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Research Article

Distribution and Ecology of *Triturus cristatus* (Laurenti, 1768) (Amphibia: Salamandridae) in Bulgaria

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Abstract: The great crested newt *Triturus cristatus* is a widely distributed species across Europe and its southernmost range reaches northwestern Bulgaria. *Triturus cristatus* is comparatively well-studied in general, however, data about its distribution and habitat preferences in Bulgaria are very scarce. This study presents the results of an extensive field research (carried out in 2021) and a review of all available previous data for the species in Bulgaria. All known localities of *T. cristatus* in the country fall into a total of 22 UTM-squares (10 x 10 km), for 10 of which the species is newly discovered. The distribution of *T. cristatus* in Bulgaria is wider than previously thought and covers almost the entire north-western part of the country. The altitudinal range is relatively wide (40–1380 m a.s.l.) but most of the localities are situated below 500 m. In terms of habitat preferences, our results demonstrate that *T. cristatus* prefers water bodies of small area (below 1000 m^2), shallow depth (0.5–1 m), muddy bottom, without reed/bulrush and without fish. Regarding the terrestrial phase, it can only be stated that in the vicinity (400 m radius) of the water bodies in which the species was found, the predominant type of land cover is "Agricultural areas", followed by "Forest and semi natural areas", but the preferences of *T. cristatus* to specific terrestrial habitats in the Bulgarian part of distribution range remain unknown.

Key words: Caudata, Balkan Peninsula, newt, mapping, habitat.

Introduction

During the last three decades, the genus *Triturus* Rafinesque, 1815 has been the subject of intensive phylogenetic research, which has led to a number of taxonomic changes, such as the transfer of some of the species-ranked taxa to other genera, the description of new taxa, the elevation of subspecies to species rank, synonymisation, etc. Since the last publications on the matter (Wielstra & Arntzen 2016; Wielstra et al. 2019), it has been accepted that the genus *Triturus* includes nine species distributed in Europe and small parts of western Asia (Frost 2023).

The great crested newt *Triturus cristatus* has the widest range among the representatives of the genus. It is distributed from Scotland, Wales and western France in the west, to the Urals in the east (occasionally even further east: Sverdlovsk Oblast and Chelyabinsk Oblast, Russia) and from the middle parts of Norway and Sweden in the north, to north-western Bulgaria in the south (Litvinchuk & Borkin 2009, Wielstra et al. 2014). Ecologically, *T. cristatus* can be considered a relatively well-studied species, but almost all studies/publications have focused on northern populations (see Arntzen 2003, Jehle et al. 2011, Fahrbach & Gerlach 2018 and references therein), while the most-southern ones still remained unexplored.

For Bulgaria, the presence of *T. cristatus* as a separate taxon with species rank was proven

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by Tzankov & Stoyanov (2008) based on external morphology and number of trunk vertebrae on specimens caught in a pond in the western part of Stara Planina Mts.; these authors provided two more localities of the species in the country. In the following years, other localities were also recorded - all in the north-western part of the country (see Wielstra et al. 2013a,b, Naumov et al. 2016, Tzankov & Slavchev 2016), but targeted studies on the distribution and especially the ecology of *T. cristatus* in the country are lacking.

The great crested newt has a high conservation status on both European (included in Annexes II and IV of Council Directive 92/43/EEC and Appendix II of the Convention on the Conservation of European Wildlife and Natural Habitats, Bern) and national level (Annexes II and III of the Biological Diversity Act of Bulgaria). It is also included in the Red Data Book of Bulgaria, as a "vulnerable species" (Tzankov & Stojanov 2015).

The main goal of the present work was to study and map the distribution of *Triturus cristatus* in Bulgaria. We also provide the first data on the habitat specifics for the species in the country.

Materials and Methods

The study area covered the north-western part of Bulgaria and included both the territory for which the species was already known, as well as adjacent territories - between the Danube River to the north and the main ridge of the Stara Planina Mts. to the south and between the state border to the west and the Vit River valley to the east. Targeted field research was carried out in 2021 (mainly in the period March-June) and included the visit of a total of 60 separate water bodies, scattered unevenly throughout the study area (Fig. 1). Different types of stagnant and slow-flowing water bodies were studied: marshes, micro dams, puddles, stream spills, flooded ditches, drainage canals, etc. Newts were captured by the use of funnel traps (approx. dimensions 50/25/25 cm; minimum exposure time 12 hours). The species affiliation of the captured newts was determined on the basis of external morphological traits: ventral coloration pattern, relative length of the forelimbs (estimated by sight), or number of the costal furrows (in larvae) (see Stojanov et al. 2011). The geographic coordinates of the studied reservoirs were recorded in the field using a handheld GPS receiver (Garmin GPSMAP 64S, accuracy ± 5 m).

Distribution mapping was performed by relating all known records of *T. cristatus* in Bulgaria (field data from 2021 and unpublished data provided by colleagues, as well as data from the available literature) to UTM (Universal Transverse Mercator) grid squares with a resolution of 10x10 km in the projection coordinate system "WGS 84 UTM 35N". To designate the squares, their codes according to MGRS (Military Grid Reference System, spatially identical with UTM) were used. The term "locality" used in the text, means a specific body of water with a proven presence of the species, at least 200 m away from another one and, as an exception, a group of small bodies of water (in close proximity to each other) or a toponym that cannot be referred to a specific body of water or refers to a terrestrial record.

The characterization of aquatic habitats in which the species was found in 2021 is based on considering the character state of eight environmental factors (modified after Naumov et al. 2020): 1) Origin: natural, semi-natural (water bodies that have formed accidentally in excavations, abandoned quarries, etc.), artificial (purposefully man-made water bodies, regardless of whether they are maintained or abandoned); 2) Surface area (m^2): < 1000, 1000–10000, 10000–100000; 3) Depth (maximum, m): < 0.5, 0.5–1, 1–1.5, > 1.5; 4) Bottom substrate: stony, sandy, muddy; 5) Underwater vegetation (relative amount to water volume): absence, < 1/3, 1/3–2/3, > 2/3; 6) Reed/Bulrush (proportional cover of the water surface): absence, < 1/3, 1/3–2/3, > 2/3; 7) Dominant vegetation type on the bank: absence, grass, shrubs, trees; 8) Presence of fish (visually observed or trapped): yes/no. Terrestrial habitats of *T. cristatus* in Bulgaria cannot be analysed directly, as field data (finding newts outside water bodies) are extremely scarce. Therefore, we adopted an approach that is widely used in such cases, assuming that newts do not move more than a few hundred meters from breeding ponds and describing the land cover in a 400 m radius around these ponds to provide an idea of potential terrestrial habitats (e.g. Joly et al. 2001 and Naumov et al. 2020). The radius corresponds to the average distance that newts travel away from water bodies (see Joly et al. 2001 and references therein) and for the habitat description, we used the level 3 categories of CORINE Land Cover (CLC) 2018.

Mapping, spatial analysis and map visualization were done using the ArcGIS 10.1 software (ESRI, Redlands, California, USA) and for the statistical analysis of differences in frequencies of analysed character states we used the Chi-square test (in cases with only one degree of freedom Yates' correction was used) in STATISTICA 10.0 (StatSoft, Inc. 2011).

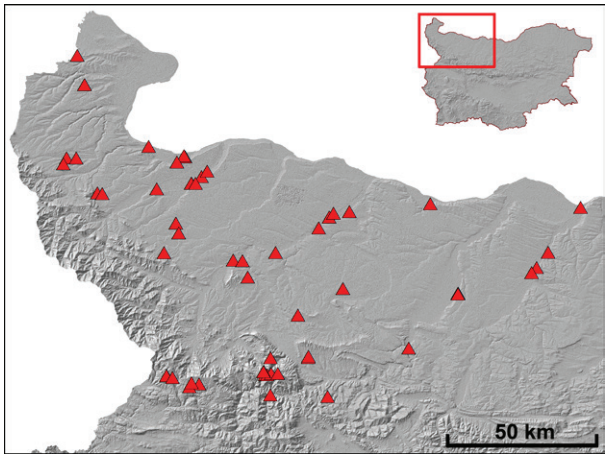

Fig. 1. The studied area relative to the territory of Bulgaria marked by red square and location of the 60 studied water bodies.

Results

Distribution

The available data (new and already published) on the distribution of *T. cristatus* in Bulgaria refer to 30 separate localities (Appendix 1). The localities fall into a total of 22 squares (10x10 km), for 10 of which the species is newly recorded and for 6 it is confirmed (Fig. 2). Collected material or morphological descriptions of the animals were not available from two localities - "Vratsa (Skaklya)" and "Skomlya Dam" (provided by Kovachev 1912 and Stoyneva & Michev 2007, respectively; Fig. 2: GN08 and FP43). However, both localities were referred to *T. cristatus* because they fall within its range and are beyond that of *T. ivanbureschi* (the same approach was used in Stojanov et al. 2011) and in 2021 only *T. cristatus* was found in the same MGRS-squares. Regarding the locality near the village of Tipchenitsa (Fig. 2: GN27), it should be noted that among the captured adult newts, 11 had a typical *T. cristatus* morphotype (throat coloration obviously different from that of the abdomen; relatively short limbs), but one male and one female had the morphotype corresponded to that typical for *T. ivanbureschi* (throat coloration almost the same as that of the abdomen; relatively long limbs); one larva with 12 costal furrows, typical of *T. cristatus*, was also captured (*T. ivanbureschi* larvae have fewer furrows, see Stojanov et al. 2011). In the other localities (indicated on Fig. 2 as new or confirmed), we found crested newts, which had only a morphotype typical for *T. cristatus*. In three water bodies, situated at the northern and eastern borders of the study area (not visualized on Fig. 2), we registered *T. dobrogicus* (MGRS: FP65 and LJ13) or *T. ivanbureschi* (MGRS: LJ01), but not *T. cristatus* morphotypes. Regarding the distribution of *T. cristatus* at the continental level (50 km UTM grid: see Wielstra et al. 2014), our data confirmed the distribution range of the species in five squares (34TFP1, 34TFP2, 34TFP4, 34TGN1, 34TGP2) and added new one: 35TKH3 (the locality near the village of Reselets; Fig. 2: KH69).

The known localities of *T. cristatus* in Bulgaria fall within a relatively wide altitudinal range (Fig. 3), between 40 m near the village of Kriva Bara and 1360–1380 m at the three localities on the ridge of Stara Planina Mts. (respectively GP13 and GN07 on Fig. 2; see also Appendix 1). The altitude of most (77%) localities is below 500 m.

Habitats

The water bodies in which newts were found were quite diverse in terms of origin, area, depth, etc. The frequencies of occurrence of the character states of the reported environmental factors, as well as Chi-square test results, are given in Table 1. Significant differences in frequencies were observed for five of the environmental factors. In terms of abiotic factors, predominant were water bodies with small area (below 1000 m^2; the area varied between 15 and 91 000 m^2), medium depth (0.5–1 m) and muddy bottom and in terms of biotic factors – those with no reeds/bulrush and no fish. For the rest of the reported factors, there were no statistically significant differences between the frequencies of the separate categories.

Only two of all known localities for *T. cristatus* in Bulgaria are identified based on individuals found outside the water bodies: the Tocheva Yama Cave (located 230 m from a surface water body source), where newts have been repeatedly found inside the cave (Tzankov & Stoyanov 2008, Naumov et al. 2016) and the town of Mezdra, where one individual was observed on a street in the town, about 175 m away from the Iskar River (K. Donchev, pers. comm.). Clearly, these findings do not provide information on terrestrial habitats of the species, but such kind of information could be indirectly obtained by analysing the land cover in the vicinity of the water bodies in which *T. cristatus* was found. In the most general sense (CLC Level 1; see Fig. 4) the most common type within a radius of 400 m around the water bodies was "Agricultural areas" (total 61.57%), followed by "Forest and semi natural areas" (34.52%) and "Artificial surfaces" (3.91%). The distribution of the shares of the separate categories at the third level is shown in Table 2. Arable lands

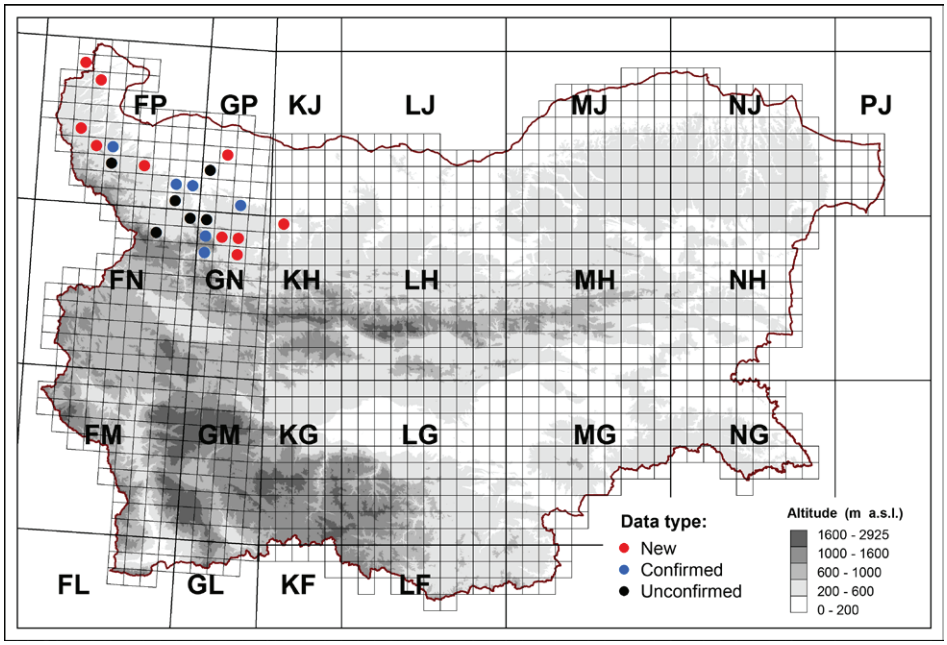

Fig. 2. Distribution of *Triturus cristatus* in Bulgaria based on a 10 km UTM grid.

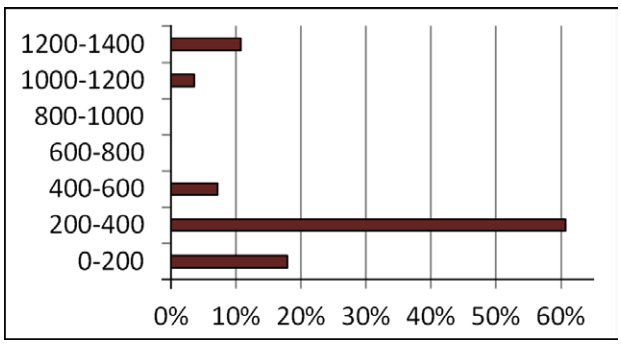

Fig. 3. Percent distribution of the localities of *T. cristatus* in Bulgaria, based on 200-m altitudinal belts (n = 28, excluding localities with ID 20 and 21 in Appendix 1).

have greatest area coverage and frequency of occurrence, while forests (which are generally considered the most preferred habitat for newts) are on fourth position concerning area coverage and are second in terms of frequency of occurrence.

Discussion

Distribution

Based on the results of this study, the approximate geographic boundaries of *Triturus cristatus* distribution in Bulgaria are the ridge of Stara Planina Mts. to the south and the valley of the Iskar River to east; to the north, the closest locality to the Danube River is at the village of Kalenik, about 16 km away from the river (Fig. 2: FP37). To the east and south of these approximate boundaries, *Triturus ivanbureschi* is distributed (Stojanov et al. 2011, Wielstra et al. 2014, 2017). An unclear case is the locality "Petrohan" (MGRS code: FN77; not marked in Fig. 2), which was interpreted by Tzankov & Stoyanov (2008) as that of *T. cristatus* [the primary information comes from Beshkov & Nanev (2002), where the locality is given as "southeast of the Petrohan Pass" and attributed to "*Triturus* superspecies *cristatus*" without any other data], but we believe that attributing this locality to both *T. cristatus* and *T. ivanbureschi* would be too speculative (except that there is no material examined, the locality is situated on the supposed boundary between the ranges of the two species). According to Tzankov & Stojanov (2015), the Bulgarian localities of *T. cristatus* are isolated from the rest of the species range, but it should be noted that this publication was prepared back in 2011 although it was not published until 2015 (N. Tzankov pers. com.). More recent data, incl. the new localities provided in this study, demonstrate that there is no geographic barrier that could isolate the Bulgarian populations from those located northwest of the state border. In support of the latter is the founding of the species on the very border between Bulgaria and Serbia near the village of Deleyna (Fig. 2: FP28), i.e., very close to the known localities in eastern Serbia (see Vukov & Kalezić 2015 and Vučić et al. 2020). To the north, however, the Bulgarian populations of the species are unlikely to be in contact to the Romanian ones, since all known localities of crested newts in the coastal strip of the Danube River (up

Table 1. Frequency of occurrence (Freq.) of the separate categories of the reported environmental factors in 21 water bodies (Appendix 1: locality ID 3-5, 6 (three water bodies), 8, 10, 11, 13, 15-19, 23-25 and 28-30) with established presence of *T. cristatus* in Bulgaria (the categories within each factor are arranged in descending order according to their frequency in %) and Chi-Square test results of frequencies by individual factors (statistically significant differences are marked with asterisks).

Factor	Category	Freq.	Chi-sq. test
Origin	Semi-natural	48%	$\chi^2 = 2.57$ df = 2 $p = 0.2765$
	Natural	33%	
	Artificial	19%	
Surface area (m^2)	< 1000	67%	$\chi^2 = 11,14$ df = 2 $p = 0.0038$**
	1000–10000	24%	
	10000–100000	10%	
Depth (maximum, m)	0.5–1	71%	$\chi^2 = 14.86$ df = 2 $p = 0.0006$***
	≤ 0.5	24%	
	1–1.5	5%	
	> 1.5	n/a	
Bottom substrate	Muddy	95%	$\chi^2 = 8,50$ df = 1 $p = 0.0036$**
	Sandy	5%	
	Stony	n/a	
Underwater vegetation (amount to water volume)	> 2/3	43%	$\chi^2 = 6.24$ df = 3 $p = 0.1006$
	< 1/3	33%	
	1/3–2/3	14%	
	Absence	10%	
Reed/Bulrush (cover of the water surface)	Absence	57%	$\chi^2 = 11.95$ df = 3 $p = 0.0075$**
	< 1/3	19%	
	> 2/3	14%	
	1/3–2/3	10%	
Dominant vegetation type on the bank	Grasses	57%	$\chi^2 = 5.43$ df = 2 $p = 0.0663$
	Trees	24%	
	Absence	19%	
	Shrubs	n/a	
Presence of fish	No	95%	$\chi^2 = 8,50$ df = 1 $p = 0.0036$**
	Yes	5%	

to about 5–10 km on both sides of the river) refer to *Triturus dobrogicus* (see Cogălniceanu et al. 2013 and Wielstra et al. 2014). There are still not enough detailed data to allow the delineation of specific hybrid zones of *T. cristatus* with *T. dobrogicus* and/or with *T. ivanbureschi* in Bulgaria, but such hybridization undoubtedly exists (see Wielstra et al. 2017). According to Wielstra et al. (2014), populations with mixed DNA are known from the Parshevitsa locality (*T. cristatus/T. ivanbureschi*; Fig. 2: GN07), as well as from localities near the villages of Karlukovo (*T. ivanbureschi/T. cristatus*) and Harlets (*T. dobrogicus/T. cristatus*). The latter two localities were presented by Wielstra et al. (2013b) as *T. ivanbureschi* and *T. dobrogicus* (these localities are not marked in Fig. 2, but the MGRS squares in which they fall are KH68 and GP24 respectively). A special case is the Lilyache locality (Fig. 2: GN09), which was assigned to both *T. ivanbureschi* (in Wielstra et al 2010, 2017) and *T. cristatus* (in Wielstra et al 2013a,b, 2014). Wielstra et al (2013a) noted that the studied samples from Lilyache contain *T. ivanbureschi* mitochondrial DNA and are also grouped with that species based on nuclear DNA, but invoked recent introgression to explain this clustering and thus treated these newts as *T. cristatus*. In this regard, it can be assumed that in other regions close to the above-defined approximate borders of the national range of *T. cristatus*, there also are contact zones where the existence of hybrid populations can be expected.

The presented data on the vertical distribution of *T. cristatus* in Bulgaria (40–1380 m a.s.l.) mostly correspond to those reported from Romania (see Fig. 5 in Cogălniceanu et al. 2013), but also cover the vertical range of the species almost completely. The highest reliably known localities of *T. cristatus* are at about 1450 m a.s.l. and are found in the Carpathians, on the territories of Ukraine and Romania (see respectively Shcherbak & Shcherban 1980 and Cogălniceanu et al. 2013).

Habitats

In terms of aquatic habitats, the results of our research indicated that *Triturus cristatus* prefers water bodies of small area (below 1000 m^2), shallow depth (0.5–1 m), muddy bottom, without reeds/bulrush and without fish. Factors such as water body origin, abundance of aquatic vegetation and nature of riparian vegetation do not appear to be of significant importance. To some extent, this corresponds to the literature habitat data summarized by Arntzen (2003), who defines the typical breeding site of *T. cristatus* as a permanent or rarely drying water body, with an area of not less than 50 m^2, depth of more than 0.5 m, with at least some aquatic vegetation and no predatory fish. Jehle et al. (2011) indicate three factors that determine the suitability of a water body as a breeding site for the crested newts: amount of sun exposure, size and the amount of vegetation.

The origin of the water bodies (natural, semi-natural or artificial) is probably a factor that itself does not influence *T. cristatus* habitat preferences (McLee & Scaife 1992, Arntzen & Teunis 1993, Beebee & Griffiths 2000, Kinne 2004). The area

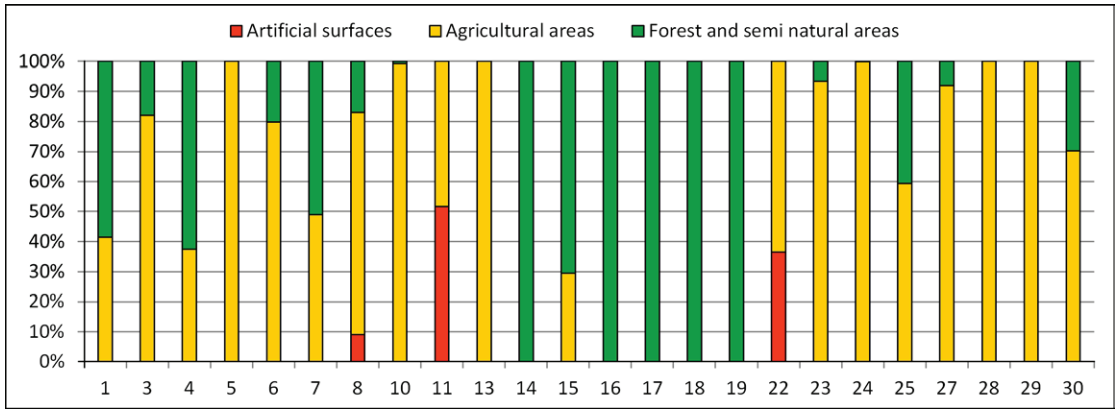

Fig. 4. Percentage distribution of the areas of the Level 1 categories of CLC within a radius of 400 m around the water bodies with established presence of *T. cristatus* in Bulgaria (the numbers under X axis refer to the localities ID in Appendix 1).

Table 2. Land cover categories within a radius of 400 m around the water bodies with established presence of *T. cristatus* in Bulgaria (generalized for 24 localities; locality ID 1, 3-8, 10, 11, 13-19, 22-25 and 27-30 in Appendix 1) arranged in descending order according to their relative area (as a percentage of the total area of all types). Fr. - number of water bodies where the respective category is present in a 400 m radius.

CLC - Level 3	Area	Fr.
2.1.1 Non-irrigated arable land	31.99%	15
2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation	16.27%	10
3.2.1 Natural grasslands	15.24%	6
3.1.1 Broad-leaved forest	10.38%	13
2.3.1 Pastures	10.19%	4
3.2.4 Transitional woodland-shrub	8.89%	10
1.1.2 Discontinuous urban fabric	3.57%	2
2.4.2 Complex cultivation patterns	3.09%	2
1.2.1 Industrial or commercial units	0.34%	1
2.2.1 Vineyards	0.04%	1
3.3.3 Sparsely vegetated areas	0.01%	1

and depth of water bodies, at least according to our observations, appear to play a significant role in habitat preferences. According to Oldham et al. (2000), who studied nearly 3000 water bodies in England, pond area is a determining factor for the biological productivity of the pond ecosystem on which newt population depends and depth is less significant, as productivity depends more on the surface area of water absorbing solar rays than on the water volume. The same authors defined water bodies with an area between 500 and 750 m^2 as optimal for *T. cristatus*. In our view, depth can be considered an indirect indicator of desiccation of water bodies, especially when long-term data are lacking (as in this case). The water regime of the ponds is undoubtedly of key importance to the successful completion of newt's metamorphosis, i.e., an annual (or near-annual) drying up of a water body before metamorphosis would result in the extinction of the local newt population. After summarizing the character of 4587 breeding sites in Germany, Jehle et al. (2011) found that about the half of them were permanent water bodies. On the other hand, intermittent drying out can have a positive effect by limiting the possibility of stocking and/or colonization of water bodies by fish or other predators that depend on the constant availability of water to a much greater extent than newts (Oldham et al. 2000). The nature of the bottom of the water body (mud, sand or stone/concrete) is a factor that is not specifically mentioned in the literature, but it is clear that the presence of mud favours the avoidance behaviour of burying in the bottom substrate characteristic for many newt species (Naumov et al. 2020).

Our results indicated, that the amount of aquatic vegetation (not including reeds/bulrush) does not have a significant effect, but it should be noted that this factor is highly dependent on the time of year, i.e. in early spring such vegetation may not have developed yet, while in summer it is abundant. According to Oldham et al. (2000), the importance of the macrophytes for the newts is expressed in providing a food base for their prey, providing cover from predators and a substrate for the egg attachment. However, above a certain plant density level, the plants limit the space for activity of the newts, incl. for mating displays. Natural succession was recognized as the most frequently observed threat to *T. cristatus* populations; according to Oldham et al. (2000), there is an optimum amount of macro-

phytes, which is expressed in a coverage between 70 and 80% of the water body. Maletzky et al. (2007) identified high density of underwater vegetation as a key factor for larval survival; Jehle et al. (2011) mentioned that crested newts often inhabit ponds at medium to advanced successional stages, possessing a vegetated shore and submerged macrophytes. The presence of reeds/bulrush cover is just a particular case of "macrophyte coverage"; it seems that its influence on *T. cristatus* has not been studied. According to our data, however, exactly this factor is indeed significant (in more than half of the investigated water bodies, reeds/bulrush were missing); the absence of such vegetation type can be a result of periodic drying up of the water bodies or other causes, which may prevent its development. In our opinion, the overgrowth with reeds/bulrush could be interpreted as the main reason for accelerating the succession in the respective water body, eventually leading to its (almost) complete desiccation. The character of the riparian vegetation is not a significant factor according to our data; however, it can be assumed that for small-surface water bodies the shading level (by trees/shrubs) would be important for the newts. According to Oldham et al. (2000), shading thwarts the development of macrophytes (and therefore their benefit to newts) and in addition, excessive vegetation development can cause eutrophication due to heavy leaf fall. On the other hand, moderate leaf fall can increase the level of nutrients in the water body, i.e. increase its biological productivity. Sztatecsny et al. (2004) established a negative correlation between the abundance of larvae and the degree of shading of the water body, noting a significant effect on the premetamorphic stages of newt's development. According to these authors, this relation testified to the importance of the successional stage of the water body and its proximity in relation to the stability of the newt population. Filoda (1981) and Maletzky et al. (2007) also identified low shading as a positive factor for the presence of *T. cristatus*.

According to numerous authors (Kuzmin 1999, Beebee & Griffiths 2000, Tzankov & Stojanov 2015), the presence of predatory/omnivorous fish in a particular water body has a negative impact on the newt populations. This is mostly because the fish feeds on the newt's eggs and/or larvae. It was also reported (e.g., Kautman & Zavadil 2001 and Hartel et al. 2007) that *T. cristatus* avoids ponds inhabited by fish. Brana et al. (1996) highlighted the negative effect of fish introductions on amphibian assemblages in mountain lakes. Our results clearly confirm these reports, as the coexistence of newts and fish was found in only one of the studied water bodies (the locality "Ochindol (3.7 km N)"; see Appendix 1), moreover the fish population detected there was not of natural origin. According to local people, individuals of the Prussian carp *Carassius gibelio* (Bloch, 1782) were deliberately introduced in 2015 or 2016 and now appear to reproduce successfully in the pond.

The preferences of *T. cristatus* to forest habitats have been recorded in a number of publications covering other parts of the species' range, highlighting the importance of the presence of deciduous or mixed forests near water bodies (Latham et al. 1996, Gustafsson et al. 2011), defining *T. cristatus* as a typical forest species (Kuzmin 1999) and establishing preference for forest areas to grasslands (Müllner 2001). However, the importance of forests seems to vary across the species range (see Jehle et al. 2011 and references therein). According to our results, forests constitute a relatively small proportion of the land cover around the known water bodies inhabited by *T. cristatus*. Instead, land used for agriculture is predominant and only a third of the potential terrestrial habitats are covered by natural vegetation. This is easily explained by the fact that most water bodies (where the species was detected) are located in plains and foothills, where the land is mainly arable used for agricultural activity. Very large sections of the forests that existed there had long been cut down. This could also be interpreted as an indication that *T. cristatus* is successfully adapting to at least some of the landscape changes occurring as a result of the human activity (according to Arntzen 2003 the great crested newt is quite plastic and its ecological preferences may vary depending on regional factors, such as food resource, day length, climate, etc.).

In conclusion, the present study largely clarifies the distribution of *Triturus cristatus* in Bulgaria, but to delineate the contact and hybrid zones with the other species of the genus *Triturus*, additional research (molecular analyses) are needed. In terms of aquatic habitats, it can be argued that the "typical" *T. cristatus* breeding pond is one of small area, shallow depth and without fish. Although the descriptions of terrestrial habitats presented here provided only a general idea, they can be used as a basis for more detailed studies in this regard.

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Appendix 1. All known localities for *Triturus cristatus* in Bulgaria (sorted alphabetically by the code of 10x10 km MGRS grid cells; see also Fig. 2). SP refers to the characters on the basis of which the localities were attributed to *T. cristatus*: EM: external morphological traits (see the section Material and Methods); NT: number of trunk vertebrae; MA: molecular analysis (1 = mitochondrial DNA; 2 = nuclear DNA); D: deductive assumption (no studied material).

ID	MGRS	Locality	N	E	Altitude	Source; notes	SP
1	FN78	Barzia	43.19669º	23.14893º	556 m	Tzankov & Stoyanov (2008)	EM
2	FN99	Tocheva Yama	43.26472º	23.34676º	281 m	Tzankov & Stoyanov (2008); Naumov et al. (2016) [as "Stoyanovo (1.3 km NE)"]	MA(1) and EM
3	FP24	Tolovitsa	43.76545º	22.59721º	201 m	this study	EM
4	FP28	Deleyna	44.07693º	22.61929º	240 m	this study	EM
5	FP33	Gara Oreshets (NW)	43.66457º	22.73324º	290 m	this study	EM
6	FP37	Kalenik	43.98993º	22.65617º	230 m	this study [this locality includes 3 water bodies in close proximity to each other]	EM
7	FP42	Borovitsa	43.58424º	22.76892º	233 m	Wielstra et al. (2013b)	MA(1)
8	FP43	Gara Oreshets (NE)	43.66275º	22.75329º	290 m	this study	EM
9	FP43	Yazovir Skomlya	n/a	n/a	265 m	Stoyneva & Michev (2007) [wrong MGRS code "FP33" in the source]	D
10	FP62	Slavotin (N)	43.58498º	23.06552º	210 m	this study	EM
11	FP62	Slavotin (SE)	43.55592º	23.07862º	220 m	this study	EM
12	FP80	Montana	43.39541º	23.23626º	150 m	Wielstra et al. (2013b) [according to Tzankov & Slavchev (2016) this water body no longer exists]	MA(1), EM
13	FP81	Erden	43.48114º	23.30958º	110 m	this study	EM
14	FP81	Stubel	43.42429º	23.34654º	273 m	Tzankov & Slavchev (2016) [given as "Pastrina Hill region (UTM: FP80)" in the source; here we provided the correct MGRS code and precise coordinates]	EM
15	FP91	Palilula	43.43193º	23.37309º	234 m	Wielstra et al. (2013b); this study	EM
16	GN07	Parshevitsa	43.13949º	23.46255º	1360 m	Tzankov & Stoyanov (2008); Wielstra et al. (2013b); this study	MA(1), EM, NT
17	GN07	Ochindol (3.8 km N)	43.13933º	23.46566º	1370 m	Naumov et al. (2016); this study	EM
18	GN07	Ochindol (3.7 km N)	43.13925º	23.47101º	1380 m	Naumov et al. (2016); this study	EM
19	GN08	Ledenika	43.19089º	23.48155º	1015 m	Wielstra et al. (2013b); this study	EM
20	GN08	Vratsa (Skaklya)	n/a	n/a	500-1000 m	Kovachev (1912)	D
21	GN09	Lilyache	43.32º	23.53º	100-500 m	Wielstra et al. (2010; 2013a,b; 2017)*	MA(1,2)
22	GN09	Chiren	43.32323º	23.5873º	301 m	Wielstra et al. (2013b)	MA(1)
23	GN18	Krapets (W)	43.19581º	23.63729º	390 m	this study	EM
24	GN18	Krapets (NW)	43.19970º	23.63746º	370 m	this study	EM
25	GN27	Tipchenitsa	43.07896º	23.70952º	580 m	this study	EM
26	GN28	Mezdra	43.14299º	23.72017º	212 m	this study [data from 2014 provided by K. Donchev]	EM
27	GP02	Gromshin	43.50883º	23.47899º	77 m	Wielstra et al. (2013b) [here we provided more precise coordinates of the locality]	EM
28	GP13	Kriva Bara	43.62338º	23.70058º	40 m	this study	EM
29	GP20	Borovan	43.40904º	23.76941º	210 m	Wielstra et al. (2013b); this study	MA(1) and EM
30	KH69	Reselets	43.23608º	24.04997º	102 m	this study	EM

* see the section Discussion