

MERTENSIELLA

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

Editor

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on behalf of the
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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) monspesulanus*, *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 me-

diaeval 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. Nonetheless, 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 involvement as a principal re-

viewer, 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, beginning with articles in the West (central Europe) and ending in the East (China). The principal 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 “stand-alone” 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. DİNÇASLAN 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), redis-

coveries 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 hiber-

nation, 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 Kuşadası, 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.

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