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

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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, LAUREN-TI 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 (ZIMMER-MANN & 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 (ME-BERT 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.

palearctic species. Due to its meristic characteristic and the large variation embedded, the analysis is focused on ventral scale values, which are exemplary in demonstrating the variation across a large geographic area.

Material and Methods

The database consists of three principal sets: Set 1 relates to personal field sampling (n = 170), Set 2 to museum specimens (n = 204), and Set 3 to the private data collection of E. KRAMER (n = 600).

Set 1: Field sampling was conducted between 1990 and 1991 at two lakes, Lake Lugano in southern Switzerland (*n*: females = 44, males = 44) and Lake Garda in northern Italy (*n*: females = 44, males = 44). Only adult snakes were sampled (total length \geq 40 cm, \approx SVL of 32 cm) to reduce the influence of allometric growth and different size/age classes. Furthermore, only animals, which still possess the entire tail (tail tip visible), were used. The snakes have been measured and marked in the laboratory and released afterwards at their site of capture.

Set 2: This group consisted of 197 dice snakes (88 females and 109 males) from the Natural History Museum of Geneva (MHNG) and another 37 preserved specimens from various collections. Latter included a few single, private specimens, as well as 14 females and 3 males from Western China measured by N. HELFEN-BERGER at the Chengdu Institute of Biology (see LIU et al. 2011), and 4 females and 3 males from Egypt stored at the Alexander König Museum, Bonn, Germany.

Set 3: The original data collection by E. KRAMER consisted of a few morphological characters, e.g. the number of ventrals/subcaudals, ocular scales, dorsal rows at the 100th ventral scale, dorsal blotches, and sublabials. The counts of ventrals and subcaudals were included in my study, as they are highly quantifiable, show sufficient geographic variations and are compatible with my data recording. KRAMER's original data volume contained 850 specimens, of which 600 specimens (281 females and 319 males) were applied for a whole-range analysis. Data on the remaining 250 specimens were redundant with my previously acquired data, as they related to Swiss specimens, which I have sufficiently covered in data Set 1, and others relate to preserved specimens from the MHNG from data Set 2. Finally, KRAMER's data helped greatly to expand the scope to study the variability of the dice snake across a large geographic area.

An additional large data set of n = 289 dice snakes previously applied for a microgeographic analysis, comparing allochthonous with autochthonous populations from the central Alps (MEBERT 2011a), was not included, as it was irrelevant in the perspective of this widegeography analysis. For data sets 1 and 2, a total of 36 out of 53 characters (weight, pholidosis, lengths, color and pattern) were initially analyzed. The selected characters include ventrals, subcaudals, dorsal and caudal scale-row reductions, various labial and ocular scales, contact between eye and supralabials, total length, and relative tail length. These morphological data were acquired from specimens mainly originating in an area from middle Europe to Turkey, but with the additional specimens from Egypt and China mentioned above. The definitions of characters, method of measuring, and application of statistical procedures for absolute and relative data is explained in MEBERT (1993, 2011a), but is briefly indicated in the text, where it was deemed helpful to prevent misunderstanding.

Specimens from geographically associated regions were grouped together especially for snakes originating from the same or closely connected drainage areas, *in sensu* river systems. If two close water systems are separated by a topographic barrier, than the samples of those areas were lumped only when they did not show major differences in the selected characters. The same method was applied to a selected group relating to a very large area, as for example in the Italian group, in which specimens from the far distant regions between Southern and Northern Italy do not show significant differences. Finally, published data were included from regions where the author has no or insufficient material, and where the results for each sex were separately shown.

Results and Discussion Ventrals (data sets 1–3)

General articles reviewing scale characteristics of a snake species often present the extreme values of scalation counts to reveal their maximum range within the species or at least on a regional basis (see GRUSCHWITZ et al. 1999). For comparative reasons, this is briefly reviewed in the following accounts. Dice snakes with the highest mean values of ventrals originate from the region north of the Black Sea between the Crimea Peninsula and the Volga delta (Caspian Sea, see below). The highest individual number of ventrals are also from dice snakes in this region (ventrals = 193), based on a female and two males. Farther east towards China, southeast towards Iran and from the Northern Turkey south to Egypt and the Persian Gulf, the number of ventrals decreases; a female from Egypt with 152 ventrals and two males with 159 ventrals, one from Egypt and one from Israel, were the lowest values found.

In literature, the lowest ventral number is 148 (SCHREIBER 1912) and may belong to a dice snake from the Levant or Egypt as well. Alternatively, SCHREIBER's particular low ventral minimum probably originates from the morphological similar viperine snake (*Natrix maura*), that generally exhibits lower ventral numbers (SCHÄTTI 1982), and was often confused with *N. tessellata* in the past. In his text, SCHREIBER (1912) mentions explicit the dice snake from France, where actually only the viperine snake occurs. The highest ventral count of 198 is listed in HECHT (1930), which is the maximum value normally referred to in publications. This record probably belongs to a specimen from the region north

of the Black Sea, where the highest values are found, but no locality is explicit mentioned for this specimen in HECHT's publication. Furthermore, before DOWLING (1951) suggested the widely accepted ventral-counting method, the anterior preventrals scales were included in counting ventrals,, thus resulting in a slightly higher number of individual ventrals. Within *N. tessellata*, this concerns mostly 1 to 2 preventrals in an individual, but up to 6 were also found.

The descriptive data show that ventrals in *N. tessellata* vary clinally over distance. Four geographic models have been selected to illustrate the clines of mean values, roughly in an east-west direction (Figs. 1–4). With a few exceptions, most regional values (means) selected for a



Fig. 1. An eastern Circum-Mediterranean cline of the number of ventral scales (means) in *Natrix tessellata*; *n* adjacent to the mean value. Regions are: PoPl (Po Plain, northern Italy and adjacent southern Switzerland), WeBa (Western Balkan), Gree: (Greece), TuBS (Turkish Black Sea Coast), TuWc (Turkish Western Coast), TuSC (Turkish South Coast), Isra (from north to south in Israel, data by WERNER & SHAPIRA 2011), Egyp (from Nile delta to El Faiyum, Egypt).



Fig. 2. Central-Southern cline of the number of ventral scales (means) in *Natrix tessellata*; *n* adjacent to the mean value. Regions are: LSWT (Lakes Region of South-West Turkey), TuSy (Turkish-Syrian border area), NoIr: (Northern Iraq), CeIr (Central Iraq), SoIr (Southern Iraq).



Fig. 3. Northern cline of the number of ventral scales (means) in *Natrix tessellata; n* adjacent to the mean value. Lit (= value from Literature without *n*). Regions are: CzSl (Czech and Slovak republics, data by REHÁK 1992), UkCa (Ukrainian Carpathians, data by SHCHERBAK & SHCHERBAN 1980), Roma (Romania, data by FUHN & VANCEA 1961), TuBS (Turkish Black Sea Coast), NoBS (North of Black Sea), EaCS (East of Caspian Sea), Kaza (Kazakhstan), NElb (North of Elburs Mts.), TkIr (Turkmenistan-Iran border area), TkUz (Turkmenistan-Uzbekistan area), AfTz (Afghanistan-Tadzikistan), Kirg (Kyrgyzistan), NWCh (North-Western China), KiCh (Kizil, China).



Fig. 4. Clinal variation in the number of subcaudal scales (means) in *Natrix tessellata*; *n* adjacent to the mean value; Lit (= value from Literature without *n*). Regions are: PoPl (Po Plain, northern Italy and adjacent southern Switzerland), WeBa (Western Balkan), Gree: (Greece), TuBS (Turkish Black Sea Coast), NeTu: Northeastern Turkey (Region between the town Kars and Lake Van), LSWT (Lakes Region of South-West Turkey), Isra (from north to south in Israel, data by WERNER & SHAPIRA 2011), Egyp (from Nile delta to El Faiyum, Egypt).

cline are based on a minimum sample of n = 5 per sex in order to remove the variation caused by sexualdimorphism of ventrals (MEBERT 2011b). Yet, the clines vary parallel in both sexes. The graphs certainly simplify the overall geographic variation, in particular in mountainous areas such as southern and eastern Turkey, where the geographic variation probably is increased due to temporary isolation. But the clines provide an overview of the variation in a species with a huge distribution. The clines orientate themselves along putative natural expansion routes including river systems, coastal areas and mountains.

A first, eastern Circum-Mediterranean cline is depicted in Figure 1. Ventral values increase in eastern direction, beginning at the western edge of its distribution, the Po Plain (southern Switzerland and northern Italy) following along the eastern Adriatic coast, across Greece to reach the highest values in this cline along the Turkish Black Sea coast. From there, ventral values decrease in populations around the Turkish Mediterranean coast, and continue to decline along the Levantine coast to reach the lowest mean of ventrals for this species in Egypt.

A second cline (Fig. 2) begins with relatively high values of ventrals in the Lakes Region of southwestern Turkey. This cline of ventral values decreases into the lowlands of southeastern Turkey/northern Syria. From there and from adjacent northern Iraq, ventral values in dice snakes continue to decrease in southern direction along Euphrates River as far as southern Iraq. A third cline (not shown) represents the central area of distribution and begins with high ventral values in northeastern Turkey. From there, the ventrals counts are slightly decreasing, but maintaining high values, following a route along the Zagros Mountains into central Iran (incl. Tehran). The cline ends with slightly lower ventral values in Fars, in southern Central Iran.

A fourth, the Northern cline, is supported by various literature data in its western part. It begins with relatively small values in the Czech Republic (Fig. 3), continues with steadily increasing values southeast along the Carpathians into Romania, and farther east to finally reach the highest ventral values for *N. tessellata* in an area between the Black Sea and the northern half of the Caspian Sea. Here, the dice snakes exhibit on average 18 ventrals more than conspecifics in Western Europe. The cline decreases again along the low-lying areas east of the Caspian Sea to reach its regional low along the southern coast of the Caspian Sea. From there, ventral values increase again into the various mountainous areas towards the East as far as into China and Afghanistan.

Subcaudals

As for ventrals, there appears to be a clinal increase in the number of subcaudals from west (Italy) to east as far as Turkey. The highest values in males are reached in western Balkan and in females in Greece (Fig. 4). The probably isolated population at Lake Iliki, central Greece, is excluded in this analysis, because it shows various unusual characters (MEBERT 1993). Turkish dice snakes exhibit low numbers of subcaudals similar to specimens from Western Europe. Animals from the Near East also show on average low numbers of subcaudals. Three males from the area between Western Syria and Egypt possess the lowest absolute values of 59 subcaudals and a female from Bralos, south of Lamia in central Greece, shows the minimum with 47 subcaudals, equal to those reported by other authors (see refs. in MEBERT 1993). The highest number of 87 subcaudals were reported by BANNIKOV et al. (1971).

Overall, the subcaudal variations are more subtle and less prominent over geographic distances than the clines in the ventral counts. As in ventrals, there are high values in *N. tessellata* from the area between the Black Sea and the northern half of the Caspian Sea, but similar high values can be found in different areas in Europe and Asia.

Color Polymorphism

A dice snake, varying from olive to beige, grey, and brown, with 4–5 rows of dorsal blotches is the common form and occurs anywhere in its large distribution. Large and small spotted dice snakes may occur in the same populations (see TUNIYEV et al. 2011). But in the Levant and Egypt, small spots and a prominent blackish nuchal angle is the common morph (BAHA EL DIN 2011, WERNER & SHAPIRA 2011). Other variations, such as melanistic and spotless (concolor) morphs can be locally absent to be very abundant, but occur over most of its huge range, including recently discovered ones, such as two concolor dice snakes from Prague, Czech Republic (Fig. 5), and Lake Garda, Italy (MEBERT 1993, and Figs. 6a–e), or the melanistic dice snakes in Slovenia, CAFUTA (2011).



Fig. 5. Patternless (concolor) *Natrix tessellata* from Prague. A hatchling and an adult with dorsal and ventral view. Photos: PETR & MIKULAS VELENSKÝ



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.



Melanism in dice snakes occurs in temperate wet to mediterranean dry areas, on mainland or islands (ME-BERT 2011c). They occur with a constant frequency of 10%–17% at Lake Lugano in southern Switzerland (ME-BERT 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 (TUNI-YEV 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. 7. A male and female (insert left) of melanistic *Natrix tessellata* from Lake Lugano, Switzerland. Photos: HERBERT BILLING & KONRAD MEBERT.



Fig. 8. Tendency to striping and longitudinally stretched dorsal blotches in *Natrix tessellata* from Lake Iliki, Greece. Preserved females from the Natural History Museum of Geneva. Photos: KONRAD MEBERT.

form occurs also with a constant frequency at Lake Iliki, in central Greece (MERTENS 1969) (Fig. 8).

Additional Morphological Characters (data sets 1 and 2)

A number of additional scale characters have been investigated in *N. tessellata* from an area between Western Europe to Eastern Turkey. Similar to the number of ventral counts, these characters show a clinal variation with increasing values for both sexes from west to east.

For example, the ventral position (relative to the ith number of ventral scales, see MEBERT 2011a) of the bilateral reduction from 19 to 17 dorsal scale-rows is shifted more posterior, i.e. closer to the vent, in specimens from farther east, with the highest values were recorded



Fig. 9. Clinal variation of the subcaudal scale position (means) of the scale-rows reductions to 8 caudal rows (= R8Cau) in *Natrix tessellata*; reR8Cau (%): relative position [(R8Cau/sub-caudals)*100]; n adjacent to the mean value; regions are: PoPl (Po Plain, northern Italy and adjacent southern Switzerland), WeBa (Western Balkan), Gree (Greece), NeTu: Northeastern Turkey (Region between the town Kars and Lake Van).

in dice snakes from Greece (see MEBERT 2011b). In comparison to snakes from Italy, the position of the reductions in Greek females is shifted by an average of 10.4%, and in males by 9.0%, towards the vent. Hence, these reductions occur approximately 17 to 20 ventrals farther posterior in Greek animals. An additional reduction to 15 dorsal scale-rows on the trunk is very rare in dice snakes east of Italy (3 out of 158 snakes), whereas up to 30% of western snakes reduce down to 15 scalerows.

The situation is comparable for corresponding scalerow reductions on the tail, but in this trait, snakes from north eastern Turkey exhibit the highest values. The reduction to 8 dorsal scale-rows is shown as an example in Figure 9. Similar to scale-row reductions on the trunk, the increase in the caudal reductions in north eastern Turkish dice snakes amounts from 5% to 10%.

Labial and ocular scales tend to increase also from west to east. For example 27.5% of the female and 7.6% of the male dice snakes from areas east of Italy evolved more than 10 sublabials, including three females with 12 sublabials and one male with unilaterally 13 sublabials. In comparison, no snake from natural populations in Western Europe showed more than 10 sublabials.

Regarding postocular scales, 90.5% of the dice snakes in the eastern group show 4 or more postoculars, whereby the increase to higher values in eastern populations begins at Greece. In more western dice snakes, only about 40% showed 4 or more postoculars. The situation is similar but less prominent in the number of preoculars. Finally, in approximately 90% of the eastern dice snakes the eye is in contact with only the fourth supralabial scale. The comparable value for snakes from western populations is substantially decreased and varies from 13% to 55%, as the eye in western dice snakes is commonly in touch with the fourth and fifth supralabials.

The longest dice snake was measured by CALINESCU (1931) and originates from a specimen from Romania with a total length of 130 cm, including 22 cm for the tail. However, the total length is dependent on the population, respectively locality, and not on the latitude itself, i.e. dice snakes from warmer, southern areas are not automatically larger, as was often written in semi-popular publications (see refs. in MEBERT 1993). Even between genetically closely related to identical populations, specimens achieve often different average total lengths, probably due to variable ecological causes, including microclimate, food, pollution, and predation, and consequently individual survival and growth. For example, based on large samples and equal methods (MEBERT 1993, 2011a), adult dice snakes of allochthonous populations in Switzerland at the lakes Geneva, Alpnach, and Brienz, achieved on average greater lengths and weights than their parental population in climatically warmer Ticino, southern Switzerland, or similarly from another autochthonous population at Lake Garda, Italy, with the smallest specimens in this comparison (MEBERT 2011b). Tails of dice snakes from western Balkan and Greece are



Fig. 10. Cluster phenogram showing the phenetic relationships in Natrix tessellata among different regions of Europe to the Near East (eastern Mediterranean). The analysis was processed with relative values of body proportions, positions of scale row reductions, and numbers of ventral/subcaudal/ cephalic scales (MEBERT 1993, 2011a). The regions are in alphabetical order: CeIt (central Italiy), CeTu (central Turkey), Gree (Greek mainland, without specimens from Lake Iliki), LaAl (Lake Alpnach, alpine Switzerland), LaBr (Lake Brienz, alpine Switzerland), LaGa (Lake Garda, northern Italy), LaGe (Lake Geneva, western Switzerland), LaIl (Lake Iliki, central Greece), LaLu (Lake Lugano, southern Switzerland), MaVa (Maggia Valley, southern Switzerland), NeEa (Near East), NeTu (North eastern Turkey), Turi (Turin, north western Italy), VeVa (Verzasca Valley, southern Switzerland), WeBa (Western Balkan, especially Dalmatian coastal region).

on average from 1% to 4% longer (relative to SVL) than in other conspecifics from western Europe to northeastern Turkey.

To investigate whether the intraspecific morphological variation is suitable to indicate physical proximity and potentially phylogenetic relatedness, a cluster analysis based on 27 normally distributed characters (various body proportions, positions of scale-rows reductions, and numbers of ventral/subcaudal scales) was processed by the method of WPGMA (Weighted Average Linkage), using standardization and correlation of mean values and standard deviation (sexes separated). Figure 10 shows phenetic similarity among male dice snakes. A similar phenetic diagram for females is displayed in MEBERT (2011a). The cluster analysis groups dice snakes that are from contiguous areas, and thus confirms that phenetic similarity represents relatedness. Even small samples like the ones from Verzasca Valley, Lake Iliki, and central Turkey are correctly grouped. This means that the remarkable geographic variation of the dice snake enables the correct allocation of a specimen with unknown geographic origin by using a multitude of morphological characters as in this study. For example, the number of ventrals and subcaudals in Israeli dice snakes resemble more those of western European specimens than the physically closer northern Turkish dice snakes. However, the Israeli snakes are correctly grouped with the Near East-Turkey sample, because of the inclusion of additional characters like scalerow reductions.

Mechanisms of Geographic Variation of Pholidosis

The geographic variation of pholidotic characters in *Natrix tessellata* is large, but its clinal pattern precludes any partitioning into regional groups, or even distinct systematic taxa. I anticipate that a future study may show that the geographic variation of morphological characters in the dice snake is consistent with the genetic structure (nine major clades in *N. tessellata* based on cytochrome b sequences) and phylogeographic history already investigated (e.g. GUICKING et al. 2009, GUICK-ING & JOGER 2011). It may also require a geographically more fine-scaled analysis, in particular along the contact zones of putative genetic or morphological groups. The clines imply some history of relatedness and regional temporary isolation, as their ranges expand and retract due to environmental changes.

Another issue relates to the potential ecological causes of the observed clinal variation of pholidotic characters, e.g. climatic factors. It has been shown that scale numbers decrease towards cooler and moister environments in Californian snakes species KLAUBER (1941), as well as in a thermal experiment with Thamnophis species Fox et al. (1961). However, in the related North American natricines Nerodia sipedon and N. fasciata, the number of ventral scales and dorsal scale-row reductions increases in populations from cooler, more northerly or mountainous (only *N. sipedon*) regions (MEBERT 2010). This suggests that a cooler climate promoted the evolution of a greater body volume via higher scale numbers, and thus body segments, to increase clutch mass (higher number or greater size of embryos) and food intake to compensate for a shorter activity season. Such a scenario may fit the most prominent clinal increase of ventral scale counts in dice snakes from the lowlands of the North Arabian Peninsula (Iraq, Syria) northward to the area with the highest ventral counts between the Black and the Caspian seas. Furthermore, there is a tendency in southern areas for increasing scale numbers from populations in the lowlands towards those in the mountains, e.g. in Turkey and the mountains between Iraq and Iran. These meristic variations are probably correlated with environmental factors, given the large seasonal climatic differences in those areas.

A similar climaparallel variation was detected in the lizard genus *Liolaemus* from Chile, whereby scale numbers increase with a correlated decrease of scales size towards the moister and cooler south (HELLMICH 1951). However, the reduced scale counts in northern and cooler areas of Europe compared to values in the warmer Mediterranean area contradicts the simplicity of the hypothesis and indicate that other selective forces may also play a role in shaping the variation of pholidotic characters. Even though, if the scale number-climate correlation is valid in some regions, other regions possibly experience a different composition of selective forces.

More complicate is the search for direct causative factors for the climaparallel variation of scale characters, and is beyond the scope of this report. Just briefly a few accounts in this regard to indicate the complexity of this issue. SOULÉ (1966) and SOULÉ & KERFOOT (1972) found within American Agamid lizards that small scales absorb heat better and reduce water loss, thus small scales have an advantage in cool and dry regions. Otherwise THORPE & BAEZ (1987, 1993) registered that within the lizards Gallotia galloti from the Canarian Island Teneriffa and G. stehlini from Gran Canaria specimens originating from cooler and higher sites have larger scales. They assumed that scale size might depend on daily and annual temperature extremes and not on the average temperature. Finally, HORTON (1972), in a study of Australian scincid lizards of the genus Egernia, found that not the scales themselves but the skin between them is relevant for the water economy. His data do no show a logical relation between scale size and regional temperature differences. HORTON (1972) deduced the variation of scale pattern to a pleiotropic effect, involved in physiological adaptations to temperature and humidity. That means the scale pattern would not adapt to ecological conditions itself.

Nevertheless, SCHMIDTLER (1986) demonstrated a geographic variation parallel to climatic parameters of seven pholidosis-characters in Turkish green lizards of the genus *Lacerta*. In general, related forms have higher scale numbers in warmer, moister regions. I compared his data from Turkish populations with dice snake populations from the same areas (MEBERT 1993). The dice snakes exhibited an opposite trend to the lizards. SCHMIDTLER's conclusions should be interpreted in the view that only one of his seven chosen characters has a relation with body surface, which might play a thermoregulatory role in climate adaptations. I do not doubt that climatic factors have their influence on scale characters within reptiles, but the conflicting results and interpretations previously presented suggest that many more factors have to be considered to solve this problem. Ultimately, the numbers of ventrals and subcaudals of dice snakes from the hot regions of Egypt, Near East and southern Iraq are similar to the ones in Italian and Switzerland, but the climate is not.

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