

BIODIVERSITY IN RELATIVELY NEGLECTED TAXA OF *TESTUDO* L., 1758 S. L.

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Abstract

A review of recent findings pertaining to systematics and conservation of *Testudo* L., 1758 s. l. (Testudines: Testudinidae) are presented in a compact format. *T. weissingeri* Bour, 1995 is a valid species. Thigh-spurs are found very frequently in *T. weissingeri* and *T. marginata* Schoepff, 1792. Release campaigns using captive or confiscated stock are a threat to wild populations. The three steppe tortoise subspecies in the genus *Agrionemys* Khosatzky & Mlynarski, 1966 are elevated in rank. Taxonomic importance of mutual relationships exhibited by plastral seam lengths is tested with reference to *T. hermanni* Gmelin, 1789. A long forgotten name is resurrected for a tortoise population in the Balkans.

Key words: Testudinidae; *Testudo* s. l.; *Agrionemys*; systematics and taxonomy; conservation

Introduction

This article is a compact, mainly taxonomic, medley based on results from recent studies dealing with various *Testudo* sensu lato taxa (as in Lapparent de Broin, 2001; Perälä, 2002a in this volume). Some inferences presented herein have been published elsewhere, and these are given a brief overview only. On the other hand, most of the results appear here for the first time. Themes which are dealt with include:

(a) Is *T. weissingeri* Bour, 1995 merely a local dwarf population of *T. marginata* Schoepff, 1792 – a subspecies of the latter at most, as suggested by Artner (1996, 2000)? The status of this taxon is much debated (Ernst et al., 2000).

(b) A related topic is the occurrence of thigh-spurs in *T. marginata* and *T. weissingeri*, taxa which are supposed to lack spurs altogether (e.g., Mertens, 1946; Pritchard, 1979), or in which these are relatively rarely encountered (e.g., Bour, 1995; Buskirk: in Bour, 1995). Results from a recent study on thigh-spur frequencies are reviewed.

(c) *T. kleinmanni* Lortet, 1883 from East of the Nile delta appeared to be morphologically peculiar, according to field and museum work. This hypothesis was tested, and the eastern population was subsequently described as a new species in an article published not long ago (Perälä, 2001a). Conservation issues pertaining to *T. kleinmanni* and the new species (Negev tortoise), and chelonians in general, are discussed critically.

(d) The opportunity arose to examine wonderfully prepared whole skeletons of (not only) *Agrionemys horsfieldii* (Gray, 1844) in the Siebenrock collection of the Vienna Natural History Museum. These specimens were inspected in detail. Comparisons were made also relative to osteological material from elsewhere, and between the three subspecies, i.e. *Agrionemys h.*

horsfieldii (Gray, 1844), *A. h. kazachstanica* Chkhikvadze, 1988 – and *A. h. rustamovi* Chkhikvadze, Amiranashvili & Ataev, 1990. For the position of *Agrionemys* as a valid genus, see Perälä (2002a, in this volume).

(e) A recent paper suggested that released or escaped (ex-captive) *T. h. boettgeri* Mojsisovics, 1889 – or – hybrids between the first taxon and *T. hermanni hermanni* Gmelin, 1789 exist in French populations (Guyot & Pritchard, 1999). This hypothesis was based on wild animals exhibiting a pectotal-femoral seam ratio atypical of *T. h. hermanni*, the subspecies native to western S Europe, in addition to differences in coloration. The interfemoral is shorter than the interpectoral in *T. h. boettgeri* (vice versa in *T. h. hermanni*), according to Bour (1987), among others. Consequently, the inference by Guyot & Pritchard (1999) had the effect that this author suffered many sleepless nights devoted to the subject. Relative to homogenous tortoise populations from elsewhere, experience from fieldwork suggested that, mutual relationships expressed by plastral seam lengths could not necessarily be used in a strictly categorical fashion for taxonomic inferences.

(f) During yet another rainy day at The Natural History Museum in London, shells of a few *T. hermanni boettgeri* from historical Dalmatia, and Bosnia-Herzegovina in the Balkans, were noted to feature rather interesting characters. More material from the same region was subsequently investigated to clarify the taxonomic significance of this finding. A population from Bosnia-Herzegovina was earlier described as *Testudo graeca* var. *hercegovinensis* Werner, 1899. *T. graeca* was used incorrectly of *T. hermanni* Gmelin throughout the 19th century (Siebenrock, 1913). The lectotype of *Testudo g. var. hercegovinensis* is specimen NMW 1222,

by designation of Bour (1987). The name is a junior synonym of *T. hermanni*, according to Siebenrock (1906; as *T. graeca*), Wermuth & Mertens (1961), and Bour (1987), among others.

Materials and Methods

For the taxonomic study, male *T. marginata* and *T. weissingeri* were examined in BMNH, MNHN, MTKD, NMW, and in the collection of R. Bour (RB) (2 living specimens). Statistical inference is based on Maximum Likelihood Factor Analysis (FA) with no rotation, Linear Discriminant Function Analysis (DFA), and univariate ANOVA. The FA was based on the following characters: CL, PL, MI, MA, GU-w, HE, ASO-w, ASO-h, BR, HUM-w, FEM-w, AN-w, NU-w, HUM-m, PEC-m, FEM-m, AN-m, PEC-w, ABD-w, V1-w, V2-w, V3-w, V4-w, V5-w, C1, C2, C3, C3, SUP-d, and SUP-v. Key to character abbreviations, and definitions, are listed in Perälä (2001a, and 2002b, this volume). Material and methods used in the *marginata* - *weissingeri* thigh-spur analysis are listed in the original article (Perälä, 2001b). Osteology of *Agrionemys horsfieldii* was examined in BMNH, MNHN (P) (= Palaeontology Dept.) and (Z) (= Zoology Dept.), NMW, and UF. Uncatalogued material of extant species in the MNHN(P) was coded with "FB" and a unique number by the author, and with letters in the MNHN(Z). The *T. hermanni* plastral seam length comparison is based on material examined in MNHN, BMNH, MTKD, and additionally, on field data collected by R. Bour in France and Greece (RB-F). Plastral seam lengths in French *T. hermanni hermanni* were analysed using Pearson correlation, and Linear Regression Analysis. One-way ANOVA was used to test plastral seam length variation among five *T. hermanni* populations in France and Italy (i.e. *T. hermanni hermanni*), and in Greece, the north-eastern Adriatic coast, and NE Balkans (*T. hermanni boettgeri*). The sexes were not pooled. Therefore, each ANOVA contains ten groups. In a separate investigation, *T. hermanni* specimens from Bosnia-Herzegovina and adjacent regions were examined in BMNH, FMNH, NMW, and UF. Museum acronyms follow suggestions by Leviton et al. (1985). The Evolutionary Species Concept was used as a theoretical basis with reference to literature cited in Perälä (2001a, 2002b). Characters used in ANOVA were standardized for maximum length (CL), following methodologies described in Perälä (2001a, 2002b). No specimens under 100 mm carapace length were used in morphometric analyses. Significance level for all statistics was set at $\alpha = 0.05$. All morphometric data were analysed using Minitab 12.1 (Minitab, Inc.).

Results and Discussion

Taxonomic status of *T. weissingeri*

In Factor Analysis, Factors F1-3 account for 88% of the variation. Factor loadings are presented in Table 1. *T. weissingeri* is fully separated from *T. marginata* in F1 + F2, and F1 + F3 score plots (Fig. 1). Thus, *T. weissingeri* is fully diagnosable in multivariate space. Discriminant Function Analysis classifies 100% of specimens into known groups (taxa). DFA with cross validation classifies 96.8% of individuals correctly (Table 2). Four cases contain missing values. 25 significant to very

highly significant differences are detected in a comparison of characters standardized for body length.

T. weissingeri males differ from *T. marginata* males by: a considerably shorter average length (ANOVA $F_{1,34} = 55.60$, $P < 0.0001$), a longer plastron (max.) (ANOVA $F_{1,34} = 12.28$, $P < 0.001$), a longer plastron at midline (ANOVA $F_{1,34} = 13.93$, $P < 0.001$), a broader midbody at bridge (ANOVA $F_{1,34} = 12.79$, $P < 0.001$), a much greater overall height (ANOVA $F_{1,34} = 18.58$, $P < 0.0001$), a very much wider anterior carapace opening (ANOVA $F_{1,34} = 25.24$, $P < 0.0001$), a higher anterior carapace opening (ANOVA $F_{1,30} = 16.88$, $P < 0.0001$), a somewhat longer bridge (ANOVA $F_{1,34} = 6.91$, $P < 0.013$), a considerably wider plastron across humerals (ANOVA $F_{1,34} = 30.70$, $P < 0.0001$), a substantially broader plastron across femorals (ANOVA $F_{1,34} = 46.51$, $P < 0.0001$), a very much wider plastron across anals (ANOVA $F_{1,34} = 22.59$, $P < 0.0001$), a wider nuchal scute (ANOVA $F_{1,34} = 19.35$, $P < 0.0001$), a slightly longer interhumeral seam (ANOVA $F_{1,34} = 6.21$, $P < 0.018$), a longer seam separating the abdominals (ANOVA $F_{1,34} = 4.42$, $P < 0.043$), a wider plastron across pectorals (ANOVA $F_{1,34} = 10.36$, $P < 0.003$), a very much broader plastron across abdominals (ANOVA $F_{1,34} = 20.54$, $P < 0.0001$), a wider second vertebral (ANOVA $F_{1,34} = 6.74$, $P < 0.014$), a wider fourth vertebral (ANOVA $F_{1,34} = 7.45$, $P < 0.010$), a very much longer third vertebral (ANOVA $F_{1,34} = 15.15$, $P < 0.0001$), a longer ventral diagonal length of first costal (ANOVA $F_{1,34} = 7.50$, $P < 0.010$), a longer ventral length of second costal (ANOVA $F_{1,34} = 9.74$, $P < 0.004$), a longer ventral length of third costal (ANOVA $F_{1,34} = 6.49$, $P < 0.016$), a shorter supracaudal (ANOVA $F_{1,34} = 7.28$, $P < 0.011$), a broader head (ANOVA $F_{1,25} = 13.39$, $P < 0.001$), and, a greater distance between eye and tympanum (ANOVA $F_{1,14} = 11.48$, $P < 0.005$). All characters are subject to individual variation. Additionally, it appears to be, but this has not been quantified (tested) yet that, the abdominals are widest at around the middle to 2/3 length in *weissingeri*, whereas the broadest region in *marginata* is located more posteriorly, very close to the inguinals.

Though published accounts are largely lacking, it is well known that scepticism about the species status, and even subspecific status, of *T. weissingeri* is wide-spread among peers (Ernst et al., 2000), and especially among serious turtle enthusiasts. It is also well known that, (not only) closely related turtles and tortoises are often very hard to tell apart by convenient methods, and by characters pertaining to superficial structures only. This is understandably frustrating to hobbyists and breeders, and sadly, even to many scientists. However, science must not let itself be infiltrated by untestable speculation, or be affected by pressure from interest groups or opinion leaders. In his criticism, Artner (1996, 2000) does not provide any such evidence against the species status of *T. weissingeri* which would satisfy contemporary scientific standards. The argumentation is based merely on opinion (Artner, 1996 and 2000), in addition to containing misconceptions about various species concepts (Artner, 2000).

It is evident that *T. weissingeri* shows considerable morphological divergence relative to *T. marginata*. What

is important from a taxonomic perspective is that, proportional differences are very prominent. *T. weissingeri* is not just smaller – size being not a reliable taxonomic character in most cases, anyway. The morphological distinction of the Peloponnese tortoise is of a calibre leaving few doubts about its taxonomic rank. *Testudo weissingeri* Bour, 1995 is a full species regardless of theoretical framework (species concept) used.

The fact that males of *T. weissingeri* exhibit larger anterior shell openings and broader plastra than male *T. marginata*, might constitute to divergent modes of feeding, and breeding, respectively. Certainly, carapaces of *weissingeri* females are wider than those of female *marginata*. This dichotomy could have a negative effect on interspecific mounting, but it would logically be a good adaptation among conspecifics. Therefore, it would appear to be an attractive hypothesis that the wide male plastra and accordingly broad female carapaces are co-adaptive traits in *weissingeri*. The importance of the differences in shell shape, the extent these differences affect behaviour, and the question whether these differences constitute to other mechanisms which keep the species apart, would have to be tested.

Testudo weissingeri and *T. marginata* are classic examples of sibling species – and certainly not an isolated case among African-Eurasian tortoises.

Thigh-spurs in *T. marginata* and *T. weissingeri*

The results, supported by Chi-square tests, suggest that thigh-spurs, which are generally supposed to be absent or relatively infrequent in both taxa, are actually very common among both examined species. Males and females do not differ significantly by their thigh-spur frequencies within or between the investigated taxa. The presence or absence of thigh-spurs, neither one of which character state is significantly more frequent than the other, cannot be reliably used as a taxonomic character in conjunction with either *T. marginata* or *T. weissingeri* – whereas on the other hand, the regularity of this variability (relatively stabile dichotomy) could itself prove to be a useful character for phylogenetic reconstructions, and it has been used as such by Perälä (2002a). A full article about this topic was published recently elsewhere (Perälä, 2001b).

Egyptian tortoise taxonomy in the broader context of chelonian conservation

The tiny eastern *T. kleinmanni* population in the Negev (Israel), and adjacent regions in northern Sinai (Egypt), was found to be distinct. This population was subsequently described as a new species in a recent article (Perälä, 2001a). The discovery of the Negev tortoise has conservation implications. CITES 1 listed *T. kleinmanni* is endangered, and it is already technically extinct in mainland Egypt (Baha El Din, 1994). The inference that *T. kleinmanni* with a highly fragmented population is actually a composite of two species should be taken into account in conservation efforts and legislation at national and international level. Such efforts would have to be carefully planned and monitored. There is an ongoing programme based on Sinai, which aims to introduce confiscated Libyan, i.e. true *T. kleinmanni* onto

northern Sinai (Wenman et al. 2001; case reviewed in: Perälä, 2001a). The Sinai programme has influential backers such as the Zoological Society of London, and the Royal Netherlands Embassy in Cairo. Animals have already been introduced on an island at Lake Bardawil (Baha El Din, 1999). This poses incalculable risks for the remaining wild populations of the Negev tortoise. It is now understood that contact between confiscated *kleinmanni* and wild Negev tortoises has already taken place (Baha El Din, in litt., spring 2001), as predicted earlier (Perälä, 2001a). The Sinai *T. kleinmanni* programme, and other well-meant but hastily executed "conservation efforts" around the Mediterranean (and elsewhere) are a direct and very serious threat to wild populations, as opposed to the intended aims of such activities. Release programmes involving various *Testudo* s. l. are also taking place on a constant basis in Spain and Morocco, and in southern Europe. These are led by various organizations, and disguised often behind terms such as "repatriation", or "reintroduction". In reality, such release campaigns are based on animal welfare philosophy rather than conservation biology. These projects deal with ex-captive or confiscated stock with unknown or uncertain origins or parentage, and which animals are released into the wild in the naïve intent to help individual animals, and to enhance the survival of local populations.

The release of animals into the wild from captive sources, whether (ex-situ) captive-bred or confiscated, involve intolerable risks and uncertainties such as genetic mixing, the spread of pathogens (all of which can never be screened for, or which are still undiscovered), ecological incompatibility, as well as ecological interactions, among others. Wild populations of *Testudo* s. l., a group still certainly containing undiscovered taxa – and even though possibly in decline in places – will do much better without the introduction of risk-bearing factors into these populations. Unwanted pets and confiscated animals must be dealt with by other means than by dumping them into the wild. Alarming, animal welfare issues and genuine conservation biology are being mixed-up with increasing speed. Well-meaning but naïve pressure groups or NGOs have become very powerful. Sadly, unscientific release campaigns are very popular not only among the public, but also among misinformed or opportunistic legislators, sponsors, and even some scientists. As for true conservation biology, efforts would have to be carefully planned, tested and prioritised. Generally, funds aimed at chelonian conservation should best be directed at scientifically monitored habitat conservation and management schemes (being beneficial to the whole regional biota), basic research, education of the public, and possibly at in-situ projects such as head-start programmes, where necessary. The Chelonian Working Group of the world's largest herpetological society, DGHT, in association with TRAFFIC Network, WWF (Germany), and other institutions, researchers, and private individuals from around the globe signed recently a resolution to stop the wanton release of chelonians from captive sources into the wild (Anonymous, 2001; Pieh, 2001). Any further releases would ignore the wide-spread consensus among wild-life officials and scientists opposing such actions,

and the future well-being of wild chelonian populations.

Bones speak

Despite having been described as subspecies, differences found between *Agriemys horsfieldii kazachstanica* and *A. h. rustamovi* were greater than mutual differences exhibited by full species in genera such as *Homopus*, Duméril & Bibron, 1835, *Gopherus*, Rafinesque, 1832, and *Chelonoidis*, Fitzinger, 1835, according to Chkhikvadze et al. (1990). Recent research supports the view that all three *A. horsfieldii* taxa are sufficiently different to warrant full species status, a stand taken here. Below is a comparison of mutually exclusive combinations of osteological characters in *Agriemys horsfieldii* (Gray, 1844), *A. kazachstanica* Chkhikvadze, 1988 and *A. rustamovi* Chkhikvadze, Amiranashvili & Ataev, 1990.

(a) Configuration of the entoplastron (hexagonal with a sharp tip in *rustamovi*; heptagonal with transversely straight - or blunt - anterior tip in *kazachstanica* and *horsfieldii*); (b) distance between dorsal plastron surface and ventral carapacial rim is very great in *kazachstanica*; (c) intermedium and ulnare are separate bones in *rustamovi* (Fig. 2) but fused in the manus of *kazachstanica* (Fig. 3) (no data on *horsfieldii*); (d) width across pterygoids at narrowest point is small in *kazachstanica* (Fig. 4), intermediate in *horsfieldii* (Fig. 5), and great in *rustamovi* (Fig. 6); (e) premaxillae are very well visible in dorsal view in *kazachstanica*, and especially in *rustamovi*, but not so in *horsfieldii*; (f) the central ridge of the triturating surface of the maxilla is only weakly developed in *horsfieldii*, as opposed to the other taxa; (g) pertaining to adults, *rustamovi* is the only population in which the parietal-supraoccipital complex can exhibit a deep notch (depression) in lateral view.

Plastral seams in *T. hermanni*

Interpectoral and interfemoral lengths are not correlated in French *T. h. hermanni* males (Pearson correlation = 0.237, $P = 0.098$), and the interfemoral length accounts only for a minute proportion of the variation found in the length of the interpectoral ($R^2 = 5.6\%$) (Fig. 7). Pectoral and femoral seam lengths show some correlation in statistical terms in females (Pearson correlation = 0.366, $P = 0.013$), but the interfemoral length accounts only for a small proportion of the variation found in the interpectoral length ($R^2 = 13.4\%$) (Fig. 8). In other words, these parameters are generally not interdependent. The findings suggest that, individuals of French *T. hermanni hermanni* do not always have to feature a pectoral seam shorter than the femoral seam, even though such a plastral relationship would be the typical condition. Lengths of pectoral and femoral seams are either not (males), or, they are only very weakly, correlated (females). Thus results based on the interpectoral-interfemoral ratio exclusively do not necessarily confirm that hybrids between *T. h. hermanni* and *T. h. boettgeri*, or dumped individuals of the latter, exist in French populations - as opposed to suggestions by Guyot & Pritchard (1999), though this is possible. In any case, the present author certainly fully shares the concern expressed by Guyot & Pritchard (1999) about the threats posed by released or dumped captive stock with

respect to the well-being of wild populations.

The strictly categorical use of "longer than / shorter than" relationships as reliable taxonomic parameters becomes even more questionable when variation in plastral seam lengths are analysed among five *T. hermanni* populations. The pectoral seam, standardized for maximum carapace length, shows very highly significant variation among five *hermanni* populations (ANOVA $F_{9, 281} = 36.59$, $P < 0.0001$; sexes not pooled) (Fig. 9). Notably, sexual dimorphism is great but it is not evaluated here. The typical interpectoral length is significantly different (Fischer's pairwise differences: $P < 0.05$) between males from all populations with the exception of Greece and E Adriatic, and E Adriatic and Italy, respectively. Interpectoral lengths among females differ significantly (Fischer's pairwise differences: $P < 0.05$) between all populations, except for Greece and E Adriatic, and NE Balkans and E Adriatic. Variation in standardized interfemoral length is very highly significant across all groups (ANOVA $F_{9, 281} = 10.70$, $P < 0.0001$) (Fig. 10). The length is significantly divergent between females in France and Greece, France and NE Balkans, France and E Adriatics, Greece and NE Balkans, NE Balkans and Italy, and Italy and E Adriatic (Fischer's pairwise differences: $P < 0.05$). Males show significantly different interpectoral lengths between the following population pairs: Greece and France, France and NE Balkans, France and E Adriatic, Italy and Greece, Italy and NE Balkans, Italy and E Adriatic, and E Adriatic and Greece (Fischer's pairwise differences: $P < 0.05$). Variation across all populations is not clinal in an east - west, or in a north - south, transect (pertaining to one gender only). Variation in the standardized humeral seam length is again very highly significant across all groups (ANOVA $F_{9, 281} = 8.06$, $P < 0.0001$), and it is not clinal in east - west, or in north - south, direction (pertaining to one gender only) (Fig. 11). Sexual dimorphism is pronounced in the NE Balkan, Italian and Greek populations. Significant differences in interhumeral lengths are detected between males from France and Italy, France and E Adriatic, Greece and Italy, and Greece and E Adriatic (Fischer's pairwise differences: $P < 0.05$). Among females, significant differences are found between populations from France and Greece, France and NE Balkans, France and E Adriatic, Greece and NE Balkans, Greece and E Adriatic, Italy and NE Balkans, and Italy and E Adriatic (Fischer's pairwise differences: $P < 0.05$).

In conclusion, the interpectoral-interfemoral ratio cannot be used as such a reliable character to discriminate between *T. hermanni hermanni* and *T. hermanni boettgeri*. The results indicate additionally that, plastral seam lengths tend to be very variable across, but not within, geographical populations of *T. hermanni*, and that there are divergent evolutionary trends among genders. Thus these characters should be best dealt with separately in taxonomic terms, regardless of how impractical this might be. Most of the variation found is not clinal (within one sex), suggesting the existence of evolutionary independent histories for some geographical populations within both current subspecies. This is likely to have taxonomic implications.

A forgotten taxon from the NW Balkan Peninsula

Examination of a large series of museum specimens revealed that a population of *T. hermanni boettgeri* Mojsisovics, 1889 from historical Dalmatia, i.e. in parts of modern coastal Croatia, Bosnia-Herzegovina, and Montenegro, is taxonomically distinct. Tortoises from approximately a region delimited by Zadar, Mostar, Bileka, and Trebinje, even localities near Budva, are unique in that typically the animals do not possess inguinal scutes, an unheard condition among *Testudo* s. l., and a very easy-to-use taxonomic character. In this population, the abdominal scute has grown posterolaterally to replace the space occupied normally by the inguinal (Fig. 12). The very tiny accessory scales, situated normally posterior to the inguinals, and between 8th marginals and the abdominal scutes, are present, but in contact with the expanded abdominals (with the inguinals in other populations). The 7th marginals, which are normally in contact with the inguinal scute in *T. hermanni*, are not projecting posteriorly, or reaching the position normally taken by the inguinal scute, in most cases. An additional stupifying character found in many, but not all, individuals in this population, is the shape of

the posterior inguinal buttress which can be heavily forked dorsally (Fig. 13). Such a structure has not been witnessed in any other population among *Testudo* sensu lato. *Testudo graeca* var. *hercegovinensis* Werner, 1899 is an available name, and will hereby be resurrected as a full species *Testudo hercegovinensis* Werner, 1899 (comb. nov.) for this population. Werner (1899), or subsequent authors, did not notice the key characteristic of the missing inguinals pertaining to this population, and the name has been taken as a junior synonym of *T. hermanni* Gmelin for a century. *T. h. hermanni* and *T. h. boettgeri*, as currently understood, are likely to be unnatural taxa, and the *T. hermanni* species complex contains certainly more taxonomic variation than is recognized here (cf. previous chapter).

Nothing is known about the status of wild populations of *T. hercegovinensis*, but the species seems to live sympatrically with *T. h. boettgeri* in at least the periphery of its distribution in the north and south, according to museum data. Diagnostic mensural data for the lectotype of *T. hercegovinensis* (Fig. 14 and 15) are given below in Table 3. Localities for *T. hercegovinensis* specimens are presented in the Appendix.

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Addendum

Just before this article was about to be printed recent news about the Egyptian tortoise program (TortoiseCare) in Egypt became available. This information is relevant with respect to the chapter on chelonian conservation / *T. kleinmanni* published above in the present article.

As a result of a discovery of wild tortoises (*Testudo wernerii* Perälä, 2001) at Zaranik Protected Area on Sinai, the local conservation program has shifted its focus to conservation of this wild population, and released *T. kleinmanni* in the same area have been collected and returned to enclosures in Cairo (Baha El Din, 2002). The same article describes the finding of a small *T. kleinmanni* population in Egypt's Western desert where the species was thought to have gone extinct. An in situ conservation assessment is under way.

These new policies adopted by TortoiseCare are very welcome news and deserve support.

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Character	Factor 1	Factor 2	Factor 3
CL	0.956	-0.294	0.000
PL	0.933	-0.280	-0.025
MI	0.957	-0.241	-0.105
MA	0.934	-0.285	0.022
GU-w	0.827	-0.094	-0.034
HE	0.946	-0.246	-0.056
ASO-w	0.931	-0.307	-0.044
ASO-h	0.900	-0.086	0.011
BR	0.885	-0.371	-0.111
HUM-w	0.932	-0.237	-0.183
FEM-w	0.908	-0.308	-0.063
AN-w	0.924	-0.184	0.092
NU-w	0.705	-0.358	-0.029
HUM-m	0.565	-0.468	-0.083
PEC-m	0.691	-0.007	-0.174
FEM-m	0.886	0.147	-0.135
AN-m	0.321	-0.947	0.000
PEC-w	0.948	-0.256	-0.100
ABD-w	0.936	-0.288	-0.122
V1-w	0.808	-0.252	0.054
V2-w	0.892	-0.340	-0.193
V3-w	0.896	-0.330	-0.239
V4-w	0.899	-0.238	-0.184
V5-w	0.901	-0.203	0.032
C1	0.940	-0.215	-0.041
C2	0.897	-0.321	-0.263
C3	0.898	-0.345	-0.189
C4	0.912	-0.203	-0.045
SUP-d	0.833	-0.372	0.066
SUP-v	0.938	-0.170	0.162
Variance	22.892	3.073	0.429
% Variance	0.763	0.102	0.014

Table 1: Factor loadings, variances and percentages of information captured from Maximum Likelihood Factor Analysis of the correlation matrix for first three Factors from analysis of males of *T. marginata* and *T. weissingeri*.

Summary of Classification			Classification with Cross-validation		
Put into...	True group		Put into...	True group	
Group	<i>marginata</i>	<i>weissingeri</i>	Group	<i>marginata</i>	<i>weissingeri</i>
<i>marginata</i>	12	0	<i>marginata</i>	11	0
<i>weissingeri</i>	0	19	<i>weissingeri</i>	1	19
Total N	12	19	Total N	12	19
N correct	12	19	N correct	11	19
Proportion	1.000	1.000	Proportion	0.917	1.000
N = 31			N = 31		
N correct = 31			N correct = 30		
Prop. correct = 1.000			Prop. correct = 0.968		
Linear Discriminant Function for Group					
				<i>marginata</i>	<i>weissingeri</i>
Squared dist. btw groups			Constant	-2.2687	-0.9049
	<i>marginata</i>	<i>weissingeri</i>	Factor 1	4.0872	-2.5814
<i>marginata</i>	0.000	12.0785	Factor 2	-0.6899	0.4357
<i>weissingeri</i>	12.0785	0.000	Factor 3	0.8372	-0.5288

Table 2: Summary of classification from Discriminant Function Analysis without and with cross-validation for males of *T. marginata* and *T. weissingeri*. Linear method for response: species. Predictors: Factor Analysis scores from Factors 1-3.

Dimensions of the lectotype of *Testudo hercegovinensis* Werner, 1899

Maximum carapace length (CL): 118.7 mm	Interfemoral length: 6.7 mm (5.6% of CL)
Maximum plastron length: 99.2 mm (83.6% of CL)	Interanal length: 12.4 mm (10.4% of CL)
Median (midline) plastron length: 88.2 mm (74.3% of CL)	Combined pectoral scute width: 83.7 mm (70.5% of CL)
Max. width within bridge area: 96.9 mm (81.6% of CL)	Combined abdominal scute width: 87.5 mm (73.7% of CL)
Max. total width (i.e. at posterior marginals): 96.9 mm (81.6% of CL)	First vertebral width: 29.0 mm (24.4% of CL)
Maximum gular scute length: 14.8 mm (12.5% of CL)	Second vertebral width: 27.4 mm (23.1% of CL)
Combined gular scute width: 27.9 mm (23.5% of CL)	Third vertebral width: 31.1 mm (26.2% of CL)
Gular height: 10.6 mm (8.9% of CL)	Fourth vertebral width: 31.3 mm (26.4% of CL)
Maximum height: 63.1 mm (53.2% of CL)	Fifth vertebral width: 38.9 mm (32.8% of CL)
Inner width of anterior shell opening: 63.7 mm (53.7% of CL)	First vertebral length: 26.2 mm (22.1% of CL)
Inner height of anterior shell opening: 21.4 mm (18.0% of CL)	Second vertebral length: 22.6 mm (19.0% of CL)
Length of bridge: 48.5 mm (40.9% of CL)	Third vertebral length: 19.6 mm (16.5% of CL)
Combined humeral scute width: 56.6 mm (47.7% of CL)	Fourth vertebral length: 24.8 mm (20.9% of CL)
Combined femoral scute width: 67.3 mm (56.7% of CL)	Fifth vertebral length: 28.9 mm (24.3% of CL)
Combined anal scute width: 50.3 mm (42.4% of CL)	First costal length: 32.5 mm (27.4% of CL)
Nuchal scute length: 7.1 mm (6.0% of CL)	Second costal length: 20.1 mm (16.9% of CL)
Maximum (posterior) nuchal scute width: 2.9 mm (2.4% of CL)	Third costal length: 22.4 mm (18.9% of CL)
Intergular length: 14.2 mm (12.0% of CL)	Fourth costal length: 27.0 mm (22.7% of CL)
Interhumeral length: 17.1 mm (14.4% of CL)	Dorsal supracaudal width: 24.4 mm (20.6% of CL)
Interpectoral length: 6.6 mm (5.6% of CL)	Ventral supracaudal width: 39.8 mm (33.5% of CL)
Interabdominal length: 34.6 mm (29.1% of CL)	Median supracaudal length: 17.1 mm (14.4% of CL)

Table 3: Dimensions of specimen NMW 1222, adult male (originally catalogued as female); "leg. Werner [presumably 1897 (Werner, 1899)], Trebinje (= type locality), gekauft von Werner, don. Steindachner iii 1904"; lectotype of *Testudo hercegovinensis* Werner, 1899 (Fig. 14-15).

Appendix

Specimens examined (relative to original results presented herein only)

Testudo marginata

BMNH 46.6.15.65, Greece, type of *T. marginata* var. *melas* Gray, 1870; BMNH 55.10.16.152, Greece; BMNH 87.3.11.1, Greece; BMNH 1934.6.2.5, Greece; MNHN 9344, no locality; MNHN 9470, Cerbosa di Firenze, Bonaparte 1840: pl 49 (= Monastero della Certosa); MNHN uncatalogued "A", Peloponnes; MNHN uncatalogued "K", 5-7 km E Megalopolis, central Peloponnes; NMW 19655:2, Pikermi bei Athen; NMW 19655:3, Akrokorinth; NMW 30061, Prevesa, Albanien (= N Greece); NMW 30066, Weg Athens-Hymethos, GR; NMW 33280, S-Euböa bei Kasystos; NMW 34240, Volos Griechenland.

Testudo weissingeri

MNHN 1989-3317 -18 (2 specimens), Proastion or Neohori; MNHN 1992-5285 (paratype), Proastio, Messenie, Grece; MNHN 1992-5286, Neo Itilo, Laconie, Grece, Peloponnese (Vallon nord); MNHN uncatalogued "B"+"J" (2 spec.), Proastio or Neohori; MNHN 9347, no exact data (Morée); MTKD D 40047-50 (4 spec.), Peloponnes, Kardamyli; MTKD D 40517, Griechenland: Peloponnes, Mani-Halbinsel; NMW 31683 (paratype), Kardamili, Peloponnes, Griechenland; NMW 33193:9, Kardamili, Griechenland; NMW 33193:1-3+5 (4 spec.), Griechenland; NMW 34280, Proastion, Griechenland; RB 1, Proastio, Messenie; RB5, Agios Nikolaos.

Agrionemys horsfieldii

MNHN(P) uncatalogued ("FB 2"), Molayan, Bassin de Kabul, Afghanistan: coll. Sevkot Sen btw 1978-81, don. L. Ginsburg (includes bone fragments and plastra of several specimens); MNHN(P) uncatalogued ("FB 4"), Afghanistan, Bassin de Kabul; NMW 10563, Kabul; UF 15925, western Pakistan; UF 19244, western Pakistan; UF 25775, western Pakistan; UF 25777, northern Pakistan; UF 25779, western Pakistan; UF 25780-5 (6 spec.), Afghanistan; UF 25788, Afghanistan; UF 25790, Afghanistan.

Agrionemys kazachstanica

BMNH 1920.1.20.628, Turkistan (= Turkestan, Kazachstan); BMNH 1994.144, 40 km W of Aynabulak rail station, 156 km NNE Almaty, Kazachstan; BMNH 1994.145, Massif Kerbulog, 20 km NNE of Kapchagay, 800m (= Kazachstan); MNHN(P) uncatalogued ("FB 5"), Alma-Ata (= Almaty) coll. Lecoq 1990; NMW 1918, Tschinas, Turkestan (= Syrdar'ya, Uzbekistan);

Agrionemys rustamovi

MNHN(Z) uncatalogued ("S3"), no locality data; NMW 92, NMW 401, NMW 1911, NMW 1915, NMW 1916, NMW 1917, NMW 1919, NMW 1920, all from Krasnowodsk, Transkaspien (= Krasnovodsk, Turkmenistan).

Testudo hermanni hermanni

BMNH 1920.1.20.794, Venice; MNHN 1919-158-9 (2 spec.), Massif des Maures: Forêt du Dom (Var), France; MTKD D 18962, Spanien: Menorca; MTKD D 31010, Toscana, Italien; MTKD D 31422, Italien: Campanien, Umgebung von Neapel; MTKD D 31501-2 (2 spec.), Apulien, Italien; MTKD D 32365, S.-Frankreich: La Garde, Freinet; MTKD D 32768-9 (2 spec.), Toscana, Italien; MTKD D 32770, Toscana, Italien; MTKD D 32806, Italien: Umgebung von Neapel; MTKD D 33600, Italien: Sardinien: Sardegna; MTKD D 33601, S.-Frankreich: Massif des Maures; MTKD D 33629, Apulien, Italien; MTKD D 33840-1 (2 spec.), Apulien, Italien; MTKD D 34301, Italien, Prov. Grossetto: Casteglione della Pescaia; MTKD D 34351, Italien: Sardinien; MTKD D 34574, Italien: Kalabrien; MTKD D 34614, Süd-Italien; MTKD D 34626, Italien: Apulien; MTKD D 34654, Süd-Italien; MTKD D 34727, Toscana, Italien; MTKD D 35670-2 (3 spec.), Süd-Italien; MTKD D 35894, Toscana, Italien; MTKD D 35895, Italien; MTKD D 36708, Süd-Italien; MTKD D 36938-9 (2 spec.), S.-Frankreich; MTKD D 36940-2 (3 spec.), Frankreich; MTKD D 36943, Apulien; Italien; MTKD D 39156, Eltern (parents): Süd-Italien; MTKD D 40520, Spanien: Balearen, Mallorca; MTKD D 40865, Süd-Italien; MTKD D 40867, Süd-Italien; MTKD D 40873, Sardinien: Italien; RB-F F1-45 & RB-F M1-50 (95 spec.), various localities in France: Capelude-La Verne, La Malière, Puades, Les Puades-Les Mourats, Romagoua, La Sauvette.

Testudo hermanni boettgeri

BMNH 95.3.2.2, Greece; MNHN 1986-999, Yougoslavie probablement; MNHN 1994-4387, Driopi (3 km E. Pyros). Messenie, Peloponnese, Grece. Alt. 500 m; MNHN 1996-8277, Milia, Messenie (Alt. 500 m), Grece; MTKD D 7157, Rumänien: Baile Herculane; MTKD D 7158-9 (2 spec.), Melnik, S.-Bulgarien; MTKD D 7161, Rumänien: Baile Herculane; MTKD D 7175-8 (4 spec.), Primorsko, Bulgarien; MTKD D 14380, Rumänien: Baile Herculane; MTKD D 14381, Melnik, S.-Bulgarien; MTKD D 14388, Harmanli, Bulgarien; MTKD D 21843, Melnik, S.-Bulgarien; MTKD D 22127, S.-Bulgarien, Blagargrad; MTKD D 22132, Bulgarien: 10 km N Obzor, Schwartzmeerküste; MTKD D 24471, Bulgarien: Marikostinovo; MTKD D 31013-6 (4 spec.), Ulcinj, Süd-Jugoslavien; MTKD D 31018, Ulcinj, Süd-Jugoslavien; MTKD D 31507, Ulcinj, Süd-Jugoslavien; MTKD D 31529, Ulcinj, Süd-Jugoslavien; MTKD D 32778, NO-Jugoslavien, Negotin; MTKD D 35630, Gythio, Griechenland: Peloponnes; RB-F 1-106 (106 spec.), various localities in Peloponnese, Greece: Driopi, Gefira, Kariuopoli, Koroni, Marathea, Megalopoli, Melissa-Egies, Milia, Neohori, Saidona.

Testudo hercegovinensis

BMNH 91.7.3.14, Zara, Dalmatia (= Zadar, Croatia); BMNH 95.3.2.2, Mostar, Herzegovina (Bosnia-Herzegovina); BMNH 97.10.26.1-2 (2 specimens), Trebinje, Herzegovina (Bosnia-Herzegovina); BMNH 1903.12.4.2-3 (2 spec.), Zavala, Herzegovina; BMNH 1933.9.3.1, Dalmatia or Herzegovina; BMNH 1934.10.4.3-4 (2 spec.), Dalmatia or Herzegovina; FMNH 211817, Bileka, Herzegovina (= Bileka, Bosnia-Herzegovina); NMW 46, Teodo, Dalmatien (= Tivat, Montenegro); NMW 1213, Herzegovina; NMW 1222, Trebinje (Bosnia-Herzegovina), lectotype of *Testudo hercegovinensis* Werner, 1899; NMW 1898, Dalmatien; NMW 1899, Trebinje (Bosnia-Herzegovina); NMW 9738:1-3 (3 spec.), Trebinje (Bosnia-Herzegovina); NMW 9738:4, Trebinje (Bosnia-Herzegovina); NMW 9738:5-8 (4 spec.), Trebinje (Bosnia-Herzegovina); NMW 19368:1, Bilek, Herzegovina (= Bileka, Bosnia-Herzegovina); NMW 19421:1, Trebinje (Bosnia-Herzegovina); NMW 19422:2-3 (2 spec.), Vrana bei Zadar (Croatia); NMW 19422:4, Vrana bei Zadar (Croatia); NMW 19423:1, Trebinje (Bosnia-Herzegovina); NMW 19423:2, Trebinje (Bosnia-Herzegovina); NMW 19423:3, Trebinje (Bosnia-Herzegovina); NMW 19425:3, Tivot, Bucht von Kotor (Montenegro); NMW 30079:1-2 (2 spec.), Bilek, Herzegovina (= Bileka, Bosnia-Herzegovina); NMW 30492:16, Budva (Montenegro); NMW 30526, Castelnuovo, Dalmatien (= Kastellnuovo); NMW 30527, Ragusa, Dalmatien (= Dubrovnik, Croatia); NMW 30528, Ragusa, Dalmatien (= Dubrovnik, Croatia); NMW 32263:6, 20, 24, (3 spec.), Lasta Grbal, Randgebirge bei Budva (Montenegro); UF 19120, Yugoslavia; UF 22374 (bone fragments of ad. male), no additional data.

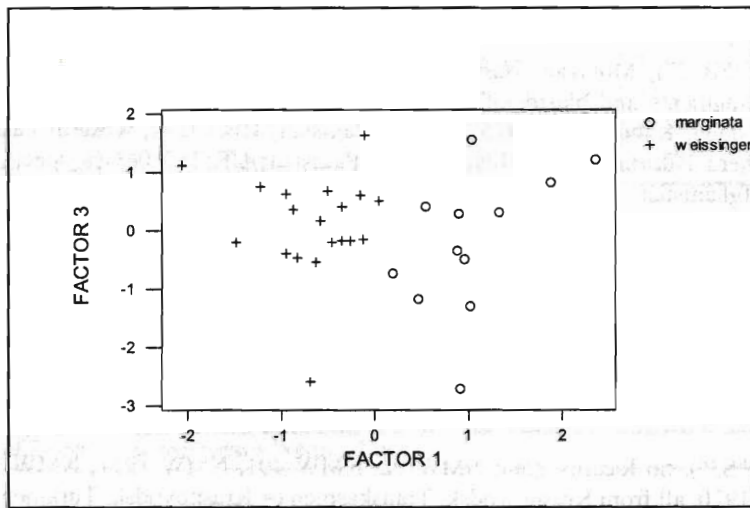


Fig. 1: Factor score plot of Factors F1 and F3 separating *T. marginata* and *T. weissingeri*.



Fig. 2: The intermedium and ulnare are separate bones in *Agrionemys rustamovi*, as seen in a mounted skeleton from the Siebenrock collection (NMW 1911, "Krasnowodsk, Transkaspien", i.e. Krasnovodsk, Turkmenistan).

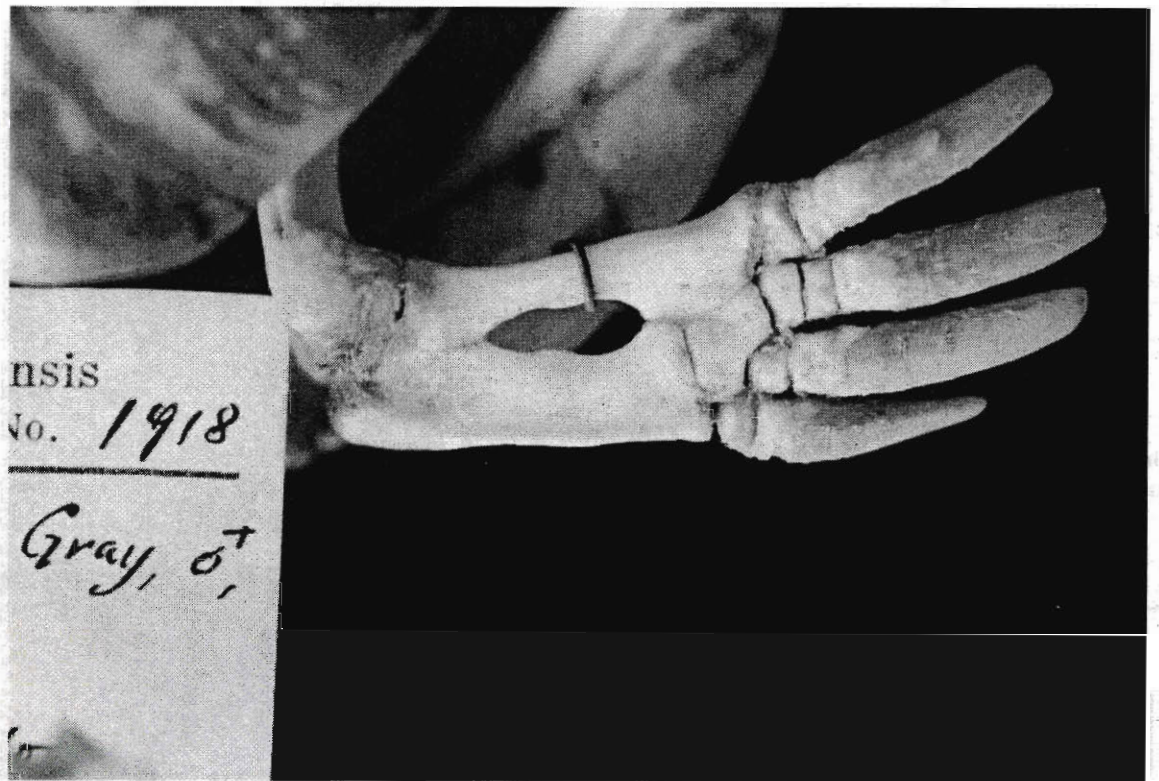


Fig. 3: The intermedium and ulnare are fused in *Agrionemys kazachstanica*. NMW 1918, "Tschinas, Turkestan", i.e. Syrdar'ya, E Uzbekistan, a mounted skeleton from the Siebenrock collection.



Fig. 4: Skull of *A. kazachstanica*, ventral aspect. NMW 1918 from "Tschinas, Turkestan", i.e. Syrdar'ya, E Uzbekistan. Siebenrock collection.

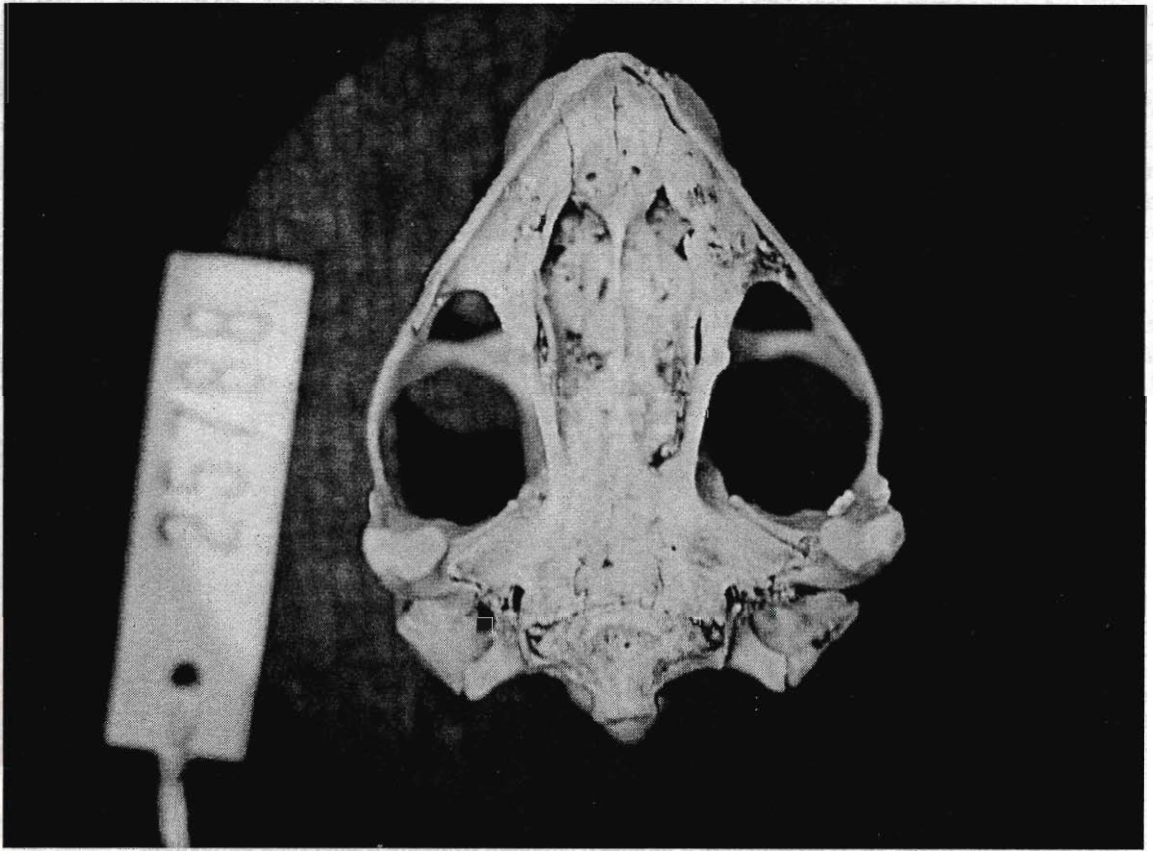


Fig. 5: Skull of *A. horsfieldii* in ventral view. UF 25788 from Afghanistan.



Fig. 6: Skull of *A. rustamovi*, ventral aspect. NMW 1919 from "Krasnowodsk, Transkaspian", i.e. Krasnovodsk, Turkmenistan. Siebenrock collection.

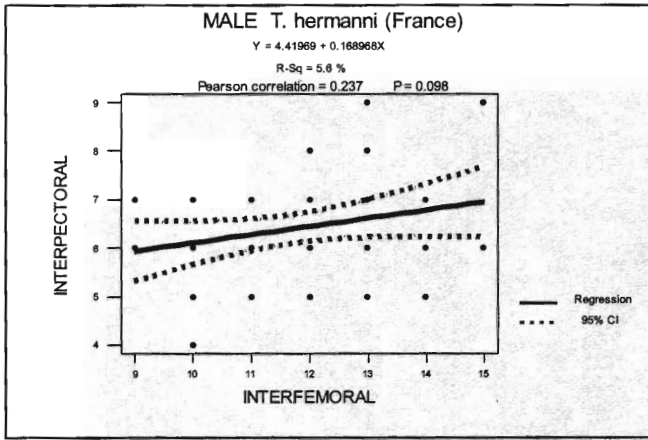


Fig. 7: Fitted line plot showing relationship of interpectoral and interfemoral length in French *T. hermanni* males.

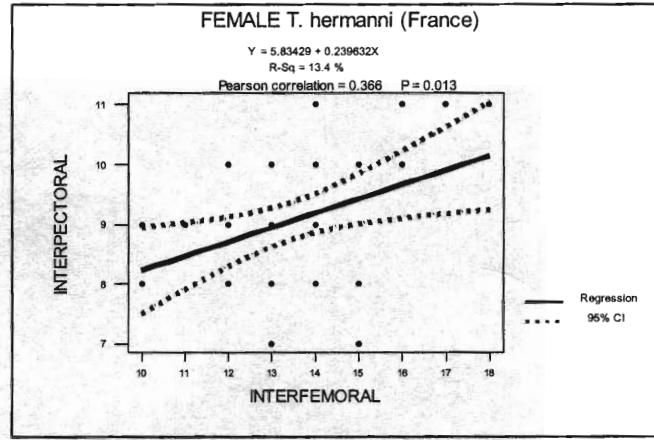


Fig. 8: Fitted line plot showing relationship of interpectoral and interfemoral length in French *T. hermanni* females.

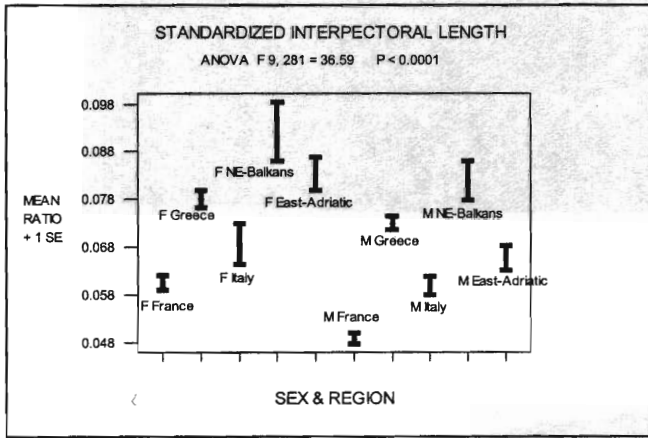


Fig. 9: Pectoral seam lengths standardized for CL among 5 populations of male (M) and female (F) *T. hermanni* from different regions. Vertical bars show mean value and standard error.

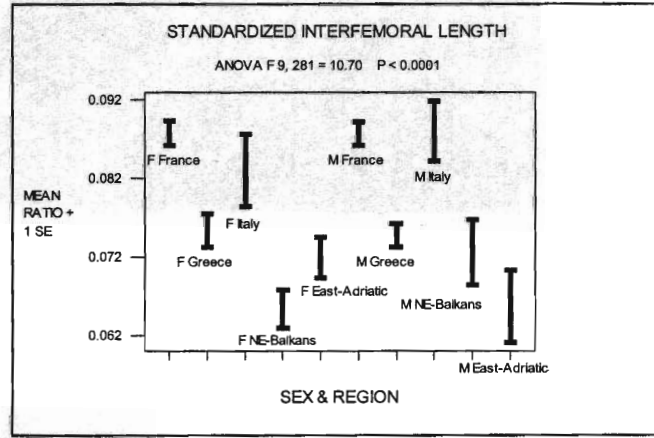


Fig. 10: Femoral seam lengths standardized for CL among 5 populations of male (M) and female (F) *T. hermanni* from different regions. Vertical bars show mean value and standard error.

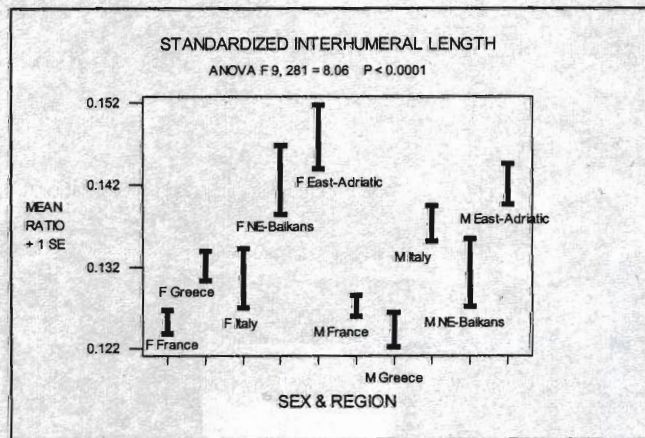


Fig. 11: Humeral seam lengths standardized for CL among 5 populations of male (M) and female (F) *T. hermanni* from different regions. Vertical bars show mean value and standard error.

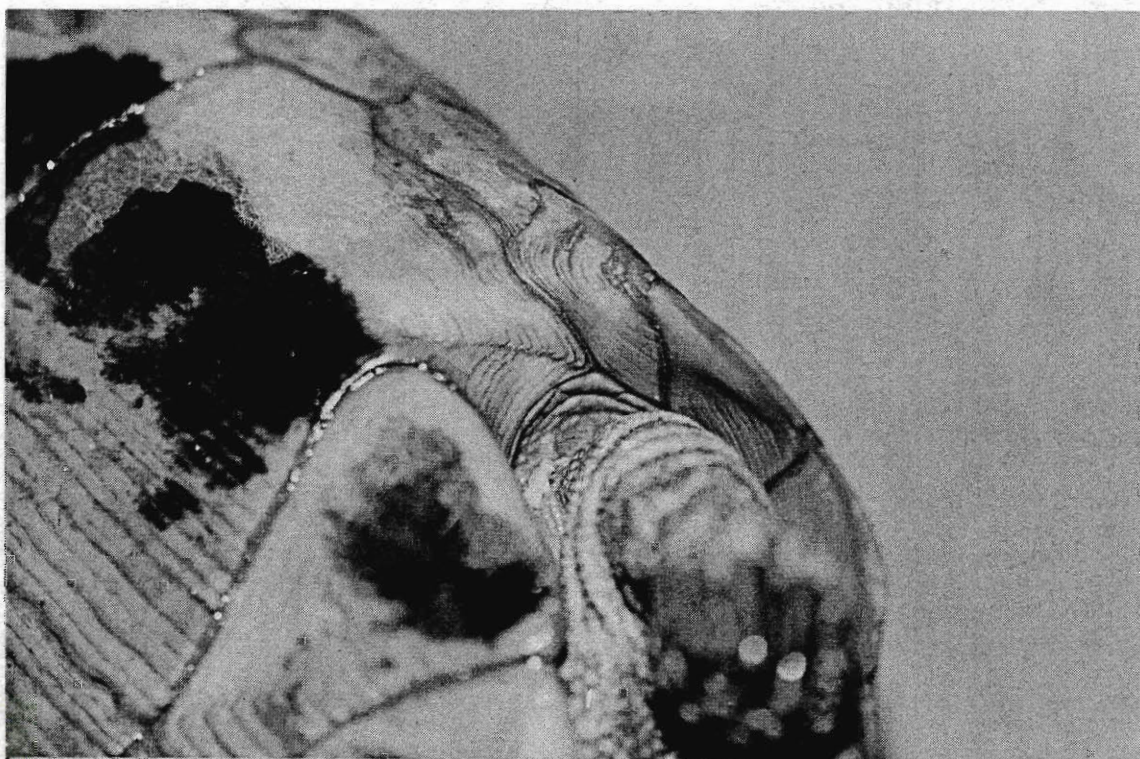


Fig. 12: BMNH 95.3.2.2: *T. hercegovinensis* specimen from Mostar (Bosnia-Herzegovina) featuring the typical lack of inguinal scutes, and the 7th marginal (located in the mid-region of the abdominal) not projecting towards, or reaching, the "inguinal pit".

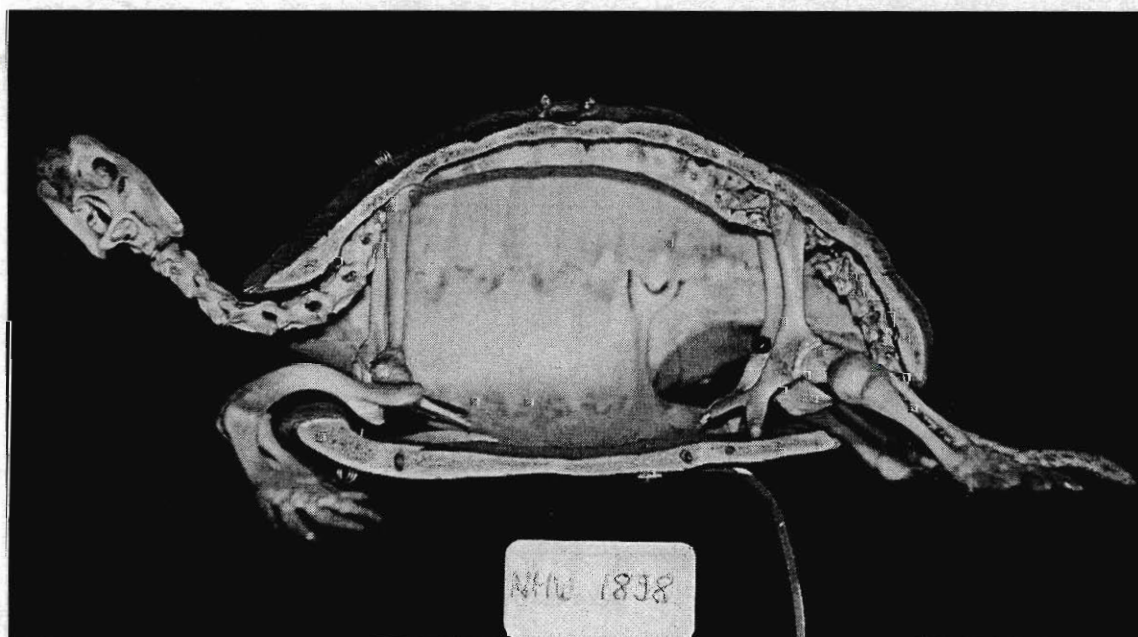


Fig. 13: NMW 1898: A mounted skeleton of *T. hercegovinensis* from "Dalmatien" (Dalmatia) in longitudinal section. The forked inguinal buttress is clearly visible. Specimen from NMW Siebenrock collection.

