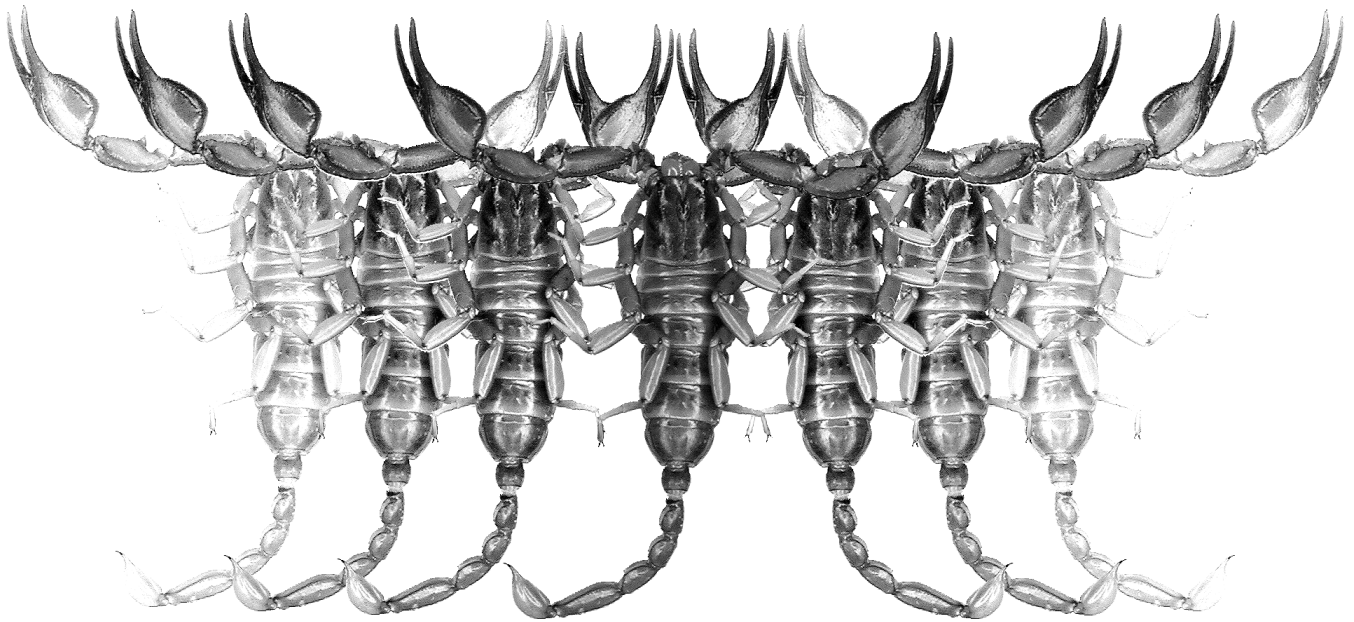# *Euscorpius*

Occasional Publications in Scorpiology

**Morphology Analysis Supports
Presence of More Than One Species in the
"*Euscorpius carpathicus*" Complex
(Scorpiones: Euscorpiidae)**

V. Fet and M.E. Soleglad

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Euscorpius

Occasional Publications in Scorpiology

Euscorpius is the first research publication completely devoted to scorpions (Arachnida: Scorpiones). *Euscorpius* takes advantage of the rapidly evolving medium of quick online publication, at the same time maintaining high research standards for the burgeoning field of scorpion science (scorpiology). *Euscorpius* is an expedient and viable medium for the publication of serious papers in scorpiology, including (but not limited to): systematics, evolution, ecology, biogeography, and general biology of scorpions. Review papers, descriptions of new taxa, faunistic surveys, lists of museum collections, and book reviews are welcome.

Derivatio Nominis

The name *Euscorpius* Thorell, 1876 refers to the most common genus of scorpions in the Mediterranean region and southern Europe (family Euscorpiidae).

Euscorpius is located on Website '**http://cos-server.marshall.edu/euscorpius**' at Marshall University, Huntington, WV 25755-2510, USA.

Morphology analysis supports presence of more than one species in the "*Euscorpius carpathicus*" complex (Scorpiones: Euscorpiidae)

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Summary

We investigate a number of scorpion populations from southern and central Europe, commonly classified under a "catch-all" name of *Euscorpius carpathicus* (L., 1767). This species includes a high number of described subspecies but its composition is not resolved. The detailed morphology analysis in the present paper includes a number of new characters, in particular individually mapped external patellar accessory trichobothria. It suggests that several clearly separated lineages are present. *E. carpathicus* (L.) is restricted here to geographically marginal populations from Romania (terra typica), which exhibit loss of one trichobothrium in the patellar series *em* (= 3). Another lineage (Austria, Croatia, Italy, France, Slovenia) is characterized here as *E. tergestinus* (C.L. Koch, 1837); it has a "standard" trichobothrial number in the patellar series *eb* (= 4), eb_a (= 4) and *em* (= 4) and exhibits only variation in the ventral and *et* series. This species includes as new synonyms the following seven subspecies described by Caporiacco (1950): *E. c. apuanus*, *E. c. concinnus*, *E. c. niciensis*, *E. c. aquilejensis*, *E. c. picenus*, *E. c. oglasae*, and *E. c. corsicanus*. A very distinct Balkan lineage is delineated based on unique trichobothrial numbers in patellar series *eb* (= 5) and eb_a (= 7); it is elevated here to the species status as *E. hadzii* Caporiacco, 1950 (Albania, Bosnia, Bulgaria, Croatia, Greece, Macedonia, Yugoslavia). This species includes as a new synonym *E. c. lagostae* Caporiacco, 1950. The fourth species-rank taxon confirmed here is *E. koschewnikowi* Birula, 1900 (Greece), with "standard" trichobothrial number in the patellar *eb* (= 4), eb_a (= 4) and *em* (= 4) series but with other unique morphological features. We fix neotypes of *E. tergestinus* and *E. hadzii*, and a lectotype of *E. koschewnikowi*. These four species and *E. balearicus* Caporiacco, another member of this complex, are contrasted in detail using trichobothrial patterns, morphometric ratios and carinal development trends as diagnostic characters.

Introduction

Scorpions of the genus *Euscorpius* Thorell, 1876 (Scorpiones: Euscorpiidae) are very common in southern Europe (Fet & Sissom, 2000). Ecologically diverse, they occupy a variety of habitats from xeric to mesic, from the Mediterranean shoreline to the high altitudes of the Alps and Balkans. Linnaeus (1767: 1038) described *Scorpio carpathicus* from Transylvanian Alps (Romania) (now *Euscorpius carpathicus*, the type species of the genus). Thorell (1876) introduced a new generic name *Euscorpius* which has been the only valid name for this genus; see Fet & Sissom (2000) for the detailed discussion and list of synonyms. Numerous species have been described in *Euscorpius*. The traditional taxonomy of this genus, based mainly on morphosculpture and coloration characters, was complicated and confusing. Already C.L. Koch (1850: 86-87) gave a survey on all the *Euscorpius* species he had described in his series "Die Arachniden", and clearly divided these species into three groups according to the number of trichobothria ("Grübchen") on the ventral aspect of pedipalp patella. By the end of the 19th century, Kraepelin (1899) considered only four "good" species, with a long list of synonyms. At this time, Birula (1900: 14) ironically noticed that "the genus *Euscorpius* belongs to such a category of systematic groups, in which the number of species accepted by a specialist depends on how well developed this specialist's passion was to compile long columns of synonymous species names". He quite correctly wrote further that "…only studying the morphology of all forms as related to their geographic distribution will we possibly make some positive conclusions about the classification of this genus". Unfortunately, Birula did not live to see the advent of chaetotaxy – a detailed trichobothrial pattern analysis which brought a new age to the taxonomy of *Euscorpius* (as well as to other scorpions).

Large and conspicuous trichobothria of *Euscorpius* were already used as taxonomic characters by Hadži (1929, 1930) and Caporiacco (1950) who used overall

trichobothrial counts on different aspects of pedipalp chela and patella for delineation of species and subspecies. During the 50 years since Caporiacco's revision, many authors attended to the intricate and intriguing taxonomy of this commonest European scorpion genus (Vachon, 1963, 1975, 1978, 1981; Ćurčić, 1968, 1971, 1972; Kinzelbach, 1975; Valle, 1975; Bonacina, 1980, 1983; Fet, 1986, 1993, 1997a, 1997b; Scherabon, 1987; Lacroix, 1991a, 1991b, 1995). Traditionally, only four species were listed: *E. carpathicus, E. germanus, E. flavicaudis* and *E. italicus* (Kraepelin, 1899; Birula, 1900, 1917; Caporiacco, 1950; Vachon, 1963, 1981; Ćurčić, 1972; Vachon & Jaques, 1977). Later, Bonacina (1980) reestablished *E. mingrelicus*. Currently, there are 10 recognized species: *E. alpha, E. balearicus, E. beroni, E. carpathicus, E. gamma, E. germanus, E. flavicaudis, E. italicus, E. mingrelicus*, and *E. tergestinus* (Fet, 2000; Fet & Sissom, 2000; Gantenbein et al., 2000, 2001; Scherabon et al., 2000), and the "splitting" of some overly inflated taxa is likely to continue.

The most recent development in *Euscorpius* taxonomy was the introduction of molecular techniques by our research team which started with the pioneering paper of Gantenbein et al. (1999) on application of 16S ribosomal RNA gene sequence analyses to assess the phylogeny of the genus *Euscorpius*. This study provided the first ever published DNA-based phylogeny among the order Scorpiones. These data revealed a phylogenetic relationship between four species (*E. flavicaudis*, *E. carpathicus*, *E. italicus*, *E. germanus*) which was different from the former views on evolution of this genus, based only on morphology (Hadži, 1931; Kinzelbach, 1975). Further work of this team and its collaborators included more detailed genetic and morphological analysis of *E. germanus*, *E. alpha*, and *E. gamma* (Gantenbein et al., 2000; Scherabon et al., 2000) as well as *E. carpathicus* (Gantenbein et al., 2001; Huber et al., 2001).

Discussion of Taxonomy

There is no comprehensive modern revision of *Euscorpius*, although this genus received a lot of attention from the Old World taxonomists starting with Linnaeus (1767) himself. Numerous species and subspecies have been described but their validity remains inconclusive, and changes constantly.

Main reason for this situation is that most authors in the past used unreliable morphological character sets to establish species (or subspecies). The traditional characters such as pectinal tooth number, coloration and metasomal carination (e.g. Birula, 1900, 1917) are often inconclusive, and so are total numbers of trichobothria which are variable on pedipalp manus and patella. Also, *Euscorpius* is so geographically diverse that the complete picture is often non-observable without analysis of many variable populations from many various countries

– a no small task – especially in the Balkans, the center of *Euscorpius* diversity. We gave serious consideration to the traditional morphological character sets – first of all, trichobothria (mechanosensory bristles on pedipalps).

Starting with Carl L. Koch (1837), large, variable in number and pattern, and easily observable trichobothria of *Euscorpius* pedipalp became a routine taxonomic character set reported by researchers (Birula, 1898, 1900, 1903, 1917; Calinescu & Calinescu 1930; Zottu, 1927). We emphasize, however, that understanding of *Euscorpius* morphological variation is impossible without separate treatment of patellar trichobothrial series (*sensu* Vachon, 1974), which unequally contribute to the variation among species. We know now that considering the total number variation of patellar trichobothria in *Euscorpius* (external or ventral) often obscures true valuable characters. Many attempts to separate taxa solely on the basis of trichobothrial number variation were not very successful and led to confusion (Hadži, 1929, 1930; Caporiacco, 1950; Ćurčić, 1972, Kinzelbach, 1975). The genus *Euscorpius* stands apart among all Euscorpiidae by its record number of described *subspecies* (Fet & Sissom, 2000; Fet, 2000; Gantenbein et al., 2000; Scherabon et al., 2000). This record number was achieved in 1890s-1970s by: (1) incorporating (without sufficient reasons) various described species-rank taxa under the "umbrella" of four main species: *E. carpathicus* (L. 1767), *E. flavicaudis* (DeGeer, 1778), *E. italicus* (Herbst, 1800), and *E. germanus* (C. L. Koch, 1837) (e.g. Kraepelin, 1899; Birula, 1900, 1917), and (2) further describing numerous subspecific forms in *E. carpathicus* (L. 1767), especially from Italy and the Balkans (Hadži, 1929; Caporiacco, 1950).

No formal subspecies at all were created within the genus *Euscorpius* before Hadži (1929) (except for "*E. tergestinus* "forma" *austriacus* Ferrari, 1872). Hadži (1929) for the first time attempted to treat enormous trichobothrial variation in *Euscorpius* (albeit only total number, not patterns). The set of "*oligotrichus*", "*mesotrichus*" and "*polytrichus*" names was published by Hadži in 1929 simultaneously (in the same work) for each of three species: *E. italicus, E. carpathicus* and *E. germanus*. The geographic treatment of Hadži was not exhaustive but concentrated on Balkan populations; Hadži (1930) continued discussion of these taxa. Later (Hadži, 1956), he explained that in erecting his 1929 subspecies he did not really adhere to the taxonomic standards (not too fixed at that time) and treated his "*oligotrichus*", "*mesotrichus*" and "*polytrichus*" forms (in each of the three species he studied) as meristic classes characterizing variation, rather than Latin names. Nevertheless, these names were, and should be, treated as available Latin names according to all further editions of the Code, up to the current 4th edition (ICZN, 1999). Caporiacco (1950) as "the first reviser" according to the

Code (ICZN, 1999, Article 24.2), declared that Hadži's set of *"oligotrichus", "mesotrichus"* and *"polytrichus"* names are available subspecific names only for *E. italicus* and therefore are homonyms for *E. carpathicus* and *E. germanus*.

Modern scorpion taxonomy based on trichobothria (Soleglad & Fet, 2001) historically started with *Euscorpius* species (Vachon, 1963); already 40 years ago Vachon appreciated the diversity of their trichobothrial counts and patterns. It is interesting that both Hadži (1929, 1930) and Caporiacco (1950) appreciated variation in trichobothrial counts of *Euscorpius*, but used total numbers for ventral and external patellar aspects. Such an approach obscured variation within individual series, which became obvious only when Vachon (1963, 1974, 1975) and Valle (1975) started distinguishing trichobothrial "series" on the external patellar aspect.

Since Caporiacco (1950) described numerous subspecies of *E. carpathicus* (mostly from Italy), only Valle (1975) attempted to discuss some of those using criteria of trichobothriotaxy. Probably because Valle used the old system of Vachon (1963) for designations of patellar external trichobothria, his data were not noticed by further researchers. However, comparing Fig. 1 in Valle (1975; scored for both sides) and Fig. 3 in Vachon (1963), we can adjust this system to the convention used today (Vachon, 1975 and later; scored for one side only) with the following formulas: D1 (variable) = (*et*-right - 1) + (*et*-left - 1); D2 (constant, always 8, i.e. 4 on each side) = 2 x (2 from *et* and 2 from *est*); D3 (constant, always 6, i.e. 3 on each side) = 2 x [(*est* - 2) + 1] (*est* is always 4); D4 (variable) = *em*-right + *em*-left; B4 (constant, always 4, i.e. 2 on each side) = *esb*-right + *esb*-left (*esb* is always 2); B3 (variable) = eb_a-right + eb_a-left; B2+B1 (B2 variable; B1 constant, always 2, *i.e.* 1 on each side) = *eb*-right + *eb*-left. This rather elaborate adjustment allows one to use Valle's statistical data, which are based on the analysis of large series from various localities, in much more detail than in Caporiacco (1950) who used only total counts for patellar external trichobothria. Valle (1975) was therefore the first to identify the most important trend in the neobothriotaxy of *E. carpathicus* complex: variation of B2 + B1 series (i.e., variation of *eb*).

Valle's system, borrowed from an old scheme created by Vachon (1963), was not used by any subsequent authors (e.g. Bonacina, 1980, 1983; Fet, 1986, 1993, 1997a, 2000; Scherabon, 1987; Michalis & Dolkeras, 1989; Soleglad & Sissom, 2001) who followed the nomenclature of Vachon (1974, 1975, 1978). Those authors who did not consider the trichobothrial character set important (or limited its use only to ventral patellar series) often obtained inconclusive or superficial results (Kinzelbach, 1975, 1982, 1985; Kritscher, 1993).

Soleglad & Sissom (2001: 70-73) demonstrated in detail the inherent problems of using total trichobothrial numbers found on pedipalp surfaces in their comparisons of various cladistic based models of neobothriotaxy. In their approach, trichobothria numbers were confined to those found in individual patellar series thus establishing, in a sense, homology at the series level. Soleglad & Fet (2001), in their analysis of the evolution of scorpion orthobothriotaxy, improved on this modeling by establishing *individual* homologies for all trichobothria, thus each trichobothrium was considered separately in a cladistic sense. This same technique was employed in this study except the application of homology argumentation was applied to *accessory* trichobothria of the pedipalp patella, therefore modeling the neobothriotaxic condition found in *Euscorpius*.

In the late 1990s, our research group and its associates were the first to apply modern molecular techniques to *Euscorpius* systematics (Fet et al., 1999; Gantenbein et al., 1999, 2000, 2001; Scherabon et al., 2000; Huber et al., 2001). The first phylogenies provided by mitochondrial DNA sequence analysis changed the systematics of *Euscorpius* dramatically, revealing lineages not suspected before from morphological approach only. In its turn, DNA data helped to reorient morphological analysis towards important character sets.

A recent study (Gantenbein et al., 2001) elevated an isolated *E. carpathicus* population (subspecies) from Balearic Islands to the species status as *E. balearicus*. The data reported in this present paper suggest that *E. carpathicus* (L., 1767) should be restricted to geographically marginal, "oligotrichous" populations from Romania (terra typica), which commonly exhibit loss of one trichobothrium in the patellar series *em*. Another, "mesotrichous" "western" lineage (Italy, France, Slovenia, Croatia, Austria) is treated here as a valid species *E. tergestinus* (C.L. Koch, 1837); it has a "standard" patellar trichobothrial number in series *eb*, eb_a and *em* (four in each series) and exhibits only variation in series *et*. In contrast, a separate "polytrichous" Balkan lineage is observed with larger numbers of patellar trichobothria in series *eb* and eb_a; it is elevated here to the species status as *E. hadzii* Caporiacco, 1950. The fourth species-rank taxon confirmed here is *E. koschewnikowi* Birula, 1900 (northeastern Greece) which possesses a "standard" trichobothrial number but exhibits other unique morphometric features.

It is important to note that the five species discussed in the present paper do not embrace all diversity of populations traditionally placed under *E. carpathicus*. Gantenbein et al. (2001) demonstrated that "western" populations from France and Italy (established in this paper as *E. tergestinus*) are genetically distant from "eastern" "*E. c. candiota* Birula" (type locality Crete), although all of them have the "standard" trichobothrial pattern ("Group A" of Fet, 2000). Status of "*E. c. candiota*" and other Aegean and Balkan populations, as well as populations from Turkey and Crimea, remains to be

addressed (see Fet, 1997a, 2000; Fet & Braunwalder, 2000). Kinzelbach (1975) maintained that all forms of *E. carpathicus* complex which had intermediate number of ventral patellar trichobothria are in fact hybrids between *E. carpathicus* and "*E. mesotrichus*" (see below). One of the conclusions in this theory was that *E. carpathicus candiota* Birula from Crete is a hybrid. However, our preliminary DNA and allozyme data on this crucial population (Gantenbein et al., 2001) in comparison with other forms from the Balkans (Fet et al., in progress) do not indicate any hybrid characterization of "*E. c. candiota*".

There are also some deviations from the "standard" trichobothrial pattern in *E. carpathicus* complex which require a further study. An enigmatic Balkan form, *E. g. croaticus* Caporiacco, 1950 (Velebit Mts., Croatia), which has *em* (=3), was moved by Gantenbein et al. (2000) to the *E. carpathicus* complex. Still another, unnamed form with *em* (=3) is found in the Rodope mountains of Bulgaria ("Group C" of Fet, 2000: 55, 58). At this moment such forms cannot be synonymized with *E. carpathicus* (L.), *s.str.*

Fet & Braunwalder (2000) outlined the controversy surrounding some Greek populations of *E. carpathicus* complex, named "*E. mesotrichus*" by Kinzelbach (1975). Kinzelbach (1975) divided *E. carpathicus* into two species, designating the second one as *E. mesotrichus* Hadži, 1929. The latter name, however, is not available since it is a junior homonym of *E. italicus mesotrichus* Hadži, 1929 (Fet 1997b). According to the International Code of Zoological Nomenclature (ICZN, 1999), the correct name for such species should be *E. tergestinus* (C. L. Koch, 1837) (this name was listed by Kinzelbach (1975) as a synonym of his "*E. mesotrichus*"). Kinzelbach (1975) further classified all described subspecific forms of *E. carpathicus* in two species (without providing sufficient justification), and observed sympatry of two different forms of *E. carpathicus* complex in Greece (Thessaly). The name "*E. mesotrichus* Hadži" was used afterwards by some authors (Vachon & Kinzelbach, 1987, Kritscher, 1993), while others (Bonacina, 1983; Fet, 1986, 1997a) did not accept Kinzelbach's division. Fet & Sissom (2000) tentatively accepted Koch's name *E. tergestinus* for those populations, using this name as an available senior synonym of homonymous *E. c. mesotrichus* Hadži. However, our current studies (Fet et al., 2002b; in progress) indicate that the Thessalian populations belong not to *E. tergestinus* (as defined in this present paper) but to at least one more separate lineage of *E. carpathicus* complex. This refers also to a number of Italian subspecies established by Caporiacco (1950) which do not fall under "standard" diagnosis of *E. tergestinus*. Further investigation of the

"*Euscorpius carpathicus*" species complex is warranted, first of all for a number of poorly studied (both named and unnamed) populations in the Balkans, Turkey, and Italy.

Methods and Material

All measurements (i.e., morphometrics) presented in this paper are in millimeters (*mm*). For meristic and morphometric statistical data presented in this paper the following conventions are used:

$$min - max \; (mean) \; (\pm SD) \; [n] \; \{cmin - cmax\} \; \check{s} \;\; cv$$

for the above *statistical data group*, *min* = minimum value, *max* = maximum value, *SD* = standard deviation, *n* = number of samples, *cmin* = corrected minimum (*mean-SD*), *cmax* = corrected maximum (*mean+SD*), *cv* = coefficient of variability (*SD/mean*). The range established by the corrected minimum and maximum is referred to as the *plus/minus standard error* range. Each statistical data group represents a dataset based on some specified partitioning (e.g., a species, a subspecies, a population, a genus, a gender, etc.).

Terminology describing chelal finger dentition and pedipalp ornamentation follows that described and illustrated in Soleglad & Sissom (2001).

Morphometric Ratios

The *Euscorpius* morphometric database is a project in progress, additional measurement sets are being added as more material becomes available and new studies are pursued. Presently, we have collected over 195 sets of measurements from sexually mature specimens representing over 4400 separate measurements — all known species of *Euscorpius* are represented. In this study 71 morphometric sets were processed across the five *Euscorpius* species addressed in this paper, 62 complete measurement sets (26 separate structure morphometrics each) and 9 representing sparse measurement sets (a set where all morphometrics are not present), in all, 38 females and 33 males were measured. Individual morphometrics comprising the measurement set are presented in Tables 1-3. The 26 morphometrics do not include *total length*, *mesosoma length* or *aculeus length*. The *metasoma length* is the sum of the lengths of its five segments and the *pedipalp length* is the sum of the lengths of the femur, patella and chela. Finally, the width of the pedipalp patella does not include the dorsal patellar spur (DPS).

Only measurements from sexually mature specimens were collected for the database. Sexual maturity of *Euscorpius* male specimens is quite apparent due to the exaggerated basal scalloping found on the pedipalpal

fingers and the considerably swollen telson vesicle, present both ventrally and laterally. Other indications are well developed pectines, exhibiting elongated teeth, and the genital papillae extending from the genital operculum. It is interesting to note that the swollen telson is not as exaggerated in the species of subgenus *Alpiscorpius*, nor in the subgenus *Tetratrichobothrius* (which includes the unique species *E. flavicaudis*), otherwise, sexually mature males of *E. italicus* and members of the *E. carpathicus* complex are quite apparent by the swollen telson alone. Maturity in female specimens is not as easy to determine, in general, only "large" specimens were used unless, based on the establishment of small sexually mature males within a population, smaller females were then utilized from that same population. Although ontogenetic differences in morphometric proportions certainly exist in *Euscorpius* to one degree or another, it clearly is the most defined in male specimens. Therefore, using sexually mature males is the most essential in conducting morphometric analysis.

In order to isolate potential morphometric ratio diagnostic characters, all possible morphometric ratios are first calculated and compared across two datasets for differences within some specified threshold. The number of possible ratios is $n!/(n-r)!r!$, where *n* is the number of morphometrics and $r = 2$ (i.e., *n* measurements taken two at a time). For this study 26 morphometrics were gathered for a large majority of specimens (considered a "full morphometric set"), therefore 325 unique ratios were calculated and compared across all possible combinations of all datasets taken two at a time (i.e., the comparison always involves two datasets). The datasets in this study were partitioned into sexually mature females and males, five species, thus ten possible dataset comparisons per gender, a total of twenty. For sexual dimorphism analysis, males and females were compared within each species, five possible dataset combinations. Also, where appropriate, subspecies and/or populations of a species were also segregated into datasets for comparison.

In this approach we calculate all possible ratios using a specific morphometric, thus determining the percentage that the morphometric is deemed "relatively large" (or "small"). A morphometric is considered "relatively large" if it is involved in a ratio whose mean value is larger in comparison and where one of the following is true: 1) it is the numerator of the ratio that is larger, or, 2) it is the denominator of the ratio that is smaller (note that, the notion of "relatively small" is equally valid, except one must reverse the conditions stated above). The ratio mean value is used since it is based on all specimens of a particular dataset. This process is initiated for all morphometrics. If the percentage of "being larger" for a particular morphometric is high, then it can be assumed with some confidence that the morphometric is in general larger (or

smaller) with respect to the other morphometrics for that dataset as compared to the same morphometric in the other dataset. For example, when we state that the carapace of one dataset is "larger" than the carapace of the other dataset — we are really stating that when used in ratios calculated from all possible morphometrics, it was "relatively larger" in a significant majority of the comparisons. We only concentrate on those morphometrics that exhibit the highest percentage of compliance to being "larger" (or "smaller"). Once these unique morphometrics are identified, meaningful ratios by combining these morphometrics across datasets can be constructed which provide the maximum differences that can be then established as significant diagnostic characters — the ultimate goal of this process. In general we consider any ratio based diagnostic character "significant" if the resulting ratio ranges based on plus/minus standard error show separation. The larger the separation (i.e., the "gap") the more significant the diagnostic character. Finally, we are only interested in morphometric ratios that hold true for both male and female specimens thus making them optimal as useful diagnostic characters.

Abbreviations

BG, private collection of B. Gantenbein; BMNH, Natural History Museum, London, UK; CAS, California Academy of Sciences, California, USA; LSL, Linnean Society of London, UK; MES, private collection of M. E. Soleglad; MZUF, Museo Zoologico "La Specola" dell'Università de Firenze, Florence, Italy; NMM, Naturhistorisches Museum, Mainz, Germany; NMW, Naturhistorisches Museum Wien, Vienna, Austria; NMNHS, Natural History Museum, Sofia, Bulgaria; PAN, Polish Academy of Science, Warsaw, Poland; UL, University of Ljubljana, Slovenia; USNM, United States National Museum (Smithsonian Institution, Washington, DC, USA); VF, private collection of V. Fet, Huntington, West Virginia, USA; ZISP, Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia; ZMB, Zoologisches Museum, Humboldt Universität, Berlin, Germany; ZMH, Zoologisches Museum Universität Hamburg, Hamburg, Germany; ZMMSU, Zoological Museum, Moscow State University, Moscow, Russia. Specimen numbers from MZUF are given as AAA/BBBB, where AAA is the "collection number" and BBBB is the "catalog number".

Systematics

The phylogenetic reevaluation of the genus *Euscorpius* is presently comprised of several joint efforts involving many research specialists (listed above) spanning molecular, morphological and biogeographic knowledge, together aiming for a revised taxonomy based on, pri-

marily, cladistic techniques. The *Euscorpius* "database" is in actuality a set of disjoint information, much of it in digital form, comprised of molecular sequences, tabulations of important meristic data such as trichobothria and pectinal tooth counts, morphometrics (i.e., measurements) extracted from sexually mature material, other structural characteristics, and detailed correlated geographic locality data. These data have been gathered from several sources — material collected by the research specialists themselves, material borrowed from colleagues and museums throughout the world, and from the massive literature that addresses the genus *Euscorpius*.

The most significant effort in the morphology portion of this analysis is the establishment of individual homologies across all major accessory trichobothria found in *Euscorpius*, in particular, those found on the external aspect of the patella. These homologues, in conjunction with other characters both morphological and molecular in nature, will be used in a comprehensive reevaluation of the genus using cladistic techniques aimed specifically at the upper intrageneric phylogeny of the genus (Fet, Soleglad & Gantenbein, in progress). Based on preliminary results from this ongoing analysis, it was clear that trichobothrial patterns involving the external *eb*, eb_a and *em* series were of particular importance in the phylogeny of this genus, and in particular series *eb*. This emphasis on the basal series is intuitive, in part, by reflecting on the stability of the basal series exhibited within other family members of Euscorpiidae (this was discussed in detail by Soleglad & Sissom (2001: 49-54) in their revision of Euscorpiidae). The more distal external series (i.e., *et*) and ventral series show much more variability and therefore are less important, only providing species level distinctions. In general the patellar external basal trichobothrial series in *Euscorpius* are quite stable within designated subclades thus providing significant characters at the highest intrageneric levels. Although we will not present established homologies for these important series in this paper (the analysis is still in progress), we can state here however, that based on preliminary results, we can segregate the five species discussed in this study into three groups based on the presence or absence of accessory trichobothria in these three external series: *eb* = 4, eb_a = 4 and *em* = 4; *eb* = 4, eb_a = 4 and *em* =3; and *eb* = 5, eb_a = 7, and *em* = 4. These three basic configurations and their relationships to the species covered in this study are discussed in detail elsewhere in this paper.

Considerable analysis involving morphometrics and subsequent derived ratios was also conducted, uncovering several good diagnostic characters for species differentiation, as well as identifying specific sexual dimorphism distinctions within a species.

Our analysis of this new morphological data suggests that several clearly separate lineages are present within *Euscorpius carpathicus* (L.). At this time, based on the large material available, we introduce four diagnosable species: *E. carpathicus* (L., 1767) (*sensu stricto*); *E. tergestinus* (C.L. Koch, 1837); *E. hadzii* Caporiacco, 1950; and *E. koschewnikowi* Birula, 1900. These four species are compared here in detail to the recently redescribed species *E. balearicus* Caporiacco, 1950 (Gantenbein et al., 2001), another member of the *E. carpathicus* complex.

Euscorpius carpathicus (Linnaeus, 1767),
sensu stricto
(Figs. 1, 3-12, 62, 65 and Table 1)

Scorpio carpathicus Linnaeus, 1767: 1038. **Holotype**: female, permanently deposited in the Linnean Society of London, No. 58. This female specimen (personally examined by V. F.), apparently subadult, was dried and pinned, and the right pedipalp and metasoma were detached and kept in a separate glass vial. Linnaeus (1767) states it originated from "Montibus Carpathicis", which most likely refers to the Transylvanian Alps in modern southwestern Romania.

Synonyms.
Scorpius banaticus C. L. Koch, 1841: 111-112, pl. CCLXXXIII, Fig. 679-680**. Lectotype** (designated here): male (BMNH), Oravit[z]a, Banat, Hungary, now Romania (Rosenhauer). **Paralectotype**: 1 female (BNMH), same label. *Notes:* Fet & Sissom (2000: 362) considered types of this taxon lost, but in December 2000 two syntypes were discovered by V.F. in London; according to the accompanying information, these specimens were donated to BMNH by Ludwig Koch in 1913. The male syntype was dismembered between metasomal segments I and II and the left pedipalp. The female was dismembered between metasomal segments I and II. Four labels were found in the vial: 1) Ungarn Rosenhauer (handwritten); 2) (four lines) *Euscorp. carpathicus* L., *banaticus* C. Koch, types, Ungarn Rosenhauer (handwritten); 3) 13.9.1.100.101 (handwritten); 4) *Euscorpius carpathicus* L (handwritten).
Scorpius oravitzensis C. L. Koch, 1842: 17-18, pl. CCCXXX, Fig. 765. Holotype (female; lost); Oravit[z]a, Hungary, now Romania (Rosenhauer).

References (selected).
Euscorpius carpathicus: Zottu, 1927: 101-103; Bunescu, 1959: 90, 93-94, Fig. 1 (map).
Euscorpius carpathicus carpathicus: Caporiacco, 1950: 201-202 (part); Fet & Sissom, 2000: 361.
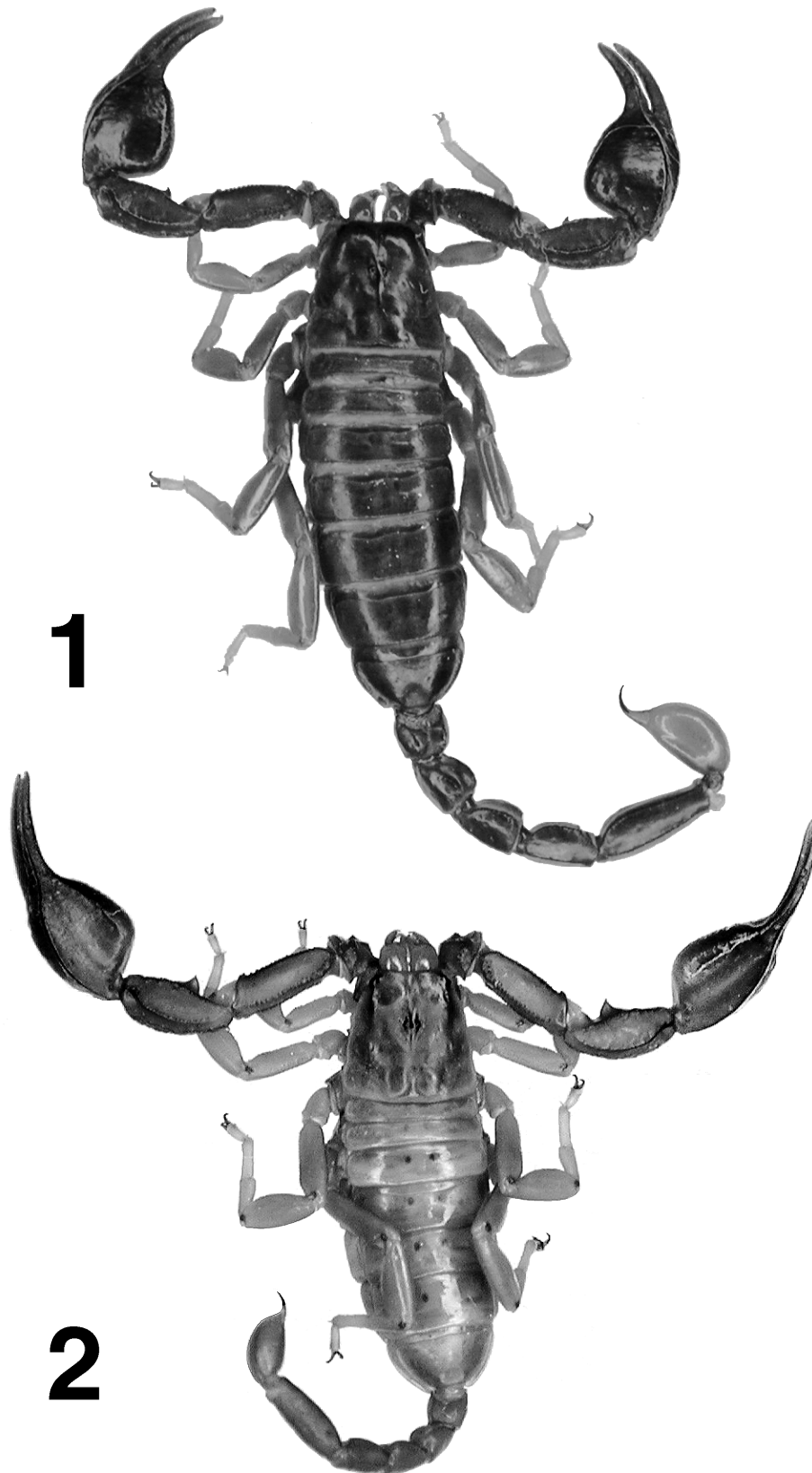
Figures 1-2: 1. *Euscorpius carpathicus* (Linnaeus), male, Mehadija, Romania. **2.** *Euscorpius balearicus* Caporiacco, female, Puerto Alcudia, Mallorca, Balearic Islands, Spain.

Euscorpius germanus banaticus: Vachon & Jaques, 1977: 409-436, Figs. 1-17; Lacroix, 1991a: 20, Fig. 94, 105-107, 117-119.
Euscorpius carpathicus banaticus: Bonacina, 1983: 3-10, Figs. 1-8; Fet & Sissom, 2000: 362.

Taxonomic history. The Linnean holotype specimen (a dried, pinned subadult female) is kept in the collection of the Linnean Society of London (LSL). According to Linnaeus (1767), it originated from "Montibus Carpathicis". This most likely refers to the Transylvanian Alps in modern southwestern Romania (Fet et al., 2002a). It is the only species of scorpion inhabiting this area, where it appears to be common in at least three isolated drainages in the Danube watershed as far east as the upper reaches of Buzeu River; see detailed map of Bunescu (1959). Scorpions are not found anywhere else in the Carpathian Mountains (Fet & Sissom, 2000).

The Linnean *Scorpio carpathicus* became the type species of the genus *Euscorpius* (Thorell, 1876); it is also the oldest published name for this genus (see Fet et al., 2002a for the detailed analysis of the scorpion species described by Linnaeus). A large number of other species described from Europe was later synonymized with *Euscorpius carpathicus* (L.), and this name became widely accepted since the 1870s (Kraepelin, 1899; Birula, 1917; Fet & Sissom, 2000). Fet & Sissom (2000) give the geographic range of this species in southern Europe from Spain to the Balkan Peninsula and further east (Crimea, Turkey). Among numerous subspecific forms deemed valid by Caporiacco (1950), the nominotypic subspecies, "*E. carpathicus carpathicus*" was poorly defined both in morphology and geographic range.

Populations of *E. carpathicus* from Romania (easternmost boundary of the genus' continuous range in Europe) have been recorded and studied for many years by a number of zoologists since Linnaeus (1767). However, these disparate data were never collated or compared to the Linnean specimen. C. L. Koch (1841, 1842) described two new species of *Euscorpius* from nearly the same place in modern Romania (territory of Hungary in the 1830s), *Scorpius banaticus* and *S. oravitzensis*. Both of these were synonymized to *E. carpathicus* (see e.g. Kraepelin, 1899) and Romanian populations were addressed as such, without any comparative analysis (Zottu, 1927; Calinescu & Calinescu, 1930; Bunescu, 1959).

Hadži (1929, 1930), Caporiacco (1950) and Valle (1975) did not study Romanian specimens in detail. Caporiacco (1950) analyzed only a single specimen from "Hungary" (now Romania) and was not conclusive as of the geographic range of the nominotypical subspecies. Kinzelbach (1975) published a short information (based on a letter of Dr. O. Kraus) on the Linnean holotype, deposited in the Linnean Society of London (LSL).

There was, however, no detailed data on morphology of the Romanian population.

Such data appeared in abundance in the late 1970s, when Vachon & Jaques (1977) analyzed a very large series (403 specimens) of "*Scorpius banaticus*" collected by C. Chyzer from Herkulesfürdo, now Baile Herculane, in Romania (historical Banat). Vachon & Jaques (1977) concluded, however, that this population belongs to *E. germanus* because of the character *em* (= 3). Bonacina (1983) studied a new series from Romania (Mt. Cozia), with *em* (= 4), and refuted opinion of Vachon & Jaques (1977); he placed *Scorpius banaticus* back in *E. carpathicus*, without a discussion of subspecies status. Fet & Sissom (2000) noted that the scope and range of the nominotypical subspecies of *E. carpathicus* were not clear.

Our current analysis of the available types of both *Scorpio carpathicus* Linnaeus, 1767 and *Scorpius banaticus* C. L. Koch, 1841, together with the study of additional material, shows clearly that these forms belong to the same species.

Diagnosis. Medium sized species, dark brown in overall coloration, no distinct patterns present. Metasomal segments and chelae somewhat stocky in appearance. Dorsal patellar spur (DPS) of reduced to medium development (see detailed morphometric analysis presented elsewhere). Pedipalp patellar external trichobothria numbers: $eb = 4$, $eb_a = 4$, $esb = 2$, $em = 3$, $est = 4$, and $et = 5$-7 (6); ventral aspect of patella 7-9 (8). Metasomal inferior lateral carinae obsolete on segments I-III and inferior median carina obsolete on segments I-IV. Pectinal tooth counts: male 7-10 (8+), female 6-9 (7). Trichobothria *em* series (= 3) and the reduced DPS are key diagnostic characters for this species.

Male. Redescription based on *Euscorpius carpathicus banaticus* male lectotype (structure details not available from this type are supplied from a mature male from Mehadija, Romania and noted as such). Measurements of male and female syntypes and other material provided in Table 1. All illustrations are based on mature specimens originating from Mehadija, Romania. Dorsal view of a sexually mature male is shown in Fig. 1.

Coloration. Overall basic color dark brown; legs, chelicerae and telson yellow-orange; pectines yellow. Pedipalp carinae slightly darker than segments. Void of any patterns.

Carapace. Smooth and shiny at 10x (Fig. 3); anterior edge straight, lacking setae. Two lateral eyes, anterior eye slightly larger; median eyes and tubercle situated anterior of middle with following length and width formulas: 262|575 (anterior edge to median tubercle center|carapace length) and 79|492 (width of median tubercle|width of carapace at that point).

	Banat, Romania (*E.c. banaticus* types)		Baile Herculane, Romania			Mehadija, Romania	
	Male	**Female**	**Male**	**Female**	**Female**	**Male**	**Female**
Total length	37.15	32.75	30.00	40.00	33.65	34.90	30.95
Carapace length	5.75	5.20	5.00	5.45	4.90	4.75	4.70
Mesosoma length	9.95	10.90	6.80	16.75	12.55	12.15	10.50
Metasoma length	15.85	12.55	13.15	13.30	12.00	13.15	11.75
Metasomal segment I							
length	2.05	1.70	1.70	1.75	1.50	1.70	1.55
width	2.25	1.95	1.85	2.05	1.85	1.95	1.95
Metasomal segment II							
length	2.45	1.95	2.05	2.05	1.90	2.05	1.80
width	1.95	1.75	1.70	1.85	1.60	1.80	1.70
Metasomal segment III							
length	2.70	2.15	2.25	2.30	2.10	2.30	2.00
width	1.85	1.70	1.60	1.75	1.50	1.70	1.60
Metasomal segment IV							
length	3.30	2.60	2.80	2.85	2.50	2.80	2.50
width	1.75	1.55	1.55	1.60	1.45	1.60	1.45
Metasomal segment V							
length	5.35	4.15	4.35	4.35	4.00	4.30	3.90
width	1.75	1.55	1.45	1.60	1.50	1.60	1.50
Telson length	5.60	4.10	5.05	4.50	4.20	4.85	4.00
Vesicle length	4.20	2.70	3.55	3.15	2.95	3.55	2.85
width	2.15	1.50	1.85	1.70	1.50	2.10	1.50
depth	2.40	1.45	2.05	1.70	1.45	2.10	1.40
Aculeus length	1.40	1.40	1.50	1.35	1.25	1.30	1.15
Pedipalp length	20.00	16.95	16.15	17.75	16.00	16.20	15.75
Femur length	4.75	4.10	3.95	4.35	3.95	3.90	3.75
width	1.80	1.55	1.55	1.80	1.55	1.55	1.55
Patella length	4.75	4.25	4.05	4.50	4.00	4.20	4.05
width	2.00	1.85	1.80	2.10	1.90	1.70	2.05
Chela length	10.50	8.60	8.15	8.90	8.05	8.10	7.95
Palm length	5.35	4.40	4.10	4.55	4.20	4.10	4.20
width	3.65	3.20	2.95	3.45	2.90	3.00	2.95
depth	4.40	3.75	3.40	4.10	3.50	3.55	3.45
Movable finger length	6.40	4.90	4.90	5.25	4.60	4.90	4.50
Pectines							
teeth	10-9	7-7	9-9	8-7	7-7	8-7+	7-7
middle lamellae	5-5	x-x	5-6	5-5	4-4+	5+-5+	4-4

Table 1: Morphometrics (mm) of *Euscorpius carpathicus* (Linnaeus).

Mesosoma. Tergites smooth lacking carination on segment VII; sternites smooth and shiney, carinae absent on segment V; stigmata quite small, slit-like to sub-oval.

Metasoma. Generally stocky in proportions. Carinae — Segments I-IV: dorsal rounded and slightly granulose on I, granulose on II-IV; dorsal lateral obsolete on I, weak and slightly granulose on II-IV; lateral obsolete; inferior lateral obsolete on I-III, smooth on IV; inferior median obsolete. Carinae — Segment V (Fig. 10): dorsal lateral rounded and rough; lateral slightly rounded; infe-rior lateral and median with slight granulation. Intercarinal areas smooth.

Telson. Vesicle smooth, swollen both laterally and ventrally (Figs. 6-7, male, Figs. 8-9, female). Aculeus forming a short conspicuous curve; 4-5 pairs of setae at vesicle/aculeus juncture. See Figs. 6-7 for lateral and ventral views of male telson from Mehadija, Romania.

Pectines. Length|width formula 403|147 (length taken at anterior lamellae|width at widest point including teeth). Pectinal tooth counts 10/9 and middle lamellae

counts 5/5; fulcra well developed; numerous fine setae situated on anterior lamellae. Sensorial areas of teeth developed along approximately 1/3 their length. Basal piece anterior edge slightly concave, length|width formula 73|136 (damaged on lectotype, data taken from sexually mature male from Mehadija, Romania).

Genital operculum. Separated most of length, genital papillae extends proximally (damaged on lectotype, data taken from sexually mature male from Mehadija, Romania).

Sternum. Pentagonal, wider than long, length|width formula 178|199.

Chelicerae. Movable finger: dorsal distal denticle considerably shorter than ventral distal denticle; dorsal edge with two subdistal denticles; ventral edge smooth, lacking serrulae, and covered with heavy brush-like setae for most of its length. Fixed finger: four denticles configured normally (basal two denticles conjoined on a common trunk).

Pedipalps. Pedipalps with somewhat stocky chelae exhibiting prominent scalloping at finger bases. Femur: dorsal and ventral internal and external carinae crenulate to serrulate; dorsal and ventral surfaces granulose, internal surface with numerous enlarged granules, and external surface smooth. Patella (Fig. 11, female): dorsal internal and ventral external and internal carinae granulate, dorsal external smooth, and exteromedian rounded and irregularly granulate. Dorsal surface granulose, ventral granulose external half, and dorsal patellar spur (DPS) of weak to medium development, ventral patellar spur (VPS) very weak, represented as small granule. Chela carinae (Figs. 4-5): digital very strong and smooth; subdigital in relief, represented by 1-2 granules; dorsal secondary obsolete; dorsal marginal rounded, continuous and with rough surface; dorsal internal rounded and smooth; ventroexternal strong extending to external condyle of finger, external to trichobothrium Et_1 and smooth with some shiney granulation on proximal one-half; ventromedian essentially obsolete; ventrointerior rounded and smooth; and external secondary strong and irregularly granulose. Chelal finger dentition: Median denticle row straight; 6/7 inner denticles, 6/7 outer denticles, and 4/5 inner accessory denticles for fixed and movable fingers respectively. Trichobothria patterns: Type C, neobothriotaxic (major additive) on patella. Femur: trichobothrium d positioned proximal in relation to i, e situated on dorsoexternal carina. Patella: ventral series number 9/8 and external series number eb = 4/4, eb_a = 4/4, esb = 2/2, em = 3/3, est = 4/4, and et = 6/6. Chela: Ventral series number 4/4, V_4 on external surface set in small dimple but removed from ventroexternal carina.

Legs. Two pairs of pedal spurs present, tarsal spines absent, ungues medium length with average curve. Tarsus III: ventral median spinule row formed by 9 elongated spinules; one pair of ventral distal spinules. Basitarsus I-IV: five proventral spinules on legs I and II.

Hemispermatophore. Well developed lamina with conspicuous basal constriction, tapered distally (Fig. 65); truncal flexure present; capsular lobe complex well developed, with small acuminate process; ental channel spinose distally, exhibiting six delicate variable sized spines (data based on specimen from Mehadija, Romania).

Female. *E. c. banaticus* female paralectotype used for comparison. Granulation of carapace, metasoma and pedipalps same as in male.

Metasoma and telson morphometrics: We compared morphometrics of six sexually mature males and females. Males and females did not exhibit undue differences in overall size, carapace lengths ranged 4.20 – 5.75 (4.75) for males and 4.30 – 5.45 (4.85) for females. The metasoma of the male is slightly thinner than it is on the female, but only exhibiting slight mean value differences (MVD) when all segment length/width ratios are compared, a range of 2 – 6.5%; plus/minus standard error overlap was considerable, exhibiting 31 – 100%. However, the considerably inflated telson vesicle of sexually mature males is quite conspicuous when compared to the thinner "teardrop" shaped telson of the female. This was dramatically illustrated using morphometrics: Morphometric ratios calculated from the carapace length divided by the vesicle width and depth showed considerable mean value differences and plus/minus standard error separation (compare Figs. 6-9):

Carapace Length/Telson Width
MVD = 30.7% Separation Gap = 189.3%
Female
3.10-3.41 (3.233) (±0.117) [6]: {3.12-3.35}š 0.036
Male
2.22-2.71 (2.473) (±0.202) [6]: {2.27-2.68}š 0.082

*Carapace Length/Telson Depth*
MVD = 42.8% Separation Gap = 408.2%
Female
3.22-3.57 (3.377) (±0.144) [6]: {3.23-3.52}š 0.042
Male
2.22-2.46 (2.366) (±0.095) [6]: {2.27-2.46}š 0.040

Genital operculum/genital papillae: On the female, the genital operculum is connected for its entire length by a membrane, whereas on males, it is separated for most of its length, exposing protruding genital papillae.

Pectinal tooth counts: The pectines are more prominent on the male, teeth longer as well as larger in number:
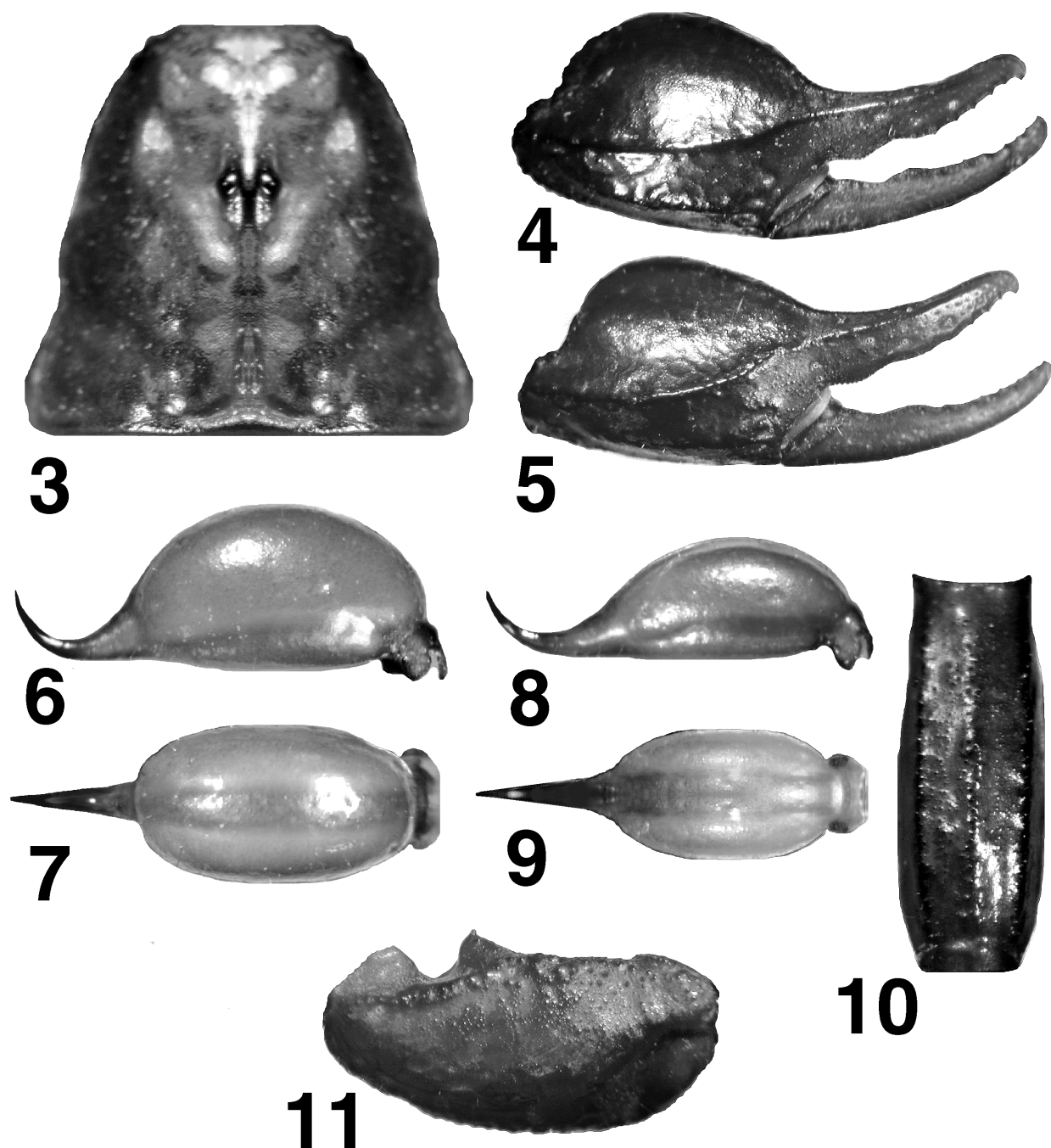
Figures 3-11: *Euscorpius carpathicus*, Mehadija, Romania. **3.** Carapace, male. **4.** Chela, male. **5.** Chela, female. **6.** Telson, lateral view, male. **7.** Telson, ventral view, male. **8.** Telson, lateral view, female. **9.** Telson, ventral view, female. **10.** Metasomal segment V, ventral view, male. **11.** Pedipalp patella, dorsal view, female.

Male
7-10 (8.562) (±0.696) [288]: {7.867-9.258}š 0.081
Female
6- 9 (7.088) (±0.572) [536]: {6.516-7.659}š 0.081

The mean value difference is 20.8%, roughly a 1.5 tooth difference between the male and female.

Comparison of type material. V. F. had the opportunity to examine the *E. carpathicus* type deposited in the Linnean Society of London. The subadult female is somewhat small in size, measuring 25.8 mm. We compared key diagnostic characters between this type specimen and the two *E. c. banaticus* syntypes, male and female, from the BMNH. In addition, we also compared both sets of type material statistically to a large database
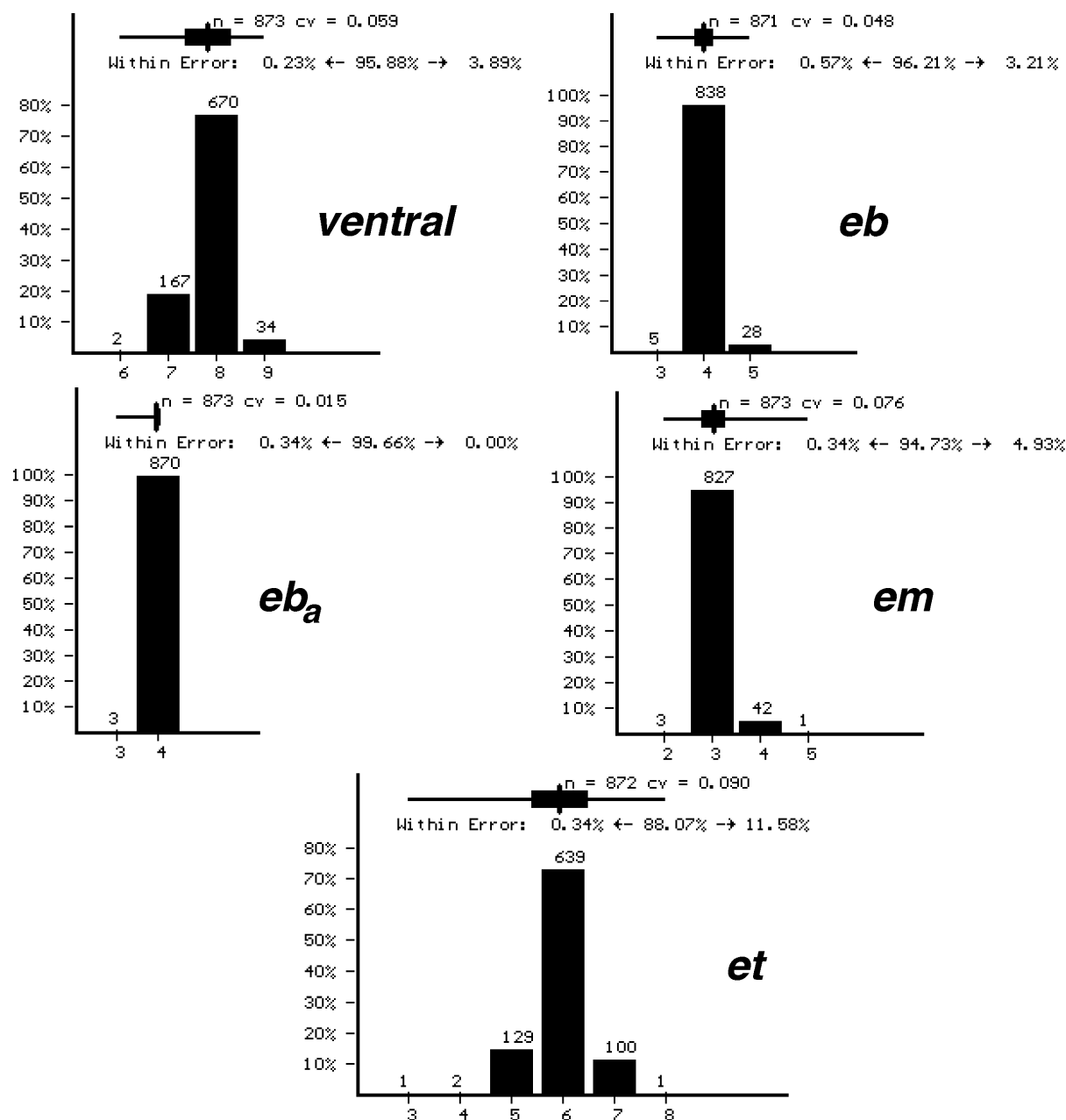
Figure 12: Statistical data for pedipalp patella trichobothrial counts of *Euscorpius carpathicus*. Horizontal bar: minimum, maximum, corrected minimum/maximum (mean-*SD* and mean+*SD*), and mean; *n* = number of samples, *cv* = coefficient of variability (*SD*/mean); vertical bars: percentage per count, number of samples per count on top and count value on bottom. *eb* = external basal, *eb$_a$* = external basal-a, *em* = external median, *et* = external terminal.

of Romanian scorpion material generated from other material examined and data extracted from Vachon & Jaques (1977). The trichobothrial patterns of the pedipalp patella external and ventral surfaces and the pectinal tooth counts of the type material exhibit close if not exact matches to the data contained in the database, as follows:

- **Patella ventral series.** *E. carpathicus* = 8/8 (left and right patellae), *E. c. banaticus* = 8/8, 8/9 (male and female, respectively), and database exhibits 8 at 76.7% (*read* "the count 8 occurred 76.7% of the time") and 9 at 3.9% – thus 83.3% of type sampling matched the majority database sampling of 8 at 76.7%.

- **Patella** *et* **series.** *E. carpathicus* = 6/6, *E. c. banaticus* = 6/6, 6/7, and database exhibits 6 at 73.3% and 7 at 11.5% – thus 83.3% of type sampling matched the majority database sampling of 6 at 73.3%.

- **Patella** *em* **series.** *E. carpathicus* = 3/3, *E. c. banaticus* = 3/3, 3/3, and database exhibits 3 at 94.7% – thus 100% of type sampling matched the majority database sampling of 3 at 94.7%.

- **Pectinal tooth counts.** *E. carpathicus*, female = 7/7, *E. c. banaticus*, female = 7/7, male = 10/9, and database sampling shows 7 for female at 68.3% and 9 and 10 for male at 50.3% and 5.9%, respectively – thus 100% of type sampling for the female matched the majority database sampling of 7 at 68.3% and for the male, 50% type sampling matched 50.3 of database sampling for 9.

These numbers show close statistical compliance between the two type materials, *E. carpathicus* and *E. c. banaticus*, as well as to the large database based primarily on Vachon & Jaques (1977). Of particular importance is the patellar *em* series containing three trichobothria, a major diagnostic character for this species in the context of the *E. carpathicus* complex. The two type materials also match in another important diagnostic character, both exhibiting reduction and/or obsolescence of the metasomal lateral and inferior carinae on segments I-III. Finally, all type material appears to have originated from southwestern Romania, the same general area as the other material examined.

Variation within species. Besides the type material of *E. carpathicus* and *E. c. banaticus*, we examined additional 37 specimens from southwestern Romania. This data plus a large population sample from Banat, Romania analyzed by Vachon & Jaques (1977), totaling 403 specimens, was also factored into this analysis, the latter for statistical comparisons. See Fig. 12 for the statistical ranges of the trichobothrial series of the patella involving well over 850 samples per series. Of particular importance is the high support for external series *em* (= 3), exhibiting a 94.7% compliance for 873 samples. Series *eb* (= 4), *eb_a* (= 4) show 95+% compliance and *et* (= 6) and ventral (= 8) show 70+% compliance. Fig. 62 illustrates a typical trichobothrial pattern of the external surface of the patella.

Material examined. **ROMANIA.** Baile Herculane, 1 male, 2 females (VF), 25 June 2001 (V. Popa); Herkulesbad (now Baile Herculane), 2 females (NMW 1896); Banat, 1 adult female (NMW); Drenkova, 4 males, 10 females (NMW 1896), 1892 (H. R. Lorenz von Liburnau); Mehadija, 11 specimens (NMW 1931), 2 males (NMW 1903); Orsova, 2 males, 1 female (ZMH), 24 December 1908 ("Mus. Frankfurt"); Saska, 1 female (NMW 1907).

Other source data. Our statistical database was fortified considerably with the 403 specimens (137 males and 266 females) analyzed by Vachon and Jaques (1977). Trichobothria and pectinal tooth numbers were extracted from this source. All material was from Baile Herculane (=Herkulesfürdo, =Herkulesbad), the historical area of Banat, Romania. This series is largely deposited in the Hungarian Natural History Museum in Budapest (122 males and 251 females), with some specimens also in the Muséum d'Histoire naturelle de Genève (7 males, 8 females) and the Muséum national d'Histoire naturelle, Paris (8 males, 7 females).

Geographical distribution. We restrict the geographic range of this species to Romania, i.e. area north of Danube. See map in Figure 57.

### *Euscorpius balearicus* Caporiacco, 1950
(Figs. 2, 13-22 , 59 and Table 5)

Euscorpius carpathicus balearicus Caporiacco, 1950: 187, 227; Vachon & Jaques 1977: 431; Bartolozzi et al., 1987: 295; Lacroix, 1991a: 19; Dupré, 1997: 15; Fet & Sissom, 2000: 361-362.
Euscorpius balearicus Gantenbein et al., 2001: 301-320.

Diagnosis **(**after Gantenbein et al., 2001). This species is small to medium in size, the largest mature female examined was only 37 mm. in length and the largest male 34 mm. Its coloration is light brownish-tan with little contrasting patterns. Proportionally, this species has a reduced metasoma and unusually large pedipalps (see morphometric ratio comparisons below). The metasomal carinae are essentially obsolete on segments I-IV except for weakly granulated dorsal carinae. Pedipalp patellar external trichobothria numbers are $eb = 4$, $eb_a = 4$, $esb = 2$, $em = 4$, $est = 4$ and $et = 6 - 10$; ventral aspect of patella $9 - 14$. The number of trichobothria occurring in the *et* and ventral series are among the largest found in the genus as a whole. Pectinal tooth counts: female $6 - 8$, male $7 - 9$.

The data presented in this paper for *E. balearicus* is based almost entirely on the analysis conducted in Gantenbein et al. (2001); this work has to be consulted on the type material data and detailed information on *E. balearicus*. A few additional specimens (see below) were added to the statistics gathered in the aforementioned paper. For completeness with the other data pre-
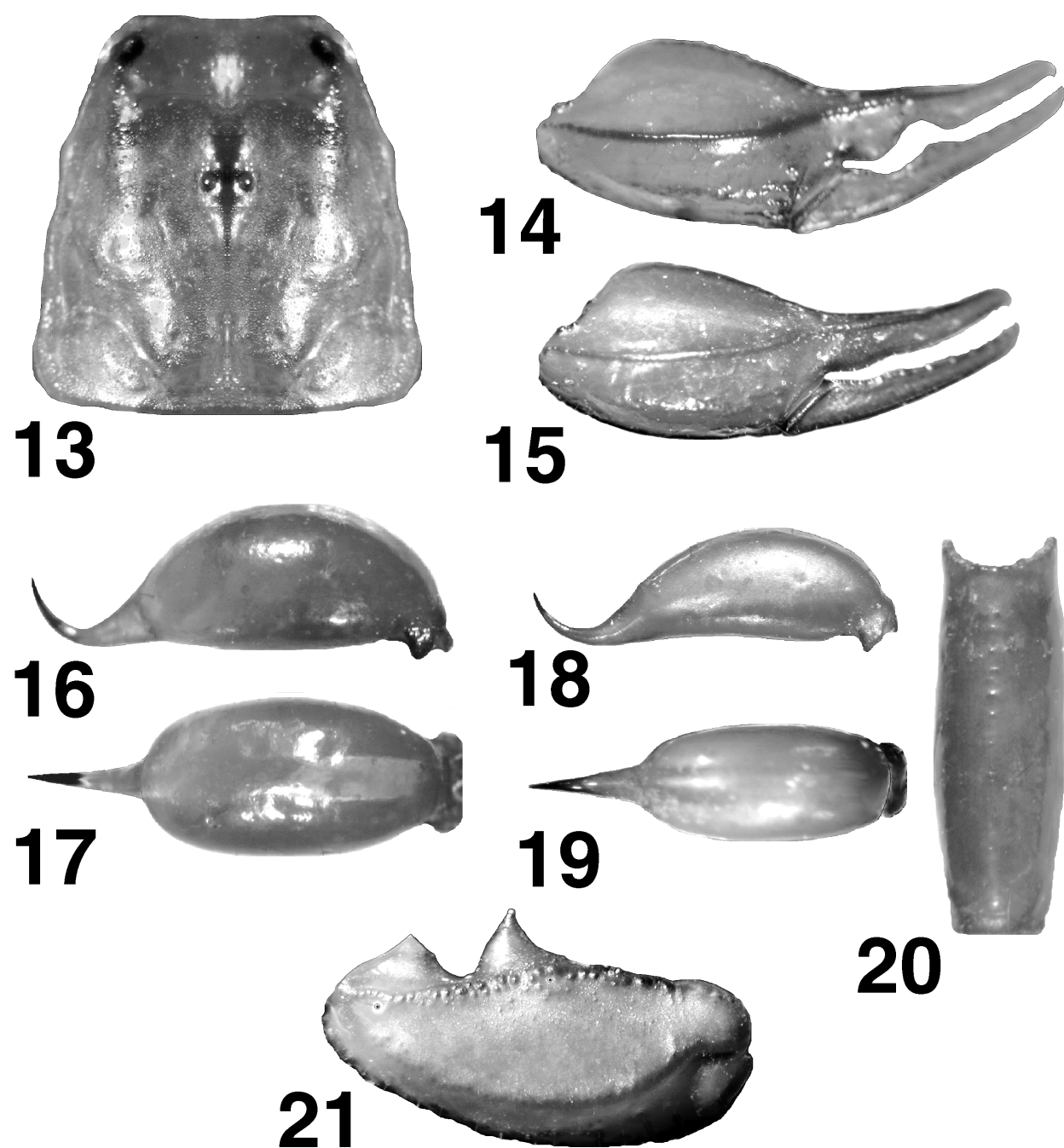
Figures 13-21: *Euscorpius balearicus*, Mallorca, Balearic Islands, Spain. Female, Puerto Alcudia, male, Soller. **13.** Carapace, male. **14.** Chela, male. **15.** Chela, female. **16.** Telson, lateral view, male. **17.** Telson, ventral view, male. **18.** Telson, lateral view, female. **19.** Telson, ventral view, female. **20.** Metasomal segment V, ventral view, male. **21.** Pedipalp patella, dorsal view, female.

sented in this paper, Fig. 2 shows the dorsal view of a female from Mallorca, Figs. 13-21 illustrate structures based on both male and female specimens from Mallorca, and Fig. 22 depicts the statistical distribution of the five pedipalp patella trichobothria series for 105 – 167 samples. External series *eb* (= 4), *eb$_a$* (= 4) and *em* (= 4) exhibit essentially 100% compliance; the *et* and ventral series reflect somewhat large ranges due to, in

part, on the curious drop in numbers in these series found on Menorca and Cabrera populations (as compared to Mallorca populations), see Gantenbein et al. (2001: 310-311). Fig. 59 illustrates a typical trichobothrial pattern of the external surface of the patella. Elsewhere, this species is contrasted in detail with the other species described herein.
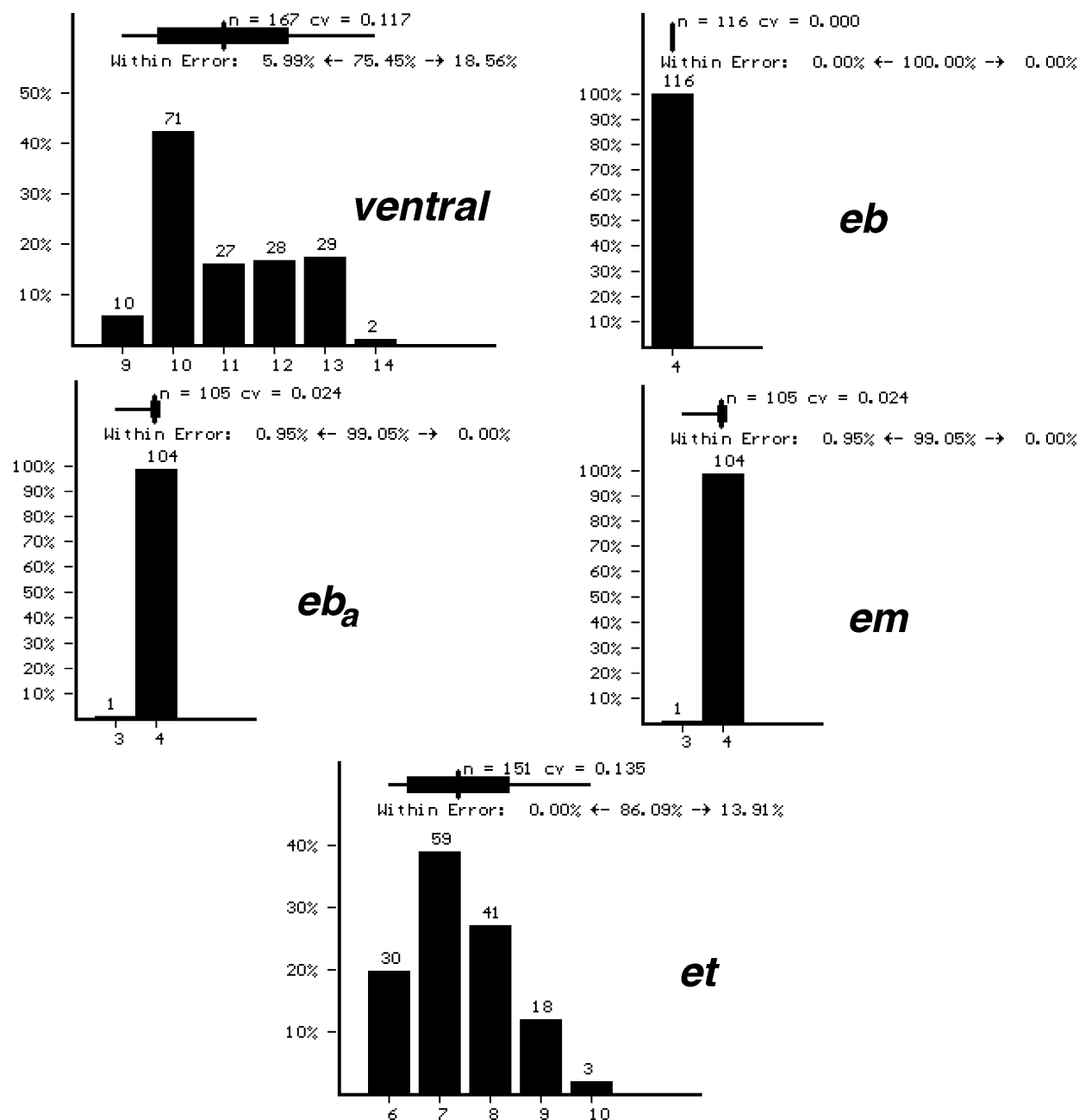
Figure 22: Statistical data for pedipalp patella trichobothrial counts of *Euscorpius balearicus*. See Fig. 12 for definition of terms.

Material examined. **SPAIN:** Balearic Islands, Mallorca: La Palma, 1 adult female (ZMH), 14 April 1896 (K. Kraepelin); Soller, 1 adult male, 2 adult females (ZMH), May 1930 (M. Knoth).

Other source data. Our statistical database was enhanced with 90 specimens originally analyzed by Gantenbein et al. (2001). These specimens originated from Mallorca, 26 females, 13 males and 4 early instars, Menorca, 1 female, 2 males and 3 early instars and the Cabrera Archipelago, 16 females, 14 males and 11 early instars. Trichobothria, pectinal tooth numbers and morphometrics were extracted from this source.

Geographical distribution. *E. balearicus* is endemic to the Balearic Islands off the coast of eastern Spain, having been reported from Mallorca, Menorca, and the Cabrera Archipelago (Gantenbein et al., 2001). See map in Figure 57.

Euscorpius tergestinus (C.L. Koch, 1837)
(Figs. 24-35, 60, 67 and Tables 2, 5)

Scorpius tergestinus C. L. Koch, 1837: 106, pl. CVII-CVIII, Fig. 247-248, Trieste, Italy (Wagner).

Syntypes (male and female), formerly in J. Sturm's collection in Nuremberg (Birula, 1917), now are presumed lost (Fet & Sissom, 2000). We designate here the neotype according to ICZN Article 75 as it is required for the purposes of clarifying the taxonomic status of certain populations, previously classified under *E. carpathicus*.

Neotype: male from Osp, Koper district, Slovenia. Label (typed): Osp, Koper, Slovenia VL14 1994, leg. B. Toškan (UL, now permanently deposited in NMW).

Synonyms.

Scorpius aquilejensis C. L. Koch, 1837: 101-103, pl. CV, Fig. 244, **syn. n**. Holotype (male; lost), Trieste, Italy (Wagner).

Scorpius concinnus C. L. Koch, 1837: 105-106, pl. CVI, Fig. 246, **syn. n**. Holotype (female; lost), no type locality. *Note*: Caporiacco (1950) treated this taxon as a valid subspecies from Italy, but the original Koch's description (p. 106) says "…was received from the late Count Jenison of Vienna, without designation of its place of origin."

Scorpius niciensis C. L. Koch, 1841: 112-114, pl. CCLXXXIII, Fig. 681, **syn. n**. Holotype (female; lost), Nice, Alpes-Maritimes, France (Will).

Scorpius tergestinus var. *austriacus* Ferrari, 1872: 657-658, **syn. n**. **Syntypes**: 2 specimens (NMW 1901), Krems, Austria, 30 June 1873 (J. Ferrari).

Euscorpius carpathicus mesotrichus Hadzi, 1929: 36-38, Fig. 5-6; a junior primary homonym of *E. italicus mesotrichus* Hadzi, 1929 (ICZN Article 57.2) (see Capra, 1939: 202; Fet, 1997b: 248); synonymized by Caporiacco (1950b: 179) with *E. carpathicus tergestinus* (C. L. Koch, 1837). Syntypes: 2 males, 7 females (depository unknown), southern Slovenia. **Not** *E. "mesotrichus" sensu* Kinzelbach (1975), as stated by Fet & Sissom (2000), **misidentification.**

Euscorpius carpathicus apuanus Caporiacco, 1950: 186, 227, **syn. n**. Types (studied): **Lectotype** (designated here according to the ICZN Article 74 from the syntype series): 1 male (MZUF 133/5931), Castelnuovo Garfagnana, Apuan Alps, Lucca, Tuscany, Italy, November 1876 (Carli). **Paralectotypes**: 3 females (MZUF 129/5928-5930), Bardono, upper Val di Magra, Massa Carrara, Tuscany, Italy, 24 October 1879 (Del Prete); 13 females, 1 male (MZUF 125/5954-5967), Apuan Alps, Lucca, Tuscany, Italy, 3 August 1875 (Del Prete). *Note*: the latter series does not have a detailed label, but Caporiacco (1950) listed the following localities: Levigliani, Valecchia, Pietrasanta, Mt. Corchia, Tambura; all in Apuan Alps, Tuscany, Italy.
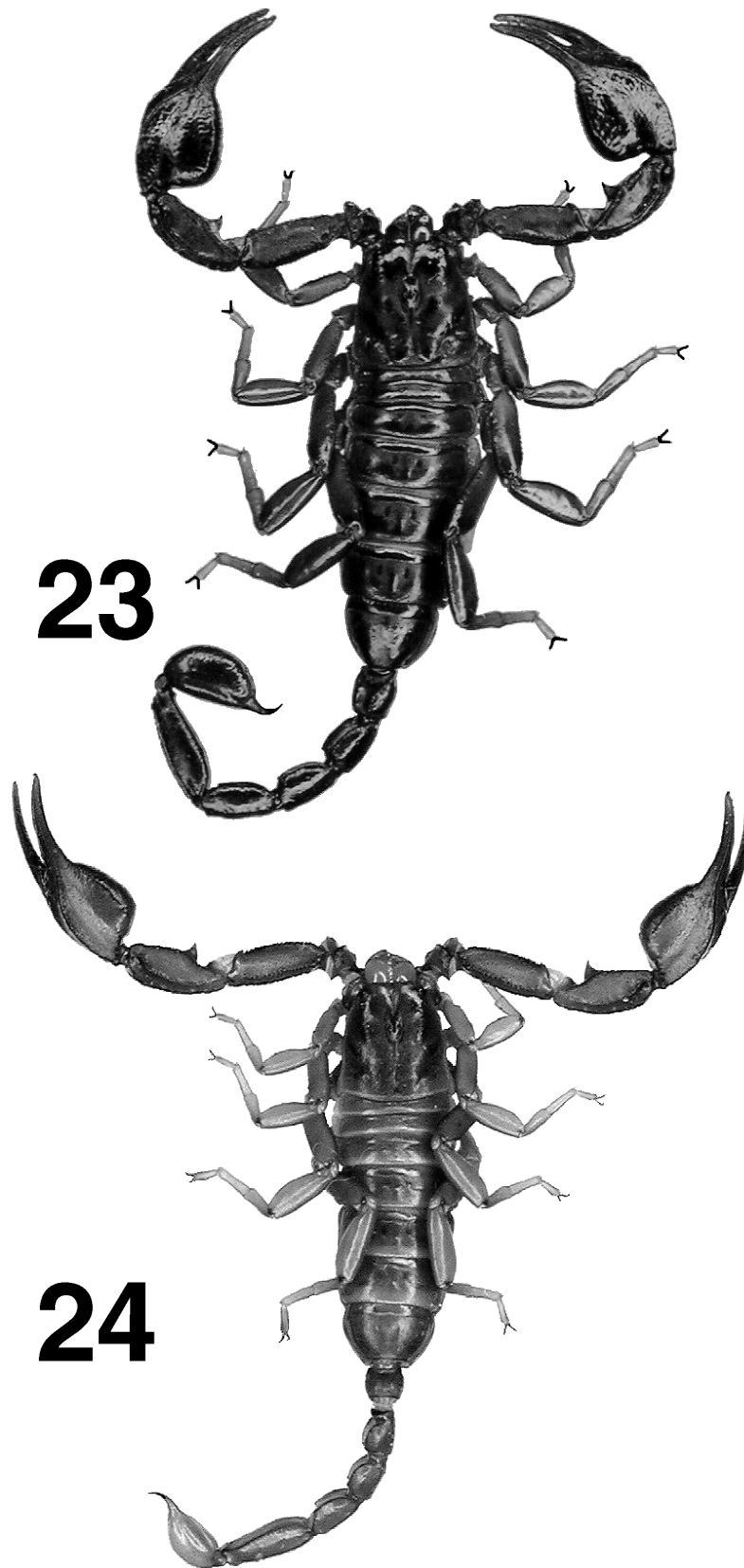
Euscorpius carpathicus corsicanus Caporiacco, 1950: 186, 227, **syn. n**. Types (studied): **Lectotype** (designated here according to the ICZN Article 74 from the syntype series): female (MZUF 65/5981), Sarteana, Corsica, France, May 1878 (G. B. Toscanelli). **Paralectotype**: 1 female (MZUF 66/5980), same label as lectotype. Other paralectotypes: 4 males, 2 females (depository unknown).

Euscorpius carpathicus picenus Caporiacco, 1950: 194, 228 (in part), **syn. n**. Types (studied): **Lectotype** (designated here according to the ICZN Article 74 from the syntype series): male (MZUF 132-5856), Avellana, Pesaro e Urbino, Marche, Italy, 15 July 1880 (G. Cavanna). **Paralectotypes**: 8 females, 5 males (MZUF 131/5838-5843, 132/5853-5855, 5857, 5859, 5860), same label as lectotype; 3 females, 2 males, 2 juv. (MZUF 161/5850-5851, 162/5864-5867, 163/5987), Caramanico, Pescara, Abruzzo, Italy, 1878 (G. Cavanna); 1 female (MZUF 180/5852), Teramo, Abruzzo, Italy, 5 Sept. 1904; 2 females, 1 male (MZUF 84/5861-5863), Vallombrosa, Reggello, Firenze, Tuscany, Italy (Giachetti); 1 male (MZUF 93/5849), San Marino, 7 July 1878 (G. Cavanna). *Note*: three specimens from the syntype series do not match *E. tergestinus* in morphology and are not included in paralectotype list.

Euscorpius carpathicus oglasae Caporiacco, 1950: 197, 228, **syn. n**. **Lectotype** (designated here according to the ICZN Article 74 from the syntype series); female (MZUF 123/5974), Montecristo Island, Livorno, Tuscany, Italy, 1879 (G. B. Toscanelli). **Paralectotypes**: 1 female (MZUF 123/5975), same label as lectotype. Other paralectotypes: 1 male (depository unknown).

References (selected).

Euscorpius carpathicus: Hadži, 1929: 36 (in part), Hadži, 1930: 57-64 (in part), Caporiacco, 1950: 178-209 (in part); Vachon, 1963: 350, Fig. 3E; Kinzelbach, 1975: 28-37 (in part); Valle, 1975: 209-234 (in part); Scherabon, 1987: 80-149, Fig. 2, 9, 15, 18, 20, 25, 28, 30; Crucitti, 1993: 289-291, Fig. 2 (in part); Fet & Braunwalder, 2000: 19 (in part); Huber et al., 2001: 273-278; Komposch et al., 2001: 267-272.

Euscorpius carpathicus tergestinus: Caporiacco, 1950: 182, 227; Valle, 1975: 225; Lacroix, 1991a: 19; Kovařík, 1997: 182.

Euscorpius carpathicus aquilejensis: Caporiacco, 1950: 182, 229; Lacroix, 1991a: 19; Fet & Sissom, 2000: 361.

Figures 23-24: 23. *Euscorpius hadzii* Caporiacco, male, Prokletije Mountains, Albania. **24.** *Euscorpius tergestinus* (C.L. Koch), female, Strunjan, Slovenia.

Euscorpius carpathicus concinnus: Caporiacco, 1950: 190-194, 228; Lacroix, 1991a: 19; Fet & Sissom, 2000: 363.

Euscorpius carpathicus niciensis: Caporiacco, 1950: 197-198; 229; Lacroix, 1991a: 17, 19, fig. 60-63, 67, 69-75, 77-78, 80-85, 87-88, 90-93; Fet & Sissom, 2000: 361.

Euscorpius carpathicus apuanus: Bartolozzi et al., 1987: 295; Lacroix, 1991a: 19; Fet & Sissom, 2000: 361.

Euscorpius carpathicus corsicanus: Bartolozzi et al., 1987: 296; Lacroix, 1991a: 17; Fet & Sissom, 2000: 363.

Euscorpius carpathicus oglasae: Bartolozzi et al., 1987: 297; Lacroix, 1991a: 19; Fet & Sissom, 2000: 365.

Euscorpius carpathicus picenus: Bartolozzi et al., 1987: 298; Lacroix, 1991a: 19; Fet & Sissom, 2000: 365.

Euscorpius tergestinus: Fet & Sissom, 2000: 372-372 (in part).

***Taxonomic history*.** Restriction of *E. carpathicus* to the Romanian populations leaves open numerous nomenclatural issues since we have to determine name and status for many populations which were traditionally included under *E. carpathicus*. Caporiacco (1950) listed numerous quantitative data on mainly Italian populations with a "standard" trichobothrial formula, which roughly positions them within Hadži's "*E. c. mesotrichus*". Realizing that this name is homonymous, Caporiacco synonymized it to *E. tergestinus* (C. L. Koch, 1837), treating the later as a valid subspecies from Italy, Slovenia and Croatia (Dalmatian coast). Our neotype specimen is selected from a locality (Osp), which lies on the border of Slovenia and Italy, on the outskirts of Trieste, Italy, from where Koch's type originated.

Caporiacco (1950), using an overly detailed system without sufficient diagnostic characters, distinguished several more subspecies from Italy and France. These included three Koch's taxa, treated as subspecies of *E. carpathicus*: *Scorpius aquilejensis* C. L. Koch, 1837; *S. concinnus* C. L. Koch, 1837; and *S. niciensis* C. L. Koch, 1841. Moreover, Caporiacco (1950) described two new subspecies from mainland Italy (*E. c. apuanus* and *E. c. picenus*), one from the Montecristo Island in the Tyrrhenian Sea (*E. c. oglasae*), and one from Corsica (*E. c. corsicanus*), which all have "standard" trichobothrial formula. We studied type series of all four Caporiacco's subspecies as well as the Italian and French material corresponding geographically to Koch's taxa; we conclude that they have no sufficient diagnostic characters to be treated as separate taxa. Therefore we declare these forms synonyms of *Euscorpius tergestinus* (C. L. Koch, 1837). Valle (1975: 227) specifically noted that all specimens from northern Italy (Piedmont and Liguria) have B2 = 6 (*eb* = 4 - 4); this refers to *E. tergestinus*. Possibly introduced populations from Aus-

tria (Scherabon, 1987; Huber et al., 2001) and Czech Republic (Táborsky, 1959) also belong here. It is likely that the *E. c. fanzagoi* Simon, 1872 from the Pyrenees in France and Spain also belongs to this species; no material from this area was available for study.

In addition to morphology, genetic data (allozymes and mitochondrial DNA) are available for a wide range of *E. tergestinus* populations from France, Italy, Slovenia, Croatia and Austria, and clearly demonstrate their relatedness (Gantenbein et al., 2001; Huber et al., 2001).

***Diagnosis*.** Medium sized species; orange-brown in overall coloration, dorsal carinae of metasomal usually pigmented, but great variability is present in different populations. Dorsal metasomal carinae distinctly granular; single inferior median carina usually visible on segment IV; ventroexternal carina of chela granulate to crenulate. Pedipalp patellar external trichobothria numbers: $eb = 4$, $eb_a = 4$, $esb = 2$, $em = 4$, $est = 4$, $et = 5\text{-}8$ (6+); ventral aspect of patella 7-11 (9). Pectinal tooth counts: male 7-10 (8+), female 6-8 (7+).

***Male*.** Redescription based on neotype. Measurements of male neotype and other material found in Table 2. All illustrations are based on mature specimens originating from Slovenia. Fig. 24 shows a dorsal view of a female from Slovenia.

Coloration. Overall color orange-brown, carapace and chelae darkest; chelicerae, telson, genital operculum, pectines and sterna yellow; internal carinae of pedipalp femur black; chelal digital and ventroexternal carinae red-black; dorsal carinae of metasoma dark brown.

Carapace. Shiney at 10x, slight granulation on lateral anterior aspect; anterior edge straight (Fig. 25). Two pairs of lateral eyes, anterior eye much larger; median eyes and tubercle quite small, situated anterior of middle, length and width formulas: 199|530 and 68|430.

Mesosoma. Tergites smooth to rough at 10x, slight indication of median carinae proximally on tergite VII; sternites smooth and shiney, sternite V carinae obsolete; stigmata small, oval-slit like in shape.

Metasoma. Carinae — Segments I-IV: dorsal granulate; dorsal lateral weak on segment I, present 1/3 of length on II-III, 1/5 on IV; lateral weak on I, obsolete II-IV; inferior lateral obsolete on segment I, round and smooth on II-IV; inferior median obsolete on I-III, weak slight granulation on proximal 1/3 on IV. Carinae — Segment V (Fig. 32): dorsal lateral rounded with scattered granulation; lateral obsolete; inferior lateral and median crenulate. Posterior granule on dorsal carinae slightly enlarged; intercarinal spaces smooth.

Telson. Vesicle highly swollen both laterally and ventrally; smooth (Figs. 28-29, male, Figs. 30-31, female). Aculeus with short abrupt curve, 6-7 pairs of se-

	Osp, Slovenia				Abruzzo, Italy (*E. c. picenus* syntypes)		Apuan Alps, Italy (*E. c. apuanus* syntypes)	
	Male neotype	Male	Female	Female	Male	Female	Female	Female
Total length	33.05	33.30	37.85	34.85	37.10	35.25	40.5	41.85
Carapace length	5.30	5.35	5.85	5.50	5.30	5.05	5.35	6.00
Mesosoma length	9.95	9.30	13.60	11.95	12.25	13.95	16.55	15.70
Metasoma length	12.95	13.50	13.55	12.80	14.25	12.00	13.90	15.05
Metasomal segment I								
length	1.70	1.75	1.80	1.70	1.90	1.55	1.80	1.90
width	1.80	1.85	1.90	1.90	2.00	1.95	2.00	2.25
Metasomal segment II								
length	2.00	2.10	2.00	1.95	2.10	1.85	2.10	2.25
width	1.60	1.60	1.75	1.60	1.85	1.75	1.80	1.95
Metasomal segment III								
length	2.15	2.25	2.25	2.10	2.40	2.05	2.40	2.55
width	1.50	1.50	1.60	1.55	1.80	1.60	1.70	1.85
Metasomal segment IV								
length	2.60	2.80	2.70	2.45	2.95	2.55	2.95	3.20
width	1.45	1.40	1.45	1.40	1.75	1.55	1.50	1.70
Metasomal segment V								
length	4.50	4.60	4.80	4.60	4.90	4.00	4.65	5.15
width	1.45	1.45	1.70	1.50	1.75	1.55	1.55	1.80
Telson length	4.85	5.15	4.85	4.60	5.30	4.25	4.70	5.10
Vesicle length	3.65	3.65	3.45	3.15	4.10	3.05	3.25	3.55
width	2.00	2.00	1.70	1.55	2.00	1.60	1.75	1.80
depth	2.30	2.25	1.85	1.60	2.30	1.50	1.55	1.75
Aculeus length	1.20	1.50	1.40	1.45	1.20	1.20	1.45	1.55
Pedipalp length	18.25	18.80	21.20	19.50	18.35	16.75	19.95	21.70
Femur length	4.55	4.75	5.35	5.10	4.45	4.00	4.80	5.30
width	1.80	1.80	1.95	1.90	1.70	1.55	1.90	2.10
Patella length	4.50	4.60	5.15	4.75	4.50	4.25	5.00	5.30
width	2.00	2.00	2.20	2.05	1.95	2.00	2.15	2.35
Chela length	9.20	9.45	10.70	9.65	9.40	8.50	10.15	11.10
Palm length	4.40	4.50	5.25	4.70	5.00	4.45	5.20	5.65
width	3.00	3.10	3.45	3.05	3.70	3.05	3.50	3.65
depth	3.55	3.45	3.90	3.40	4.00	3.40	3.75	4.25
Movable finger length	5.55	5.65	6.20	5.85	5.70	4.80	5.80	6.30
Pectines								
teeth	7-8	8-8	6-7	7-5	9-9	7-8	7-7	7-7
middle lamellae	5+-4+	4+-x	4-4	x-x	6-6	5-5	4+-5	x-x

**Table 2:** Morphometrics (mm) of *Euscorpius tergestinus* (C.L. Koch).

tae at vesicle/aculeus juncture. Slight enlarged granule with setal pair present at juncture.

Pectines. Length|width formula 200|115. Tooth counts 7/8, middle lamellae 4+/5; fulcra well developed; minute yellow setae scattered on anterior lamellae; sensorial areas elongated along tooth edge, approximately 1/3 tooth surface. Basal piece with slight broad concave indentation on anterior edge; length|width formula 63|147.

Genital operculum. Separated most of length, genital papillae protruding slightly from proximal edge.

Sternum. Pentagonal, wider than long, length|width formula 162|178.

Chelicerae. Movable Finger: Ventral distal denticle extends beyond dorsal counterpart; dorsal edge with two subdistal denticles; ventral edge smooth, lacking serrulae and covered with heavy brush-like setae. Fixed Finger: four denticles configured normally.
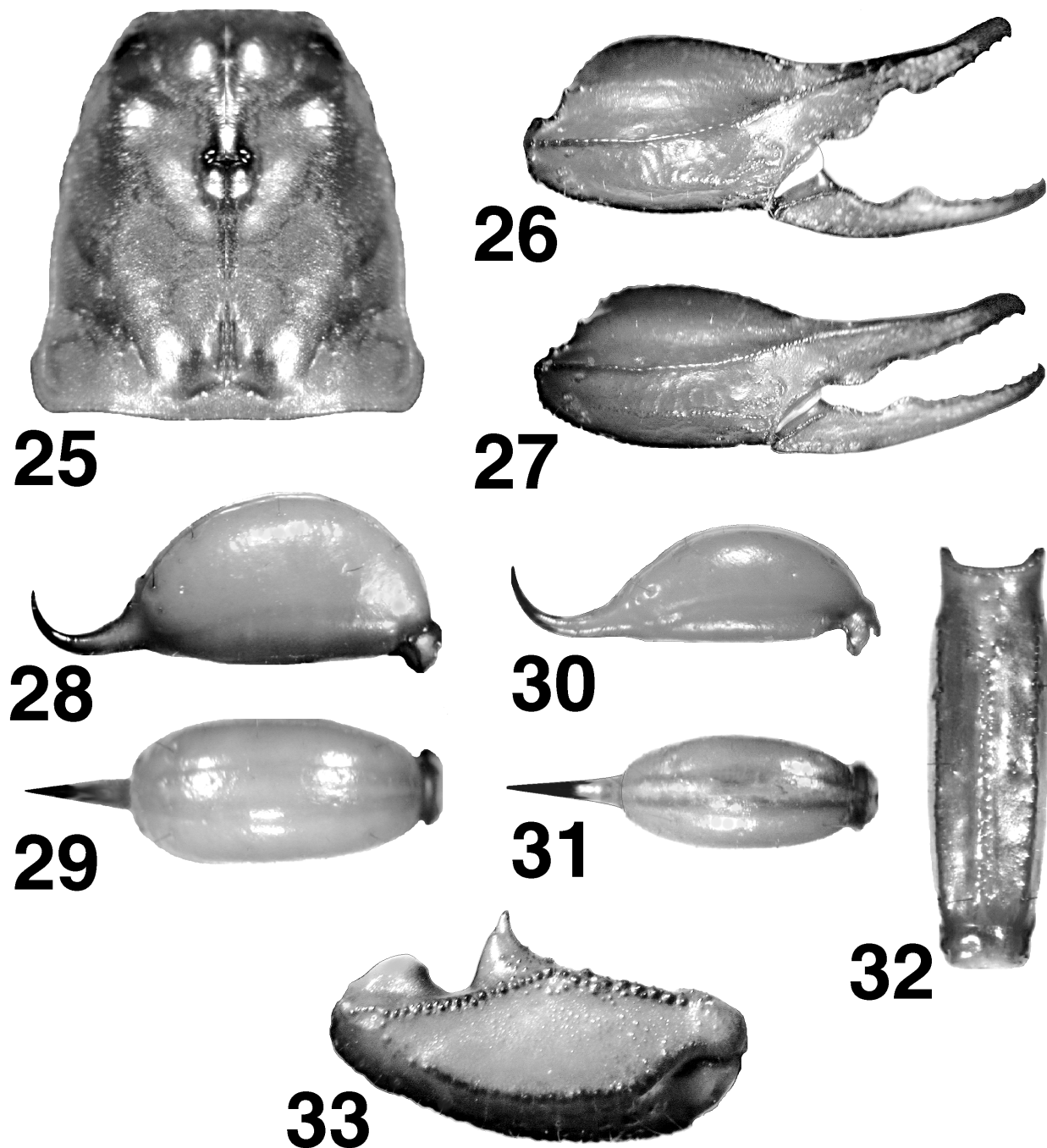
Figures 25-33: *Euscorpius tergestinus*, Osp, Slovenia. **25.** Carapace, male. **26.** Chela, male. **27.** Chela, female. **28.** Telson, lateral view, male. **29.** Telson, ventral view, male. **30.** Telson, lateral view, female. **31.** Telson, ventral view, female. **32.** Metasomal segment V, ventral view, male. **33.** Pedipalp patella, dorsal view, female.

Pedipalps. Prominent scalloping at chelal finger bases. Femur: dorsal internal and ventral internal and external serrulate; dorsal external crenulate; dorsal and ventral surfaces covered with granules; internal face with serrulated row of granules. Patella (Fig. 33, female): dorsal internal serrulate; dorsal external and ventral internal crenulate; ventral external smooth to granu-lar; exteromedian rounded irregularly granulate; dorsal surface covered with granules; ventral surface smooth to slightly granulate; DPS well developed, VPS represented as small granule. Chela carinae (Figs. 26-27): digital strongly developed, granular on proximal one-fourth; sub-digital represented as a single granule; dorsal secondary very weak; dorsal marginal rounded smooth to

granular; dorsal internal very rounded with scattered granulation; ventroexternal strong, crenulate, extending to external condyle; ventromedian essentially obsolete; ventrointernal rounded and granulose; external secondary irregularly granulose. Chelal finger dentition: inner denticles 6/7, outer denticles 6/7, inner accessory denticles 4/5, fixed and movable fingers respectively. Trichobothria patterns: Type C. neobothriotaxic (major additive) on patella. Femur: trichobothrium *d* situated proximal to *i*, *e* slightly distal to both, situated on dorsoexternal carina. Patella: ventral series number 9/9 and external series number eb = 4/4, eb_a = 4/4, esb = 2/2, em = 4/4, est = 4/4, et = 6/6. Chela: Ventral series 4/4, V_4 found on external surface in a dimple.

Legs. Two pedal spurs, no tarsal spine. Tarsus-III: ventral median row composed of 7 stout spinules, terminating with a single offset distal pair. Basitarsus I-IV: 5 proventral spinules on legs I and II.

Hemispermatophore. Well developed lamina with conspicuous basal constriction, tapered distally (Fig. 67); truncal flexure present; capsular lobe complex well developed, exhibiting an acuminate process; ental channel spinose distally, exhibiting seven delicate variable sized spines (data based on specimen from Osp, Slovenia).

Female. Female specimen from Osp, Slovenia used for comparison. Granulation on female same as that described for male neotype.

Metasoma and telson morphometrics: We compared a full set of morphometrics for 10 females and 9 males spanning populations from France, Italy and Slovenia. Great variability in overall size is exhibited across populations for these 19 measurement sets, as reflected by the carapace length: Osp, Slovenia, 5.50-5.85 [2] females, 5.30-5.50 [3] males; western Italy, 5.30-5.85 [2] females, 4.65-4.70 [2] males; eastern France 4.80 female, 4.20 male; dwarf population from Strunjan, Slovenia, 3.80 female and 3.70 male; *E. c. picensis* syntypes, Italy, 5.05-5.55 [2] females, 4.85-5.30 [2] males; and *E. c. apuanus* syntypes, Italy, 5.35-6.00 [2] females. In general, the male was slightly smaller than the female in all groups. The metasoma of the male is slightly thinner than it is on the female, but only exhibiting slight mean value differences when all segment length/width ratios are compared, a range of 2.1 – 7.2%; plus/minus standard error overlap was considerable, 21 - 86%. However, the considerably inflated telson vesicle of sexually mature males is quite conspicuous when compared to the thinner elongated telson of the female. This is illustrated using morphometrics: Morphometric ratios calculated from the carapace length divided by the vesicle width and depth showed considerable mean value differences and plus/minus standard error separation (compare Figs. 28-31):

Carapace Length/Telson Width
MVD = 34.8% Separation Gap =155.3%
Female
3.09-3.54 (3.350) (±0.165) [010]: {3.18-3.52}š 0.049
Male
2.14-2.68 (2.486) (±0.185) [009]: {2.30-2.67}š 0.074

Carapace Length/Telson Depth
MVD = 51.8% Separation Gap = 260.7%
Female
3.20-3.73 (3.431) (±0.169) [010]: {3.26-3.60}š 0.049
Male
2.06-2.58 (2.260) (±0.161) [009]: {2.10-2.42}š 0.071

Genital operculum/genital papillae: For the female, the genital operculum is connected its entire length by a membrane; completely separated on the male where genital papillae protrude proximally.

Pectinal tooth counts: The pectines are more prominent on the male, teeth longer and larger in number:

Male
7-10 (8.543) (±0.664) [199]: {7.878-9.207}š 0.078
Female
5- 9 (7.315) (±0.721) [298]: {6.595-8.036}š 0.099

The mean value difference is 16.79%, roughly a 1+ tooth difference between the male and female.

Variation within species. Besides the designated male neotype from Osp, Slovenia, we examined an additional 178 specimens from France, Italy, Slovenia and Croatia (this includes the 53 French and Italian specimens identified as *E. carpathicus* in Gantenbein et al. (2001)). Our statistical database was augmented considerably with data from Caporiacco (1950), including another 481 specimens.

Fig. 34 shows the statistical distribution of the patella ventral and external *et* trichobothria series broken down into the various Caporiacco subspecies, ordered from a west to east to southern direction. The Croatian populations have the largest trichobothria numbers in these two series, but match fairly close to the topotypical population (near Trieste, Italy) and the most distant populations, southeastern France (*E. c. niciensis*) and Corsica (*E. c. corsicanus*), exhibiting only a one trichobothrium mean difference in both series with the French populations and less than one trichobothrium difference with the topotypical population. Note that *E. c. corsicanus* exhibited 9-10 and 7 trichobothria in the ventral and *et* series for the two specimens available for study, approaching the numbers exhibited in the Croatian populations. In Caporiacco's key he stated ranges of 9-11 (10) and 6-7 (7) for these two series but did not provide individual breakdowns or number of specimens examined. Fig. 35 shows the statistical distribution for all five patellar series, based on over 1250 samples. External series
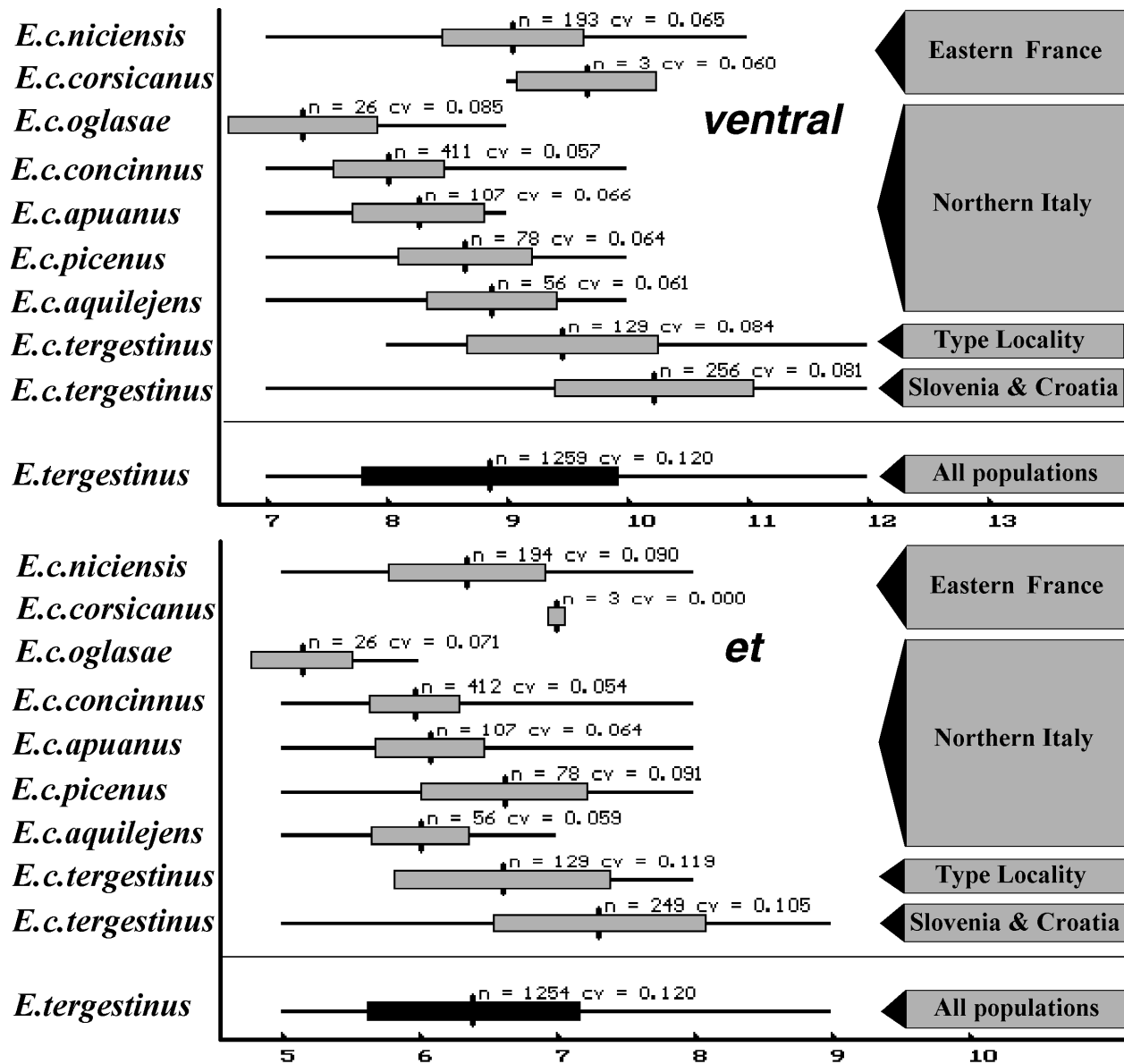
Figure 34: Statistical distribution of pedipalp patella ventral and external *et* trichobothrial series of *Euscorpius tergestinus* broken down into Caporiacco's subspecies from a western (southeastern France) to eastern (northern Italy and Slovenia) to southern (Croatia) direction. Note: the Trieste, Italy area is the type locality of *E. tergestinus* and the Slovenia/Croatia area populations were originally declared by Caporiacco as *E. c. tergestinus* as contrasted with his other subspecies. *et* = external terminal. See Fig. 12 for definitions of other terms.

eb (= 4), *eb$_a$* (= 4) and *em* (= 4) exhibit essentially 100% compliance; *et* (= 6) shows 61% compliance and the ventral series exhibit 70% compliance for counts 8-9 combined. Fig. 60 illustrates a typical trichobothrial pattern of the external surface of the patella.

Seven of Koch's and Caporiacco subspecies are synonymized here with *E. tergestinus,* five of which have been analyzed in the present paper: *E. c. niciensis* (identified as those listed under *E. carpathicus* from France in Gantenbein et al., 2001), *E. c. picenus* (Caporiacco syntypes), *E. c. apuanus* (Caporiacco syntypes as well as those listed from Tuscany under *E. carpathicus* in Gantenbein et al., 2001), *E. c. oglasae* (Caporiacco syntypes) and *E. c. corsicanus* (Caporiacco syntypes). Note that Gantenbein et al. (2001, p. 307-308), reported a close affinity from a molecular perspective (allozyme and DNA data) between populations from France, Piedmont, Tuscany, Austria, Slovenia and Croatia, exhibiting only 2-4% divergence in base pair mismatches (16S mtDNA); all these populations belong to *E. tergestinus* as defined here and span its entire geographic range. A subset of the same data was published by Huber et al. (2001) in-
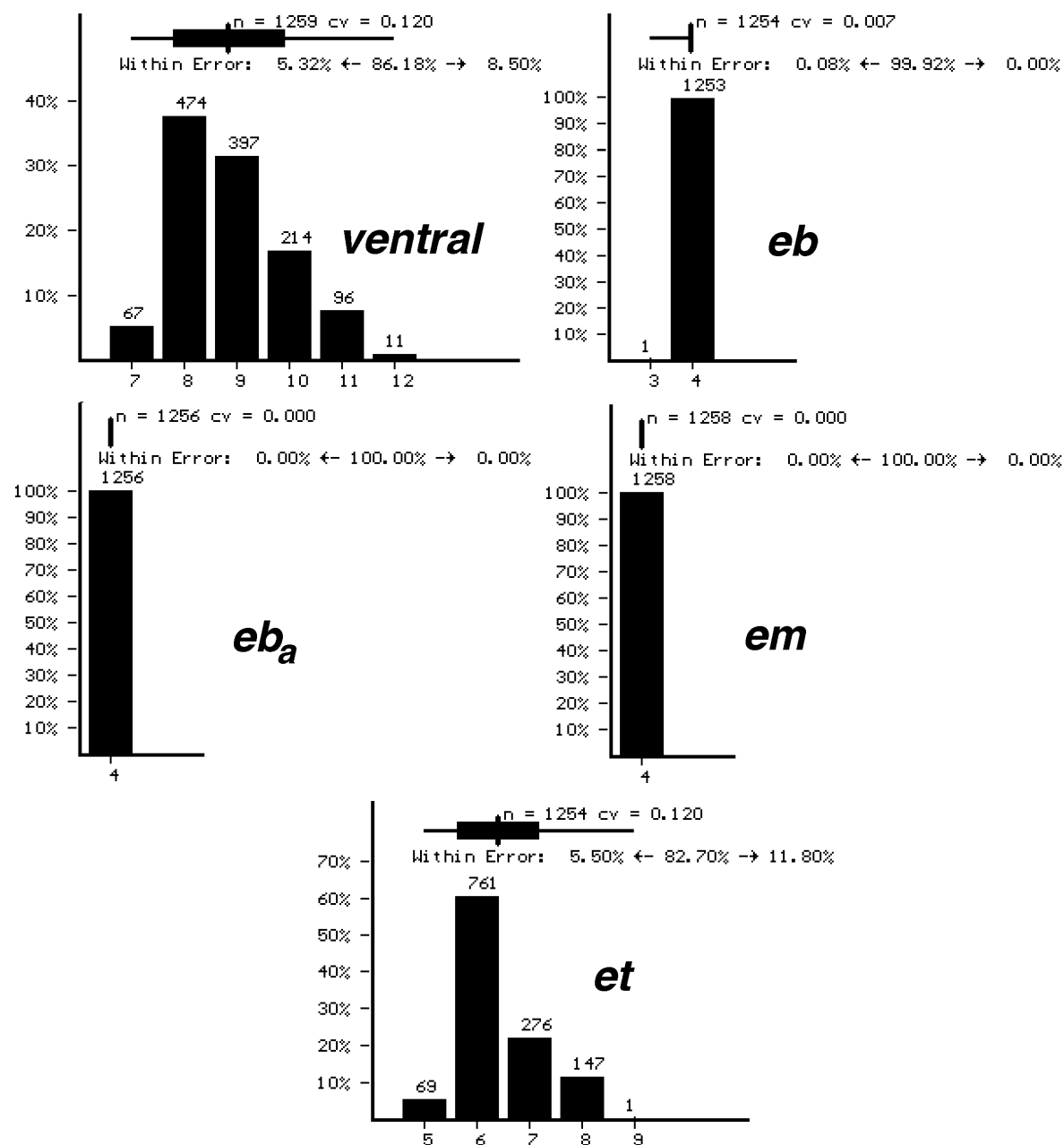
Figure 35: Statistical data for pedipalp patella trichobothrial counts of *Euscorpius tergestinus*. See Fig. 12 for definition of terms.

cluding additional DNA data from Slovenia. The morphometrics of six populations were analyzed, 19 specimens in all: in general the morphometrics were consistent across topotypical specimens of *E. tergestinus*, and the three subspecies, only *E. c. picenus* exhibiting a slightly heavier metasoma, spanning mean value differences from *E. tergestinus* topotypes of 2.1 – 12.3% (based on five females and six males). The granulation and carinal development of the metasoma and pedipalps were compared between topotypical specimens and the five subspecies: the pedipalp carinae development was consistent across all six populations; only *E. c. picenus* showed an affinity for a less granulated metasoma than the other populations.

***Material examined.* CROATIA.** Brioni Grande (now Veliki Brijun) Island, 2 females (NMW 2178), 4 June 1911 (F. Werner); Cazza Island, 2 females (NMW 1891); Kastel Stari (=Castelvecchio), 3 specimens (NMW); Losinj Island, 2 females, 1 male (NMW 11746); Oruda Island, 2 specimens (NMW 2160); Parman Island, 3 females (NMW 1876); Planchetta Island

(now Pločica, near Korčula), 2 specimens (NMW 2146); Plavnik Island, 4 females, 1 male (NMW), 4 June 1986 (H. L. Nemeschkal); Rab (=Arbe) Island, 2 females (NMW 2119); Rijeka (=Fiume), 3 females (NMW 1904 and NMW 1872); Rovinj (=Rovigno), 1 female, 1 male (NMW 1881); Scoglio Oruda Grande, 3 specimens (NMW 2145); Solta Island, 3 females (ZMH), Sept. 1891 (F. Werner); Zadar (=Zara), 2 females, 4 males, 1 specimen (NMW 13287), 18 Sept. 1888 (R. Sturany); **FRANCE.** Alpes-Maritimes: Mathis, 5 adult females, 3 subadult females, 9 adult males, 1 subadult male (BG) (A. Scholl); Peyruis, 5 adult females, 4 subadult females, 2 adult males (BG) (A. Scholl); **ITALY.** Piedmont: La Morra, 1 subadult female, 1 adult male (BG) (B. & I. Gantenbein); Liguria: Boschetto, 6 females, 2 males (NMW); Vernazza, 7 adult females, 2 subadult females, 6 adult males (BG) (C. Largiadèr); Friuli-Venezia Giulia: Grignano, 2 females, 2 males (NMW), 30 Sept. 1893; Nabresina, 4 females, 3 males (NMW 1877); Tuscany: Elba Island, Procchio, 3 subadult females, 3 adult males, 1 subadult male (BG) (A. Scholl); **SLOVENIA.** Črniče, 2 specimens (BG) (M. Kuntner); Nova Gorica, 6 specimens (NMW 2117); Koper district: Osp, 19 adult females, 6 subadult females, 14 adult males, 3 subadult males, 1 juvenile male (NMW), 1994 (B. Toškan); Postojna, 2 specimens (NMW), Sept. 1956 (de Lattin); Škocjan, 2 females, 3 males (UL), May 1953 (handwritten label by J. Hadži, identified as "*E. carpathicus mesotrichus*"); Strunjan, 2 adult females, 1 adult male (NMW).

Other source data. We included Caporiacco's (1950) comprehensive statistical data for species and subspecies originally identified as *E. c. tergestinus* (72 specimens), *E. c. concinnus* (206 specimens), *E. c. niciensis* (84 specimens), *E. c. aquilejensis* (28 specimens), *E. c. picenus* (39 specimens), *E. c. apuanus* (39 specimens), and *E. c. oglasae* (13 specimens), a total of 481 specimens distributed over France, Italy, Slovenia and Croatia. Trichobothria and pectinal tooth numbers were extracted from this source.

Geographical distribution. Austria, Croatia (coast), France (southeast; Corsica), Italy (north), Monaco, San Marino, Slovenia. See map in Figure 57.

Euscorpius hadzii Caporiacco, 1950
(Figs. 23, 36-46, 63, 66 and Table 3)

Euscorpius carpathicus hadzii Caporiacco, 1950: 180; a new replacement name for *Euscorpius carpathicus polytrichus* Hadži, 1929, a junior primary homonym of *Euscorpius italicus polytrichus* Hadži, 1929)

(ICZN Articles 57.2, 60). Elevated here to the species rank.

The original specimens of Jovan Hadži were never recorded in his 1929 paper, and have not been found among Hadži's collections (Dr. Boris Sket, University of Ljubljana, Slovenia, pers. comm.). We designate here the neotype according to ICZN Article 75 as it is required for the purposes of clarifying the taxonomic status of certain populations, previously classified under *E. carpathicus*. A statement of characters differentiating this species, and a detailed redescription, are given below.

Neotype: male from Prokletije Mountains, northern Albania (NMW 1913). Label: Coll. Musei Vindobonensis Inv. No. 1913; Nord-Albanien: Prokletije, 1200 m: 20.VII.1914; Penther leg. (36 spec.).

Synonyms.
Euscorpius carpathicus polytrichus Hadži, 1929: 37; types not designated, locality unknown.
Euscorpius carpathicus lagostae Caporiacco, 1950: 180, **syn. n**. **Lectotype** (designated here according to the ICZN Article 74 from the syntype series): male (MZUF 72/5968, "from the Vienna Museum", i.e. NMW), Lagosta (now Lastovo) Island, Adriatic Sea, Croatia, 2 April 1936. **Paralectotypes**: 1 female (MZUF 72/5969, "from the Vienna Museum"), same label as lectotype; 1 male (NMW 2157), Meleda (now Mljet) Island, Croatia, 12 April 1906.

References (selected).
Euscorpius carpathicus polytrichus: Hadži, 1930: 32-34, Fig. 1-2; Ćurčić, 1971: 96-97, Fig. 4 (map).
Euscorpius carpathicus hadzii: Valle, 1975: 231; Lacroix, 1991a: 19; Fet & Sissom, 2000: 363.
Euscorpius carpathicus lagostae: Bartolozzi et al., 1987: 297; Lacroix, 1991a: 19; Fet & Sissom, 2000: 364.

Taxonomic history. Hadži (1929) described this "robust race" as a subspecies *E. carpathicus polytrichus,* without type specimens and locality, without a verbal description, in Table IV (p. 37), as a form having 12 to 14 ventral and 28 to 34 external trichobothria on pedipalp patella. According to the ICZN Article 12, these data still constitute a description. Next year, Hadži (1930) gave an extended description (p. 32-34) of a series from Kalinovik, Bosnia (PAS; studied by V.F. in 1987), and one specimen from Albania (Hadži, 1930, Fig. 1-2). These specimens, however, do not have type status since they were not described in 1929.

Caporiacco (1950) discovered that *E. carpathicus polytrichus* is a homonym, and explicitly introduced a new substitute name (*nomen novum*), *E. c. hadžii*. Capo-

	Euscorpius hadzii						*Euscorpius koschewnikowi*		
	Prokletije Mountains, Albania				Lastovo Island, Yugoslavia (*E. c. lagostae* syntypes)		Mt. Athos, Greece		
	Male neotype	Male	Female	Female	Male	Female	Females (*L)		Male
Total length	40.15	40.20	40.90	40.05	29.30	29.70	43.05	46.15	34.70
Carapace length	5.75	5.60	5.75	5.95	4.30	4.30	5.75	6.10	4.90
Mesosoma length	13.10	13.60	16.75	15.40	8.30	11.30	17.80	19.50	10.25
Metasoma length	15.85	15.55	13.85	14.00	12.30	10.65	14.95	15.50	14.75
Metasomal segment I									
length	2.10	2.15	1.85	1.85	1.60	1.35	2.05	2.10	2.00
width	2.10	2.05	1.95	1.95	1.50	1.40	1.85	1.95	1.70
Metasomal segment II									
length	2.55	2.50	2.20	2.20	1.90	1.60	2.35	2.45	2.40
width	1.85	1.75	1.70	1.70	1.30	1.20	1.50	1.60	1.40
Metasomal segment III									
length	2.70	2.70	2.35	2.40	2.10	1.85	2.55	2.65	2.50
width	1.75	1.60	1.50	1.60	1.25	1.15	1.45	1.55	1.35
Metasomal segment IV									
length	3.25	3.30	2.90	2.90	2.50	2.20	3.10	3.25	3.10
width	1.60	1.55	1.45	1.50	1.20	1.10	1.40	1.45	1.30
Metasomal segment V									
length	5.25	4.90	4.55	4.65	4.20	3.65	4.90	5.05	4.75
width	1.75	1.60	1.50	1.55	1.25	1.15	1.35	1.40	1.30
Telson length	5.45	5.45	4.55	4.70	4.40	3.45	4.55	5.05	4.80
Vesicle length	4.10	4.10	3.25	3.15	3.35	2.40	3.25	3.55	3.75
width	2.15	2.00	1.50	1.70	1.95	1.20	1.55	1.55	1.80
depth	2.50	2.50	1.50	1.75	1.45	1.20	1.55	1.75	1.95
Aculeus length	1.35	1.35	1.30	1.55	1.05	1.15	1.30	1.50	1.05
Pedipalp length	20.75	19.70	19.85	20.80	14.80	14.75	20.55	22.10	18.3
Femur length	5.20	5.00	5.10	5.25	3.65	3.70	5.25	5.55	4.70
width	1.95	1.95	2.10	2.10	1.45	1.45	1.90	2.10	1.70
Patella length	5.05	4.75	4.80	5.10	3.70	3.65	5.15	5.45	4.70
width	2.10	2.05	2.25	2.35	1.55	1.70	2.10	2.40	2.00
Chela length	10.50	9.95	9.95	10.45	7.45	7.40	10.15	11.10	8.90
Palm length	5.25	4.90	4.80	5.05	3.80	3.75	5.55	6.00	4.90
width	3.80	3.50	3.45	3.60	2.85	2.40	3.70	4.10	3.10
depth	4.20	4.15	4.05	4.10	3.10	2.80	3.70	4.20	3.20
Movable finger length	6.45	6.00	5.80	6.00	4.50	4.25	5.60	5.75	4.75
Pectines									
teeth	10-10	x-10	8-8	8-8	9-9	8-8	7-7	6-7	8-8
middle lamellae	6-6	x-4	4-4	4-4	5+-5+	5-5	4-4	4-4	4-4+

Table 3: Morphometrics (mm) of *Euscorpius hadzii* Caporiacco, **stat. nov**. and *E. koschewnikowi* Birula (***** female lectotype).

riacco examined only one specimen (from "Ivan Pass" (now Ivan Sedlo), Bosnia, MNHN). Fet & Sissom (2000: 363) considered this specimen a holotype; however, it is a mistake, since there was no name-bearing type specimen designated by Hadži. Article 72g of the Code states "if a new name is proposed for a species group taxon to replace a prior one, both names have the same type", and the Ivan Sedlo specimen was not explicitly designated as a neotype by Caporiacco (1950). Therefore, a neotype had to be designated for *E. c. hadžii* as we did above, following ICZN Article 75 to clarify taxonomic status of the taxon.
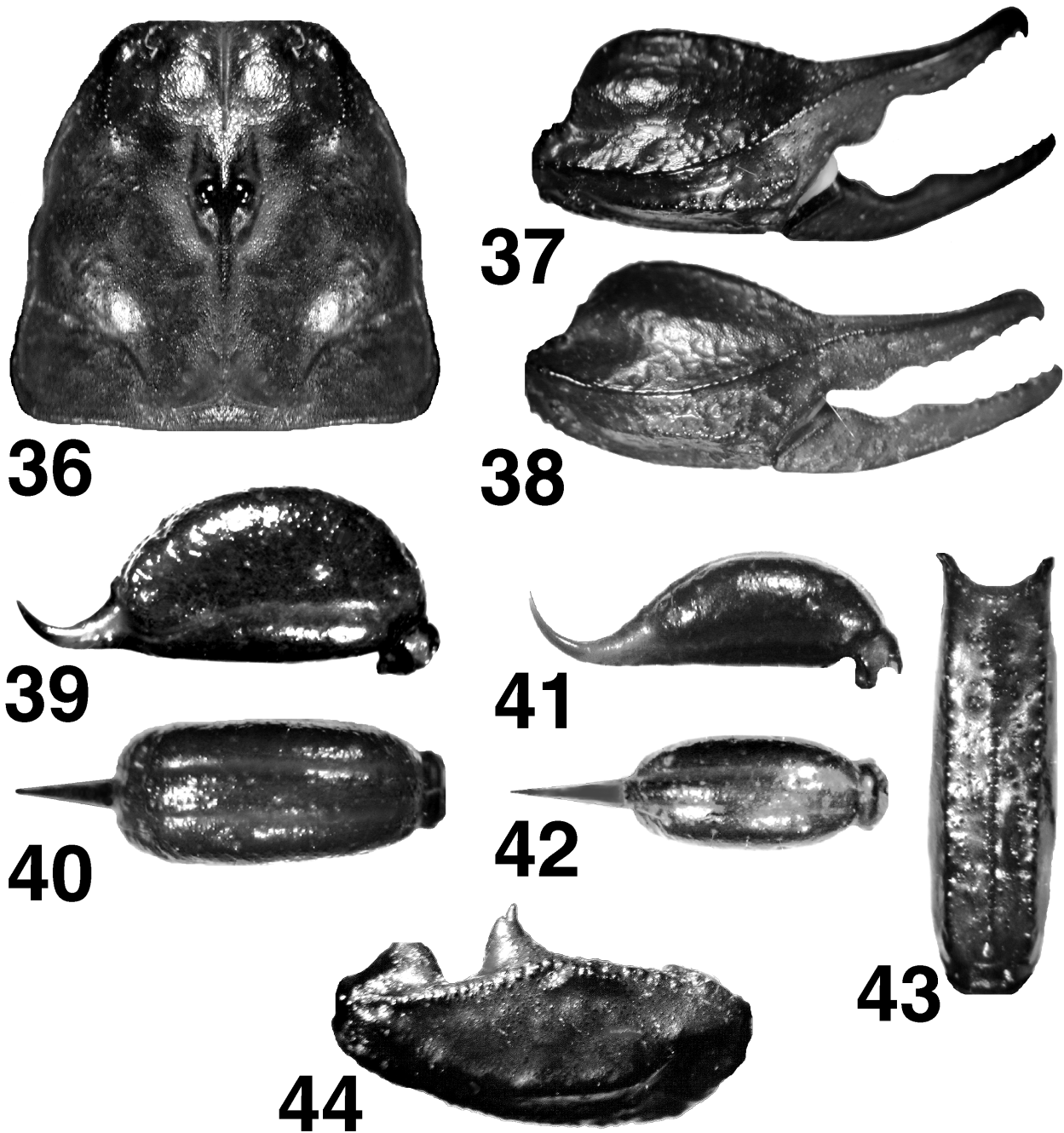
Figures 36-44: *Euscorpius hadzii*, Prokletije Mountains, Albania. **36.** Carapace, male. **37.** Chela, male. **38.** Chela, female. **39.** Telson, lateral view, male. **40.** Telson, ventral view, male. **41.** Telson, lateral view, female. **42.** Telson, ventral view, female. **43.** Metasomal segment V, ventral view, male. **44.** Pedipalp patella, dorsal view, female.

Hadži (1930) listed this form for Bosnia (Kalinovik at Treskavica Mts.), Montenegro (Podgorica; mountains above Cattaro, now Kotor), Kosovo (Pritzend, now Prishtina), western Serbia (Zlatibor Mts.), and Albania (no locality). The series from Kalinovik (PAN) was studied by V.F. Caporiacco (1950: 179) correctly noted that he could not assign Hadzi's subspecies to any forms known from the Italian mainland, Sicily, Sardinia, or Corsica.

After 1950, nobody recorded *E. c. hadzii*. The range of *E. hadzii* fits quite well into "polytrichous" populations of *E. carpathicus* in the Balkans as Ćurčić (1971: 87, Figs. 2, 4) shows in his maps. Kinzelbach (1975) probably included this species under his "*E. mesotrichus*". Valle (1975, Tab. 3) reported "polytrichous" populations with B3 = 11 – 14 (eb_a 5 – 7) from Macedonia, Croatia and Bosnia. Fet (2000) listed this form from Albania and Bulgaria as "*E. carpathicus* Form B" without assigning

to any subspecies. It was also collected from Paramythia, Epirus, NW Greece by Michalis & Dolkeras (1989).

Diagnosis. Medium to large species, coloration variable, ranging from almost complete black to lighter orange brown, essentially lacking contrasting patterns. Metasoma somewhat elongated, dorsal patellar spur (DPS) well developed (see morphometric analysis presented elsewhere). Pedipalp patellar external trichobothria numbers: $eb = 5$, $eb_a = 6\text{-}8$ (7), $esb = 2$, $em = 4\text{-}5$ (4), $est = 4$, $et = 6\text{-}9$ (7+); ventral aspect of patella 9-13 (11). Pectinal tooth counts: male 7-11 (9), female 7-9 (8). The eb series of 5 and eb_a series of 7 are major diagnostic characters for this species.

Male. Redescription based on neotype. Measurements of male neotype and other specimens provided in Table 3. All illustrations are based on mature specimens originating from Prokletije Mountains, Albania. Fig. 23 illustrates a sexually mature male from Albania.

Coloration. Basic color dark brown to black, pedipalps and carapace darkest; mesosoma, metasoma and telson slightly lighter; legs and chelicerae medium brown; sternum, genital operculum, pectines and sternites I-IV dark yellow, sternite V dark brown. No discernable patterns present.

Carapace. Overall surface rough at 10x but interocular area slightly shiney in appearance (Fig. 36). Anterior edge straight. Two pairs of lateral eyes, anterior eye slightly larger; median eyes and tubercle medium to small, situated anterior of middle with length and width formulas: 250|575 and 84|482.

Mesosoma. Tergites rough in appearance at 10x; carinae of tergite VII essentially obsolete. Sternites shiney, carinae of segment V obsolete. Stigmata small, short, oval-slit like in shape.

Metasoma. Generally elongate in overall proportions. Carinae — Segments I-IV: dorsal rounded with scattered granulation; dorsal lateral slightly rounded to obsolete on I, obsolete on II-IV; lateral obsolete; inferior lateral slight trace to obsolete on segments I-II, rounded on III-IV; inferior median obsolete on segments I-III, slight trace on IV. Carinae — Segment V (Fig. 43): dorsal lateral rounded and rough; lateral obsolete; inferior lateral delicately granulate; inferior median irregularly granulate. Most posterior granule of dorsal carina slightly enlarged; intercarinal spaces smooth I-IV, scattered small granules on V.

Telson. Vesicle quite swollen both laterally and dorsally (Figs. 39-40, male, Figs. 41-42, female), covered with small scattered granules. Aculeus forming short conspicuous curve; 5-7 pairs of setae at vesicle/aculeus juncture. Small rounded granule with setal pair at base of aculeus, forming small subaculear tubercle.

Pectines. Well developed, teeth elongated, length|width formula 293|126; teeth 10-10; middle lamellae 6-6. Fulcra well developed for entire pecten; delicate yellow setae found on anterior lamellae; sensorial areas of teeth extending their length, approximately 1/3 of surface. Basal piece with slight rounded anterior indentation; length|width formula 79|157.

Genital operculum. Separated most of length, genital papillae extends well below plates.

Sternum. Pentagonal, wider than long, length|width formula 346|377.

Chelicerae. Movable finger: dorsal distal denticle considerably shorter than ventral counterpart; dorsal edge with two subdistal denticles; ventral edge smooth, no serrulae, covered with thick brush-like setae. Fixed finger: four denticles configured normally.

Pedipalps. Prominent scalloping at chelal finger bases. Femur: dorsal internal and external, and ventral internal serrulate; ventral external crenulate; dorsal and ventral surfaces covered with minute granules; external surface smooth; internal face with 8 or more large granules. Patella (Fig. 44, female): dorsal and ventral carinae crenulate; exteromedian rounded, scattered granulation; dorsal surface with minute granules; ventral face smooth; dorsal patellar spur (DPS) well developed and sharp, VPS present as small granule. Chela carinae (Figs. 37-38): digital strong and generally smooth, slight trace of granulation; sub-digital as one rounded granule; dorsal secondary essentially obsolete; dorsal marginal very rounded, irregularly covered with large granules; dorsal internal weak, rounded and rough; ventroexternal strong, smooth, extending to external condyle, external to trichobothrium Et_2; ventral median weak, highly rounded; ventral internal medium, smooth and rounded; external secondary strong, irregularly granulate. Chelal finger dentition: median denticle row straight; 6/7 internal denticles, 5-6/7 outer denticles, 3-4/4 internal accessory denticles for fixed and movable fingers respectively. Trichobothria patterns: Type C, neobothriotaxic (major additive) on patella. Femur: trichobothrium d proximal to i, e slightly distal, situated on dorsoexternal carina. Patella: ventral series number 10/10 and external series number $eb = 5/5$, $eb_a = 7/7$, $esb = 2/2$, $em = 4/4$, $est = 4/4$, $et = 7/7$. Chela: Ventral series number 4/4, V_4 on external surface well removed from ventroexternal carina.

Legs. Two smooth pedal spurs, no tarsal spines. Ungues stout, unguicular spine well developed. Tarsus III: 9-12 stout ventral spinules terminating in one pair of stout spinules. Basitarsus I-IV: 7 and 5 proventral spinules found on legs I and II, respectively.

Hemispermatophore. Well developed lamina with conspicuous basal constriction, tapered distally (Fig. 21); truncal flexure present; capsular lobe complex well developed, exhibiting an acuminate process; ental channel spinose distally, exhibiting eight delicate variable
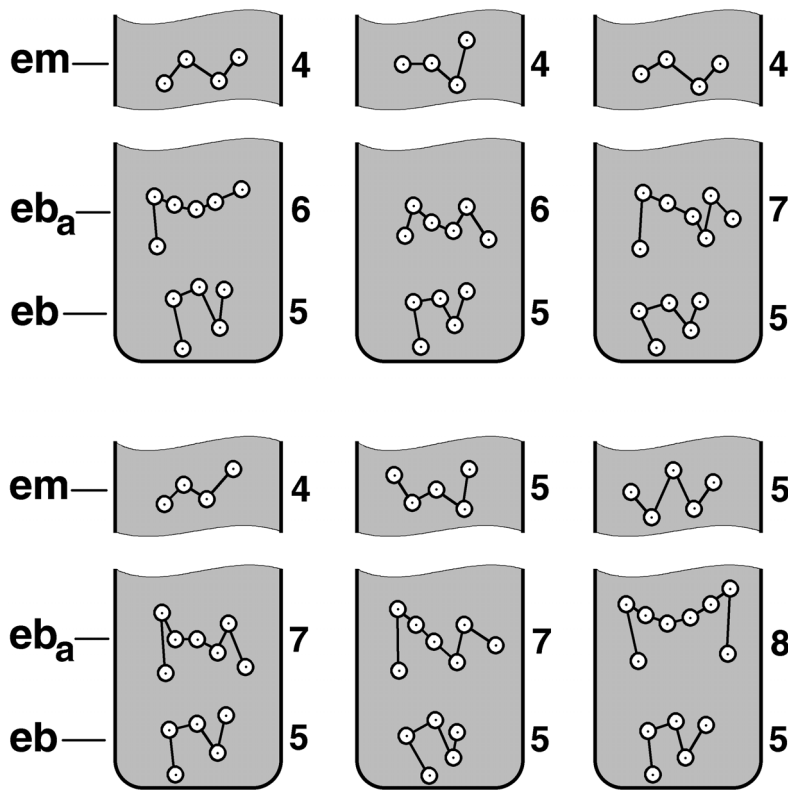
Figure 45: Diagrammatic trichobothrial patterns of external aspect of pedipalp patella (partial) showing variability in position and number of trichobothria for *Euscorpius hadzii*. Numbers found in each series is situated right of each diagram. *em* = external median, *eb$_a$* = external basal-a, and *eb* = external basal.

sized spines (data based on specimen from Prokletije Mountains, Albania).

Female. Female specimen from Prokletije Mountains, Albania used for comparison. Granulation essentially the same as in male neotype except telson vesicle is smooth and ventroexternal carina of chela is granular.

Metasoma and telson morphometrics: Eight sexually mature females and males were compared from a morphometric perspective. Males and females did not exhibit large differences in overall size, but did show some differences between three populations: carapace lengths ranged 5.45-5.75 (5.60) [6] males, 5.75-6.35 (6.05) [6] females, Albania; 4.6 male and 5.1 female, Bulgaria; and 4.30 for both male and female, *E. c. lagostae* syntypes, Croatia. The male metasoma was proportionally thinner than that of the female, but exhibiting a somewhat low mean value difference, ranging only 2.8 - 6.3% across the five segments (length/width); plus/minus standard error overlap was considerable, 22 – 78%. As seen throughout the genus *Euscorpius*, the exaggerated swollen telson vesicle found on sexually mature males is noticeably different than that found on the female. Two morphometric ratios involving the carapace length divided by the width and depth of the telson illustrate this difference, exhibiting significant mean value differences and plus/minus standard error separation (compare Figs. 39-42):

Carapace Length/Telson Width
MVD = 40.5% Separation Gap = 270.2%
Female
3.56-4.32 (3.786) (±0.253) [008]: {3.53-4.04}š 0.067
Male
2.54-2.93 (2.696) (±0.131) [008]: {2.56-2.83}š 0.049

Carapace Length/Telson Depth
MVD = 60.3% Separation Gap = 1167%
Female
3.45-3.79 (3.661) (±0.143) [008]: {3.52-3.80}š 0.039
Male
2.22-2.38 (2.283) (±0.051) [008]: {2.23-2.33}š 0.022

Genital operculum/genital papillae: On the female, the genital operculum is connected for its entire length by a membrane. On the male, it is separated for most of its length with genital papillae readily visible.

Pectinal tooth counts: The pectines are more prominent on the male, teeth longer as well as larger in number:

Male
7-11 (9.060) (±0.998) [067]: {8.062-10.058}š 0.110
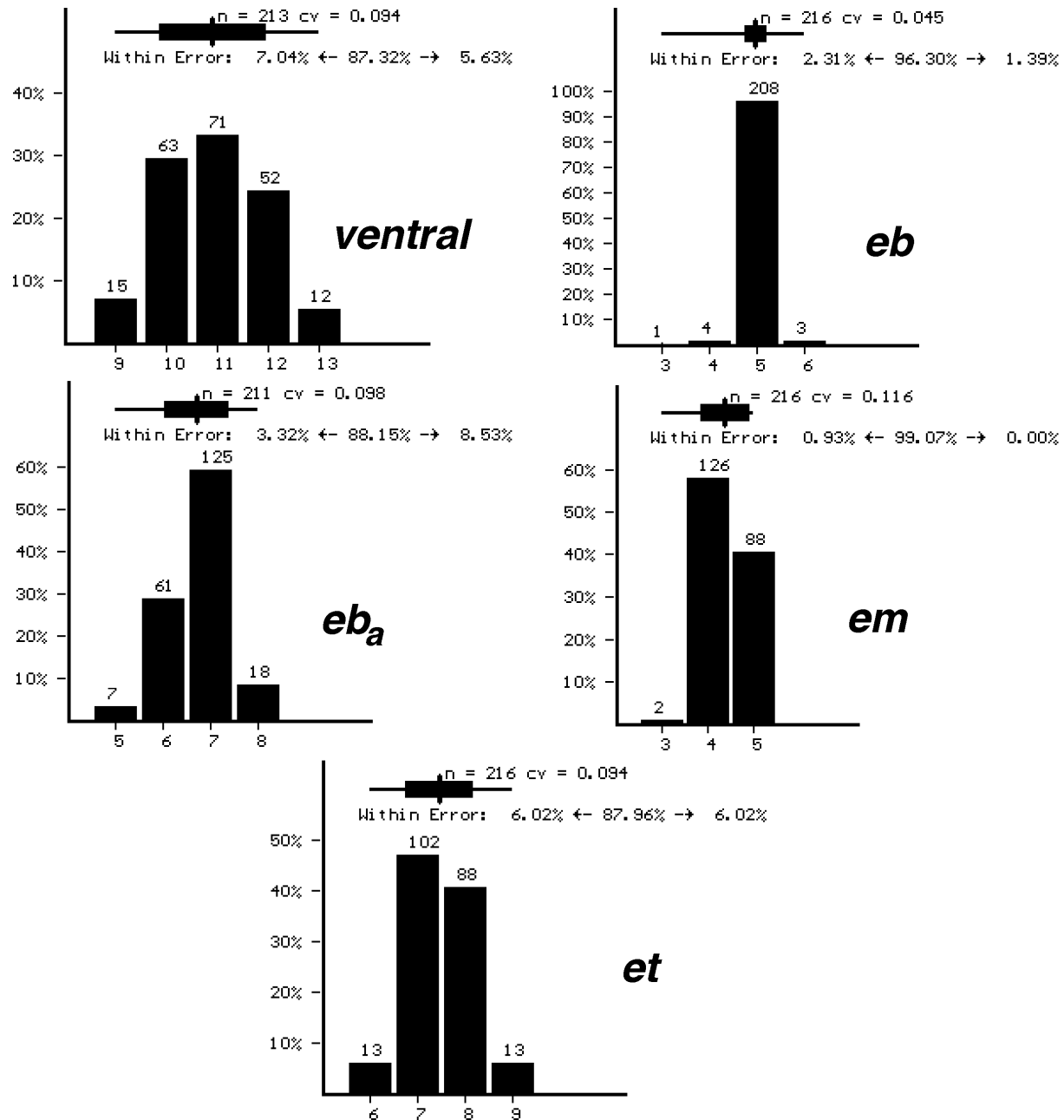Female
7-10 (8.050) (±0.520) [100]: {7.530- 8.570}š 0.065

n = 213 cv = 0.094
Within Error: 7.04% ← 87.32% → 5.63%

40%

30%

20%

10%

15   63   71   52   12

ventral

9   10   11   12   13

n = 216 cv = 0.045
Within Error: 2.31% ← 96.30% → 1.39%

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%

208

eb

1   4   3

3   4   5   6

n = 211 cv = 0.098
Within Error: 3.32% ← 88.15% → 8.53%

60%

50%

40%

30%

20%

10%

125   61   7   18

eb$_a$

5   6   7   8

n = 216 cv = 0.116
Within Error: 0.93% ← 99.07% → 0.00%

60%

50%

40%

30%

10%

126   88   2

em

3   4   5

n = 216 cv = 0.094
Within Error: 6.02% ← 87.96% → 6.02%

50%

40%

30%

20%

10%

102   88   13   13

et

6   7   8   9

Figure 46: Statistical data for pedipalp patella trichobothrial counts of *Euscorpius hadzii*. See Fig. 12 for definition of terms.

The mean value difference is somewhat low, 12.5%, roughly a one tooth difference between the male and female.

Variation within species. Besides the designated male neotype, we examined an additional 107 specimens widely distributed throughout the Balkans (see map shown in Fig. 57).

Fig. 46 shows the statistical distribution of five trichobothria series of the patella. Key diagnostic char- acters, *eb* = 5 and *eb$_a$* = 6-7, are supported by this data, showing 96% and 88% compliance, respectively; series *em* shows 58% and 41% compliance for counts 4 and 5 respectively; series *et* exhibits 88% compliance for counts 7-8 combined and the ventral series has a 87% compliance for counts 10-12 combined. Fig. 45 illus- trates diagrammatically various patterns found in *E. hadzii* for the *eb*, *eb$_a$* and *em* trichobothria series. Fig. 63 illustrates a typical trichobothrial pattern of the external surface of the patella.

We examined a male and female syntype of *E. c. lagostae* from Lagosta (now Lastovo) Island, Croatia. *E. c. lagostae* exhibits the key diagnostic trichobothria numbers for external series *eb* = 5, *eb$_a$* = 6-8 and *em* = 5. These two syntypes differed considerably in overall size and coloration with that found in the populations from northern Albania: carapace length 4.3 versus 5.45-6.35 (see Table 3); golden brown coloration versus dark brown to black. Comparing morphometrics of these syntypes with seven males and females each from Albania and Bulgaria, *E. c. lagostae* had a slightly thinner metasomal segment V, exhibiting a 5.7-8% mean value difference, otherwise, all other morphometrics were consistent. With respect to carinal development on the metasoma and pedipalp, *E. c. lagostae* had a crenulated ventroexternal carina on the chelal palm as contrasted to a smooth carina found on the Albanian male neotype.

Material examined. **ALBANIA**. Prokletije Mts., 10 adult females, 3 subadult females, 2 juvenile females, 4 adult males, 2 subadult males, 4 juvenile males (NMW 1913), 20 July 1914 (A. Penther); Prokletije Mts., 4 adult females, 3 adult males (CAS), 20 July 1914 (A. Penther); Shkoder District, Prokletije Mts., Boga, 10 females, 6 males (NMHNS), May 1993 (P. Beron); **BOSNIA & HERZEGOVINA**: Herzegovina, 15 km S of Trebinje, Mosko-Trebinje road, 1 female, 1 male (VF), 3 August 2000 (P. Trontelj); Stolac near Višegrad, 5 females (NMW 13361), 1905 (A. Penther); Sarajevo, 1 male, 1 female (NMW 1882) (F. Siebenrock); Herzegovina, foothills of Baba/Bjelas(n)ica, SW of Gačko, Vučja Bara, 2 females, 2 males (NMW), August 1900 (R. Sturany); **BULGARIA.** Pazardzhik District, Gabrovnica, 7 females, 1 male (NMNHS 117), 6 April 1986 (P. Beron); Blagoevgrad District, Petrich, 3 females (NMHNS 111), 29 July 1983 (K. Marincheva); Blagoevgrad District, Kresna, 1 female, 2 males (NMHNS), 14 May 1981 (P. Beron & S. Andreev); 2 females, 1 male (NMHNS), 30 April 1983 (P. Beron & K. Marincheva); **CROATIA**. Lapad Peninsula, 1 female (NMW), 25 September 1933; Lagosta Island (now Lastovo) (NMW) (see above for type material of *E. c. lagostae*); Korčula (Curzola) Island, 1 female, 1 male (NMW), 17-24 September 1925 (handwritten label by J. Hadži, identified as "*E. c. polytrichus*"); Lissa (now Vis) Island, 3 specimens (NMW), February 1888 (F. Steindachner); Meleda (now Mljet) Island, 5 females (ZMH), 8 August 1957, 1 male (ZMH), 26 Aug. 1974 (M. Dzwillo); **GREECE**. Epiros: Paramythia, 2 females (ZMH 62), 14 July 1986 (K. Michalis & P. Dolkeras); Zante Island (now Zakynthos), 1 adult male (NMW), March 1936 (J. Eiselt); **YUGOSLAVIA**. Montenegro: Crkvice, 2 adult females, 1 adult male (VF); Durmitor, 2

subadult females (NMW); Moraca Bay, 2 females (NMW); Smokov Ujevac (3 km SE Sv. Stefan/Lovcen), 100 m, 3 females, 1 male (NMW 11756), 10 June 1969 (K. Bauer & G.-H.Leute).

Other source data. NONE.

Geographical distribution. Albania, Bosnia & Herzegovina, Bulgaria (southwest), Croatia, Greece (northwest), Macedonia, Yugoslavia (Kosovo, Montenegro, Serbia). See map in Figure 57.

Euscorpius koschewnikowi Birula, 1900
(Figs. 47-56, 61 and Table 3, 5)

Euscorpius koschewnikowi Birula, 1900: 19-20.

Lectotype (designated here): female from Russik (= St. Panteleimon Monastery), Mt. Athos (Agion Oros), Chalkidiki, Macedonia, Greece (ZISP 1000). Two labels were found in one vial: 1) 1000 *Euscorpius koschewnikowi* Birula, spec. orig. Macedonia, A. Kharuzin**,** 1886; 2) ZISP 1000, *E. koschewnikowi* Bir. female type. **Paralectotypes**: 1 male, 2 females (ZMMSU Tb-36), same locality as lectotype; two labels in one vial: 1) *Euscorpius koschewnikowi* n.sp., ♂ ♀ det. A. Birula; 2) Inv. Tb-36.

Synonyms. None.

References (selected).
Euscorpius koschewnikovi (incorrect subsequent spelling): Birula, 1917: 105, 129.
Euscorpius koschevnikovi (incorrect subsequent spelling): Fet, 1986: 3-6.
Euscorpius carpathicus koschewnikovi (incorrect subsequent spelling): Fet & Sissom, 2000: 364.

Taxonomic history. This species was described by Birula (1900) and virtually forgotten until Kinzelbach (1975) listed it as a synonym of *E. carpathicus*. Fet (1986) scored the quantitative data of the type series but was unsure as to its taxonomic status. Fet & Sissom (2000) listed it as a subspecies of *E. carpathicus*, but noted that its status was still uncertain. Four original specimens were brought to Russia by the ethnographist A. N. Kharuzin from the Russian monastery of St. Panteleimon (otherwise called "Russik", or "Roussikon"), of the Orthodox Christian monastic community of Mt. Athos. The latter occupies the easternmost promontory of Chalkidiki peninsula in Macedonia, northeastern Greece (Kadas, 1997); the St. Panteleimon is located on the promontory's western side, on the coast of the Singitic Gulf. Birula (1900: 19) in his original Russian text mentioned in the label data also "o. Prokl" which was
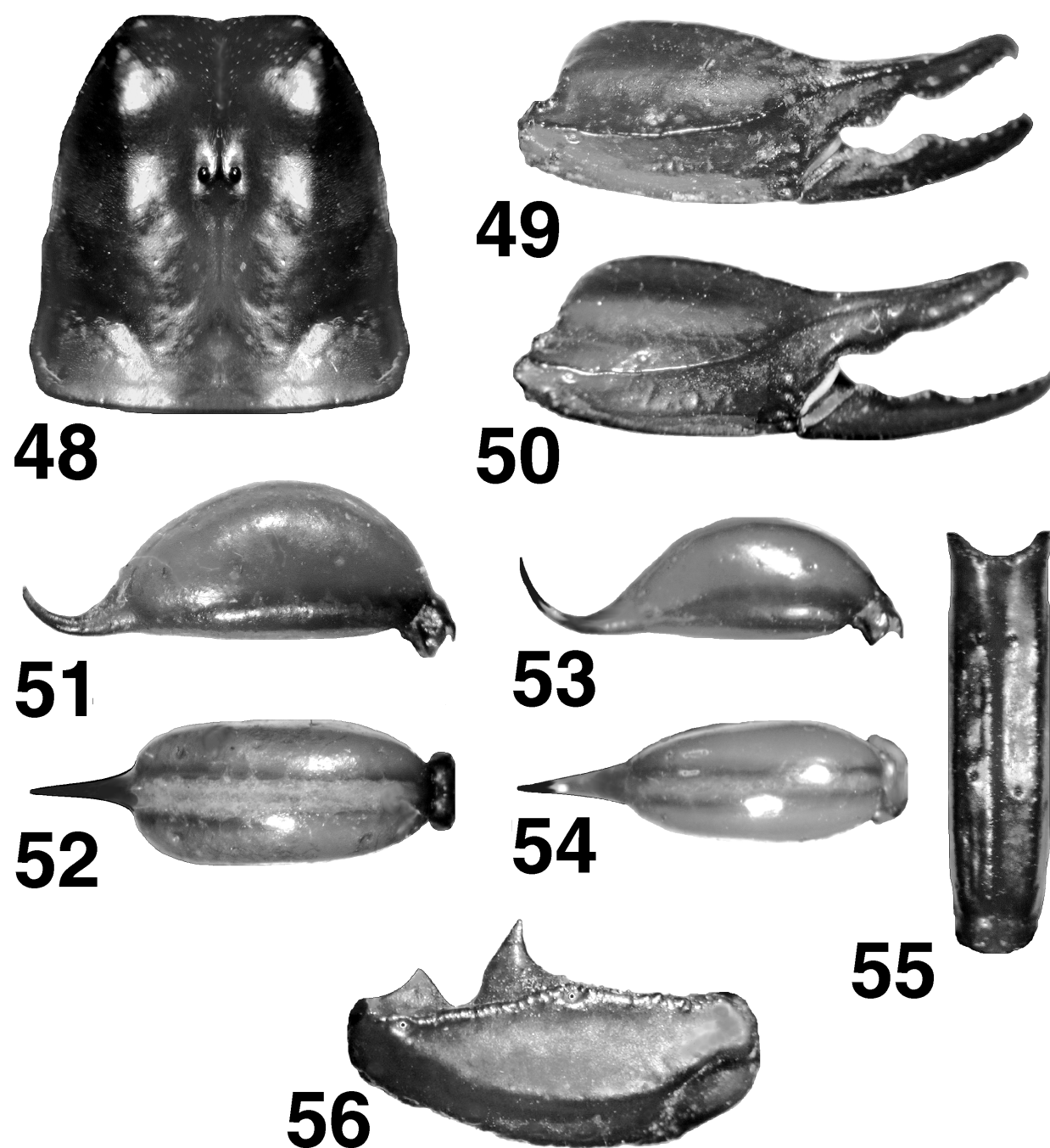
Figure 47: *Euscorpius koschewnikowi* Birula, female lectotype, Mt. Athos, Greece.

interpreted as "o[strov] Prokl" ("Proclos Island") by Bi-rula (1917: 212) and repeated by Fet (1986) and Fet & Sissom (2000). However, no island of this name has been found on a large-scale map of Mt. Athos. Since the abbreviation "o." in Russian stands for both "ostrov" and "otets" (for a title in clergy), this could be an abbreviated name of the original collector, "o[tets] Prokl" ("F[athe]r Proclos). The species was named after the director of the Zoological Museum of Moscow University, and one of the world's first conservation scientists, G. A. Kozhev-nikov (1866-1933). This species was never reported again in 100 years since its description.

Diagnosis. Medium to large sized species, medium to dark brown in color, mesosoma, metasoma, telson and legs lighter in color; no contrasting patterns. Metasoma quite slender, all segments longer than wide on both female and male; chelal palm slender, width and depth essentially equal in dimension; dorsal patellar spur (DPS) very well developed (see detailed morphometric analysis presented elsewhere). Species quite smooth, exhibiting minimum granulation except for the pedipal-pal femur and patella carinae. Pedipalp patellar external trichobothria numbers: $eb = 4$, $eb_a = 4$, $esb = 2$, $em = 4$, $est = 4$ and $et = 5$-6; ventral aspect of patella 8. Pectinal tooth counts: female 6-7, male 8. The exceptionally slender and smooth metasoma are key diagnostic char-acters of this species.

Figures 48-56: *Euscorpius koschewnikowi*, Mt. Athos, Greece. **48.** Carapace, female (lectotype). **49.** Chela, male. **50.** Chela, female. **51.** Telson, lateral view, male. **52.** Telson, ventral view, male. **53.** Telson, lateral view, female. **54.** Telson, ventral view, female. **55.** Metasomal segment V, ventral view, female. **56.** Pedipalp patella, dorsal view, female.

Female. Redescription based on female lectotype. Measurements found in Table 3. All illustrations are based on mature specimens originating from Mt. Athos, Chalkidiki, Greece. Fig. 47 shows dorsal view of female lectotype from Mt. Athos, Chalkidiki, Greece.

Coloration. Medium dark brown, pedipalps and carapace the darkest; carinae of pedipalp darker; mesosoma, chelicerae, legs, telson, lighter yellow-orange. No discernible patterns.

Carapace. Shiney and smooth, anterior edge straight (Fig. 48). Two pairs of lateral eyes, anterior slightly

larger; median eyes and tubercle quite small, advanced from middle, length and width formulas: 241|575 and 58|477.

Mesosoma. Tergites and sternites smooth and shiney, no trace of carinae on tergite VII or sternite V. Stigmata very small, sub-oval in shape.

Metasoma. Elongated, all segments longer than wide, generally smooth. Carinae — Segments I-IV: dorsal obsolete on segment I, round and smooth on II, smooth on III-IV; dorsal lateral obsolete on I, smooth and rounded anterior one-half on II-III, smooth on IV; lateral obsolete; inferior lateral obsolete on segment I-II, smooth and rounded on III-IV; inferior median obsolete. Carinae —Segment V (Fig. 55): dorsal lateral smooth; lateral obsolete; inferior lateral smooth with traces of minute irregular granulation; inferior median smooth and rounded. Anterior granule of dorsal and dorsal lateral carinae obsolete; intercarinal spaces smooth.

Telson. Elongated in shape; vesicle smooth (Figs. 51-52, male, Figs. 53-54, female). Aculeus with gradual curve; 4-5 pairs of setae on vesicle/aculeus juncture.

Pectines. Length|width formula 210|100. Pectinal tooth counts 7/7; middle lamellae 4/4. Fulcra developed for entire pecten; numerous small yellow setae on anterior lamellae; sensorial areas on proximal edge of tooth, occupying 1/4 to 1/5 tooth surface. Basal piece large, no anterior indentation, length|width formula 89|173.

Genital operculum. Connected along entire surface with membrane.

Sternum. Pentagonal, length|width formula 1|1.

Chelicerae. Movable Finger: Dorsal distal denticle noticeably offset from ventral counterpart; two subdistal denticles; ventral edge smooth, lacking serrulae, and covered with heavy brush-like setae along most of edge. Fixed Finger: four denticles configured normally.

Pedipalps. Elongated, chelal palm thin, width and depth equal in dimension. Femur: dorsal and ventral internal carinae crenulate; dorsal external weak rounded with slight granulation; ventral external rounded; dorsal surface smooth to rough; ventral surface covered with small granules. Patella (Fig. 56, female): dorsal and ventral internal rounded and granulate to crenulate; dorsal external weak rounded with slight granulation; ventral external weak and granular; exteromedian irregularly granular; dorsal and ventral surfaces smooth; DPS very long and pointed, VPS essentially obsolete, basal seta present. Chela carinae (Figs. 49-50): digital strong and smooth; sub-digital represented by single granule; dorsal secondary obsolete; dorsal marginal rounded and smooth; dorsal internal very rounded and rough; ventro-external strong and smooth; ventral median obsolete; ventral internal round and smooth; external secondary smooth to rough. Chelal finger dentition: inner denticles 6/7, outer denticles 7/7, inner accessory denticles 4/5, fixed and movable fingers, respectively. Trichobothria patterns: Type C, neobothriotaxic (major additive) on patella. Femur: trichobothrium *d* situated proximal to *i, e* slightly distal to both. Patella: ventral series number 8/8 and external series number $eb = 4/4$, $eb_a = 4/4$, $esb = 2/2$, $em = 4/4$, $est = 4/4$, and $et = 5/6$. Chela: Ventral series 4/4, V_4 situated on external surface, removed from exteroventral carina.

Legs. Two pairs of pedal spurs present, tarsal spines absent. Tarsus III: median ventral spinule row composed of 9 bristle-like spinules; one offset pair of ventral distal spinules. Basitarsus I-IV: 4 and 2 proventral spinules on legs I and II, respectively.

Male. Male syntype specimen from Mt. Athos, Chalkidiki, Greece used for comparison. Granulation of male same as that described for female lectotype.

Metasoma and telson morphometrics: We compared a full set of morphometrics for two females and one male from the type locality. Variability in overall size is exhibited, the male smaller as reflected by the carapace length: 5.75-6.10 [2] females, 4.90 [1] male. The metasoma of the male is slightly thinner than it is on the female, exhibiting slight mean value differences when all segment length/width ratios are compared, with a range of 1 – 10.7%. The considerably inflated telson vesicle of sexually mature males is quite conspicuous when compared to the thinner elongated telson of the female. Morphometric ratios calculated from the carapace length divided by the vesicle width and depth showed considerable mean value differences (compare Figs. 51-54):

Carapace Length/Telson Width
MVD = 40.4%
Female
3.71-3.94 (3.823) (±0.160) [002]: {3.66-3.98}š 0.042
Male
2.72-2.72 (2.722) (±0.000) [001]: {2.72-2.72}š 0.000

Carapace Length/Telson Depth
MVD = 43.2%
Female
3.49-3.71 (3.598) (±0.158) [002]: {3.44-3.76}š 0.044
Male
2.51-2.51 (2.513) (±0.000) [001]: {2.51-2.51}š 0.000

Genital operculum/genital papillae: For the female, the genital operculum is connected its entire length by a membrane; completely separated on the male where genital papillae protrude proximally.

Pectinal tooth counts: The pectines are more prominent on the male, teeth longer and larger in number:

Male
8-8 (8.000) (±0.000) [002]: {8.000-8.000}š 0.000
Female
6-7 (6.667) (±0.516) [006]: {6.150-7.183}š 0.077

The mean value difference is 20%, roughly a 1+ tooth difference between the male and female, based on the limited data.
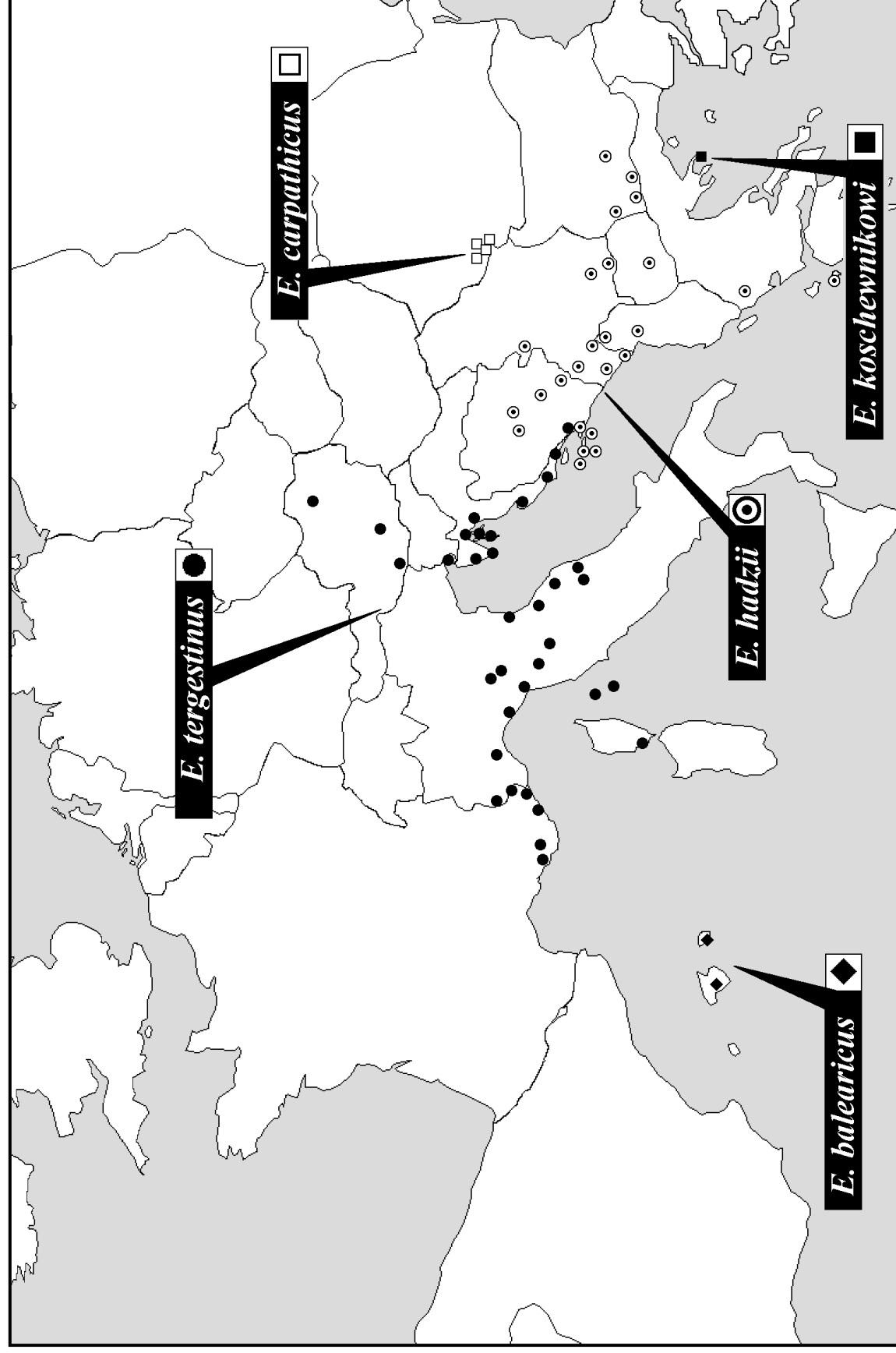
Figure 57: Map of central and southern Europe showing distribution of "*Euscorpius carpathicus*" complex material examined for this study.

Variation within species. No variability was detected based on the limited material, four specimens.

Material examined **(type series)*.* GREECE**. Mt. Athos, Chalkidiki: 1 adult female (ZISP), 1886 (A. Kharuzin); 1 adult male, 1 adult female, and 1 juvenile female (ZMMSU), 1886 (A. Kharuzin).

Geographical distribution. See map in Figure 57. Only known from type locality, Mt. Athos, Chalkidiki, Greece.

Comparative Analysis of "*Euscorpius carpathicus*" Complex Species

In this section we contrast important diagnostic characters identified in this paper across all five species of the "*Euscorpius carpathicus*" complex. The characters discussed below are presented in the order of their importance. It is strongly suggested here that the complex trichobothrial patterns found in this genus form the basis for any sensible revision of *Euscorpius*. They provide key diagnostic characters at the highest intrageneric levels which require the establishment of important accessory trichobothria homologies, as well as at the lower species level where comprehensive statistical distributions of trichobothria numbers provide key diagnostic information. Morphometric ratios have also shown their benefit in differentiating the species discussed in this study, especially in those ratios where separation of ranges based on one standard error are evident. Pectinal tooth counts, carinal development, and granulation provide, at best, a tertiary level of diagnostic potential in the differentiation of *Euscorpius* species, variability is to be expected in these characters, especially if the species has a somewhat large geographical distribution. Finally, in general we dismiss differences in overall size, coloration, and/or subtle patterns — it is clear that much of this is population based being influenced by geographical and/or microhabitat dynamics.

Table 4 presents the diagnostic characters discussed below utilizing the following conventions: Each diagnostic character is "color-coded" to indicate its relative significance as a diagnostic character: *black* indicates a significant character valid against all other species; *gray* indicates a character that is valid against one or more species; and *white* indicates minor diagnostic characters. These same color-code conventions are used in the morphometric ratio histograms shown in Figs. 70-77.

Trichobothria

The five species of the "*Euscorpius carpathicus*" complex discussed in this paper can be segregated based on three fundamental configurations found in the pedipalp patella external trichobothria basal series. Figure 58 illustrates these three fundamental patterns:

1. ***eb*** = 4, ***eb$_a$*** = 4 and ***em*** = 4 — characteristic of *E. balearicus, E. tergestinus* and *E. koschewnikowi*

2. ***eb*** = 4, ***eb$_a$*** = 4 and ***em*** = 3 — characteristic of *E. carpathicus*

3. ***eb*** = 5, ***eb$_a$*** = 6-8 (7) and ***em*** = 4-5 (4+) — characteristic of *E. hadzii*

These basic forms involve the presence and/or absence of important accessory trichobothria. The stability exhibited in the *eb* series is essentially unvarying within the subclades it delineates. For example, currently in our *Euscorpius* trichobothria database, representing over 6000 samples per series, well less than one percent deviate from the *eb* (= 4) or *eb* (= 5) pattern. The *eb$_a$* and *em* series are also important but they do exhibit minor variability within some of the designated subclades. The *et* and ventral series exhibit by far the most variability and therefore require large statistical samples in order to be used as species level diagnostic characters. As mentioned elsewhere in this paper, an effort is in progress (Fet, Soleglad and Gantenbein) to establish homology of major accessory trichobothria across the genus *Euscorpius* for subsequent cladistic analysis. Although we will not present these homologues here, we will as a minimum state that the *eb* (= 5) pattern exhibited by *E. hadzii* and its close relatives of the "sicanus" group (e.g., *E. c. sicanus, E. c. canestrinii* etc., Fet et al., 2002b; Fet et al., in progress), involve *different* accessory trichobothria than those found in the species *E. flavicaudis*, which also has five trichobothria in this series, therefore an issue of homology. The reduced number of trichobothria in the *em* series (= 3) found in *E. carpathicus* is only matched by the *Euscorpius* subgenus *Alpiscorpius*, thus makes it unique within the *E. carpathicus* complex (note that, however, we are currently investigating some other unidentified populations that also have *em* = 3). Species *E. balearicus, E. tergestinus* and *E. koschewnikowi* conform to the standard "4-4-4" configuration and therefore are distinguished, in part, on statistical ranges of the ventral and *et* series. *E. balearicus* has by far the highest number of trichobothria in the patellar *et* and ventral series of these three species, thus providing a good diagnostic character against the other two species. *E. tergestinus* and *E. koschewnikowi* cannot be separated by trichobothria alone. Figure 64 illustrates the five important patellar trichobothria series based on a large statistical database supporting these distinctions (well over 2400 data samples per trichobothria series are consid-

		E. carpathicus	*E. balearicus*	*E. tergestinus*	*E. hadzii*	*E. koschewnikowi*
Trichobothria	*eb*	4	4	4	**5**	4
	eb_a	4	4	4	**6-8 (7)**	4
	em	**3**	4	4	4-5	4
	et	5-7 (6)	**6-9 (7+)**	5-8 (6+)	**6-9 (7+)**	5-6
	Ventral	7-8 (8)	**9-13 (11)**	7-11 (9)	**9-13 (11)**	8
Pectines	*female*	6-8 (7+)	**6-7 (6+)**	6-8 (7+)	**7-9 (8)**	6-7
	male	7-10 (8+)	**7-8 (7+)**	7-10 (8+)	**7-11 (9)**	8
Morphometric Ratios	DPS_L/Pat_W	**short DPS**	---	---	---	**long DPS**
	$MovF_L/M\text{-}V_L$	---	**long finger**	---	---	---
	$Ped_L/Meta_L$	---	**long ped**	---	---	---
	Che_L/Che_W	---	**long chela**	---	---	---
	Che_L/Che_D	**heavy palm**	**thin palm**	---	---	---
	Che_W/Che_D	---	---	---	---	**narrow depth**
	Meta: L/W	**heavy meta**	---	---	**slender meta**	**slender meta**
	$Meta_W/MovF_L$	**short finger**	**long finger**	**short finger**	---	---
Granulation/Carinae	*Meta-Quotient*	---	---	**most developed**	---	**least developed**
	Ped-Quotient	---	---	**most developed**	---	**least developed**
	I-IV: dorsal / *V: inf-med*	gran / wk-gran	wk-gran / wk-gran	**gran-pigm crenulate**	gran / wk-gran	**obso-smooth smooth**
	Chela: V1	smooth	gran-prox	**crenulate**	smooth	smooth
	Telson	smooth	smooth	smooth	**wk-gran**	smooth

Table 4: Key diagnostic characters separating species of "*Euscorpius carpathicus*" complex. *Black* boxed data depicts major diagnostic characters valid against *all* other species; *gray* boxed data depicts important diagnostic characters valid against one or more species; *white* boxed data depicts minor diagnostic characters. *Meta-Quotient* and *Ped-Quotient* = carinal development "quotient" of metasoma and pedipalp. *DPS* = dorsal patellar spur, *Pat* = patella, *MovF* = movable finger, *M-V* = metasomal segment V, *Ped* = pedipalp, *Che* = chela, *Meta* = metasoma; $_L$ = length, $_W$ = width, $_D$ = depth; *gran* = granulate, *wk* = weak, *pigm* = pigmented, *prox* = proximal, *obso* = obsolete.
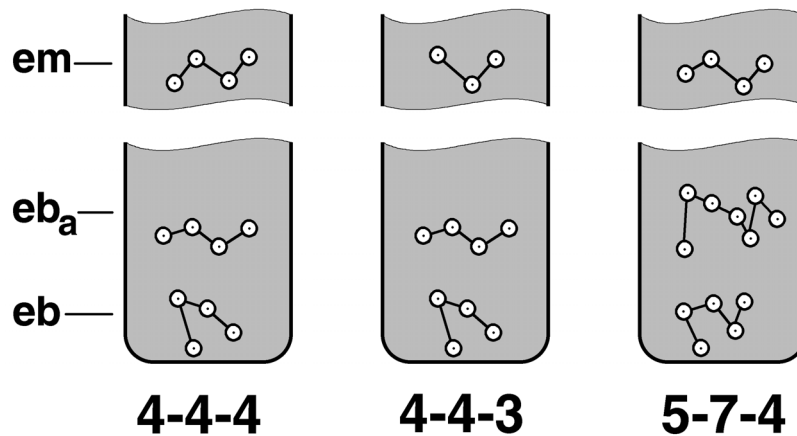
Figure 58: Diagrammatic trichobothrial patterns of external aspect of pedipalp patella (partial) showing fundamental series configurations found in the *"Euscorpius carpathicus"* complex: the *eb*-*eb*$_a$-*em* = **"4-4-4"**, **"4-4-3"** and **"5-7-4"** configurations. *em* = external median, *eb*$_a$ = external basal-a, and *eb* = external basal.

ered). Figs. 59-63 show typical trichobothrial patterns of the external aspect of the patella for these five species.

Table 5 presents the statistical data of the ventral and *et* series for *E. balearicus*, *E. tergestinus* and *E. koschewnikowi*: The mean value differences between *E. balearicus* and *E. tergestinus* for ventral and *et* series is 24% and 15%, respectively, and 38% and 26% between *E. balearicus* and *E. koschewnikowi* (the latter is based on only eight samples). The plus/minus standard error range overlap for these same series is 10% and 52%, and 0% and 0%, respectively, for the three species comparisons. For *E. balearicus* and *E. tergestinus*, the ventral series easily satisfies the two criteria for continuous data gap coding (i.e., mean value differences >= 15% and plus/minus standard error range overlap < 33%; see Fet, Soleglad & Barker, 2001, p. 146), exhibiting slightly over a two trichobothria count difference between the two species. The *et* series, however, does not quite satisfy continuous data gap coding requirements for *E. balearicus* vs. *E. tergestinus*, especially with respect to plus/minus standard error range overlap, showing roughly a one trichobothrium count difference. For *E. balearicus* and *E. koschewnikowi*, the criteria for continuous data gap coding is easily satisfied, exhibiting roughly a three and 1 1/2 trichobothria difference for the ventral and *et* series, respectively.

Hemispermatophores

Figs. 65-67 illustrate the hemispermatophores of three species described in this paper as well as present the specialized terminology used herein. In general these hemispermatophores exhibit the same overall structure as that described by Soleglad & Sissom (2001, Fig. 119, for *E. mingrelicus* from Batumi, Georgia). The hemispermatophore, classified as lamelliform, has a well developed *lamina* exhibiting a *truncal flexure* at its base. The lamina, broad at its base, tapers considerably distally and exhibits a conspicuous *basal constriction*. The *dorsal trough* is well developed at the base of the lamina

as it extends to the *capsular lobe complex* area. An unique spinose *ental channel* is located midpoint on the ental aspect of the *trunk* extending distally to the capsular lobe complex. The delicate spines forming the distal aspect of this channel fold inwards towards the capsular lobe complex. Great variability is present in the number and relative size of spines on the distal portion of the ental channel (see below for species *E. flavicaudis*). The capsular lobe complex is somewhat small to medium in size, showing one or two substructures, the basic lobe, which can exhibit variable degrees of complexity in its structure, and an optional *acuminate process*, which may be formed simply or show more substantial form. The spinose ental channel is of particular importance since it is quite unique, only known elsewhere in the genus *Megacormus*, also a member of Euscorpiidae.

Vachon (1948) was the first to illustrate a variety of *Euscorpius* hemispermatophores, including two of the species described in this paper. His sketches include *E. carpathicus* from Romania (*"banaticus* from Hungary"), *E. tergestinus* from France and *E.* "*candiota*" from Crete (both latter as "*E. carpathicus mesotrichus*"; the species name for the Crete population remains to be confirmed), as well as *E. italicus, E. flavicaudis* and *E. germanus*. Hemispermatophores were illustrated by Kinzelbach (1975) for two species of *Euscorpius carpathicus* complex from mainland Greece, and by Scherabon (1987) for *E. germanus* and *E. tergestinus* (as *E. carpathicus*) from Austria. However, the only important study was conducted by Molteni et al. (1984) who analyzed the variability of the capsular lobe complex for three forms, currently considered separate species of subgenus *Alpiscorpius*: *E. germanus germanus* (now *E. germanus*, Gantenbein et al., 2000) from northeastern Italy (Udine); *E. g. alpha* (now *E. alpha*, Gantenbein et al., 2000) from northern Italy (Bergamo) and "*E. mingrelicus caporiaccoi*" (a species of "*E. mingrelicus*" complex, close to *E. gamma*; Scherabon et al., 2000) from Bosnia. In their study the capsular lobe complex was segregated into three subareas: primary lobe, internal and external as-
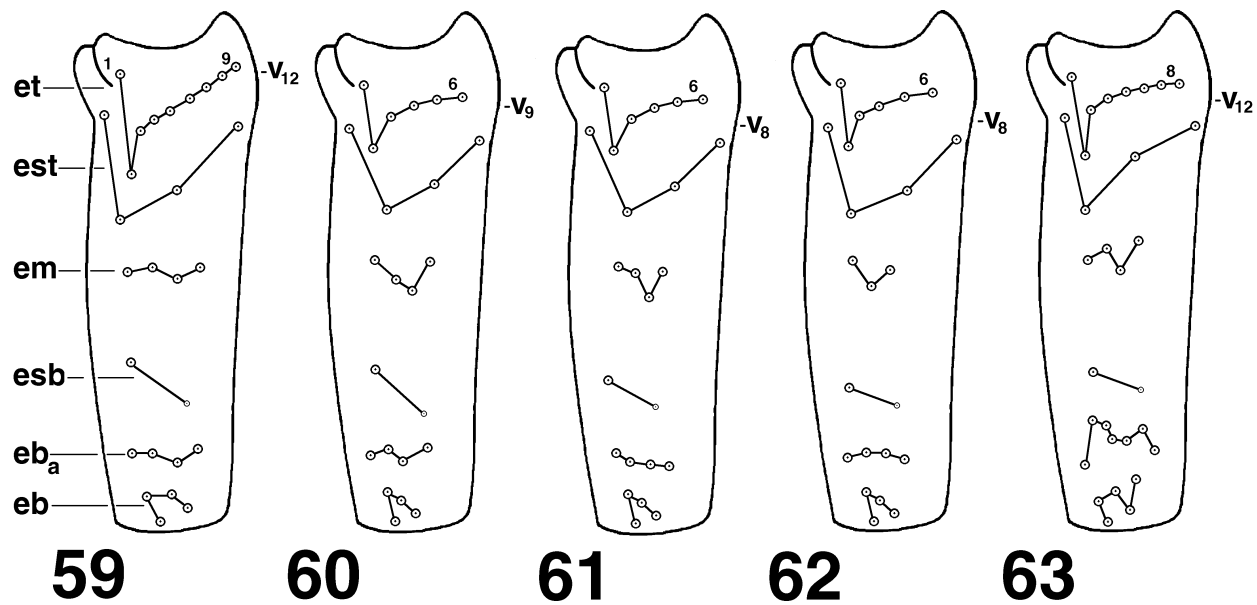
Figures 59-63: Idealized trichobothrial patterns of external aspect of pedipalp patella. **59.** *Euscorpius balearicus*. **60.** *E. tergestinus*. **61.** *E. koschewnikowi*. **62.** *E. carpathicus*. **63.** *E. hadzii*. *et* = external terminal, *est* = external subterminal, *em* = external median, *esb* = external suprabasal, *eb$_a$* = external basal-a, and *eb* = external basal; *V* = ventral.

pects, and the basal lobe (which, in part, is our acuminate process). Ten specimens per species were studied, both right and left hemispermatophores, thus 60 samples in all. These substructures were quantified as to various subtle forms detected in the sample set (see their Tables 1-3). Three interesting results were evident from this study (based on our analysis of the data): 1) out of 30 pairs of hemispermatophores (left and right), 12 exhibited differences to one degree or another, reflecting 40% asymmetry; 2) within the three species, 20 samples per, 22 unique configurations were observed, eight for *E. alpha*, ten for *E. germanus* (i.e., none of the specimens agreed) and four for *E. m. caporiaccoi*. Based on the best possible total result (i.e., three configurations, one per species), this suggests considerable variability within a species showing a very low average of 15.8% compliance; and 3) from a phenetic aspect, comparing similarities in the substructures between the three species, we see that *E. alpha* is more similar to *E. m. caporiaccoi* than it is to *E. germanus* (47% more similar), not an expected result. The least similarity was shown between *E. germanus* and *E. m. caporiaccoi*. Now it must be stressed here that most of these observed differences were quite subtle in nature. Both Vachon (1948, Figs. 6, 7, 14) and Molteni et al. (1984, Figs. 11-14) also illustrated the hemispermatophore of species *E. italicus* and *E. flavicaudis*. Of particular interest in all these figures was that the ental channel of *E. flavicaudis* lacked the spinose structure at the distal end, as first noted by Vachon (1948: 67). We were able to confirm this on two specimens from France and the island of Corsica (both left and right hemispermatophores were examined): the inner aspect of the distal portion of the ental channel is formed into a single small pigmented hook-like process, otherwise the distinctive finger-like spines are not present. All other *Euscorpius* hemispermatophores so far reported in the literature or studied by us have a spinose ental channel (this accounts for eleven species and subspecies). Three species of *Megacormus* so far studied also have spinose ental channels exhibiting multiple delicate spines (Sissom, 1994, Figs. 8-10). Based on *Megacormus*, it is clear that the condition found on *E. flavicaudis* is derived.

Although there are differences in the capsular lobe complex illustrated in Figs. 65-67, we have decided not to use this structure at this time as a diagnostic character for these three species. Due to the variability discussed above (involving three closely related taxa), it seems clear that more material must be studied before any conclusions can be made as to the "typical" form of the capsular lobe complex on a species by species basis. Also, great variability is shown in the number and relative size of the delicate spines formed on the ental channel. Possibly the form and number of these spines may prove to be valid diagnostic characters at the species level, if proved consistent within the species, since we see that *E. flavicaudis* is unique in this respect. Otherwise, the overall structure of the lamina, trunk and dorsal trough area are generally the same in morphology as well as in relative proportions. Finally, of particular importance, is the existence of an ental channel, spinose or otherwise, which is present in all *Euscorpius* species so far analyzed and/or reported.
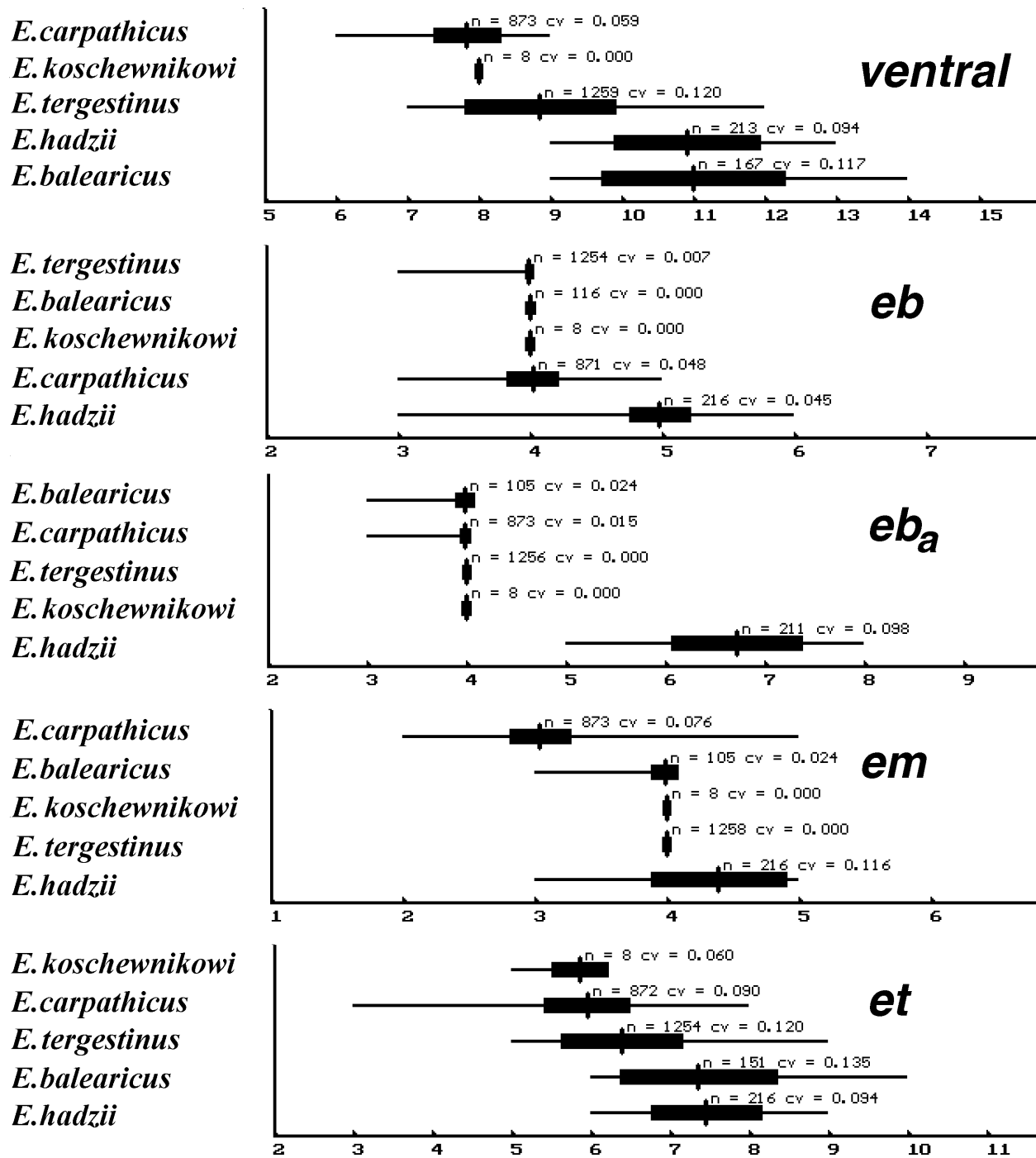
Figure 64: Comparison of pedipalp patella trichobothrial counts for *"Euscorpius carpathicus"* complex species. Horizontal bar: minimum, maximum, corrected minimum/maximum (mean-*SD* and mean+*SD*), and mean; *n* = number of samples, *cv* = coefficient of variability (*SD*/mean). *eb* = external basal, *eb$_a$* = external basal-a, *em* = external median, *et* = external terminal.

Pectinal Tooth Counts

Fig. 68 illustrates the statistical breakdown of male and female pectinal tooth counts spanning the five species discussed in this paper, depicting well over 600 male and 1000 female samples. It is clear from the his-togram that *E. balearicus* in general has the smallest pectinal tooth counts and *E. hadzii* has the largest. *E. balearicus* exhibits a mean value difference range from the other four species, 8.4 - 22.8% and 0 – 25% for males and females, respectively. *E. hadzii* exhibits 5.8 – 22.8% and 10 – 25% for males and females. This is a

Ventral		
E.balearicus	9-14 (11.006) (±1.282) [167]: {9.724-12.288}š	0.117
E.tergestinus	7-12 (8.866) (±1.061) [1259]: {7.805- 9.927}š	0.120
E.koschewnikowi	8 (8) (±0.000) [8]: {8.000- 8.000}š	0.000

et		
E.balearicus	6-10 (7.371) (±0.997) [151]: {6.373-8.368}š	0.135
E.tergestinus	5- 9 (6.402) (±0.768) [1254]: {5.634-7.170}š	0.120
E.koschewnikowi	5- 6 (5.875) (±0.354) [8]: {5.521-6.229}š	0.060

Table 5: Trichobothrial statistical ranges of patellar ventral and external et series for species conforming to 4-4-4 configuration.

valid diagnostic character between *E. balearicus* and *E. hadzii*, with a 22.8% and 25% MVD — exhibiting plus/minus standard error range separation, a 2 and 1 ½ tooth difference between males and females, but is of limited use for differentiation between the other species. As to fulcra development, all five species have well developed fulcra for the entire length of the pecten, unlike certain species of the subgenus *Alpiscorpius* (especially the females) where the distal fulcra are considerably reduced in development or essentially absent altogether (Soleglad & Sissom, 2001: 67).

Morphometric Ratios

We present eight unique morphometric ratios that provide excellent diagnostic characters separating the five *E. carpathicus* complex species discussed herein. These are illustrated graphically in Figs. 70-77 and are based on 71 sets of morphometrics (i.e., measurements extracted from 71 specimens). Note that in these figures the histogram bars are color-coded for consistency with Table 4. See the **Methods & Material** section for information on the technique employed in the identification of these ratios.

Dorsal patellar spur (DPS)/patella width. The relative development of the DPS was discussed in length in Soleglad & Sissom (2001: 59-62) in their revision of the family Euscorpiidae. It was suggested that within certain genera the relative length of the DPS seemed dependent, in part, on the relative elongation of species within the genus (i.e., *Euscorpius*, *Megacormus* and *Scorpiops*). For *Euscorpius*, they contrasted species *E. flavicaudis* and *E.germanus*, a relatively elongated and a stocky species, respectively. In this study it was clear that *E. carpathicus*, the most stocky of the five species analyzed herein, had a somewhat reduced DPS as compared to the other species (this is clearly visible in the dorsal views of the five species shown in Figs. 1, 2, 23, 24, 47). In addition, *E. koschewnikowi*, a species that exhibits the most slender metasoma, had the longest DPS. We quantified these differences by constructing a ratio based on the length of the DPS and the distance from trichobothrium d_2 to the dorsoexternal carina (see Fig. 69 for the

exact method of measurement). The histogram in Fig. 70 illustrates the results of these ratios based on measurements extracted from 84 samples, males and females (note that sexual dimorphism is not evident with this particular ratio). *E. carpathicus* has by far the shortest DPS, illustrating a significant 95% plus/minus standard error separation gap from the closest species. *E. koschewnikowi*, exhibiting the longest DPS, illustrated a very significant separation gap from the closest species, 168%, although this is based on only six samples. The other three species had relatively the same DPS development (90-100% overlap of plus/minus standard error ranges), somewhat on the long side when compared to *E. carpathicus*. We consider this morphometric ratio a significant diagnostic character for both species *E. carpathicus* and *E. koschewnikowi*. Figs. 11, 21, 33, 44, 56 illustrate the dorsal aspect of the pedipalp patella showing the relative development of the DPS in female specimens for all five species.

Movable finger length/metasoma segment V length & pedipalp length/metasoma length. Gantenbein et al. (2001) first discussed the unusual elongated pedipalp and likewise short metasoma found in *E. balearicus* as compared to western populations of *E. tergestinus* (referred to as *E. carpathicus* in that paper). This is demonstrated with two ratios, both involving the pedipalp and the metasoma. Figs. 71-72 show these two morphometric ratios for both females and males calculated across all five species. In order to maximize the significance of the elongated pedipalp and relatively smaller metasoma of *E. balearicus*, ratios were created by dividing the relatively "smaller" structure (i.e., the metasoma) into the relatively "larger" structure (i.e., the pedipalp). The first ratio compares the movable finger of the chela with the length of metasomal segment V, the second ratio compares the lengths of the pedipalp (the sum of lengths of the femur, patella and chela) and the metasoma (lengths of segments I through V). Readily seen from the histograms in Figs. 71-72, *E. balearicus* resulting ratios are completely isolated from the other four species, exhibiting significant plus/minus standard error range separation to the closest species, 92 - 236%. Also of importance, which further emphases the elongated pe-

(ental view)

(ental view)

66

65

lamina

basal
constriction

truncal
flexure

dorsal
trough

trunk

capsular lobe
complex

acuminate
process

(ental view)

ental channel

spinose
area

(ental view)

67
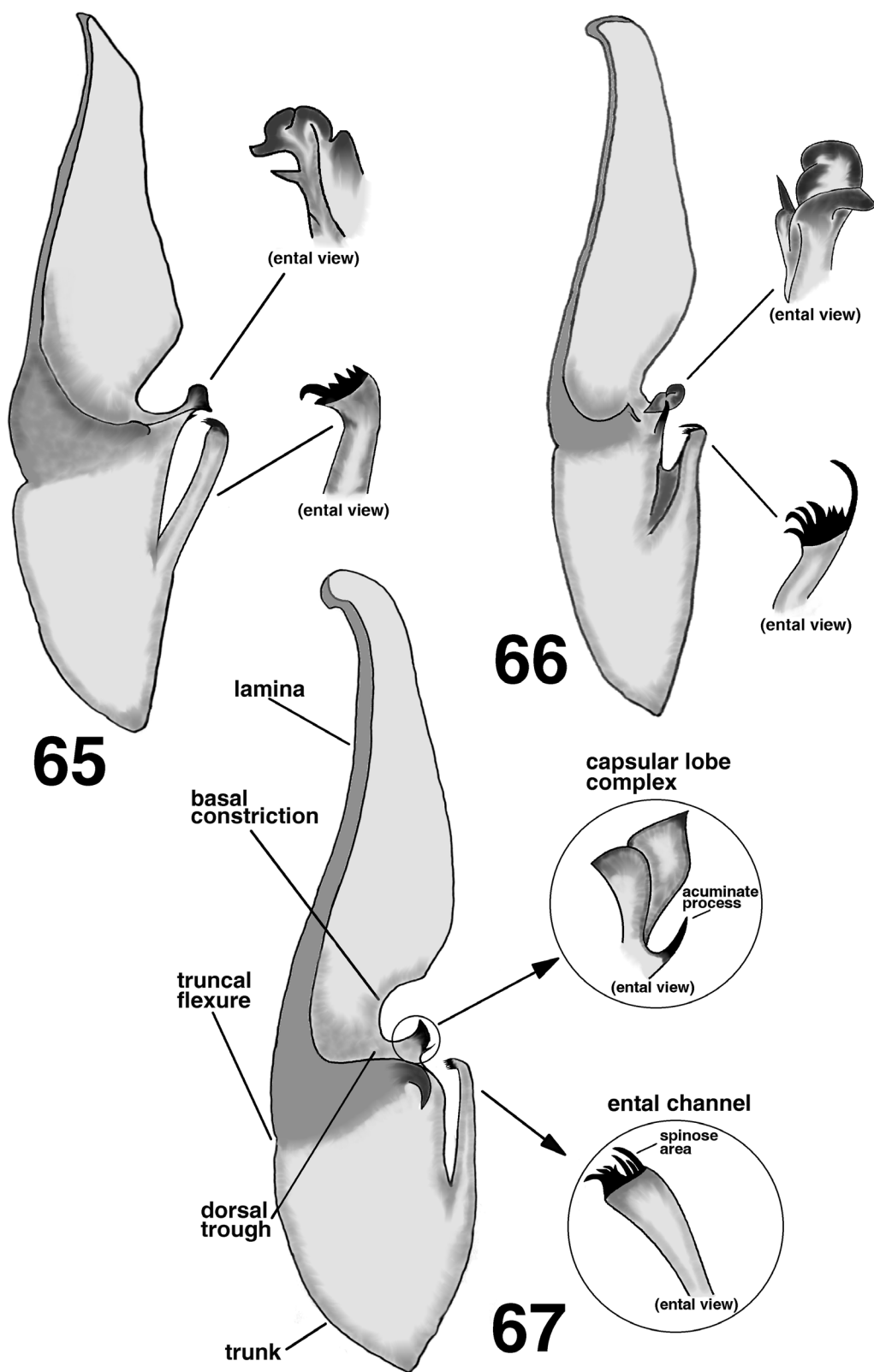
Figures 65-67: Right hemispermatophore, dorsal view, illustrating specialized terminology. **65.** *Euscorpius carpathicus*, Mehadija, Romania. **66.** *E. hadzii*, Prokletije Mountains, Albania. **67.** *E.tergestinus*, Osp, Slovenia.
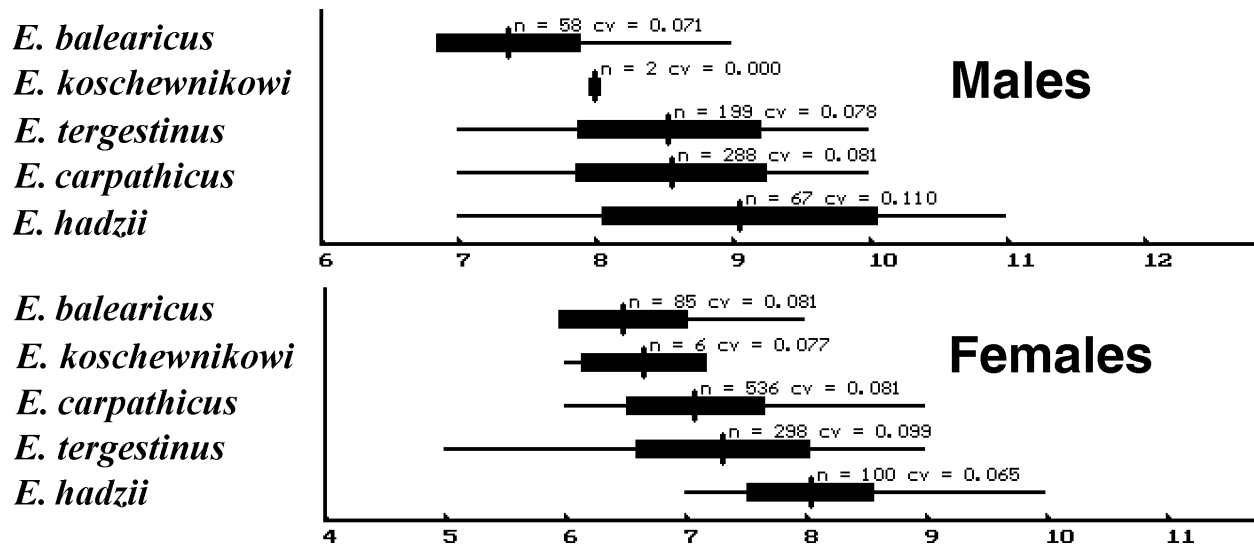
Figure 68: Comparison of pectinal tooth counts for "*Euscorpius carpathicus*" complex species. See Fig. 64 for definition of terms.

dipalp and reduced metasoma of *E. balearicus*, the other species were closely clustered showing significant overlap. The unusually elongated pedipalp of *E. balearicus* is even quite apparent from the dorsal view of an adult female shown in Fig. 2. We consider these two ratios significant diagnostic characters separating *E. balearicus* from the other four species. Also apparent from Fig. 72 is that *E. carpathicus* resulted in the smallest overall ratio, this is due to its somewhat bulky metasoma and stout pedipalp (see below for more analysis).

Chela length/chela width & chela length/chela depth. During this study we discovered that *E. balearicus* also has a somewhat slender chelal palm when compared to the length of the chela. Figs. 73-74 show histograms illustrating two morphometric ratios for females and males calculated across all five species, the chela length divided by the palm width and depth, respectively. For the first ratio, involving the chelal width, *E. balearicus* was isolated from the closest species, showing separation of plus/minus standard error ranges of 2 - 38%. For the second ratio, involving the chelal depth, *E. balearicus* and *E. koschewnikowi* were clustered, showing minimal overlap with *E. tergestinus*. We consider the first ratio an important diagnostic character separating *E. balearicus* from the other species. The second ratio is valid for a subset of species. Again, as alluded to above, *E. carpathicus* showed a tendency to have the most stout chela in three out of four histograms.

Chela width/chela depth. The chela palm width of *E. koschewnikowi* is essentially equal to its depth, which in general, is highly unusual in *Euscorpius*. The plus/minus standard error range separation exhibited by *E. koschewnikowi* in Fig. 75 is 33 - 123% from the closest

species, clearly a good diagnostic character for this species as based on the limited data. The other four species show considerable overlap.

Metasoma segments I-V: length/width. Fig. 76 shows histograms (females only) contrasting the thinness of the metasoma by constructing ratios for segments I, III and V, length divided by its width. It should be noted that all five segments were analyzed in this study, both male and female. For females, we see that *E. koschewnikowi* has by far the thinnest metasoma (based on two samples) in contrast to *E. carpathicus*, which has the heaviest metasoma. The heavy metasoma of *E. carpathicus* is quite evident when comparing segment V illustrated for all fives species (Figs. 10, 20, 32, 43 and 55).
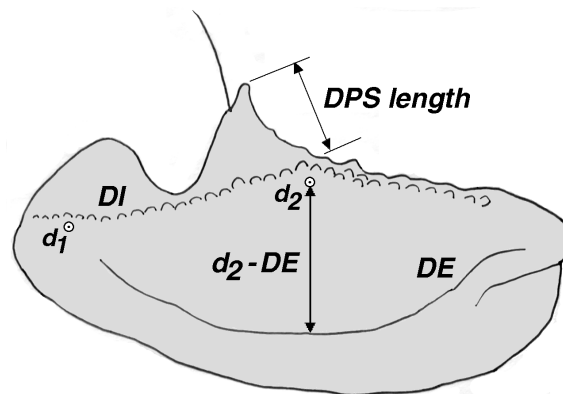

Figure 69: Dorsal patellar spur (DPS) ratio: DPS length/distance between trichobothrium d_2 and dorsoexternal (DE) carina. DPS length = perpendicular distance from dorsointernal (DI) carina and distal tip of DPS.
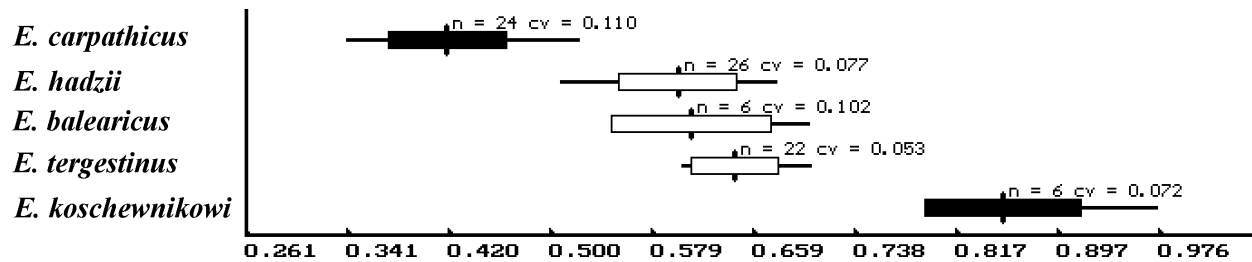
Figure 70: Morphometric ratio (male and female): **DPS length/distance between trichobothrium** d_2 **and dorsoexternal carina**. See Fig. 69 for method of measurement. *Black* bars indicate a significant diagnostic character distinct from all other species, *gray* bars indicate a diagnostic character distinct from other gray bar species, *white* bars indicate no special distinction. Horizontal bar: minimum, maximum, corrected minimum/maximum (mean-*SD* and mean+*SD*), and mean; n = number of samples, cv = coefficient of variability (*SD*/mean).
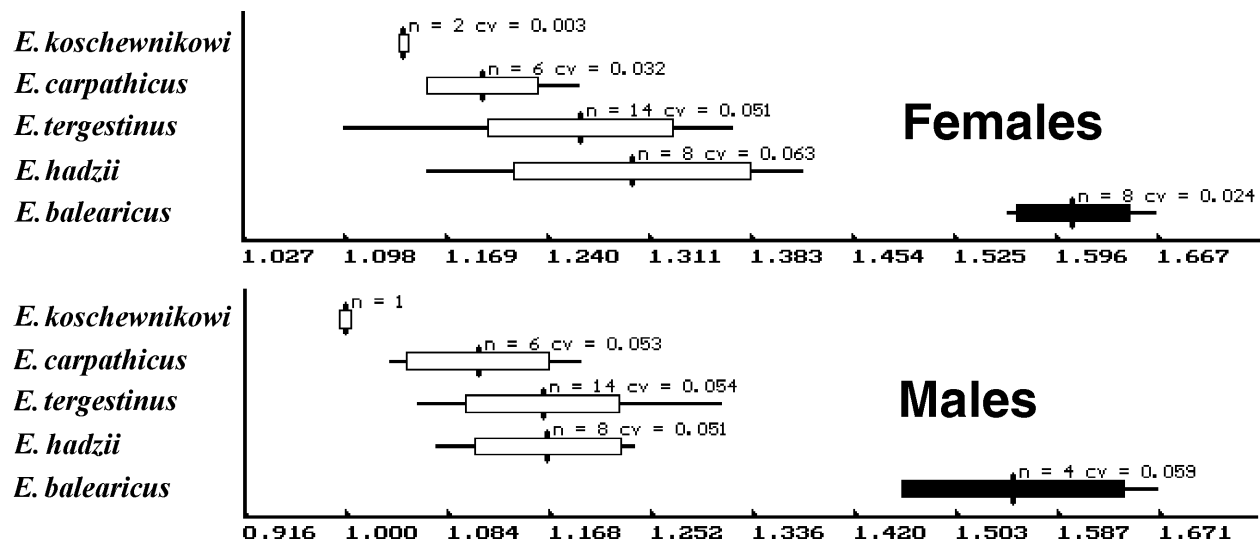
Figure 71: Morphometric ratio: **movable finger length/metasomal segment V length**. See Fig 70 for definition of other terms.
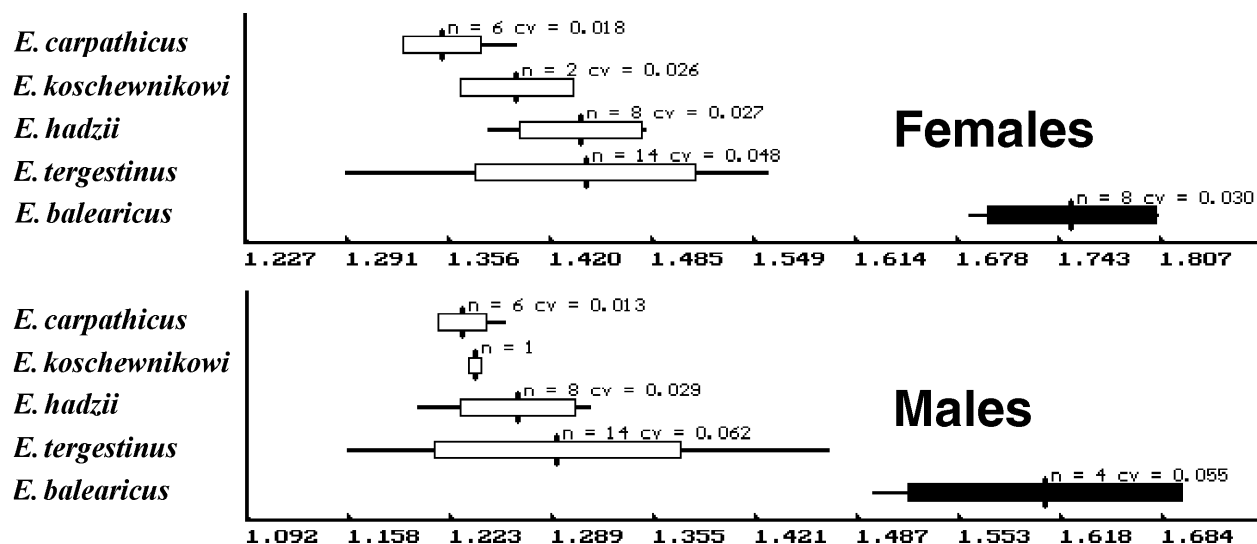
Figure 72: Morphometric ratio: **pedipalp length/metasoma length**. See Fig 70 for definition of other terms.
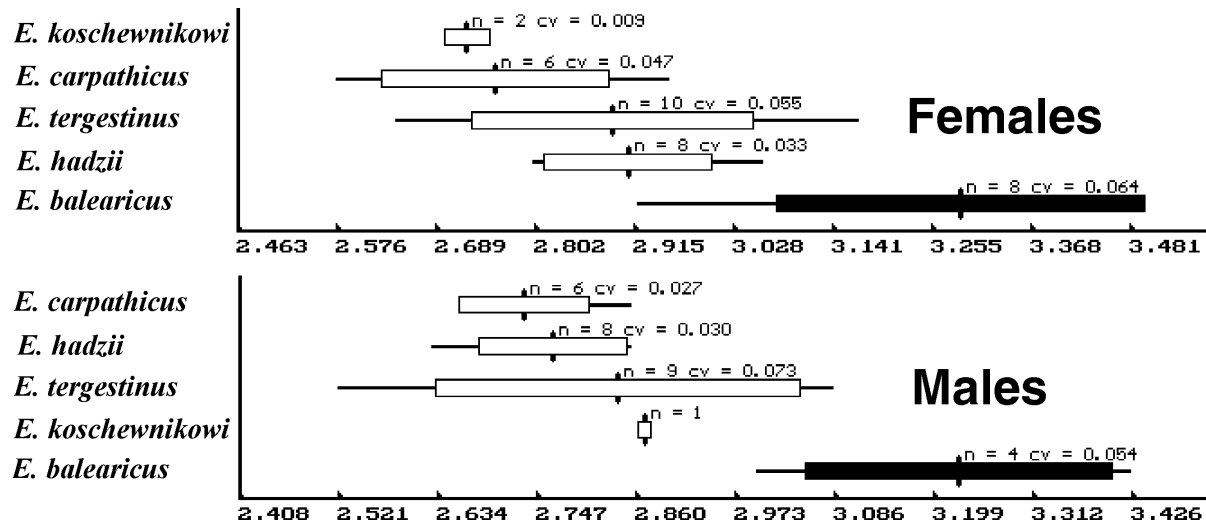
Figure 73: Morphometric ratio: **chela length/chela width**. See Fig. 70 for definition of other terms.
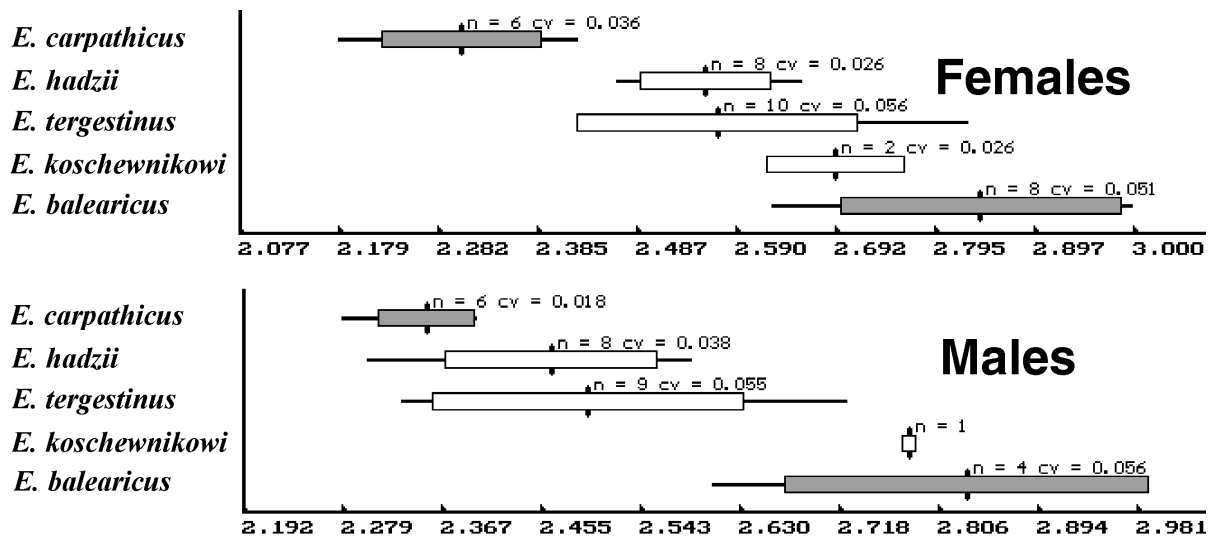
Figure 74: Morphometric ratio: **chela length/chela depth**. See Fig. 70 for definition of other terms.
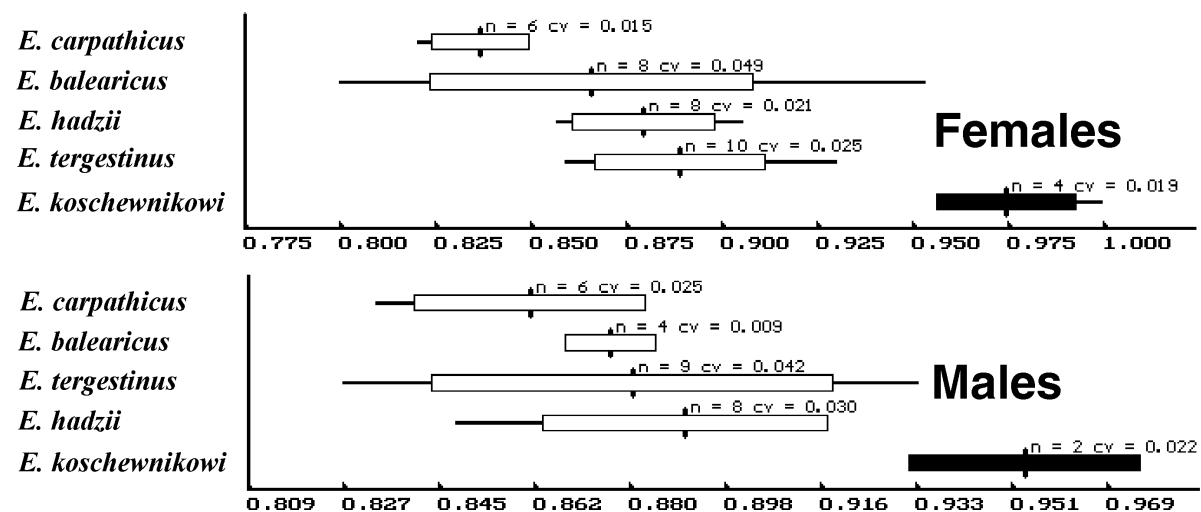
Figure 75: Morphometric ratio: **chelal palm width/chelal palm depth**. See Fig. 70 for definition of other terms.
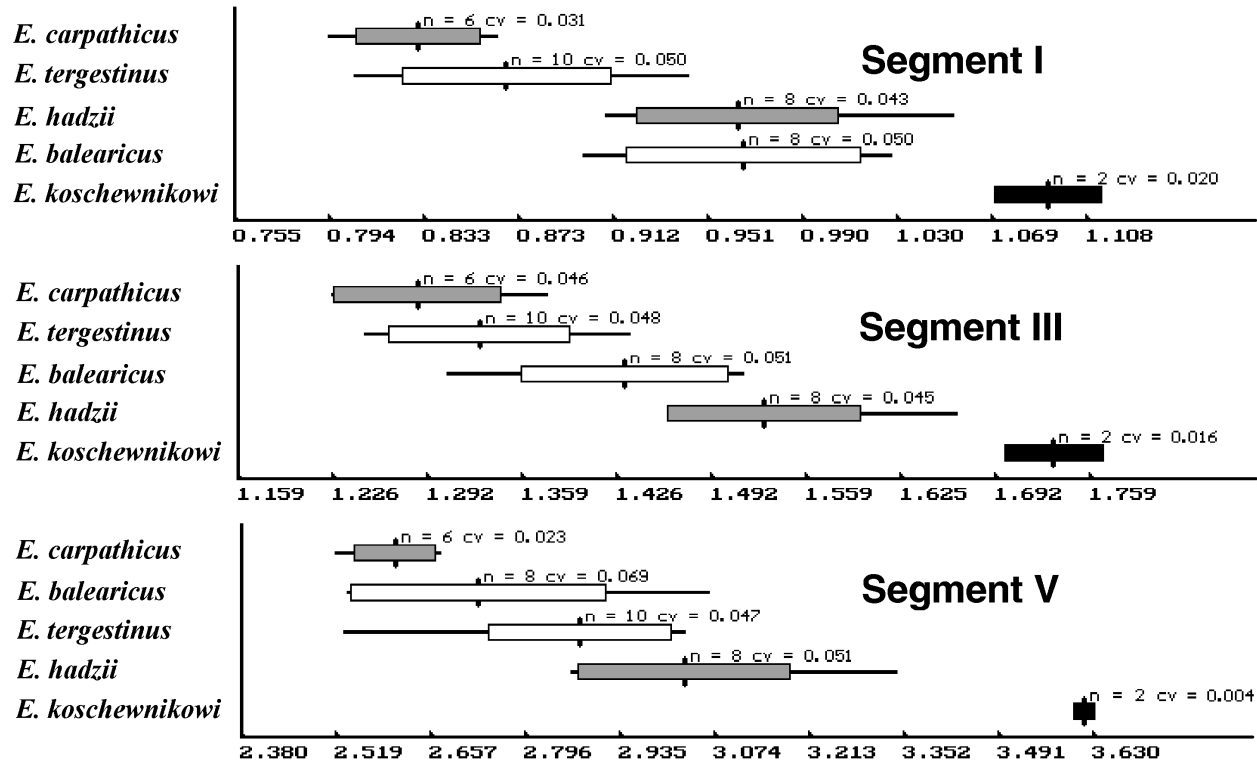
Figure 76. Morphometric ratio (female only): **metasomal segments I, III and V, length/width**. See Fig. 70 for definition of other terms.

The plus/minus standard error range separation exhibited by *E. koschewnikowi* is significant, clearly a good diagnostic character (this was evident with all five metasomal segments for both genders). Also, *E. hadzii*, when compared to *E. carpathicus*, exhibited somewhat significant separation for both females and males, all five segments. *E. balearicus* and *E. tergestinus* clustered together in nine out of ten histograms. *E. koschewnikowi* has the thinnest metasoma of any *Euscorpius* species so far examined, which includes all now recognized species (based on over 150 morphometric sets). In fact, the metasoma of the lectotype specimen, a mature female, is even thinner than any known male specimen of other species, which is significant since male specimens in general have slightly thinner metasomas than females of the same species. The thin metasoma of *E. koschewnikowi* is quite conspicuous visually when compared to the other four species discussed in this paper. Compare illustrations of metasomal segment V in Figs. 10, 20, 32, 43, and 55.

Metasoma segments I-V: width/movable finger length. During this analysis it became clear that *E. carpathicus* had the stoutest metasoma and pedipalp chela of the five species studied. The somewhat stout chela of *E. carpathicus* is even evident in the dorsal view presented in Fig. 1 of a sexually mature male from Mehadija, Romania. There was evidence of this in the his-

tograms shown in Figs. 73-75 where *E. carpathicus* consistently indicated the heavier chela. We can quantify this character by creating a ratio that maximizes the stoutness of the metasoma (thus with a relatively fatter width) and the shortness of the chelal movable finger — that is, a species complying to both of these trends will have the largest ratio value. Fig. 77 shows this ratio for females only across all five species where the width of metasomal segments I, III and V is divided by the length of the chelal movable finger. In all cases *E. carpathicus* exhibited the largest ratio value indicating that it does indeed have a relatively shorter movable finger (in the previous morphometric ratios we already demonstrated that *E. carpathicus* had a relatively stouter metasoma). Although we only show three ratios for females, *E. carpathicus* did comply across all five segments, showing separation in plus/minus standard error ranges.

In summary, we can conclude that *E. balearicus* has the relatively longest pedipalp and likewise smaller metasoma of the four species, clearly a reliable diagnostic character. Note, except for being in general smaller in all dimensions, the metasoma of *E. balearicus* was not necessarily thinner or fatter as compared to the other four species. The chelal palm of *E. balearicus* was also considerably thinner than the other four species, especially when compared to *E. carpathicus*, which demonstrated the more stouter chelae, again a reliable diagnostic char-
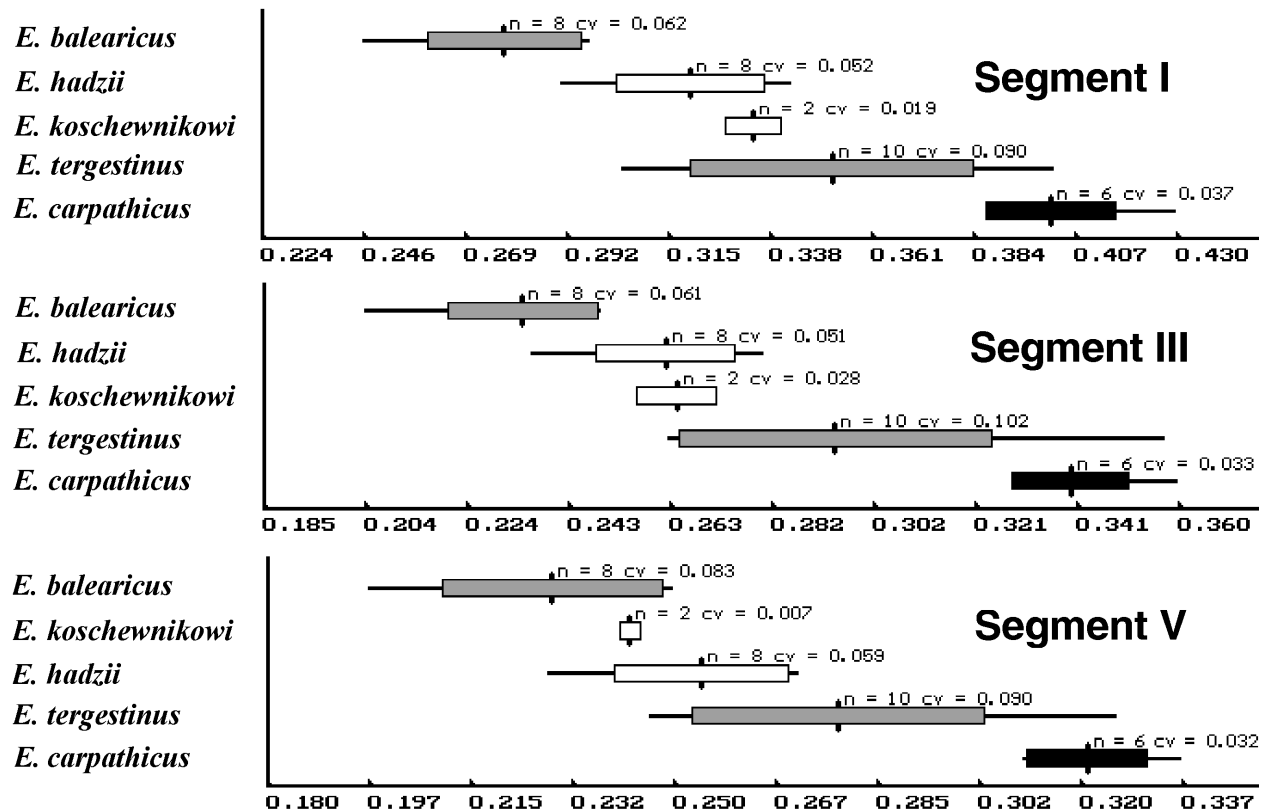
Figure 77: Morphometric ratio (female only): **metasomal segments I, III and V width/movable finger length**. See Fig. 70 for definition of other terms.

acter. *E. carpathicus* had the stouter metasoma whereas *E. koschewnikowi* and *E. hadzii* had the thinnest, a reliable diagnostic character between these species. The short movable finger of *E. carpathicus* (reflective of its overall stout chela) when combined as a ratio with the width of metasomal segments (reflective of its overall stout metasoma), exhibited significant separation from the other four species. *E. tergestinus* was the only species that did not stand out in these ratio comparisons: in all sixteen histograms presented in Figs. 70-77, *E. tergestinus* never exhibited the largest or smallest ratio value. We should state here that this may be attributed, in part, to the somewhat large geographical range and variable definition of *E. tergestinus* proposed in this paper in contrast to the limited geographical ranges found in some of the other species.

Carination/Granulation

In general, *Euscorpius* species are somewhat smooth, and in many cases, shiney in overall appearance, any significant carination only evident on the pedipalps. The metasoma of most species have weak carination, some of which may be granular, especially on the dorsal aspect. The inferior carinae are usually obsolete on segments I-III and in many cases on segment IV. However,

except for the subgenus *Alpiscorpius*, most species do have distinct inferior carinae on segment V and usually with some degree of granulation. The variability and weakness of the inferior carinae of *Euscorpius* has caused confusion in the past as to the development of the inferior median carinae — whether they are paired or single on segments I-IV (considered at one time an important diagnostic character at the subfamily level; e.g., Werner, 1934; Mello-Leitão, 1945). Birula (1917) reported a single inferior median keel for *Euscorpius* which was essentially ignored by other early workers. Soleglad (1976) and Stockwell (1992) either discussed and/or suggested they were single in their revisions of chactoid and iurid scorpion groups and Soleglad & Sissom (2001: 64-67) finally established their singularity by actually illustrating a single inferior median carina on segments III and IV for two species of *Euscorpius* (i.e., *E. tergestinus*, identified as *E. carpathicus*, and *E. italicus*).

For the five species analyzed in this study we constructed a "carinae development quotient" that measured the degree of carinal development for the metasoma and pedipalp. Since there is variability in individual carinal development, we thought that a metric that included all carinae would be more comprehensive. For the metasoma we included 24 distinct carinae composing seg-

ments I-IV (five per segment) and four carinae for segment V. For the pedipalp, three, four and eight carinae (a total of 15 carinae) were considered for the femur, patella and chela, respectively (note that the subdigital carina is not considered in these quotients due to its essentially obsolescent state). Each carina was evaluated on a scale from 0 to 6, spanning individual development states from obsolete (a zero weight) to serrulate (a weight of 6). Other intermediate states were smooth, rough, partially and/or weakly granulate, granulate, and crenulate. Following are the resulting cumulative quotient weights ordered from the smallest to the largest:

Metasoma
E. koschewnikowi **(13)** < *E. balearicus* **(21)** < *E. hadzii* **(28)** < *E. carpathicus* **(35)** < *E. tergestinus* **(45)**

Pedipalp
E. koschewnikowi **(36)** < *E. carpathicus* **(39)** < *E. hadzii* **(52)** < *E. balearicus* **(53)** < *E. tergestinus* **(59)**

Two observations can be made from the above data: 1) *E. koschewnikowi* has the least developed carinae for *both* the metasoma and the pedipalp, and likewise, *E. tergestinus* has the most developed carinae on these two structures; and 2) although more carinae are considered for the metasoma (24 versus 15), the pedipalp quotients were considerably higher, caused in most part by the usually crenulate to serrulate condition of the femoral and patellar carinae and likewise highly reduced development of the metasomal carinae, conditions commonly found throughout the genus. The maximum quotients possible, summing all five species, are 720 and 450, for the metasoma and pedipalp respectively. For the metasoma we have a total quotient of 142, exhibiting a low 19.7% saturation and for the pedipalp, we have 239, showing 53.1% saturation, again illustrating the significantly more developed carinae on the pedipalp. The quotients for *E. tergestinus* were 3.46 and 1.64 times greater than those exhibited in *E. koschewnikowi*, metasoma and pedipalp respectively. This implies that the metasoma is the most important of the two characters for differentiating these two species. *E. koschewnikovi* has by far the smoothest metasoma of any known *Euscorpius* species, excluding possibly the subgenus *Alpiscorpius* species.

Individual carinae that stand out as potential diagnostic characters for the two species forming end points of the carination metric are the smooth dorsal carinae of segments I-IV and inferior median carina of V exhibited by *E. koschewnikowi*, and for *E. tergestinus*, the pigmented granular dorsal carinae of segments I-IV and the crenulate condition of the inferior median carina of segment V. Also, for *E. tergestinus*, the ventroexternal carina (*V1*) of the chela is crenulate whereas it is usually smooth on the other species. Finally, the telson vesicle of *E.hadzii* is covered with minute granules, whereas it is smooth on the other species.

Acknowledgements

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