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THE SCORPIONS (ARACHNIDA : SCORPIONES) OF THE AEGEAN AREA : CURRENT PROBLEMS IN TAXONOMY AND BIOGEOGRAPHY

Victor Fet[1] **& Matt E. Braunwalder**[2]

[1]**Department of Biological Sciences, Marshall University, Huntington, West Virginia 25755-2510, USA**
[2]**ARACHNODATA, Frauentalweg 97, CH-8045 Zurich, Switzerland**
(e-mail : admin@arachnodata.ch)

ABSTRACT. The fauna and zoogeography of the scorpions in the Aegean area are not well researched and based upon specimens randomly collected and described by various authors in the past 150 years. A first revision ot the scorpions in this region was provided by Kinzelbach in 1975 (completed with maps in 1985). However, the taxonomical validity of some species and most of the subspecies, first of all those in the genus *Euscorpius* (Euscorpiidae) is still unclear and their geographic ranges remain rather uncertain. Current comparative studies on mitochondrial DNA and nuclear gene (allozymes) variation (Gantenbein et al., 1999a, b) of these scorpions, revealed such promising first results that, as a consequence, a longer-termed research project is now introduced to analyze the scorpion fauna of the Aegean area on a larger scale and with requested close collaboration of zoologists from universities in Greece, Turkey and Cyprus.

INTRODUCTION

The first revision of the scorpion fauna of the circum-Aegean area in Europe and the adjacent parts of Asian Turkey was published by KINZELBACH (1975). It was not only a compilation of most noteworthy data that had been published by previous authors, but also the introduction of a new theory of the phylogeny of the subfamilies Euscorpiinae (now family Euscorpiidae) and Calchinae (now Iurinae, family Iuridae) included by Kinzelbach in the family Chactidae. This theory was based upon alleged mechanisms of hybridization, and the coincidence of distributional patterns of morphological characteristics with the results of the reconstruction of distribution during the Tertiary period. Earlier contributions and often contradictory data relevant to this subject have been published by BIRULA (1917), HADZI (1931), VACHON (1947a, 1947b, 1951, 1953) and CAPORIACCO (1950). Kinzelbach's phylogenetic and zoogeographical theories have since not been discussed or confirmed except by himself (KINZELBACH, 1982, 1985; VACHON & KINZELBACH, 1987), although a few more recent papers deal with the taxonomy and zoogeography of the scorpions in general or particular species in this area (VOULALAS & MICHALIS, 1977; BONACINA, 1980, 1982; FRANCKE, 1981; MICHALIS & KATTOULAS, 1981; SISSOM, 1987; MICHALIS & DOLKERAS, 1989; KRITSCHER, 1993; CRUCITTI, 1993, 1995a, b; LACROIX, 1995; GANTENBEIN et al., 1999b).

Corresponding author : V. Fet, e-mail : fet@marshall.edu

PROBLEMS IN THE TAXONOMY AND BIOGEOGRAPHY OF SCORPION TAXA IN GREECE, TURKEY AND CYPRUS

Below, we describe the current problems in taxonomy and biogeography for all scorpion taxa occurring in Greece, Turkey and Cyprus.

Family BUTHIDAE C. L. Koch, 1837
Genus *MESOBUTHUS* Vachon, 1950

Mesobuthus gibbosus (Brullé, 1832)

This common species is recorded from Albania, Yugoslavia (Montenegro), Greece, Cyprus, Turkey (except north), Syria, and Lebanon. Recent studies of distribution and ecology in Greece include CRUCITTI & MARINI (1987), CRUCITTI (1993), and CRUCITTI et al. (1998). The species is well-defined and separated from

other species of *Mesobuthus* which inhabit exclusively Asia (from eastern Turkey to China). Some variation exists across the range but its extent is poorly studied. A subspecies *M. g. anatolicus* Schenkel, 1947 was described from Kayseri, Anatolia (types in Basel Museum) and later confirmed by KINZELBACH (1975). However, KRITSCHER (1993) doubted the existence of a clear separation between the European and Asian populations of *M. gibbosus*. Further, detailed investigation combined with genetic methods is necessary; and first genetic data on this species are being currently obtained (B. Gantenbein et al., pers. comm). The type locality of *M. gibbosus* is unclear and was referred only to "Morea" (=Peloponnesos). Type(s?) probably are lost. Designation of the neotype is planned from Greece. In addition, the status of Eastern Mediterranean populations (east Turkey, Syria, Lebanon) is unclear. If confirmed as a separate taxon, there is an available name for these populations since EHRENBERG in 1829 described his *"Androctonus" nigrocinctus* from the mountains near Beirut (juvenile type in Berlin Museum). This name was for a long time considered a synonym of *M. gibbosus* (in fact being a senior synonym) (BRAUNWALDER & FET, 1998).

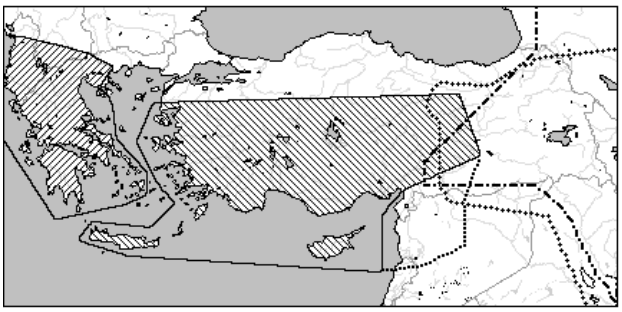

Fig. 1. – Distribution of *Mesobuthus* (Buthidae) according to Kinzelbach (1985): / / / *M. gibbosus* (Brullé), \ \ \ *M. g. anatolicus* (Schenkel), + + + *M. eupeus* (C.L. Koch), - . - . - *M. caucasicus* (Nordmann), ... *M. gibbosus ssp.* (maybe identical with *„Androctonus"nigrocinctus* Ehrenberg 1829).

No other buthids are known from Greece and the Balkans. The record of *Androctonus bicolor* (Ehrenberg, 1829) from Thessaly in Greece (MICHALIS & DOLKERAS, 1989) is erroneous and is based on *Mesobuthus gibbosus* (V. F., observations of the original material in the Zool. Museum Hamburg). From eastern Anatolia, there are confirmed records of some characteristically Asian species of buthids: *Mesobuthus eupeus* (C.L.Koch, 1838), *M. caucasicus* (Nordmann, 1840), *Androctonus crassicauda* (Olivier, 1807), *Leiurus quinquestriatus* (Ehrenberg, 1829), and *Compsobuthus matthiesseni* (Birula, 1905) (KINZELBACH, 1985; KOVÁRIK, 1996). Their study could be beneficial for further understanding of the taxonomy and zoogeography of Asian buthid genera. Any records of other species of Buthidae from Turkey should be confirmed. The occurrence of *B. occitanus* on Cyprus also also requires verification.

Family IURIDAE Pocock, 1893
Subfamily IURINAE Pocock, 1893
(= CALCHINAE Birula, 1917)

Genus *Calchas* Birula, 1899
(=*Paraiurus* Francke, 1985)

The new generic name *Paraiurus* was proposed for this genus by FRANCKE (1985), but FET & MADGE (1987) demonstrated that Birula's name is valid. The single species of this monotypic genus, *C. nordmanni* Birula, 1899, was described from the northeastern Anatolia (Russian territory before 1918; ?oruh River drainage; type in the Zoological Institute, St. Petersburg, Russia) but later found also in the southeast and south of Turkey (KINZELBACH, 1982, 1985) and off the Aegean coast on the Greek islands of Samos (SISSOM, 1987) and Megisti (Kastellorizo) (collected by the staff of the Natural History Museum of Crete). The most southern occurrence of *C. nordmanni* from Antakya (Gulf of Iskendurun) has recently been communicated by Kovárik (collection Kovárik, pers. comm.) The full range of this rare species is still unknown as its current distribution appears to be in six disjunct populations. Also its ecology requires further detailed observations.

Genus *Iurus* Thorell, 1876

The only species currently recognized is *Iurus dufoureius* (Brullé, 1832), common in the southern Greece, the Aegean islands and southern Turkey. Its ecology in Peloponnesos was recently studied by CRUCITTI (1995a, b). The type locality is unclear and was referred only to "Morea". Type(s?) probably is lost. Designation of the neotype is planned from Greece. The status of subspecies *I. d. asiaticus* Birula, 1903 (type in St. Petersburg) from Anatolia is problematic. Francke (1981) considered it a separate species. KRITSCHER (1993) analyzed a larger series of specimens and concluded that this form has only the status of a subspecies. Variation of this species from

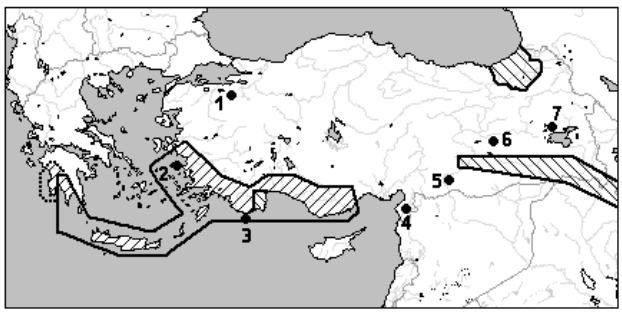

Fig. 2. – Distribution of Iuridae: *Iurus dufoureius* (Brullé) according to Kinzelbach (1985) / / / ; Crucitti (1995b) ..... *Calchas nordmanni* (Birula) according to Kinzelbach (1985) \ \ \ and recent new findings: 1 = Vachon & Kinzelbach (1987); 2 = Island of Samos (Sissom, 1987); 3 = Mengisti Island (collection Braunwalder); 4 = Antakya; 5 = Halfeti, 6 = Malatya, 7 = Nemrut Dagi (collection Kovarik, pers.comm.).

Greece, Turkey and the island populations should be studied in detail using genetic techniques, thus adding new data for the study of its origin and distribution initiated by VACHON (1947a, b; 1953).

Family SCORPIONIDAE Latreille, 1802

Genus *Scorpio* Linnaeus, 1758

Scorpio maurus Linnaeus, 1758. This is an extremely polymorphic, arid Asian-African species (or possibly a species complex) (BIRULA, 1910; LEVY & AMITAI, 1980). In the southeastern Anatolia, the endemic Middle Eastern subspecies (or maybe a species) *S. m. fuscus* (Ehrenberg, 1829) is found. This population represents the northernmost extreme of its range and should be important for a comparative study with populations from Syria, Iraq, Lebanon, Jordan and Israel in morphological, genetic and ecological aspects. The neotype specimen of *S. m. fuscus* should be designated from Lebanon.

Family EUSCORPIIDAE Laury, 1896

Genus *Euscorpius* Thorell, 1876

This is the most widespread genus of scorpions in the discussed region, where it includes at least three, and possibly five or more, species. Multiple subspecific forms are described, but their validity is not clear. A wealth of information is scattered in the literature (published in Italian, German, French, Serbo-Croatian, Russian etc.) but a comprehensive modern revision of the entire genus has never been done and is long overdue.

Euscorpius carpathicus (Linnaeus, 1758)

Species complex [including "E. mesotrichus Hadzi 1929"= E. tergestinus (C.L. Koch, 1837)].

Traditionally treated as one species (DI CAPORIACCO, 1950; VACHON, 1981; FET, 1986, 1989, 1997a), *E. carpathicus* is the most widespread scorpion species in Europe (from Baleares to Crimea; see Fet 1997a), with a large number of valid subspecies (over 20!). A number of those forms is described from Greece (including the islands of the Ionian and Aegean Seas), but their validity is unclear. KINZELBACH (1975) divided *E. carpathicus* into two species, designating the second one as "*E. mesotrichus* Hadzi, 1929". This name, however, is not available since it is a junior homonym of *E. italicus mesotrichus* Hadzi, 1929 (Fet 1997b). According to the International Code of Zoological Nomenclature, the correct name for such species should be *E. tergestinus* (C.L. Koch, 1837) (which was listed by KINZELBACH (1975) as a synonym). KINZELBACH (1975) classified all variation of the described subspecific forms of *E. carpathicus* into two species, without providing sufficient justification. His observation of sympatry for *E. carpathicus* and "*E. mesotrichus*" in Greece (Ossa, Pindos, Pilion, and Olympus) led to the conclusion of their sympatry over a wide area of the Mediterranean, and to restriction of the range of true *E. carpathicus* to the Eastern Mediterranean and Southeast Europe. The name "*E. mesotrichus* Hadzi 1929" was used afterwards by some authors (VACHON & KINZELBACH, 1987, MICHALIS & DOLKERAS, 1989; KRITSCHER, 1993), while others (BONACINA, 1983; FET, 1986, 1989, 1997a) did not accept Kinzelbach's division, but no detailed, critical analysis has yet been published. The type locality for *E. carpathicus* is Romania (type in the Linnean Society, London), and that for *E. tergestinus* is Trieste, Italy (type lost; neotype designation is planned). DI CAPORIACCO (1950) indicate that Koch's form inhabits also part of Italy, the Dalmatian coast of ex-Yugoslavia (now Croatia) and possibly goes as far eastward as Taigetos in Greece. No study has been done (but is much needed) of all these forms all over their range; the first results of genetic analysis (Gantenbein, Fet et al., in progress) reveal high variation and the possible existence of more than two species in this complex.

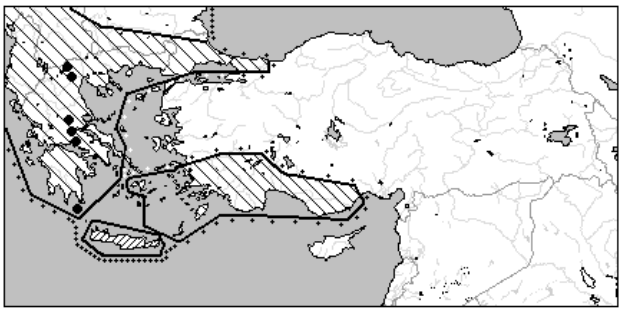

Fig. 3. – Distribution of *E. carpathicus* (L.) \ \ \ and *E. c. candiota* (Birula) / / / (and black dots) according to Kinzelbach (1985). + + + distribution range of *E. carpathicus* (Fet & Braunwalder, present study).

KINZELBACH (1975) also promoted a species origin theory, which, in fact, advocated a purely hybridogenic origin for all *Euscorpius* species. The only substantiation for this theory was an ordered characterization of meristic morphological characters (number of trichobothria on pedipalp). In particular, KINZELBACH (1975) maintained that all forms of the *E. carpathicus* complex that had an intermediate number of trichobothria are in fact hybrids between *E. carpathicus* and *"E. mesotrichus"*; one of the conclusions in this theory was that the entire Crete population, described by BIRULA (1903) as *E. candiota* (syntypes in St. Petersburg), is in fact a hybrid. Further analysis is warranted, including detailed genetic comparisons (allozyme and DNA techniques) of this crucial Crete population with other "intermediate" morphological forms from the Balkans as well as with two alleged ancestral species.

An additional problem in *E. carpathicus* complex concerns some localized, probably disjunct mountain populations in the Balkans, first of all "*E. germanus croaticus*" Caporiacco, 1950 (Croatia, Bosnia-Herzegovina; type

from Velebit Mts in Zoological Museum, Florence, seen) and a similar (if not identical) form from the Western Rhodopi Mts in Bulgaria (Smolyan District, our data, unpublished); the latter form most likely will be found within the territory of Greece. These forms have morphological characters indicating their affinity to *E. carpathicus* rather than to *E. germanus*, although its reduced trichobothrial formulae match those of *E. germanus*. Further studies should clarify the status of these populations, which could constitute glacial relicts of *E. carpathicus* complex.

Euscorpius italicus (Herbst, 1800)

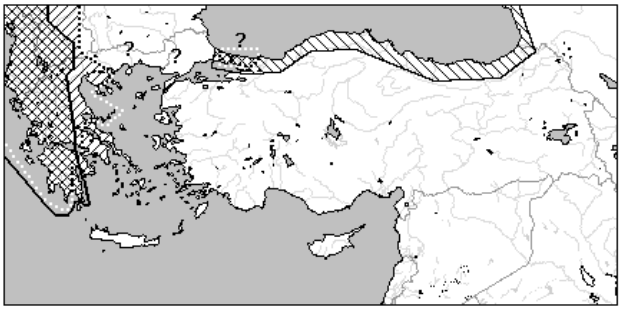

Fig. 4. – Distribution of *Euscorpius italicus* (Herbst) \ \ \ and *„Euscorpius mesotrichus* Hadzi, 1929" = ?*Euscorpius tergestinus* (C.L. Koch) / / / according to Kinzelbach (1985). ? = estimated but not yet verified occurrence of *E. tergestinus* (Fet & Braunwalder, present study).

This species is found from France to the Caucasus (Caporiacco, 1950; Kinzelbach, 1975). No subspecies are currently recognized (Vachon, 1981; Bonacina, 1982). Caporiacco (1950) and Vachon (1981) characterized an unusual "oligotrichous" form from Taigetos, Greece. Crucitti (1995a) observed ecology, probably of the same form as "*Euscorpius* cf. *italicus*". From new DNA-based information available (analysis of the 16S rRNA mitochondrial DNA gene sequences by Gantenbein et al., 1999b) it appears that *E. italicus* holds a derived place in the phylogenetic tree of the genus *Euscorpius* and is very closely related to *E. carpathicus* complex (or maybe even to a certain part of it). Since the major diagnostic character set in *E. italicus* appears to be a dramatic increase in trichobothrial numbers (Vachon, 1975, 1981), it is very important that "oligotrichous" *E. italicus* forms from Greece be studied in their relation to "polytrichous" forms of *E. carpathicus* known from the Balkans (Caporiacco, 1950), to further clarify phylogeny of these species. In addition, the range and status of the Black Sea coast populations (all Anatolia to Russia) has to be reanalysed. Designation of the neotype for *E. italicus* is planned from Italy.

Euscorpius mingrelicus (Kessler, 1874) (and related taxa)

Kinzelbach (1975) treated this taxon as a subspecies of *E. germanus* (C.L. Koch, 1837). Bonacina (1980)

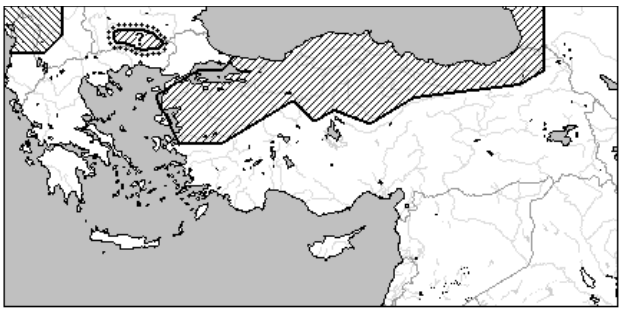

Fig. 5. – Distribution of *Euscorpius germanus* (C.L. Koch) \ \ \ and *Euscorpius mingrelicus* (Kessler) / / / (Euscorpiidae) according to Kinzelbach (1985). + + + and ? probably a form of *E. carpathicus („E. germanus croaticus")* (Fet & Braunwalder, present study).

demonstrated that this species is separate, and that in fact the major part of the range formerly recognized for *E. germanus*, belongs to *E. mingrelicus*. *E. germanus* (C.L. Koch, 1837) was described from the historical Tyrol (now Trentino-Alto Adige in northeast Italy) (type lost; neotype designation is planned) (Fet & Braunwalder, 1997). Since Bonacina (1980) separated *E. mingrelicus*, this species appears to be the most geographically restricted of all *Euscorpius*, occupying the southern part of the Alpine belt in Italy, Switzerland, Austria, and Slovenia; there is no evidence that true *E. germanus* is found in Greece.

E. mingrelicus was originally described from Georgia (Caucasus) (type lost; neotype designation is in press). However, it is recorded from northeast Italy to Russia; its presence in Greece requires confirmation, and its distribution in the Balkans and Turkey is poorly documented.

An additional species, *E. gamma* Caporiacco, 1950, has been now separated from this complex (Scherabon et al., in press). Subspecific structure requires revision; recently, Lacroix (1995) described three new subspecies from Anatolia in addition to three already existing (*E. m. mingrelicus, E. m. phrygius* and *E. m. ciliciensis*; see Birula, 1898; Bonacina, 1980; Fet, 1986, 1993). It appears that the species is found over the entire Anatolian Peninsula, including high mountain ranges (Bulghar Dagh, Taurus Mts). It is not clear which form is found on the Aegean islands (Tinos and Ikaria; Kinzelbach 1975); we suggest that these records might refer to *E. carpathicus*. Designation of the neotype for *E. mingrelicus* is planned from Georgia.

CONCLUSIONS

Application of modern molecular phylogenetic techniques, especially DNA-based (Gantenbein et al., 1999a, 1999b) opens unprecedented opportunities for the study and interpretation of ancient and diverse scorpion fauna of one of the most complicated biogeographic regions of the world, the Eastern Mediterranean (Oosterbroek & Arntzen, 1992). The molecular data analysis should be

combined with detailed morphological investigation and exhaustive geographic sampling to re-analyse and reveal the importance of diagnostic characters in order to understand real taxonomic relationships and reconstruct the history of taxa. It is thus our goal to reanalyze extensive collections accumulated in all major European museums and to establish international cooperation, which is necessary to further facilitate and support these studies with new material and ecological data. For this purpose, we are initiating a long-term comprehensive project for which we invite regional zoologists, university professors and students, and amateurs to actively participate. This project will be coordinated by the non-profit Swiss agency ARACHNODATA, which currently runs a number of international cooperative projects (Switzerland, USA, Middle East) on the taxonomy, biology, ecology and zoogeography of scorpions.

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