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Distribution and characteristics of aquatic habitats of newts and Yellow-bellied Toads in the district of Ioannina (Epirus, Greece)

(Amphibia: Caudata: Salamandridae; Anura: Discoglossidae)

Verbreitung und Charakterisierung der aquatischen Lebensräume von Molchen und Gelbbauchunken im Bezirk Ioannina (Epirus, Griechenland)

(Amphibia: Caudata: Salamandridae; Anura: Discoglossidae)

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KURZFASSUNG

Die Studie beschreibt aquatische Lebensräume und Verbreitung von *Triturus alpestris veluchiensis* WOLTERSTORFF, 1935, *T. carnifex macedonicus* (KARAMAN, 1922), *T. vulgaris graecus* (WOLTERSTORFF, 1905) und *Bombina variegata scabra* (KÜSTER, 1843) im Bezirk ("nomos") Ioannina, im Norden Griechenlands. *Bombina variegata* wurde am häufigsten angetroffene, gefolgt von *T. alpestris* und *T. carnifex*. *Triturus vulgaris* schient selten zu sein. Die vier Taxa unterschieden sich in ihren Biotoppräferenzen und ihrer geographischer Verbreitung. Funde von *Triturus alpestris* waren auf die höchst gelegenen Standorte im Norden und Osten des Bezirks beschränkt. Die Art wurde in alpine Seen, aber auch kleinflächigeren Habitaten, wie etwa Viehtränken und Teiche gefunden. In vier Populationen wurden pädomorphe Individuen festgestellt. *Triturus vulgaris* fand sich nur in den Niederungen im Zentrum des Bezirks. Die Art bewohnte Wasserspeicher, Bewässerungsbecken und Viehtränken. *Triturus carnifex* und *B. variegata* hatten eine weitere Verbreitung und bewohnten eine größere Vielfalt von Lebensräumen. Unter den untersuchten Arten war *B. variegata* die einzige, die in fließenden Gewässern (kleine Bäche) vorkam. In großen Flüssen oder Seen waren weder Molche noch Gelbbauchunken gefunden worden. Wassermolche und Gelbbauchunken besetzen im Bezirk Ioannina eine größere Vielfalt an Standorten und weisen ein größeres Verbreitungsgebiet auf als bisher angenommen. Große Populationen von pädomorphen Individuen waren selten. Seen, die diese beherbergen, sollten geschützt werden.

ABSTRACT

The study describes the aquatic habitats and distribution of *Triturus alpestris veluchiensis* WOLTERSTORFF, 1935, *T. carnifex macedonicus* (KARAMAN, 1922), *T. vulgaris graecus* (WOLTERSTORFF, 1905) and *Bombina variegata scabra* (KÜSTER, 1843) in the district ("nomos") of Ioannina, Northern Greece. *Bombina variegata* was found to be the most common species, followed by *T. alpestris* and *T. carnifex* while *T. vulgaris* seemed to be rare. The four taxa differed in habitat use and geographic distribution. Records of *T. alpestris* were limited to the highest sites in the north and east of the district. This species inhabited alpine lakes, but also smaller habitats such as drinking troughs and ponds. Four populations contained paedomorphic individuals. *Triturus vulgaris* appeared to be restricted to low altitude sites in the centre of the district where it lived in reservoirs, watering basins and drinking troughs. *Triturus carnifex* and *B. variegata* had a wider distribution and occupied a broader spectrum of habitats. *Bombina variegata* was the only species studied which lived in running waters (small brooks). Neither newts nor Yellow-bellied Toads were found in large rivers and lakes. In the district of Ioannina both habitat variety and distribution range of newts and Yellow-bellied Toads turned out to be greater than previously known. Alpine lakes containing very large populations of paedomorphic individuals should be protected given the rarity of the phenomenon.

KEY WORDS

Amphibia: Caudata: Salamandridae: *Triturus alpestris veluchiensis*, *T. carnifex macedonicus*, *T. vulgaris graecus*; Anura: Discoglossidae: *Bombina variegata scabra*; distribution; ecology; aquatic habitat; paedomorphosis; species assemblage; conservation; district of Ioannina, Epirus, Greece

INTRODUCTION

Although both ecology (e.g., GRIFFITHS 1996; BEEBEE 1997) and distribution of amphibians at local (e.g., DELAUGERRE & CHEYLAN 1992), national (e.g., CABELA et al. 2001) and European (GASC et al. 1997) scales starts to be well known, these topics have been little explored in continental Greece, and more particularly in the district of Ioannina

(Epirus). Moreover, the Balkan Peninsula is a hotspot of biodiversity, containing a high number of endemic taxa which have not been studied intensively yet (GASC et al. 1997; MYERS et al. 2000). Knowledge of habitat use and local status of these populations is needed to better understand the ecology of the taxa, and from a larger point of view, the adaptation of amphibians to supra-Mediterranean and montane environments. It will also be beneficial for the application of conservation measures to a class of animals in decline all over the world (e.g., HOULAHAN et al. 2000), including the Balkans (KALEZIC & DZUKIC 2001).

The district of Ioannina is bordered by Albania in the north and six Greek districts. Elevations are highest in the north and east in the Gramos, Smolikas, Tymphi (Gamila), Mavrovouni, and Lakmos mountain massifs (fig. 1). Smolikas, Gramos, and Tymphi, the three highest summits, reach 2,637 m, 2,520 m and 2,497 m a.s.l., respectively, but the bottoms of the large valleys are below 500 m elevation. Kasidiaris, Mitsikeli and Tomaros are hills in the centre and west of the district. Most of these mountainous areas are part of the North Pindos, with the exception of Tomaros and Lakmos, which belong to the South Pindos (SFIKAS 1980). Two national parks have been designated in Ioannina: Vikos-Aoos and Valia Calda, also called Pindos (HANDRINOS & AKRIOTIS 1997).

Ten amphibian taxa are known from the district of Ioannina: *Bombina variegata scabra* (KÜSTER, 1843), *Bufo bufo spinosus* DAUDIN, 1803, *Bufo viridis viridis* LAURENTI, 1768, *Hyla arborea arborea* (LINNAEUS, 1758), *Rana ridibunda* PALLAS, 1771 (*Rana balcanica* SCHNEIDER, SINSCH & SOFIANIDOU, 1993, junior synonym for *Rana kurtmuelleri* GAYDA, 1940 is considered a synonym of *Rana ridibunda*: OHLER 1997; PLÖTNER & OHST 2001), *R. epeirotica* SCHNEIDER, SOFIANIDOU, KYRIAKOUPOULOU-SLAVOUNOU, 1984, *R. graeca* BOULENGER 1891, *Salamandra salamandra salamandra* (LINNAEUS, 1758), *Triturus alpestris veluchiensis* WOLTERSTORFF, 1935, *T. carnifex macedonicus* (KARAMAN, 1922) (CYRÉN 1935; SCHNEIDER et al. 1984; SMIRINA & SOFIANIDOU 1985; BREUIL & PARENT 1987; CRUCITTI & GENTILI 1987; CRUCITTI & TRINGALI 1987; ADAMAKOPOULOS & HATZIRVASANIS 1988; BREUIL & PARENT 1988; PAPAIOANNOU 1988; SOFIANIDOU & SCHNEIDER 1989; GRILLITSCH & GRILLITSCH 1991; BREUIL 1992; SCHNEIDER & SINSCH 1992; SCHNEIDER et al. 1993; SOFIANIDOU et al. 1994; BRINGSØE 1995; KYRIAKOPOULOU-SKLAVOUNOU et al. 1997; PÉREZ MELLADO et al. 1999; DENOËL et al. 2001; PLÖTNER & OHST 2001; DENOËL 2003; DENOËL & SCHABETSBERGER 2003; DENOËL et al. 2004). Paedomorphosis has been found in some populations of *Triturus alpestris veluchiensis* inhabiting the district (SMIRINA & SOFIANIDOU 1985; BREUIL & PARENT 1987; BREUIL 1992; DENOËL et al. 2001; DENOËL 2003; DENOËL & SCHABETSBERGER 2003; DENOËL et al. 2004). *Rana dalmatina* BONAPARTE, 1840, *Pelobates syriacus balcanicus* KARAMAN, 1928, and *Triturus vulgaris graecus* (WOLTERSTORFF, 1905) have been known from North-West Greece (BOUSBOURAS & IOANNIDIS 1997a, 1997b), thus, their occurrence in the district of Ioannina was to be expected.

The aim of this study was to contribute to the knowledge of the biogeography and the status of the three species of newt and the Yellow-bellied Toad of the district of Ioannina in providing data on their populations, aquatic habitats and distribution.

MATERIALS AND METHODS

In the administrative district ("nomos") of Ioannina water bodies inventoried for the presence of amphibians from 6 July to 26 August 1999 were found in following the roads of the district. High altitude lakes were localized on the topographical maps of the Hellenic Army Geographical Service. The description of the habitat is given in the "results" section. In most cases, surface area of the aquatic habitats was measured and water depth determined with a plumb line (following parallel transects across the water sites). The present study is focused on *Triturus alpestris*, *T. vulgaris*, *T. carnifex* and *Bombina variegata* that are usually present in the water until summer while adults of the other species, such as *B. viridis*, *H. arborea*, *R. ridibunda*, *R. epeiro-*

tica and *R. graeca* leave the water earlier (ASIMAKOPOULOS et al. 1990; KYRIAKOPOULOU-SKLAVOUNOU 2000). The presence of newt larvae and recently metamorphosed yellow-bellied toad juveniles has also been recorded.

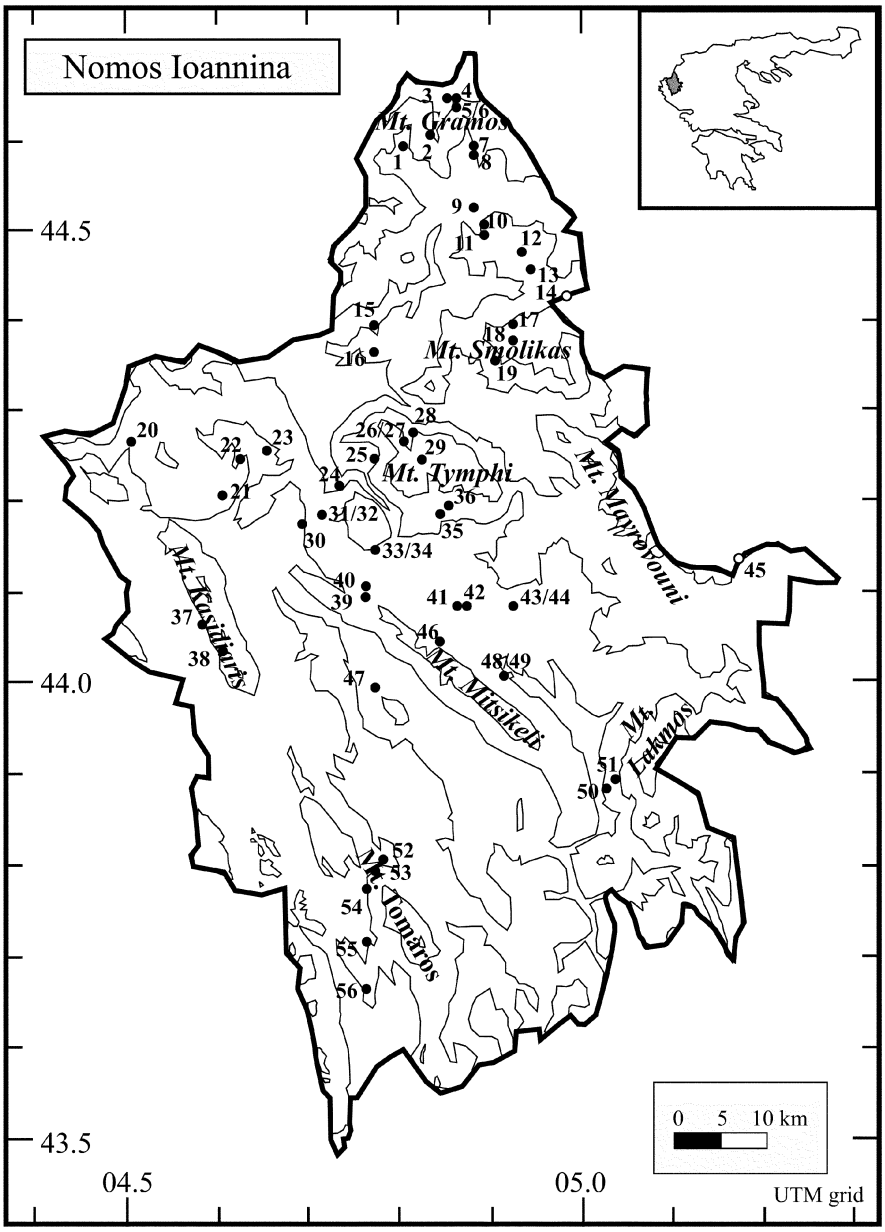

Fig. 1: Studied localities in the district of Ioannina (Greece). See table 1 for details.
Abb. 1: Untersuchte Standorte im Bezirk Ioannina (Griechenland): siehe auch Tabelle 1.

Amphibians were counted by sight or caught by landing net and minnow traps. In two alpine lakes, capture-mark-recapture methods were applied to estimate population size (Petersen index) (DENOËL & SCHABETSBERGER 2003). For that purpose, individuals were marked by tattooing with Alcian blue (JOLY & MIAUD 1989). Amphibians were temporarily maintained in containers filled with water. They were released in their natural habitat after observation. Paedomorphic newts were distinguished from metamorphic newts by the presence of gill slits and three pairs of external gills, from larvae by the presence of a developed cloaca.

Universal Transverse Mercator projection was used to specify the position of the newts with an accuracy of 1 km (World Geodetic System 1984 Ellipsoid). The district of Ioannina falls within the 34S and 34T UTM grid zones. Its surface area is 4,990 km². Distribution maps were drawn from Tactical Pilotage Charts 1:500,000 (G3A and F3D) and from the administrative map of nomos Ioannina 1:200,000. The position of the aquatic sites was determined by using a Global Positioning Device (Garmin® II Plus) and topographical maps. When amphibians were found in more than one aquatic habitat at the same place (e.g., in a drinking trough and a nearby reservoir), they were given identical site numbers in the text and table 1, however supplemented by different accessorial letters (e. g., "a" and "b") to distinguish them.

RESULTS AND DISCUSSION

I found newts and/or Yellow-bellied Toads in 56 locations (62 stations when considering different habitats located at the same place) in the administrative district ("nomos") of Ioannina (table 1, fig. 1). Amphibians were present in the mountain massifs of Gramos, Smolikas, Tymphi, Mavrovouni, Kasidiaris, Mitsikeli, Lakmos and Tomaros. Some populations were also observed at the border or outside these mountainous chains. In most of the 62 studied stations (69%) I found only one amphibian species among the four species studied, in others two (27%) or three (3%). *Bombina variegata* was the most common taxon (in 79% of the stations), followed by *T. carnifex* and *T. alpestris* (24% and 23%, respectively). *Triturus vulgaris* (here mentioned from the district for the first time) seemed uncommon (8%) at the time of the year. In terms of apparent populations size, *T. alpestris* was by far the most abundant taxon (e.g., more than twenty thousands in a single alpine lake) while, in other species, less than 100 individuals and even often only a few adults were found per site. Yellow-bellied Toads and newts were found in different kinds of aquatic habitats (table 1; fig. 2), large rivers (Aoos, Voidomatis, Sarandaporos, Kalamas) and large natural and artificial lakes (Pamvotidis = "Ioannina" and Aoou) excluded.

Aquatic habitats

Bombina variegata was the only amphibian found in brooks (fig. 3a). Water level of these brooks was relatively low (a few cm in some of them; maximum: 70 cm at one site) due to summer drought; some of them contained also fishes, crayfish and crabs. Other brooks were totally dried out. Although being a rather exceptional phenomenon, *T. alpestris* has been known to occur in running waters in Greece (BREUIL & PARENT 1987, pers. obs.), including in the Tymphi mountains (BREUIL & PARENT 1987), but was not recorded in this kind of habitat during this study.

Watering basins are man-made reservoirs bordered with gentle slopes (fig. 3c), typically circular in shape, built in concrete and used to water cattle (however, not always directly accessible to it). Although water level decreases during hot periods, the reservoirs are usually filled all the year, providing a safe place for amphibian development. Their depth ranged between 50 and 100 cm. They were mostly inhabited by *Triturus carnifex* and *T. vulgaris*, but rarely by *T. alpestris* and *B. variegata*. Green frogs (*Rana* sp.), *Natrix natrix persa* (PALLAS, 1814) and *Emys orbicularis hellenica* (VALENCIENNES, 1832) also used this habitat.

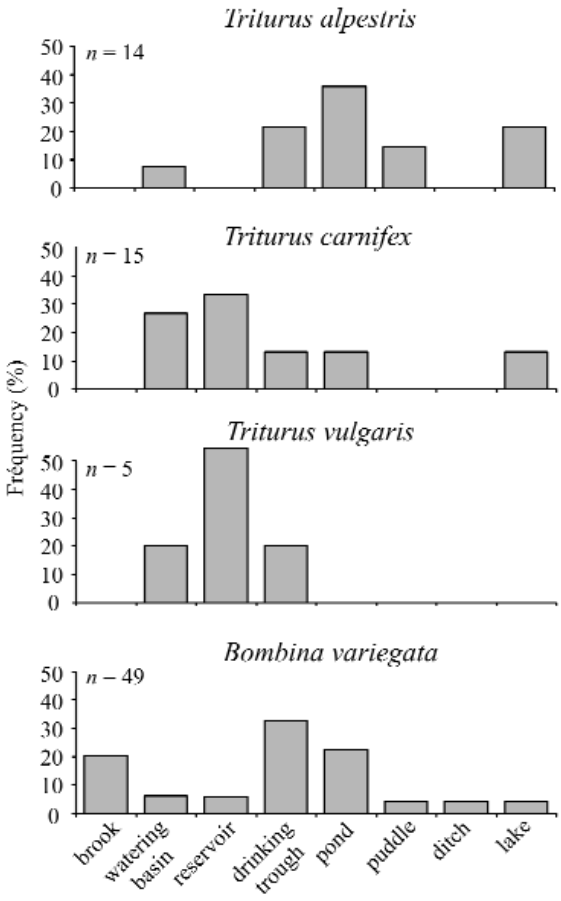

Fig. 2: Aquatic breeding habitats of *Triturus alpestris*, *T. carnifex*, *T. vulgaris* and *Bombina variegata* in the district of Ioannina (Greece).
Abb. 2: Aquatische Lebensräume von *Triturus alpestris*, *T. carnifex*, *T. vulgaris* sowie *Bombina variegata* im Bezirk Ioannina (Griechenland).

Reservoirs are man-made basins, built in concrete with vertical walls. Their shape is quadrangular. Cattle has no access to reservoirs. This habitat was mainly occupied by *T. carnifex* and *T. vulgaris*. Some of the reservoirs may constitute a trap for amphibians, particularly for Yellow-bellied Toads. They were usually deep (1 to 2.5 m) and provided water for amphibians during summer.

Drinking troughs are shallow (20-30 cm water depth) man-made habitats (fig. 3b), sometimes in connection with reservoirs or springs. They may have replaced small primary habitats (springs, small ponds) in some cases. Troughs are usually of elongated rectangular shape and sometimes elevated above the bottom which means that amphibians have to climb vertical walls to reach it. This habitat was inhabited by *B. variegata* and the three newt species. It is usually not a trap for newts, which easily climb vertical structures (pers. obs.).

Table 1 (this and opposite page): Stations in the district of Ioannina (Greece) where newts and Yellow-bellied Toads where found in the present study. UTM - Universal Transverse Mercator grid (1 x 1 km); *T.* - *Triturus*, *B.* - *Bombina*; Alt - altitude (m); Surf - water body surface (m²); Depth - maximum water depth (cm); A - adults, J - metamorphosed juveniles, L - larvae.

Site/Stelle	Locality/Fundort	Mountain/Gebirge	UTM	Alt	Surf
1	Plikati	Gramos	34T-0480-4459	1100	7
2	Oxiron	Gramos	34T-0483-4460	1560	-
3	Farmaki (1)	Gramos	34T-0485-4464	1830	3000
4	Farmaki (2)	Gramos	34T-0486-4464	1790	3
5	Aetomilitsa (1)	Gramos	34T-0486-4463	1700	0.6
6	Aetomilitsa (2)	Gramos	34T-0486-4463	1550	28
7	Paliovoulia (Vasi Rema)	Gramos	34T-0488-4459	1190	3
8	Paliovoulia	Gramos	34T-0488-4458	1050	400
9a	Langada (1a)	-	34T-0488-4452	820	-
9b	Langada (1b)	-	34T-0488-4452	820	-
10	Langada (2)	-	34T-0489-4450	1160	-
11	Langada (3)	-	34T-0489-4449	1250	-
12	Fourka (1)	Smolikas	34T-0493-4447	1640	7
13	Fourka (2)	Smolikas	34T-0494-4445	1440	28
14	Fourka (3)	Smolikas	34T-0498-4442	1700	90
15	Exohi	-	34T-0477-4439	680	-
16	Grolliorracha	-	34T-0477-4436	740	-
17	Micrilimni	Smolikas	34T-0492-4439	2100	1500
18	Drakolimni	Smolikas	34T-0492-4437	2140	7000
19	Metra Toska	Smolikas	34T-0490-4435	1430	-
20	Pogogniani	-	34S-0450-4426	760	2
21	Vissani	-	34S-0460-4420	820	50
22	Agios Posmas	-	34S-0462-4424	580	100
23	Geroplatanos	-	34S-0465-4425	570	100
24	Aristi	Tymphi	34S-0473-4421	720	5
25	Micro-papingo (1)	Tymphi	34S-0477-4424	1180	3
26	Xerolimni	Tymphi	34S-0480-4426	1770	1000
27a	Valtos (=Rizina) (a)	Tymphi	34S-0480-4426	1750	25000
27b	Valtos (=Rizina) (b)	Tymphi	34S-0480-4426	1750	-
28	Drakolimni	Tymphi	34S-0481-4427	2000	10000
29	Loutsa Rabozi	Tymphi	34S-0484-4418	1975	-
30a	Kalivia (a)	-	34S-0469-4417	620	300
30b	Kalivia (b)	-	34S-0469-4417	620	7
31	Elafotopos (1)	Tymphi	34S-0471-4418	980	64
32	Elafotopos (2)	Tymphi	34S-0471-4418	960	300
33a	Monodendri (1a)	Tymphi	34S-0477-4414	1120	64
33b	Monodendri (1b)	Tymphi	34S-0477-4414	1120	-
34	Monodendri (2)	Tymphi	34S-0477-4414	1140	300
35	Tsepelovo	Tymphi	34S-0484-4418	1280	-
36	Lakkoboui – Stani Trava	Tymphi	34S-0485-4419	1400	-
37	Lavdani	Kasidiaris	34S-0458-4406	720	-
38	Aetopetra	Kasidiaris	34S-0460-4403	860	15
39	Asprangeli	Mitsikeli	34S-0476-4409	920	450
40a	Paliochori (a)	Mitsikeli	34S-0476-4410	870	64
40b	Paliochori (b)	Mitsikeli	34S-0476-4410	870	1.5
41	Kipi (Riziana 1)	-	34S-0486-4408	880	-
42	Kipi (Riziana 2)	-	34S-0487-4408	880	-
43	Leptocaria (1)	-	34S-0492-4408	1000	10
44	Leptocaria (2)	-	34S-0492-4408	1000	-
45	Stavros	Mavrovouni	34S-0517-4413	1660	7
46a	Manassis (a)	Mitsikeli	34S-0484-4404	1080	4
46b	Manassis (b)	Mitsikeli	34S-0484-4404	1080	-
47	Neochori	-	34S-0477-4399	480	-
48	Kalivari (1)	Mitsikeli	34S-0491-4400	640	-
49	Kalivari (2)	Mitsikeli	34S-0491-4400	640	-
50	Krapsi (1)	Lakmos	34S-0502-4388	640	-
51	Krapsi (2)	Lakmos	34S-0503-4389	1000	12
52	Agh. Anastasia (1)	Tomaros	34S-0478-4380	520	-
53	Agh. Anastasia (2)	Tomaros	34S-0477-4379	560	-
54	Baousii	Tomaros	34S-0476-4377	720	-
55	K. Asprochori	Tomaros	34S-0476-4371	500	-
56	Elafos	Tomaros	34S-0476-4366	620	-

Tab. 1 (diese und gegenüberliegende Seite): Fundorte von Molchen und Gelbbauchunken im Bezirk Ioannina im Rahmen dieser Studie. UTM - Universal Transverse Mercator–Raster (1 x 1 km); Alt - Seehöhe (m); Surf - Gewässeroberfläche (m²); Tiefe - maximale Gewässertiefe (cm); *T.* - *Triturus*, *B.* - *Bombina*; A - erwachsene Tiere; J - metamorphosierte Jungtiere; L - Larven.

Site/Stelle	Depth/Tiefe	Habitat	*T. alpestris*	*T. carnifex*	*T. vulgaris*	*B. variegata*
1	50	drinking trough				10 A
2	-	ditch				7 A
3	>250	lake	67 A	1 A		3 A
4	30	puddle-pond	3 A, 50 L			7 A
5	30	puddle-pond	12 L			3 A, 5 J
6	130	pond	11 A, >100 L			8 A
7	-	drinking trough	1 L			2 A
8	30	pond-swamp		6 L		
9a	-	drinking trough				3 A, 4 J
9b	-	spring				
10	-	drinking trough				1A
11	5	ditch				11 A, 7 J
12	30	drinking trough	15 L			
13	60	watering basin	>50 L			4 A, 1 J
14	70	pond	2 A, >200 L	3 A		5 A
15	-	drinking trough				2 A
16	-	drinking trough				2 A
17	30	pond	6 A, 21 L			8A
18	495	lake	26111 A	2 A		
19	-	brook				1 A
20	20	drinking trough				1 A, 2 J
21	-	watering basin		>500 L		
22	100	reservoir		3 A		
23	50	watering basin		1 L		
24	30	drinking trough				1 A
25	30	drinking troug				10 A, 10 J
26	50	pond				10 A
27a	100	swamp/spring	>56 A			>20 A
27b	100	brook				
28	370	lake	5491 A, >50 J			5 A
29	30	pond	>200 A			
30a	50	watering basin		>30 A, >30 L		
30b	30	drinking trough				3 A
31	20	reservoir		1 A	9 A	
32	100	watering basin			5 A	
33a	-	reservoir		1 A		15 A
33b	-	drinking trough		2 A		5A, 30 J
34	-	watering basin		50 A, >500 L		10 A
35	-	watering basin				10 A, >200 J
36	-	drinking trough				1 J
37	20	brook				4 A, 1 J
38	20	pond				7 A, > 40 J
39	>60	reservoir		7 A	5 A	
40a	250	reservoir		1 A	1 A, 10 L	
40b	20	drinking trough				5 A
41	-	brook				10 A, 1 J
42	-	brook				10 A
43	25	pond				15 A, 5 J
44	-	pond				1 A, 1 J
45	-	drinking trough	1 A, 1 L			4 A
46a	12	drinking trough				6 A
46b	2	brook				3 A
47	-	drinking trough		7 J	1 A, 1 L	
48	4	brook				2 A, 1 J
49	50	brook				A
50	-	drinking trough				3 A, 3 J
51	5	spring-pond				1 A
52	70	brook				5 A
53	3	brook				1 A, 1 J
54	>100	reservoir				1 A
55	-	brook				1 A, 1 J
56	10	reservoir				10 A, 1 J

Alpine lakes are usually deep (maximum recorded depth: 4.95 m) oligotrophic natural water bodies in high elevations (fig. 3d). Most were inhabited by *T. alpestris*, and some *B. variegata* and *T. carnifex*. *Bufo viridis* was also observed in such sites.

Other aquatic habitats assessed were ponds, puddles, springs, swamps and ditches. Some ponds were used for the same purpose as watering basins but did not have an artificial coating. Various ponds and swamps were relatively deep (around 1 m), but not so springs and ditches (less than 20 cm depth). While all these water bodies can be inhabited by *B. variegata*, *T. carnifex* and *T. vulgaris* were never found in ditches and puddles.

Fifty-seven percent of the aquatic habitats where newts and Yellow-bellied Toads were found were artificial (reservoirs, watering basins, drinking troughs) (table 1). They were built to assure water reserves for stock farming. Human activities have thus favoured the presence of amphibians in such relatively dry habitats. Most likely they allow for a larger range and potentially a better connectivity between natural sites (brooks, ponds and lakes) in the district of Ioannina. Because *T. vulgaris* was only found in man-made habitats, it is at risk of extinction in the district if such artificial environments disappeared. After all, the development of new agricultural practices using automatic water delivery or the construction of closed reservoirs constitute a threat to amphibians. BOUSBOURAS & IOANNIDIS (1987a) report on draining and pumping activities and the imission of pesticides in the Prespa area (Northern Greece). Draining and pumping do not seem to be important threatening factors to newts and Yellow-bellied Toads in the district of Ioannina, whereas such techniques may be detrimental to amphibian species which live close to large areas of cultivated land.

In seventeen sites assessed, neither newts nor Yellow-bellied Toads were found, whereas other amphibians were present. This was the case in large rivers (e.g., Aoos) or canals that are inhabited by green frogs, but also in some brooks, reservoirs, watering basins, drinking troughs, and ponds some of which containing fishes.

Altitudinal distribution

The four studied amphibian species significantly differed by their altitudinal range (Kruskal-Wallis *H*-test, $p = 0.001$; fig. 4). The median altitudinal locations were 1,725 m for *T. alpestris*, 1,080 m for *B. variegata*, 950 m for *T. carnifex*, and 920 m for *T. vulgaris*. *Triturus alpestris* occurred in higher places than the three other species (Mann-Whitney *U*-test, $p < 0.05$). The other comparisons, i.e. between *T. carnifex* and *T. vulgaris*, *T. carnifex* and *B. variegata*, and *T. vulgaris* and *B. variegata* are not significant, indicating similar altitudinal distribution ranges (Mann-Whitney *U*-test).

Species assemblages

The most frequent species association in the district of Ioannina was that of *T. alpestris* and *B. variegata* (11 stations), the others were communities of *T. carnifex* and *B. variegata* (5 stations), *T. vulgaris* (4 stations) and *T. alpestris* (3 stations). *Triturus vulgaris* was never seen in syntopy with *T. alpestris* or *B. variegata* (table 1).

Other amphibian species were also associated with the four species considered in this study. Green frogs (*Rana ridibunda* or *R. epeirotica*) were the most common syntopic species (19 stations out of 62), particularly with *T. carnifex* (9 stations) and *B. variegata* (8 stations). Syntopic green frogs inhabited various habitats: lakes, ponds, watering basins, drinking troughs, and reservoirs. *Bufo v. viridis* was also found at high elevations syntopically with *T. alpestris* and *B. variegata*. Syntopies also concerned *R. graeca*, *S. s. salamandra*, *H. a. arborea*, and *B. bufo spinosus*.

Newt assemblages are common in Europe (GRIFFITHS 1996), with up to five species inhabiting the same pond in Western France (ARNTZEN & DE WIJER 1989). In such cases, each taxon is expected to differentially use the available resources (JOLY & GIACOMA 1992). Such resource partitioning decreases interspecific competition and favours coexistence. However, newt species can also segregate in habitat selection (SCHOORL & ZUIDERWIJK 1981). Among the three species of newts occurring in the nomos of Ioannina, there is some partition-

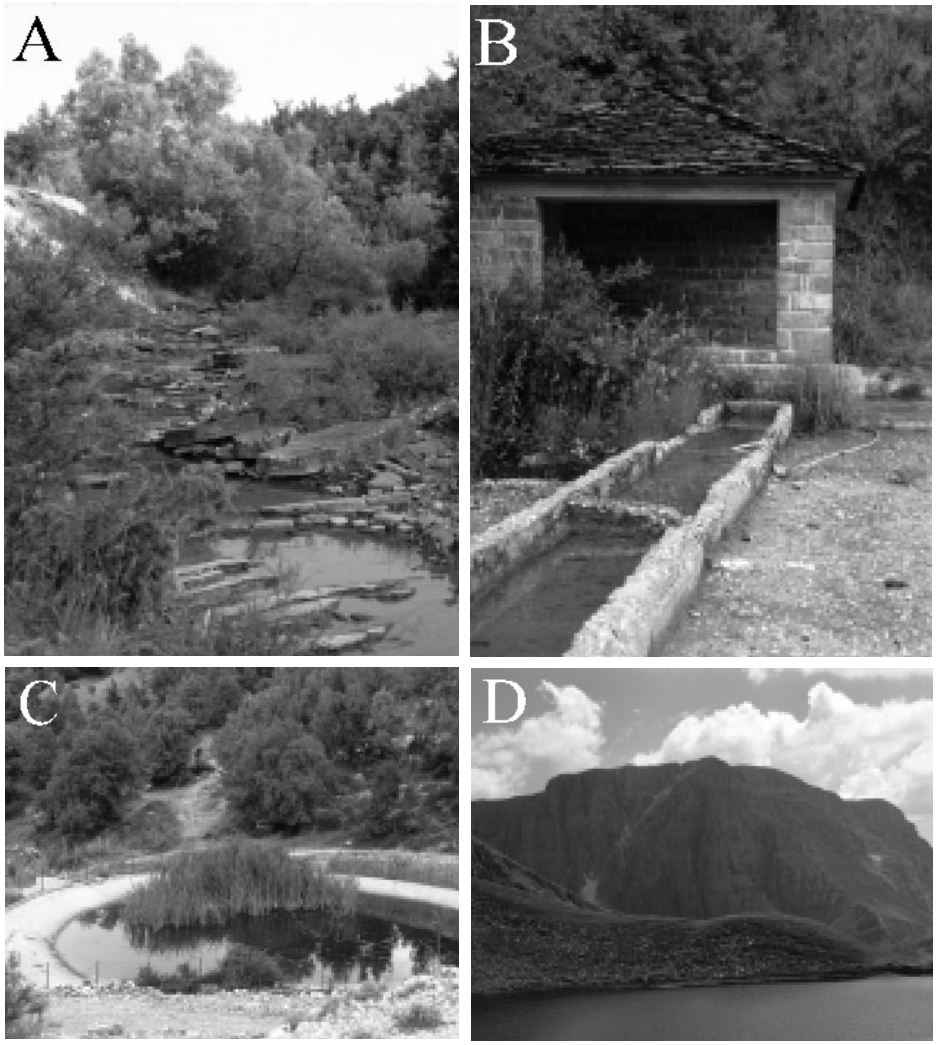

Fig. 3: Breeding habitats of amphibians in the district of Ioannina (Greece).
A - Brook in Kipi (site 42); B - Drinking trough in Manassis, Mitsikeli (site 46); C - Watering basin in Monodendri, Tymphi (site 34); D - "Drakolimni" alpine lake, Tymphi (site 28).

Abb. 3: Aquatische Lebensräume von Amphibien im Bezirk Ioannina (Griechenland).
A - Bach in Kipi (Standort 42); B - Viehtränke in Manassis, Mitsikeli (Standort 46); C - Bewässerungsbecken in Monodendri, Tymphi (Standort 34); D - "Drakolimni" alpiner See, Tymphi (Standort 28).

ing in altitudinal distribution and aquatic habitat selection (this study). Additionally there is time partitioning as several amphibian species breed before newts and Yellow-bellied Toads do (ASIMAKOPOULOS et al. 1990; KYRIAKOPOULOU-SKLAVOUNOU & LOUMBOURDIS 1990; BOUSBOURAS & IOANNIDIS 1997a).

Triturus alpestris veluchiensis WOLTERSTORFF, 1935

Greek Alpine Newts were found in 14 aquatic sites of the district, all in the northern mountainous areas: Tymphi, Smolikas, Mavrovouni and Gramos mountains (table 1, fig. 5). All stations were above 1,190 m

a.s.l. with the highest one at 2,140 m (table 1; fig. 4). Alpine Newts frequented mainly alpine lakes, ponds and drinking troughs but also watering basins and puddles (fig. 2). Surface and maximum water depth of the aquatic sites ranged from 0.6 to 25,000 m² and from 0.3 to 4.95 m respectively. In deep alpine lakes, newts occupied all micro-habitats including the deepest layers. Sexual displays were observed in such high elevation lakes. The largest population sizes were found in the largest and deepest sites: two permanent alpines lakes, both called Drakolimni. One is located in Smolikas and the other in Tymphi. Other large populations were found at Valtos, Farmaki and Loutsa Rabozi. Only a few individuals were observed in the other sites (table 1).

Drakolimni, Smolikas (site 18). This lake is the highest record location in the district of Ioannina (2,150 m elevation). Its maximum depth is 3.7 m and the surface covers 0.7 ha. It is surrounded by alpine pasture. Sheep flocks regularly used the lake for drinking. Some pine trees were present close to the lake. Size of the aquatic population was estimated at 26,111 (95 % confidence interval: 22,331 - 32,032; calculation based on a sample of 1887 adult individuals) adult Alpine Newts, including paedomorphic and metamorphic individuals (DENOËL & SCHABETSBERGER 2003). Paedomorphs constituted 74% of the adult population. Two adults of *T. carnifex macedonicus* were also found in the lake along with *B. viridis viridis*.

Drakolimni, Tymphi (site 28; fig. 3d). This lake is located on a pass at an elevation of 2,000 m. The depth of the lake is 4.95 m and its surface covers 1 ha. It is surrounded by alpine pasture. A small sheep flock frequented the site on a daily basis. Size of the aquatic population was estimated at 5,491 (95 % confidence interval: 4,300 - 8,007; calculation based on a sample of 474 adult individuals) adult Alpine Newts, including both paedomorphic and metamorphic individuals (DENOËL & SCHABETSBERGER 2003). Paedomorphs constituted 34% of the adult population. Terrestrial juveniles have been found close to the lake. *Bufo viridis* and *Bombina variegata* were also present in the Drakolimni area.

Valtos, Tymphi (site 27); a large, U-shaped swamp. Aquatic vegetation is dense except in a 400 m² open area. Sheep flocks used the swamp area. Consequently, the swamp floor was covered with sheep faeces. The water is very eutrophic. A cold spring (5°C) irrigates the swamp from its eastern arm, however, the water temperature in the swamp is higher (around 15°C in early August). The spring proper is 1 m deep, 2 m in diameter and its water is clear. A small river also crosses the swamp. Fifty-six adult newts were caught in the open area of the swamp, and a few individuals in the spring and vegetated areas, but the total population is larger. Both paedomorphs and metamorphs were observed. Paedomorphs constituted 34% of the adult population. *Bufo v. viridis* and *Natrix natrix persa* were also found in the swamp.

Farmaki, Gramos (site 3); a 3,000 m² lake close to the crest separating Greece from Albania; it was fed by a brook, but the water in the lake was turbid. Some bulrush surrounded the lake. Sixty-seven adult Alpine Newts were caught, including both paedomorphs and metamorphs, but the population size is larger. Paedomorphs constituted 57% of the adult population.

Loutsa Rabozi, Tymphi (site 29); a large pond (around 60 m long), almost dry at the end of August 1999 (1-30 cm water depth). The water is retained in the pond by an artificial dam. Aquatic vegetation is abundant. More than 200 metamorphic Alpine Newts were observed. They were mainly found along the shore. Because of the shallow depth, their backs were often above the water surface. Drying caused puddles isolated from the pond which were occupied by newts moving from hole to hole.

In the district of Ioannina, the Alpine Newt was the amphibian species that has received the most attention from scientists (SMIRINA & SOFIANIDOU 1985; BREUIL & PARENT 1987; ADAMAKOPOULOS & HATZIRVASANIS 1988; BREUIL & PARENT 1988; PAPAIOANNOU 1988; BREUIL 1992; BRINGSØE 1994, 1995; SOTIROPOULOS et al. 1995; KYRIAKOPOULOU-SKLAVOUNOU et al. 1997; DENOËL et al. 2001; DENOËL 2003; DENOËL & SCHABETSBERGER 2003). BREUIL & PARENT (1987) first gave a distribution map of Alpine Newts in Greece with four sites in

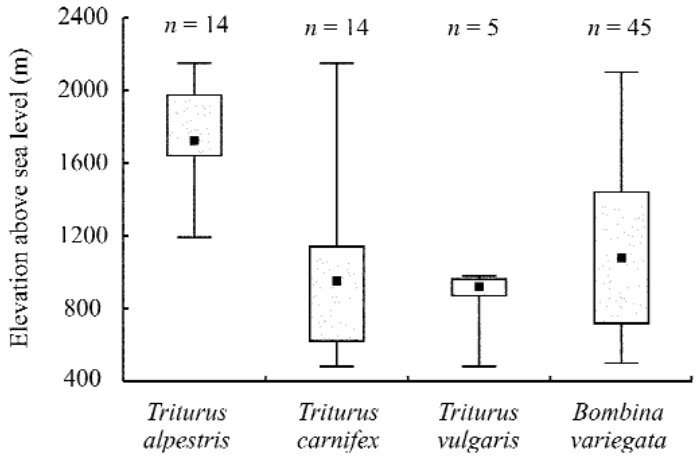

Fig. 4: Altitudinal distribution (median, quartiles, range) of *Triturus alpestris*, *T. carnifex*, *T. vulgaris* and *Bombina variegata* in the district of Ioannina (Greece).
Abb. 4: Vertikale Verbreitung (Median, Quartile, Spannweite) von *Triturus alpestris*, *T. carnifex*, *T. vulgaris* und *Bombina variegata* im Bezirk Ioannina (Griechenland).

Smolikas and Tymphi. These four sites are still inhabited by Alpine Newts. BREUIL & PARENT (1987) found paedomorphs in Micrilimni; I only observed metamorphs there. Maybe the shallowness of the swamp inhibits permanent aquatic life at this altitude (2,150 m). ADAMAKOPOULOS & HATZIRVASANIS (1988) prospected Greek mountains and - in addition to the sites described in the present study - found four more localities for metamorphic Alpine Newts in Smolikas Mountains in the east of Drakolimni. *Triturus alpestris* was also found at a locality close to the Katara pass, in the east of Metsovo (G. H. PARENT, pers. comm.). The present study reports the presence of the Alpine Newt in ten more sites than described in previous studies. Moreover, in addition to the fact that Greek Alpine Newts use large natural habitats in the north of their distribution range, this study shows that small artificial aquatic habitats such as drinking troughs are also suitable breeding sites. In different environments in Central Greece and the Peloponnese, Alpine Newts have also been found in restricted artificial habitats, including ditches, drinking troughs and cement reservoirs (BRINGSØE 1985; ADAMAKOPOULOS & HATZIRVASANIS 1988; BRINGSØE 1994). Of course, population size in such water bodies is much smaller than in Alpine lakes, however, it can be sufficient to allow reproduction and may consequently be a step towards the dispersion of newts, colonisation of new areas, and recolonisation after potential catastrophes.

Greek Alpine Newts have been assigned to the subspecies *T. alpestris veluchiensis* (WOLTERSTORFF 1905; ARANO & ARNTZEN 1987; BREUIL & PARENT 1988). However, morphologic (BREUIL & PARENT 1988; pers. obs.) and genetic (KYRIAKOPOULOU-SKLAVOUNOU et al. 1997) differentiation has been observed among the Greek populations suggesting that the situation is probably more complex. BREUIL & PARENT (1988) considered Smolikas populations to be different from the others. Smolikas and Tymphi populations are located in the Vikos-Aoos National Park. Conservation efforts should be made to protect the habitat of these probably endemic populations, which in this area exhibit colour (e. g., specimens with large black spots) and developmental (paedomorphs) variants.

Triturus vulgaris graecus
(WOLTERSTORFF, 1905)

Smooth Newts were found in only five sites, in hilly areas at the west border of the Tymphi and Mitsikeli mountains (table 1; fig. 5). The altitudinal distribution ranged from 480 m to 980 m (fig. 4). Smooth Newts inhabited reservoirs, watering basins and drinking troughs (fig. 2). Surface and maximum water depth of the aquatic sites ranged from a few square meters to 450 m^2 and from 0.2 to 2.5 m respectively. Only a few individuals were found at each station.

This is the first account on the presence of the Smooth Newt in the district of Ioannina. Both number of populations and population size observed were small. Population size was probably slightly underestimated given that Smooth Newt adults had almost finished breeding activities at the time of my visit and some of them left the water. BOUSBOURAS & IOANNIDIS (1997a) reported Smooth Newts to inhabit streams and cold waters. However, I found only frogs, toads and salamanders in running waters. Moreover, my observations show that Smooth Newts preferred the warmer sites in the district of Ioannina. The absence of the Smooth Newt from Alpine lakes is most probably due to its avoidance of cold high altitude environments (KUZMIN & ZUIDERWIJK 1997).

Triturus carnifex macedonicus
(KARAMAN, 1922)

Crested Newts have been found in 14 locations, in both mountainous and hilly areas of the district of Ioannina: Gramos, Smolikas, Tymphi and Mitsikeli, but also in the Upper Thiamis Valley (West of Tymphi and Mitsikeli) (table 1; fig. 5). Altitudinal distribution ranges from 480 m to 2140 m a.s.l. (fig. 4). *Triturus carnifex* inhabited mainly artificial habitats, i.e. reservoirs and watering basins. They were also found in drinking troughs, ponds and alpine lakes (fig. 2). Surface and maximum water depth of the aquatic sites ranged from 1 to 7,000 m² and from 0.2 to 3.7 m respectively. The largest populations were observed at two sites at the border of the Tymphi mountains: Kalivia and Monodendri.

Kalivia, Tymphi (site 30a); a 300 m² circular watering basin close to the road. It is surrounded by fences, preventing access to sheep which have to use a drinking trough just below. Crested Newt population was composed of at least 30 adults and 30 larvae. Green frogs, *N. natrix persa* and *Emys orbicularis hellenica* also frequented the site.

Monodendri, Tymphi (site 34; fig. 3c); a 300 m² circular watering basin close to the road. Aquatic vegetation is well developed (e.g. *Typha* sp.). The population of Crested Newts was composed of more than 50 adults and 500 larvae. There was also *Bombina variegata* in this site.

The finding of *T. carnifex* at 2,140 m elevation a.s.l. (site 18: Drakolimni of Smolikas) is to my knowledge, the highest record known so far. However, only two adult specimens were found in this lake, perhaps new colonizers. The closest populations were found about 10 km north-east of Drakolimni at Fourka (site 14). The subspecies *macedonicus* of the *T. carnifex* found in the south-western part of the Balkans has recently been resurrected (ARNTZEN & WALLIS 1999). It is considered to be an endangered taxon affected by habitat loss (BOUSBOURAS & IOANNIDIS 1997a; KALEZIC & DZUKIC 2001).

Bombina variegata scabra
(KÜSTER, 1843)

Yellow-bellied Toads are widespread in the district of Ioannina. Forty-five populations were found in all main mountain ranges and also in between them (table 1; fig. 5). Altitudinal distribution ranges from 500 to 2,100 m (fig. 4). Yellow-bellied Toads were present in all aquatic habitats of the district of Ioannina, with the exception of the large rivers and lakes. They were commonly observed in drinking trough, brooks and ponds, but also frequented watering basins, reservoirs, puddles, ditches and alpine lakes (fig. 2). Surface and maximum water depth of the aquatic site ranged from 0.6 to 25,000 m² and from 0.02 to 4.95 m respectively. However, in deep alpine lakes, Yellow-bellied Toads were restricted to shallow areas close to the shoreline. Most populations contained only a few adult indi-

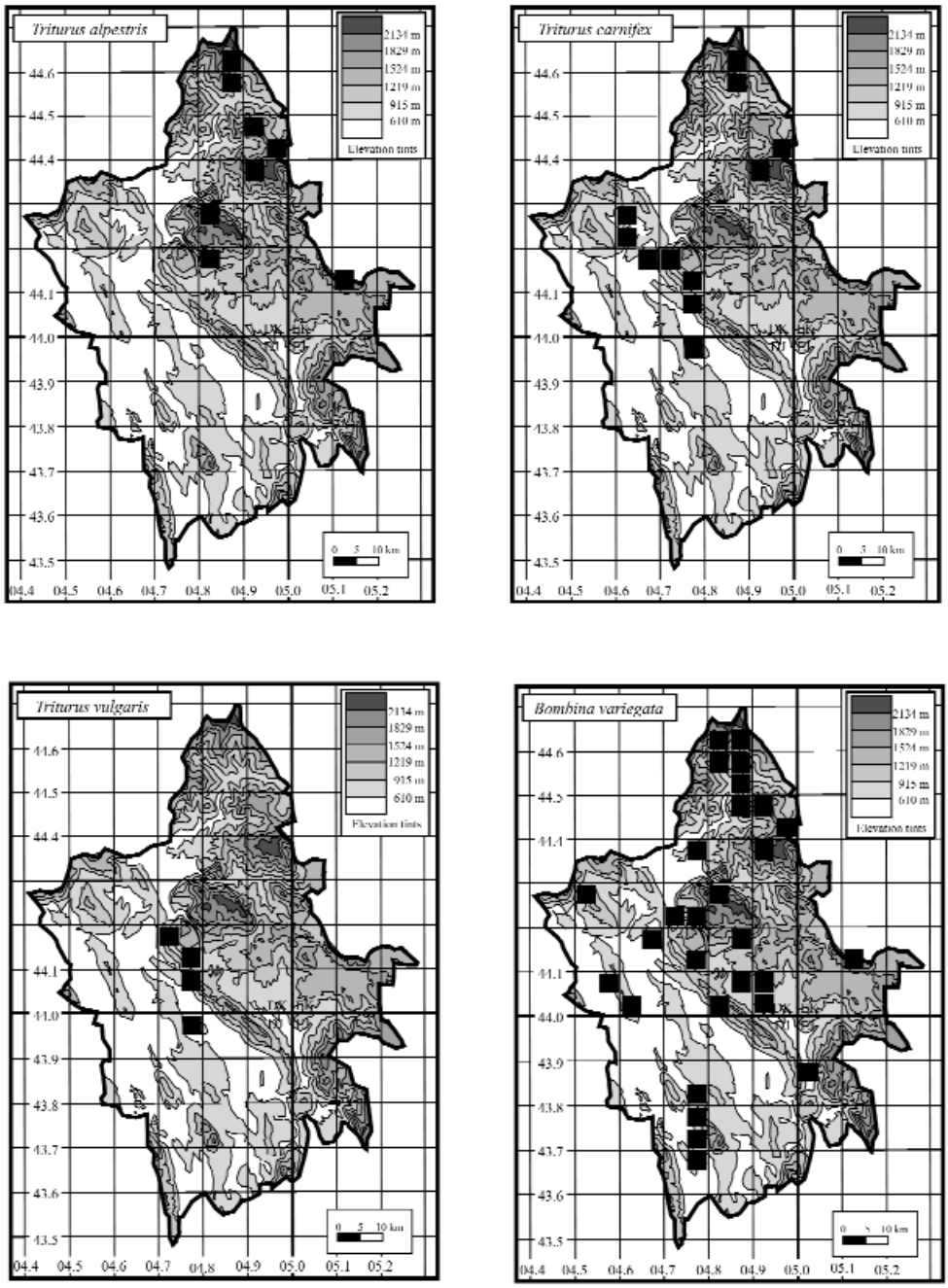

Fig. 5: Distribution map of newts and Yellow-bellied Toads in the district of Ioannina, Greece (UTM grid). A - *Triturus alpestris*; B - *Triturus carnifex*; C - *Triturus vulgaris*; D - *Bombina variegata*.

Abb. 5: Verbreitungskarten von Molchen und Gelbbauchunke im Bezirk Ioannina, Griechenland (UTM-Raster). A - *Triturus alpestris*; B - *Triturus carnifex*; C - *Triturus vulgaris*; D - *Bombina variegata.*

viduals, but also some juveniles and tadpoles.

The Yellow-bellied Toad is a rather opportunistic amphibian that colonized most of the available aquatic habitats not too low in elevation, just avoiding the bottom of large valleys. As an exception CRUCITTI & TRINGALI (1987) reported one individual found at low elevation (around 500 m) close to Konitsa. The observation of a population in Micrilimni lake in the Tymphi mountains (2,100 m) constitutes the maximum altitude known for this species, which is consistent with specifications presented in GOLLMANN et al. (1997). Contrary to newts, the Yellow-bellied Toad has been observed in running aquatic systems inhabited by fishes, crayfish and crabs. Because of the wide spectrum of colonized habitats and their large distribution across the district of Ioannina, Yellow-bellied Toads are not threatened immediately. However, number of individuals observed was usually small, making this animal a vulnerable subspecies.

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