The dice snake is an evolutionary very successful snake, one of the few snake species that colonized three continents, ranging from Switzerland and Germany in central Europe to Egypt in Africa, and as far east as Xinjiang province in China. It has conquered a huge variety of habitats, from oases in deserts of Jordan, Syria and Iran, to marine habitats in the Mediterranean and Black Sea, from below sea level in the Caspian Sea to mountainous valleys as high as 2800 m, and from remote sites in the steppes of central Asia to thriving populations in busy cities such as Prague and Bucharest. Yet, the knowledge of this piscivorous and very prolific semi-aquatic snake is relatively marginal. This volume of the Mertensiella series represents the status quo of knowledge about the biology, distribution, and conservation of this versatile snake species by compiling a total of 57 articles and one DVD, involving more than 122 co-/authors, with contributions from more than 22 countries, while touching 14 additional countries in summary articles. The compendium is lavishly pictured to give you a good impression of the diversity of habitats and snakes from many countries.

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The Dice Snake, *Natrix tessellata:*
Biology, Distribution and Conservation of a Palaearctic Species

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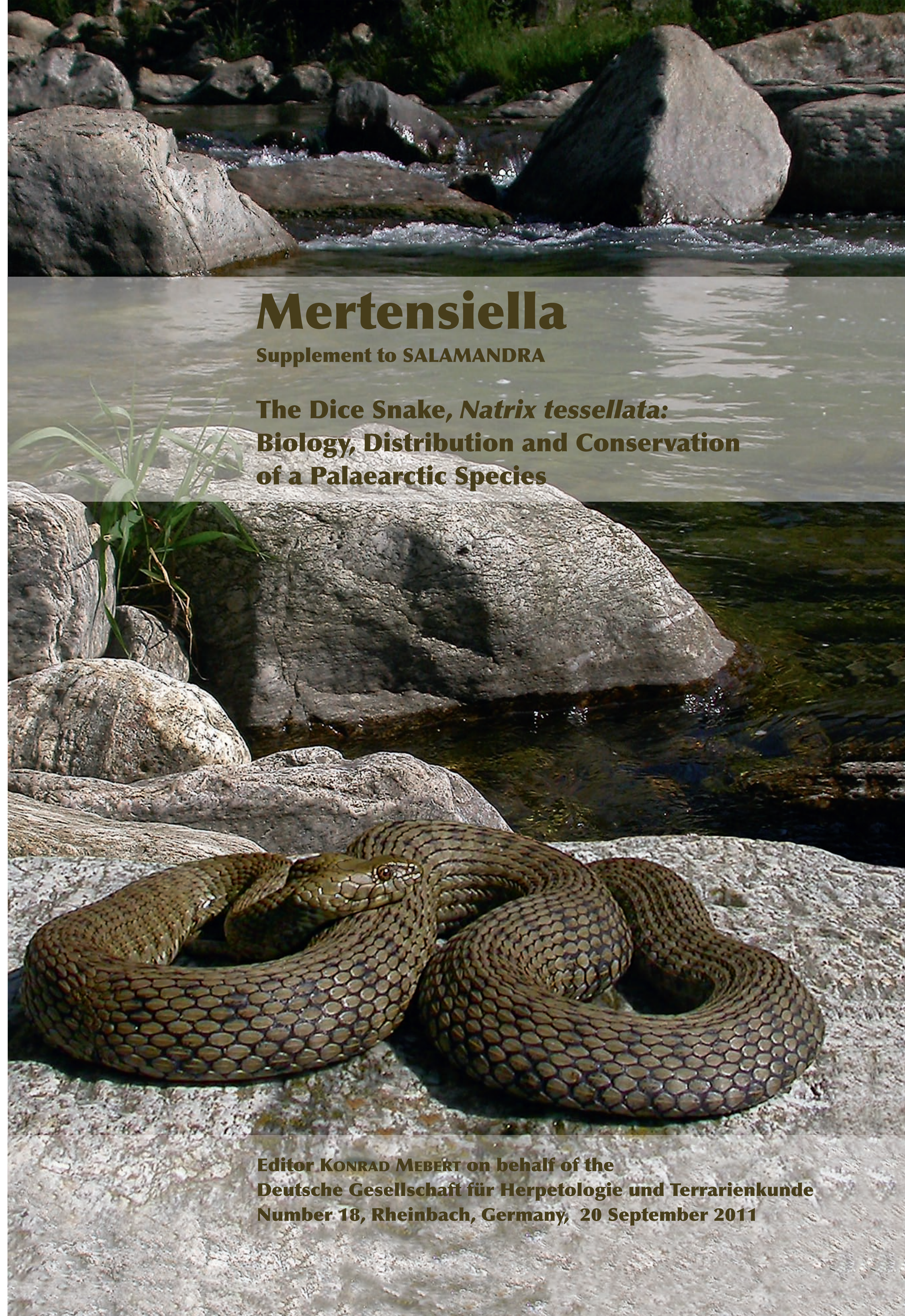

Mertensiella

Supplement to SALAMANDRA

The Dice Snake, *Natrix tessellata:* Biology, Distribution and Conservation of a Palaearctic Species

Editor Konrad Mebert on behalf of the
Deutsche Gesellschaft für Herpetologie und Terrarienkunde
Number 18, Rheinbach, Germany, 20 September 2011

MERTENSIELLA

The Dice Snake, *Natrix tessellata*: Biology, Distribution and Conservation of a Palaearctic Species

Editor

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Photo front cover:
A heavily gravid dice snake at its uppermost location at 800 m a.s.l. in the Leventina Valley, Ticino, Switzerland. Photo: Konrad Mebert

Photos back cover:
Left below – a dice snake (*Natrix tessellata*) that swallowed a common frog (*Rana temporaria*) with only its hands still sticking out, Maggia Valley, Ticino, Switzerland. Photo: Konrad Mebert
Right above – a dice snake captured a minnow in Lake Cornino, northeastern Italy. Photo: Wolfgang Pölzer
Right below – a dice snake passing dripping water, Sava River, Slovenia. Photo: Miha Krofel

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Preface

Had I known, what it takes to produce and edit such a voluminous compendium about a single reptile species, I would probably never put myself on this strenuous path. With more than 3000 hours of my personal time, and not counting those of other participants, the task was monumental. The result speaks for itself with a total of 57 articles and one DVD, involving more than 122 co-/authors, with contributions from more than 22 countries, while touching 14 additional countries in summary articles. To elucidate the production of such a cross-border endeavour and for reasons of my personal laborious involvement into compiling this book, I opted to incorporate also personal accounts into the evolution of this Mertensiella volume 18, besides the usual aspects of history, content, and format.

The Beginning

From 2005 on I was asked several times by a representative of the German Herpetological Society DGHT (Deutsche Gesellschaft für Herpetologie und Terrarienkunde) whether I would head the production and edit a Mertensiella volume (a book series with each volume loosely treating a particular herpetological topic) about the dice snake, *N. tessellata*. For two years, I resisted these requests, as I feared an excessive amount of private work and insufficient voluntary authors to contribute articles. Indeed, I was aware of only little contemporary research on *Natrix tessellata* at that time. Yet, I knew, from my personal research with this species, I had folders and drawers full with data that awaited its publication for more than a decade. After renewed requests by the DGHT, I conceded some interest. But as mentioned above, my fear about the comprehensiveness and work load such a project requires was justified. It maybe comes at no surprise that during the four years of producing this volume at least 16 children were born to authors in this Mertensiella. Darwin wishes them all a happy welcome.

It was not until late 2007, that I seriously considered this editorial task. Weeks before the annual DGHT meeting in October in Hallein, Austria, I briefly did a search to see, whether there are sufficient potential contributions for such a volume, setting the goal to incorporate at least 20 articles. To my surprise, this goal was quickly achieved up to the meeting and I subsequently agreed to proceed with this project. To my second surprise, the number of contributions has tripled half a year later, accumulating to more than 100 co-authors on the mailing list. Since the amount of potential contributions exceeded my initial expectations by far, I asked to partition the articles into two volumes for a speedier release of a first volume. Even though, that idea did not materialize, and hence, required the increased amount of time for the release of the now single volume, the waiting for this Mertensiella about the dice snake was hopefully worth the patience. It is not a full monography, as some important aspects such as experimental behavioral studies or inner anatomy are missing [for interesting articles about morphological aspects see the histological investigation about the venom apparatus in the dice snake (Gygax 1968, 1971) and the skin sensory organs by Walztöhny & Ziswiler (1979)]. However, this volume represents the status quo of knowledge about this versatile, semi-aquatic snake species.

It was in the early 1990s, when I first worked with the dice snake, researching morphological aspects for my Master thesis at the University of Zürich, Switzerland (Mebert 1993, and related articles on pages 11, 71, and 94. A couple of years later, M. Gruschwitz, S. Lenz, V. Lanka and me produced a large contribution (> 60 pages, Gruschwitz et al. 1999) about the dice snake in the Handbuch series by W. Böhme. In this monographic review, it was my personal goal to incorporate all available literature about the dice snake, even translating it from different languages. Although I did not get access to all pertinent references, in particular missing various articles from the period and geography referring to the former Soviet Union, the text was and remained up to this Mertensiella the most comprehensive about *N. tessellata*.

Already during the 90s, I wondered, why a snake species with such an extensive Palaearctic distribution and locally high abundance didn't receive more attention. Indeed, the dice snake is one of the few snake species that naturally occurs on three continents, including Europe, Asia, and Africa. In latter case, it ranges at least for a few hundred kilometers into Egypt (Baha El Din p. 401), but possibly being in the process of expanding farther south along the Nile River towards Sudan. The others snake species sharing the three-continent distribution are *N. natrix, Malpolon (insignitus) monspessulanus, Macroprotodon cucullatus,* and *Eryx jaculus*. The reasons for the lack of attention to *N. tessellata* in most of the last century probably relates to its missing in countries of Western and Middle Europe with a long tradition of natural science, in particular France, Great Britain, the Benelux countries, and Scandinavia, where instead the grass snake, *N. natrix*, and the adder, *Vipera berus*, are/were common species and easy to study. The distribution of the dice snake in Austria, Germany and Switzerland, other countries with a long history of natural science, is relatively reduced with only peripheral or a few small, isolated populations, whereas in Italy, yet another country with a great herpetological emphasis, the ecological research on dice snake occurred only in the last decade of the 20th Century with studies concentrated around L. Luiselli (see p. 147 for a review by Capula et al.). But I presume that this lack is not going to persist. Then, with the fall of the Iron Curtain, Eastern and Western European countries increasingly promote exchange and homogenization of intercultural and scientific affairs, a trend affecting also like-minded herpetologists. As a consequence, I expect a higher rate of studies and publications about the dice snake in the future to come. Already the large scale research by international teams at Histria, Romania (Carlsson et al. p. 237, Kärvemo et al. p. 245), and Golem Grad, FYR Macedonia (Sterijovski et al. p. 298), are signs of this "spring" in international research collaborations.

Goals

The principal goal for this Mertensiella about *N. tessellata* evolved from originally containing a collection of articles about the dice snake with a focus on middle Europe to finally representing the status quo of knowledge of this species across its huge range. In accordance with its large distribution, there is probably no other snake species that lives in the neighborhood of so many diverse landscapes and influential historic societies at the same time. For example, it occurs in the sight of mediaeval towns and lowland riparian lands in Germany, Austria, and Czech Republic, south to steep mountain river valleys in the Swiss and Italian Alps, to the ancient Colosseum in Rome and the Acropolis in Athens, the pyramids of Giza in Egypt, the ancient cities and ruins of Ephesos, Petra, Palmyra, and Persepolis in Turkey, Jordan, Syria, and Iran, respectively, to the rivers in the steppes of Russia, Ukraine, and Kazakhstan, to the Basra Swamps in Iraq, to coastal areas of the Mediterranean, Black, and Caspian seas, to valleys and plateaus in mountains of the Caucasus, the Hindu Kush and Pamir in Afghanistan, and it expanded as far east in Asia as to experience oriental influences in north-western China, even inhabiting the fringes around the Tarim desert.

A second goal was to edit and format the articles to become "easy" to read, so they could be understood globally by most interested in biology and reptiles. Hence, English became the preferred text language due to its international access and ease to understand. Consequently, I helped in the compilation of English written articles, where this became suitable. Only three articles were left in the German language, a concession to the predominantly German membership of the DGHT that supported this project.

Editorial and Review Process, Co-authorships

Besides writing in English, which is a foreign language for most authors in this volume, there were several problems that arose from an international and "intercultural" project of this scope. For example, many valuable references are written in languages "foreign" to the respective authors, including German, containing many relevant publications (historic and recent) about the dice snake. Furthermore, many "older" articles are difficult to access in remote libraries or are chapters in a book, that is expensive or not on the market anymore. To reduce that problem, I acquired the permission from the "Aula Verlag" (publishing house) to disseminate the monographic chapter about *N. tessellata* from the "Handbuch der Reptilien und Amphibien Europas" (Gruschwitz et al. 1999). Even though the Handbuch-text is in German, free translation programs are available online, and so the text could serve as a relevant tool to compare the information in each contribution with already existing ones.

Possibly due to great heterogeneity of subject-related knowledge, insufficient time for a volume without impact factor, and variable English skills among authors and reviewers, the review process itself quickly became unsatisfactory. Nontheless, my desire was to homogenize the texts into "legible" English and to have incorporated up-to-date literature related to the dice snake and various topics in the volume. These aspiring goals resulted in my frequent involvment as a principal reviewer, as I could benefit from a particularly large collection and readings on related literature accumulated over two decades in this field, and from decent English skills (after having spent 9 years in the USA) and analytical writing.

Even though, there were some discussions about the required quality, scope, and comprehensiveness of the articles, in which not all authors agreed to my challenging propositions, I finally had to stand behind this volume. Hence, I asked everyone to invest their time to get the best out of their contributions, in terms of content, English, structure, quality of illustrations, and sound interpretation of their results. I regarded it as very important, that texts are sound and generally understandable, that the messages in images and graphs are evident. One should be able to follow the information without having to consult technical books, dictionaries, or detailed maps. Consequently, a number of authors preferred that I get involved directly as a co-author to incorporate pertinent information from my own data on more than 1000 specimens of this species and from my studies on related American Natricines (Mebert 2010), to complement missing geographic data, rework graphs, utilize my literature collection, and finally to reword and structure many parts in the texts. Ultimately, the comprehensive effort and work devoted to the co-authored articles, in addition to the countless hours put into the other articles, has required an extraordinary use of private time over four years, but ultimately has added in harmonizing at least partially among the extremely heterogeneous forms of the originally submitted articles. As a result, I hope the information put together in this Mertensiella is satisfactory to a large potential readership.

As this volume should represent the status quo of knowledge on *N. tessellata*, we rather worked hard to include as many articles as possible than just to reject them. Hence, based on an early list of putative contributions, only three submissions were reviewed/rejected and never made it into a revised version, including articles from Albania, Russia, and Moldova. Three other articles went through the first review process, but were finally withdrawn by the authors for various reasons, including articles from Romania, Israel, and Armenia. Another 15–20 potential articles were initially suggested, but ultimately were never submitted in a written form, including suggested titles from Slovakia, Lebanon, Greece, Iran, Kazakhstan, Hungary, Romania, Serbia, Montenegro, Austria, and the Czech Republic. All these putative articles may still be published sometime in the future in other books or journals. Besides the initial three, more global articles, the content is structured in a geographic mode, as the sequence of the principal articles roughly follows in a north-to-south direction, beginnig with articles in the West (central Europe) and ending in the East (China). The prinicpal articles are followed by the short Photo Notes and a brief introductory text to the DVD.

Format

We formatted most of the articles to be independent from other articles in this volume, so they could be distributed electronically as PDFs, respectively as "standalone" papers. Consequently, cross referencing to other articles in this Mertensiella was not indicated as "this volume" in the literature list, but was noted as in a regular journal by using author names and year in the text, and the full citation format in the literature list. For similar reasons, we left some general, repetitive information among the articles. I decided also to focus on content and sound explanation of issues in the articles, and be relatively tolerant on inconsistencies in grammar and formats within and among articles. For example, it would take an excessive and inappropriate amount of time to research and harmonize all the language-related different naming of persons and locations, as well as corresponding rules that originate from such a multitude of cultures as can be found in this Mertensiella.

With "Photo Notes" a new style of articles was incorporated. These short articles use photographs concerning various aspects of *N. tessellata* followed by a brief text (kind of an extended legend). Such a document contains one picture or a set of pictures, rendering information and observations that do not normally find entry into a standard article, but are considered worthy to be published.

With this volume of the Mertensiella series, a change of its physical size from a smaller format to a DIN A4 format was selected for a number of reasons. First, the Mertensiella series is a supplement to the "Salamandra", the herpetological science-journal of the DGHT published in English with an international focus. This and the "Elaphe", the society's internal and German-written journal, are published in DIN A4 format. Hence, the new Mertensiella format is in line with the other principal publications of the DGHT. Second, the A4 format allows for more flexibility and larger figures. And third, it reduces the thickness (page number) of an already large volume.

Content

Several contributions reflect rudimentary studies in terms of methods, temporal duration and number of individual snakes included. Some studies have been executed as "short" projects, ill-financed and without direct academic support. Some projects were financed by local authorities. They may lack long-term data or do not represent a multi-year investigation, as is often desired for a comprehensive understanding on a species- or population-level. Consequently, there are fewer conclusions that can be drawn. However, the overall data gathered still merit their publication, as the sum of smaller studies may still lead to a larger understanding. The articles may also serve as a platform or stepping stone for subsequent studies.

The contents in this Mertensiella are very variable. A few contributions deal with the genetic and morphological variation across large areas of its vast distribution, e.g. phylogeography by Guicking & Joger (p. 1), or geographic variation and sexual dimorphism of external morphological characters by Mebert (p. 11, p. 94). That significant morphological geographic variation exists across even relatively short distances of 40 to 100 km and can help to identify the origin of introduced dice snakes was exemplified by Mebert (p. 71). Furthermore, he elaborates the high frequency of scale abnormalities in introduced dice snakes, and relates deformed ventral scales to fused vertebrae. This and the occurrence of exceptionally short (in body segments) dice snakes is viewed in the context of inbreeding in introduced populations, as the few specimens that started the population constituted a severe bottleneck. Brecko et al. (p. 20) found significantly narrower and more streamlined heads in dice snakes from populations that consumed fish than in dice snakes those with frogs in their stomachs, suggesting a phenotypically plastic response to the local abundance of prey types.

Some basic articles provide first or updated national accounts on the geographic distribution, conservation status, and observations on habitat and other ecological aspects of *N. tessellata*, e.g. for Croatia (Jelić & Lelo p. 217), Romania (Strugariu et al. p. 272), Egypt (Baha el Din p. 401), Jordan (Amr et al. p. 393), and with the inclusion of some morphological data also for Bulgaria (Naumov et al. p. 288), Iran (Rajabizadeh et al. p. 414), and China (Liu et al. p. 430). Other articles deal with similar topics on a more regional level, e.g. Dínçaslan et al. (p. 370), for western Turkey, who included also information on geographic variation of blood serum proteins, Ahmadzadeh et al. (p. 403) for the south-eastern coast of the Caspian Sea in Iran, including also data on reproduction and population characteristics, and Smole–Wiener (p. 197), and Kammel & Mebert (p. 188), for Carinthia and Styria in southern Austria, respectively. Latter contribution also reports on the recolonization by the dice snake after a larger river rehabilitation program and looks at the effects of hydroelectric power plants. Tuniyev et al. (p. 343) present new and old distribution data, and accounts on color pattern, sympatric herpetofauna, activity and conservation of dice snakes along the Caucasus isthmus, except for most of Georgia, which is covered by Frotzler et al. (p. 357). Latter updated the geographic distribution of the dice snake in Georgia and compared its habitat with the sympatric grass snake. Some authors report or include information on recently detected, new peripheral populations and surprising rediscoveries of dice snakes, such as the 500 km range extension across the Tarim desert in China (Liu et al. p. 430), first populations of the Baltic Sea Drainage Basin (Vlček et al. p. 177), rediscoveries on the island of Cyprus (Göçmen & Mebert p. 383), and within the capital of Romania, Bucharest (Strugariu et al. p. 272).

In Germany, Lenz & Schmidt (p. 30) summarized the results of an extensive, nationwide project to support the few remaining populations of dice snakes with various practical measures of habitat improvement. One of the measures included the rearing and subsequent release of dice snakes to support the population of the Lahn River with juveniles about which Trobisch & Gläßer-Trobisch report (p. 49). The most northern population in Germany is the focus of a historical account and assessment of its problematic conservation status (Obst & Strasser p. 58).

A summary about the fossil data of *N. tessellata* from the East European Plain is given by Ratnikov & Mebert (p. 337). The oldest fossil records of *N. tessellata* originate from the Middle Pliocene and suggest a continuous presence since that period, but its range limits varied with frequent climatic and topographic fluctuations. Covering part of that same region, Kotenko et al. (p. 311) investigated the current northern range limit of *N. tessellata* and a few environmental correlates in more details for Ukraine and the Don River Basin in Russia. Farther east in the Samara region, Russia, Litvinov et al. (p. 330) investigated the most northern population confirmed for *N. tessellata*, situated along the Volga River. They also measured various body and ambient temperatures and experimentally tested the temperature optimum for dice snakes. Similarly, Scali (p. 131) compared temperature and other ecological variables between *N. tessellata* and its congeneric competitor, the viperine snake *N. maura*, at one of their few sites of natural sympatry in northern Italy. Differences were found in microhabitat selection and temporal activity, as the dice snake was observed in comparatively deeper streams, being more piscivorous, and less nocturnal. These two species were also compared at a site in Switzerland, where *N. maura* occurs autochthonous and *N. tessellata* was introduced many decades ago. Compared with the viperine snake, *N. tessellata* occupied shore zones that were relatively more open and inhabited more often steep slopes. Metzger et al. (p. 86) found a large overlap in the trophic niche between both species at the same site, regarding seasonal preferences and prey types. In this case, the introduction of the larger *N. tessellata* and the subsequent trophic competition probably is the principal cause for the decline in the native *N. maura* population over the last two decades. Information on other interspecific differences with the grass snake *N. natrix* regarding feeding/foraging, as well as aquatic and terrestrial habitat use, are presented through studies in Croatia (Janev Hutinec & Mebert p. 225), Greece (Ioannidis & Mebert p. 302), and marginally also for Georgia (Frotzler et al. p. 357), Italy (Capula et al. p. 147), and Iran (Ahmadzadeh et al. p. 403). The Greek study also looks at the pattern of hibernation, terrestrial activity and the high road mortality of more than 1000 *N. tessellata* annually on a 2 km shore road of the study site.

Line transect methods were applied to compare utilized with non-utilized habitats by dice snakes in Slovenia (Zagar et al. p. 207), whereas Mebert et al. (p. 117) calculated detection probability and site occupancy to assess the conservation status of dice snakes in Ticino, representing the principal autochthonous distribution in Switzerland. Both studies show that dice snakes can find appropriate habitat to maintain healthy populations in even intensively cultivated and anthropogenic modified landscapes, as long as a narrow belt of suitable structure along water bodies and sufficient prey persists.

Most snake species are usually rather secretive and difficult to sample in sound numbers for population level studies. Therefore, the unusually high density in some populations of the dice snake renders this species as an extremely valuable representative of snakes to be utilized for scientific purposes of this species and to foster greater understanding for the biology of snakes in general. In this context, long term studies in central Italy (Capula et al. p. 147), and more recently, large scale studies initiated in coastal Romania (Carlsson et al. p. 237, Kärvemo et al. p. 245) and on an island in Prespa Lake, FYR of Macedonia (Sterijovski et al. p. 298), have been (or will be) compiling a multitude of relevant data on the natural history of *N. tessellata.* Studied aspects included dietary habits, thermal ecology, reproduction, various behavioral aspects, parasite load, and hormones. A comprehensive literature review on parasitism in dice snakes is presented by Mihalca (p. 255), whereas Bakiev et al. (p. 325) researched parasites and diet in individuals from the Volga River Basin, Russia. Unusual is the find of a juvenile adder *(Vipera berus)* in the stomach of a juvenile dice snake. Similarly unusual is the consumption of a larger green lizard and a mouse found in a diet analysis of Turkish dice snakes (Göçmen et al. p. 365).

Three small radiotelemetric studies give us a greater insight into the activity pattern of individual *N. tessellata*. For example, Neumann & Mebert (p. 39) report on a short study in Germany, where three gravid females were radiotracked almost daily over two months. They found little movements of the snakes only up to 15 m away from the water line and up to 100 m along the shore during the summer. Interestingly to note that these semi-aquatic snakes descended only every 4–5 days from their terrestrial shelter on the river bank to forage in the water, but else remained on land to rest and thermoregulate. Conelli et al. (p. 100) revealed seasonal movements (different summer and winter habitats) at one site in southern Switzerland, whereas the dice snakes at two other sites in the region remained relatively sedentary, i.e. were active and hibernated in the same area. A radiotelemetric study in Prague, Czech Republic, found individual movement differences within one population, as some snakes migrated from the shore habitat inland to the hibernaculum for the winter, whereas other individuals hibernated directly in the river bank, the actual summer foraging habitat (Velenský et al. p. 157). They collected also many other fascinating information, such as data on ecdysis and oviposition, duration of hibernation, and rapid colonization and population growth at that particular site after a complete shore reconstruction.

Short contributions deal with the rare occurrence of interspecific hybrids in the genus *Natrix* (Mebert et al. p. 154), anecdotal accounts of nocturnal behavior in dice snakes (Mebert et al. p. 234), and fatal hunting accidents of dice snakes (Mebert & Pölzer p. 145). Even shorter are the Photo Notes, which illustratively present information on feeding of introduced spiny fish, and more unusual stomach contents such as small rocks (Velikov p. 447, Mebert p. 448, respectively), the first records on melanistic dice snakes from Slovenia and the only known albino in this species (Cafuta p. 442, Mebert p. 441, respectively), predation by a snake and a gull (Jelić p. 450, p. 451, respectively), large mating aggregations (Mebert & Ott p. 437), distance records from the water (Mebert p. 453), brief accounts on a successful method to manually attract dice snakes by eliciting waves in the water (Mebert & Trapp p. 445), and an impressive image of a dice snake in the water, with its upward position of eyes and nostrils just above the water surface, which likely enables the dice snake to remain partially submerged in the water as a visual protection against predators (Trapp & Mebert p. 440). Not only in Photo Notes, but overall in this Mertensiella, we used plenty of pictures and graphs, as figures often convey the messages more efficiently than lengthy descriptions. Finally, the volume is complemented with a DVD by Egerer & Mebert, showing various sequences of the dice snake in its natural environment with footages about foraging, courting, and other activities in Austria and Greece.

Parallel Activities and Future Perspective

In the process of producing this Mertensiella about the dice snake, opportunities were taken in 2009 to promote international research for this species in a workshop at the SEH- (Societas Europea Herpetologica) Meeting in Kuşadasi, Turkey, and at a field herpetological conference in Bad Kreuznach, Germany, focusing on *N. tessellata* with a more middle European perspective. Latter was also the result of the dice snake having been selected and promoted as the "reptile of the year – 2009" by the DGHT (Lenz et al. 2009).

What will the future bring in regards to research with *N. tessellata*. The large scale studies in Macedonia (Sterijovski et al. p. 298) and Romania (Carlsson et al. p. 237, Kärvemo et al. p. 245) likely will continue. Possibly, new population level studies will join, as locations in Montenegro, Bulgaria, Greece, and at many sites along the Caspian Sea are particularly suited due to high densities of dice snakes. A finer phylogeography for populations in the Balkans could shed light on the ancient Greek clade compared to more recent Balkan-European clade north of Greece (Guicking & Joger p. 1). A radiotelemetric study is currently investigating the interspecific situation between *N. tessellata* and *N. maura* at Lake Geneva, Switzerland (S. Ursenbacher, pers. comm.). Peripheral populations will attract more attention in the future, in particular the distribution in Poland, the expansion in Egypt towards Sudan, the mountains in southern Romania, the limital distribution from Persepolis to the Persian Gulf in Iran, and also in Pakistan and China. Further studies that I am personally involved or interested are: (a) a potential study about the effects of environmental contaminants and parasites on dice snakes from the Caspian Sea coast of Azerbaijan; (b) a re-assessment of the population status of dice snakes at Lake Alpnach, central Switzerland, after the population has experienced a severe breakdown in the mid-1990s; (c) investigating the origin of the introduced dice snakes in Lake Zürich by genetic means; (d) assessment of the conservation needs and supporting measures for the northernmost German population at Meissen; (e) relationship and origin of the Baltic Basin populations; (f) populations ecology of dice snakes on Aegean islands; (g) marine habits in populations from the Mediterranean to the Caspian Sea; (h) colonization of islands by means of msats; (i) and various publishing project on already existing data.

Finally, I would like to thank the DGHT for supporting this comprehensive project, in particular Andreas Mendt for his layout work, Jörn Köhler for his variable advice and help as a chief editor, and DGHT-vice president Axel Kwet, for his patience and endurance listening to my worries, lamenting, and his subsequent assistance.

I would like to express my sincere gratitude to all authors for their contributions and to get through the multi-layered revision process with me. It was often not easy, but I am certain, that one way or another, we all have benefitted from this project. At the end, we can be proud of the product in our hands. Many thanks to Goran Dusej (adviser of my diploma work with *N. tessellata*), Michael Gruschwitz, Sigrid Lenz, Iliana and Alice Mebert and Maya Henggeler, all who somewhere crossed my path that finally led to this Mertensiella.

Merenschwand, September 2011

Konrad Mebert

References

Gruschwitz, M., Lenz, S., Mebert, K. & V. Laňka (1999): *Natrix tessellata* (Laurenti, 1768) – Würfelnatter. – In: Böhme, W. (Ed.): Handbuch der Reptilien und Amphibien Europas, **Vol. 3**/Schlangen II. – AULA-Verlag, Wiesbaden, Germany: 581–644.

Gygax, P. (1968): Die Entwicklung der Giftdrüse bei *Natrix tessellata*. – Rev. Suisse Zool. **75**: 549–557.

Gygax, P. (1971): Entwicklung, Bau und Funktion der Giftdrüse (Duvernoy's gland) von *Natrix tessellata*. – Acta trop. **28**: 226–274.

Lenz, S., Mebert, K. & J. Hill (2008): Die Würfelnatter: Reptil des Jahres 2009. – In: Die Würfelnatter, Reptil des Jahres, Aktionsbroschüre. – DGHT, Rheinbach, Deutschland.

Mebert, K. (1993): Untersuchungen zur Morphologie und Taxonomie der Würfelnatter *Natrix tessellata* (Laurenti 1768) in der Schweiz und im südlichen Alpenraum. – M.S. thesis, Zoological Museum, University of Zürich, Switzerland.

Mebert, K. (2010): Massive Hybridization and Species Concepts, Insights from Watersnakes. – VDM Verlag, Saarbrücken, Germany.

Walztöhny, D. & V. Ziswiler (1979): Vergleichend - morphologische Untersuchungen an den Hautsinnesorganen der Blindschleiche *Anguis fragilis* (Anguidae) und der Würfelnatter, *Natrix tessellata* (Colubridae). – Rev. Suisse Zool. **86** (3): 705–712.

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Molecular Phylogeography of the Dice Snake

Daniela Guicking & Ulrich Joger

Abstract. Molecular phylogenetic and phylogeographic studies based on mitochondrial cytochrome b sequences and nuclear ISSR-PCR genomic fingerprinting were performed to elucidate the evolutionary history and intraspecific variation of *Natrix tessellata*. The results of our studies revealed a well-resolved phylogeny and identified nine mitochondrial DNA haplotype clades, associated with animals from Iran, southern Greece, Jordan/Egypt, Turkey, Caucasus, Kazakhstan, Uzbekistan, Crete, and Europe except for southern Greece, respectively. Molecular data suggest that *N. tessellata* originated in southwest Asia during the Miocene and underwent a basal radiation around the Miocene-Pliocene boundary with further differentiation of the Middle Asian and European lineages during the Pleistocene. Nuclear data suggest admixture of mitochondrial clades in northern Turkey and the northeastern Aral Sea region. Low geographic differentiation among specimens of the main European lineage points to a severe population bottleneck during the late Pleistocene.

Key words. Serpentes, *Natrix tessellata*, phylogeography, molecular genetics

Introduction

To shed light on the evolution and intraspecific variation of the dice snake (*Natrix tessellata*, Laurenti 1768), we performed a series of molecular phylogenetic and phylogeographic studies (Guicking et al. 2002, Guicking 2004, Guicking et al. 2004, Guicking et al. 2006, Guicking et al. 2009). The use of molecular markers has proven particularly useful in taxa that show only weak and mainly clinal geographic variation of phenotypic traits, as is probably the case in *N. tessellata* (Laňka 1978, Mebert 1993, Gruschwitz et al. 1999).

Molecular markers have the great advantage that they can be easily applied to any living organism and offer a nearly unlimited pool of variability. Variation in molecular markers that are selectively neutral or close to neutral provides tools for dating divergence times, and thus allows to estimate a temporal framework for the evolutionary history of a species, even if it is not or only scarcely represented in the fossil record (Cruzan & Templeton 2000). In phylogeny, molecular tools are applied to reveal the relationships between taxa. In phylogeography, geographical patterns of genetic structure are described and used to infer the history and processes underlying that structure (Avise et al. 1987, Avise 2000, Knowles & Maddison 2002). Today, a variety of molecular markers are available for studying geographic association and evolution. Due to its high mutation rate, strictly maternal inheritance and ease of handling, mitochondrial DNA (mtDNA) has been, and still is, the preferred marker system for phylogeographic studies in animals (Bermingham & Moritz 1998, Avise 2000). Whenever possible, additional information is gathered from the nuclear genome. Due to the different mode of inheritance (the mitochondrial genome is maternally inherited, the nuclear genome biparentally) a comparative analysis of data from the two genomes allows inference of distribution and gene flow patterns that cannot be obtained from a single data set alone.

In the present study, we review the most important results from a number of molecular phylogenetic and phylogeographic studies on *N. tessellata*, paying particular attention to the temporal-spatial origin of the species, its intraspecific diversity, and geographic distribution of variation.

Material and Methods

As a source of DNA, blood or tissue samples were collected from living animals, road kills and museum specimens. In addition, we used shed skin when available. In total, samples from 305 specimens were included (see Appendix). DNA was isolated following standard protocols (Sambrook & Russell 2001). Sequences of the mitochondrial cytochrome b gene and three subunits of the NADH-Dehydrogenase were obtained and analysed by phylogenetic methods based on maximum parsimony, maximum likelihood and Bayesian inference (for more details see Guicking et al. 2006, 2009). The robustness of individual branches was assessed by nonparametric bootstrapping (Felsenstein 1985). Genomic ISSR-PCR (inter simple sequence repeats polymerase chain reaction) fingerprints were generated to compare nuclear data against mitochondrial data. ISSR-PCR involves primers during DNA amplification that are designed from di-, tri- or tetranucleotide repeat motifs and thus are complementary to microsatellites (simple sequence repeats). Because of the abundance of microsatellites in the genome, a single oligonucleotide will usually prime several fragments of different lengths in each PCR. Gel-electrophoretic separation of PCR products thus generates characteristic multi-locus fingerprint patterns of the template DNA. Fragment patterns are interpreted as

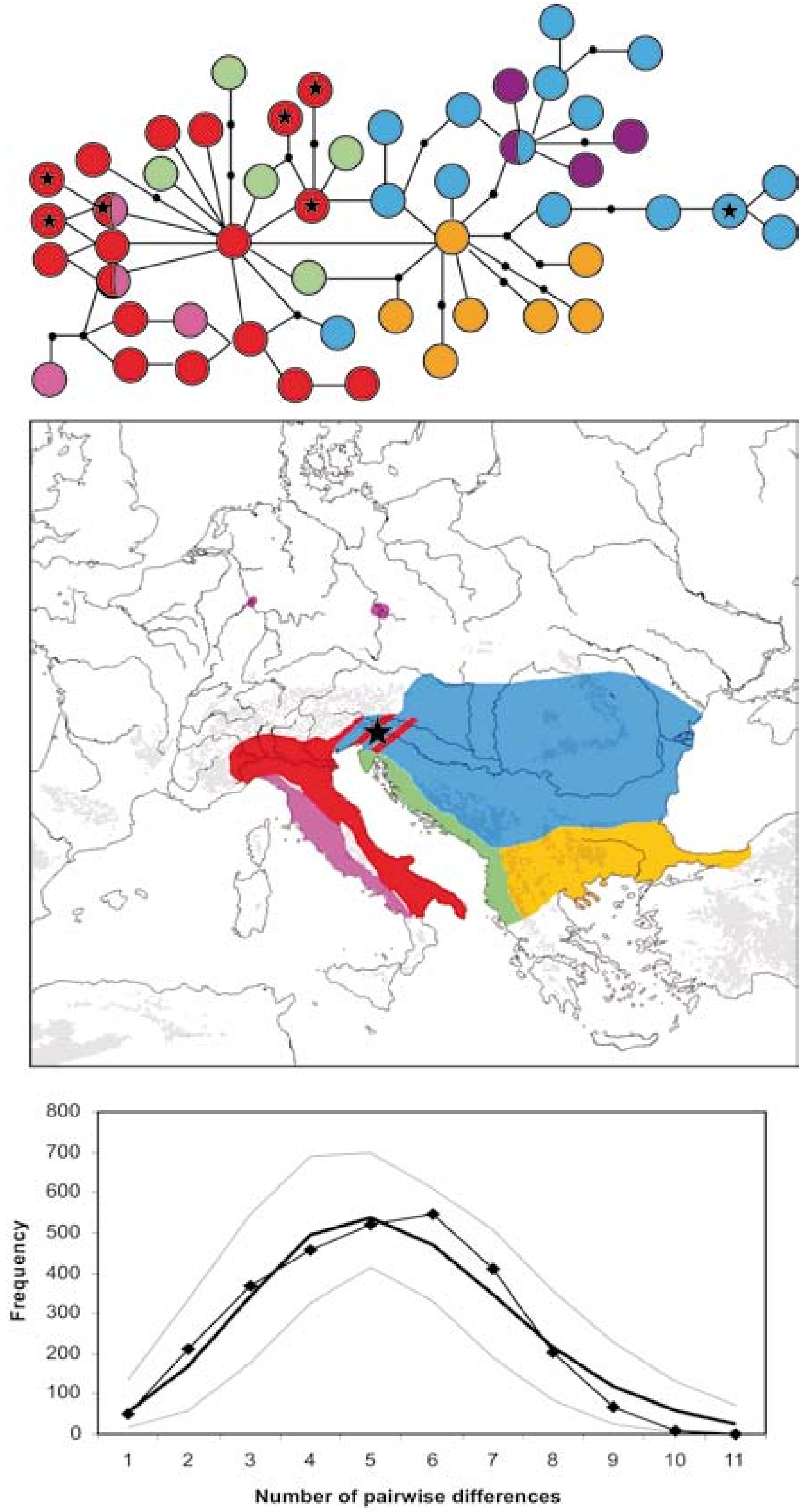

Fig. 4. Above: Statistical parsimony network of all cytochrome b haplotypes belonging to lineage 'Europe'. Each line represents one mutational change, and black dots represent missing intermediate haplotypes. Six geographic regions were defined as shown in the map (middle) and overlaid on the network to illustrate geographic association of haplotypes. Haplotypes found in Slovenian *Natrix tessellata* are indicated by an asterisk. Below: Frequency distribution of pairwise number of mutational differences (mismatch distribution) between individuals of European *N. tessellata*. Diamonds represent the observed data, the bold curve is the "sudden expansion model" fitted to the data, and thin lines delineate the 2.5 and 97.5 percentile values of 1000 simulated samples.

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Geographic Variation of Morphological Characters in the Dice Snake (*Natrix tessellata*) *

Konrad Mebert

Abstract. Pholidotic characters and a few body proportions have been investigated in dice snakes (*Natrix tessellata*) from the western limit south of the Alps to those from northeastern Turkey. All scale characters vary clinally, mostly with increasing values in representatives from west (Italy) to east (Turkey). With the donation of a large private data collection by the late E. Kramer, the geographic variation of ventral scale counts could be studied across the entire range of *N. tessellata*. The ventrals not only increase from west to east, but also from south (Egypt to Iraq) to north (northwest of the Caspian Sea), and from lowlands to mountains in southern areas. The possibility of climaparallel variation in scale characters is briefly discussed. Body proportions show no large-scale geographic correlation, but rather appear to depend on environmental characteristics pertinent to a particular population.

Key Words. *Natrix tessellata*, morphology, geographic variation, cline, driving forces

Introduction

The geographic variation of exterior features within the huge range of the dice snake (*Natrix tessellata*, Laurenti 1768) has not been well studied to date. Approximately 100 years ago, Dürigen (1897) and Schreiber (1912) have investigated the variation of scale characters and color morphs in *N. tessellata*, and included also earlier works by other authors. In 1930, Hecht tried to evaluate the morphological variation in dice snakes, but ultimately, the samples of these researchers were not representative for a species with such an extensive range. Mostly, related works of the dice snake concerned morphological variation on a national level, e.g. Romania (Fuhn & Vancea 1961), Ukrainian Carpathians (Shcherbak & Shcherban 1980), Czech and Slovakian republics (Kminiak & Kaluz 1983, Rehák 1992), Western Germany (Lenz & Gruschwitz 1993), Austria (Zimmermann & Fachbach 1996), Israel (Werner & Shapira 2011), China (Liu et al. 2011), Turkey (Dincaslan et al. 2011), Iran (Rajabizadeh et al. 2011), and Bulgaria (Naumov et al. 2011). Some studies give summarized mean values for snakes originating from widely distributed localities. For example, Baran (1976) applied such mean values for dice snake samples covering the huge area from the Dalmatian Coast, to Israel and Iran, whereas Bannikov et al. (1977) showed similar results averaged over all the former Soviet States. But information about geographic variation is lost in these summary results. A closer look at geographic variation across borders without loosing the perspective for regional character expression was achieved by Laňka (1978). He noted differences in the number of ocular scales and to a smaller extent also concerning the number of labial shields between animals of the North (Czech Republic) and the South (Romanian-Bulgarian Black Sea Shore). Southern dice snakes tend to have a higher number of scales/shields.

Unfortunately, sexual dimorphic scale-characters in dice snakes, in particular the number of ventrals and subcaudals, and to some degree even the number of postoculars or the arrangement of some labials (Mebert 1993), should be analyzed separated by sex in order not to confound regional expression of characters. Therefore, an earlier work by the author attempted to diminish this lack of precision and method by analyzing a number of morphological characters on a regional basis, but over a larger geographic area and separated by sex (Mebert 1993, 1996, Gruschwitz et al. 1999).

However, these studies focused on a comparison of autochthonous and allochthonous populations of dice snakes from the central Alps (Mebert 2011a), including an analysis of sexualdimorphism (Mebert 2011b), and only a few data were presented about the wider geographic variation of morphological characters. Finally, Kramer et al. (1982) published one paragraph with nine lines on data about the whole-range geographic variation of 9 morphological characters based on 850 preserved specimens. Their preliminary results divided the dice snake into a Mediterranean and an East European-Asian group. This study was not further elaborated, but the raw data was donated to the author (see below). Even though, this report will remain preliminary as well, since more data already received are not included and await new and different statistical analyses, the presentation of data on a finer geographic scale on some selected and easy quantifiable characters of morphology is feasible, reflecting the scope of variation in this truly

*) This article is in honor of the late Eugen Kramer, who submitted his meticulously acquired data on more than 600 preserved dice snakes and never had the chance to see its inclusion in studies such as this one.

Melanism in dice snakes occurs in temperate wet to mediterranean dry areas, on mainland or islands (Mebert 2011c). They occur with a constant frequency of 10%–17% at Lake Lugano in southern Switzerland (Mebert 1993, Fig. 7), only to be completely unknown in nearby Lake Como 10 km farther east without any physical barrier between the two lakes. There is no visible pattern, where melanistic or concolor dice snakes occur, except that their frequency appears to be higher towards the center of its distribution, mainly between the southern Balkan and the Caspian Sea. But they are also known from areas north of the Black Sea, east into Kazakhstan, Kyrgyzstan, Uzbekistan, and south into Iran, Iraq and Syria (Mebert 2011c, and E. Kramer, unpubl. data).

A rare morph, in which the blotches are partially striped or at least appear to be stretched longitudinally, has been found occasionally at the Caspian Sea (Tuniyev et al. 2011), Syria (e.g. Ataibe east of Damascus), and at Persepolis, northeast of Shiraz, southern Iran (Mertens 1969 and E. Kramer, unpubl. data). This

Fig. 6. Large variation of dorsal and ventral pattern in *Natrix tessellata* from Lake Garda in Italy, including concolors, weakly spotted to prominently spotted specimens; a–d (dorsal views), e (ventral view). Photos: Konrad Mebert.

Fig. 7. A male and female (insert left) of melanistic *Natrix tessellata* from Lake Lugano, Switzerland. Photos: Herbert Billing & Konrad Mebert.

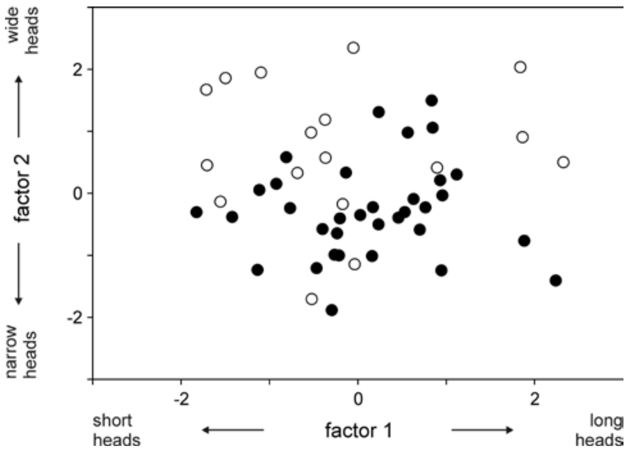

Fig. 2. Graph illustrating the results of a factor analysis performed on the size-corrected craniometric data. Note that individuals with fish in their stomachs (closed circles) exhibit relatively narrower snouts than individuals with frogs in their stomachs (open circles).

vealed narrower snouts (smaller distance between the eyes and nostrils) and a reduced frontal surface area (Figs. 2, 3). Scores on the first principal component axis correlated with the number of prey found in the stomach (Spearman r = -0.413; P = 0.001). Thus snakes that had more prey in their stomachs had relatively shorter heads.

We do not have enough data to statistically test for differences in head morphology between populations of which the diet is known. But we placed the data for the head morphology (PCA axis 2, Fig. 4) against the population information together with the known diet of individuals for that region. The two out of five populations with on average the widest head shape and four out of five populations with the most narrow head shape appear to be feeding on frog and fish respectively. The other populations had no individuals with any stomach contents, so their diet remains unclear.

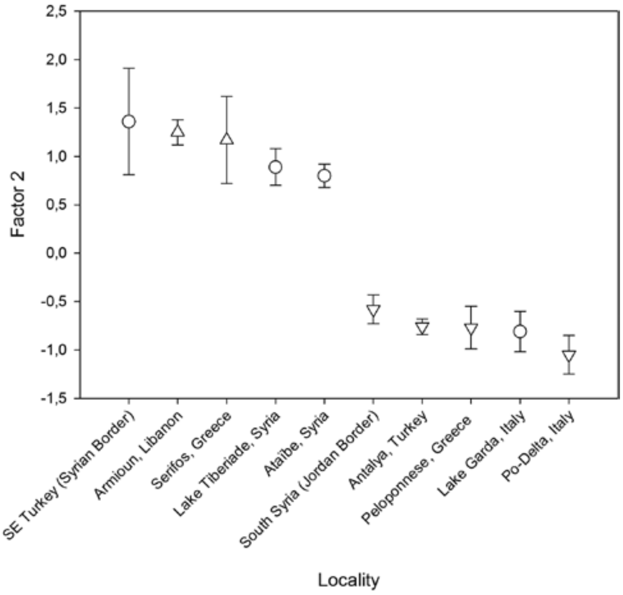

Fig. 4. Graph illustrating the results of the second axis of the factor analysis performed on the craniometric data against the locality data. Illustrated are the top five populations with the on average largest frontal head shape and the on average smallest frontal head shape. The triangles with the top upward are populations that have fed on frogs. The downward positioned triangles are populations that have fed on fish. The circles represent populations without a known diet. There is a trend that populations with on average a larger frontal head shape feed on frogs, whereas the populations with the smallest frontal head shape feed on fish.

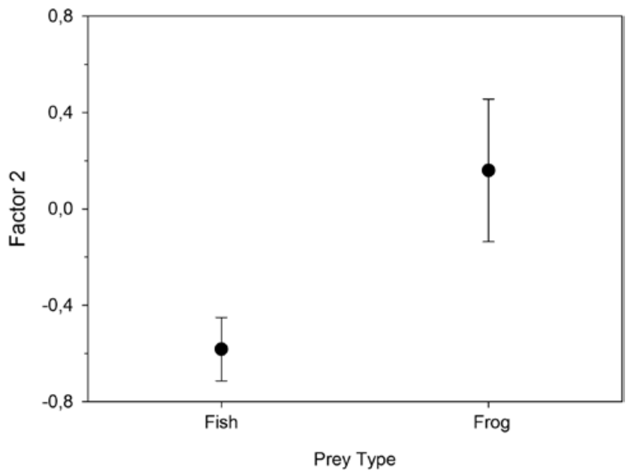

Fig. 3. Plot illustrating the difference in head shape between snakes that had fish and frogs in their stomachs. Snakes feeding on fish have significantly narrower snouts than snakes feeding on frogs. Illustrated are means ± standard errors.

Discussion

Our results show that individuals that consumed fish had more streamlined heads than individuals with frogs in their stomachs (see Fig. 5). These data thus confirm prior suggestions that striking at prey frontally under water may impose a constraint on the evolution of head shape in these snakes. Although we predicted that individuals who consumed frogs would have a larger relative head width as principal determining factor, our results show that inter-ocular length and projected frontal surface play a more important role. The larger projected frontal surface of the head may increase drag during striking and swimming of the frog eating specimens. It would therefore be interesting to compare the underwater striking performance and gape distance of dice snakes selecting between the two types of prey, as well as their habitat use and behavior. If these intraspecific differences in morphology mirror those found among Natricine species, we predict that specimens with relatively large frontal surfaces will be found in drier habi-

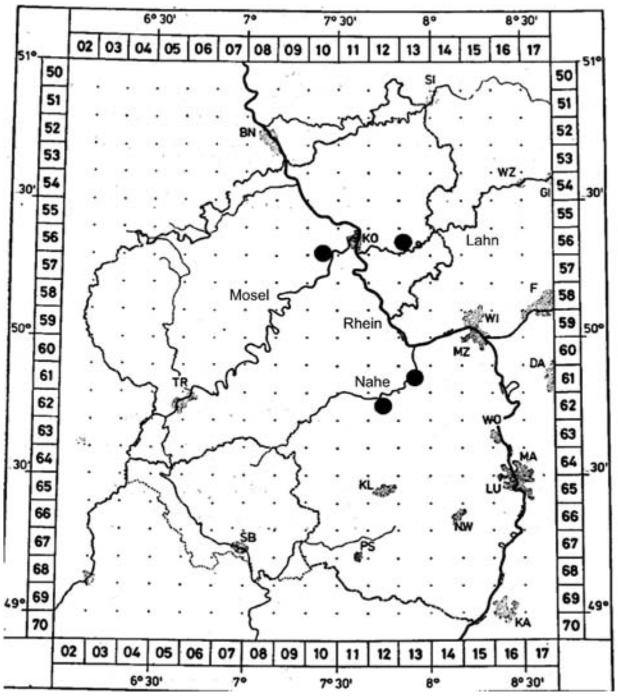

Abb. 2. Verbreitung der Würfelnatter in Rheinland-Pfalz (verändert nach Gruschwitz 1985)

Distribution of the dice snake in Rhineland-Palatinate (modified after Gruschwitz 1985).

Abb. 3: Ehemaliges Campingplatz-Gelände an der Mosel vor der Umgestaltung, Zustand 1993.

Former camping site at the river Mosel prior its restructuring, state 1993. Foto: S. Lenz

kehr auf einer angrenzenden Bundesstrasse zu schützen (vgl. Abb. 3).

Lahn: Auch an diesem Fluss bestand historisch ein flächiges Vorkommen am Unter- und Mittellauf (u.a. Bunenfeldern) in die Uferstrukturen und besonders den Ausbau zur Bundeswasserstrasse in den 60er Jahren wurde das Vorkommen der Würfelnatter auf eine kleine Reliktpopulation am Unterlauf reduziert (Gruschwitz 1978, 1985, vgl. Abb. 2). Ziel war es hier, den Lebensraum der Art durch die naturnahe Umgestaltung einer angrenzenden, vormals als Campingplatz genutzten Fläche, zu erweitern und gleichzeitig gegen den Ver-

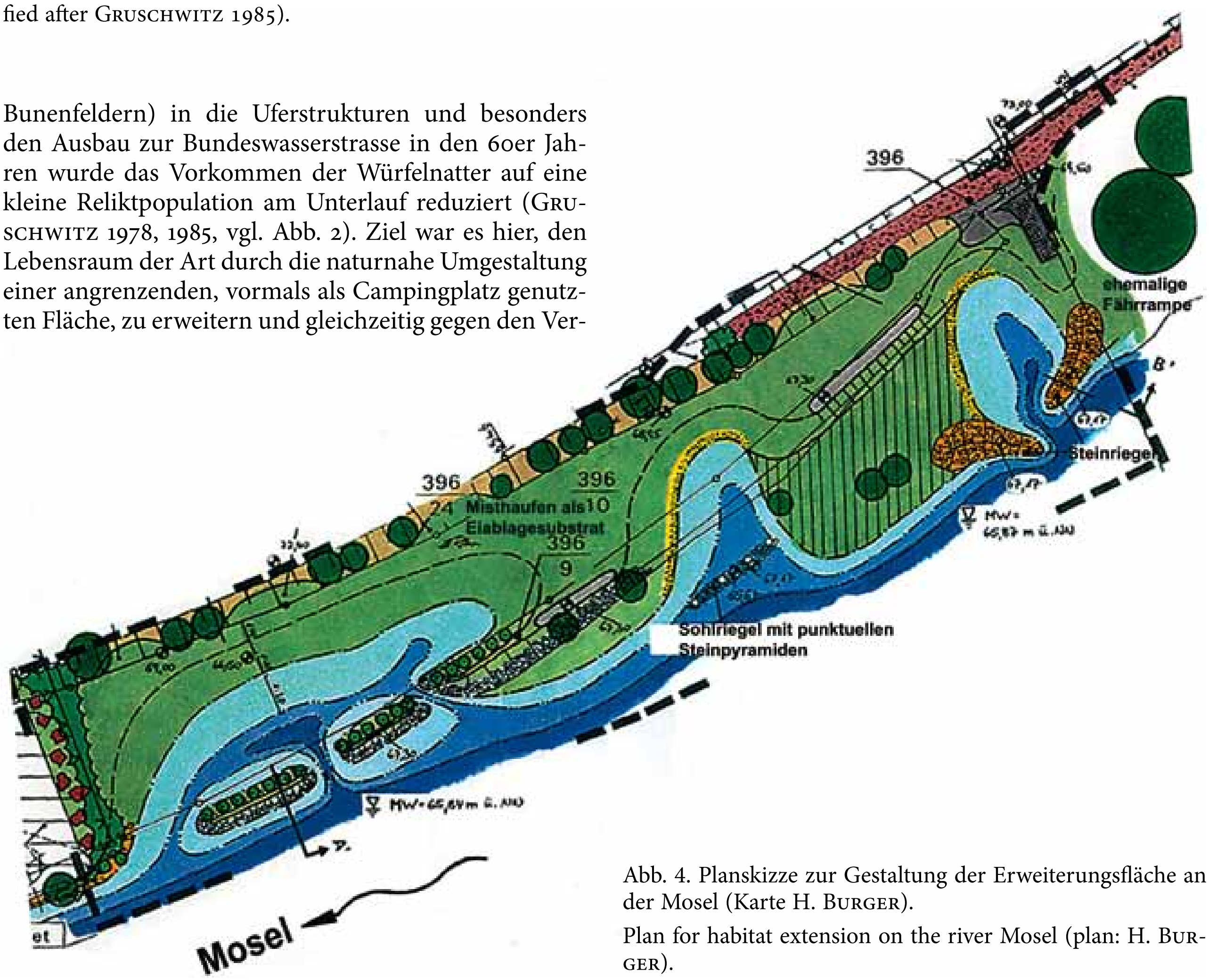

Abb. 4. Planskizze zur Gestaltung der Erweiterungsfläche an der Mosel (Karte H. Burger).

Plan for habitat extension on the river Mosel (plan: H. Burger).

period from May–July the rainfall in this area accumulates only 160–180 mm (Niehuis 1996). Therefore, the Nahe Valley is one of the warmest and driest regions in whole Germany. Today, the Nahe Valley is shaped by viniculture with many steep and rocky slopes used for cultivating vine grapes or left temporary as fallow land, yielding arid grassland and dry slope. An abundance of crevices and dry stone walls provide an ideal habitat for many reptiles, yielding large populations of grass snakes (*Natrix natrix*), smooth snakes (*Coronella austriaca*), western green lizards (*Lacerta bilineata*) and European wall lizards (*Podarcis muralis*) (Lenz & Herzberg 1996). The Nahe Valley is also home of the largest dice snake population (*N. tessellata*) in Germany. Three parts of the valley with a total area of approximately 300 ha have been declared as nature protection areas (NSG) and are also part of the European ecological network Natura 2000.

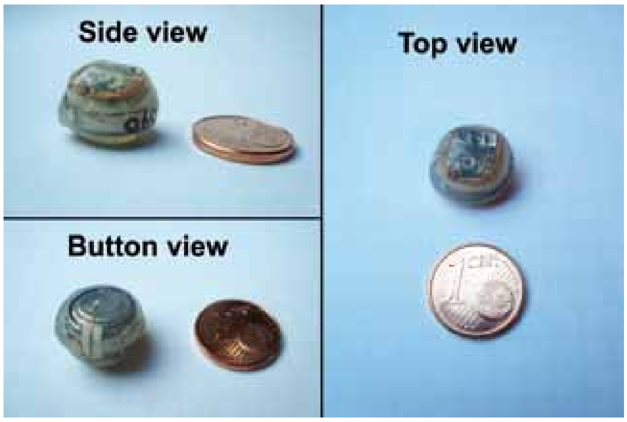

Fig. 3. Transmitters from different views; the button cell (battery) is visible in the bottom view.

The district road K58 runs parallel to the shore along most of the river course and is also part of the "Nahe-Radwanderweg" (Nahe bike tour road), which is highly frequented by cyclists from spring to autumn. Every year dozens of dice snakes are killed along this route, especially during the spring and autumn migrations, but also while basking on the asphalt road (Niehuis 1996). The road's dissection of the snake habitat is the most serious threat for this isolated population at the Nahe River. The nearest population of dice snakes at the rivers Mosel and Lahn are more than 60 km air distance away and thus, an exchange of individuals is not possible (Niehuis 1996). Another relevant threat for the local population at the Nahe River is the disturbance through recreation activities. Despite of a ban by the local public authority, certain tributaries of the river are strongly frequented by canoeists and people with rubber boats in the summer months (Niehuis 1996). In summary, the river Nahe can be characterized as an ideal habitat for dice snakes due to a close-to-nature river course, containing numerous gravel banks and areas of shallow water for fishing, and a xerothermic microclimate along slopes, vineyards, and dry stone walls, providing many suitable hiding places and sites for oviposition and incubation.

The survey took place on one of the population hotspots, an approximately 800 m long section along the river Nahe. The center of this area extends over approximately 400 m along the district road. This is the section where the highest number of dice snakes is killed each year. For reasons of protection, I abstain from a more detailed description as well as supplemental map material.

Materials and Methods

General methods followed recommendations by Amrhein (2006). Transmitters (Biotrack Ltd., UK: http://www.biotrack.co.uk) were spheres with a length and width of 12 mm and a height of 10 mm (see Fig. 3). The weight was 4.5 g with a pulse rate of 40 per minute and a pulse length of 15 ms. The transmitters were designed for a minimum runtime of four months according to Biotrack. A maximum range of 150 m was determined via two blind tests on a plain without obstacles. Measuring inaccuracy at a distance of 75 m was approximately 5 m, at a distance of mare than 120 m up to 10 m. The receiver „TRX-16S" from Wildlifematerials International Inc, USA (http://www.wildlifematerials.com) in combination with a Yagi-antenna was used to detect the transmitter signals.

One main focus of this study was the identification of the local oviposition sites, so only adult females were considered for the implantation of transmitters, which were implanted subcutaneously (Figs. 4 and 5). Isofluran was used for the anaesthetization. After the surgery, the dice snakes were kept in quarantine for 4–5 days before being released at the site of their capture. The implantations of the transmitters were carried out by the veterinarian J. Wiechert (Mainz, Germany).

Fig. 4. Subcutaneous implanting of the transmitter.

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The Rearing of Dice Snakes: Part of a Concept for the Sustainable Conservation of Endangered and Isolated Populations in Western Germany

Dietmar Trobisch & Andrea Gläßer-Trobisch

Abstract. As part of a large project on the conservation of three remnant populations of dice snakes in western Germany, we managed the rearing of dice snakes with the aim of their reintroduction. A detailed service contract was issued between the German Herpetological Society (DGHT) as contractee and the authors as contractors. Eight gravid dice snakes were caught in June 1999 in the nature reserve "Schleuse (= lock) Hollerich" along the River Lahn and subsequently housed in terraria. After oviposition by each female, the snakes were returned and released at their place of origin. A total of 97 eggs were laid, of which 77 hatchlings emerged. They were reared for their first year in captivity and their growth was documented regularly. Some snakes showed symptoms of disease and a small number died. In June 2000, 66 young dice snakes were released into the nature reserve "Nieverner Wehr (= weir)", a stepping stone habitat on the River Lahn, that was newly designed in connection with the aforementioned test and development project.

Key words. Squamata, *Natrix tessellata,* western Germany, Rhineland-Palatinate, River Moselle, River Lahn, reintroduction, stepping stone habitat, rearing.

Zusammenfassung. In Deutschland ist die Würfelnatter *Natrix tessellata* vom Aussterben bedroht und besteht aus nur noch drei autochthonen, kleinen, isolierten Populationen im Westen des Landes an den Rhein-Nebenflüssen Mosel, Lahn und Nahe im Bundesland Rheinland-Pfalz. Eine vierte Population im Osten des Landes an der Elbe im Bundesland Sachsen war in der Mitte des 20. Jahrhunderts ausgestorben und wurde im Rahmen des im Folgenden beschriebenen Projektes wiederangesiedelt (Schmidt & Lenz 2001). Von 1997 bis 2001 fand unter der Trägerschaft der Deutschen Gesellschaft für Herpetologie und Terrarienkunde (DGHT) ein Erprobungs- und Entwicklungsvorhaben statt unter dem Titel „Entwicklung und Vernetzung von Lebensräumen sowie Populationen bundesweit bedrohter Reptilien an Bundeswasserstraßen am Beispiel der Würfelnatter an den Flüssen Mosel, Lahn und Elbe". Das Vorhaben wurde vom Bundesamt für Naturschutz mit Mitteln des Bundesumweltministeriums und von den Ländern Rheinland-Pfalz und Sachsen gefördert (Herzberg et al. 1997). Als Bestandteil dieses sogenannten „Würfelnatterprojekts" wurde unter anderem die Aufzucht von Würfelnattern in Menschenobhut mit dem Ziel der Wiederansiedlung durchgeführt. In einem Werkvertrag zwischen der DGHT (Auftraggeber) und den Autoren (Auftragnehmer) waren deren Aufgaben genau vorgeschrieben. Es wird im Zusammenhang mit der Haltung und Pflege der Tiere auch über den erforderlichen Zeitaufwand und die Finanzierung des Projektes berichtet. Acht trächtige Weibchen wurden im Juni 1999 im Naturschutzgebiet „Schleuse Hollerich" an der Lahn gefangen und in Terrarien untergebracht. Nachdem alle je ein Gelege abgesetzt hatten, wurden sie wieder zu ihrem Fundort zurückgebracht. Aus insgesamt 97 Eiern schlüpften 77 Jungtiere, die ein Jahr lang in Zimmerterrarien aufgezogen wurden. Ihr Wachstum wurde regelmäßig dokumentiert. Bei einigen Schlangen traten Krankheitssymptome auf, an denen manche auch verstarben. Im Juni 2000 wurden 66 Würfelnattern im Naturschutzgebiet „Nieverner Wehr", einem im Zusammenhang mit dem anfangs erwähnten Erprobungs- und Entwicklungsvorhaben neu gestalteten Trittsteinhabitat an der Lahn, ausgesetzt.

Schlagwörter. *Natrix tessellata*, Westdeutschland, Rheinland-Pfalz, Mosel, Lahn, Erprobungs- und Entwicklungsvorhaben, Wiederansiedlung, Trittsteinhabitat, Aufzucht.

Introduction

In Germany, dice snakes are threatened by extinction with only three autochthonous, but small and isolated populations remaining in the western Federal State of Rhineland-Palatinate along the Rhine tributaries Moselle, Lahn and Nahe (Gruschwitz & Günther 1996, Gruschwitz et al. 1999, Niehuis 1996). To increase the chance for the long-term survival of these populations, the so-called "Dice Snake Project" was set up by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) within the framework of "Testing and Development Projects in Nature Conservation and Landscape Management". The project was titled "Development and Cross-linkage of Habitats and Populations of Nationally Threatened Reptiles alongside German Federal Waterways, Using the Example of Dice Snakes on the Rivers Moselle, Lahn and Elbe". A fourth German population existed on the River Elbe in the eastern Federal State of Saxony. It became extinct in the middle of the 20th century, but an attempt to restart a new population with dice snakes from the nearby Czech Republic was part of the aforementioned project (Schmidt & Lenz 2001). The Ger-

Tab. 4. Reproduction data of female dice snakes.

animal no.	shedding date	oviposition date	clutch size (infertile eggs)	weight of female after oviposition	weight of the clutch	hatching date	duration of incubation	number of hatchlings
1	20.06.	01.07.	19(1)	132	111,7	03.-04.08.	33-34	13
2	19.06.	01.07.	7(5)	--	--	05.08.	35	2
3	20.06.	04.07.	15(0)	120	101,7	06.-07.08.	33-34	14
4	19.06.	04.07.	14(2)	117	94,6	06.-07.08.	33-34	12
5	03.07.	04.07.	12(0)	96	67,4	08.-09.08.	35-36	12
6	27.06.	08.07.	11(0)	134	69,6	10.-12.08.	33-35	10
7	08.07.	11.07.	8(0)	70	46,3	14.-15.08.	34-35	8
8	12.07.	18.07.	11(0*)	89	88,6	20.-21.08.	33-34	6

*The fertility of the eggs of this clutch could not be judged exactly.

ucts, tissue and contents of organs for microscopical evidence of living pathogenic organisms). Nearly all samples contained microorganisms (flagellates) and eggs of worms (strongylides). After consulting some veterinarians of the "AG Amphibien- und Reptilienkrankheiten" (Working Group for Amphibian and Reptile Diseases) of the DGHT, we dispensed with carrying out antiparasite treatments before oviposition based on their recommendations. The eight animals were housed in five aqua-terraria with the measurements 100 cm x 60 cm x 50 cm (L × W × H). One third of the floor space was partitioned off by a 10 cm high glass wall and subsequently filled with water. Since peat has proved to be an attractive oviposition substrate for snakes, it was used as floor cover for the dry sections of the terraria. These sections were furnished with flat pieces of cork bark and slates for shelter as well as branches for climbing. As heat source, we used a 50 Watt heating cable and a 40 Watt incandescent reflector lamp. For additional lighting, strip lights were fixed above the terraria. The temperatures in the individual basins ranged between 22 °C and 35 °C (underneath the lamp) during the day, whereas all heating and lighting was switched off for ten hours during the night. Trout fry of about 10 cm length was offered as food, but none of the gravid females accepted any before oviposition.

Fig. 5. Incubator with boxes containing clutches of dice snakes.

Oviposition and Return of the Mothers

All females shed their skin before oviposition and laid a viable clutch of eggs in the moist peat, both under the slate plates and under the cork bark (Tab. 4). The freshly laid eggs were discovered mostly early in the morning, but in two cases the process was not finished until midday. One or two days after oviposition, the dice snakes began to feed on the trout fry. After a suitable recovery

Fig. 6. Clutch of dice snake no. 1, beginning of hatching.

autochtonous males from Lake Lugano. Usually, dice snakes from natural populations show a decreased frequency of fused subcaudal scales (2–12%).

The tendency of developing a higher degree of abnormalities in the introduced populations of the lakes Alpnach and Brienz is reinforced by the discovery of five males that exhibit an unusually large reduction of the number of ventral scales from 15% to 20% (Fig. 2). Males from the central Alpine region (n > 200) have on average 170 ventral scales (with the minimum found at 161, Mebert 1993). But the five dwarf males exhibit ventral scales counts from 130 to 140. X-rays not only confirm that the vertebrae are equally reduced, but that the positions of semi-ventrals correlate with fused vertebrae (Fig. 3).

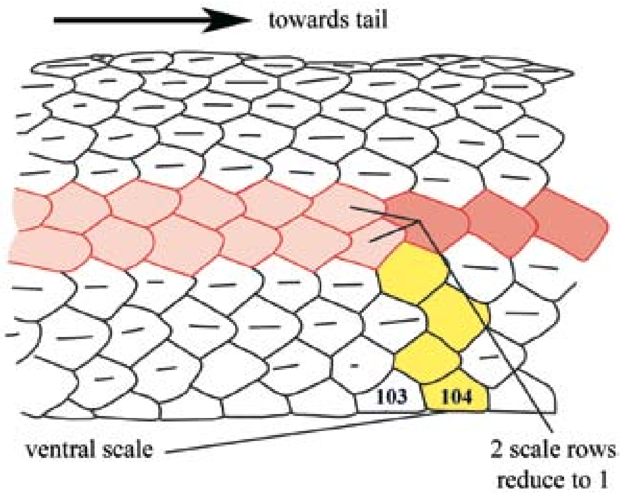

Fig. 4. Pattern of dorsal scale row reduction. The reduction occurs bilaterally, whereby two longitudinal scale rows (light red) are reduced to one row (dark red). The position of the reduction is related to the i^th^ number of ventral scale. In this example, begin with the first scale of the reduced row (dark red), count in a zig-zag way to the venter by following the yellow scales up to the ventral scale Nr. 104, which represents the i^th^ number of ventral scale for this reduction.

Fig. 2. Effect of inbreeding? A dwarf male *Natrix tessellata* from the introduced population of Lake Brienz with only 139 ventrals and many abnormal scales (white lines).

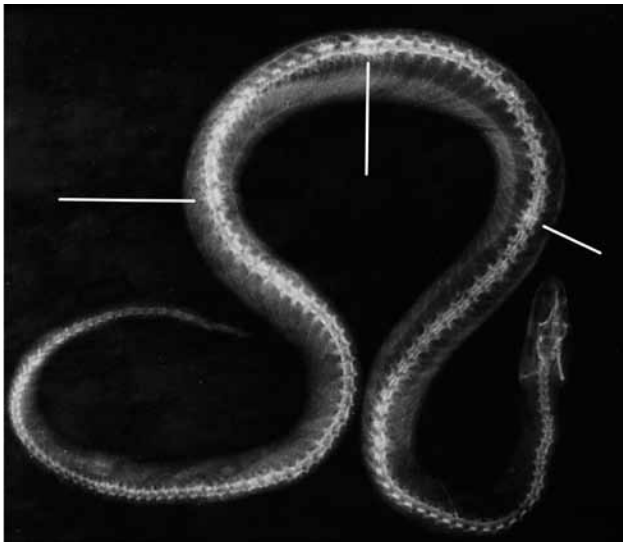

Fig. 3. X-ray of the same specimen as in Fig. 2. The white lines point to fused vertebrae, corresponding with abnormal ventral scales.

In most mid-sized snakes, the number of longitudinal dorsal scale rows is being reduced bilaterally towards the vent and tail (Fig. 4). In dice snakes, such scale row reductions occur near the mid-body and again near the vent (cloaca). Multiple reductions of scale rows over even shorter body segments occur on the tail, enabling its drastic tapering. The average ventral positions of such "bilateral scale row reductions" are valuable meristic characters and quantitative traits. On the tails of dice snakes, well identifiable reductions occur from 8 scale rows down to 6 and again down to 4 scale rows. These reductions occur in introduced snakes significantly closer to the vent than in indigenous dice snakes (Fig. 5). Another significant difference relates to head proportions. The posterior head length of dice snakes from the lakes Alpnach and Brienz, and to a lesser degree those from Lake Geneva, are larger than in snakes from the natural populations of the lakes Lugano and Garda (Fig. 6).

Despite these differences between introduced and natural populations, a cluster analysis based on 27 normally distributed characters (body proportions, positions of scale row reductions, and numbers of ventral/subcaudal scales) show that the dice snakes from the introduced populations phenetically resemble more their geographically nearest dice snakes from the lakes Lugano and Garda, than the individuals from the Balkan or those as far as the Near East (for females see Fig. 7). A similar phenetic diagram for males is displayed in Mebert (2011a). The analysis shows also that female dice snakes from all three introduced populations are phenetically closest to eachother, which also applies to the introduced males of the lakes Alpnach and Brienz,

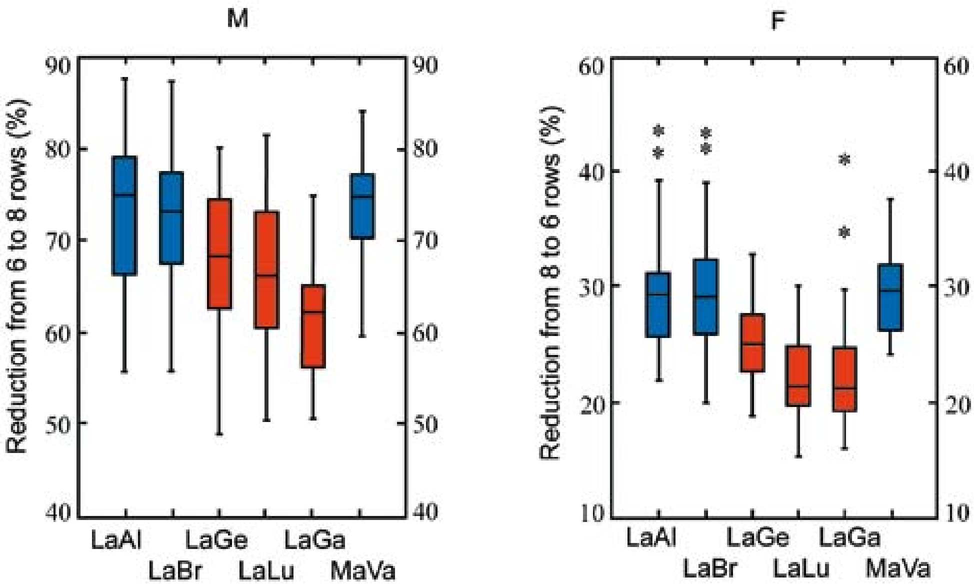

Fig. 5. Relative positions (% of subcaudal scales beginning at vent) of scale row reductions on the tail in *Natrix tessellata* from the Central Alps. The lower, middle and upper horizontal borders of a box represent the quartiles of 25%, 50%, and 75% of the data (medians), respectively. Displayed are the average reduction positions from 6 down to 4 scale rows in males (left), and from 8 down to 6 rows in females (right). Blue shows the three populations from the same genetic stock, the Maggia Valley, whereas reddish represents other populations with different origins (see text): introduced populations LaAl (Lake Alpnach), LaBr (Lake Brienz), and LaGe (Lake Geneva); indigenous poplations LaLu (Lake Lugano), LaGa (Lake Garda), and MaVa (Maggia Valley).

whereas the males from Lake Geneva group closer with males from the lakes Lugano and Garda (Mebert 2011a).

Origin of Introduced Snakes and Reanalysis

Subsequent interviews with responsible persons have revealed that the population at Lake Alpnach originates from 15–25 dice snakes sampled in the Maggia Valley in 1944 and 1945. The snakes were then transported over the Gotthard Pass (> 2000 m a.s.l.), which is the direct route and pass leading northward through the adjacent alpine ridges, thus posing the natural barrier for any current northward expansion of this species. The dice snakes were subsequently released at the shore of Lake Alpnach, near Stansstad. These Maggia-individuals constitute the initial stock of an increasing population at that lake, which provides suitable conditions along its southerly exposed rocky shores (Fig. 8). Around 1960, approximately 60 specimens were removed from this growing population and introduced at Lake Brienz in another alpine valley (Fig. 1).

To adequately incorporate the new information, 26 preserved dice snakes from the parental population of the Maggia Valley were morphologically investigated. The results showed indeed the close phenetic affinity between the dice snakes from the lakes Alpnach and Brienz with those from Maggia Valley, in particular the larger posterior head length (Fig. 6) and the positions of scale row reductions on the tail (Fig. 5). The similar and extraordinary variation of these characters not only

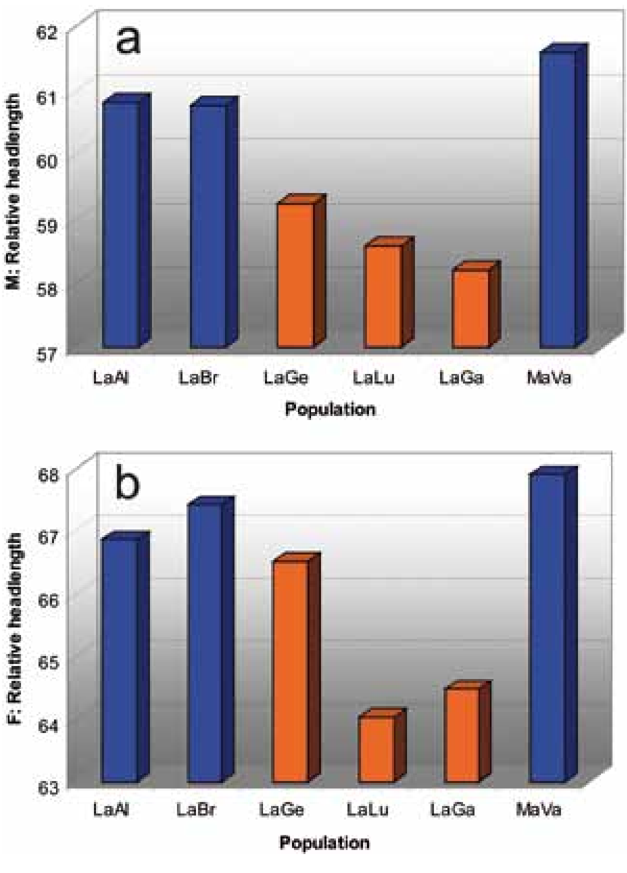

Fig. 6. Posterior head length (relative) of *Natrix tessellata* from introduced and indigenous populations in the Central Alps (see text for definition of posterior head length): labels and colors as in Figure 5m; (a) M = males, (b) F = females.

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Different Habitat Use of Dice Snakes, *Natrix tessellata*, among Three Populations in Canton Ticino, Switzerland – a Radiotelemetry Study

Alberto E. Conelli, Marco Nembrini & Konrad Mebert

Abstract. Nine adult female dice snakes, *Natrix tessellata*, from three different sites were tracked during an entire season using radiotelemetry. The study sites represent the variation of habitats occupied by dice snakes in the canton Ticino (southern Switzerland); a relatively intact and protected river delta (Bolle di Magadino), a semi-natural stream (Arbedo) and a lake ecosystem with strong human influence (Riva San Vitale). The radio-tracked dice snakes were found only in the immediate surroundings of the open water surface with 97% of the locations occurring at less than 20 m distance from the water. The most frequent structures selected by the monitored animals for sheltering, thermoregulation and oviposition were artificial rocky embankments (rip-raps) and other similar retaining works (i.e. stone walls) covered with light vegetation and well exposed to the sun. The snakes avoided forest habitat with dense monotonous vegetation or artificial stream reaches with concrete banks and a low ecomorphological value (lack of microstructure). The rather long monitoring period at the Bolle di Magadino site allowed us to identify relevant seasonal changes in their habitat use. During the fall, the snakes moved from the summer habitat towards the hibernation sites at the edge of the flood plain. In spring, they used the same migration route to return to their summer habitat.

Key words. *Natrix tessellata*, Bolle di Magadino, Arbedo, Riva San Vitale, natural and anthropogenic habitat, seasonal migration

Introduction

The dice snake (Colubridae: *Natrix tessellata*, Laurenti 1768) is a semiaquatic species that inhabits most watercourses that are rich in fish and provide shores with a variable, mostly rocky structure. Its natural distribution in Switzerland is limited to areas south of the alpine mountain range, predominantly in Canton (= province) Ticino and in the two southern valleys, Misox and Poschiavo, in the Canton Grison. Introduced populations north of the Alps have persisted at the lakes of Geneva, Brienz, Alpnach, and Zürich (Mebert 1993, Hofer et al. 2001, Mebert et al. 2011).

Natrix tessellata is considered as one of the most threatened reptiles in Switzerland (Hofer et al. 2001) It is classified in category EN (endangered) according to criteria of the IUCN for the Red List of threatened reptiles in Switzerland (Monney & Meyer 2005). Its habitats are in progressive decline due to disadvantageous alterations of watercourses, such as obstructions, cemented and sealed walls along shores, dredgings, reclamations of land near the watercourse, corrections of the river bed, and modifications of the water regimen (Hofer et al. 2001, Fossati & Maddalena 2003). The permanent Committee of the European Council, in charge of the implementation of the Berne Convention, has formally demanded the protection of the dice snake populations in the canton Ticino, in particular those of the Sopraceneri (northern Ticino), based on the recommendation n° 26 of 1991. The strategy of the Canton Ticino for the study and conservation of its amphibians and reptiles has targeted the protection of the dice

Fig. 1. Three study sites with distinct ecosystems for *Natrix tessellata* in Canton Ticino, southern Switzerland.

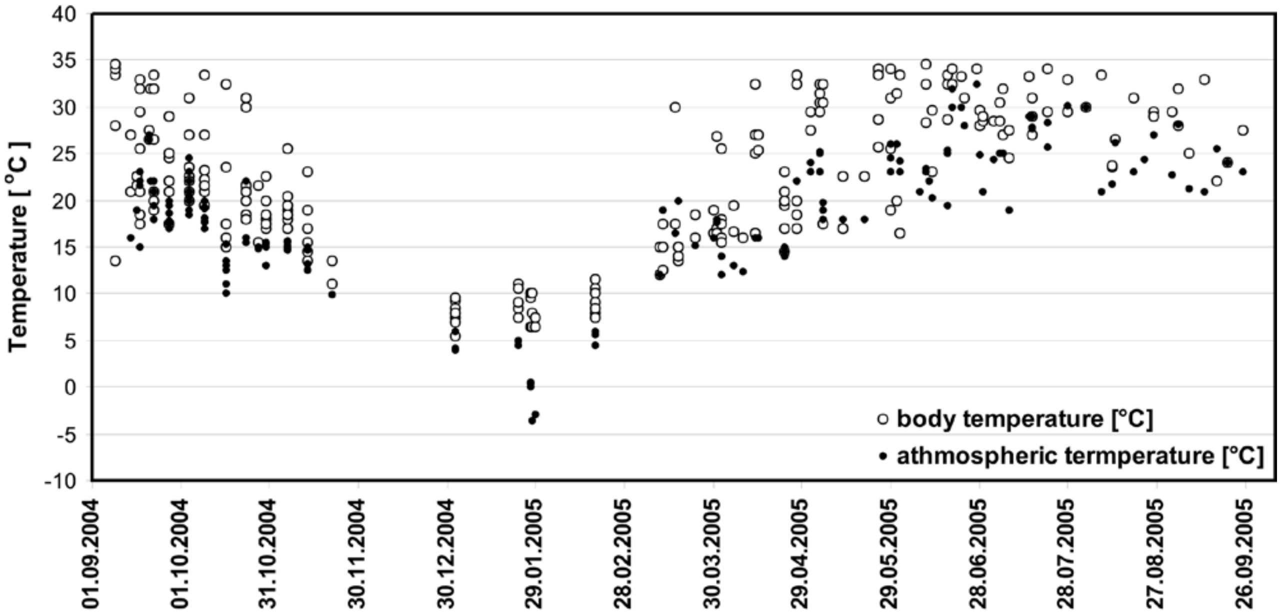


Fig. 15. Body (snakes) and ambient (outside the hibernacula) temperatures during hibernation in *N. tessellata* of Ticino, Switzerland.

After surgery the snakes were monitored in a terrarium for approximately 48 hours and then released at the exact location of their capture. The entire operation was subject to an authorization procedure of the Federal Decree for the Protection of Animals (OPAn).

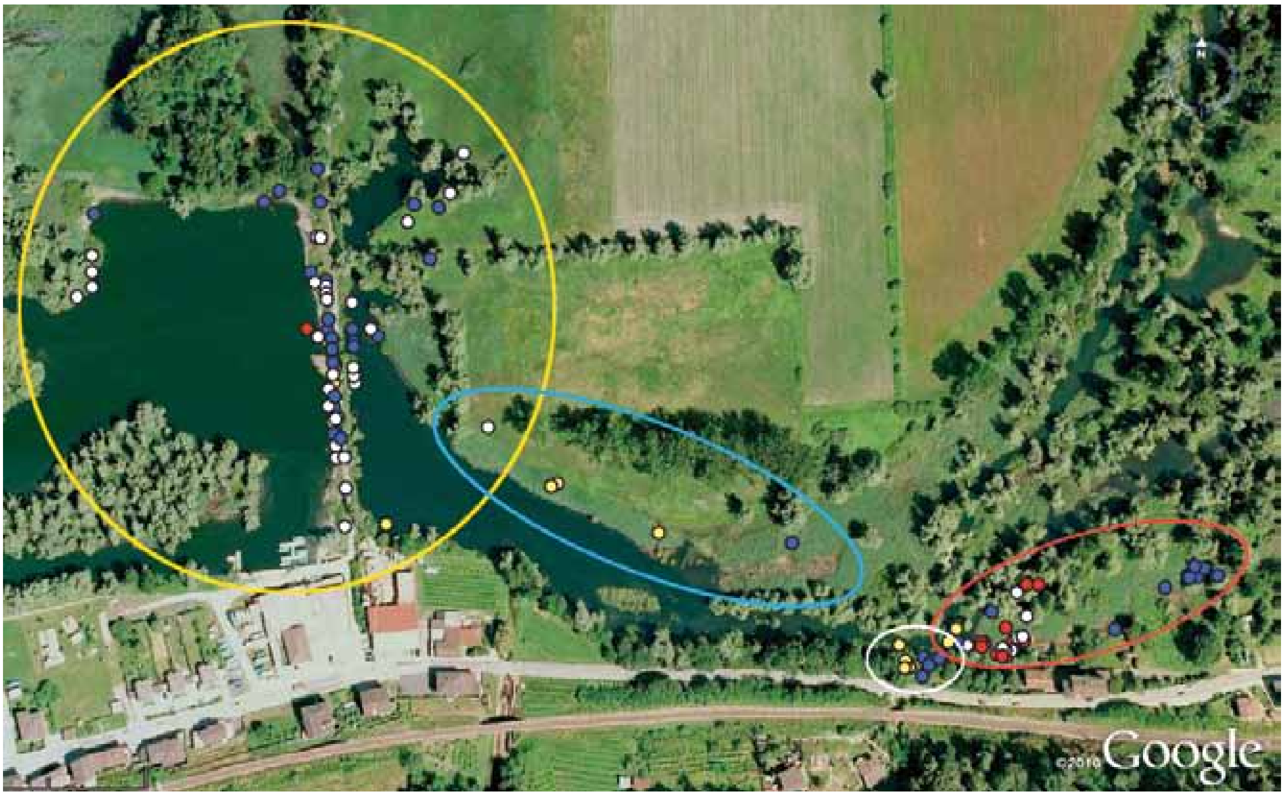
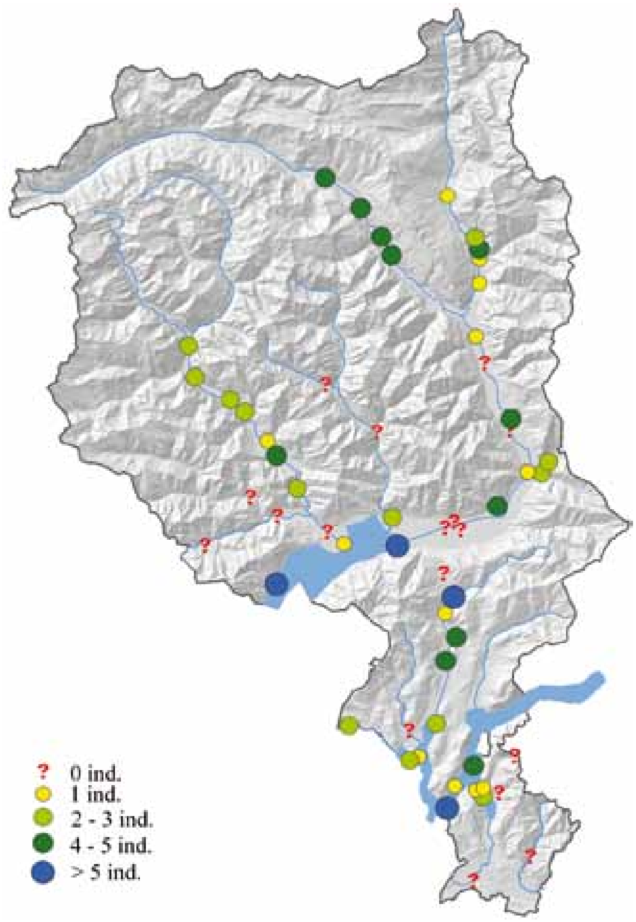


Fig. 16. Summer (yellow circle) and winter (white oval) habitats for *N. tessellata* in the Bolle di Magadino, Ticino, southern Switzerland. Red oval denotes a post-hibernation residence for dice snakes (see Fig. 17) that was used for several weeks until their migration (blue oval) to the summer habitat.



detection probability. Some variables were recorded in the field, whereas others were obtained through analysis on spatial geographic data with the application of ESRI ArcGIS 9.2.

Results

With 167 visits in the two years, we had an average of 2.93 (± 0.32) visits per object. A total of 218 *N. tessellata* sightings were recorded, with an average of 1.31 (± 2.18) snakes per visit. The presence of the species was confirmed in 40 out of 57 linear objects by direct observation, representing approximately 70% of all objects (Ψ*naive estimate* = 0.702, Fig. 5).

The first step of the analysis was a goodness-of-fit test (MacKenzie & Bailey 2004). We found that the model fitted the data well. (χ^2 = 1.44, p = 0.17, 10,000 bootstraps). This suggests that the assumptions of the model are met. The procedure for selecting the model (information-theoretic model selection [Burnham & Anderson 2002]) enabled to highlight the variables that best explain the detection probability p and the proportion of sites occupied Ψ (Tab. 3).

Fig. 5. Maximun number of *N. tessellata* observed at each surveyed object during a 2 hour visit. Original map and data by KARCH with modifications by the authors. © karch/swisstopo.

Tab. 3. *Model selection*: The model that describes the data best is the one with the lowest AIC value. Models with w <0.0001 are not shown, with the exception of the null model with constant ψ and p. AIC = Akaike information criterion, w = Akaike weight, K = number of model parameters, ψ = proportion of sites occupied, p = probability of detection, SE = standard error.

Model	***AIC***	***ΔAIC***	***w***	***K***	***ψ***	***SE(ψ)***	***p***	***SE(p)***
Ψ (*NO_REC*), p (*ECO*, *VEG*)	198.68	0	0.5223	5	0.78	0.08	0.61	0.07
Ψ (*NO_REC*), p (*ECO*)	200.08	1.40	0.2594	4	0.76	0.08	0.63	0.06
Ψ (.), p (*ECO*, *VEG*)	201.90	3.22	0.1044	4	0.82	0.06	0.59	0.07
Ψ (*NO_REC*), p (*VEG*)	203.29	4.61	0.0521	4	0.77	0.08	0.61	0.06
Ψ (.), p (*ECO*)	204.55	5.87	0.0278	3	0.80	0.06	0.61	0.06
Ψ (*LAST_REC*), p (*VEG*)	206.06	7.38	0.013	4	0.77	0.08	0.61	0.06
Ψ (.), p (*VEG*)	207.67	8.99	0.0058	3	0.81	0.06	0.60	0.06
Ψ (.), p (*STRUCT*)	207.92	9.24	0.0051	3	0.82	0.07	0.58	0.06
Ψ (*NO_REC*, *LAST_REC*), p (.)	208.67	11.28	0.0035	3	0.73	0.09	0.66	0.05
Ψ (*VEG*), p (*VEG*)	209.64	10.96	0.0022	4	0.82	0.14	0.59	0.07
Ψ (*NO_REC*), p (.)	209.96	11.28	0.0019	3	0.73	0.07	0.66	0.05
Ψ (*LAST_REC*), p (.)	212.39	13.71	0.0006	3	0.74	0.08	0.65	0.05
Ψ (.), p (*VEG*)	213.16	14.48	0.0004	3	0.76	0.07	0.64	0.06
Ψ (*PEND*), p (.)	214.00	15.32	0.0002	3	0.74	0.08	0.65	0.05
Ψ (*VEG*), p (.)	214.00	15.32	0.0002	3	0.74	0.08	0.65	0.05
Ψ (.), p (*LAST_REC*)	214.81	16.13	0.0002	3	0.81	0.07	0.59	0.06
Ψ (.), p (*OPERATOR*)	214.95	16.27	0.0002	3	0.75	0.07	0.66	0.07
Ψ (*STRUCT*), p (.)	215.02	16.34	0.0001	3	0.74	0.09	0.65	0.05
Ψ (.), p (*ALT*)	215.03	16.35	0.0001	3	0.77	0.07	0.64	0.06
Ψ (*WATER*), p (.)	216.87	18.19	0.0001	3	0.75	0.08	0.65	0.05
Ψ (.), p (.)	218.51	19.83	0	2	0.75	0.07	0.65	0.05
Weighted Mean					0.78	0.08	0.61	0.07

Fig. 6. A rip-rap along the lakeshore inhabited by a dense population of *N. tessellata*, Brissago, Lake Maggiore. A typical man-made object suitable for dice snakes. Photo: Konrad Mebert.

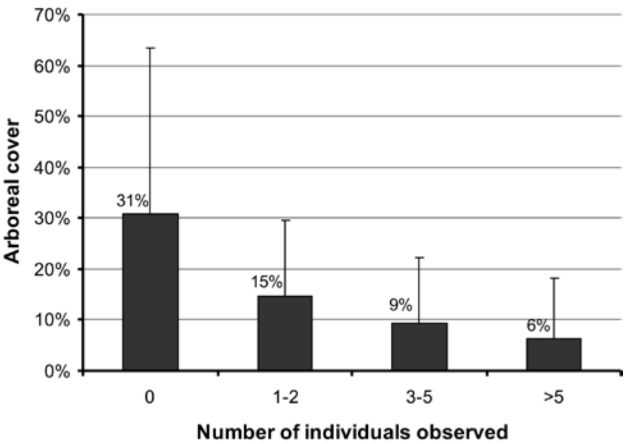


Fig. 7. Relationship between the maximum number of individuals observed during a visit (*Max ind*) and the degree of arboreal vegetation cover (*Veg*).

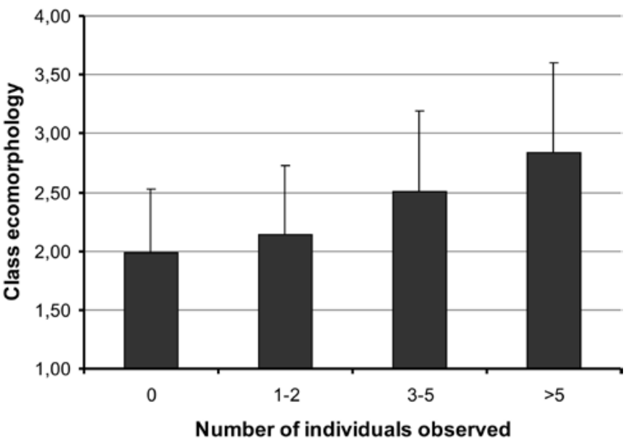


Fig. 8: Relationship between the maximum number of individuals observed during a visit and the ecomorphology class (*Eco*: 1 = river or lake shore from natural to semi-natural, 2 = little compromised (artifical), 3 = strongly compromised, 4 = fully artificial).

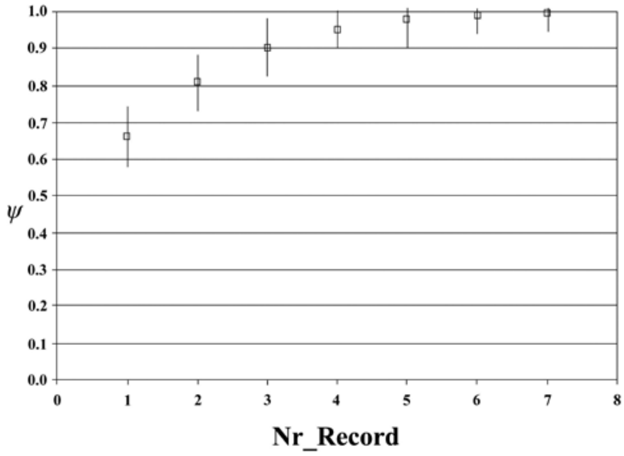


Fig. 9. Probability of occupation of a site (Ψ) depending on the number of records of *N. tessellata* from the database of the KARCH (*Nr_Record*), according to the prediction of the model Ψ (*Nr_Record*), *p* (*Eco*, *Veg*).

Regarding the detection probability *p*, the best explanatory variables are: (1) the class of ecomorphology (*Eco*) of the stream or lake shore according to a graduated modular system ("Modul-Stufen-Konzept", Hütte & Niederhauser 1998), and (2) the arboreal tree cover (*Veg*) in a buffer of 20 meters along the river or lake shore (calculated by using GIS analysis applied on national maps 1:25'000). The model indicates that the detection probability *p* is lower along rivers and lakeshores characterized by a natural or semi-natural ecomorphology compared with sites exhibiting little or substantial anthropogenic influence. For example, such sites often yield artificial embankments, such as rip-raps (embankment made of large block stones, Fig. 6) and other retaining works (i.e. stone walls). Further, the model indicates that *p* is lower at sites with high arboreal tree cover compared to sites with low or no tree cover. An *a posteriori* analysis of these variables in function with the maximum number of individuals observed per site confirms their importance (Fig. 7); unfortunately, we could not estimate abundance using the Royle (2004) models, most likely because the closure assumption was violated (M. Kéry & B.R. Schmidt, unpublished results). With regard to the variable *Eco* (class of ecomorphology), the sites where the species has not been observed yielded an average of *Eco* = 1.98 (± 0.54), which corresponds to watercourses and lakeshores with little anthropogenic influence (Fig. 8). Sites where one or more individuals were observed, showed a gradual increase in the class of ecomorphology (artificiality of the bank/shore) to reach its highest level in a group of sites with more than five observed individuals, which yielded an average value of *Eco* = 2.83 (± 0.77). This group corresponds to water courses or lakeshores that are heavily modified by man. As regards to canopy cover (*Veg*), sites, where no snakes could be detected, yielded a relatively high average with *Veg* = 30.7% (± 32.27), hence, approximately a third of these sites are covered with shading trees. Sites with one

Burnham, K.P. & D.R. Anderson (2002): Model Selection and Multimodal Inference: A Practical Information-Theoretic Approach. Second Edition. – Springer-Verlag, New York

Carlsson, M., Kärvemo, S., Tudor, M., Sloboda, M., Mihalca, A.D., Ghira, I., Bel, L. & D. Modrý (2011): Monitoring a Large population of dice snakes at Lake Sinoe in Dobrogea, Romania. – Mertensiella **18**: 237–244.

Conelli A.E. & M. Nembrini (2007): Studio radiotelemetrico dell'habitat della Biscia tassellata, *Natrix tessellata* (Laurenti, 1768) in tre popolazioni del Cantone Ticino (Svizzera). – Bollettino della Società Ticinese di Scienze Naturali **95**: 45–54.

Conelli, A.E. & M. Nembrini (2009): Conservazione della Natrice tassellata in Ticino – Piano d'Azione Specifico Sintesi degli Studi 2004–2009. – Unpubl. report.

Conelli, A.E., Nembrini, M. & K. Mebert (2011): Different habitat use of dice snakes, *Natrix tessellata*, among three populations in Ticino Canton, Switzerland. – A radiotelemetry study – Mertensiella **18**: 100–116.

Conelli, A.E., Nembrini, M., Mebert, K. & B.R. Schmidt (2009): Monitoraggio della Biscia tassellata, *Natrix tessellata* (Laurenti, 1768) nel Cantone Ticino (Svizzera). – Bollettino della Società Ticinese di Scienze Naturali **97**: 27–34.

Duda, M., Grillitsch, H., Hill, J. & R. Klepsch (2007): The dice snake *Natrix tessellata* (Laurenti, 1768), in the Southern Vienna Basin and along the eastern edge of the Alps (Lower Austria) (Squamata: Serpentes: Colubridae). – Herpetozoa **20**(1/2): 35–56 (in German with English abstract).

Fossati, A. & T. Maddalena (2003). Strategia cantonale per lo studio e la protezione di Anfibi e Rettili, Principi e indirizzi. – Ufficio cantonale natura e paesaggio, Museo cantonale di storia naturale, Esperto del KARCH. Repubblica e Cantone Ticino.

Grillitsch, H. & A. Cabela (1992): Das potentielle Verbreitungsgebiet der Würfelnatter, *Natrix t. tessellata* (Laurenti, 1768), in Österreich. – Herpetozoa **5**(3/4): 119–130.

Gruschwitz, M., Lenz, S., Mebert, K. & V. Lanka (1999): *Natrix tessellata* (Laurenti, 1768) – Würfelnatter. – In: Böhme W. (Ed.): Handbuch der Reptilien und Amphibien Europas, **Vol. 3**/Schlangen II. – AULA Verlag, Wiesbaden, Germany: 581–644.

Hofer, U., Monney, J.C. & G. Dušej (2001): I rettili della Svizzera: Distribuzione, Habitat, Protezione. – Birkhäuser Verlag, Basel, Switzerland.

Hütte, M. & P. Niederhauser (1998): Ecomorphologie Niveau R (région). Méthodes d'analyse et d'appréciation des cours d'eau en Suisse. – L'environnement pratique Nr. 27, Office Fédéral de l'Environnement (OFEV), Bern, Switzerland.

Kéry, M. (2002): Inferring the absence of a species – A case study of snakes. – Journal of Wildlife Management **66**: 330–338.

Kéry, M. (2004): Extinction rate estimates for plant populations in revisitation studies: importance of detectability. – Conservation Biology **18**: 570–574.

Kéry, M. (2008): Estimating abundance from bird counts: binomial mixture models uncover complex covariate relationships. – The Auk **125**: 336–345.

Kéry, M. & B.R. Schmidt (2008): Imperfect detection and its consequences for monitoring for conservation. – Community Ecology **9**: 207–216.

Lenz, S., Mebert, K. & J. Hill (2008): Die Würfelnatter – Reptil des Jahres 2009. – In: Die Würfelnatter, Reptil des Jahres, Aktionsbroschüre. – DGHT, Rheinbach, Germany.

Luiselli, L. (2006): Site occupancy and density of sympatric Gaboon viper (*Bitis gabonica*) and nose-horned viper (*Bitis nasicornis*). – Journal of Tropical Ecology **22**: 555–564.

MacKenzie, D.I. (2005): What are the issues with presence-absence data for wildlife managers? – Journal of Wildlife Management **69**: 849–860.

MacKenzie, D.I. & L.L. Bailey (2004): Assessing the fit of site-occupancy models. – Journal of Agricultural, Biological, and Environmental Statistics **9**: 300–318.

MacKenzie, D.I., Nichols, J.D., Lachman, G.B., Droege, S., Royle, J.A. & C.A. Langtimm (2002): Estimating site occupancy rates when detection probabilities are less than one. – Ecology **83**: 2248–2255.

Mazerolle, M.J., Bailey, L.L., Kendall, W.L., Royle, J.A., Converse, S.J. & J.D. Nichols (2007): Making great leaps forward: accounting for detectability in herpetological field studies. – Journal of Herpetology **41**: 672–689.

Mebert, K. (1993): Untersuchungen zur Morphologie und Taxonomie der Würfelnatter *Natrix tessellata* (Laurenti 1768) in der Schweiz und im südlichen Alpenraum. – M.S. thesis, Zoological Museum, University of Zürich, Switzerland.

Mebert, K. (1996): Comparaison morphologique entre des populations introduites et indigènes de *Natrix tessellata* de l'Arc Alpin. – Bull. Soc. Herp. Fr. **80**: 15–25

Mebert, K. (2001): Die Würfelnatter am Lopper. – Naturforschende Gesellschaft Ob- und Nidwalden (NAGON), Grafenort, Switzerland: 156–161

Mebert, K. (2007): Die Würfelnatter am Brienzersee. – UTB Publ., Thun, Switzerland: 156–161.

Mebert, K. (2011a): Introduced and indigenous populations of the dice snake, *Natrix tessellata,* in the Central Alps – Microgeographic variation and effect of inbreeding. – Mertensiella **18**: 71–79.

Mebert, K. (Ed.) (2011b): The Dice Snake, *Natrix tessellata*: Biology, Distribution and Conservation of a Palaearctic Species. – Mertensiella **18**, DGHT, Rheinbach, Germany

Meisner, F. (1820): Ueber die in der Schweiz einheimischen Schlangen überhaupt und die Vipern insbesondere. – Museum der Naturgeschichte Helvetiens. I. Band (11): 81–95.

Meyer, A., Zumbach, S., Schmidt. B. & J.-C. Monney (2009): Auf Schlangespuren und Krötenpfaden – Amphibien und Reptilien der Schweiz. – Haupt Verlag, Bern, Switzerland.

Monney, J.-C. & A. Meyer (2005): Rote Liste der gefährdeten Reptilien der Schweiz. –Bundesamt für Umwelt, Wald und Landschaft, Bern, und Koordinationsstelle für Amphibien- und Reptilienschutz in der Schweiz, Bern, BUWAL-Reihe: Vollzug Umwelt.

Neumann, C. & K. Mebert (2011): Migration behavior of endangered dice snakes (*Natrix tessellata*) at the River Nahe, Germany. Mertensiella **18**: 39–48.

Pellet, J. & B.R. Schmidt (2005): Monitoring distributions using call surveys: estimating site occupancy, detection probabilities and inferring absence. – Biological Conservation **123**: 27–35.

Preston, F.W. (1979): The invisible birds. – Ecology **60**: 451–454.

Strugariu, A., Gherghel, I., Ghira, I., Covaciu-Marcov, S.D. & K. Mebert (2011): Distribution, habitat preferences and conservation of the dice snake (*Natrix tessellata*) in Romania. – Mertensiella **18**: xxx–yyy.

Royle, J.A. (2004): N-mixture models for estimating population size from spatially replicated counts. – Biometrics **60**: 108–115.

Royle, J.A. & J.D. Nichols (2003): Estimating abundance from repeated presence-absence data or point counts. – Ecology **84**: 777–790.

Velenský, M., Velenský, P. & K. Mebert (2011): Ecology and ethology of dice snakes, *Natrix tessellata*, in the city district Troja, Prague. – Mertensiella **18**: 157–176.

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Fatal Hunting Accidents: Killing of Dice Snakes (*Natrix tessellata*) by Bullheads (*Cottus gobio*)

Konrad Mebert & Wolfgang Pölzer

Abstract. We report on two similar hunting accidents involving a dice snake and a bullhead fish. Predator and prey died in both accidents, which occured on the southern slopes of the Alps, one in Switzerland and one in Italy.

Key words. *Natrix tessellata, Cottus gobio*, prey, predation, fatal accident

Accident 1

A female dice snake of 98 cm was observed foraging on 25 July 2006 among rocks in the river Maggia near the campground Piccolo Paradiso, Avegno, Switzerland. The struggle with the pictured 10 cm long bullhead appeared to begin around 10:40, when erratic movements of the snake were observed by several tourists. It lasted for approximately 30 minutes, whereupon the snake slowed down its movements and apparently died, while the fish was still alive. They were subsequently removed from the water when the photographer arrived (Fig. 1). It is not clear, what caused its death, since the opening of the airtube was still free to breathe air. The accounts from bystanders were not sufficient to clarify, whether the fish could keep the snake for such a prolonged period under water, until the snake drowned. Oxygen requirement are likely to be higher under stress situation and reduces the time a dice snake can remain submerged.

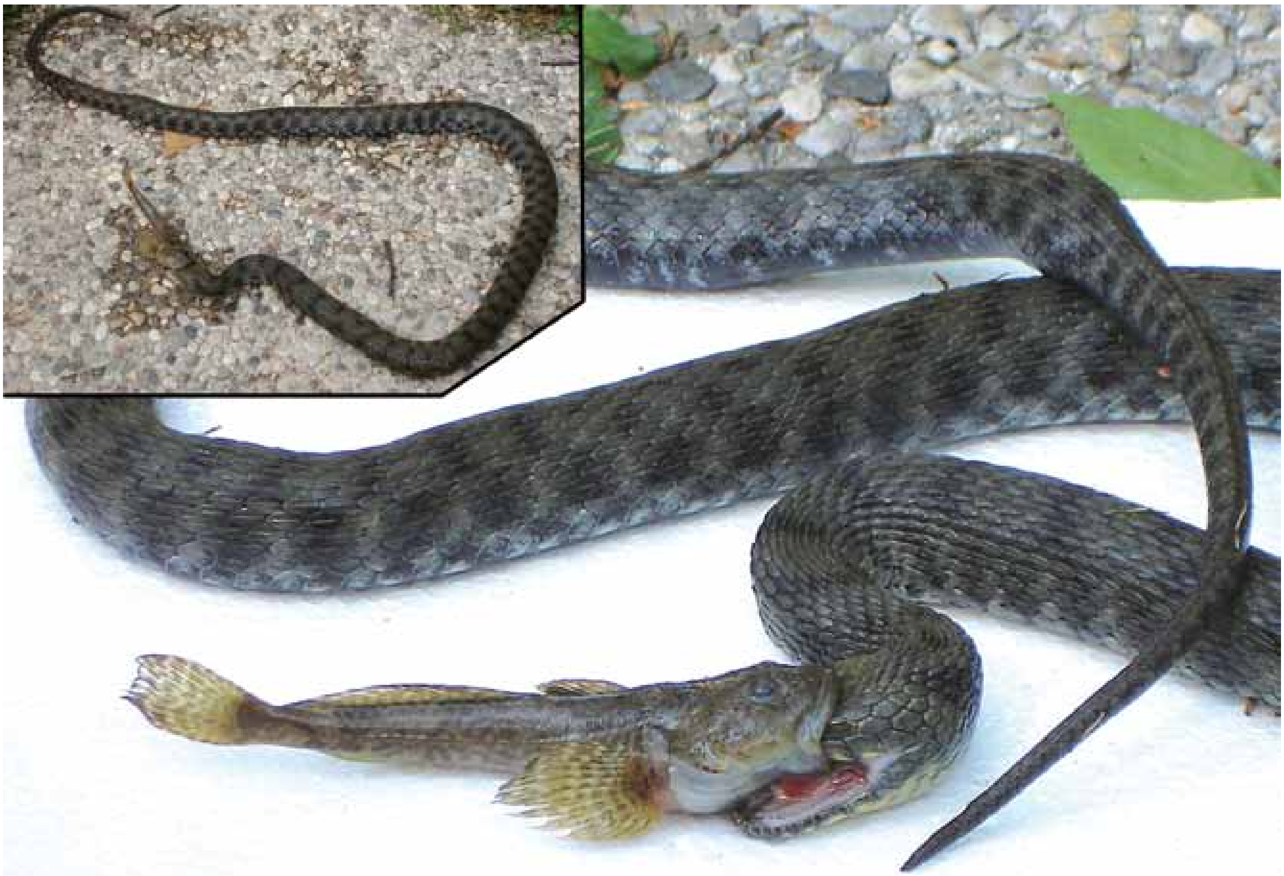

Fig. 1. Photo: Marco Cattaneo.

study area, delimiting the total habitat to a size of at least 1555 m.

History

Štěpánek (1949) was the first to mention Prague as a locality for the dice snake, though he gave no more details. Zdeněk Vágner, a keeper at the zoo, observed the dice snake in the 1940's (pers. comm.). In the 1960s and 1970s, Aldo Olexa, a past reptile keeper at Prague Zoo, observed dice snakes at the Vltava River (pers. comm.).

The construction of the present embankment began in 1980, when the second author started to monitor the dice snake with 3–4 visits per year in the study area (P. Velenský, unpubl.). At that time, the embankment was significantly lower, the stones were sealed with concrete leaving the embankment devoid of crevices and, hence, important refuges for the dice snake as there are today (Fig. 7). In addition, the bank was divid-

Fig. 9. The cover of a sewer manhole that guides wastewater to the sewage plant, and the open sewer, a 6 m deep trap for snakes. Photo: Mikuláš Velenský and Konrad Mebert

Fig. 7. Remains of the old, sealed embankment, and below the new, loose assemblage of rocks. Photo: Mikuláš Velenský

Fig. 10. A ladder leading down the sewer manhole with adult dice snakes sitting on it. Photo: Mikuláš Velenský

Fig. 8. A fishpond in the Prague Zoo that is used as a hunting ground by young dice snakes. Photo: Konrad Mebert

Fig. 11. Hatchlings fallen into the sewer manhole. Photo: Mikuláš Velenský

Fig. 29. Panoramatic view of a part of the major hibernation site. Photo: Mikuláš Velenský

Ecdysis

On 3 July 2005 at the start of our monitoring program, the majority of the females had freshly shed, and the last females just before shedding were recorded on 9 July. Approximately six weeks later, females with opaque eyes ready for shedding or others right after shedding were recorded again from 20 to 30 August. In 2006 the first wave of ecdysis took place between 24 June and 3 July, and then again from 2 August to 20 August. Of the five snakes caught for the telemetry study on 14 April 2006, two males and one female had just shed, whereas two females exhibited opaque eyes and shed on 20 August.

In summary for both years on record, adult female dice snakes shed their skin twice a year. The first shedding occurred before oviposition, at the end of June to early July. The second shedding was accomplished in August. Males in preecdysis state were sampled at a similar period as the females, but we have insufficient information to state that they shed twice a year.

Autumn Migration

Females' activity in the summer area gradually decreased during August. Females leaving the summer

Fig. 30. Migration of male dice snake no 3. After his release on 23 August (yellow X), the male moved to point 1 within two days, stayed for 19 days (25 August to 11 September), and begun its return towards the hibernation site. He moved on 12 September to point 2, on 13 September to point 3, where he remained until the next day, and continued to point 4, where it rested until the morning of 19 September, when he climbed up to its hibernation site (white X).

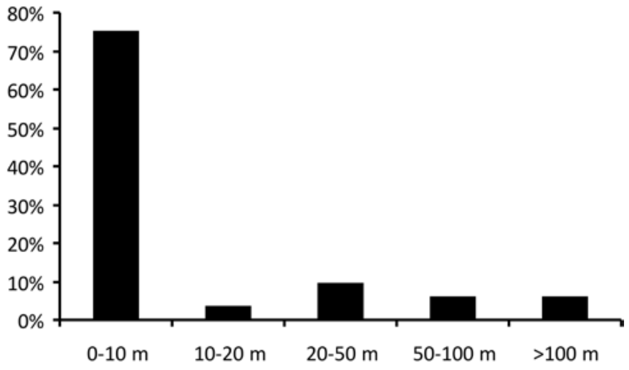

Fig. 5. Proportion of capture sites of dice snakes (*Natrix tessellata*) in relation to the distance from the nearest water body in Slovenia (n = 117).

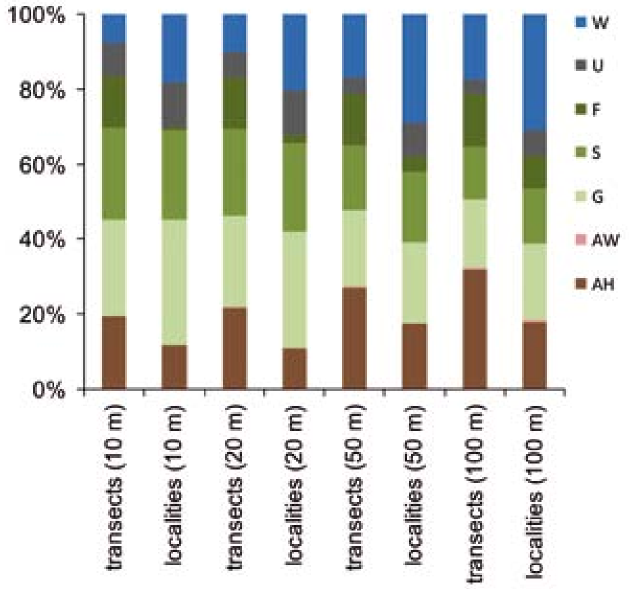

Fig. 6. Available habitat types (transects) and habitat types used by dice snakes (*Natrix tessellata*) (localities) at study area Sava Site with buffer zones of 10, 20, 50 and 100 meters around transect lines or capture sites. Habitat types are: water body (W), urban land (U), forest (F), shrubs (S), grassland (G), agricultural land with woody plants (AW), and agricultural land with herbaceous plants (AH).

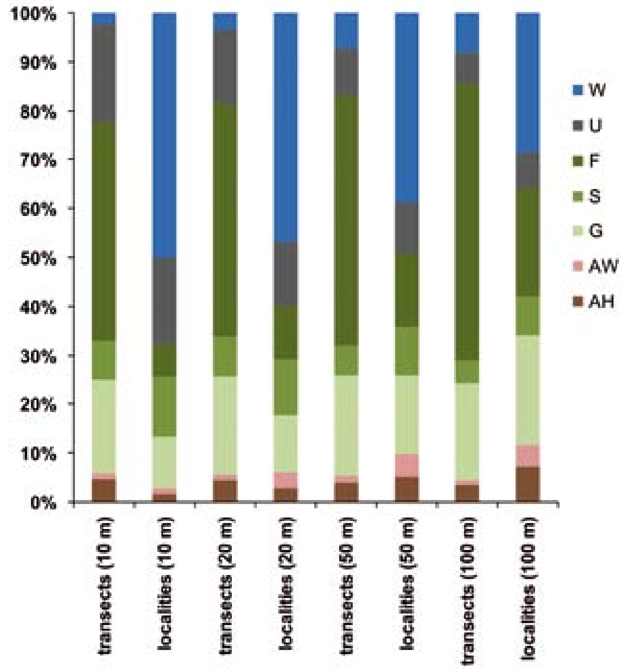

Fig. 7. Available habitat types (transects) and habitat types used by dice snakes (*Natrix tessellata*) (localities) at study area Kolpa Site with buffer zones of 10, 20, 50 and 100 meters around transect lines or capture sites. See Fig. 6 for legend on habitat.

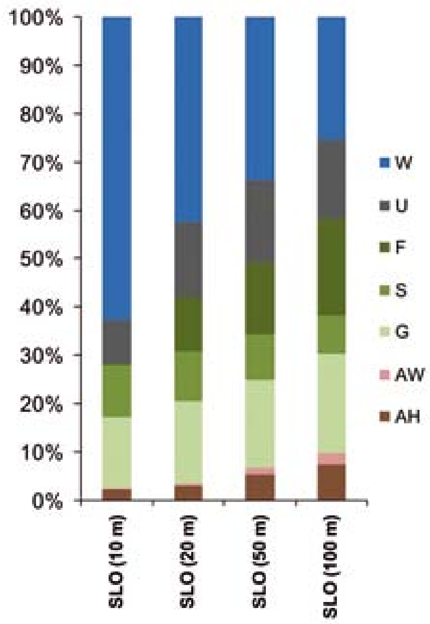

Fig. 8. Average land use in a 10, 20, 500 and 100 meter buffer zone around capture sites of dice snakes (*Natrix tessellata*) in Slovenia (n = 117) (see Fig. 6 for legend on habitat types).

tance from all inspected transect lines. Next, we calculated habitat composition for dice snakes by applying circle buffers around individual snake finds with the perimeter of 10, 20, 50 and 100 meters. The maximum buffer includes known average home ranges of dice snakes, which are approximately 0.23–2 hectares in size (Conelli & Nembrini 2007, Conelli at al. 2011, Neumann & Mebert 2011). We compared the available habitat types in the area with habitat types actually occupied by dice snakes using ESRI ArcView 3.2 software. The same software was combined with the digital elevation model (DEM 25) and land use (MKGP 2007) to analyze habitat use on a country-wide scale from the second data set (see above).

Results

Distribution in Slovenia

All currently known localities of dice snakes in Slovenia are distributed across 104 UTM squares of 10 x 10 km with 117 precise locality records (Fig. 4). This represents 39% of all UTM squares in Slovenia. The majority of localities with dice snakes in Slovenia lie between 140 and 285 m a.s.l. (Q_1 and Q_3 quartile). Based on precise data only, dice snakes have been observed from sea level, at the saltpans of Sečovlje and at Škocjanski zatok in coastal Slovenia (Basiaco et al. 1997), to the elevation of 495 m a.s.l. at Ribnica, southern Slovenia.

Habitat Use

Regional scale: A total of 11 dice snakes were recorded at the Sava Site and 12 dice snakes at the Kolpa Site. All of the finds were made along the river banks or very close to the water. Maximum distance from the nearest water body was 92 m (Fig. 5).

At Sava Site, available habitat types are relatively uniformly distributed with a slightly larger portion of agricultural land with herbaceous plants, grasslands and shrubs (Fig. 6: transects). There is only little agricultural land with woody plants available as habitat. Comparison between habitat availability and habitat occupied by dice snakes (Fig. 6: localities) show that the snakes were detected more often in water, grasslands and urban areas than expected from the habitat availability. On the other hand, snakes were found less often in forest and agricultural land with herbaceous plants than expected.

Fig. 9. Site of several dice snakes (observed in left lower corner of image) near a cliff approximately 50–100 m above a cool mountain stream at Zaga, at 370 m a.s.l. in northwestern Slovenia. Presumably, dice snake seek that area for thermoregulatory activities, possibly also oviposition and hibernation, as the cool temperatures of the shady canyon below, where they would forage, are unlikely areas to provide suitable elevated temperatures. Shaded areas, in particular in the canyon, were digitally elucidated to get a better view on the structure and height of the cliff. Photo: Konrad Mebert.

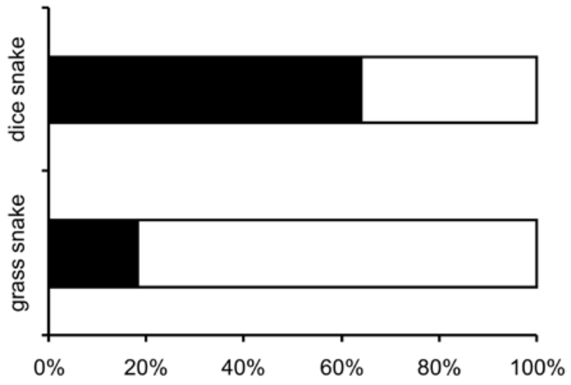

Fig. 3. Selection of prey type in dice snakes (*Natrix tessellata)* and grass snakes (*Natrix natrix*) according to preferred swimming depth of fish species. Black = benthic, white = water column.

There were significant differences in using microhabitats between dice snakes and grass snakes, resulting in a very low niche overlap O_{jk} for those two species of 0.302. Shallow lake, area of common reed and canals were chosen similarly frequent. An obvious difference was in their frequency of using ponds (dice snakes 4.8%, grass snakes 32.6%), and running water (dice snake 23.1%, grass snake 4.34%) (Fig. 4). A significant difference was also found for substrate use. Although both species mainly used substrate with dense vegetation (53.3% of dice snakes and 81.5% of grass snakes), dice snakes were found more frequently on stony substrate (31.4%) than grass snakes (4.35%).

The majority of dice snakes were caught in water (71.6 %), whereas in grass snakes the proportion of animals caught in water (53.3%) and land was similar (46.7%). Dice snakes appeared to forage most often on the lake ground and were similarly frequently detected in the water column and the surface (Fig. 5). In contrast, nearly all grass snakes (93.6%) were observed on the water surface, and those detected on the lake ground or in the middle of the water body were so in shallow water

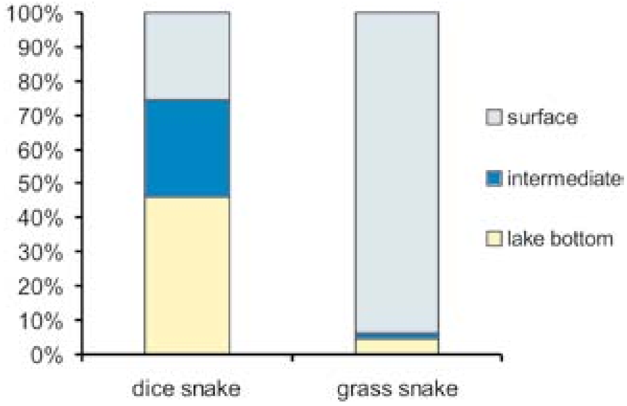

Fig. 5. Position of snakes in the water column. Legend defines proportion of snakes found on the water surface, within the water column (intermediate), and on the lake bottom.

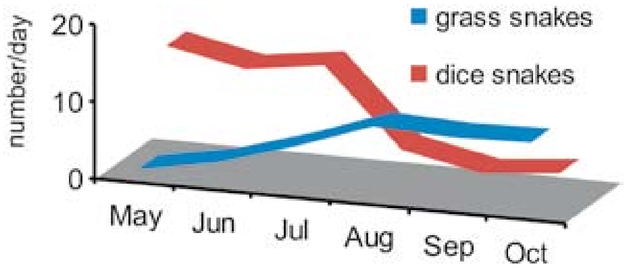

Fig. 6. Annual activity of dice snakes and grass snakes from Baćina lakes: number/days – number of snakes caught per field day.

(depth < 50 cm). Yet, the overlap between these two species is with $O_{jk} = 0.671$ still relatively high.

For dice snakes a visually greater activity was recorded in the first part of the year from May–July, whereas for grass snakes activity was greater in the second part of the year from July–October (Fig. 6). Dice snakes extended their activity over a longer daily period than syntopic grass snakes. Difference in types of activity between dice snakes and grass snakes is shown in Fig. 7.

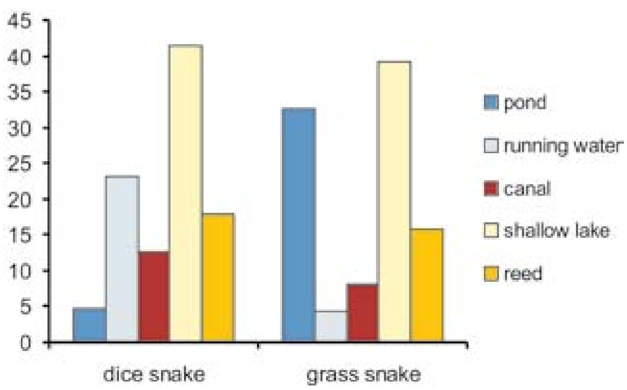

Fig. 4. Microhabitat usage in dice snakes and grass snakes at Baćina lakes.

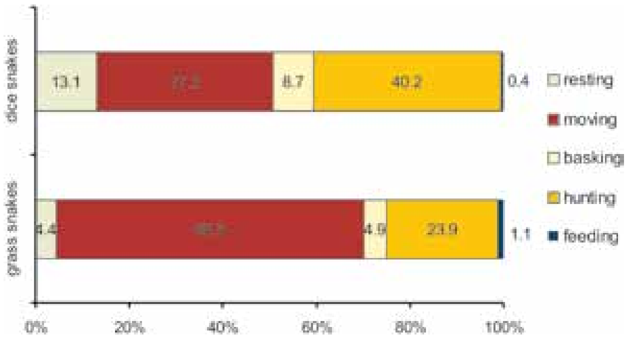

Fig. 7. Proportional distribution of activity types summarized over two seasons in dice snakes (*Natrix tessellata)* and grass snakes (*Natrix natrix*) from Baćina lakes.

Fig. 2. The ruins in Histria as seen in late summer: above) Facing south, with Lake Sinoe, as close as 20 m from the ruins, in the left part of the picture; below) In the southern part of the ruins facing northeast with the main wall to the far left.

each captured snake time consuming and ineffective, hence releasing the snakes exactly at the point of capture (e.g. within 10 m) has proven logistically difficult. However, capture-recapture data from other studies involving dice snakes indicates that the snakes exhibit a familiarity of their surroundings within a few hundred meters (Bendel 1997, Lenz & Gruschwitz 1993, Conelli & Nembrini 2007, Conelli et al. 2011, Neuman & Mebert 2011, Velensky et al. 2011), hence, the release of individuals some distance from their capture site can be justified.

Fieldwork was conducted during most of the active season 2006 and intermittently during 2007 and 2008, specifically between the following dates for each respective season: 27 March – 17 October 2006, 17 April – 18 October 2007 and 8 April – 19 October 2008. The intensity of fieldwork, i.e. total number of field days, varied between seasons and years (Tab. 2). In 2006 there was an almost daily presence of at least two persons, whereas the senior author conducted most fieldwork alone in the following two seasons, except during two weeks in spring and five days in July 2007 and four days in 2008. Fieldwork intensity is presented in Table 2 as days of successful snake capture. Thus, days of unsuccessful work due to weather are equated with days of no fieldwork due to absence. We have divided each season into two periods of equal length for analytical purposes. The date of separation, 8 July, roughly corresponds to the end of ovipositing by gravid females, these being the last to leave the waters in the vicinity of the ruins after hibernation, supposedly having been foraging nearby during pregnancy. All snakes, except gravid females, appear to be rather mobile and only stay along a given stretch of shoreline for a few days for foraging (Kärvemo et al. 2011). Hence, the first period (Period 1) approximates the time of dispersal from hibernation grounds to mid season, while the second period (Period 2) encompasses the time of return. We compared fieldwork success between years, between periods within years and within periods between years for total number of snakes caught compared to expectations derived from both mean values of captured snakes per day of capture (C/DOC) and captures per day per field worker (C/DOC/MNP, i.e. Capture per Day of Capture per Mean Number of Persons) using X^2-tests. To analyse capture rate (C/DOC) over periods and years, an ANOVA test was applied using the software package R (R Development Core Team 2006).

Only adult individuals are included in the present article. We defined adults as having a minimum snout-vent length (SVL) of 48 cm in males and 55 cm in females in accordance with Lusielli & Rugiero (2005).

Tab. 1. Statistic summary of SVL and tail length measurements for adult male and female *Natrix tessellata* from Histria, as defined in this report, from three consecutive field seasons combined. All individuals with severed tails have been removed.

	Females (n = 1522)		Males (n = 1810)	
	SVL	Tail Length	SVL	Tail Length
Mean	70.37	17.15	57.95	16.25
Mode	72.50	16.50	56.50	16.50
Median	69.50	17.10	57.70	16.30
Range	55.00–99.00	12.50–23.50	48.00–74.50	11.50–20.60
Stand. Dev.	±8.33	±1.88	±4.78	±1.42
Lower Quartile	64.30	15.70	54.52	15.30
Upper Quartile	76.10	18.50	61.10	17.20

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Parasitism in the Dice Snake (*Natrix tessellata*) – a Literature Review

Andrei Daniel Mihalca

Abstract. A review of studies on the parasitic fauna of dice snakes is presented. The highest number of parasitological works originates from former soviet authors. The systematic diversity of parasites is high and includes Protozoa (4 genera), Trematoda (19 genera), Cestoda (3 genera), Acanthocephala (2 genera), Nematoda (22 genera) and Arthropoda (1 genus). General life-cycles and contamination routes, as well as the pathogenic effect of parasites on dice snakes, are discussed.

Keywords. Squamata, *Natrix tessellata*, parasites, helminth, protozoa, trematoda, cestoda, nematoda, arthropoda

Introduction

Since its description by Laurenti in 1768, several authors published results regarding parasitic fauna of dice snakes from various locations throughout its distribution range. By far, the highest amount of parasitological works on *Natrix tessellata* relates to former soviet authors dealing with helminth fauna. Except original articles and communications, several reviews on parasitic helminths of reptiles from the former USSR were published, usually as part of a general review on reptile parasite fauna. For example, Sharpilo (1964) reviewed the larval nematodes parasitic in reptiles from Ukraine and followed with an extensive review on parasitic helminths of reptiles from the USSR (Sharpilo 1976). Two bibliographical lists were published by Markov et al. (1969) for ecology and parasitology (i.e. parasitic protozoa, helminths and arthropods) of Squamata and by Markov et al. (1972) for helminthology (trematodes, cestodes, nematodes and acanthocephalans) of Squamata. More recent reviews on the helminths of reptiles from the Volga basin were published by Evlanov et al. (1996, 2001, 2002) and Kirillov (2002, 2006) with Bakiev (2004) summarizing the previous data on parasites of snakes from the middle Volga region. Reviews on protozoa of reptiles were made by Ovezmukhammedov (1987, 1991). However, all of these reviews are available only in Russian and are focused on specific regions of the former USSR. One review work published in English, including data on dice snakes is the extensive checklist of nematodes parasitic in amphibians and reptiles by Baker (1987).

The current review presents a systematic account of all parasitic species recorded in *N. tessellata* across its entire geographical range. Original papers, communications, case reports and reviews are all considered and cited. Specific data on epidemiology, life cycles and pathology will be mentioned where available. Comments on possible misidentification are also provided.

Diversity, Ecology and Biology of Parasites in *Natrix tessellata*

Ecology of a host greatly influences its parasitic fauna. As in many other semiaquatic snakes, the diversity of parasitic species in dice snakes is relatively high. Most of the parasitological publications on *N. tessellata* are host reports from certain geographical areas, with the majority of them including data on parasite location in the host and epidemiological results (prevalence, intensity range, mean intensity). All these data are summarized in Tables 1–6.

The general overview of literature suggests that the majority of the examined snakes are infected by helminth parasites (prevalence of parasitism was 100% in many of the studies), whereas protozoans and arthropods have rarely been reported. One reason for the low number of protozoans reported in dice snakes is because usually parasitological exams skipped the techniques for unicellular parasites and focused on helminth fauna instead. Even though, some studies included microscopic examinations, their results were negative for protozoan parasites (Markov & Bogdanov 1965, Markov et al. 1969). Except mites, arthropod parasites were rarely reported, mainly because of the partly aquatic life style of dice snakes. Like in the case of protozoans, few studies included ectoparasitological data, and if they did, most reported negative results (Markov & Bogdanov 1960, 1964, Markov et al. 1969).

Among helminths, adult and larval trematodes are the most prevalent parasites in *N. tessellata* (Biserkov 1989, Kirin 1994, Kirillov et al. 2001, Kirillov 2002, 2006). In a study about the Volga Delta, Ivanov (1952, 1954) found that 100% of the dissected *N. tessellata* were infected with trematodes, 20% with nematodes and 5% with each, cestodes and acanthocephalans. Regarding the number of species, nematodes constituted the most diverse group in dice snakes. Overall, 22 genera of nematodes, 19 of trematodes, 4 of protozoans, 3 of cestodes, 2 of acanthocephalans and one genus of Arthropoda have been found in *N. tessellata*. However, in some

Fig. 4. Group of snakes drowned in a single small fishing net in the vicinity of Golem Grad. The snakes were caught when chasing fish embedded in the mesh, the net was set for 3–4 hours in the water. This picture provides a snapshot of the population, and clearly illustrates sexual size dimorphism with smaller males (on the left) and larger females (right) along with the colour polymorphism from classical diced, concolor to melanistic snakes (from left to right). Although fishing is officially banned around Golem Grad (at least in the Macedonian part of the lake), this photo suggests that poaching does not only endanger fish, but could be a potential threat to dice snakes as well, and in turn may influence the whole ecosystem.

BERT 2010, TUNIYEV et al. 2011). We currently study the ecological trade-offs associated with each pattern. But our Capture-Mark-Recapture (CMR) study also involves sexual, predatory and anti-predatory behaviours (predators are abundant, otters and raptors for instance), along with hormonal aspects and long-term population monitoring.

There are several places on earth where snake populations are still prosperous, for example North America (Garter snake; SHINE et al. 2006), North Australia (although the cane toad invasion may set the systems at lower density levels for long periods; SHINE 2010), several islands around Australia (BONNET et al. 2002) and in the Caspian Sea (TUNIYEV et al. 2011), China (Sheado Island, SHINE et al. 2002), Brazil (MARQUES et al. 2002), or in the Pacific (New Caledonia; BONNET et al. 2009). We note that many of these examples are represented by relatively well protected islands. Golem Grad does not make exception to this general tendency that small islands represent the last pieces of the lost paradise. We hope that Golem Grad will be a study system that will enrich our knowledge on snake ecology and that will also contribute to improve the conservation of these reptiles. We notably expect that our study will be useful to better determine sustainable levels of tourism, and activity which is quickly growing in this part of the world.

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References

BONNET, X., PEARSON, D., LADYMAN, M., LOURDAIS, L. & D. BRADSHAW (2002): "Heaven" for serpents? A mark-recapture study of Tiger Snakes (*Notechis scutatus*) on Carnac Island, Western Australia. – Austral Ecology **27**: 442–450.

BONNET, X., BRISCHOUX, F., PEARSON, D. & P. RIVALAN (2009): Beach-rock as a keystone habitat for sea kraits. – Environmental Conservation **36**: 62–70.

CARLSSON, M., KÄRVEMO, S., TUDOR, M., SLOBODA, M., MIHALCA, A., GHIRA, I., BEL, L. & D. MODRÝ (2011): Monitoring a large population of dice snakes at Lake Sinoe in Dobrogea, Romania. – Mertensiella **18**: 245–254.

KWET, A. & K. MEBERT (2010): The Dice Snake *Natrix tessellata*. – Reptilia (GB) **72**: 39–43.

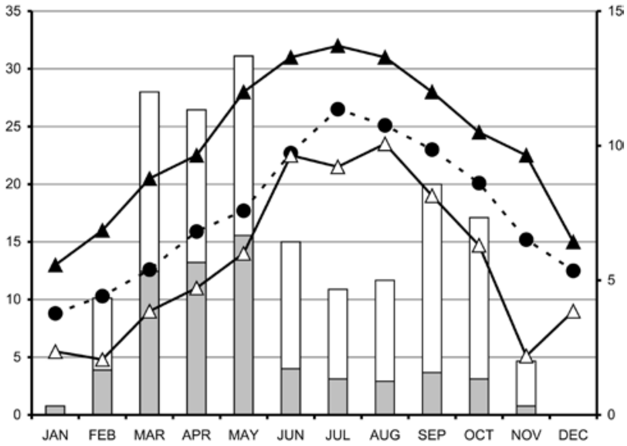

Fig. 6. Daily mean number of active *Natrix tessellata* per month (bars) along a 2.1 km road segment north of Prokopos Lagoon, Strofylia, Greece, plotted against minimum and maximum water levels (triangles) and mean air temperatures (circles). Grey part of the bar represents adults and white part individuals under 45 cm total length. Data collected during surveys in 2003 and 2004.

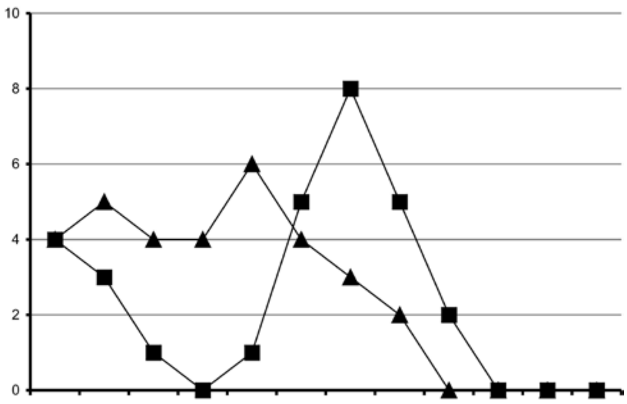

Fig. 7. Number of active *Natrix tessellata* during road counts on 18 April 2003 (triangles) and 29 October 2004 (squares) along a 2.1 km road segment north of Prokopos Lagoon, Strofylia, Greece. The horizontal axis is time in GMT+2.

with a decline at noon and a significant increase around dusk and at the early night hours.

The salinity of the Prokopos lagoon varies significantly during the year. In 2004 an environmental station 20 meters from the northern coast, where the road surveys were conducted and a connection to the sea exists, measured the salinity of the water. It ranged from 0.7 to 28 ppm (= psu) with the exception of the period from July to September, when the salinity increased to values between 32 to 43 ppm. A second station in the southern part of the lagoon where the majority of freshwater is collected, recorded similar fluctuations but the maximum salinity was with 29 ppm much lower. *N. tessellata* were active in the northern part of the lagoon even when the salinity reached saltwater levels.

Discussion

The degree of habitat overlap between the two species is low in Strofylia, even though both species can be found in a similar variety of aquatic habitats and do not exclude each other (weak correlation of a negative Spearman's coeffcient), but they inhabit the variety of aquatic habitats to different proportions. For example, *Natrix tessellata* prefers the larger water bodies that support large fish populations and avoids areas with temporary water, such as streams, ponds, and wet meadows. It seems to cope well with increased levels of salinity and the densest populations have been observed in a lagoon that yields brackish to saltwater during most of the year (Fig. 8). In contrast, *N. natrix* is distributed more evenly across the various water types. It appears to frequent similarly often temporary and permanent water bodies and prefers smaller open water bodies with abundance of shore- and floating-vegetation that have the largest breeding concentrations of frogs and toads such as ponds, wet meadows, marsh and shallow lake. A similar low overlap in the use of water habitats between *N. tessellata* and *N. natrix* has also been reported from southern Croatia (Janev Hutinec & Mebert 2011). The low interspecific overlap was attributed to their different availability and preference of prey, as *N. tessellata* was feeding exclusively on fish and *N. natrix* mostly on amphibians. In sympatric populations from Central Italy, *N. tessellata* is feeding exclusively on fully aquatic prey consisting of fish and tadpoles, whereas the more terrestrial *N. natrix* feeds to approximately 90% on amphibians, including migrating toads (Luiselli & Rugiero 1991, Filippi et al. 1996). An increased underwater vision ability of *N. tessellata* compared to *N. natrix* has been technically investigated and confirmed by Schaeffel & Mathis (1991). The availability of preferable prey items in correlation with distinct behavior was not studied in the Strofylia area, but could also explain the differences in habitat preferences (see Tab. 1 for availability and abundance of prey types in different habitats).

For example, the absence of *N. tessellata* from the surveyed stream is not understandable at the first glance, as this species has been observed in many rivers and streams throughout Greece (Trapp 2007, Valakos et al. 2008). However, stream-lake segregation has also been observed in the region of Prespa Lake, northern Greece, where *N. tessellata* is considered more common in or near the lakes and *N. natrix* is found in drainage ditches and streams (Ioannidis & Bousbouras 1997). But elsewhere, *N. tessellata* also inhabits streams (see refs. in Gruschwitz et al. 1999) or simply occupies all available open aquatic habitats, lentic and lotic systems (Mebert et al. 2011a). For example, *N. tessellata* thrives in three Mediterranean streams of central Italy with permanent or temporary water, where it feeds up to 90% on fish (Luiselli et al. 2007). At our study site in Strofylia, the observed absence of fish and the scarcity of frogs in the studied stream probably render that aquatic habitat undifferent ecological conditions and should be taken into consideration. In this paper villages are indicated as v., urban villages as u.v., others are given without special indications. In the Rostov and Volgograg provinces of Russia all settlements are correspondingly divided into cities (towns), khutors (kh.), i.e. rural homestead, small settlements, and stanitsas (st.), i.e. big villages.

Results and Discussion

The locality data on *N. tessellata* are separated in two categories. The first category includes all localities inside its continuous range, where the species is relatively abundant and the distance between neighboring populations is not more than a few tens of kilometers. The second category represents several populations that are isolated. Some of these populations are situated far north from the continuous range of the dice snake. The northern limit of the dice snake's range in Ukraine and the Don River Basin in Russia is shown on the map (Fig. 1).

Continuous Range

In Transcarpathian Ukraine *N. tessellata* is quite common. In the foothills of the southern part of the Ukrainian Carpathians and territories adjacent to the Dniester in the west of the Podolian Eminence the dice snake is associated with the Dniester valley and lower reaches of left and right tributaries of this river (Shcherbak & Shcherban' 1980, Shaitan 1999, Dotsenko 2003). In the Black Sea region its range includes most of the Odesa Province (no finds are known from its northernmost part, which might be due to insufficient exploration of this area), all the territories of the Mykolaiv, Kherson, Zaporizhzhya and Donets'k provinces, and most districts of the Crimean Autonomous Republic (Shcherbak 1966, Tarashchuk 1987, Kotenko & Kukushkin 2003, Dotsenko & Radchenko 2005, Kotenko 2007 and unpubl., Karmyshev unpubl.). In the Dnipropetrovs'k Province there are few known localities of the dice snake (Tsemsh 1937, Bulakhov et al. 2007, Kotenko unpubl.), likely reflecting insufficient prospecting in this region. Even less is known about its distribution in the Kirovograd Province, with sightings of the dice snake from only a few localities (NNHM, Kotenko

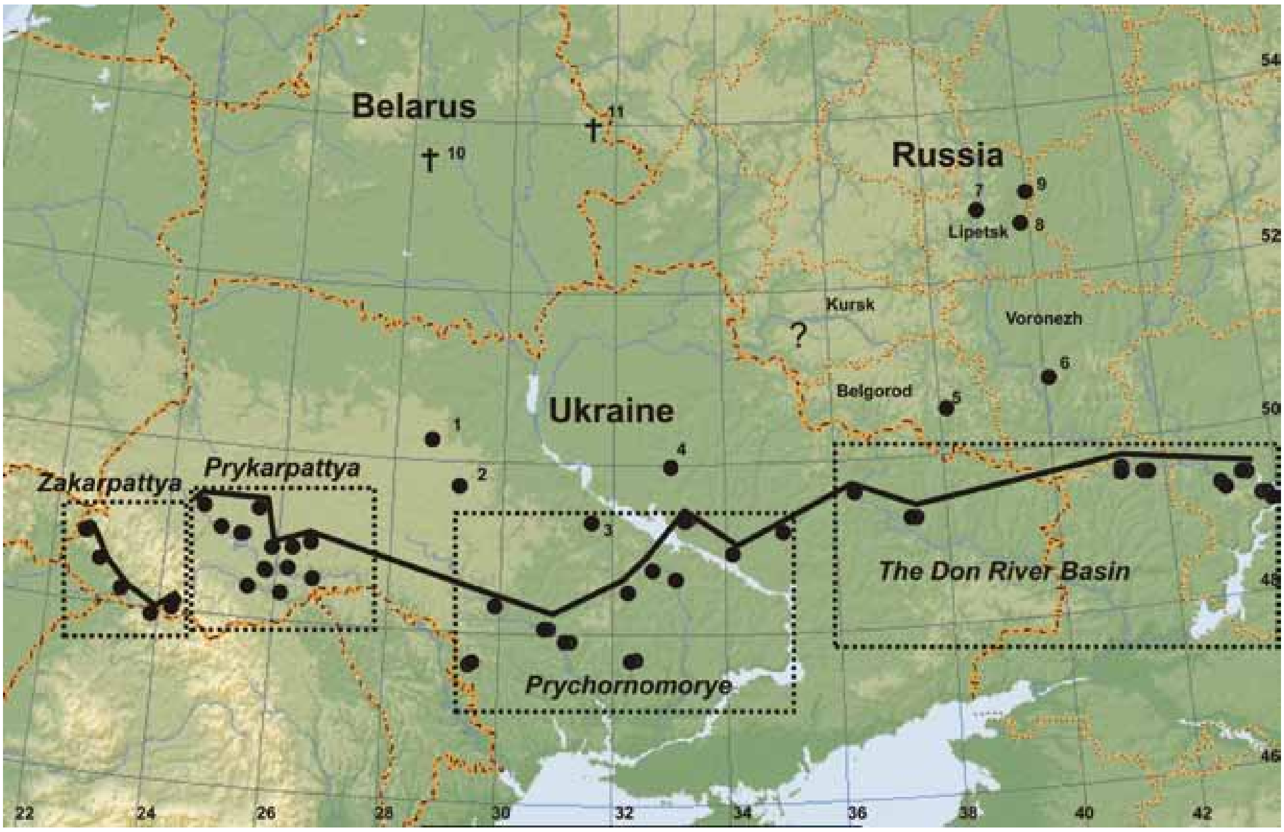

Fig. 1. The northern border of the continuous range of *Natrix tessellata* and the northernmost isolated localities in Ukraine and in the Don River basin in Russia. ● – recent populations (references and more information on localities see in the text): (1) Zhytomyr, Denyshi and the Lisova Kamyanka River; (2) Ruzhyn; (3) Cherkasy Province, no locality data; (4) Lubny and Matskova Luchka; (5) the Userdets River; (6) the Bityug River; (7) the Don River, Galichya Gora Nature Reserve; (8) Yarlukovo; (9) Preobrazhenovka. – † – fossil findings according to Ratnikov (2009): (10) Drozdy, 1.5 km to the north of Pionersky settlement, Minsk District, Belarus, Holocene; (11) v. Lopatino, Mstislav District, Mogilev Province, Belarus, Holocene.

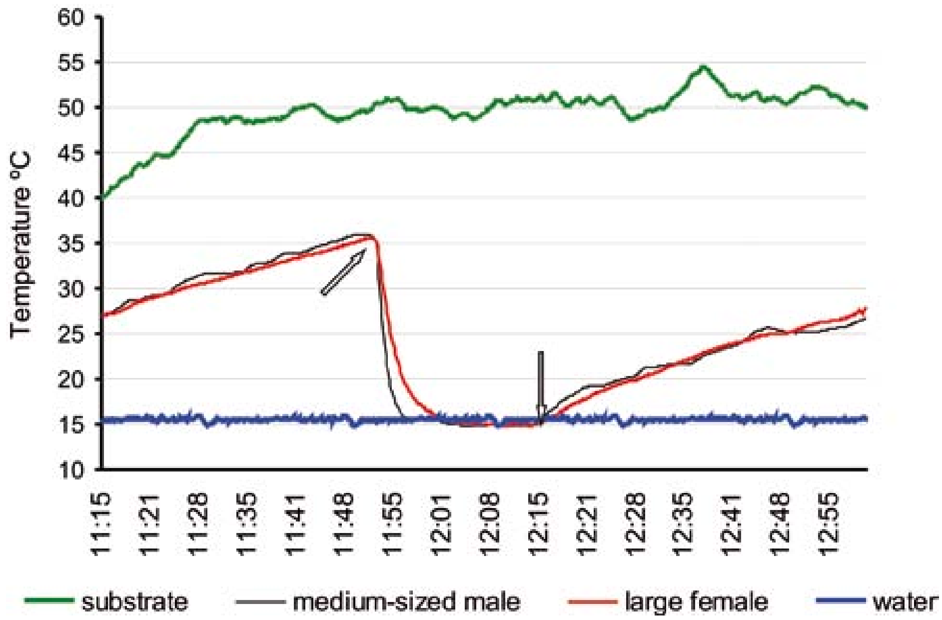

Fig. 5. Dynamics of internal body (stomach) temperature in a dice snakes immersed into cold water. Arrows indicate moments of imnmersion into and removal from water.

ach. During this heating period the snake's body temperature reached its maximum at 35.6 °C. The temperature of the cooling bath ranged from 14.8–16.0 °C, Subsequent to the immersion of the snake, its body cooled rapidly. Within nine minutes the body temperature dropped to 19.7 °C by an average of 2.2 deg/min until it stabilized at the level of the water temperature. After removing the snake from the water, its body temperature slowly began to rise at an average of 0.3 deg/min, until it leveled at 27.9 °C. The speed of temperature rise was nearly seven times less than its decrease. An even faster cooling rate of 4.0 deg/min was obtained by immersing a male dice snake (Fig. 5). Presumably its smaller size (SVL 570 mm, tail length 150 mm) was responsible for the rapid cooling

In summer, the water temperature at the Samara Bend ranges from 22.5–26.4 °C (mean 23.9 ± 0.57 °C), and the body temperature of dice snakes removed from the water produced similar values from 20.7–28.3 °C (mean 23.6 ± 1.08 °C), i.e. it approximately corresponded to the water temperature, similar to results found for dice snakes in Luiselli & Zimmermann (1997), Scali (2011), and Velenský et al. (2011) Under such temperature conditions, dice snakes can stay for a long period in the water and still maintain a fair amount of relevant physiological processes.

References

Bogdanov, O.P. (1962): Reptiles of Turkmenia. – The Turkmen Academy of Science, Ashkhabad, Turkmenistan (in Russian).

Brown, G.P. & P.J. Weatherhead (2000). Thermal ecology and sexual size dimorphism in northern water snakes, *Nerodia sipedon*. – Ecological Monographs **70**: 311-330.

Chikin, Y.A. (1981): Dice snake activity in a mountainous part of the Augren River. – In: Darevskij, I.S., Ananjeva, N.B., Barkagan, I.S., Borkin, L.Y., Sokolova, T.M. & N.N. Ščerbak (Eds.): Problems of Herpetology, Proceeding of the III Herpetological Conference. – Abstracts, Nauka, Leningrad **5**: 151 (in Russian).

Hailey, A. & P.M.C. Davies (1987): Activity and thermoregulation of the snake *Natrix maura*. 1. r and K thermoregulation. – Journal of Zoology of London **213**: 71–80.

Lakin, G.F. (1990): Biometry. – Visshaya shcola, Moscow (in Russian).

Luiselli, L. & P. Zimmermann (1997): Thermal ecology and reproductive cyclicity of the snake *Natrix tessellata* in southeastern Austria and central Italy: A comparative study – Amphibia-Reptilia **18**: 383–396.

Olearius, A. (1906): Description of Travel to Moscovia and via Moscovia to Persia and back. –Publ. A.S. Suvorin, Saint-Petersburg, Russia (in Russian).

Osipova, V.B. (1993): Amphibians and reptiles. – In: Vertebrates of Ulyanovsk Province. – Simbirskaya Kniga, Ulyanovsk: 50–63 (in Russian).

Popov, V.A. (1949): Reptiles. – In: Fauna of Tataria (Vertebrates). – Kazan: 141–149 (in Russian).

Scali, S. (2011): Ecological comparison of the dice snake (*Natrix tessellata*) and the viperine snake (*Natrix maura*) in northern Italy. – Mertensiella **18**: 131–144.

Shcherbak, N.N. (1966): Amphibians and Reptiles of the Crimea. – Naukova dumka, Kiev (in Russian).

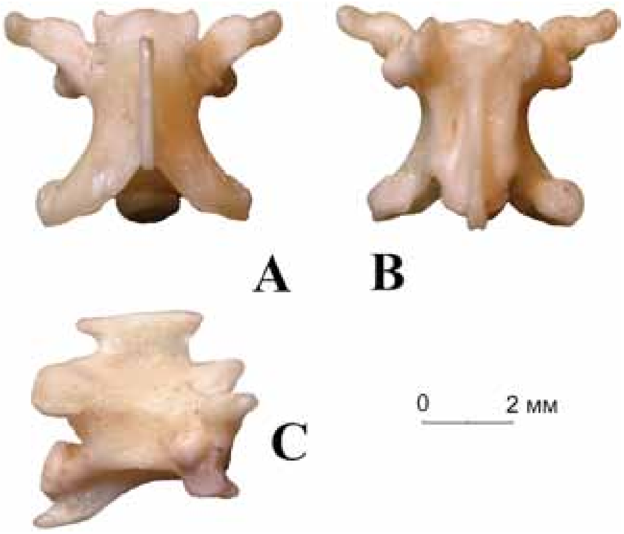

Fig. 1. Trunk vertebra of *Natrix natrix*: A – dorsal view, B – ventral view, C – lateral view.

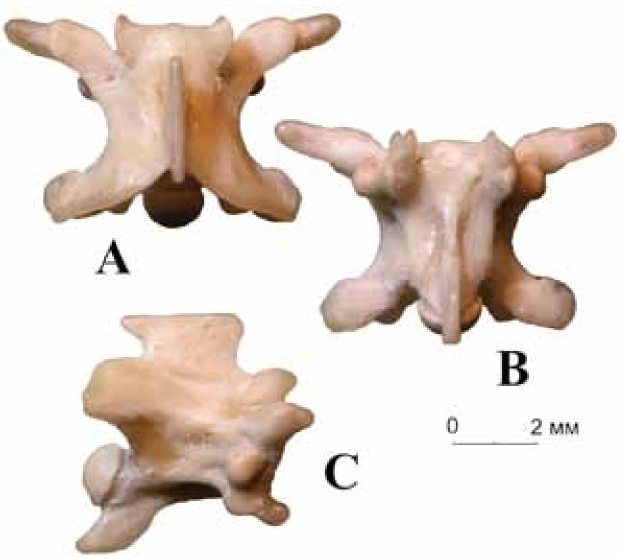

Fig. 2. Trunk vertebra of *Natrix tessellata*: A – dorsal view, B – ventral view, C – lateral view.

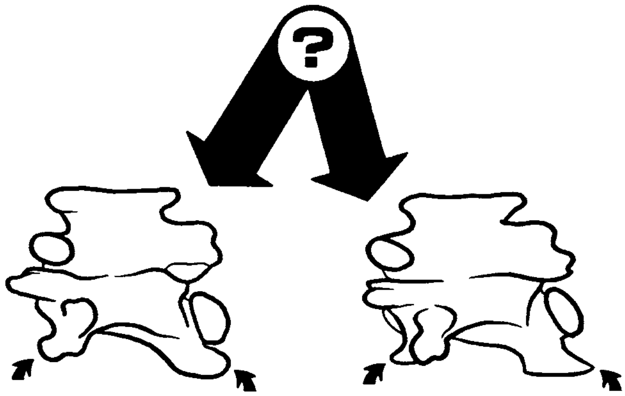

Fig. 3. Morphological differences between trunk vertebrae of *Natrix natrix* (left) and *N. tessellata* (right) (after Szyndlar 1984).

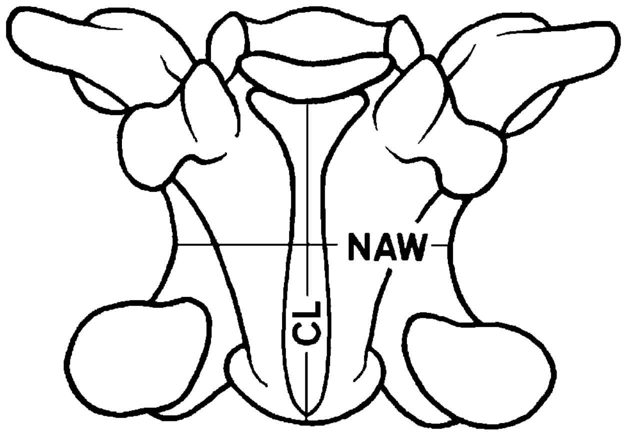

Fig. 4. Principal measurements of snake vertebrae applied (after Auffenberg 1963): CL – centrum length, NAW – width of interzygapophyseal constriction.

retically, any vertebrae could belong to *N. maura*, especially those from older sediments. Fossil remains of the second taxon, *N. megalocephala,* a species closely related to or being conspecific with *N. natrix*, were not available for this study. Moreover, this species is not unanimously regarded as valid (e.g. Velenský 1997, Orlov & Tunijev 1999, Guicking et al. 2006).

Fossil Remains of *Natrix tessellata*

Within the East European plain, there are currently 10 localities known that revealed fossil remains of *Natrix tessellata* from the Pliocene through the Holocene (Fig. 5, Ratnikov 2002a, b 2003). Table 1 shows the numbers of fossils found at each locality in the East European plain. A prevoius record of *N. tessellata* from Zmeevka-2 (Ratnikov 1989, 2002a) has subsequently been determined as incorrect.

Stratigraphic positions of localities are shown in Table 2. The oldest fossil records of *N. tessellata* in Eastern Europe are from the Pliocene sediments of Kotlovina (Ukraine). Unfortunately, the fauna sample at this site is mixed from three horizons, consisting of very little Lower Pliocene (MN 15b: approx. 4.0–3.5 million BP), about 70% from the Middle Pliocene (MN16: 3.5–2.6 million BP), and about 30% from the Upper Pliocene (MN17: 2.6–1.8 million BP) (A.S. Tesakov pers. comm.). The most likely age of *N. tessellata* vertebrae is Middle Pliocene due to the large proportion of this horizon. Thus, if this hypothesis is correct, the oldest fossil of *N. tessellata* dates back to the Middle Pliocene. Vertebrae of *N. natrix* are found at the same locality, which roughly coincides with its oldest fossil remains from Central Europe from the Beremend-1 locality in Hungary (Szyndlar 1991).

Fig. 10. Lake Sevan at 1.900 m a.s.l., Armenia. Photo: B. & S. Tuniyev

Fig. 13. Taman Peninsula, Russia. Photo: B. & S. Tuniyev

Fig. 11. Gobiid fish are the principal prey of *N. tessellata* along the Caucasus isthmus: (A) A juvenile dice snake swallowing a *Neogobius rhodioni* at the Black Sea coast, Photo: B. & S. Tuniyev; (B) a dice snake vomited three adult monkey gobies *N. fluviatilis* and (C) a single specimen is swallowing one at Absheron National Park, Azerbaijan. Photos: T. Kirschey

Fig. 14. Oil drilling platform inhabited by *Natrix tessellata*. Photo: T. Kirschey

Fig. 12. Sandy shore habitat of *Natrix tessellata* at the Sea of Azov, Russia. Photo B. & S. Tuniyev

tatives of the genus *Natrix*. The coastal habitats apparently provide ideal conditions for *N. tessellata*, as for decades, we have observed high densities of this species along the coast of the Caspian Sea of Daghestan to Azerbaijan, and also in the surroundings of the Taman Peninsula at the Black Sea (Figs. 9, 13) and the Sea of Azov. The density of the coastal populations were 20–30 specimens per 100 m at the Caspian Sea, up to 10 specimens per 100 m at the Sea of Azov and the Taman coast, but only single specimens were observed along the Black Sea coast of the Caucasus. The dice snake is able to swim considerable distances off shore to forage for fish in the sea. Near Sochi it was caught in the Black Sea at distance 200 m from the shore and vomited a stargazer (*Uranoscopus scaber*), a bottom-dwelling fish. Laňka (1978) observed an adult dice snake approximately 3 km distant from the Bulgarian coast in the Black Sea. In Azerbaijan, dice snakes were found sitting on historical oil drilling platforms in the Caspian Sea up to a maximum of 4 km distance to the next platform or island, and up to 8–9 km away from the mainland coast (Fig. 14). Khonjakina (1969) lists additional saltwater

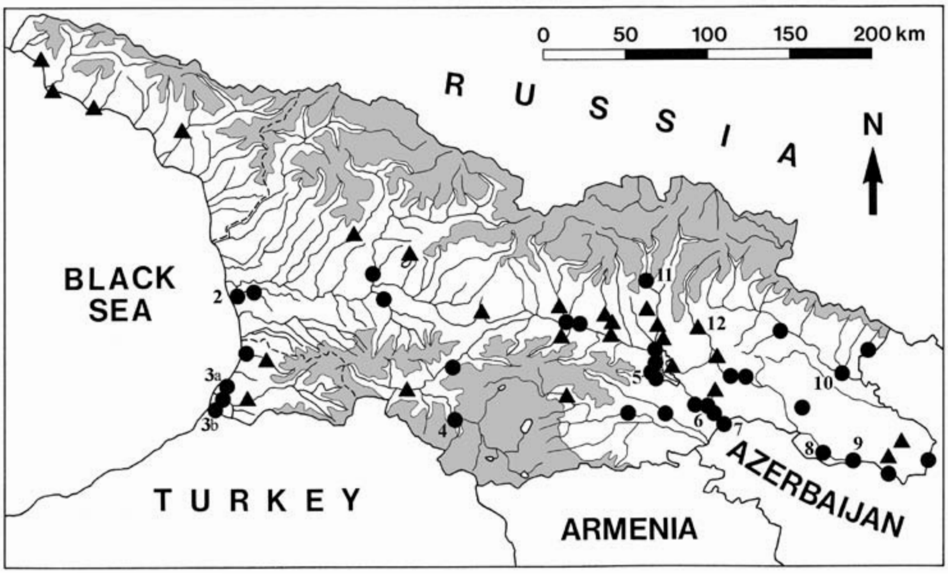

Fig. 1. Map of Georgia, showing the sites where *N. tessellata* is known to occur.

Shaded areas: regions >1500 m a.s.l., triangles: data from literature and from unpubl. observations of D. Tarkhnishvili and T. Kirschey, circles: personal observations of the authors. Numbers 2–12 refer to figures.

Abb. 1. Karte von Georgien mit den bekannten Fundorten von *N. tessellata*. Graue Flächen: Gebiete >1500 m Seehöhe, Dreiekke: Angaben aus der Literatur und nicht publizierte Beobachtungen von D. Tarkhnishvili und T. Kirschey, Kreise: Eigene Beobachtungen der Autoren. Nummern 2–12 beziehen sich auf die Abbildungen.

However, Nikolski (1913) mentioned an occurrence at Tsalka "close to Tbilisi". Tsalka lies at 1400 m in the eastern part of the Lesser Caucasus, ca. 60 km west of Tbilisi, but this record needs to be confirmed since at that time it was common to label locations by referring to the nearest town. Hence, the account may refer to locations somewhere downstream along the Khrami or Algeti rivers on the road from Tbilisi to Tsalka, where the occurrence of dice snakes was confirmed later. Nevertheless, an occurrence at Tsalka cannot be ruled out at the moment.

In Georgia, *N. tessellata* inhabits several different types of water bodies, such as ponds, lakes, marshes, brooks, rivers and channels, with either still or slow to fast running water. It is found in almost every type of landscape (lowland swamp forests and marshes at the Black Sea coast, where annual precipitation exceeds 2000 mm, to steppes and semi-deserts in the east, Figs. 1–12). The only exceptions are high mountain regions and dense montane forests in areas with particulary wet climates, probably due to the dice snake's preference for open, sun-exposed habitats (Mebert 2011).

The highest concentration of localities lies within the dry basins of central and eastern Georgia with numerous records from the catchments of all the main river systems. The species has also populated the majority of persistent lentic (non- or slow-moving) water bodies, such as ponds and lakes in that area. *N. tessellata* appears to have benefited from some aspects of agriculture, as it was often observed in plantations of water reserves and artificial channels used either for drainage or irrigation.

In eastern Georgia, we sometimes found the dice snake in substantially higher numbers than the grass snake, especially on the banks of water bodies with more or less bare ground or open vegetation. Occasionally, *N. tessellata* even occurs in ditches along temporary brooks in gorges and ravines of savannas, steppes and semi-deserts of the Shiraki region in the southeast, where grass snakes were never observed. An analogous situation has been reported from the Iberian Peninsula, where *N. maura* is more frequent than the sympatric *N. natrix astreptophora* in drier regions (Braña 1998). In semi-deserts of the Shiraki-region in southeastern Georgia, the dice snake appears to depend exclusively on tadpoles and juveniles of the marsh frog, *Pelophylax ridibundus*, for food. Generally, in riparian forests of central and eastern Georgia, the two species were observed to be roughly equally distributed, but frequencies varied considerably between sites.

In contrast, in the humid west, grass snakes were observed in much higher numbers than *N. tessellata*; often up to ratios of a couple of dozens grass snakes to one dice snake. Here, the dice snake can be found in various coastal habiats, including brackish and even marine environments along the Black Sea. It inhabits the Kolkheti lowlands, reaching the forelands and foothills of the Greater Caucasus along the Rioni River and its tributaries.

Although some observations were made in swamp forests such as in the Kolkheti Nature Reserve at the Pichora River, close to Poti, a preference for more open habitats seems to be apparent. Frequent fieldwork in Adjara´s forests (southwestern Georgia), well known

Fig. 4. Khertvisi (1126 m a.s.l.) in the Lesser Caucasus, where the Paravani River (left) meets the upper Mtkvari (right), is the highest altitude, where we observed a *N. tessellata* (insert). Photo: T. Bader & C. Riegler

Abb. 4. Chertwisi (1126 m Seehöhe) im Kleinen Kaukasus, wo der Parawani-Fluss (links) auf den Oberlauf der Kura trifft (rechts), ist das höchstgelegene Vorkommen, wo wir eine *N. tessellata* (eingefügt) beobachten konnten.

Fig. 5. Kus Tba (Turtle Lake), Tbilisi. *N. tessellata* occurs in almost all suitable habitats around the capital. Photo: T. Bader & C. Riegler

Abb. 5. Kus Tba (Schildkrötensee), Tiflis. *N. tessellata* kommt in beinahe allen geeigneten Habitaten um die Hauptstadt vor.

Fig. 6. Artificial channel for irrigation near Gardabani, southeast of Tbilisi. Dice snakes profit from plantations of artificial lakes, ponds, water reservoirs and channels.

Abb. 6. Künstlicher Bewässerungskanal bei Gardabani, südöstl. Tiflis. Würfelnattern profitieren von künstlich angelegten Seen, Teichen, Wasserspeichern und Kanälen.

for their richness in endemics, did not yield any dice snakes apart from the coastal region, where the species is quite common in swampy areas of the lowlands (e.g. Denk et. al. 2001). At low elevations, it also occurs along small rivers of the densely forested, hilly terrain along the coast up to 200 m a.s.l. In the Chorokhi Valley, the species occurs in drier conditions upstream in the Turk-

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Morphology and Blood Proteins of Dice Snakes from Western Turkey*

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Abstract. Dice snakes *Natrix tessellata* from the Lakes Region in southwestern Turkey (Beyşehir, Akşehir-Eber, Karamuk lakes) and from Uluabat Lake, Marmara Region in northwestern Turkey were compared by means of morphology (pholidosis, body measurement ratio, color pattern) and blood-serum proteins that were analyzed by polyacrylamide gel electrophoresis and densitometry methods. Pholidosis (number of preocular and supralabial scales) and color-pattern, as well as electrophoretic figures of blood serum proteins, showed significant differences between the dice snakes from Beyşehir Lake compared to those of other lakes in the region, as well as those from Uluabat Lake. Some thoughts on those differences and its relevance to taxonomic questions are presented.

Key words. Ophidia, colubridae, morphology, polyacrylamide gel electrophoresis, south- and northwestern Turkey.

Introduction

The dice snake *Natrix tessellata* (Laurenti, 1768) has a widespread distribution from Germany and Italy in the west to southeast Europe and Egypt in the south, across Russia and Arabian countries to Central Asia such as North Afghanistan (possibly North Pakistan) and West China (Gruschwitz et al. 1999, Sindaco et al. 2000). This species can be found across Turkey up to an altitude of 2500 m in suitable biotopes (Başoğlu & Baran 1980). There are many studies that tried to shed light on the taxonomy and systematic of *N. tessellata*. Initial taxonomic grouping was based on morphological comparisons, including morphometric characters and ratios, pholidosis and color-pattern (Strauch 1873, Bedriaga 1879, Boettger 1888, Boettger 1890, Schreiber 1912, Venzmer 1919, Werner 1902, Werner 1903, Werner 1919, Hecht 1930, Bodenheimer 1944, Mertens & Wermuth 1960, Fuhn & Vancea 1961, Kramer & Schnurrenberger 1963, Mertens 1969, Baran 1976, Lanka 1978, Lenz & Gruschwitz 1993, Mebert 1993, 1996, and Göçmen & Böhme 2002). Baran (1976) indicated that *N. tessellata* from Turkey is consistent with the nominate subspecies *N. tessellata tessellata.* However, only one supposedly morphologically distinct subspecies has been accepted up to the last century (Hecht 1930), with that being questioned as well by Gruschwitz et al. (1999).

The first indication of a different *Natrix tessellata* subspecies living in Turkey originated from Bedriaga's (1879) assignation of dice snakes caught around Çanakkale, Trabzon, and Valley Fırat as *Tropidonotus hydrus* (based on Pallas' 1771 *Coluber hydrus* with typically 3 preoculars and 4 postoculars), whereby *Tropidonotus* is the former generic name of *Natrix*. Although Boettger (1888, 1890), Venzmer (1919) and Werner (1902, 1919) agreed with this idea for Turkish dice snakes, Dürigen (1897), Schreiber (1912), Hecht (1930), Bodenheimer (1944), and Mebert (2011) reported variably that the arrangements of ocular scales exhibits a more complex geographic variation and that 3 preocular and 4 postouclar scales were also found in samples from other areas of *N. tessellata*. Therefore, the former authors declared *T. hydrus* and *N. tessellata* as synonyms, which was followed by other authors for dice snakes from the same general area (e.g. Mertens 1969, Gruschwitz et al. 1999, Mebert 2011).

Other described subspecies of the dice snake from Turkey have been disregarded after additional analyses. For example, Baran (1976) suggested in his review of material collected across Turkey that *N. tessellata vosseleri* (Werner 1914) from the area between Antalya and Burdur should be accepted as synonymous with the nominate subspecies. Hecht (1930) described *N. viperinus* from Turkey. But Mertens & Wermuth (1960) declared that the characteristics of *N. viperinus* actually belonged to *N. maura*, a closely relates species whose nearest populations are 1000s of km away in northern Italy. Kramer & Schnurrenberger (1963) also shared this idea of those individuals being *N. maura*, whereas Baran (1976) accepted *N. viperinus* as a synonym of the nominate species (*N. tessellata*). Regardless, whether the former ssp. designation originates from, for example, mislabeled and foreign *N. maura* or whether those *Natrix* specimens are somewhat aberrant Turkish *N. tessellata*, there is no clear argument based on morphological data to maintain any other taxonomic unit for Turkey than the nominate form up to this moment. However, genetic investigation indicates that northern and eastern Turkey (southern, central and western areas have not been studied) is inhabited be a different clade of *N. tessellata* than specimens from the extreme northwestern area of Turkey (Guicking et al. 2009, Guicking & Joger 2011).

* Some data in this manuscript were included in the Ph.D. thesis of Yunus Emre Dinçaslan.

in Gruschwitz et al. 1999, Litvinov et al. 2011, Liu et al. 2011, Tuniyev et al. 2011). It was even used to support the former subspecific status of *Natrix tessellata heinrothi* (Hecht 1930), but this character was refuted due to similar occurrence of melanistic dice snakes in other populations (e.g. Mertens 1969, Gruschwitz et al. 1999).

Type A: These are dice snakes with typically black spots dorsally and laterally over an olive green to gray brown background on the neck and dorsum (Figs. 2a, b). While black spots usually form four rows, some specimens yield also whitish spots to vertical lines between the black spots along frontal and lateral sides of the body. In some individuals black spots on the dorsum begin as four rows, fuse to three rows and split into four rows farther caudad or vice versa. The venter is dirty white or yellowish with black spots on the anterior part of the body, which increasingly expand caudad until they form the principal background color. There may be yellowish-white scattered spots over this background.

Type B: This is a unicolored, spotless morph (Fig. 2c). The dorsum is gray to olive green. There may be a black stripe bilaterally over the back of the head, which expandes from the neck and fades caudad but sometimes becomes prominent again posteriorly. The venter is pinkish to white in the front with a black stripe that increasingly widens posteriorly up onto the tail, equivalent to Type A.

Type C: These are melanistic dice snakes or abundistic specimens (generally darkening skin, albeit not black) as can be seen in Fig. 2d.

Electrophoretic Analysis of Blood-Serum Proteins

Sexually mature specimens were used for the electrophoretic analysis of blood-serum proteins. Since there were no qualitative differences between genders, males and females were evaluated together.

The electrophoretic figures of blood-serum proteins were similar among Akşehir-Eber, Karamuk and Lake Uluabat populations, and they were subsequently lumped together and compared with dice snakes from the Beyşehir population. Gel photographs directly comparing the electrophoretic separations of blood-serum proteins between a dice snake from Beyşehir Lake and one from the Uluabat population, representing the group with specimens from the Akşehir-Eber, Karamuk and Uluabat lakes, are shown in Figure 3. In addition, a gel photograph of blood-serum proteins with densitometry curves is shown for an individual from the Beyşehir population (Fig. 4) and another one from the Uluabat population (Fig. 5). As seen in Figure 3, dice snakes from the Beyşehir population produced rates of fractions in the albumin region that migrated faster than those from snakes from the Uluabat population (and thus equally

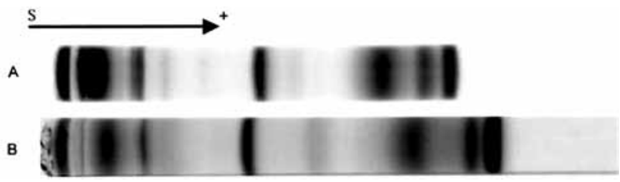

Fig. 3. Blood-serum protein electropherograms of representative specimens from two different populations of *Natrix tessellata*. A: Uluabat, B: Beyşehir. The albumins are the bands on the left end, and the globulins are those adjacent to the left.

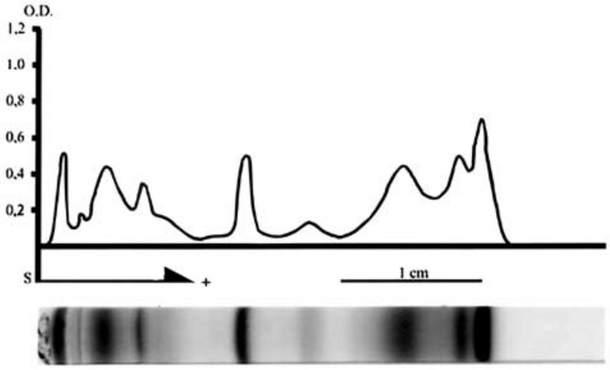

Fig. 4. Gel photograph and densitometric tracing curve showing the electrophoretic separation of the blood-serum proteins obtained from a *Natrix tessellata* of Lake Beyşehir, Turkey. OD: Optical density, S: Start (junction between the stacking and separation of gels).

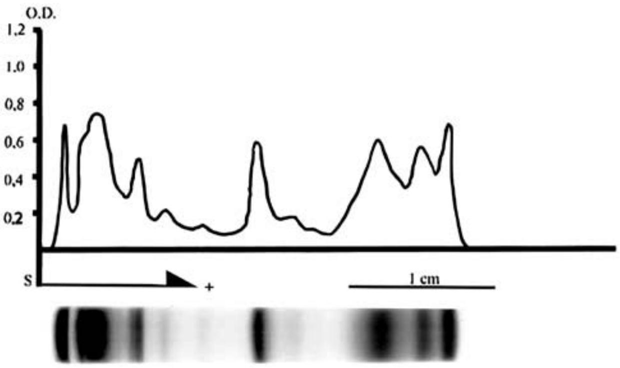

Fig. 5. Gel photograph and densitometric tracing curve showing the electrophoretic separation of the blood-serum proteins obtained from a *Natrix tessellata* of Lake Uluabat, Turkey OD: Optical density, S: Start (junction between the stacking and separation of gels).

for the remaining populations). Qualitatively, there are 12 fractions in the blood-serum protein samples in the specimen from Beyşehir and Uluabat, 2 in the albumin region and 10 in the globulin region. Small differences are visible between the corresponding fractions in the globulin region (Figs. 4 and 5). Quantitatively, in the Beyşehir specimen the density of the albumin fraction um of Torino, Italy (Elter 1981 and Fig. 1). It was verified by the late E. Kramer (Schätti & Sigg 1989) and subsequently also examined by the second author (KM). The whereabouts of the second specimen remains unknown. Böhme & Wiedl (1994) shared the opinion that the Torino (Turin) specimen might be introduced to the island by someone. That specimen had 166 ventrals and 70 subcaudals (Schätti & Sigg 1989, and confirmed by KM). This ventral scale count is intermediate between the mean value of male dice snakes from Egypt (ventrals = 164.8, n = 6) and those from Israel (ventrals = 166.2, n = 42, Werner & Shapira 2011), and is substantially lower than in dice snakes from the nearest mainland, the Turkish southern coastal area between Antalya to Antakya (mean ventrals of males = 177.2, n = 19, Mebert 1993). The low ventral scale values, the rather small dorsal spots, and the prominent black nuchal angle are typical, but not exclusive, for *N. tessellata* from Egypt to the Levant (E. Kramer in litt, and pers. unpubl. data), supporting the suspicion, that this specimen was introduced from the south. Since naval traffic is common between Cyprus and the nearby mainland in the surrounding mainland, all inhabited by *N. tessellata*, the possibility of an introduction could not have been dismissed at that moment.

Fig. 1. Ventral and dorsal view of the juvenile dice snake from near Nicosia, Northern Cyprus. Stored as MCSNT 18024 in the Natural History Museum of Torino, Italy.

In 2002, Göçmen & Böhme (see also Göçmen et al. 2009) published the finding of two preserved *N. tessellata* in the Zoological Collection of the Aegean University at Bornova-Izmir, Turkey Göçmen & Böhme 2002, Göçmen et al. 2009 (Fig. 2a, b). The two juveniles were sampled in 1960 at Gönyeli Lake, Nicosia, northern Cyprus (Fig. 3). They challenged the view that the Torino voucher specimen from Cyprus could have wrong locality data or was introduced to the island by man. Gönyeli Lake is a site inland, rendering the undeliberate introduction via ships rather unlikely.

Finally, on a field excursion to the Gönyeli area in 2007, a first live *N. tessellata* was sampled at Gönyeli Lake by the senior author (Göçmen et al. 2008). It is a young female (Fig. 4), whose morphological data together with those from the other preserved specimens are listed in Table 1. The four preserved specimens allow

Fig. 2. Juvenile dice snakes sampled in 1960 from Gönyeli Lake, Nicosia, Northern Cyprus. Preserved at the Zoological Department, Ege Üniversity, Izmir, Turkey (ZDEU 114/1960-1 and 2): female (A), male (B).

Fig. 3. Google image of the Gönyeli Lake, Nicosia, Northern Cyprus, with the new finding indicated in the yellow circle.

Tab. 1. Morphological data of four preserved dice snakes.

Characters	ZDEU 253/2007-♀	ZDEU 114/1960-1 ♂*	ZDEU 114/1960-2 ♀*	MCSNT 18024 ♂
	Gönyeli Lakelet, Nicosia/ N. Cyrpus	Gönyeli Lakelet, Nicosia/ N. Cyrpus	Gönyeli Lakelet, Nicosia/ N. Cyrpus	Nicosia/ N. Cyrpus
Head Length(HL)	15.14	11.2	11.1	
Head width (HW)	9.28	4.0	3.9	
Snout-vent Length	415	261	238	
Tail Length (TL)	112	66.0	56.0	
Frontal Length (FL)	4.78	3.5	3.4	
Rostral Height (RH)	1.75	1.5	1.4	
Rostral Width (RW)	3	2.4	2.2	
Preoculars (PreO)	3//3 (R//L)	2//2	3//3	2/2
Postoculars (PostO)	4//4	4//4	4//4	4//3
Supralabials (SpL)	8//8	8//8	8//8	8//8
Sublabials (SbL)	9//10	10//10	10//10	10//10
Temporal (T)	1//1	1//1	1//1	1//1
Posttemporals (PostT)	2//2	2//2	2//2	
Ventrals (V)	168	175	177	166
Subcaudals (SubC)	70	72	62	70
Supraoculars (SpO)	1//1	1//1	1//1	1//1
Frenals (F)	1//1	1//1	1//1	1//1
Nasal (N)	1//1	1//1 (semidivided)	1//1	1//1
Gulars (G)	4	4	4	4
Anal (A)	1/1	1//1	1//1	1//1
Dorsals (D)	19	19	19	

*published data in Göçmen & Böhme, 2002-ZME

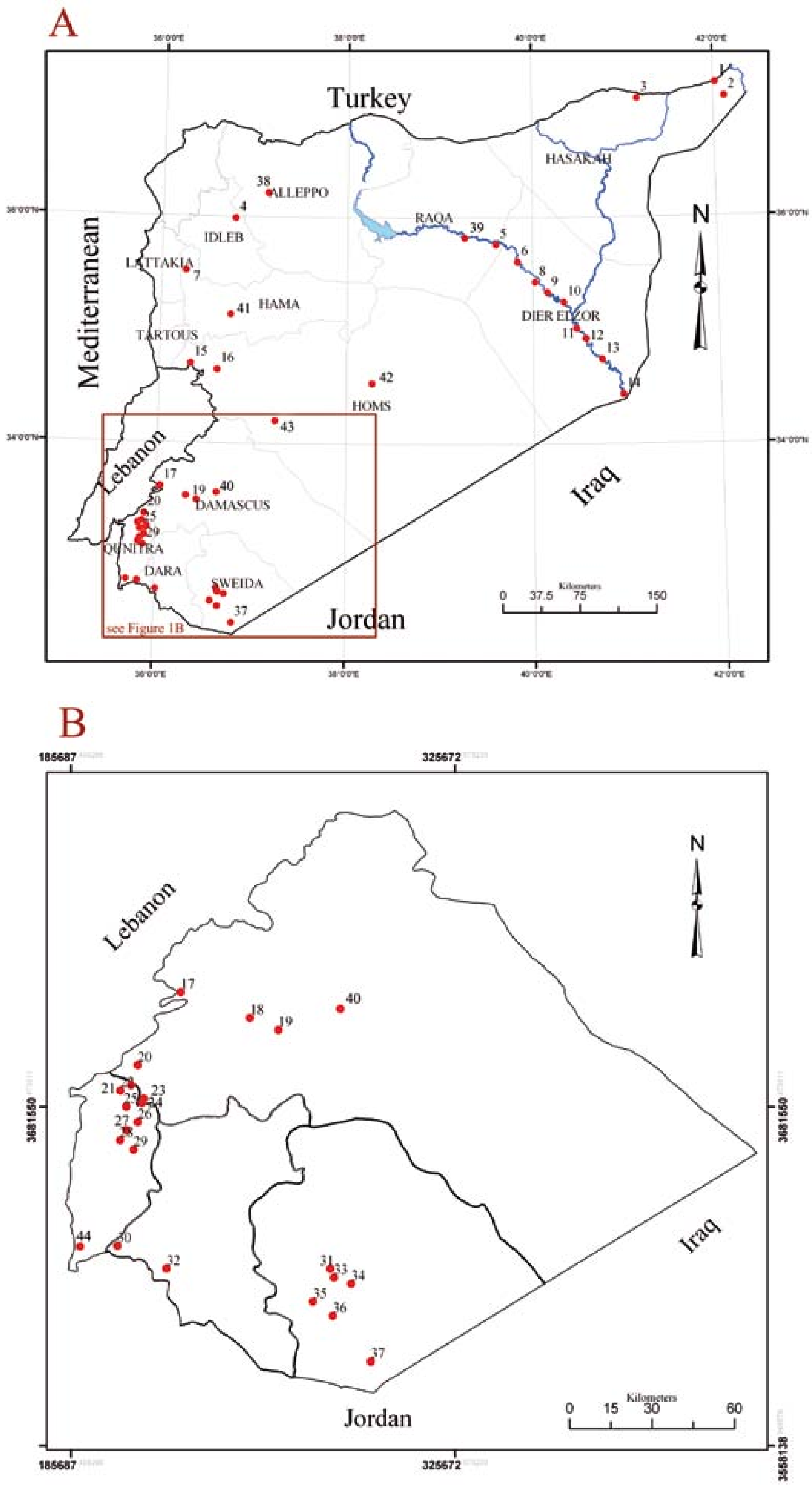
A
Turkey
Mediterranean
Lebanon
Iraq
Jordan
ALLEPPO
IDLEB
LATTAKIA
HAMA
TARTOUS
HOMS
RAQA
HASAKAH
DIER ELZOR
DAMASCUS
QUNITRA
DARA
SWEIDA
see Figure 1B
N
Kilometers
0 37.5 75 150
B
Lebanon
Iraq
Jordan
N
Kilometers
0 15 30 60
185687
325672
3681550
3558138

Fig. 3. A bag filled with *Natrix tessellata* collected by snake collectors from the Al-Mozirieb fish farm.

Fig. 4. Hundreds of *Natrix tessellata* languish in containers for sale in the animal market in Damascus.

some ponds over a period of 8 months, with those at Masil Al Fawar on a daily basis. According to his accounts, *N. tessellata* was difficult to observe, because it reacted rapidly to human approach by fleeing into the water and hiding or disappearing in the water and under water plants for hours. He also described the combination of feigning death and aposematic behavior of Syrian *N. tessellata*, including turning its eyes to the mouth corner, opening its mouth, twisting its tail and exposing its contrastingly coloured ventral side.

We found the basic dorsal color of *N. tessellata* to vary from gray, olive, to reddish brown. Very pale yellowish to olive specimens were also observed as well as dark to melanistic specimens. The dark form represents 3% of all our observed specimens (Fig. 3).

Trade of *N. tessellata* in Syria

Over the past years, we visited the animal market in downtown Damascus several times. More than 10 shops are specialized in selling live local animals (birds, mammals and reptiles). We have observed that tens of *N. tessellata* specimens were placed in crowded water containers, including several dead specimens. These snakes are sold for about 2 US$ a piece as "aquarium" animals. They are sent to Turkey and Europe by buses and other land transport as indicated by customs officers on the borders. They are not consumed or used as a subscription for folk medicine or other traditional practices. In 2004, the Royal Society for the Conservation of Nature in Jordan seized a "bag of snakes" which contained over 100 *N. tessellata* specimens originating from Syria (Amr et al. 2007). These snakes most likely are condemned to die.

In February 2009, the senior author visited the animal market in downtown Damascus and observed nine jars filled with snakes (*N. tessellata* and perhaps a few *N. natrix*), originating from fish farms in the Al Ghab area. Each jar contained probably up to 100 snakes (Fig. 4). Other dice snakes at this animal market are collected from Zarzar Lake.

In these shops, the unfortunate snakes die within two weeks, presumably due to the stress and/or suffocation inflicted by the crowded conditions and lack of food. Snakes sold to private consumers usually do not survive more than two weeks with their new owners, as some told us that they kept the snakes in fish aquaria without proper feeding and rearing conditions.

A great threat stems from the many fish farms that have been established in Syria, There, *N. tessellata* is persecuted in great numbers. Farmers consider these snakes as a pest that feed on young fish and remove and kill them regularly. In one occasion at a fish farm in Al-Mozirieb, we observed a bag filled with tens of freshly collected *N. tessellata* (Fig. 3). In Al Ghab, along the Orontes River, we encountered many killed snakes near fish farms and agricultural areas.

The continuance of such illegal trade will very probably affect the status of *N. tessellata* in Syria, and in the worst case, lead to a drastic decline in local populations. Overcollecting of certain species raises the need to evaluate the level of trade and make sure that it is not causing irreversible declines in wild populations. A proper management plan for a sustainable harvest is desired, as it has been done for another semi-aqautic snake species (Micucci & Waller 2007). In Syria, no records to track the imports and exports of reptiles are available. The lack of information implies that population declines due to overcollecting could be going undetected. Further investigation should focus on the actual number of traded animals in Syria (Amr et al. 2007).

The concept of conservation in its broad spectrum is not yet fully realized in Syria, despite the presence of a conservation authority. This is mainly due to lack of experience and knowledge in this multidisciplinary task. Syria has no area-based environmental laws or protected area system dedicated explicitly towards conserving

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Notes on Distribution and Morphology of the Dice Snake (*Natrix tessellata*) in China

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Abstract. In China the dice snake (*Natrix tessellata*) is only recorded from the westernmost area, the Xinjiang Uygur Autonomous Region. A brief review on distribution and morphology of the dice snake in China is presented. Scalation was used to quantify its morphological variation in China. The frequency and range of head scale counts (supralabial, infralabial, preocular, postocular, supraocular, temporal), as well as the number of dorsals, ventrals and subcaudals is recorded. Scale variation could be divided into three categories: (1) no variation (dorsal and supraocular), (2) occasional variation (infralabial, preorbital, supralabial, postorbital and temporal), and (3) continuous variation (ventral, subcaudal). The variation of temporal scales is discussed in details. All freshly sampled specimens were deposited in the Museum of Xinjiang Agricultural University.

Key words. *Natrix tessellata*, China, habitat, new distant records, scalation, temporal scales

Introduction

The dice snake (*Natrix tessellata*) has an extensive distribution from central and southern Europe east to the countries of the Middle East and the Nile Delta and across Iran, Russia, Kazakhstan into China (Bannikov et al. 1977, Gruschwitz et al. 1999), from where it is only recorded from the Xinjiang Uygur Autonomous Region (e.g. Shi et al. 2002, Wang et al. 2005). Studies on the dice snake in China have been focused on diet, movement and reproduction (Zhao 1978, Zhao et al. 1998), population ecology (Wang et al. 1987), karyotype analysis (Li et al. 1988) and circulatory system (Zhang et al. 1990).

According Wang et al. (1987) and Zhao et al. (1998) the dice snake in China needs at least 4–5 years to reach maturity. Mating season concentrates from early May to early June in China. During the mating season, the dice snake was found to usually occupy in- and outflows of fish ponds, rice fields and other lotic habitats, whereas few have been observed in lentic, relatively still water (Wang et al. 1987). Depending on the habitats and food conditions the diet of dice snakes varied accordingly. In fish ponds, the diet consisted almost exclusively of fish, whereas dice snakes in rice paddies preyed on little toads and tadpoles, but not fish. Again in other habitats insects and rodents were consumed (Wang et al. 1987, Wang et al. 2005). In Wensu County, the dice snake emerged from hibernation in early April. Because of the low temperature, they surfaced only in the afternoon in the first two weeks. They became more active in May to June with activity peaks between 8–10 am and 3–5 pm (Wang et al. 1987).

Scalation is a significant character in snake taxonomy (Zhao et al. 1998). Studies on scale variation from a large number of specimens enables a finer taxonomic sorting at inter- and intraspecies levels. Moreover, these data could help to address some phylogenetic and biogeographic problems (Chen & Zhao 2007). The purpose of this work is to provide the existing basic information on the morphology, including color pattern, body lengths, and scalation of the dice snakes from Chinese herpetological collections and their geographical distribution.

Materials and Method

The principal data was obtained from 101 specimens of *Natrix tessellata*, all deposited in the Museum of Xinjiang Agriculture University. Nine scale counts were recorded: three from the body (trunk) and six from the head (Tab. 1). A few data were received from an earlier acquisition by the second author and N. Helfenberger from the Zoological Museum of the School of Life Science, Sichuan University, Chengdu, Sichuan, China. These data were added after the principal analysis and include 16 dice snakes (2 males, 14 females) from Kizil, near site 17 (Fig. 1) and one male from Kashi City. Ventral scales (VENT) were counted according to Dowling's (1951) method, and the counting of subcaudals (SUBC), began with the first scale pair posterior to the vent (cloaca) and excluded the terminal tail tip. Cephalic (head) scale counts were made on both sides of the head. We used Microsoft Office Excel 2003 and SPSS 11.5 to analyze the data.

Results

Distribution

In accordance with its aquatic habits (Gruschwitz et al. 1999), the dice snake inhabits freshwater habitats including rivers, ponds, dams, and ditches of oases across all of the Xinjiang Autonomous Region. Consequently, Figure 1 shows a rather discontinuous distribution

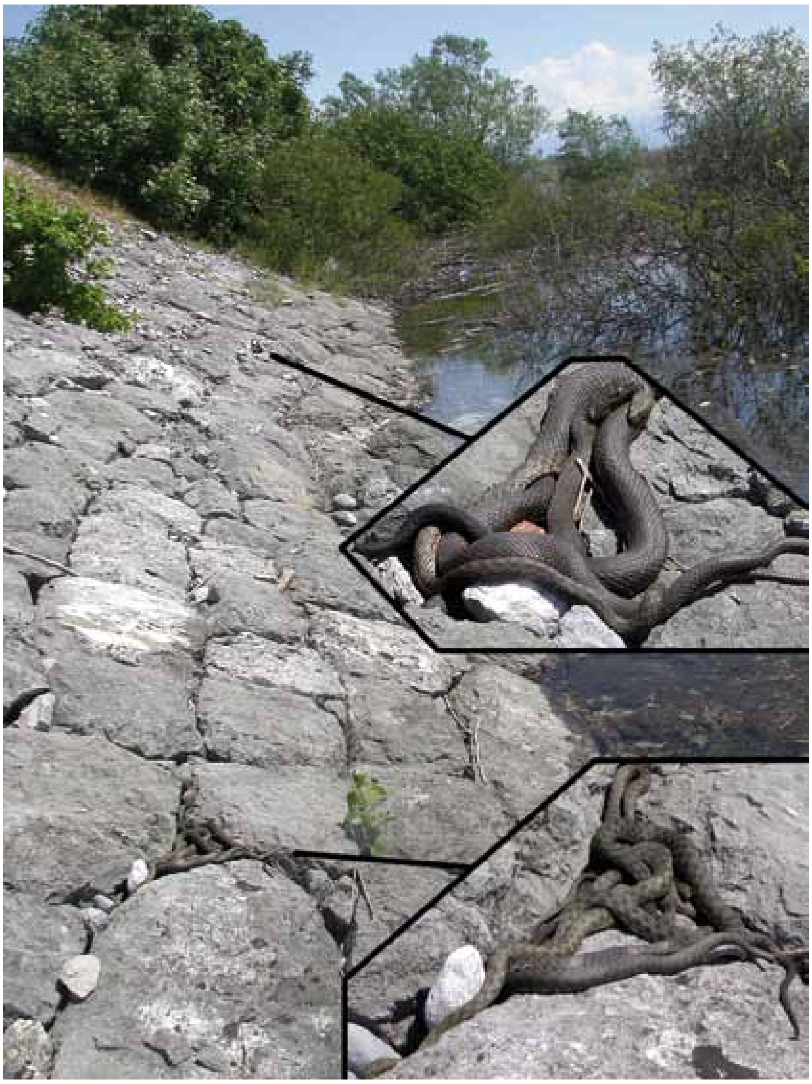

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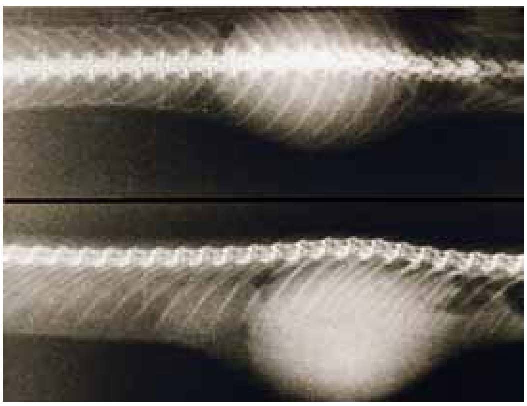
Fig. 1. A dice snake that consumed a common frog (*Rana temporaria*), Maggia, southern Switzerland, 24 April 2004. Photo: Konrad Mebert



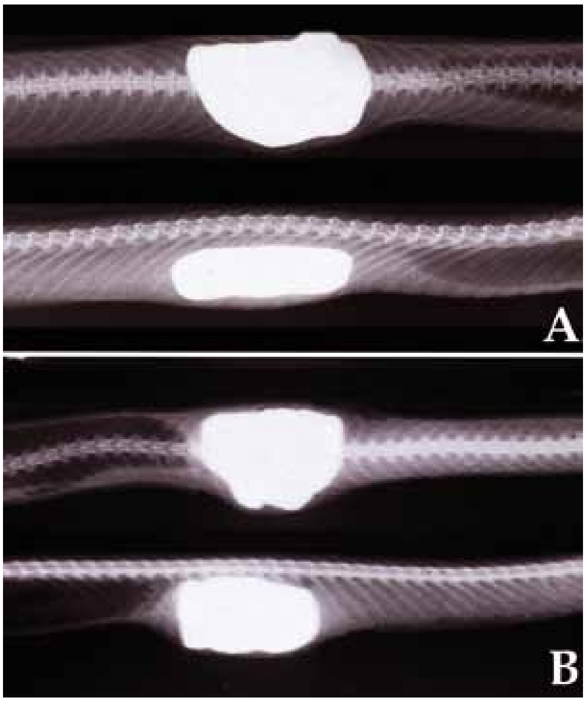


Fig. 2. Dice snakes having swallowed a stone, Switzerland: (A) Lake Alpnach, September 1993, (B) Lake Brienz, June 1991. X-Ray: Cantonal Animal Clinic, Zürich

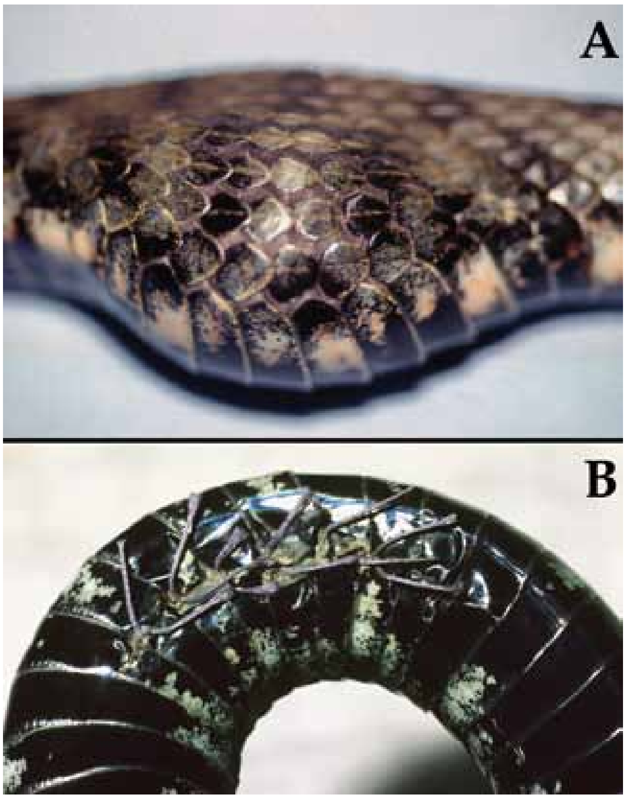


Fig. 4. Before (A) and after (B) the surgical removal of the peach pit from the female dice snake in Figure 3. Photo: Konrad Mebert

Fig. 3 (left). A female dice snake consumed a peach pit (stone), Lake Geneva, October 1991. X-Ray: Cantonal Animal Clinic, Zürich

DVD

Dice Snake (*Natrix tessellata*) the Elusive Water Beauty

The dice snake, *Natrix tessellata*, is a semi-aquatic snake, exhibiting well adapted behaviors to many types of water bodies. This DVD provides life film sequences of this snake species taken directly from its natural environment at three sites in Europe. This footage complements in a lifelike manner the scientifc articles presented in this Mertensiella volume.

First scenes are filmed at the Schwechat River and in the Kamp River Valley near Vienna, Austria. Here, a short clip segment exhibits how close dice snakes can dwell to human society, as the snakes inhabit the supporting wall of the outdoor platform of a restaurant. It is also amazing to see dice snake swimming in rather strong currents and make use of the interstitial topography to move across the stream bottom, possibly to reduce the drag imposed by the current, to be more cryptic against predators and simultaneously ready to snap at any fish prey hiding in the crevices. Before landing, dice snakes often take on a periscope position by "standing" in the water a few meters before the shore with the head barely breaking the surface and the tail anchored around an object on the stream bottom. This way, a snake is able to scan the shore area for any potential danger.

The second location shows film sequences from the brackish water lagoon at Kaiafa on the Peloponnese Peninsula, Greece. Dice snakes are shown foraging by a sit-and-wait strategy while hanging from a branch with the head in the water, ambushing mosquitofish passing by. Another scene demonstrates the speed of swallowing a fish, after a dice snake captured a mullet in a more open area of the lagoon.

The foraging method is also compared to the sympatric grass snakes (*Natrix natrix*) which hunts for frogs on the water surface, whereas dice snakes focus on fish below the water surface. In the reed grass of the lagoon good basking places are not common, and dice snakes have to share this resource with the European pond turtle (*Emys orbicularis*).

Dice snakes usually mate on land. But in a sidearm of the lagoon, mating activities could be filmed in the water. The clip shows how males nervously follow receptive females, which by exuding pheromones become irresistible for males. Finally, the reproductive sequence is accomplished with a brief mating act in the water. Astonishing to see in one sequence, that a female, the larger sex, can be quite small (young) to exert an urging "follow-me" response to males. This indicates, that even small females send out attracting pheromones and, hence, possibly are sexually mature before the end of their second year of life.

A digitalized sequence from an underwater film made with the super 8 technique in 1982 shows a dice snake foraging on the bottom of Ohrid Lake, FYR Macedonia. Interesting to see, how the snake uses the rocky ground structure to wait motionless before striking for unwary fish, not always successful.

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