278. https://doi.org/10.1163/18759866-07604005

Arntzen JW, Wallis G (1999) Geographic variation and taxonomy of crested newts (*Triturus cristatus* superspecies): morphological and mitochondrial DNA data. Contributions to Zoology 68(3): 181–203. https://doi.org/10.1163/18759866-06803004

Chen IC, Hill JK, Ohlemüller R, Roy DB, Thomas CD (2011) Rapid range shifts of species associated with high levels of climate warming. Science 333(6045): 1024–1026. https://doi.org/10.1126/science.1206432

Danelis T, Theodoropoulos A, Toli EA, Bounas A, Korakis A, Sotiropoulos K (2023) Defining evolutionary conservation units in the macedonian crested newt, *Triturus macedonicus* (Amphibia;

Salamandridae), in a biodiversity hotspot. Diversity 15(5): 671. https://doi.org/10.3390/d15050671

Degani G, Meerson A (2024) Transcriptome variation in banded newt (*Ommatotriton vittatus*) during its life cycle and habitat transition. Comparative Biochemistry and Physiology Part D: Genomics and Proteomics 50: 101203. https://doi.org/10.1016/j.cbd.2024.101203

Denoël M (2004) Distribution and characteristics of aquatic habitats of newts and yellow-bellied toads in the district of Ioannina (Epirus, Greece). Herpetozoa 17: 49–64.

Diamond S, Martin R (2016) The interplay between plasticity and evolution in response to human-induced environmental change. F1000Research 5: 2835. https://doi.org/10.12688/f1000research.9731.1

Escoriza D, Ben Hassine J (2023) Microhabitat use by Mediterranean ribbed newts: newts in highly fluctuating conditions? Journal of Natural History 57(9–12): 744–757. https://doi.org/10.1080/00222933.2023.2210800

Hickling R, Roy DB, Hill JK, Fox R, Thomas CD (2006) The distributions of a wide range of taxonomic groups are expanding polewards. Global Change Biology 12(3): 450–455. https://doi.org/10.1111/j.1365-2486.2006.01116.x

Naumov B, Tzankov N (2008) First record of *Triturus macedonicus* (Karaman, 1922) (Amphibia: Salamandridae) in Bulgaria. Historia Naturalis Bulgarica 19: 111–114.

Panagoulia D, Dimou D (1995) Climatic instability and low-flow regimes. Water Resources Management under Drought or Water Shortage Conditions, 29–34.

Papaioannou H, Batistatou A, Mavrogiorgou MC, Konidaris C, Frillingos S, Briasoulis E, Vareli K (2015) High incidence of dorsal dark spots in north-western Greek populations of alpine newts *Ichthyosaura alpestris* (Salamandridae, Caudata). Herpetology Notes 8: 589–598. https://www.biotaxa.org/hn/article/view/12776

Romano A, Arntzen JW, Denoel M, Jehle R, Andreone F, Anthony B, Schmidt B, Babik W, Schabetsberger R, Vogrin M, Puky M, Lymberakis P, Crnobrnja-Isailovic J, Ajtic R, Corti C (2009) *Triturus carnifex*. The IUCN Red List of Threatened Species 2009: e.59474A11947714.

Sotiropoulos K, Legakis A, Polymeni RM (1995) A review of the knowledge on the distribution of the genus *Triturus* (Rafinesque, 1815) in Greece. Herpetozoa 8: 25–34.

Speybroeck J, Beukema W, Bok B, Voort J (2016) Field guide to the amphibians and reptiles of Britain and Europe (Wildlife Guides). Bloomsbury, 101 pp.

Tiberti R, Mangiacotti M, Bennati R (2021) The upward elevational shifts of pond breeding amphibians following climate warming. Biological Conservation 253: 108911. https://doi.org/10.1016/j.biocon.2020.108911

Urban MC, Richardson JL, Freidenfelds NA (2014) Plasticity and genetic adaptation mediate amphibian and reptile responses to climate change. Evolutionary Applications 7(1): 88–103. https://doi.org/10.1111/eva.12114

Valakos E, Pafilis P, Sotiropoulos K, Lymberakis P, Maragou P, Foufopoulos J (2008) The Amphibians and Reptiles of Greece. Chimaira: Frankfurt am Main, 159 pp.

Walther GR, Post E, Convey P, Menzel A, Parmesan C, Beebee TJC, Fromentin JM, Hoegh-Guldberg O, Bairlein F (2002) Ecological responses to recent climate change. Nature 416(6879): 389–395. https://doi.org/10.1038/416389a

Wielstra B, Arntzen JW (2011) Unraveling the rapid radiation of crested newts (*Triturus cristatus* superspecies) using complete mitogenomic sequences. BMC Evolutionary Biology 11(1): 162. https://doi.org/10.1186/1471-2148-11-162

Wielstra B, Litvinchuk S, Naumov B, Tzankov N, Arntzen JW (2013) A revised taxonomy of crested newts in the *Triturus karelinii* group (Amphibia: Caudata: Salamandridae), with the description of a new species. Zootaxa 3682: 441–453. https://doi.org/10.11646/zootaxa.3682.3.5

Wielstra B, Sillero N, Vörös J, Arntzen JW (2014) The distribution of the crested and marbled newt species (Amphibia: Salamandridae: *Triturus*) – an addition to the new atlas of amphibians and reptiles of Europe. Amphibia-Reptilia 35(3): 376–381. https://doi.org/10.1163/15685381-00002960

Wielstra B, Arntzen JW (2016) Description of a new species of crested newt, previously subsumed in *Triturus ivanbureschi* (Amphibia: Caudata: Salamandridae). Zootaxa 4109(1): 73–80. https://doi.org/10.11646/zootaxa.4109.1.6

Wielstra B, McCartney-Melstad E, Arntzen JW, Butlin RK, Shaffer HB (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. https://doi.org/10.1016/j.ympev.2018.12.032

Wielstra B, Arntzen JW (2020) Extensive cytonuclear discordance in a crested newt from the Balkan Peninsula glacial refugium. Biological Journal of the Linnean Society 130(3): 578–585. https://doi.org/10.1093/biolinnean/blaa062