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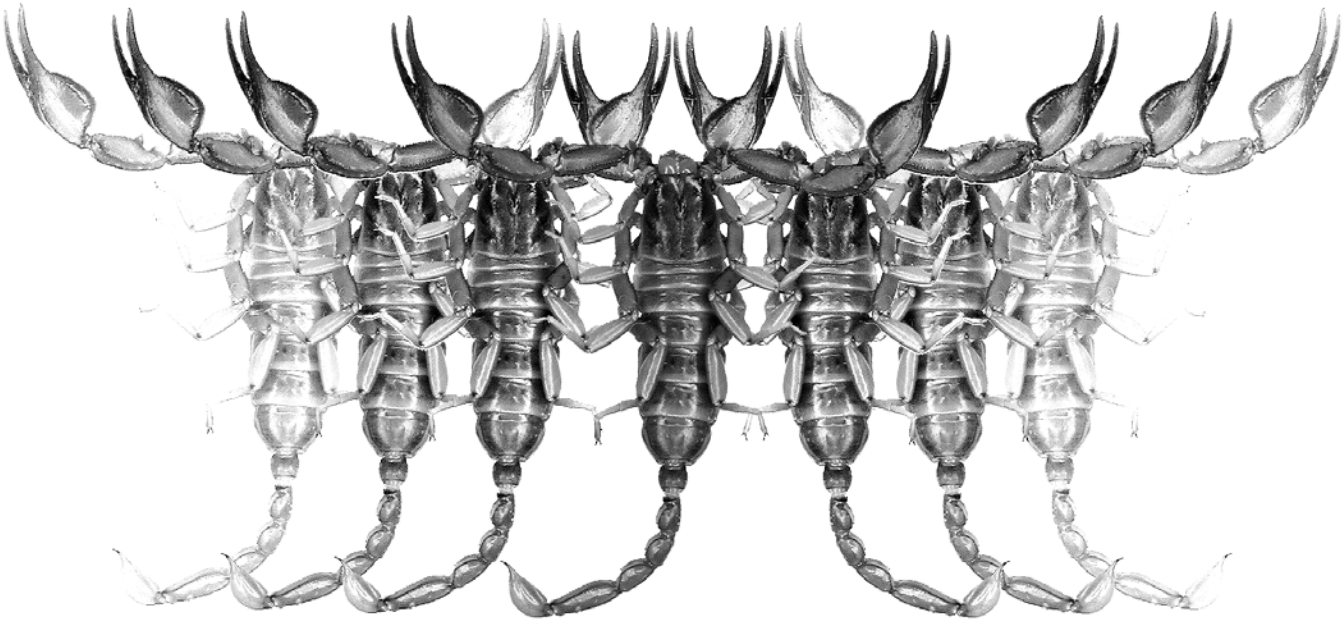

Etudes on Iurids, III. Revision of the Genus *Iurus* Thorell, 1876 (Scorpiones: Iuridae), with a Description of Two New Species from Turkey

František Kovařík, Victor Fet, Michael E. Soleglad & Ersen Aydın Yağmur

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Etudes on iurids, III. Revision of the genus *Iurus* Thorell, 1876 (Scorpiones: Iuridae), with a description of two new species from Turkey

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Summary

This revision is based on a comprehensive analysis of largely new, very extensive material encompassing 341 specimens (58 from Greece and 283 from Turkey). The type species *Iurus dufoureius* (Brullé, 1832) is restricted to Greece. *Iurus asiaticus* Birula, 1903 is confirmed as a distinct species, limited to eastern Anatolia. Most widespread in southern Turkey is another species, *Iurus kraepelini* von Ubisch, 1922, which is here restored from synonymy. We also describe two new species from Turkey: *Iurus kadleci*, **sp. nov.** from Antalya and Mersin Provinces (sympatric with *I. kraepelini*), and *Iurus kinzelbachi*, **sp. nov.** from İzmir and Aydın Provinces; therefore, fauna of Turkey includes four species of *Iurus*. Neotypes of *I. dufoureius* and *I. kraepelini*, and lectotype and paralectotypes of *I. asiaticus* are designated. Status of *Iurus* populations from the eastern Aegean islands of Greece (Fourni, Karpathos, Kasos, Rhodes, Samos, Saria) remains to be determined. A map of the distribution of *Iurus* is presented, based on 198 localities (79 in Greece and 119 in Turkey).

Introduction

This large work represents a revision of the genus *Iurus* Thorell, 1876 (Iuridae). Our analysis of the extensive material (341 specimens, 58 from Greece and 283 from Turkey) revealed an unexpected and complex structure of the genus *Iurus*, which currently includes **at least *five* species**.

We restrict the nominotypic ***Iurus dufoureius* (Brullé, 1832)** to the "Western clade" of Parmakelis et al. (2006), i.e. mainland Greece (Peloponnese) and Crete, as well as small islands of Kythira and Gavdos. A neotype for *I. dufoureius* from the Peloponnese is designated since the syntypes of Brullé are lost.

Within Anatolia, we discover four species, of which two are new. We justify the species status of ***Iurus asiaticus* Birula, 1903** (originally described as a subspecies of *I. dufoureius* from Gülek Pass, Adana Province), and designate a lectotype and paralectotype for its existing syntype series. We demonstrate, however, that this species is limited to the eastern Anatolian mountains, mainly in the eastern Mersin, Adana, Kahramanmaraş, and Adıyaman Provinces.

Most of the southern Anatolian populations belong to the forgotten species ***Iurus kraepelini* von Ubisch, 1922**, described from Finike (Antalya Province), which is here restored from synonymy. We designate a neotype for it since the holotype is lost. This species is widespread in Muğla, Antalya, and western Mersin Provinces. The ranges of *I. asiaticus* and *I. kraepelini* appear to be closely allopatric, separated in Mersin by the Bolkar range of the eastern Taurus Mountains, one of the most important biogeographic boundaries in Anatolia (Çiplak, 2003).

We also describe two *new*, peripheral and distinct species of *Iurus* from Turkey. One of these, ***Iurus kinzelbachi* sp. nov.,** occupies a limited range in western Anatolia, first discovered and studied there by Koç & Yağmur (2007, as *I. d. asiaticus*). We know that the range of this species has been reduced recently since we also studied old material from the now extinct population from the suburbs of İzmir. Some features of *I. kinzelbachi* **sp. nov.** point at its relatedness to the Greek *Iurus dufoureius* rather than to three other Anatolian species.

Another new species, ***Iurus kadleci* sp. nov.,** is described from Antalya and Mersin Provinces. This species is sympatric with *I. kraepelini* (in Akseki, Antalya, both were collected in the same habitat) but clearly different morphologically.

Finally, the status of the populations from six eastern Aegean islands (Fourni, Karpathos, Kasos, Rhodos, Saria, and Samos) remains to be determined; limited material does not allow us to associate them with *I. dufoureius* or with any of the Anatolian species.

In this paper, following the historical **introduction**, we present the detailed section on **systematics,** which includes the genus-level discussion highlighted with many SEM micrographs, where *Iurus* is compared to its sister genus *Calchas*; distribution maps and an illustrated key; and detailed descriptions of five *Iurus* species, including two new species; **breeding**, which includes data highlighting the rearing of *Iurus kraepelini*, accompanied by photographs of all ontogenetic stages from the first instar to adult; **embryo morphology**, where, for the first time, a detailed description is given of the *I. dufoureius* late embryo, accompanied by photographs and SEM micrographs; **ecology and biogeography** that provides a brief discussion of the distribution of *Iurus* and preferred habitats; and, finally, three **appendices** that provide complete locality data (including latitude/longitude), summary of neobothriotaxy in *Iurus*, and complete morphometric comparisons of all five *Iurus* species (separately for males and females).

History of study

The genus *Iurus* (Iuridae) was described by Thorell (1876) and has a relatively brief but confusing taxonomic history. Its type species was described by Brullé (1832: 58–59, pl. 28, fig. 1) as *Buthus dufoureius*, from the ancient Messene, in Peloponnese (then called Morea), in newly independent Greece. Messene (now Messini, Messinia Prefecture) is located on the slopes of Mt. Ithomi (798 m a.s.l.), 30 km NW of Kalamata. A brief description of Brullé (1832) includes number of pectinal teeth as 10 for female and 11 for male. These historical syntypes of Brullé are lost. Later in this paper, we designate a neotype from Peloponnese, a female chosen from the available material from the closest locality to Messini, between Artemisia and Kalamata.

C. L. Koch (1837: 46–49, pl. 122, fig. 279) described the same species from Peloponnese (no exact locality) as *Buthus granulatus*. The two species were synonymized by Karsch (1879: 102), shortly after Thorell (1876) established genus *Iurus*, naming *Buthus granulatus* Koch as its type species.

The first records of *Iurus* for Crete (as "*Scorpius gibbus*") were published by Lucas (1853) and Raulin (1869); and for Rhodes, by Thorell (1877). Werner (1938) had already listed *Iurus* from Peloponnese, Kythira, Crete, Karpathos, Rhodes, and Samos.

The first record of *I. dufoureius* for Anatolia (Birula, 1898: 135) was of three specimens, a large (maybe adult) female and two juveniles, collected by Martin Holtz in 1897 at Gülek, a famous pass in the Taurus Mts., called "Cilician Gates" by the ancients. The Gülek female was later discussed in comparison with Crete specimens by Birula (1903: 297–298), and was given the name as a new subspecies, *Iurus dufoureius asiaticus*, with a rather brief description. The type series, which includes the large female, designated below as lectotype of *I. asiaticus*, and two juvenile paralectotypes, still exists in Zoological Insitutute, St. Petersburg, Russia, where Birula's scorpion collection is kept.

A new species *Iurus kraepelini* was described from "Fineka" (now Finike) in southern Anatolia by Magda von Ubisch (1922). Its holotype, with pectinal teeth count of 13–11, formerly in Stuttgart, was lost in World War II (W. Schawaller, pers. comm., 2008). Based on its rather general description, Vachon (1947b: 26) synonymized *I. kraepelini* with *I. dufoureius asiaticus*; however, Vachon never analyzed Birula's types of *I. d. asiaticus*.

Roewer (1943), in a bizarre confusion, described a new genus *Chaerilomma* (with one species, *Chaerilomma dekanum*, allegedly from India; type was in SMFD but not found by Kovařík, 2002), which much later was discovered to be a synonym of *Iurus* (Vachon, 1966a; Francke, 1981). The label was obviously wrong, and we do not know the true provenance of Roewer's specimen, other than its morphology matched the Crete population (Francke, 1981). Interestingly, the *same* paper (Roewer, 1943: 235) lists a specimen of *Iurus* from Anatolia (Ovacik), collected and correctly identified by Roewer himself (!), also deposited in SMFD.

Vachon (1947a, 1947b, 1948, 1951) mentioned *Iurus* in his works on scorpions of Turkey, as new records became available, still extremely scarce (only two specimens collected by C. Kosswig in 1946 and 1949 in Silifke and Korykos, near Silifke). Map of Vachon (1951: 343) shows only two localities for *Iurus* in Anatolia (Silifke and Gülek). A special biogeographic paper on *Iurus* was also published by Vachon (1953) who outlined its range as Peloponnese, Kythira, Crete, Karpathos, Rhodes, Samos, and southern Anatolia; the map of Vachon (1953: 98) shows four localities, adding Finike (after von Ubisch, 1922) and Tarsus (a new locality). The Ovacik locality near Fethiye, which was reported by both Werner (1902, 1936a) and Roewer (1943), was never mentioned by Vachon. No new Anatolian records were published for the following 20 years; in fact, *Iurus* was so poorly known that it was altogether omitted from a brief review of Turkish scorpions by Tolunay (1959), who otherwise correctly reproduced Vachon's data.

Marking the history of study of this genus is a constant dearth of specimens. *Iurus* seems to be a rare scorpion in nature, and few museums had a chance to amass a large series of material. As a result, the true diversity of the genus *Iurus* has never been assessed

properly. Even when Vachon (1953) specifically wrote on this "*grand scorpion noir*" and recognized its biogeographic importance and taxonomic uniqueness, he never studied more than a couple of specimens. When he published an insightful and detailed revision of Roewer's *Chaerilomma*, Vachon (1966a) only compared Roewer's male of an alleged Indian species to a *single* male from Tarsus (MNHN RS 3007), both marvellously pictured by Maurice Gailliard. Even images of *Iurus* appearing in the great monograph of Vachon (1974) were based on the same Tarsus specimen (which we had a chance to examine in the present study).

After many decades of a relative neglect, the first modern and comprehensive review of *Iurus* was published by Kinzelbach (1975) who studied all circum-Aegean scorpion fauna and listed a number of new localities based on several European museum collections as well as personal field studies. Kinzelbach (1975) treated *Iurus* as monotypic, with only one species, *Iurus dufoureius*.

The map of Kinzelbach (1975, fig. 9) included *Iurus dufoureius* range in Greece as the Peloponnese, Crete, Karpathos, Rhodes, and Samos. The islands of Kythira, Kos, and Leros were listed as "known only from the locals but not confirmed by specimens." A record from Kythira, however, had already been published by Werner (1937), and is now confirmed (Stathi & Mylonas, 2001). Records from Kos (Kinzelbach, 1975) and Samos (Vachon, 1953; Francke, 1981) were considered as dubious by Stathi & Mylonas (2001). However, Kritscher (1993) collected a specimen from Samos, as did Vignoli in 2003 (Francke & Prendini, 2008; FKCP). In addition, Fet (2000) reported a specimen from Kasos Island, collected by P. Beron and V. Beshkov in Stylokamara Cave. For Anatolia, the insert on the map of Kinzelbach (1975) covered the entire southern peninsula to the Gulf of Iskenderun in the east. Only three exact Anatolian localities were plotted, all coastal; however, in his map legend, Kinzelbach (1975: 25) listed twelve localities as new for Anatolia, based on the examination of several European museum collections: Pazarkoy (SE Egridir), Silifke, Cennet (NE Silifke), Çiglikara, Narli Kioi ("Marli Kioi") near İzmir, Bodrum, Aspendos (E Antalya), Gazane, Dodurga ("Dorduga"), Mersin, Antalya, and Şile. Similar extrapolated maps were later published by Kinzelbach (1985) and Vachon & Kinzelbach (1987).

Detailed field studies of Crucitti (1995a, 1995b, 1998, 1999b) in the Peloponnese for the first time provided substantial data on distribution and ecology of *Iurus dufoureius*. For Anatolia, Crucitti (1999: 87–88) described the range of *Iurus* as "the whole Mediterranean region of Turkey, including the Chain of Taurus between the districts of Mugla and Tarsus." For the southwestern Peloponnese, the map of Crucitti (1998, fig. 1) shows 18 localities. These and other distributional records for Greece, along with some new data, were recently summarized by Facheris (2007a, 2007b), whose map shows over 30 localities for Peloponnese and 13 localities for Crete, as well as localities on Kythira and Gavdos islands.

More records from Anatolia were published by Crucitti & Malori (1998) and Francke & Prendini (2008). The map of Crucitti (1999, fig. 2) does not plot precise localities but shows a "presumptive" range from İzmir to Adana, but not as far east as maps of Kinzelbach (1975, 1985). The map given by Crucitti & Cicuzza (2001) had 13 localities plotted for Anatolia. Most recently, Yağmur, Koç & Akkaya (2009) listed 29 new localities for Anatolia based on extensive new collections by Turkish zoologists, and extended the known range of *Iurus* considerably to the east.

Recently, Parmakelis et al. (2006) published a phylogeographic study of *Iurus* based on mtDNA (16S rDNA) marker, recovering two clades for seven localities across the range of the genus: three for the western clade (Peloponnese, Kythira, Crete) and four for the eastern clade (Rhodes, Karpathos, Megisti, Anatolia). They indicated that the level of mtDNA sequence divergence (above 5 %) between all pairwise comparisons could justify elevation of the two described subspecies (*I. d. dufoureius* and *I. d. asiaticus*) to species rank (see below on the history of this issue). Parmakelis et al. (2006), however, refrained from making taxonomic decisions until a detailed morphological study. We offer such a study here, focusing primarily on largely unexplored Anatolian populations of *Iurus*.

Probably the fact that *Iurus* was classified for over 100 years in Vaejovidae did not facilitate its revision: no modern European researcher studied vaejovids at generic level, while North American taxonomists were unfamiliar with *Iurus*. Note that Stahnke (1974: 215), in the first comprehensive revision of high-level taxa of Vaejovidae, studied only a single female of *Iurus*. Both Vachon (1966a, 1974) and Stahnke (1974) noted a separate position of this genus, and of then monotypic Iurinae (equivalent to current Iuridae). Francke & Soleglad (1981) outlined Iuridae as a family (equivalent to the current superfamily Iuroidea), which in fact is not closely related to Vaejovidae (Stockwell, 1989; Soleglad & Fet, 2003b; Fet & Soleglad, 2008). Still, a few attempts to address taxonomy of *Iurus* (Francke, 1981; Kritscher, 1993) were not conclusive due to the limited material available. In addition, no connection between *Iurus* and its sister genus *Calchas* Birula, 1899, then classified in Chactidae, was made until Vachon (1971) who was the first modern researcher to see a specimen of *Calchas*. Francke & Soleglad (1981) first brought the two genera together under Iuridae (again, examining only a single female *Calchas*). See Fet, Soleglad & Kovařík (2009) for detailed information on *Calchas*, a very important taxon for understanding *Iurus*.

Our attention to *Iurus* was warranted by several factors. First, it was the importance of Iuroidea and Iuridae for the high-level scorpion systematics and phylogeny, namely a separate, basal position of this group (Stockwell, 1989; Soleglad & Fet, 2003b; Fet et al., 2004; Fet & Soleglad, 2008). Second, the unusual trichobothrial pattern of Iuridae, noticed by Vachon (1974) and Stahnke (1974), when studied in more detail, yielded previously unknown extensive and variable neobothriotaxy (Soleglad, Kovařík & Fet, 2009), including that in the unique population near İzmir (described here as *I. kinzelbachi*, **sp. nov.**). Third, our recent revision of the sister genus *Calchas* (Fet, Soleglad & Kovařík, 2009) revealed its "hidden diversity" in Anatolia, which prompted us to pay more attention to *Iurus* that is even more widespread in this area. Fourth, a tentative identification of a distinctive, new species from Anatolia (described here as *I. kadleci,* **sp. nov.**), required a careful reanalysis of the Anatolian populations. Finally, the availability of numerous new material, which has been recently collected by Turkish zoologists, allowed us to assess many populations across the entire range of *Iurus.*

Subspecies controversy

Iurus dufoureius dufoureius (Brullé, 1832) and *I. d. asiaticus* Birula, 1903 have been traditionally treated as subspecies by the authors who maintained the monotypy of the genus (e.g. Vachon, 1947b; Kinzelbach, 1975, 1982). These subspecies, however, were never revised until Francke (1981) first suggested that *I. d. asiaticus* should be given species status.

Francke (1981) studied the type of *Chaerilomma dekanum* Roewer from SMFD (no correct locality known, assumed to be from Greece), and compared it to "additional specimens from Crete, Rhodes and Turkey." In his paper, however, Francke (1981) listed the data only for one male from Crete and four specimens from Turkey: two from "Namrum" (=Namrun, now Çamlıyayla; but see below for corrected labels), and two from Antalya; no data were listed for Rhodes. Francke (1981: 221) mentioned that Birula's subspecies was described as having 12 pectinal teeth versus 9 in the "nominate subspecies from Crete." This is not exact: Birula (1903: 297) clearly stated that Crete specimens have 9 pectinal teeth but otherwise do not differ from typical "Greek" (i.e. Peloponnese) specimens, which have 10 or 11. Birula's ZISP collection, in fact, has an unpublished specimen from Taygetos Mts. (Peloponnese) as well as Gülek and Crete specimens. Birula (1903) did not address Crete as part of Greece because Crete since 1898 was an autonomous state still under Ottoman rule, and joined Greece only in 1913. Francke (1981) concluded that his Anatolian specimens were a separate species, *I. asiaticus*. He suggested that populations from Rhodes and Karpathos Islands also belong to *I. asiaticus*.

Francke (1981: 222) also suggested that, since Thorell (1877: 193–195) placed under *Iurus granulatus* a female from Greece as well as a male from Rhodes, this makes *Buthus granulatus* C. L. Koch, 1837 an available senior synonym of *Iurus asiaticus* Birula, 1903. This is, however, incorrect, since Koch's original name was clearly given to a Peloponnese population. Therefore *Buthus granulatus* C. L. Koch, 1837 is a junior synonym of *Iurus dufoureius* (Brullé, 1832), as synonymized by Karsch (1879); the Rhodes specimens of Thorell are not name-bearing.

The opinions on species or subspecies status of *I. asiaticus*, as well as on its volume, have varied after its elevation to species level by Francke (1981). Kritscher (1993) analyzed a larger series of specimens, mostly from Karpathos, and treated *I. d. asiaticus* as a subspecies found in Karpathos, Rhodes, Samos, and Turkey.

Sissom & Fet (2000) listed *I. d. asiaticus* as a subspecies and explained: "Francke (1981) considered *Iurus dufoureius asiaticus* Birula, 1903 from Turkey and the Aegean a separate species. Kritscher (1993) analyzed a larger series of specimens and concluded that this form has only a status of subspecies." The subspecies rank was followed by Fet (2000), Fet & Braunwalder (2000), Parmakelis et al. (2006), Facheris (2007a, 2007b), Kaltsas, Stathi & Fet, (2008), and Yağmur, Koç & Akkaya (2009).

At the same time, other authors (Crucitti & Malori, 1998; Kovařík, 1999, 2002; Crucitti & Cicuzza, 2001; Stathi & Mylonas, 2001) continued recognizing *I. asiaticus* as a separate species. Stathi & Mylonas (2001: 293) noted also that they "found specimens from Rodos and Karpathos that are clearly *I. dufoureius*, similar to individuals from Crete," thus disagreeing with both Francke (1981) and Kritscher (1993) on the geographic scope of *I. dufoureius* (or *I. d. dufoureius*). On the contrary, the mitochondrial DNA-based phylogeny by Parmakelis et al. (2006) did not group Rhodes and Karpathos populations with the nominotypical *I. dufoureius* from the Peloponnese; instead, these populations formed a clade with populations from Anatolia and Megisti (*I. kraepelini*, see below).

In the present paper, we do not employ the subspecies category as we demonstrate that species-level differences exist between several of *Iurus* populations in Greece and Turkey, amounting to at least five species. The Rhodes and Karpathos populations, as well as those from other Eastern Aegean islands, designated here as *Iurus* sp., are a subject of a separate study (Soleglad et al., in progress).

Material and Methods

Abbreviations

The four-letter institutional abbreviations listed below and used throughout are mostly after Arnett et al. (1993), or introduced here to accommodate other collections: BMNH, Natural History Museum, London, UK; FKCP, personal collection of František Kovařík, Prague, Czech Republic; MBCH, personal collection of Matt E. Braunwalder, Zürich, Switzerland; MCNH, Natural History Museum of Crete, Irakleio, Crete, Greece; MESB, personal collection of Michael E. Soleglad, Borrego Springs, California, USA; MNHN, Muséum national d'Histoire naturelle, Paris, France; MTAS, Museum of the Turkish Society of Arachnology, Ankara, Turkey; MZUF, Sezione di Zoologia "La Specola", Museo di Storia Naturale dell'Università di Firenze, Florence, Italy; NHMW, Naturhistorisches Museum Wien, Vienna, Austria; NMPC, National Museum, Prague, Czech Republic; RKRO, personal collection of Ragnar Kinzelbach, Rostock, Germany; SMFD, Senckenberg Museum, Frankfurt, Germany; SMNS, Staatliches Museum für Naturkunde, Stuttgart, Germany; SOFM, National Museum of Natural History, Sofia, Bulgaria; VFWV, personal collection of Victor Fet, Huntington, West Virginia, USA; ZISP, Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia; ZMHB, Museum für Naturkunde der Humboldt-Universität zu Berlin, Berlin, Germany.

Terminology and conventions

The systematics adhered to in this paper follows the classification as established in Fet & Soleglad (2005) and as modified in Fet & Soleglad (2008). Terminology describing pedipalp chelal finger dentition follows that described and illustrated in Soleglad & Sissom (2001), that of the sternum follows that in Soleglad & Fet (2003a), and the metasomal and pedipalp carination, and leg tarsus armature follows that described in Soleglad & Fet (2003b). Trichobothrial nomenclature and hypothesized homologies are those described and illustrated in Vachon (1974). Techniques using maximized morphometric ratios follow those described in Fet & Soleglad (2002: 5) and further established in Soleglad & Fet (2008: 57–69).

SEM microscopy

To investigate *Iurus* morphology, various structures were dehydrated in an ethanol series (50, 75, 95, and two changes of 100%) before being dried and coated with gold/palladium (ca. 10 nm thickness) in a Hummer sputter coater. Digital SEM images were acquired with a JEOL JSM-5310LV at Marshall University, West Virginia. Acceleration voltage (10–20 kV), spot size, and working distance were adjusted as necessary to optimize resolution, adjust depth of field, and to minimize charging. The SEM fixation protocol for the embryos was as follows. The embryos were transferred from 70% ethyl alcohol into Phosphate-Buffered Saline (PBS) with two changes (in ca. 15ml vial) about 30 min each; fixed in fresh 5% glutaraldehyde with 4% formaldehyde in 0.1M cacodylate buffer in refrigerator for 48 hrs; rinsed ten times with distilled water; fixed in 2% OsO_4 for 2−3 hours; rinsed three times in distilled water, and placed into 50% ethanol.

Material Examined

We examined the total of 341 specimens of *Iurus* (58 from Greece and 283 from Turkey). For the list of material with labels, see below under species names.

In addition to the five species described and defined in detail below, we also examined the following 7 specimens from Greece (eastern Aegean islands), currently under further study, and identified here as ***Iurus* sp.: Greece:** *Karpathos*: eastern part of the island, Apella Beach, ♂ sbad., born in captivity from a ♀ collected 6 July 2005, leg. M. Colombo (MESB; Figs. 48, 95). *Kasos*: Stylokamara Cave, 6 May 1984, 1 ♂, leg. P. Beron (SOFM 96). *Rhodes*: 1 ♂, Kritia ("Kastelo"), May 1887, leg. E. von Oertzen (ZMHB 8069) (Figs. 49, 94, 102); Mt. Filerimos (Eremofilo), 1 ♀, 1 juv (MZUF 1069); Archangelos, 2 May 1987, 1 ♀, leg. P. Beron (SOFM 158). *Samos*: Aghios Nikolaos, 3 km W of Karlovasi, 27 June 2003, 1 ♀, leg. V. Vignoli (FKCP) (Fig. 96, 104). Fig. 103 shows a live juvenile specimen from Rhodes.

Our map (Fig. 74) is based on 198 localities from literature as well as unpublished museum and private collections, including 35 localities from Peloponnese and 119 from Anatolia. For a full list of localities, sources, and geographic coordinates, see Appendix A. We exclude Kos and Leros islands from the distribution of *Iurus* until confirmed. We also did not plot obviously introduced specimens from Egypt (Thorell, 1877; Kraepelin, 1899; Birula, 1903), Beirut ("Syria", Kinzelbach, 1975), and records from Gökce-Kısık near Eskişehir (Werner, 1902) and Şile near Istanbul (Kinzelbach, 1975), far from the main range and probably also introductions or incorrect labels. We also did not include the single existing record from Cyprus, published only recently (Kamenz & Prendini, 2008: 43) but based on an old series of specimens, identified as *I. d. dufoureius*, with an unclear label ("Cyprus: Rolle", ZMHB 7497). We suspect that this locality was confused with Crete, since there have been no other records of *Iurus* from Cyprus. Franz Hermann Rolle

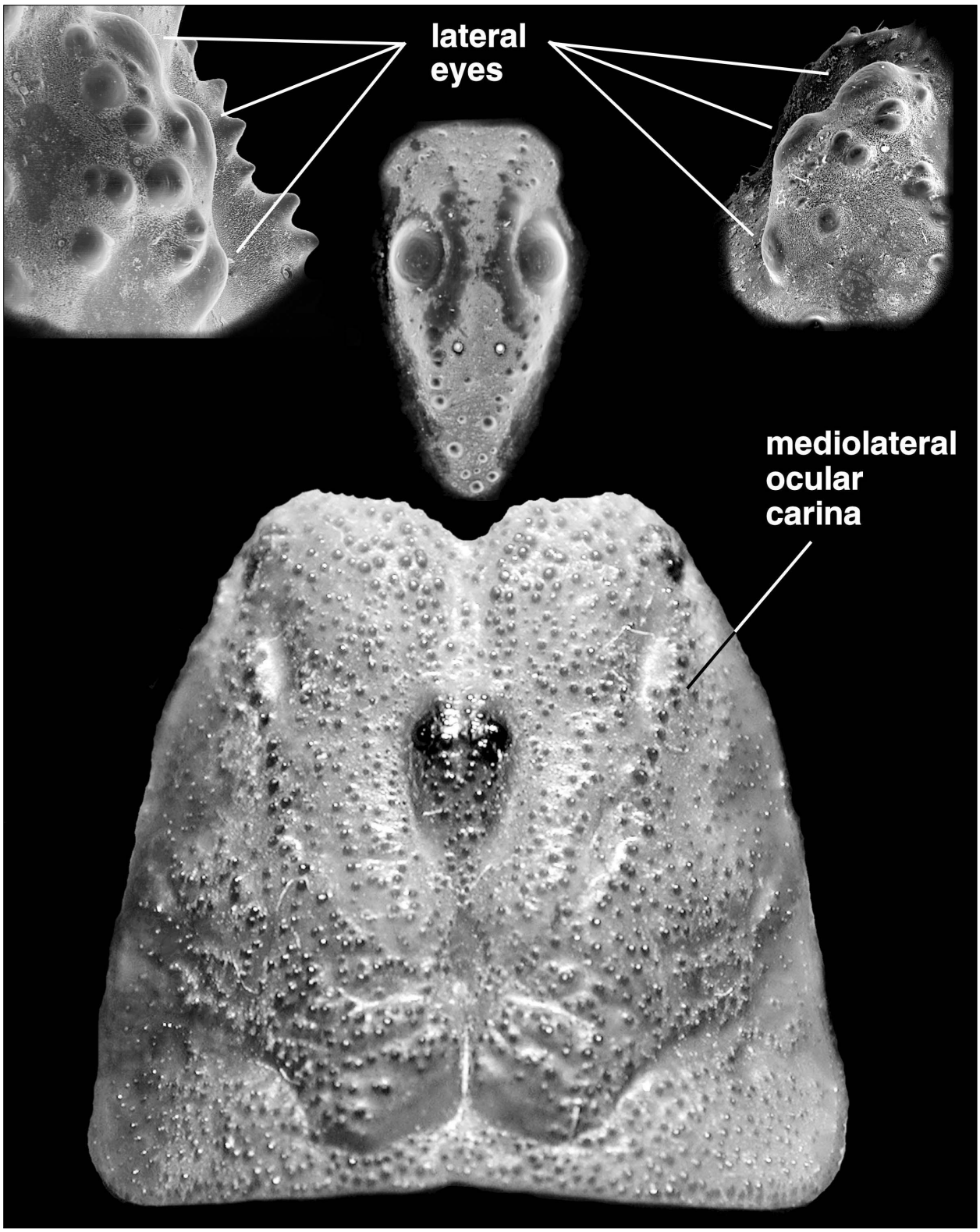


Figure 1: Carapace and close-up of median and lateral eyes. Carapace of *Iurus kinzelbachi*, **sp. nov.**, adult male, İzmir, İzmir, Turkey. Median and left lateral eyes (right, 50x) of *I. dufoureius*, subadult female, Krini, Gythio, Laconia, Greece. Right lateral eyes (left, 75x) of *I. asiaticus*, 4 km E Kaşlıca Village, Adıyaman, Turkey. *Three* lateral eyes and a well developed mediolateral ocular carina are indicated.

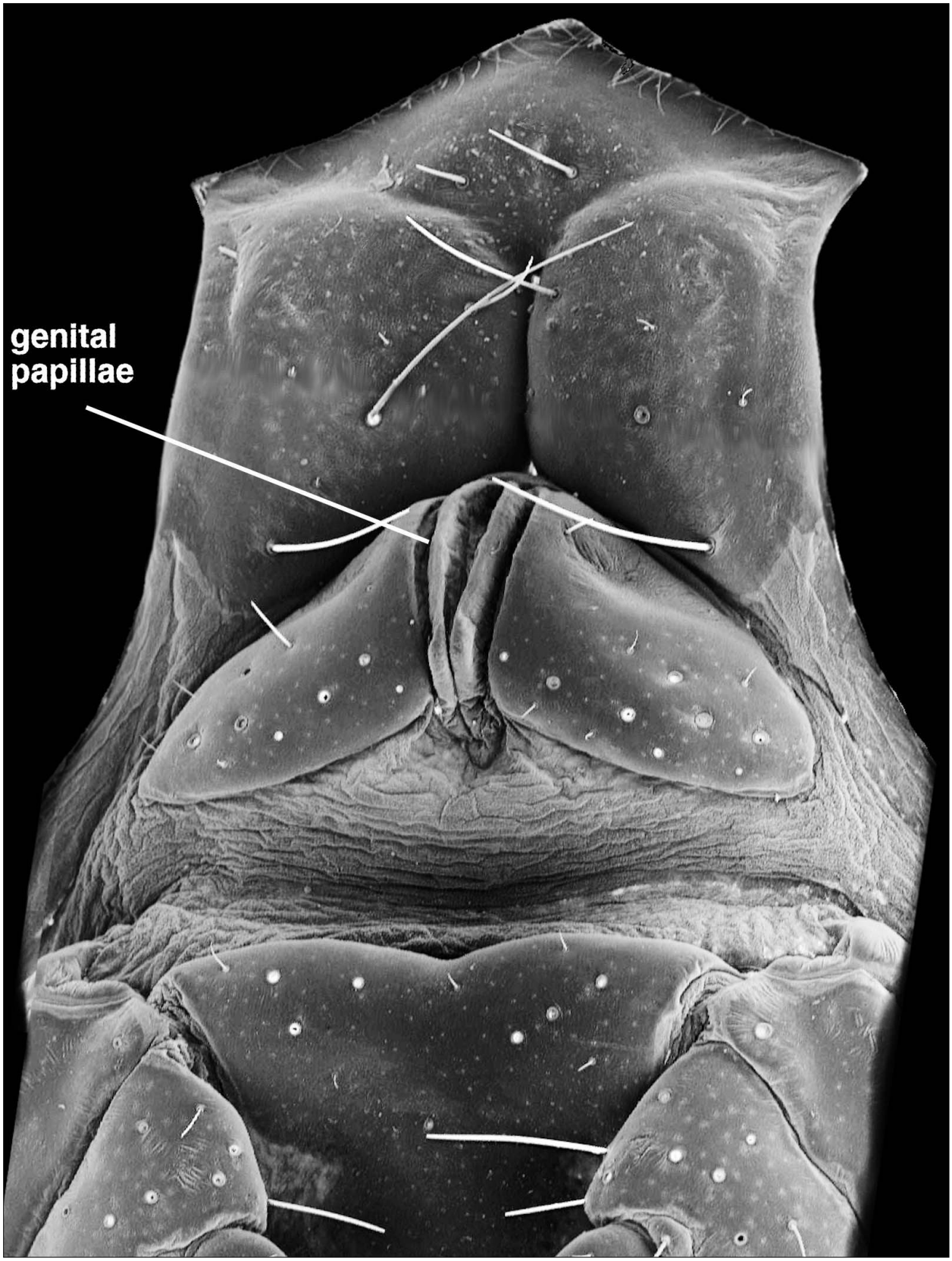


Figure 2: Sternopectinal area (35x) of *Iurus kraepelini*, juvenile male, Akseki, Antalya, Turkey. The conspicuous genital papillae visible between the genital operculum sclerites are indicated.

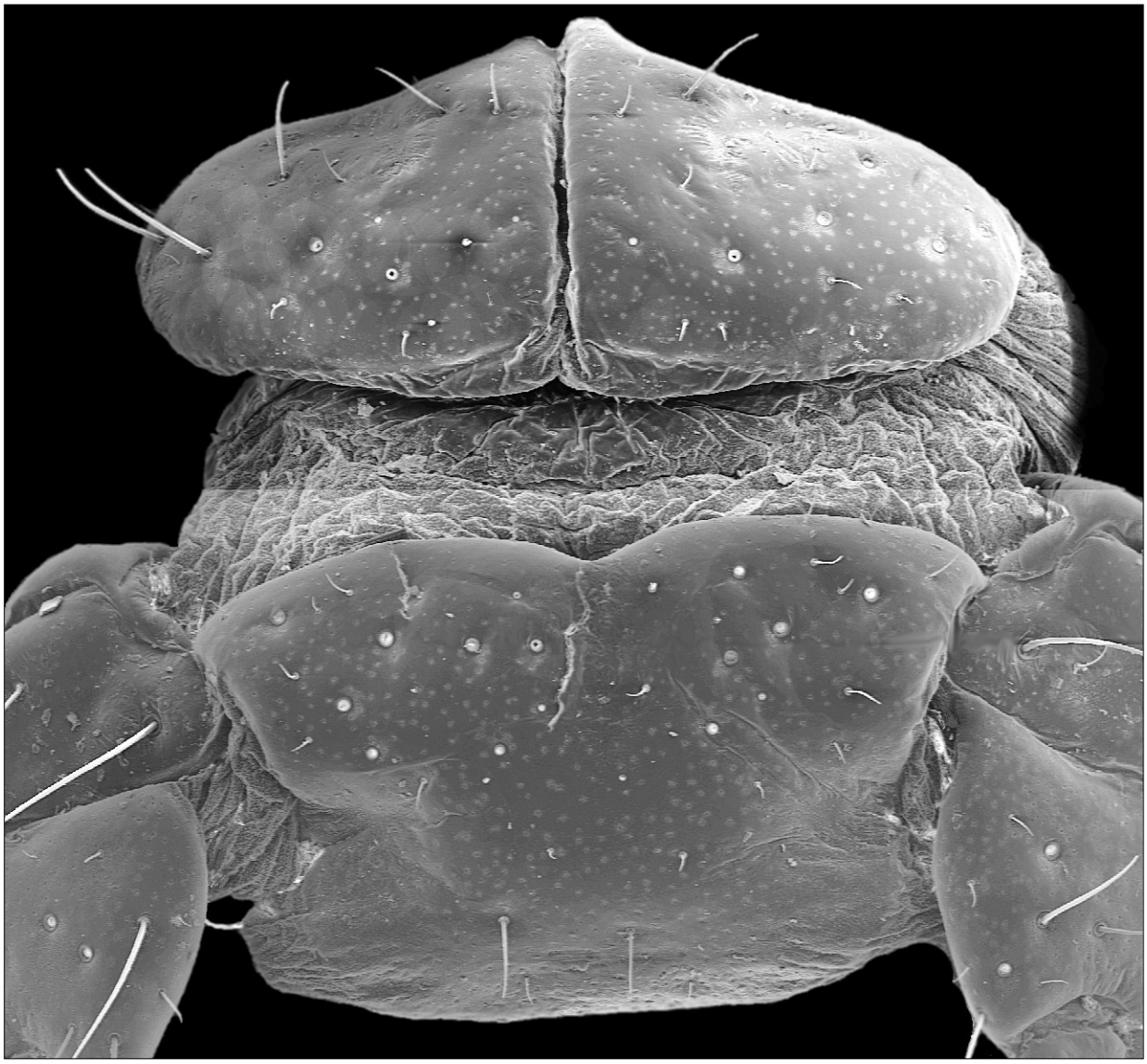


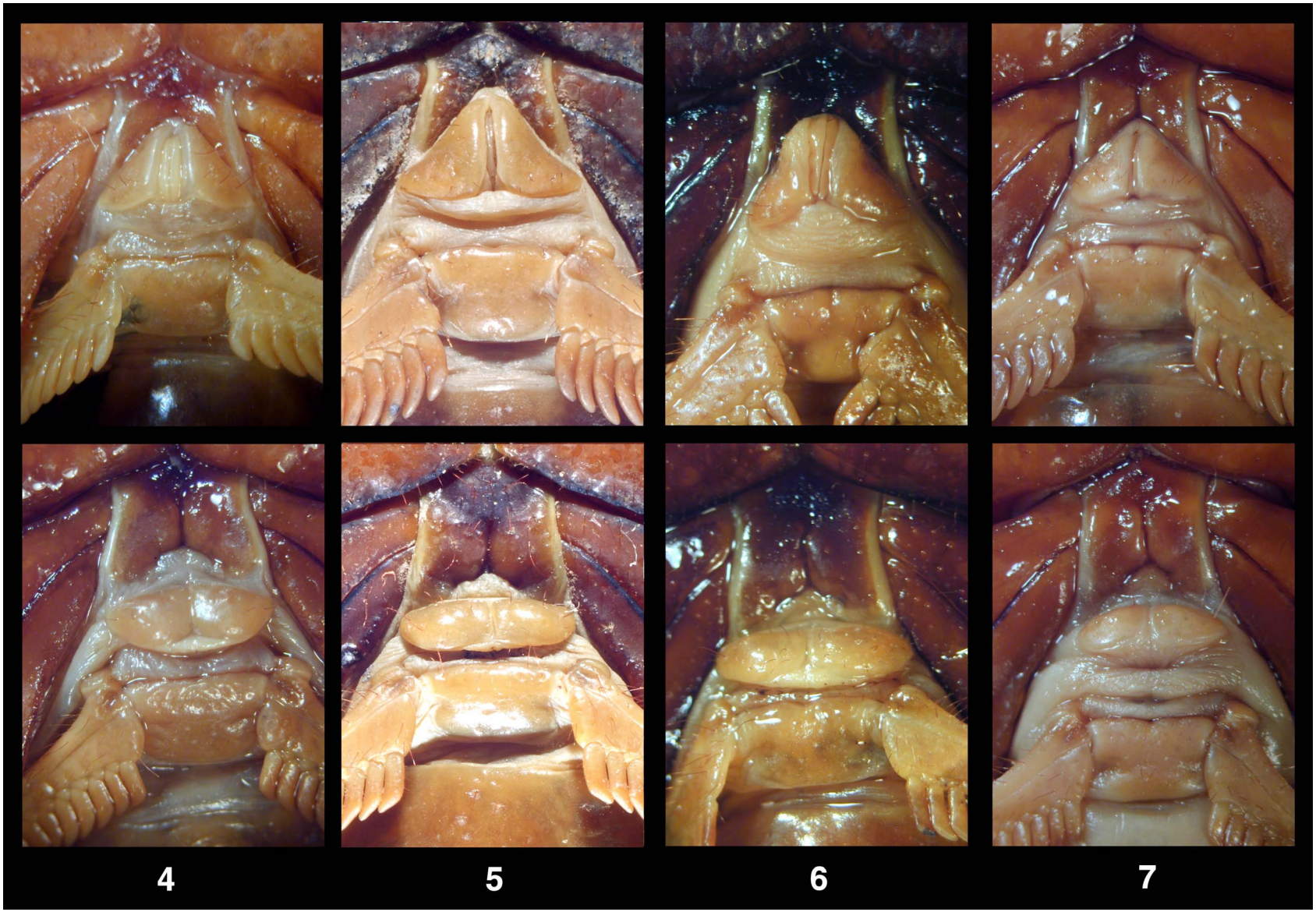
Figure 3: Genital operculum and pectinal basal piece (35x) of *Iurus asiaticus*, adult female, 4 km east of Kaşlıca Village, Adıyaman, Turkey. Note the wide genital operculum with sclerites fused medially.

(1864–1929), a German zoologist, was also a dealer who supplied scorpions to the museums; his other specimens of *Iurus* without any exact label exist in ZMHB (see Material Examined) and BMNH ("Mersina", 95-11.9.14; J. Beccaloni, pers. comm).

Systematics

The systematics of superfamily Iuroidea has been discussed in detail in four recent papers: (1) Soleglad & Fet (2003b), a high-level cladistic analysis of extant scorpions, where Iuroidea was originally declared; (2) Fet et al. (2004), an analysis of the leg tarsal spination of Iuroidea, where a key to all six genera was provided and genus *Hoffmannihadrurus* was described; (3) Fet & Soleglad (2008), a cladistic analysis of Iuroidea with an emphasis on subfamily Hadrurinae, where *Hoffmannihadrurus* was reestablished; and (4) Fet, Soleglad & Kovařík (2009), a systematic revision of the genus *Calchas*, where two new species were described.

Order **SCORPIONES** C. L. Koch, 1850
Suborder Neoscorpiones Thorell et Lindström, 1885
Infraorder Orthosterni Pocock, 1911
Parvorder Iurida Soleglad et Fet, 2003
Superfamily Iuroidea Thorell, 1876
Family Iuridae Thorell, 1876



Figures 4–7: Sternum, genital operculum, and pectinal basal piece of *Iurus* male (top) and female (bottom). **4.** *I. dufoureius*, Kurtaina, Greece (male); Nedontas River, between Artemisia and Kalamata, Greece (female neotype). **5.** *I. kinzelbachi*, **sp. nov.**, Dilek Peninsula, Aydın, Turkey. **6.** *I. kraepelini*, Akseki, Antalya,Turkey. **7.** *I. kadleci*, **sp. nov.**, Akseki, Antalya,Turkey.

Genus *Iurus* Thorell, 1876

Iurus Thorell, 1876: 11; type species by original designation *Iurus granulatus* (C. L. Koch, 1837) [= *Iurus dufoureius* (Brullé, 1832)].

Synonyms:

Chaerilomma Roewer, 1943: 237–238; type species *Chaerilomma dekanum* Roewer, 1943 [= *Iurus dufoureius* (Brullé, 1832)] (synonymized by Vachon, 1966a: 453–461).

References (selected):

Iurus: Thorell, 1877: 193; Pavesi, 1878: 360; Simon, 1879: 115; Kraepelin, 1894: 183; Kraepelin, 1899: 178; Werner, 1902: 605; Borelli, 1913: 2; Caporiacco, 1928: 240; Werner, 1936b: 17; Menozzi, 1941: 234; Gruber, 1963: 308; Gruber, 1966: 424; Vachon, 1966a: 453; Vachon, 1966b: 215; Stahnke, 1974: 114; Vachon, 1974, fig. 141, etc.; Kinzelbach, 1975: 21; Francke, 1981: 221; Kinzelbach, 1982: 58; Kinzelbach, 1985: Map IV; Vachon & Kinzelbach, 1987: 102; Kovařík, 1992: 185; Kritscher, 1993: 381; Crucitti, 1995a: 1; Crucitti, 1995b: 91; Crucitti, 1998: 31; Crucitti & Malori, 1998: 133; Kovařík, 1998: 136; Crucitti, 1999a: 87; Crucitti, 1999b: 251; Kovařík, 1999: 40; Fet, 2000: 49; Fet & Braunwalder, 2000: 18; Sissom & Fet, 2000: 419; Crucitti & Cicuzza, 2001: 227; Karataş, 2001: 14; Stathi & Mylonas, 2001: 290; Kovařík, 2002: 16; Fet et al., 2004: 18; Kovařík & Whitman, 2005: 113; Parmakelis et al., 2006: 253; Facheris, 2007a: 1; Facheris, 2007b: 1; Koç & Yağmur, 2007: 57; Fet & Soleglad, 2008: 256; Francke & Prendini, 2008: 218; Kaltsas, Stathi & Fet, 2008: 228; Soleglad, Kovařík & Fet, 2009: 2; Yağmur, Koç & Akkaya, 2009: 154.

Jurus (incorrect subsequent spelling): Karsch, 1879: 101; Karsch, 1881: 90; Simon, 1884: 351; Kraepelin, 1894: 183; Birula, 1898: 135; Birula, 1903: 297; Penther, 1906: 62; von Ubisch, 1922: 503; Werner, 1934a: 162; Werner, 1934b: 282; Werner, 1937: 136; Werner, 1938: 172; Vachon, 1947a: 162; Vachon, 1947b: 2; Vachon, 1948: 62; Vachon, 1951: 343; Vachon, 1953: 96.

Distribution. GREECE: mainland: Peloponnese; islands: Crete, Fourni, Gavdos, Karpathos, Kasos, Kithyra, Megisti, Rhodes, Samos, Saria. TURKEY (Anatolia): Adana, Adıyaman, Antalya, Aydın, Isparta, İzmir, Kahramanmaraş, Karaman, Konya, Mersin, Muğla, and Niğde Provinces.

Diagnosis

General appearance. Large-sized scorpion (85–100 mm); generally dark grey to black in color; chelae elongate, robust and carinated, exaggerated lobe found on movable finger in males; metasoma with well-developed carinae, dorsal carinae highly serrated; telson elongate, vesicle-aculeus juncture subtly defined, vesicle ventral surface covered with setae. Pectinal tooth counts 10–16 in males, 7–14 in females. Carapace granular, with deep narrow indentation; median eyes and tubercle small, located on anterior three-eighths; three lateral eyes; mediolateral ocular carinae strongly developed.

Important taxonomic characters. Tibial spurs absent on legs III–IV; leg tarsus ventral surface with single row of densely populated spinule clusters, terminating in an enlarged pair of distal clusters. Femoral trichobothrium *d* located on external surface; *e* located slightly distal of *d*; chelal trichobothrium *db* positioned at fixed finger midpoint; *Db* located ventrally of external (*E*) carina, in line with *Eb* series; patellar trichobothrium *i* located on internal surface, adjacent to *DI* carina. Prepectinal plate absent in female. Stigma medium to long, slit-like in shape. Large conspicuous ventral accessory (*va*) denticle of cheliceral movable finger located at finger midpoint; vestigial serrula present on juveniles and subadults, essentially absent in adults. Hemispermatophore lamina elongate with non-spatulate, pointed terminus; lamellar internal base lacking triangular protuberance; capsular area with strongly developed acuminate process with truncated tip. Chelal finger median denticle (*MD*) groups number 14–16; inner denticles (*ID*) 11–16. Patellar dorsal (DPS) and ventral (VPS) spurs strongly developed and conspicuously doubled.

Detailed Analysis of Morphology at Genus Level

Here, we describe basic morphology specific to genus *Iurus*. The species assignments are as accepted further in this paper. Since the second iurid genus, *Calchas*, has been revised recently (Fet, Soleglad & Kovařík, 2009), we can now contrast *Iurus* with *Calchas* in great detail for all morphology described below, which follows each structure analysis subsection.

Carapace

The carapace of *Iurus* is characterized by its conspicuous anterior emargination and exaggerated mediolateral ocular carinae (Fig. 1). In general, the entire surface of the carapace is covered with various sized granules, the larger found on the anterior half. There are exceptions, however, within the five species; the interocular area is partially smooth in *I. asiaticus* and *I. kraepelini*.

Three lateral eyes are present in all species, the most posterior eye smaller than the others. Close-up views of

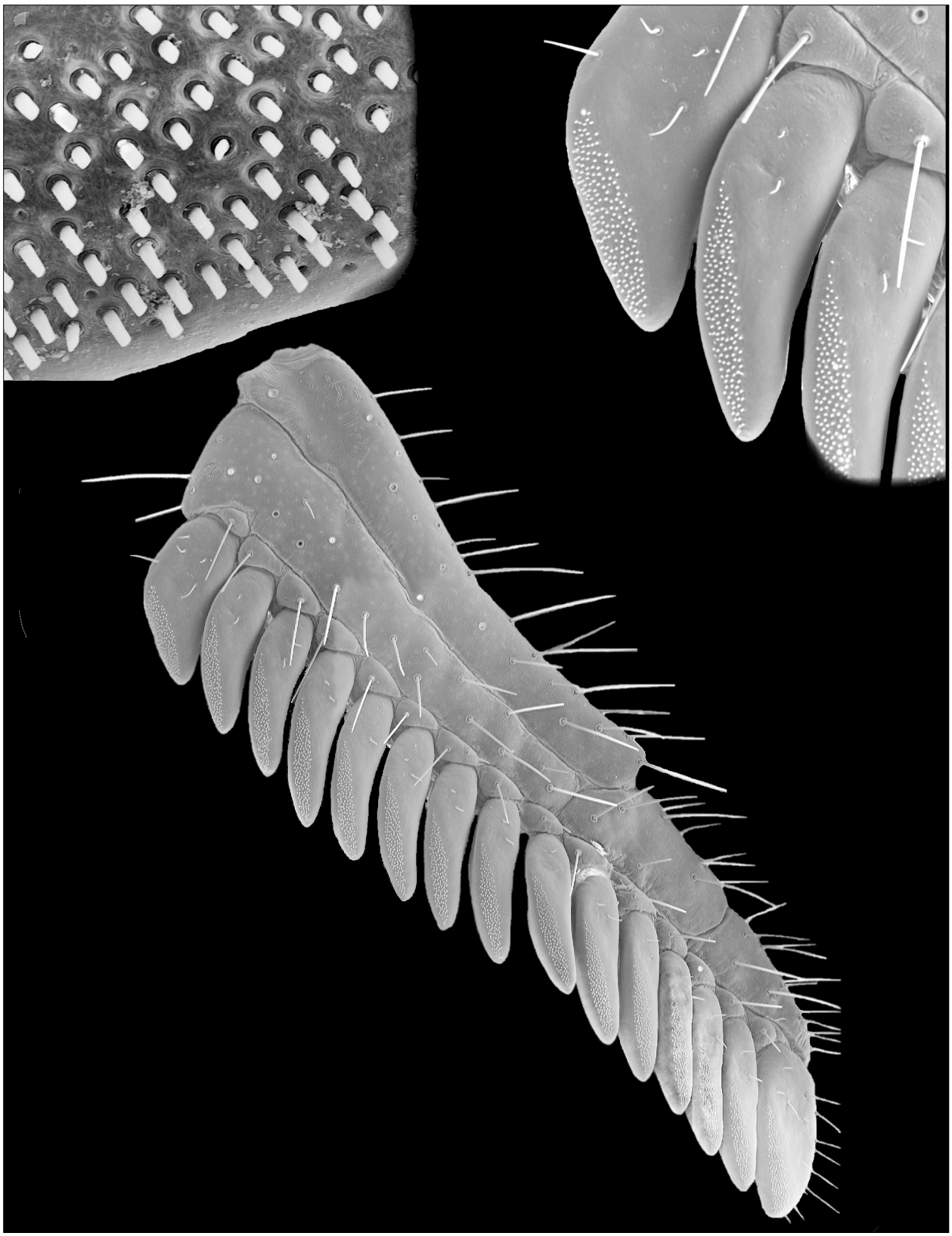


Figure 8: Pecten (35x), close-up of basal teeth (100x), and close-up of peg sensilla of basal tooth (500x) of *Iurus kraepelini*, juvenile male, Akseki, Antalya, Turkey.

Figure 9: Pecten (35x) and close-up (75x) of peg sensilla of *Iurus dufoureius*, subadult female, Krini, Gythio, Laconia, Greece.

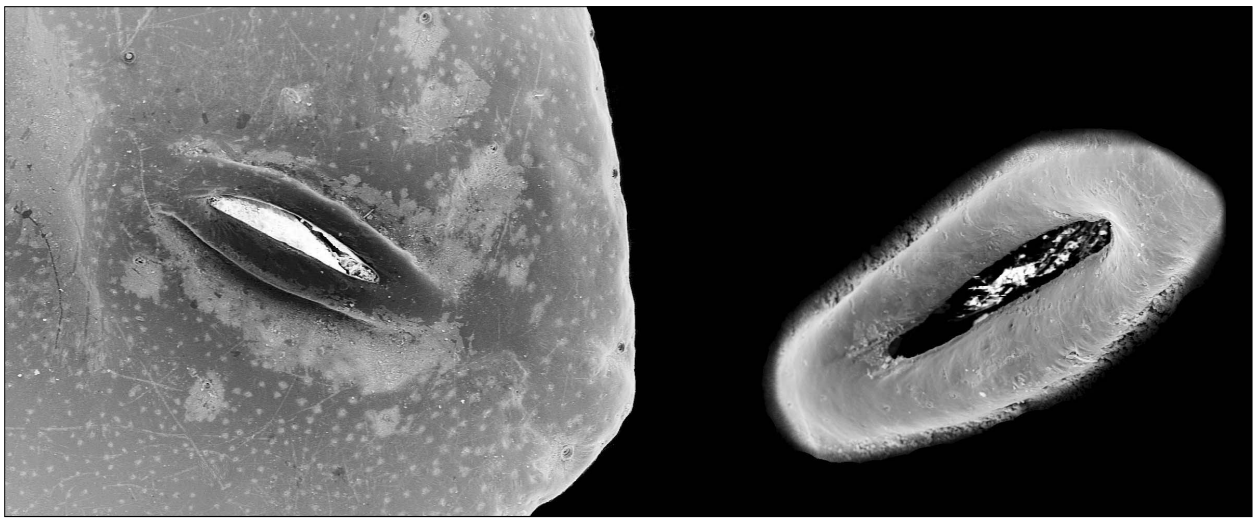


Figure 10: Stigma, *Iurus dufoureius*, subadult female, Krini, Gythio, Laconia, Greece**. Left.** Left stigma III. **Right.** Close-up of right stigma IV.

the eyes for *I. dufoureius* and *I. asiaticus* are shown in Fig. 1. The median tubercle and eyes are relatively small, with the ratio of median tubercle width / carapace width (at that point) ranging 0.134–0.164 (0.147) [5]. The median eyes are situated anteriorly with the median tubercle position / carapace length ranging 0.346–0.402 (0.375) [5].

The anterior emargination and mediolateral ocular carinae of the carapace were first defined as diagnostic of Iuridae by Fet et al. (2004: 23, figs. 53, 54) and presented as characters in their cladistic analysis of Iuroidea (Fet & Soleglad, 2008: character 23 (state=1), character 24 (state=1)) where both were synapomorphies for Iuridae.

Comparison to *Calchas*. As stated above, both *Iurus* and *Calchas* exhibit anterior emarginations and developed mediolateral ocular carinae. Both of these characters, however, are much more exaggerated in *Iurus*, whereas in *Calchas* they are less developed. Both genera have relatively small median eyes and tubercle, their width ratios essentially the same. The median eyes are situated more anteriorly in *Calchas*, with a length ratio of 0.241–0.310 (0.289) [7] (Fet, Soleglad & Kovařík, 2009: 9), exhibiting a mean value difference (MVD) of 30 %. *Iurus* has three lateral eyes per side whereas *Calchas* has only two (interestingly, at one time, this difference was used to place these two genera into separate families!).

Mesosoma

The *Iurus* **sternum** (Fig. 2) conforms to the type 2 sternum as defined by Soleglad & Fet (2003a). This structure is typically longer than wide (*I. dufoureius* is an exception) with a well-defined posterior emargination forming two convexed lateral lobes. The apex is not particularly deep or offset from the lobes. The sternum tapers anteriorly. Of particular interest, a membraneous plug is present between posterior region of the lateral lobes in female *Iurus*, typically vestigial or absent in the male (Figs. 3–7). The entire sternocoxal area of *I. kraepelini* is illustrated in Soleglad & Fet (2003a: fig. 8; referred to as *I. dufoureius*).

The **genital operculum** exhibits considerable sexual dimorphism in *Iurus*. In the female, the individual sclerites are much wider than long and are fused medially most of their length (all five species are illustrated in Figs. 3–7, and all five species, male and female, are illustrated under the individual species descriptions). In the male, each sclerite is subtriangular in shape, roughly as long or longer than wide, and the sclerites are separated most of their length. In addition, in the male, well-developed **genital papillae** (Fig. 2) are visible between the two plates, but not extending posteriad of the operculum. Fet & Soleglad (2008: character 10 (state=0)) hypothesized this genital papillae configuration (as found in *Iurus*) as symplesiomorphic for family Iuridae; i.e. the same configuration as in the outgroup *Chaerilus* (parvorder Chaerilida).

The **pectines** in *Iurus* are fully developed, exhibiting all major substructures common to most scorpions (Figs. 8, 9). Three anterior lamellae are present, the most basal one significantly longer than the middle and distal lamellae. Middle lamellae, if present, are marginally formed. Well-developed fulcra are present between the inner bases of pectinal teeth. The pectinal teeth are well-developed in *Iurus*, exhibiting well-defined sensorial areas on their inner distal edges. The sensorial areas are densely populated with peg sensilla, which are shaped as uniform, elongated cylin-

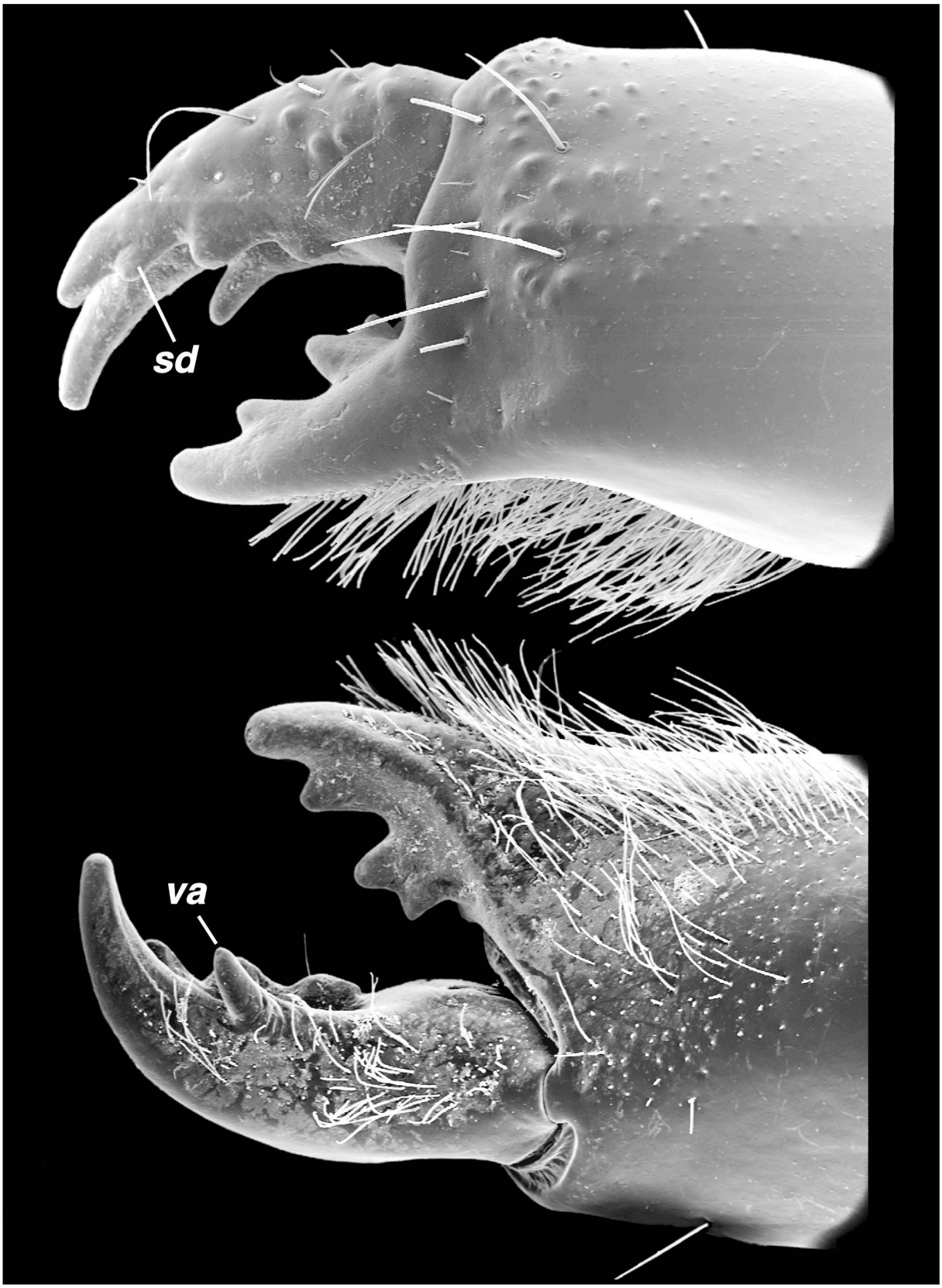


Figure 11: Chelicera (35x), *Iurus dufoureius*, subadult female, Krini, Gythio, Laconia, Greece. Dorsal view (top, left chelicera reversed), ventral view (bottom, right chelicera). Diagnostic large midfinger placed ventral accessory (*va*) denticle and large single subdistal (*sd*) denticle indicated.

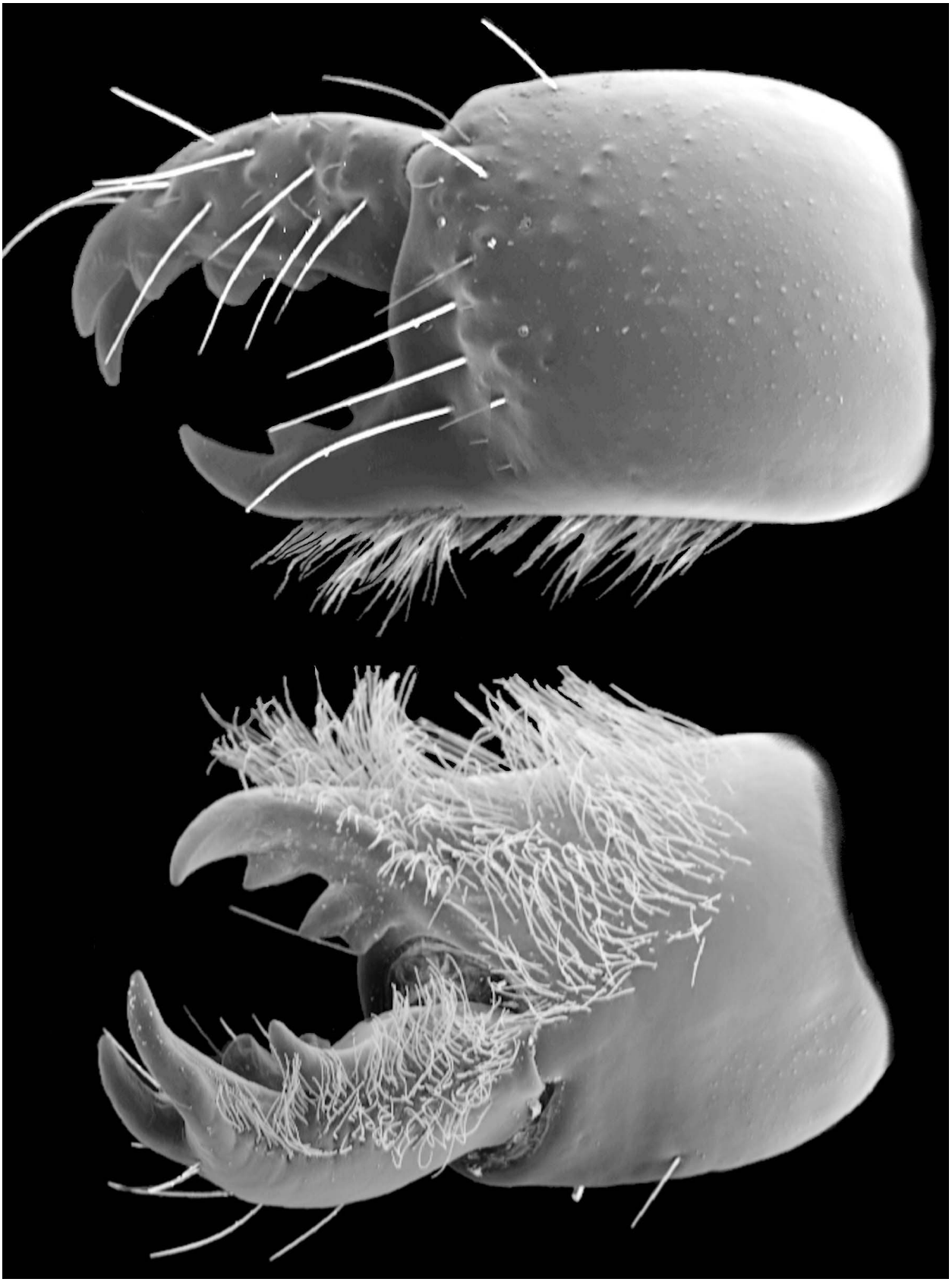


Figure 12: Chelicera (35x), *Iurus kraepelini*, juvenile male, Akseki, Antalya, Turkey. Dorsal view (top, left chelicera reversed), ventral view (bottom, right chelicera).