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Historical and contemporary ranges of the spadefoot toads *Pelobates* spp. (Amphibia: Anura) in the Balkan Peninsula

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Abstract. We outline the historical and contemporary ranges of two spadefoot toad species (*Pelobates fuscus* and *P. syriacus*) in the Balkan Peninsula, including the adjacent area based upon published data and our own investigations, as well as from indirect paleogeographical and paleoecological data. We estimate that approximately 13% of the historical range of *P. fuscus* was lost during the last 100 years. The distribution range of *P. syriacus* in the Balkans is much larger than previously known, rather compact but disjunctive. The range of *P. fuscus* penetrates deeply into the Balkans, but has a rather fragmented distribution. The two species are sympatric along the lower course of the Danube, the western Black Sea coast and, further to the south, in the vicinity of the Bosphorus Strait. We refined the borders of the sympatry zone, especially in Serbia. We suggest that special conservation measures are required for the isolated populations of both species, remnants of a formally continuous distribution range.

Key words: species range, spadefoot toads, *Pelobates*, chorology, Balkan, paleogeography.

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I. INTRODUCTION

Two spadefoot toad (*Pelobates* spp.) species are encountered within the Balkans. The common spadefoot toad *Pelobates fuscus* (LAURENTI, 1768) has an extensive range, which covers most of the plains and hilly regions (up to 810 m) of central, eastern and southeastern Europe (NÖLLERT 1997; ZAVADIL et al. 1995; KUZMIN 1999). The present range of the eastern spadefoot toad (*Pelo-*

bates syriacus BOETTGER ,1889) is bounded by the Pannonian Plain and the Danube River area on the north, the Morava River valley on the west, the Mediterranean shoreline on the south, and Transcaucasia on the east (e.g. SOFIANIDOU 1997). The vertical distribution of this species ranges from sea level to 1,935 m (KUZMIN 1999). Almost no other amphibian species in Europe leads such a secretive life as the spadefoot toads (*Pelobates* spp.). Therefore, it is particularly difficult to find reliable indicators of their presence. They are strictly nocturnal outside the breeding season and hide during daylight in deep burrows. Their distribution is limited to areas with sandy soils, heath lands and deciduous woodlands with loamy soils, while the spawning biotopes include a variety of permanent or semi-permanent ponds. This causes their actual distribution to be discontinuous and patchy (e.g. NÖLLERT 1990). The spadefoot toads are highly specialized and have a narrow ecological niche that selects for lower levels of genetic diversity (SHPUN et al. 1993). The larval stage of spadefoot toads lasts longer than in other amphibians (2 to 4 months), and the larvae are larger than in any other European anurans (NÖLLERT 1997; KUZMIN 1999). A high level of fluctuation in population size, which can decrease to near-extinction, was observed, at least for *P. fuscus* (JEHLE et al. 1995). Not surprisingly, the spadefoot toads are considered to be declining in many parts of their range (JEHLE et al. 1995; NÖLLERT 1997; SOFIANIDOU 1997; EGGERT 2002).

The Balkans are of crucial importance for an understanding of the many poor known attributes (historical and current chorology, phylogeography, taxonomical diversity, conservation matters etc.) of spadefoot toads in Europe for several reasons. First, the southernmost portion of the range of *P. fuscus* and the northernmost portion of the range of *P. syriacus* are located in the Balkans and adjacent areas (NÖLLERT 1997; SOFIANIDOU 1997). Second, this peninsula is also the only region where these species occur in sympatry (e.g. FUHN 1960; DŽUKIĆ 1974). Third, the last post-glacial range expansion of *P. fuscus* into central and western Europe most probably started from this area (EGGERT et al. in prep.). It should be kept in mind that despite being rather widespread and having abundant populations locally, due to their secretive life-style spadefoot toads were described quite late in many countries in the area. Thus, *P. syriacus* was described from Macedonia only in 1928 (KARAMAN 1928), in Bulgaria in 1932 (MÜLLER 1932), in Romania in 1954 (BĂCESCU 1954) and in Greece in 1975 (BÖHME 1975).

In this paper, based upon published and unpublished distributional data completed with historic data inferred from distributional data and paleogeographical studies, we have outlined the historical and contemporary geographical ranges of the two spadefoot toad species in the Balkans, in an attempt to make out the potential migration routes, and identify populations that require with priority conservation measures.

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II. MATERIALS AND METHODS

A r e a s t u d i e d

In contrast to the Iberian and Apennine peninsulas, the Balkan Peninsula is not separated physically from the European mainland by mountain barriers and therefore communicates widely with the Central Europe. As a result, the northern and, especially, western boundaries of the Balkan Peninsula have never been demarcated precisely. Here we define the dividing line between the Alps and

Dinarides (Dinaric Alps) as the northwestern border of the Balkan Peninsula. Geographically the Balkan Peninsula can be characterized as a land of mountains and ravines. Lowland areas suitable for the spadefoot toads in terms of breeding sites and terrestrial habitats are restricted mainly on the northern and eastern parts. On the north, the flood plains of the Sava River and of the lower reach of the Danube River are lowland areas. Restricted lowlands expand southwardly into Balkan Peninsula, along the valleys of main tributaries of the Sava and Danube rivers and on the east along the Black Sea coast, including Thrace. We also included in our analysis the southern parts of the Pannonian plain, as well as northern Slovenia and southern Romania, to cover the entire area of sympatry.

Distribution data

The dataset of locations where spadefoot toads were recorded used in the present study consists of unpublished original records, as well as previously published data on spadefoot toad chorology within the Balkans and adjacent areas. Most records came from inventories based on the presence of tadpoles, juveniles or adults in aquatic or terrestrial habitats, including those taken from killed specimens encountered on roads. In a few cases, data came from the discovery of bone remains in ingluvia or in nests of birds of prey.

In the absence of direct chorological evidences, parts of presumably historical ranges were inferred from the position of the Neogene lakes remnants, which formed a system of huge marshes, which lasted until the middle of the last century in the Balkans (Serbia, Macedonia, Bulgaria). Essential for the presence of spadefoot toads, these basins were covered with sand and loess sediments. These areas were suitable for spadefoot toads, in terms of appropriate soils and breeding sites. Most of these lakes have been drained and transformed into agricultural land.

During 2001-2003 we have searched intensively for spadefoot toads along the whole historical range, except for Albania and Greece, especially in areas without incidence data but where spadefoot toads are likely to occur. Negative results of our attempts were taken as the evidence of toad's absence from these areas. The percentage of the *P. fuscus* range lost during the last 100 years was estimated from distribution maps using the Image Tool 3.00 software.

III. RESULTS

We recorded new localities of the common spadefoot toad during our inventory in the lowland area of central and eastern Serbia – the Great Morava River valley, the Drina River valley, and in the valley of South Morava, more to the south than previously noted (Fig. 1). In spite of extensive searches, we failed to confirm the presence of *P. fuscus* in lowland areas south of the South Morava up to Grdelica Canyon, although we found there a relict population of fire-bellied toads (*Bombina bombina*), a species with an almost identical range to *P. fuscus* (NÖLLERT 1997). We consider the Grdelica Canyon as the southernmost extent of the historical species' range in central Serbia. Another *P. fuscus* penetration into the central Balkans is along the Timok River, in the western part of the Wallachian-Pontic Basin (Fig. 1).

The easternmost range of the Italian common spadefoot toad (*P. fuscus insubricus*) penetrates in the Balkan Peninsula (Trieste area, Fig. 1). Common spadefoot toads vanished from this region since 1970's (LAPINI et al. 1999 and references therein), so the Balkan range of the Italian taxon can be considered as a historical one. In the western part of the Balkan Peninsula, three known records mention the town of Rijeka (MATISZ 1896; DEPOLI 1898) (Fig. 1). Due to considerable habitat alteration, especially breeding site destruction, this part of the species' range can also be considered as historical. The occurrence of *P. fuscus* in Croatia (northern Dalmatia) along the northern part of the eastern Adriatic coastal zone has been acknowledged a long ago, but without the precise location (GERMAR 1817; LEYDIG 1877; WERNER 1897). There is also much indirect evidence from paleogeographical, geological and paleoecological data for the possible presence of *P. fuscus* in the fa-

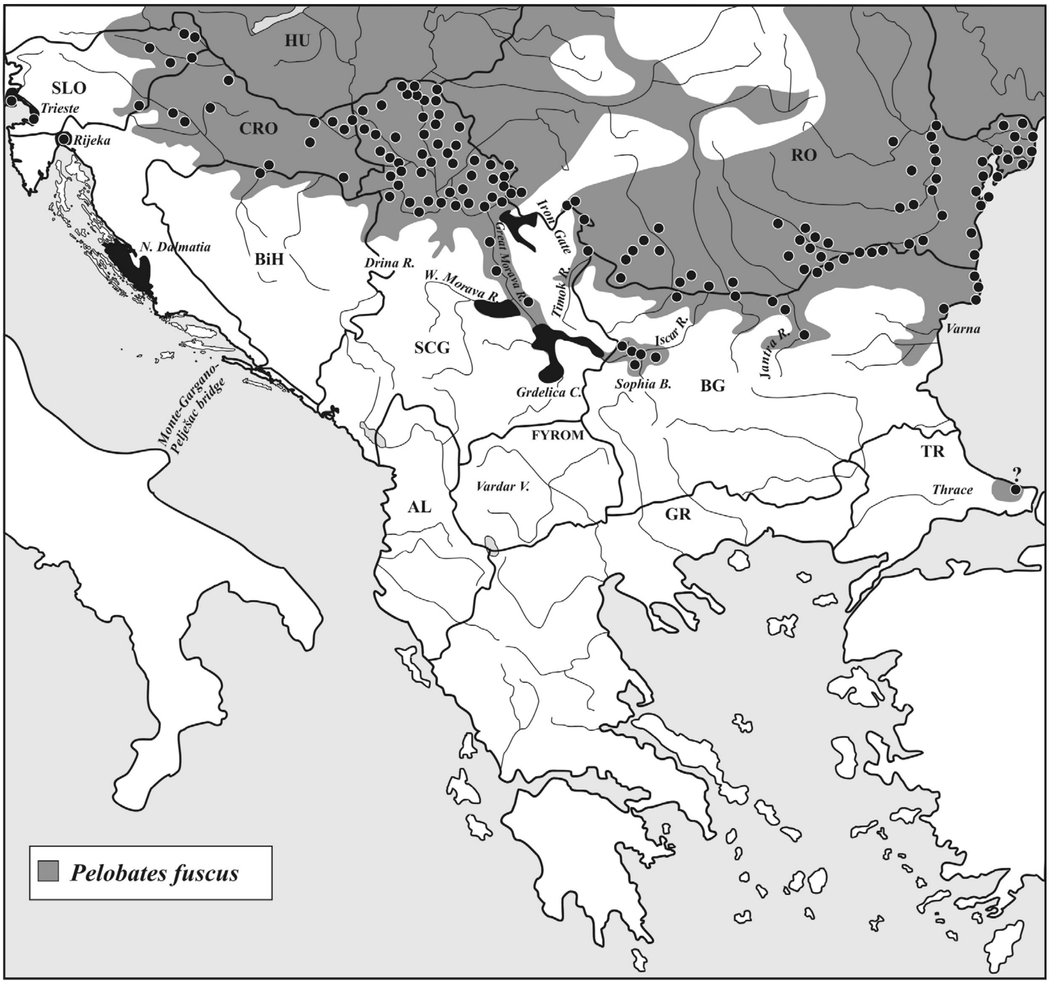

Fig. 1. The historical (in black) and present-day (in grey) ranges with the geographical distribution of *P. fuscus* on the Balkan Peninsula and adjacent areas. Location sites are presented by dots.

vourable habitats in this area (e.g. MEISSNER 1970; STEVANOVIĆ et al. 1992; ANDREONE et al. 1993; ADAMS & FAURE 1997). Therefore, we included the Northern Dalmatia in recent historical range of *P. fuscus*.

In Bulgaria and the part of southern Romania included in this study, the distribution records are mostly confined to the area along the Danube River and the Black Sea coast. The only significant penetrations into the Balkan continental mass are along the Jantra River valley, and the isolated populations in the Sophia Basin, at altitudes ranging between 506 - 680 m above sea level, the maximum elevation recorded in the Balkans (BEŠKOV & BERON 1964; BEŠKOV & NANEV 2002). Three of the known locations from this area are confined to the former bottom area of a previous lake, while two locations were recorded on higher terraces within the Sophia Basin.

A contemporary isolated population of *P. fuscus* has been discovered in Turkish Thrace, near the Bosphorus Strait (EISELT 1988), but this finding needs confirmation. This is by far the southernmost extent of the species' range (Fig. 1). Confounding the issue, however, is the fact that this site is 400 km from the nearest known *P. fuscus* population.

Overall, we estimated that during the last century the range of *P. fuscus* diminished with about 13% in the Western and Central Balkans. No estimation of range restriction could be done for Romania due to the scarcity of historical records. It was long considered a very rare species in Romania (KIRIȚESCU 1903; CĂLINESCU 1937; BĂCESCU 1941), and even later on FUHN (1960) listed only 43 known locations throughout the country, roughly 15% of the present-day known localities.

During our study new localities were also found for *P. syriacus*. According to available data, the range of *P. syriacus* in the Balkans is disjunctive (Fig. 2). Smaller areas of occurrence for *P. syriacus* within the Balkans include the south-easternmost portion of the Pannonian Plain, the narrow sandy lowland along the right descending bank of the Danube River and the Great Morava valley, including the lower zones of the Western Morava and Southern Morava drainages. Most likely, Grdelica Canyon on the south and the Danube's "Iron Gates" on the east demarcate the border between these two portions of the eastern spadefoot toad's range within the Balkans (Fig. 2).

The largest portion of the distribution range includes Greece, FYR Macedonia, eastern and southern Bulgaria, Turkish Thrace and Romania (Black Sea coastal area and along the Danube River). The lowlands of the north-eastern portion of Serbia (downstream the Danube's "Iron Gates"

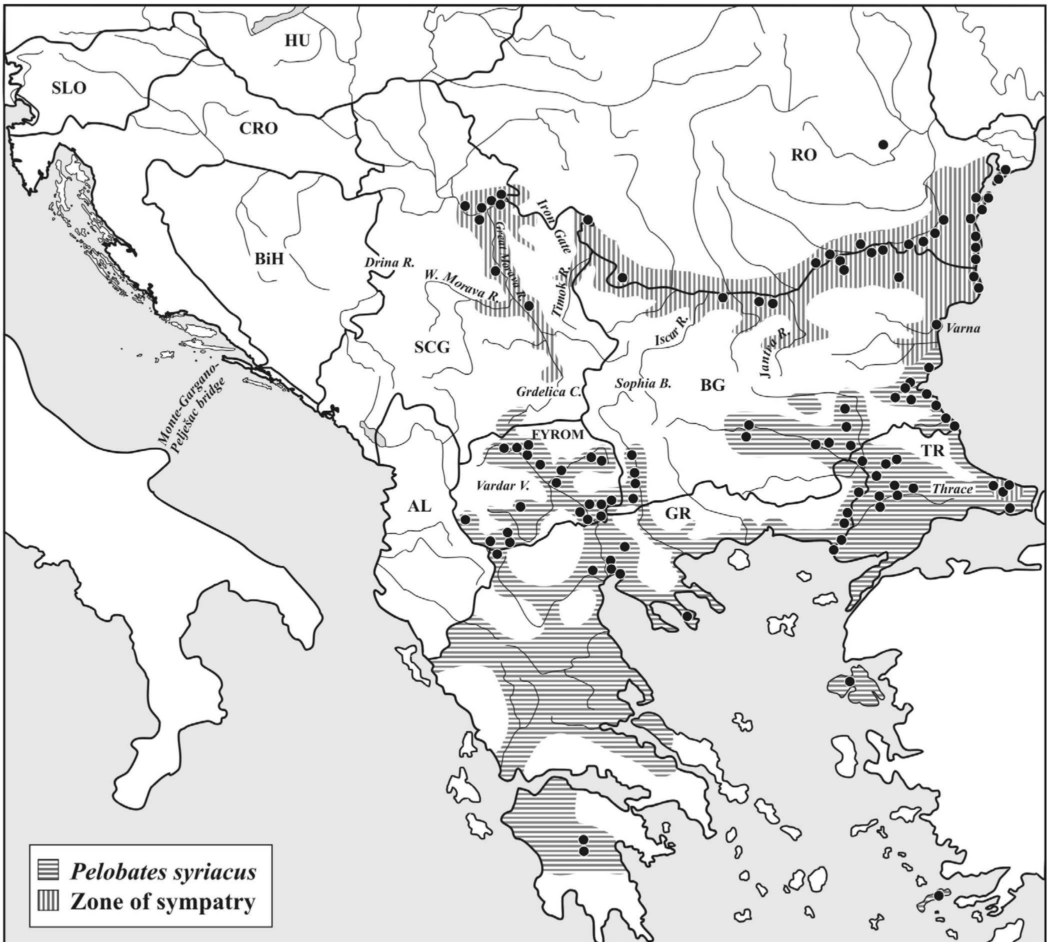

Fig. 2. Present-day ranges with the geographical distribution of *P. syriacus* on the Balkan Peninsula and adjacent areas, with the zones of sympatry with *P. fuscus.* Location sites are presented by dots.

area) and the Timok River valley can be added. A considerable part of the species range is in Greece (Fig. 2; range borders from SOFIANIDOU 1997). It was reported from about 150 aquatic biotopes within 40 regions all over the Greek mainland (SOFIANIDOU pers. comm.). However, we found only a few full location data from literature of which none related to historical locations, since its presence in Greece was reported only in 1975 by BÖHME. Thus we could not infer the relationship between historical and contemporary ranges for the eastern spadefoot toad in the Balkans.

The two spadefoot toad species were known to occur in sympatry along the lower course of the Danube, along the western coast of the Black Sea and, further to the south, in the vicinity of the Bosphorus Strait (DŽUKIĆ & PASULJEVIĆ 1983; EISELT 1988; COGĂLNICEANU 1991). Our recent findings enlarge the zone of sympatry to encompass the Great Morava valley area, including South Morava, as well as the northeastern portion of Serbia (Fig. 2). It is possible that an even larger area of sympatric expanding into the eastern and southern Serbia exists in spite of negative results of our searches for spadefoot toads in these areas.

IV. DISCUSSION

The results of the present study indicate that the distribution patterns of the two spadefoot toad species in the Balkan Peninsula are more complex than currently accepted. Thus we found a deep penetration of the range of *P. fuscus* into the Balkans, with a rather fragmented distribution, as well as a much larger distribution range than previously known of *P. syriacus*.

Contraction of geographical range is a common occurrence for many species today (e.g. CHANNEL & LOMOLINO 2000 a), and especially for amphibians (STUART et al. 2004). Apparently this is also the case with spadefoot toads in the Balkans where the current known area of distribution was much reduced. The range lost was most likely due to human-induced changes like habitat degradation (mostly due to drainage practices), use of pesticides and fertilizers, xerification and introduced species (mostly fishes) or pathogens as happened for many animal and plant species.

We suggest that in both spadefoot toad species range loss occurred mostly at the periphery of the historical range (for a general discussion see LESICA & ALLENDORF 1995; CHANNELL & LOMOLINO 2000 b). This happens since populations near the edge of the species' geographical range boundary are usually more prone to extinction due to small population size, low level of immigration and high genetic drift (e.g. HOFFMANN & BLOWS 1994). Besides the present report for the Balkans, considerable shrinkage of *P. fuscus* range occurred elsewhere also. Thus, in France only a small remnant population survives in the most western part of the species range, which has been depleted of the common spadefoot toad since the 19th century (EGGERT 2002). Contemporary populations from the Sophia plain and the northernmost populations from Romania, as well as historical populations from Trieste and Rijeka regions, can be considered as remnants which were originally at the edge of the historic range of *P. fuscus*, but are now located outside what is currently the contiguous species range. The question of whether southern populations of *P. fuscus* in Serbia are connected with those populations in the Sophia Basin, the main Bulgarian area with isolated *P. fuscus*, remains unanswered. We have indirect evidence, however, that this may have been the case, at least during the Neogene, when the system of oval-shaped hydrologically connected or isolated lakes extended from central Serbia to eastern Bulgaria (STEVANOVIĆ 1982). A second hypothesis that the common spadefoot toad populations in the Sophia Basin originated as the result of a connection with the conspecific populations from the lowland Danube region (via the Iskar River) is much less likely due to the presence of canyons which apparently act as significant geographic barriers.

The outlined Adriatic Coast part of the *P. fuscus* range could be only a remnant of a much larger area during the last glaciation period. Namely, the Adriatic Sea went through considerable changes during the Pliocene and Pleistocene, especially during the Würm glaciation (STEVANOVIĆ et al. 1992). The sea level was about 100 m lower than it is today, with its northernmost extent at what is now the vicinity of the Monte-Gargano-Pelješac bridge (see Fig. 1; FURON 1950; BOGNAR 1987:

VAN ANDEL & TZEDAKIS 1996). The recession of the sea created the possibility for the presence of alluvial and moraine plains with sand deposits, the preferred substrate for the spadefoot toad (MEISSNER 1970; ANDREONE et al. 1993), as well as breeding habitats (e.g. swamps and marshes along the rivers Po, Pro-Soča, Raša and Rječina) for the spadefoot toad in these areas.

The taxonomic significance of spadefoot toad populations from eastern Adriatic coastal area, i.e. whether they belong to the nominotypical subspecies or the Italian taxon (*P. f. insubricus*), is still a matter of debate. It seems prudent to consider the possibility of a connection between the main range of the Italian taxon and refugial portions of its range in the littoral zone of Croatia and Northern Dalmatia, at least until the beginning of the twentieth century. The hypothesis that spadefoot toads from these areas belong to the nominotypical subspecies is less likely zoogeographically due to significant barriers along the two rivers which confine the subspecies ranges to lowlands in Slovenia and Croatia.

The common spadefoot toad populations from the central part of Europe originated as the result of colonisation from the southern refugia which probably took place after the last glaciations (Upper Dryas), as suggested by the high mitochondrial cytochrome b gene diversity found in southern refugial areas versus the uniformity found in Central and Western European populations (EGGERT et al. in prep.). Also, the Balkan samples of *P. fuscus* belong to the so-called western type of *P. f. fuscus*, which was identified both by DNA flow cytometry and by allozyme data in Eastern Europe (BORKIN et al. 2001). A less likely hypothesis is that the contemporary Balkan populations of this species are newcomers from Central Europe rather than being descendents of ancient pre-Pleistocene populations.

Fragmentation of the previously more or less contiguous eastern spadefoot range within the Balkans probably occurred during the Pleistocene climatic changes. *Pelobates syriacus* survived in the Balkans in a few restricted refugial zones presumably corresponding to the two continuous present-day parts. A morphometrical study of *P. syriacus* populations from the Balkans and Anatolia suggested that populations from Serbia are a distinct taxon (UGURTAS et al. 2002). However, the levels of differentiation between specimens from these two disjunctive areas still remain to be investigated genetically. Dispersal can only happen along two possible corridors, the Morava-Vardar valleys and along the Danube, through which only a low gene flow might occur (see Fig. 2). In contrast to *P. fuscus*, isolated populations of *P. syriacus*, which persist outside what is now a contiguous range, do not exist in the Balkan Peninsula, except for a northernmost isolated population in Balta Albă, Romania (Fig. 2). It is possible that there are more isolated populations surviving in the area, but the intensive agriculture practices and accelerated aridisation of the area have severely diminished available reproductive sites and probability of survival (COGĂLNICEANU & VENCZEL 1993).

A great deal of effort and resources should be spent protecting the isolated peripheral populations, remnants of a formally continuous distribution range, because of their potential for evolutionary change (CRANDALL et al. 2000). The Balkans are the area of greatest conservation concern for spadefoot toads, especially the Sophia Basin (with its relict *P. fuscus* populations), but also the isolated population in Turkish Thrace and other populations, which penetrated deeply into Balkan territory. As species often persist at the edge of their historical distributions (CHANNELL & LOMOLINO 2001 b), the importance of the Balkans spadedefoot toad populations for conservation is undisputable.

REFERENCES

ADAMS J. M., FAURE H. (eds) 1997. QEN members. Review and Atlas of Palaeovegetation: Preliminary land ecosystem maps of the world since the Last Glacial Maximum. Oak Ridge National Laboratory, TN, USA.

ANDREONE F., FORTINA R., CHIMINELLO A. 1993. Natural history, ecology and conservation of the Italian spadefoot toad, *Pelobates fuscus insubricus*. Societa Zoologica La Torbiera (eds), Novara.

BĂCESCU M. 1941. Sur la présence de *Vipera ursinii ursinii* Bonap. en Moldavie et quelques observations sur la biologie de *Pelobates fuscus* Laur. en Roumanie. *Comptes Rendus de l'Académie des Sciences Roumaine*, **5**: 63-69.

BĂCESCU M. 1954. [*Pelobates syriacus balcanicus* KARAMAN, a new frog for the fauna of Romania]. *Comunicările Academiei R.P.R.*, **4**: 483-490. (In Romanian).

BEŠKOV V., BERON P. 1964. Catalogue et Bibliographie des Amphibiens et des Reptiles en Bulgarie. Académie Bulgaire des Sciences, BAN, Sofija.

BEŠKOV V., NANEV N. 2002. [Amphibians and Reptiles of Bulgaria] Sofia-Moskva: Pensoft. (In Bulgarian).

BOGNAR A. 1987. [Relief and geomorphological characteristics of Yugoslavia]. [In:] I. BERIĆ (ed.) – Great Geographical Atlas of Yugoslavia. S.N. Liber, Zagreb. Pp. 12-22. (In Croatian).

BÖHME W. 1975. Zum Vorkommen von *Pelobates syriacus* BOETTGER 1889 in Griechenland (Amphibia: Pelobatidae). *Senckenbergiana Biologica*, Frankfurt a. Main, **56**: 199-201.

BORKIN L. J., LITVINCHUK S. N., ROSSANOV J. M., MILTO K. D. 2001. Cryptic speciation in *Pelobates fuscus* (Anura, Pelobatidae): evidence from DNA flow cytometry. *Amphibia-Reptilia*, **22**: 387-396.

CĂLINESCU R. 1937. [New geographic data on the distribution of *Pelobates fuscus* LAUR. in Romania]. *Buletinul Societății Naturaliştilor din România*, **11**: 21. (In Romanian).

CHANNELL R., LOMOLINO M. L. 2000a. Trajectories to extinction: spatial dynamics of the contraction of geographical ranges. *Journal of Biogeography*, **27**: 169-179.

CHANNELL R., LOMOLINO M. V. 2000b. Dynamic biogeography and conservation of endangered species. *Nature*, **403**: 84-86.

COGĂLNICEANU D. 1991. A preliminary report on the geographical distribution of Amphibians in Romania. *Revue Roumaine Biologie - Biologie Animale*, **36**: 39-50.

COGĂLNICEANU D., VENCZEL M. 1993. [Considerations regarding the present status of amphibians and reptiles in Romania]. *Ocrotirea naturii şi a mediului înconjurător*, **37**: 109-114. (In Romanian).

CRANDALL K. A. 2000. Considering evolutionary processes in conservation biology. *Trends in Ecology and Evolution*, **15**: 290-295.

DEPOLI G. 1898. I Rettili e gli Anfibi del territorio di Trieste. *Rivista Italiana di Scienze Naturali* (Siena), **18**: 47-50.

DŽUKIĆ G. 1974. [Contribution to herpetology of Serbia]. *Glasnik Prirodnjačkog muzeja*, Ser. B., **29**: 105-110. (In Serbian with English summary).

DŽUKIĆ G., PASULJEVIĆ G. 1983. [On chorological demarcation of the species *Pelobates fuscus* (LAURENTI, 1768) and *Pelobates syriacus* BOETTGER, 1889 (Amphibia, Pelobatidae) in Yugoslavia]. Zbornik II Simpozijum faune Srbije. Pp. 139-142. (In Serbian with English summary).

EGGERT C. 2002. Le déclin du pélobate brun (*Pelobates fuscus*, Amphibien Anoure): de la biologie des populations à la structuration génétique. *Bulletin de la Société Zoologique de France*, **127**: 273-279.

EISELT J. 1988. Krötenfrösche (*Pelobates* gen., Amphibia Salientia) in Turkisch-Thrakien und Griechenland. *Annalen des Naturhistorischen Museums in Wien*, **90**: 51-59.

FUHN I. 1960. Amphibia. Fauna Republicii Populare Romine.Vol. 14. Academia Republicii Populare Romîne, Bucharest.

FURON R. 1950. Les grandes lignes de la paléogéographie de la Méditerranée (tertiaire et quaternaire). *Vie et Milieu*, **1**: 131-162.

GERMAR E. F. 1817. Reise nach Dalmatien und in das Gebiet von Ragusa. Leipzig & Altenburg: Brockhaus.

HOFFMANN A. A., BLOWS M. W. 1994. Species borders: ecological and evolutionary perspectives. *Trends in Ecology and Evolution*, **9**: 223-227.

JEHLE R., HÖDL W. ,THONKE A. 1995. Structure and dynamics of central European amphibian populations: a comparison between *Triturus dobrogicus* (Amphibia, Urodela) and *Pelobates fuscus* (Amphibia, Anura). *Australian Journal of Ecology*, **20**: 362-366.

KARAMAN S. L. 1928. [III Contribution to herpetology of Yugoslavia]. *Bulletin de la Société Scientifique de Skopje* **4,** Section des Sciences Naturelles, **1**: 129-143. (In Serbian).

KIRIȚESCU C. 1903. Contributions à la faune des batraciens de Roumanie. *Bulletin de la Société Sciences Bucarest*, **12**: 243-265.

KUZMIN S. L. 1999. The Amphibians of the Former Soviet Union. Sofia: Pensoft.

LAPINI L., DELL'ASTA A., BRESSI N., DOLCE S., PELLARINI P. 1999. Atlante Corologico degli Anfibi e dei Rettili del Friuli-Venezia Giulia. Comune di Udine, Pubblicazione N. 43, Udine.

LEYDIG F. 1877. Die Anuren Batrachier der Deutschen Fauna. Max Cohen & Sohn (eds), Bonn.

LESICA P., ALLENDORF F. W. 1995. When are peripheral populations valuable for conservation? *Conservation Biology*, **9**: 753-760.

MATISZ J. 1896. [Living world of the karst slopes and seaside]. [In:] Hungarian Districts and Cities (Encyclopedia), Fiume and Hungaro-Croatian Seaside. Apolo, Budapest. Pp. 401-419. (In Hungarian).

MEISSNER K. 1970. Obligatorisches Lernen im Funktionskreis der Vergrabehandlung von *Pelobates fuscus fuscus* LAUR. (Anura). Ein Beitrag zur Ethometrie des Appetenzverhaltens. *Zoologische Jahrbucher Physiologie*, **75**: 423-469.

MÜLLER L. 1932. Beiträge zur Herpetologie der südosteuropäischen Halbinsel. 1. Herpetologisch Neues aus Bulgarien. *Zoologischer Anzeiger*, **100**: 299-309.

NÖLLERT A. 1990. Die Knoblauchkröte. Wittenberg Lutherstadt: Die Neue Brehm-Bücherei, Ziemsen Verlag.

NÖLLERT A. 1997. *Pelobates fuscus* (LAURENTI, 1768). [In:] J.-P. GASC et al. (eds) – Atlas of Amphibians and Reptiles in Europe. Paris: Societas Europae Herpetologica, Museum National d'Histoire Naturelle. Pp. 110-111.

SHPUN S., HOFFMAN J., NEVO E., KATZ U. 1993. Is the distribution of *Pelobates syriacus* related to its limited osmoregulatory capacity? *Comparative Biochemistry and Physiology*, **105A**: 135-139.

SOFIANIDOU T. S. 1997. *Pelobates syriacus* BOETTGER, 1889. [In:] J.-P. GASC et al. (eds) – Atlas of Amphibians and Reptiles in Europe. Paris: Societas Europae Herpetologica, Museum National d'Histoire Naturelle. Pp. 112-113.

STEVANOVIĆ P. 1982. [Historical Geology. Cenozoic]. Beograd: Univerzitet u Beogradu. (In Serbian).

STEVANOVIĆ P., MAROVIĆ M., DIMITRIJEVIĆ V. 1992. [Geology of Quaternary]. Beograd: Naučna knjiga. (In Serbian).

STUART S. N., CHANSON J. S., COX N. A., YOUNG B. E., RODRIGUES A., FISCHMAN D. L., WALLER R. W. 2004. Status and trends of amphibian declines and extinctions worldwide. *Science*, **306**: 1783-1786.

UGURTAS I., LJUBISAVLJEVIĆ K., SIDOROVSKA V., KALEZIĆ M. L., DŽUKIĆ G. 2002. Morphological differentiation of the eastern spadefoot toad (*Pelobates syriacus*) populations. *Israel Journal of Zoology*, **48**: 13-32.

VAN ANDEL T. H., TZEDAKIS P. C. 1996. Palaeolithic landscapes of Europe and environs, 150,000-25,000 years ago: an overview. *Quaternary Science Reviews*, **15**: 481-500.

WERNER F. 1897. Die Reptilien und Amphibien Oesterreich-Ungarns und der Occupationsländer. Wien: A. Pichler's Witwe & Sohn.

ZAVADIL V., ROZINEK R., ROZINEK K., NECAS P. 1995. Extrem hochgelegene Vorkommen der Knoblauchkröte, *Pelobates fuscus* (LAURENTI, 1768), in der Tschechischer Republik (Anura: Pelobatidae). *Herpetozoa*, **8**: 43- 47.