Euscorpius

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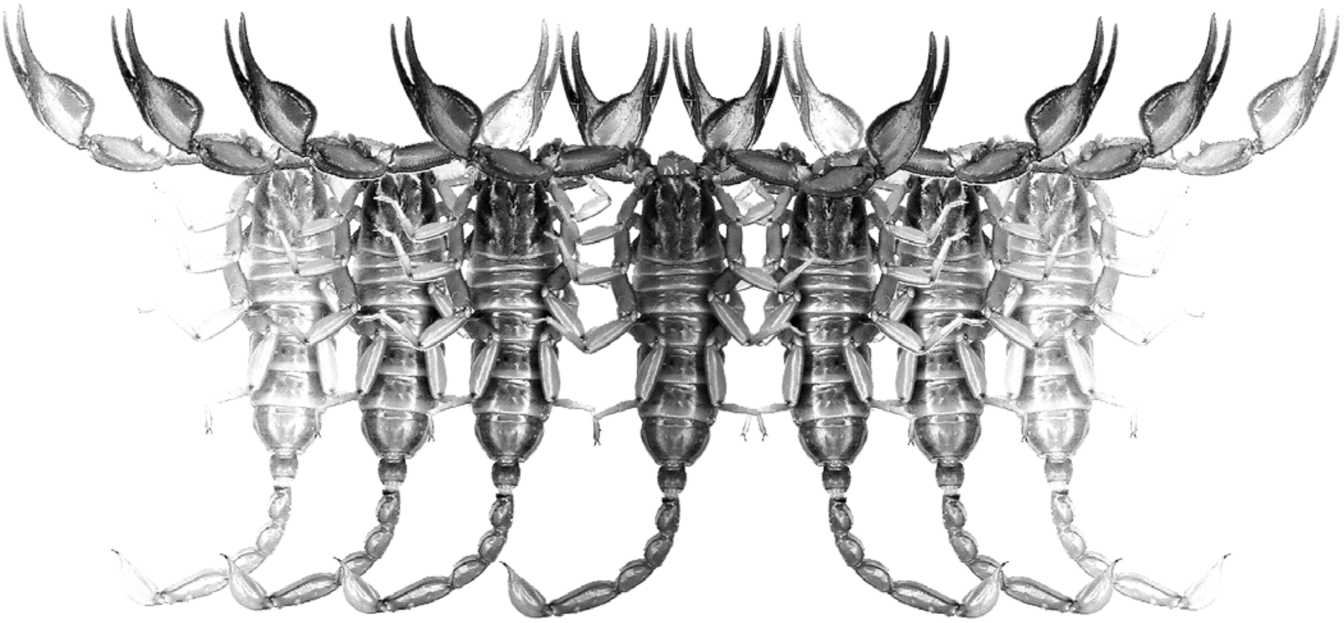

Etudes on Iurids, II. Revision of Genus *Calchas* Birula, 1899, with the Description of Two New Species (Scorpiones: Iuridae)

Victor Fet, Michael E. Soleglad & František Kovařík

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- **MCZ**, Museum of Comparative Zoology, Cambridge, Massachusetts, USA
- **MNHN**, Museum National d'Histoire Naturelle, Paris, France
- **NMW**, Naturhistorisches Museum Wien, Vienna, Austria
- **BMNH**, British Museum of Natural History, London, England, UK
- **MZUC**, Museo Zoologico "La Specola" dell'Universita de Firenze, Florence, Italy
- **ZISP**, Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia
- **WAM**, Western Australian Museum, Perth, Australia
- **NTNU**, Norwegian University of Science and Technology, Trondheim, Norway
- **OUMNH,** Oxford University Museum of Natural History, Oxford, UK

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Etudes on iurids, II. Revision of genus *Calchas* Birula, 1899, with the description of two new species (Scorpiones: Iuridae)

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Summary

The relict, phylogenetically important scorpion genus *Calchas* Birula, 1899 (Iuridae) remained monotypic since its description. Its sole species, *Calchas nordmanni* Birula, 1899, was known only from northeastern Turkey until Kinzelbach (1980) published first records from southern and southeastern Turkey. A few more localities have been reported from Turkey; the species was also found on two Greek islands, Samos and Megisti. We analyzed significant material (63 specimens, including a previously unpublished large series from Naturhistorisches Museum Wien), and concluded that *three* distinct, disjunct species exist rather than one widespread species as previously thought. Two new species are described: *Calchas birulai* **sp. nov.** (southeastern Turkey, northern Iraq; 30 specimens studied) and *Calchas gruberi* **sp. nov.** (southern Turkey; Megisti Island and Samos Island, Greece; 23 specimens studied). The type species *Calchas nordmanni* Birula, 1899 (10 specimens studied) is restricted to northeastern Turkey.

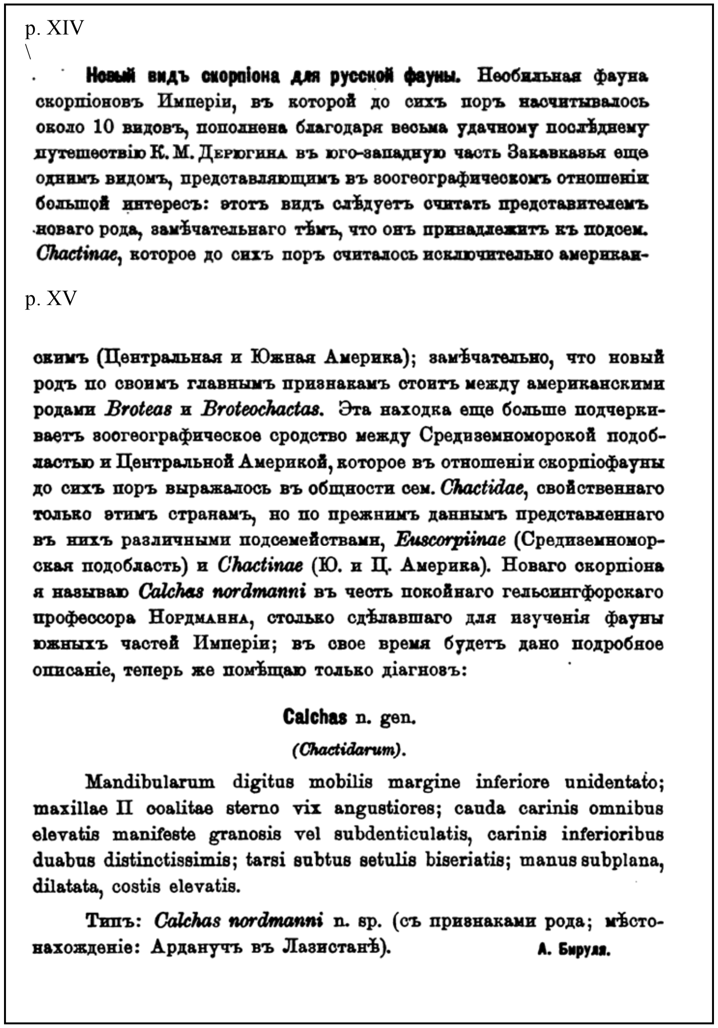
Introduction

The scorpion genus *Calchas* Birula, 1899 has attracted considerable attention due to its phylogenetic position. Along with its sister genus *Iurus*, it comprises family Iuridae Thorell, 1876, one of the most basal families of parvorder Iurida (Soleglad & Fet, 2003b; Fet & Soleglad, 2008), and possesses a unique combination of ancestral and derived features. *Calchas* has been often discussed in systematic, biogeographic, and phylogenetic contexts for over 100 years (Birula, 1899, 1900, 1905, 1912, 1917a, 1917b; Werner, 1934; Vachon, 1971, 1974; Kinzelbach, 1975, 1980; Francke & Soleglad, 1981; Fet & Braunwalder, 2000; Stathi & Mylonas, 2001; Soleglad & Fet, 2003b; Fet et al., 2004; Fet & Soleglad, 2008; Kaltsas et al., 2008).

Birula's original brief description of genus *Calchas* and species *C. nordmanni* (Birula, 1899) is reproduced and translated here (Fig. 1). It included a diagnosis in Latin and comments in Russian, justifying original placement in Chactidae (from which it, however, differed so much that a separate monotypic subfamily Calchinae was created for this genus later by Birula, 1917a). This publication, and the subsequent detailed description (Birula, 1900) were based only on two syntype females collected by Konstantin Deryugin in Ardanuç (now Artvin Province, Turkey) in July 1898 (see Deryugin, 1899, for the details of this collection trip). This area (Çoruh River watershed) yielded not less than 15 additional specimens, collected by Russian naturalists (E. König, B. Lindholm, P. Nesterov, and Yu. Voronin) between 1904 and 1911 (Table 1, Fig. 2). All of these specimens were collected within the erstwhile Russian Empire, some along the border with the Ottoman Empire.

At least 11 or 12 of these specimens were kept by Alexei A. Birula in St. Petersburg, Russia (ZISP). Nothing was known about the fate of Birula's collection for a long time. Although Vachon (1971) loaned and redescribed a single male from ZISP, Kinzelbach (1980) suggested that most of Birula's specimens were lost. However, Fet (1989a, 1989b) confirmed existence of syntypes (two subadult females from Ardanuç, coll. K. Deryugin, ZISP 942). Our Fig. 2 presents a copy from Birula's original handwritten log book still kept in ZISP along with the Birula's surviving collection (courtesy Viktor Krivochatsky). The first two entries in this list (ZISP 942, 943) are in A. A. Birula's own hand. At least five of Birula's specimens, including two syntypes, are still deposited in ZISP. Specimens ZISP 1393, 1394 and 1395 (the adult male studied by Vachon, 1971) are in alcohol, and two syntypes ZISP 942 are dry. A large lot ZISP 943 (B. Lindholm leg.) could not be found (Viktor Krivochatsky, pers. comm., 2008).

In addition, some specimens of *C. nordmanni* studied by Birula belonged to the Caucasian Museum in Tiflis, now Georgian National Museum, Tbilisi, Georgia (GNM). The Georgian researchers (Vera Pkhakadze, pers. comm., 2009) report that this museum still has, in alcohol, at least 12 specimens of *C. nordmanni* from the



p. XIV

Новый видъ скорпіона для русской фауны. Необильная фауна скорпіоновъ Имперіи, въ которой до сихъ поръ насчитывалось около 10 видовъ, пополнена благодаря весьма удачному послѣднему путешествію К. М. Дерюгина въ юго-западную часть Закавказья еще однимъ видомъ, представляющимъ въ зоогеографическомъ отношеніи большой интересъ: этотъ видъ слѣдуетъ считать представителемъ новаго рода, замѣчательнаго тѣмъ, что онъ принадлежитъ къ подсем. *Chactinae*, которое до сихъ поръ считалось исключительно американ-

p. XV

скимъ (Центральная и Южная Америка); замѣчательно, что новый родъ по своимъ главнымъ признакамъ стоитъ между американскими родами *Broteas* и *Broteochactas*. Эта находка еще больше подчеркиваетъ зоогеографическое сродство между Средиземноморской подобластью и Центральной Америкой, которое въ отношеніи скорпіофауны до сихъ поръ выражалось въ общности сем. *Chactidae*, свойственнаго только этимъ странамъ, но по прежнимъ даннымъ представленнаго въ нихъ различными подсемействами, *Euscorpiinae* (Средиземноморская подобласть) и *Chactinae* (Ю. и Ц. Америка). Новаго скорпіона я называю ***Calchas nordmanni*** въ честь покойнаго гельсингфорскаго профессора Нордманна, столько сдѣлавшаго для изученія фауны южныхъ частей Имперіи; въ свое время будетъ дано подробное описаніе, теперь же помѣщаю только діагнозъ:

Calchas n. gen.
(*Chactidarum*).

Mandibularum digitus mobilis margine inferiore unidentato; maxillae II coalitae sterno vix angustiores; cauda carinis omnibus elevatis manifeste granosis vel subdenticulatis, carinis inferioribus duabus distinctissimis; tarsi subtus setulis biseriatis; manus subplana, dilatata, costis elevatis.

Типъ: ***Calchas nordmanni*** n. sp. (съ признаками рода; мѣстонахожденіе: Ардanучъ въ Лазистанѣ).

А. Бируля.

p. XIV

A new species of scorpions for the Russian fauna. A scarce scorpion fauna of the Empire, which hitherto comprised about 10 species, has been supplemented, due to a quite lucky recent travel by K. M. Deryugin to the southwestern portion of Transcaucasia, by one more species, quite interesting in zoogeographical context; this species should be considered a representative of a new genus, remarkable since it belongs to the subfamily *Chactinae*, hitherto considered to be exclusively American

p. XV

(Central and South America); it is remarkable that the new genus in its main characters is positioned between the american genera *Broteas* and *Broteochactas*. This finding further emphasizes the zoogeographical affinity between the Mediterranean Subregion and Central America, which in scorpiofauna hitherto was expressed in their common family Chactidae, found only in those lands, but previosuly represented there by different subfamilies, *Euscorpiinae* (Mediterranean Subregion) and *Chactinae* (S. and C. America). The new scorpion is named by me *Calchas nordmanni* in honor of the late Professor Nordmann of Helsingfors, who did so much for the study of the fauna of the southern parts of the Empire; its detailed descritpion will be given in due time, while now I submit only a diagnosis:

Calchas n. gen.
(*Chactidarum* [*Chactidae*])

Inferior margin of movable finger of mandibles [chelicerae] with one tooth; maxillae II [gnathobases] more narrow than sternum; all carinae on cauda [metasoma] elevated, granular, in part denticulate; two distinct inferior carinae; tarsi ventrally with two rows of short setae; chela manus flattened, wide, with elevated carinae.

Type: ***Calchas nordmanni*** n. sp. (with the characters of the genus); locality: Ardanuç in Lasistan).

A. Birula

Figure 1: Original description of *Calchas* (Birula, 1899). **Left**. Text in Russian, diagnosis in Latin. **Right**. English translation.

material studied and published by Birula (1905, 1912, 1917a, 1917b) (Table 1).

Two wonderful books by Birula (1917a, 1917b), available in English translations since the 1960s, are still an important source for an extended description and scarce details on locality and life history of *Calchas nordmanni* in northeastern Turkey.

The genus has remained monotypic since its description. Its sole species, *Calchas nordmanni* Birula, 1899, has been for a long time known only from a limited area, which until 1917 belonged to the Russian Empire. This area (now within Artvin and Erzurum Provinces, northeastern Turkey) was among the territories ceded by Russia to Turkey by the Treaty of Brest-Litovsk in 1918, later confirmed by the Treaty of Kars in 1921. *Calchas nordmanni* has never been found in the adjacent Georgia (before 1991, the USSR) (Fet, 1989a, 1989b; Sissom & Fet, 2000), although a number of sources claimed so (e.g. Rikhter, 1945; Vachon & Kinzelbach, 1987).

It seems that until 1971 no European author realized that this genus inhabits Turkey; it was never included in the reviews of Turkish fauna published by Vachon (1947a, 1947b, 1951, 1966) and Tolunay (1959). Meanwhile, the entire known range of *Calchas* was within Turkey since 1918; however, both Werner (1934) and Millot & Vachon (1949) loosely referred to *Calchas* without a country reference, as inhabiting “Transcaucasia”. The term was usually used to designate the combined area of Armenia, Azerbaijan, and Georgia (now independent countries; “republics” of the USSR before 1991).

Vachon (1971) for the first time listed *Calchas* as present in Turkey; he also was the first European researcher to see a specimen. Using modern systematic criteria, especially trichobothrial patterns, Vachon provided a detailed redescription of one of the Birula’s specimens, loaned from Russia (an adult male from Artvin, ZISP 1395, see Fig. 2). This important paper, with beautiful artwork by Maurice Gaillard that always accompanied Vachon’s works, was published in Russian (with French summary) in a central Russian journal, *Entomologicheskoe Obozrenie* (translated from French, which explains a few typos and some unusual deviant terminology), It was also almost simultaneously published in English as *Entomological Review*, with the text translated again from the Russian (the original French text was never published!). Vachon (1971) observed for the first time that *Calchas* (then placed in Chactidae) is very close to *Iurus* (then placed in Vaejovidae). This study also allowed for the incorporation of *Calchas* into Vachon’s monumental study of trichobothrial patterns in scorpions (Vachon, 1974).

Birula (1917b: 156) was correct when he predicted: “The scorpion fauna of Asia Minor is still too little known to allow the determination of the western and southern boundaries of the range of *Calchas nordmanni*.” However, no new additional records of *Calchas* were published between 1917 and 1980. Kinzelbach (1975: 28) first indicated that new specimens of *Calchas nordmanni* from Turkey existed in European collections (ZMUH). Later, he (Kinzelbach, 1980) published not only additional records from the northeast (Tortum and Yusufeli) but also was the first to report widely disjunct records of *C. nordmanni* from both southern Turkey (Kumluca in Antalya Province) and southeastern Turkey (Siirt). Another new record from Urfa (now Şanlıurfa, southeastern Turkey) was added by Kinzelbach (1982).

Francke & Soleglad (1981) reestablished family Iuridae, and demonstrated that *Calchas* and *Iurus* are sister genera, therefore removing *Calchas* from Chactidae. They examined, however, only a single, previously unpublished female of *Calchas* (MNHN RS 6452, loaned to O. Francke, reexamined here), collected by Jean Garzoni in 1971 in “Bilejdik”. This locality is not entirely clear. A map of Kinzelbach (1985), reproduced by Vachon & Kinzelbach (1987, fig. 6) and Fet & Braunwalder (2000), shows it as a very disjunct population in Bilecik (or Biledjik), a provincial center in northwestern Turkey (west from Bursa). This MHHN specimen was also seen and its locality listed as “Biledjik” by Kamenz & Prendini (2008). At the same time, Vachon & Kinzelbach (1987: 99) use a different spelling when they report finding *Calchas* “in the region of Birecik as well as in region of Antalya”. Now, Bi**rec**ik (but not Bi**lec**ik!) is in southeastern Turkey (an ancient Birtha on Euphrates) and falls well within the range of *Calchas* discussed in the present paper. Crucitti & Vignoli (2002: 459) first commented on this confusion. Wilson Lourenço (pers. comm., 2008) informed us that Garzoni indeed collected along the Syrian border in the southeastern Turkey. We therefore consider the provenance of MNHN RS 6452 female as Birecik (Şanlıurfa Province), and include this specimen among the paratypes of *C. birulai* **sp. nov.** (see below). Prof. Ragnar Kinzelbach (pers. comm., May 2009) confirms that the published locality of *Calchas* in Bilecik (northwestern Turkey) was an error, and should indeed read Birecik. An additional specimen from the environs of Birecik (across Euphrates in Gaziantep Province) has been studied here (see below and Fig. 58).

Sissom (1988) reported a single specimen of *Calchas nordmanni* (as *Paraiurus nordmanni*), collected on 23 April 1979 on the Greek island of Samos by the Polish malacologist Adolf Riedel. We examined the Samos specimen (FMNH) and verified Sissom’s placement in *Calchas* (see below). This disjunct locality was, however, doubted by Kaltsas et al. (2008: 227) since D. Kaltsas did not find *Calchas* in the specified locality during his regular visits to Samos between 2006 and 2008, including the exact label locality (south slope of Mt Spiliani). At the same time, other Riedel material

REFERENCE	SPECIMENS & RECORDS	SPECIES as established in this paper
Birula, 1899: XIV–XV (in Russian, diagnosis in Latin, without figures)	Genus and species diagnosis (see Fig. 1); type locality: Russian Empire, "Southwestern Transcaucasia", "Ardanuç in Lasistan"; no information on type specimens.	*Calchas nordmanni* Birula, 1899
Birula, 1900: 252–256 (in German, without figures). *Note*: in all Birula's specimen labels, a date in parentheses refers to European (new, Gregorian) calendar; date outside parentheses refers to the old (Julian) calendar used in Russia before 1918. The difference between two calendars was 12 days in the 19th century, and 13 days in the 20th).	The first detailed description of *female syntypes*: Russian Empire, Batum Province, Lasistan [now Turkey, *Artvin Province*], Çoruh River, Ardanuç, in houses, 5(17) July 1898, 2 ♀ subad. (ZISP 942), K. M. Deryugin leg. See Deryugin (1899) for the first-hand report of his Çoruh expedition. Existence of these specimens has been first confirmed in print by Fet (1989a, 1989b); see also Fig. 2.	*Calchas nordmanni* Birula, 1899
Birula, 1905: 130–131 (in German, without figures)	The first description of a single *male* (which does not belong to the type series), 1 ♂ ad. (GNM 212), Kars Province [now Turkey, *Erzurum Province*], Oltu District, N of Oltu, border post Erük [now Örik], 30 May (12 June) 1904, E. König leg. This specimen still exists in GNM (Vera Pkhakadze, pers. comm.. 2009).	*Calchas nordmanni* Birula, 1899
Birula, 1911: 175–177, figs. 2–3 (in German)	A new series of 10 specimens from Batum Province [now Turkey, *Artvin Province*]: 2 ♀ ad., 1 ♂ ad., 2 ♂ juv., 5 ♀ juv., Lomashen (Lomasheni) near Artvin, 10 (23) June 1909, P. V. Nesterov leg. The first illustration of genital area emphasizing prepectinal plate of female (fig. 3) and its absence in male (fig. 2). Of all these specimens, only one is preserved (ZISP 1342, see Fig. 2).	*Calchas nordmanni* Birula, 1899
Birula, 1912: 124 (in German, without figures)	Another new series of 10 specimens from the Caucasian Museum in Tiflis (now GNM, Tbilisi, Georgia) from the environs of Artvin (Khakhauch, Lomashen, Svetibar), and Oltu (Anzov). The important adult male from Lomashen ([Lomasheni, 5 km E of Artvin], July 1911, Yu. N. Voronov leg.) exists as ZISP 1395 (see Fig. 2; redescribed by Vachon, 1971). At least 8 other specimens (from Khakhauch, Svetibar, and Anzov) still exist in GNM (label data by Vera Pkhakadze, pers. comm.. 2009, and reconstructed from Birula, 1912, 1917b, and other sources): Russian Empire, Batum Province [now Turkey, *Artvin Province*]: 1 ♀ ad., 1 ♀ subad., 1 ♀ juv. (GNM 243, two specimens exist), Khakauch, Keniya Mts., left bank of Çoruh River, SE Artvin, July 1911, Yu. N. Voronov leg.; 3 ♀ juv., 1 ♂ juv., 1 ♀ pull. (GNM 211) Svetibar [Svetibari] near Artvin, July 1911, Yu. N. Voronov leg.; Kars Province [now Turkey, *Erzurum Province*], 1 ♀ juv. (GNM 519), Oltu District, Anzov [now Anzav], 24 August (6 September) 1905, E. König leg. (Birula, 1912: 124; 1917a: 149; 1917b: 154).	*Calchas nordmanni* Birula, 1899
Birula, 1917a: 138–153, figs. 11–15; Birula, 1917b: 143–159, pl. II, figs. 1–9, pl. IV, figs. 1–2 (original books in Russian, both available also in English translation).	Two 1917 books summarized all information on *Calchas nordmanni* studied by Birula since 1899; all this material originated from Batum or Kars Provinces of the Russian Empire (now Artvin and Erzurum Provinces of Turkey). Birula (1917b: 144) published a list of ZISP collection which then included 17 specimens: 2 ♀ syntypes from Ardanuç; a series of 9 (not 10 as in Birula, 1911) specimens from a Lomashen collected by P. V. Nesterov in 1909 (see above), plus the following new material collected in 1910–1911: Batum Province [now Turkey, *Artvin Province*]: 1 ♀ ad., Çoruh River, near Borçka Village, 15 (28) May 1910, P. V. Nesterov leg.; 1 ♂ juv., 2 ♀ juv., ear Artvin, 29 May (11 June) 1912, 1 ♀ ad., B. Lindholm leg.; Kars Province [now Turkey, *Erzrurum Province*]: 1 ♂ juv., Oltu District, near Oltu, 12 (25) July 1910, P. Nesterov leg. Of these 17 specimens, only four still exist in ZISP collection (ZISP 942, 1393, 1394). It also includes 1 ♂ (ZISP 1395) from Artvin (1911, Voronov leg., originally listed by Birula, 1912: 124 for the Caucasian Museum), redescribed by Vachon (1971). See Fig. 2 for further details.	*Calchas nordmanni* Birula, 1899

Vachon, 1971: 406–408, figs. 1–12	1 ♂ (ZISP 1395), from Artvin, redescribed (collector's name misspelled as "N. Voronin"); see Fig. 2 and also Birula (1912, 1917a, 1917b).	*C. nordmanni* Birula, 1899
Kinzelbach, 1980: 169–174, figs. 1–5	Turkey, *Artvin Province*, Yusufeli, 30 April 1971 (ZMUH), C. Kosswig leg.; *Erzurum Province*: 1 ♀ (ZMUH), Tortum, 1970, C. Kosswig leg. (Kinzelbach, 1980, figs. 3–4); *Siirt Province*: Siirt, 18 and 20 June 1972 (ZMUH), C. Kosswig leg.; *Antalya Province* [listed incorrectly as "Antakya" on pp. 169 and 174!]: 1 ♀ subad. (NMM), "20 km N of Kumluca", 12 August 1972, R. Kinzelbach leg. (Kinzelbach, 1980, figs. 1–2).	*C. nordmanni* Birula, 1899 (Tortum, Yusufeli). *C. birulai*, **sp. nov.** (Siirt). *C. gruberi*, **sp. nov.** (Antalya).
Francke & Soleglad, 1981: 245	Turkey, 1 specimen [♀] (MNHN RS 6452), 23 April 1971, "Bilejdik" [*Şanlıurfa Province*, Birecik, see Introduction], [J. Garzoni leg.], det. M. Vachon.	*C. birulai*, **sp. nov.**
Kinzelbach, 1982: 58	Turkey, *Erzurum Province*: Tortum, April 1970 (NMM 0203), C. Kosswig leg.; *Şanlıurfa Province*: Urfa [now Şanlıurfa], Karaçadağ Mts., 1200 m a.s.l., 18 April 1981 (NMM 0500), W. Heinz leg.; *Antalya Province*, "15 km NE of Kumluca", 12 August 1972 (NMM 0250), R. Kinzelbach leg. (same specimen as reported in Kinzelbach, 1980).	*C. nordmanni* Birula, 1899 (Tortum) *C. birulai*, **sp. nov.** (Şanlıurfa) *C. gruberi*, **sp. nov.** (Antalya)
Kinzelbach, 1985, Map IV	Turkey, general (estimated?) range map. The range is projected far toward Black Sea coast (Rize and Trabzon Provinces) and into the southeast Turkey (Hakkari Province) and northern Iraq, which was not confirmed by published specimens.	*C. nordmanni* Birula, 1899 (northeast) *C. gruberi*, **sp. nov.** (Antalya). *C. birulai*, **sp. nov. (**Birecik)
Vachon & Kinzelbach, 1987: 99	Turkey, general range map, repeats Kinzelbach's (1985) map IV but adds Bilecik in the northwest [Birecik! - see Introduction; in the text, "region of Birecik" (different spelling!) is mentioned; depository and specimen data unspecified; refers to MNHN RS 6452].	*C. nordmanni* Birula, 1899 (northeast) *C. gruberi*, **sp. nov.** (Antalya) *C. birulai*, **sp. nov. (**Birecik)
Sissom, 1988: 272	Greece, Samos Island: 1 ♂ subad. (FMNH), south slope of Mt. Spiliani, 2 km N of Pithagorion, 23 April 1979, A. Riedel leg.	*C. gruberi*, **sp. nov.** (tentative assignment)
Kovařík, 1997: 184	Turkey, *Diyarbakır Province*: Kavurma Köyü, 10 km NE Ergani, 1400 m a.s.l., 39°41'E, 38°19'N, 27 April 1989, "2 juvs." (HNHM), G. Fabian, G. Ronkay, & L. Ronkay leg.; *Şanlıurfa Province*: Halfeti, 1990, "5 juvs." (HNHM), G. Ronkay leg.; Halfeti, valley of Euphrates, 500 m a.s.l., 15–22 April 1990, "3 juvs." (HNHM), B. Herzig & G. Ronkay leg. See text for details on the specimens.	*C. birulai*, **sp. nov.**
Fet & Braunwalder, 2000: 18	Turkey and Greece, general range (fig. 6). New localities listed (F. Kovařík, pers. comm., specimen data unspecified): Turkey, *Adiyaman Province*: Nemrut Dağı (fig. 6, locality 7, incorrectly placed on map; *Malatya Province*: Malatya (fig. 6, locality 6); *Şanlıurfa Province*: Halfeti (fig. 6, locality 5); *Antalya Province*: "Antakya" (fig. 6, 4) [incorrect, should be Antalya – F.K.]; Greece, Megisti (=Kastelorizo) Island (I. Stathi/NHMC, pers. comm.) (fig. 6, locality 3). The map includes Bilecik in the northwest (fig. 6, locality 1) [should be Birecik! - see above.]. The range, following Kinzelbach (1985), is projected toward Black Sea coast and into northern Iraq, which was not confirmed by published specimens (N Iraq is first confirmed in the present paper; R. Kinzelbach, pers. comm.)	*C. nordmanni* Birula, 1899 (northeast) *C. birulai*, **sp. nov.** (Halfeti, Malatya, Nemrut Dağı) *C. gruberi*, **sp. nov.** (Antalya, Megisti)
Stathi & Mylonas, 2001: 290, 293	Greece, Megisti (=Kastelorizo) Island (Crete), southeastern part of the island, Mandraki, Paleokastro (NHMC), "big populations", specimen data unspecified.	*C. gruberi*, **sp. nov.** (tentative assignment)
Crucitti & Vignoli, 2002: 458–459	Turkey, *Artvin Province,* Çoruh River, near Artvin, and between Artvin and Yusufeli, July–August 1999 [P. Crucitti & V. Vignoli leg.], depository and specimen data unspecified. Also mentioned (as unpublished data) by Crucitti, 1999: 87.	*C. nordmanni* Birula, 1899
Karataş & Çolak, 2005: 4	Turkey, *Gaziantep Province*: Şahinbey, Güllüce Village, lower slopes of Mt. Ellezi, 13 September 2003, 1 ♂, 1 ♀ (ZDNU 2003/524/1-2); Şahinbey, Güllüce Village, 21 September 2003, 1 ♂ (ZDNU 2003/573/1), 1 ♀ (ZDNU 2003/573/2) [A. Karataş & M. Çolak leg.]	*C. birulai*, **sp. nov.**
Kamenz & Prendini, 2008: 43, pl. 62	Turkey, *Artvin Province*: 1 ♀ (AMNH [LP 2246]), Ardanuç [misspelled "Ardanug"], 26 August 2001, A. Karataş leg.; *Gaziantep Province*: 1 ♂ (AMNH [LP 4333]), Şehitkamil District, Incesu Köyü, 7 May 2005, E. Aydin [Yağmur] leg. (listed as "Antep-Sehitkamil: Incesu Köyü"). Also 1 ♀ (MNHN RS 6452, see above) from Birecik is listed, as "Biledjik".	*C. nordmanni* Birula, 1899 (Ardanuç) *C. birulai*, **sp. nov. (**Incesu Köyü, Birecik)

Table 1: Specimens and records listed in the literature as *Calchas nordmanni*.

with the identical label data exists (e.g. an opilionid *Zachaeus anatolicus*, see Snegovaya & Staręga, 2008: 73). A large reproducing population of *C. nordmanni* was discovered by the NMHC staff on the Greek island of Megisti (=Kastelorizo, the easternmost point of Greece) (Fet & Braunwalder, 2000; Stathi & Mylonas, 2001). Both Samos and Megisti are located very closely to the Anatolian coast.

Kovařík (1997), based on new collections by Hungarian zoologists, listed three new localities in southeastern Turkey (Diyarbakır, Malatya, and Şanlıurfa Provinces; HNHM). Fet & Braunwalder (2000) referring to a personal communication of F. Kovařík, reiterated two of those localities, and added (based on FKCP collection) two more localities: Nemrut Dağı (Adıyaman Province) and Antakya; the latter, however, was reported in error (corrected here; should be Antalya).

Crucitti & Vignoli (2002: 459) collected *Calchas nordmanni* is northeastern Turkey, close to type localities in Çoruh valley. Karataş & Çolak (2005) and Kamenz & Prendini (2008) added two new localities from southeastern Turkey (Gaziantep Province).

Our research group (Soleglad & Fet, 2003a, 2003b; Fet et al., 2004, 2006a, 2006c; Graham & Fet, 2006) further investigated the phylogenetic position of *Calchas* and published important new morphological data on this genus.

Ragnar Kinzelbach (pers. comm., May 2009) kindly shared with us unpublished materials and data on *Calchas* from Turkey, and also pointed at an unpublished specimen from northern Iraq (famous Geli Ali Beg waterfalls in Kurdistan), a new country record for *Calchas* (see below and map on Fig. 38). He also reports a sighting of a scorpion (not collected) that very likely could be *Calchas*, in northern Syria, Latakia Governorate, Slinfah (Slennfé), 35.583°N, 36.183°E, oak forest. This scorpion was seen by the late Prof. Dr. Adel Hamwi, who started a scorpion collection at the Department of Zoology, University of Damascus. We include this unconfirmed locality, under question, in our map (Fig. 38).

Our new morphological analysis, presented below, demonstrates that the taxon currently called "*Calchas nordmanni*" in fact includes *three* well-defined, allopatric species. We describe two new species, and restrict *Calchas nordmanni* Birula, 1899 to the populations from northeastern Turkey, approximately to the original area characterized by Birula. In Table 1, we list all *published* data on specimens and localities identified as *Calchas nordmanni*. Part of this material is assigned to two new species established in this paper, and the majority of these specimens have been studied by us.

This paper continues a series of publications on Iuridae that we launched recently with an important discovery of neobothriotaxy in *Iurus* (Soleglad et al., 2009).

Material and Methods

Abbreviations

The institutional abbreviations listed below and used throughout are mostly after Arnett et al. (1993).

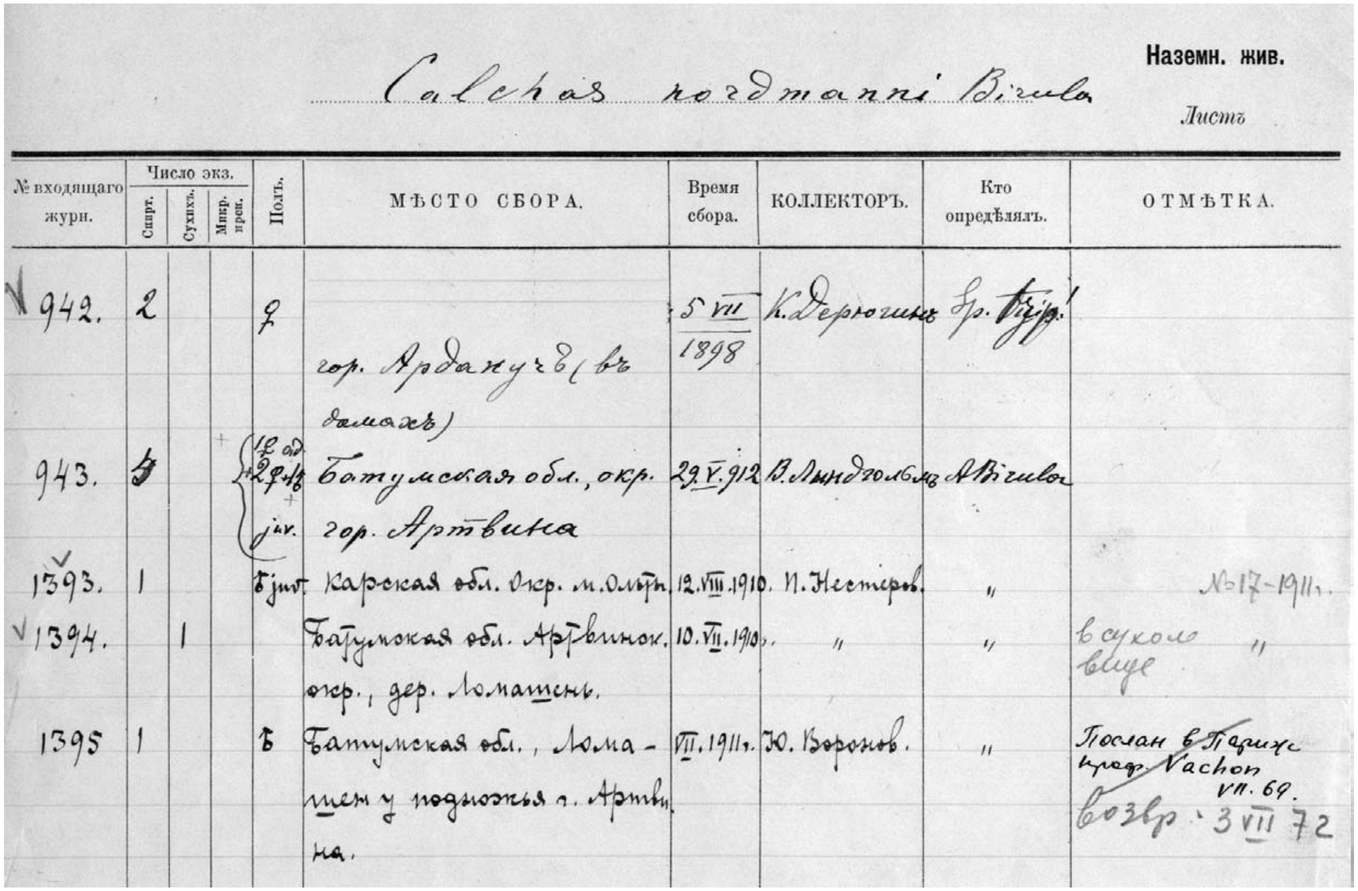
AMNH, American Museum of Natural History, New York, New York, USA
FKCP, collection of František Kovařík, Praha, Czech Republic
FMNH, Field Museum of Natural History, Chicago, Illinois, USA
GNM, Georgian National Museum, Tbilisi, Georgia
HNHM, Hungarian Museum of Natural History, Budapest, Hungary
MNHN, Muséum national d´Histoire naturelle, Paris, France
NHMC, Natural History Museum of Crete, Irakleio, Crete, Greece
NMM, Naturhistorisches Museum, Mainz, Germany
NMW, Naturhistorisches Museum Wien, Vienna, Austria
VF, collection of Victor Fet, Marshall University, Huntington, West Virginia, USA
ZDNU, Zoology Department, Niğde University, Niğde, Turkey
ZISP, Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia
ZMUH, Zoologisches Institut und Zoologisches Museum, Universität Hamburg, Hamburg, Germany
ZSRO, Zoologische Sammlung der Universität, Rostock, Germany

Terminology and conventions

The systematics adhered to in this paper is current and therefore follows the classification as established in Fet & Soleglad (2005) and as modified 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). Techniques using maximized morphometric ratios follow those described in Fet & Soleglad (2002: 5) and further amplified in Soleglad & Fet (2008: 57–69).

SEM microscopy

To investigate scorpion 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



Calchas nordmanni Birula

Наземн. жив.

Листъ

№ входящаго журн.	Число экз. Спирт.	Сухихъ.	Микр. преп.	Полъ.	МѢСТО СБОРА.	Время сбора.	КОЛЛЕКТОРЪ.	Кто опредѣлялъ.	ОТМѢТКА.
✓ 942.	2			♀	гор. Ардануч (въ домахъ)	5 VII 1898	К. Дерюгинъ	Sp. typ.!	
943.	~~5~~ 4			1♀ ad. 2♀+1♂ juv.	Батумская обл., окр. гор. Артвина	29.V.912	В. Линдгольмъ	A. Birula	
✓ 1393.	1			♂ juv.	Карская обл. Окр. м. Олты.	12.VIII.1910.	П. Нестеровъ.	"	№17-1911.
✓ 1394.		1			Батумская обл. Артвинск. окр., дер. Ломашенъ.	10.VII.1910.	"	"	в сухом виде "
1395	1			♂	Батумская обл., Ломашен у подножья г. Артвина.	VII.1911.	Ю. Воронов.	"	Послан в Париж проф. Vachon VII. 69. возвр. 3 VII 72

Registration number	Number of specimens			Gender	Locality	Date [“old calendar”]	Collector	Who identified	Notes
	in alcohol	dry	microscope slides						
942	2			♀	Transcaucasia, Lasistan, Ardanuç town (in houses)	5 July 1898	K. Deryugin	Sp. typ.	
943	4 (corrected from 5)			1 ♀ ad. + 2 ♀ + 1 ♂ + juv.	Batum Province, near Artvin town	29 May [1]912	V. Lindholm	A. Birula	
1393	1			♂ juv.	Kars Province, near Olty village	12 August 1910	P. Nesterov	“	No. 17 - 1911
1394		1			Batum Province, Artvin District, Lomashen village	10 July 1910 [1]	P. Nesterov	“	in dry condition
1395	1			♂	Batum Region, Lomashen “at the foot of g. Artvin”[2]	July 1911	Yu. Voronov	“	sent to Prof. Vachon in Paris July [19]69, returned 3 July [19]72

optimize resolution, adjust depth of field, and to minimize charging.

Specimens examined

We examined a total of 61 specimens (FKCP, HNHM, MNHN, NMM, NMW, VF, ZMUH) from northeastern, southern and southeastern Turkey, as well as one specimen from Samos Island, Greece (FMNH), and one juvenile specimen from Megisti Island, Greece (VF). In our opinion, the majority of the examined specimens belong not to *Calchas nordmanni* Birula, 1899, but to two new, geographically disjunct species. These two species are described below and compared to *C. nordmanni*. A detailed list of specimens and label data are provided under each species.

🡄 **Notes:** [1] should be 10 June 1909 (see Birula, 191: 175; 1917b: 144, 158); [2] the label is confusing; in Russian, the first-letter abbreviation "g" could stand for both "town" ("g[orod]") and "mountain" ("g[ora]"). Artvin is a spectacular city on a mountaintop above the Çoruh River. A popular Turkish song says: *Ölmeden önce Parisi değil Artvini Gör arkadaşım...*("Not Paris, my friend, see Artvin before you die").

Figure 2: ***Calchas nordmanni* Birula in ZISP. Top,** the original handwritten collection list in the museum journal from ZISP (courtesy V. A. Krivochatsky, ZISP). **Bottom,** Translation from Russian. Two first entries (ZISP 942 and 943) are in A. A. Birula's hand, in "old" (pre-1918) Russian orthography. Note that ZISP 1395 male was loaned to M. Vachon in 1969, and returned in 1972 (see Vachon, 1971, for its redescription). Birula (1917b: 144) listed as in ZISP possession (without registration numbers) 17 specimens corresponding to lots 942 (two ♀ syntypes), 943 (1 ♀ ad., 1 ♂ juv., 2 ♀ juv.), 1393 (♂ juv), and 1394 (Birula listed a large series, but only a single specimen still exists in ZISP), as well as 1 ♀ ad from Borçka (see Table 1). Of the 11 specimens listed in this museum journal, currently ZISP collection has only five, including two female syntypes. Lot ZISP 943 lot could not be found (V. A. Krivochatsky, pers. comm..) Lot ZISP 1395 (1 ♂ from Lomashen, Yu. Voronov leg.) was not listed by Birula (1917b) as in ZISP possession but this material was mentioned in the text (Birula, 1917b: 154). Additional Voronov material (Birula, 1912: 24 listed 8 specimens) and some other specimens studied by Birula, which belonged to the Caucasian Museum in Tiflis, are still deposited there (GNM, Tbilisi, Georgia, see Table 1).

Systematics

The systematics of superfamily Iuroidea has been discussed in detail in three 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 erected; and (3) Fet & Soleglad (2008), a cladistic analysis of Iuroidea with an emphasis on subfamily Hadrurinae, where *Hoffmannihadrurus* was resurrected.

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

Genus *Calchas* Birula, 1899

Type species *Calchas nordmanni* Birula, 1899, by original designation.

Synonyms:
Paraiurus Francke, 1985. See Fet & Madge (1987) and Sissom & Fet (2000) for details on synonymy.

Taxonomic History

The taxonomic position of *Calchas* remained vague for decades. Birula (1899, 1905) placed it in Chactidae but remarked in detail on its difference from other chactids (specifically comparing *Calchas* to New World Brotheinae and Chactinae). Eventually, Birula (1917a: 138, 164) created for this genus a separate monotypic subfamily, Calchinae. Much "missing link" talk has been made (Birula, 1917a, 1917b) of its *tibial spur*, unique for non-buthids, which indeed could be a plesiomorphic feature. Other features appeared to place *Calchas* closer to *Chaerilus*, and for a while it was listed under Chaerilinae (within Chactidae) (Werner, 1934; Millot & Vachon, 1949). The precarious family status of *Calchas* has not been challenged until Vachon (1971) redescribed it and cautiously indicated "affinities between Chactidae and Vaejovidae" – i.e. between *Calchas* and *Iurus*! In the mid-1970s, Vachon (1974) and Stahnke (1974) simultaneously launched a major reassessment of scorpion family-group taxa, especially so-called "chactoids" (trichobothrial Type C scorpions). In an important paper that followed in the same revisionary vein, Francke & Soleglad (1981) reestablished family Iuridae, and demonstrated that *Calchas* and *Iurus* are sister genera, therefore moving *Calchas* from Chactidae to Iuridae (subfamily Iurinae). Calchinae Birula, 1917 became a synonym of Iurinae Thorell, 1876; see Soleglad & Fet (2003b: 110) for details. This relationship was further emphasized when Soleglad & Fet (2003b) limited Iuridae to these two Mediterranean genera, separating New World family Caraboctonidae.

Diagnosis

General appearance. Small to medium sized scorpion (22–52 mm); chelae robust and carinate, metasoma with well developed carinae. Pectinal tooth counts small, 5–9 male, 5–8 female. Carapace granular, highly tapered anteriorly with small narrow indentation; median eyes and tubercle small, located on anterior one-quarter; two lateral eyes; mediolateral ocular carinae of medium development.

Important taxonomic characters. Legs III–IV with tibial spur; ventral surface of tarsus covered with large socketed setae and populated with irregular spinule clusters medially on at least its base. Femoral trichobothrium *d* located on dorsal surface; *e* located considerably distal of *d*; chelal trichobothrium *db* positioned at base of fixed finger; *Db* located dorsally of digital (*D1*) carina, not in line with *Eb* series; patellar trichobothrium *i* located on dorsal surface, adjacent to *DI* carina. Well developed prepectinal plate present in female; stigma short and sub-oval in shape. Large ventral accessory (*va*) denticle of cheliceral movable finger located at finger base; highly developed serrula present. Hemispermatophore lamina lightly sclerotized, spatulate in shape; lamellar internal base with triangular-shaped protuberance; capsular area with moderately developed acuminate process with subtle truncated tip. Chelal finger median denticle (*MD*) groups number 6–8; inner denticles (*ID*) 5–7. Patellar dorsal (DPS) and ventral (VPS) spurs weakly developed and generally doubled.

Detailed Analysis of Morphology at Genus Level

Here, we describe basic morphology specific to genus *Calchas*. Where appropriate, we also highlight three major sources that deal with *Calchas*: Birula (1917a, 1917b), where a detailed low-level description is provided of the type species *C. nordmanni*; Vachon (1971), where excellent illustrations of the trichobothrial pattern, chelicerae, leg, and chelal finger dentition are provided for a male of *C. nordmanni* from Birula's original collection; and Kinzelbach (1980), providing a detailed survey of all *Calchas* reports plus additional data on some morphology.

Carapace

The carapace of *Calchas* has essentially the same structure across all three species, exhibiting medium to heavy granulation, a highly tapered anterior edge with a small narrow indentation, and small median eyes positioned well ahead of the middle (Fig. 3). The ratio of median eye position (measured from carapace anterior edge to center of median eyes) to the carapace length is less than one-third, ranging 0.241–0.310 (0.289) [7]. The median eyes and tubercle are relatively quite small, the width of eye tubercle as compared to the carapace width at that position ranges 0.138–0.178 (0.157) [6]. [Incidentally, the median eye position and width morphometrics in *Calchas* match or exceed that reported by Soleglad & Fet (2008: fig. 126) for the genera *Pseudouroctonus* and *Uroctonites* in their revision of Vaejovidae. As with *Calchas*, scorpions of these genera have very small median eyes and tubercles which are situated well in advance of the middle.] *Calchas* has two lateral eyes per side, the posterior eye as large or slightly larger than the anterior eye (also see species level illustrations, Fig. 44 and Fig. 61). Diagnostic of family Iuridae are the well-developed mediolateral ocular carinae found on the anterior third of the carapace. In *Calchas* these carinae are of medium development, not as defined as in genus *Iurus*.

The anterior indentation 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.

Birula (1917a) provides a very detailed description of the carapace of *C. nordmanni*, from which we provide relevant excerpts:

> "…The carapace … elongated; … its anterior margin with a shallow notch opposite the ocular tubercle; the whole surface of the carapace covered with very fine but distinctly marked dense granulation … Ocular tubercle clearly shifted anteriad, set at a distance from the anterior margin of approximately 1/4 of the length of the carapace; it is comparatively small, flat …. eyes are small, the distance between them being not more than the diameter of an eye. The lateral eyes are very small, not greater than the surrounding tubercles, black, shining, separated from the margin of the carapace by a marginal crest …".

Kinzelbach (1980: fig. 4) illustrates the lateral eyes of *C. nordmanni* showing two lateral eyes within the low profile tubercle, the anterior eye slightly larger than the posterior eye. However, shown posterior to the tubercle is another possible smaller eye as suggested by Kinzelbach. Francke & Soleglad (1981: 245) state that the specimen they examined had three lateral eyes on the left side. We have examined many specimens of all three species and could only detect two lateral eyes, as illustrated in Figs. 3, 44, and 61. However, the latero-anterior edge of the carapace is granulate, granules sometimes occurring within the lateral eye tubercle, thus darkly pigmented as the eyes. We suspect these darkened granules could be easily mistaken for additional eyes.

Mesosoma

The *Calchas* **sternum** (Fig. 4) conforms to the type 2 sternum as defined by Soleglad & Fet (2003a). This

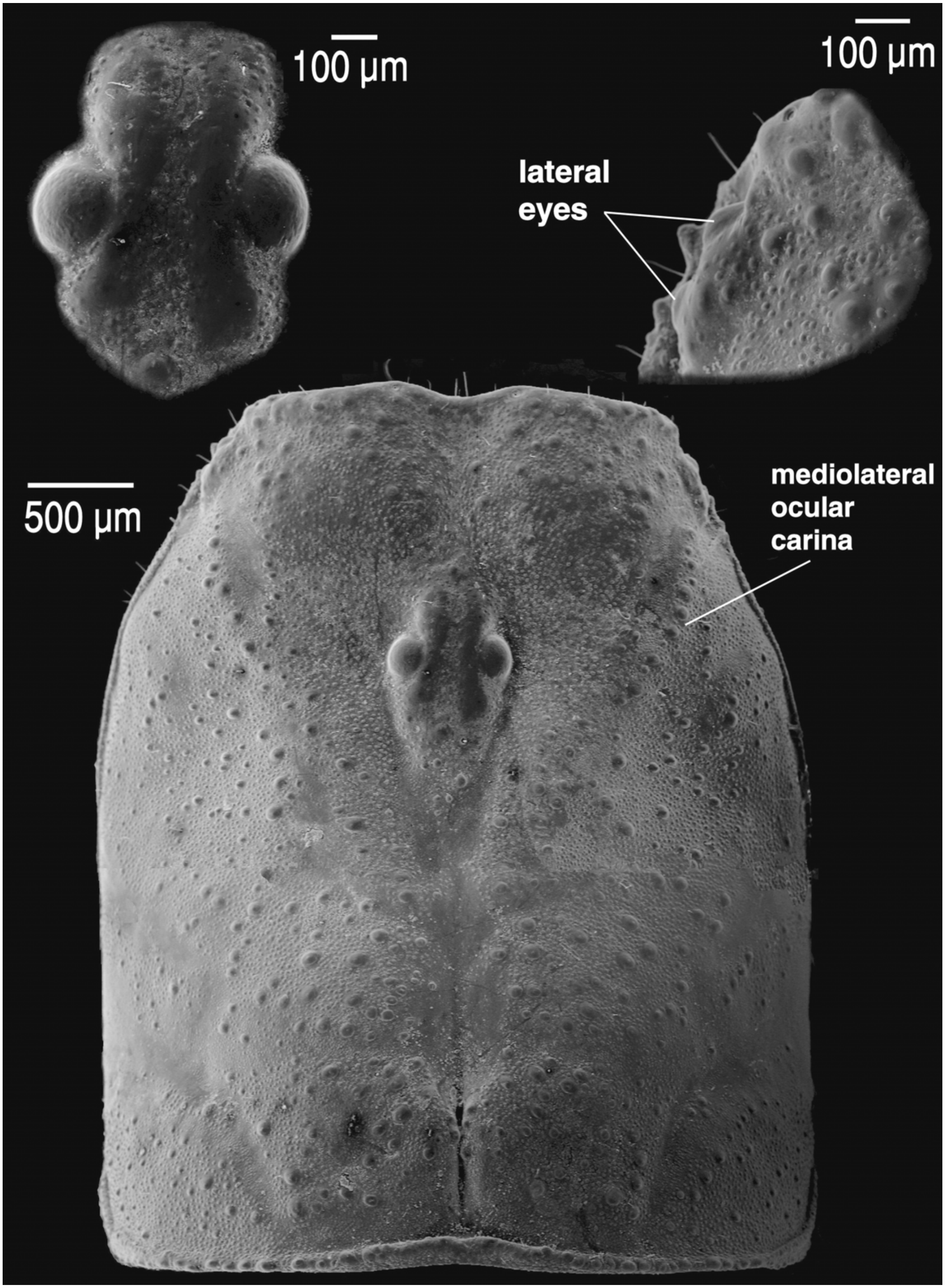


Figure 3: Carapace and close-up of median and left lateral eyes in *Calchas gruberi*, **sp. nov.**, female, Antalya, Turkey. Lateral eyes and mediolateral ocular carina indicated.

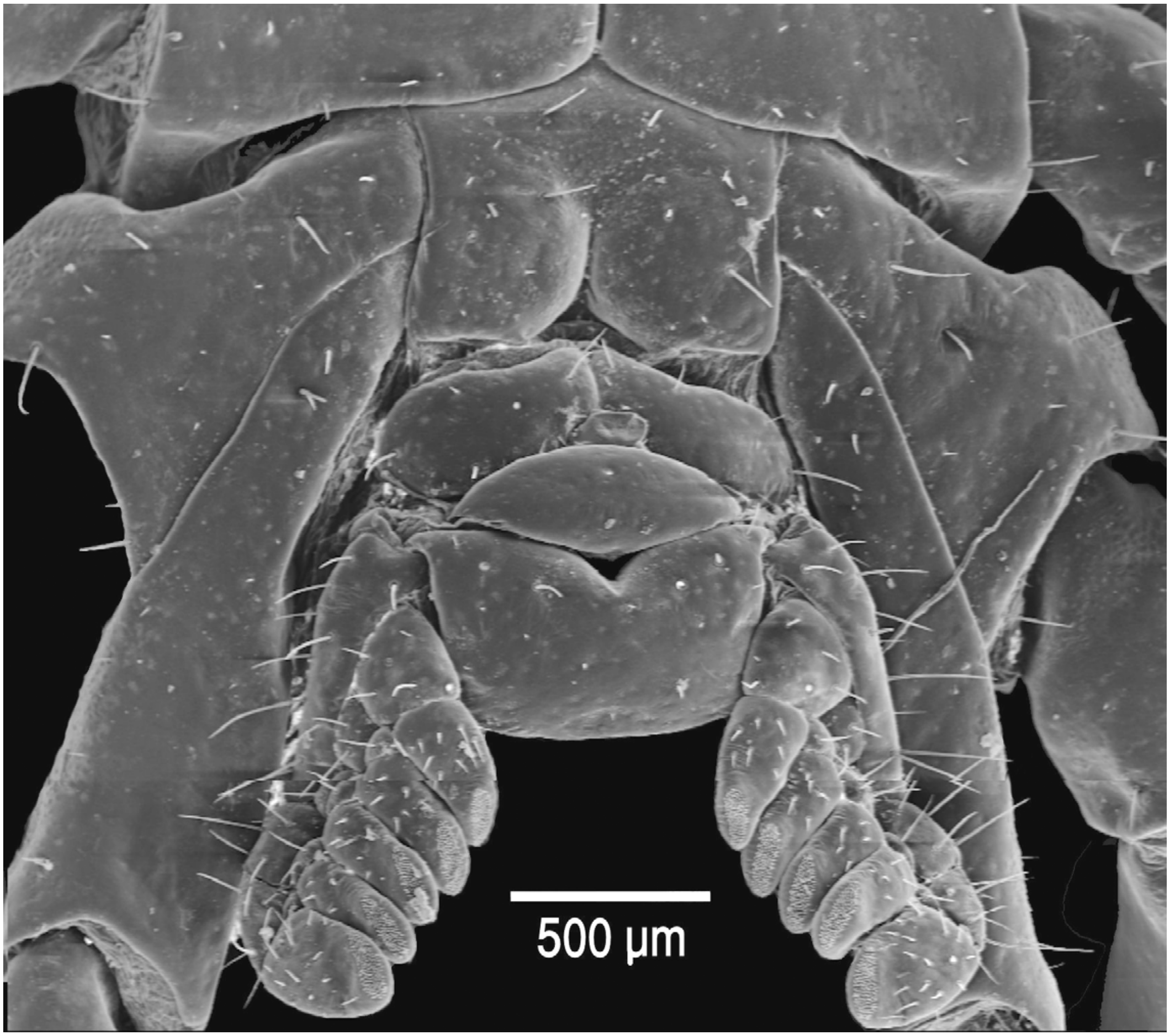


Figure 4: Sternopectinal area of *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey, showing sternum, genital operculum, prepectinal plate, basal piece, and pectines.

structure is wider than long 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. The entire sternocoxal area of *C. gruberi*, **sp. nov.**, is illustrated in Soleglad & Fet (2003a: fig. 8; referred to as *C. nordmanni*).

The **genital operculum** exhibits considerable sexual dimorphism in *Calchas*. In the female (all three species are illustrated in Fig. 35), the individual sclerites are much wider than long and are fused medially most of their length. In the male, each sclerite is subtriangular in shape, roughly as long or longer than wide, separated most of their length. In addition, in the male, well-developed **genital papillae** are visible between the two plates, but not extending posterior of the operculum. Fet & Soleglad (2008: character 10 (state=0)) hypothesized this genital papillae configuration symplesiomorphic for family Iuridae (i.e., same configuration found in *Iurus*) where it also existed for outgroup *Chaerilus* (parvorder Chaerilida).

Unique to genus *Calchas* is a considerably well-developed **prepectinal plate** always found only in the females of all ages (Figs. 5, 35). This plate, situated between the genital operculum and the pectinal basal piece, is fully sclerotized and is as wide as or wider than an individual operculum sclerite. In species *C. nordmanni* and *C. birulai*, **sp. nov.**, the prepectinal plate is somewhat swollen medially, making its length almost equal to that of the genital operculum. In species *C. gruberi*, **sp. nov.**, this plate is a little less swollen medially, thus having a more slender appearance though still quite well developed. The prepectinal plate is not found in the male.

This structure was first identified by Birula (1911: 176) and can be clearly seen on the illustrations of *C. nordmanni* by Birula (1911, fig. 3; 1917a, fig. 12B;

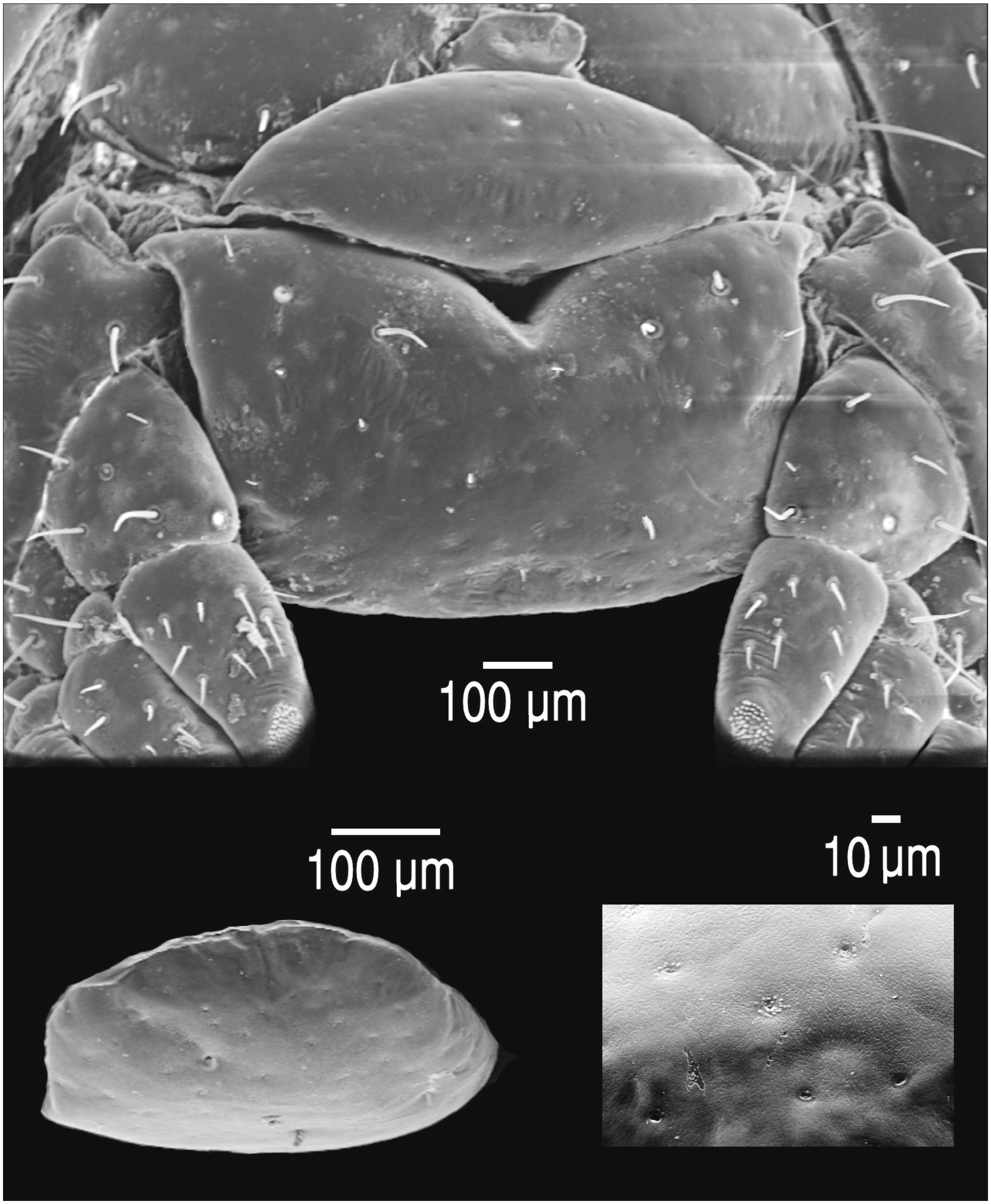


Figure 5: Prepectinal plate in *Calchas*. **Top.** Close-up of prepectinal plate of *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey. **Bottom.** Detached prepectinal plate of *C. gruberi*, **sp. nov.**, female, Antalya, Turkey, and close-up showing surface of the plate.

1917b, Pl. II, fig. 2). It seems that after Birula, the prepectinal plate in *Calchas* has *never* been mentioned—although at least the Birula (1911) paper published in German was immediately accessible to the European scientists, and it clearly described this "…am Hinterrande der Genitalöffnung liegenden Querwulste; ein

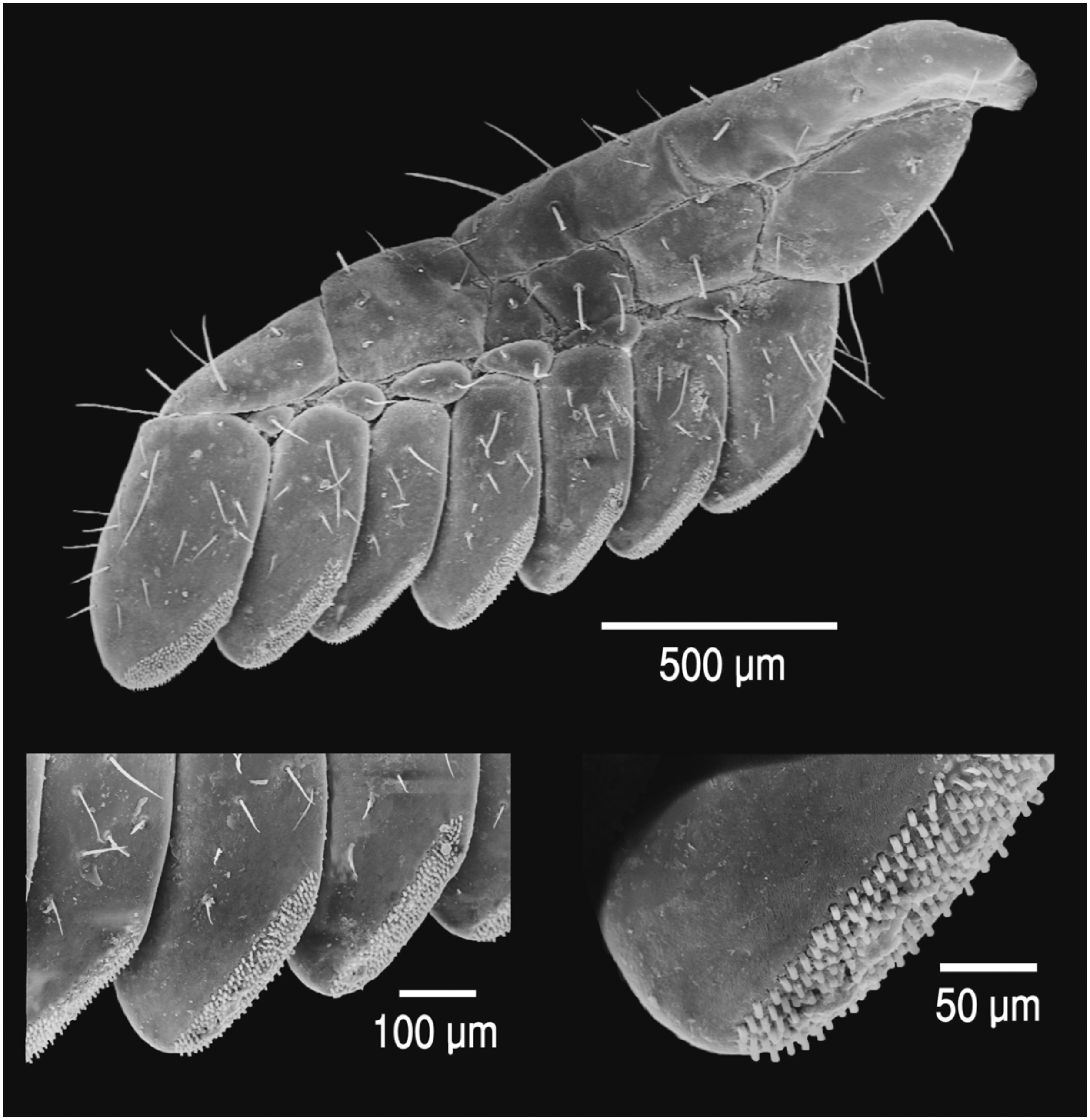


Figure 6: Pecten of *Calchas gruberi*, **sp. nov.**, female, Antalya, Turkey, showing close-up of peg sensilla.

solcher Querwulst fehlt bei den anderen mir bekannten Skorpionen. [a transverse thickening at the posterior end of the genital opening; such a transverse thickening is absent in all scorpions known to me].” The English translations (Birula, 1917a, 1917b), which appeared in the 1960s, describe this structure clearly: “an elliptical transverse thickening which is wanting in males…the transverse crest at the posterior end of the genital aperture is very well developed in females of any age” (Birula, 1917b: 152–153, transl. B. Munitz, 1965) and “elliptic transverse thickening present in female i.e. immediately behind genital aperture; same thickening absent in male. …Transverse ridge behind genital aperture clearly developed in female… the above-mentioned difference in structure of the genital area helps in distinguishing the sex of very small specimens of *Calchas* ” (Birula, 1917a: 147–178, transl. J. Salkind, 1964). In the original Russian text, Birula also used non-specific terms “utolshchenie [thickening]” or “valik” [ridge], clearly having no established terminology for this unique structure.

The modern term “prepectinal plate” originates from Kjellesvig-Waering (1986) who claimed its existence in some fossil and extant scorpions between the

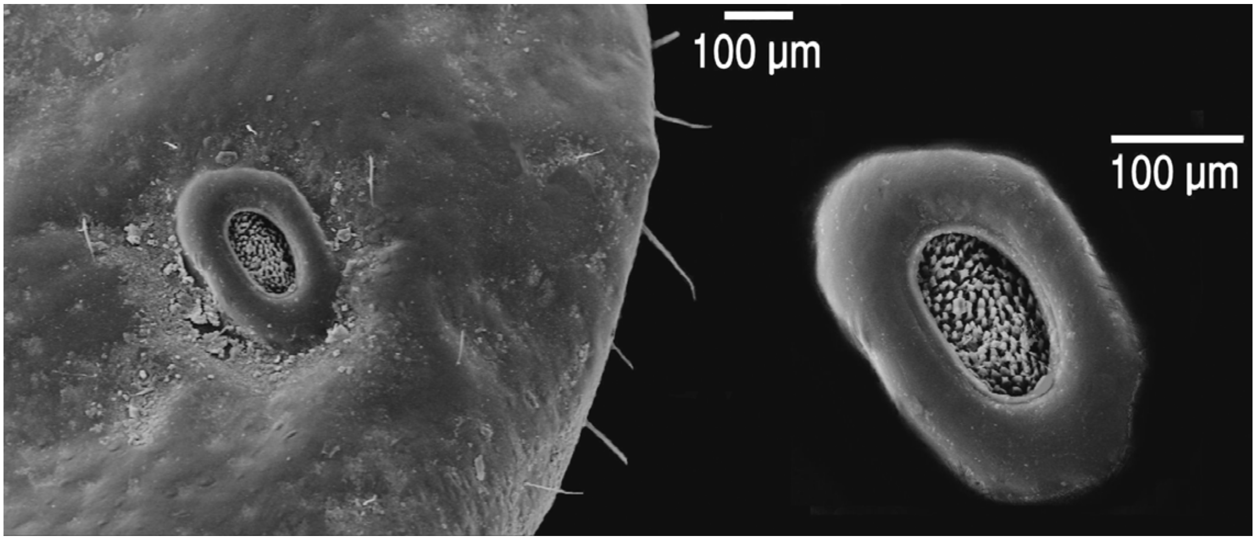


Figure 7: Fourth left lung stigma in *Calchas gruberi*, **sp. nov.**, female, Antalya, Turkey.

operculum (segment X) and the pectinal plate (segment XI). Existence of such a structure in fossil scorpions still has to be confirmed (J. Dunlop, pers. comm., 2008). This issue is important for general scorpion morphology since only seven mesosomal segments are currently accepted in scorpions, but Kjellesvig-Waering (1986) suggested that the prepectinal plate could indicate that the fundamental scorpion mesosoma should be considered as having eight segments; he also indicated existence of prepectinal plate in some *males*, but not *females* (*Calchas* has a reverse situation) of the extant New World Buthidae. Sissom (1990: 148) and Farley (1999: 125; 2001: 20, 25) reviewed this structure based on Kjellesvig-Waering (1986) but did not mention *Calchas*. We use this term, keeping in mind that it is unclear whether the structure discussed by Kjellesvig-Waering (1986) is homologous to the prepectinal plate found in *Calchas*. The function of the prepectinal plate is not known.

The ***pectines*** in *Calchas* are fully developed, exhibiting all major substructures common to most scorpions (Figs. 4, 6). Three anterior lamellae are present, the most basal significantly longer than the middle and distal lamellae. Middle lamellae are present but only extend below the basal anterior lamellae, the area below the middle and distal lamellae is occupied by these lamellae. The number of middle lamellae ranges from two to six (the largest number of six found in a male *C. gruberi*, **sp. nov.**, from the Greek island of Samos). Well-developed fulcra are present between the inner bases of pectinal teeth. The pectinal teeth are well-developed in *Calchas*, 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 cylinders (see close-up in Fig. 6). The pectinal **basal piece** is well-developed in *Calchas*, longer than the genital operculum in the female. Anterior edge exhibits a somewhat wide deep indentation.

Birula (1917a) says the following for the sterno-pectinal area in *C. nordmanni*:

> "…sternum with a deep groove, running from the posterior margin to its middle and divided into three parts by shallower grooves … the sternum is pentagonal, anteriorly noticeably narrowed … the genital opercula of the male have the shape of a triangle with unequal sides … the genital opercula of the female are very narrow and have the shape of transverse, elongate-oval … in addition, there is a convex elliptical crest behind the genital pore of the female …".

In the species-level descriptions of *C. birulai*, **sp. nov.**, and *C. gruberi*, **sp. nov.**, we illustrate the sterno-pectinal area of both genders (Figs. 47, 52 and Figs. 64, 70).

The lung **stigmata** (spiracles) in *Calchas* are somewhat small, suboval in shape (Fig. 7). They are angled roughly 45º toward anterointernal direction. The fine structure of the posterior spiracle margin (Kamenz et al., 2005) can be seen in Fig. 7.

Chelicerae

In Figures 8–9, the dorsal and ventral surfaces of the *Calchas* chelicera are illustrated. This chelicera conforms to the definitive form as described for superfamily Iuroidea: ventral edge equipped with a large basal denticle (*va*), hypothesized as synapomorphic by Soleglad & Fet, 2003b (character 42, state=2) and Fet & Soleglad, 2008 (character 9, state=1). The dorsal edge has a single large subdistal (*sd*) denticle, classified as symplesiomorphic (Soleglad & Fet, 2001; Fet & Soleglad, 2008). In addition, we see, as characteristic of

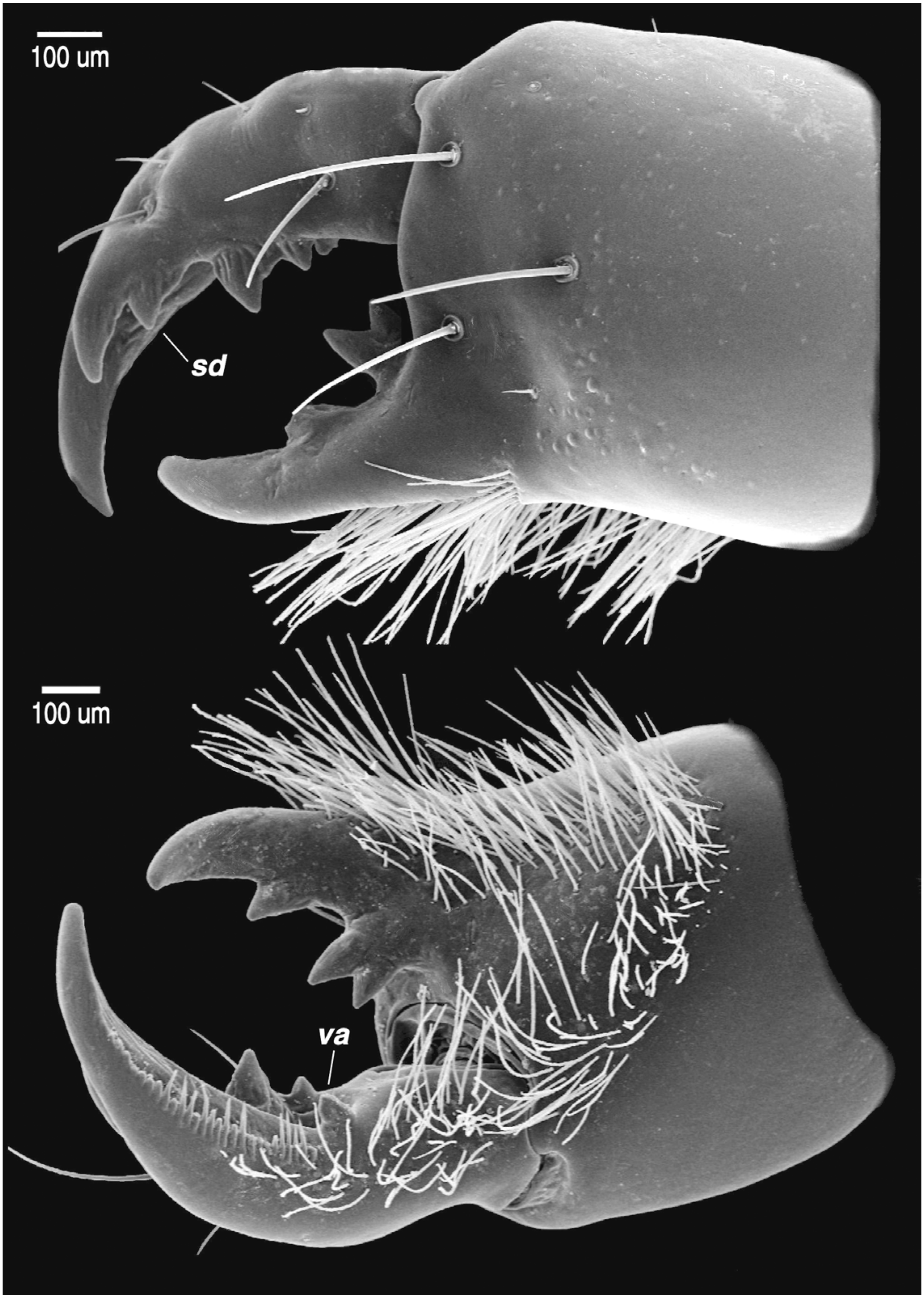


Figure 8: Chelicera, *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey. Dorsal view (top, right chelicera), ventral view (bottom, left chelicera reversed). Diagnostic large basal ventral accessory (*va*) denticle and large subdistal (*sd*) denticle indicated.

the chelicerae specific to *Calchas* within the Iuridae, that the large ventral denticle is positioned quite basal on the ventral edge (in *Iurus* it is located more midfinger). The well-developed **serrula** (compare to *Iurus*; Graham & Fet, 2006, fig. 2) is present on the ventral edge (Fig. 9), composed of 20 or more contiguous tines; it begins at the base of the large *va* denticle and continues along the ventral edge to the distal aspect of the finger. In some *Calchas* specimens (see Figs. 53 and 69), the ventral edge mid-area exhibits two or more small denticles, some of which are pigmented, giving the ventral edge a somewhat irregular crenulate appearance. This additional dentition was first reported by Soleglad & Fet (2003b: fig. 52).

The cheliceral fixed finger is typical of Recent scorpions, with four denticles, median (*m*) and basal (*b*) denticles conjoined on common trunk. Ventral accessory (*va*) denticles are not present.

The ventral distal half of the cheliceral palm is covered with a heavy growth of setae (Fig. 8) extending along the ventral edge of the movable finger and the inner surface of the fixed finger where it is the heaviest. At the inner base of the fixed finger the setae is neatly aligned in a curious ridge that extends to the dorsal surface, and then abruptly ends.

Concerning the chelicerae, Birula (1917a) writes:

> "…The rigid cheliceral finger is armed on the dorsal margin with two large denticles, the posterior one apically bilobed; the ventral margin of this finger is devoid of denticles; the movable finger is armed on the dorsal margin with three denticles, the median of which is the largest and the posterior very small; the ventral margin of the movable finger with large blunt denticle set near the base …".

Vachon (1971: figs. 8–9) first illustrated the *Calchas* chelicerae where he emphasized the well-developed serrula, which, incidentally, was not reported by Birula (1917a, 1917b). This oversight can be explained by the fact that serrula in scorpions, albeit visible under a regular microscope, was only discovered in 1944 (Graham & Fet, 2006).

Pedipalps

The **trichobothrial pattern** of genus *Calchas* was illustrated and discussed in detail by Soleglad et al. (2009: fig. 1) where it was contrasted with its sister genus *Iurus*. Therefore we will not discuss it here in any detail except to note that the full trichobothrial patterns of the three species of *Calchas* are illustrated in this paper under their individual discussions below (Figs. 41, 54, and 71). We will point out, however, that although a very unusual pattern in itself, representative of the family Iuridae, the pattern seen in *Calchas* did exhibit significant differences in individual trichobothrial positions from that found in *Iurus*. Similarly, at the species level, again we see noted differences in certain trichobothria positions, significant enough to be considered diagnostic of these species. This is discussed below. Figure 10 shows two trichobothria of *C. gruberi* illustrating the areola and corresponding bristle attachment. These closeup images also show a bristle that is partially "dislodged" from the areola on the patella, illustrating the complex structure of the bristle base. No less than three close fitting concentric shafts are present, the bottom shaft, which is attached to the areola, exhibits a ring which possibly keeps the adjacent shaft from extending any further into the areola. Vachon (1971: figs. 2–7) was the first to illustrate the trichobothrial pattern of *Calchas* from one of Birula's specimens (not a type) of *C. nordmanni*. Kinzelbach (1980: fig. 2) illustrated this pattern of a female from Antalya, Turkey, identified at that time as *C. nordmanni* (designated in this paper as *C. gruberi*, **sp. nov.**).

Soleglad & Sissom (2001: 59–62; figs. 148–160), in their phylogenetic revision of Euscorpiidae, first introduced, as new terms for scorpion morphology, **dorsal (DPS) and ventral (VPS) patellar spurs** and used these structures in their cladistic analysis. In particular, subfamily Scorpiopinae (character 15, state =2) was differentiated, in part, from this character alone. Fet & Soleglad (2002: figs. 69–70) also used morphometrics of the DPS to assist in the identification of certain species of genus *Euscorpius* (family Euscorpiidae). The DPS/VPS were illustrated by Soleglad & Fet (2003b: fig. 96) for *Calchas* where they provided a detailed analysis of these structures. In our Fig. 11 we show a minimally developed DPS/VPS for *C. gruberi*, illustrating two small spurs both dorsally and ventrally. We refer to these as "doubled" DPS/VPS. Accompanying the two spur sets is a large seta, represented in our figures only as enlarged areolae. These spurs are quite small, considerably smaller than those exhibited in *Iurus*. In addition, we see below, in the description of *C. birulai* male holotype, that the VPS is single, not showing a second small spur. There is no evidence of the *DPSc* or *VPSc* carinae in *Calchas*.

The **chelal carinae** configuration in *Calchas* complies with the "eight-carinae" configuration as identified in Soleglad & Sissom (2001: 41–44; figs. 43–72). As illustrated in our Figure 12, based on a male *C. nordmanni*, this configuration excludes the ventromedian (*V2*) and subdigital (*D2*) carinae. Soleglad & Sissom (2001: character 20, state=0) characterized genus *Iurus* as conforming to this carinal configuration. Fet & Soleglad (2008: character 6, state=0) showed that this configuration, as reflected in family Iuridae, is symplesiomorphic, being present in other presumably more primitive parvorders, whereas in family Cara-

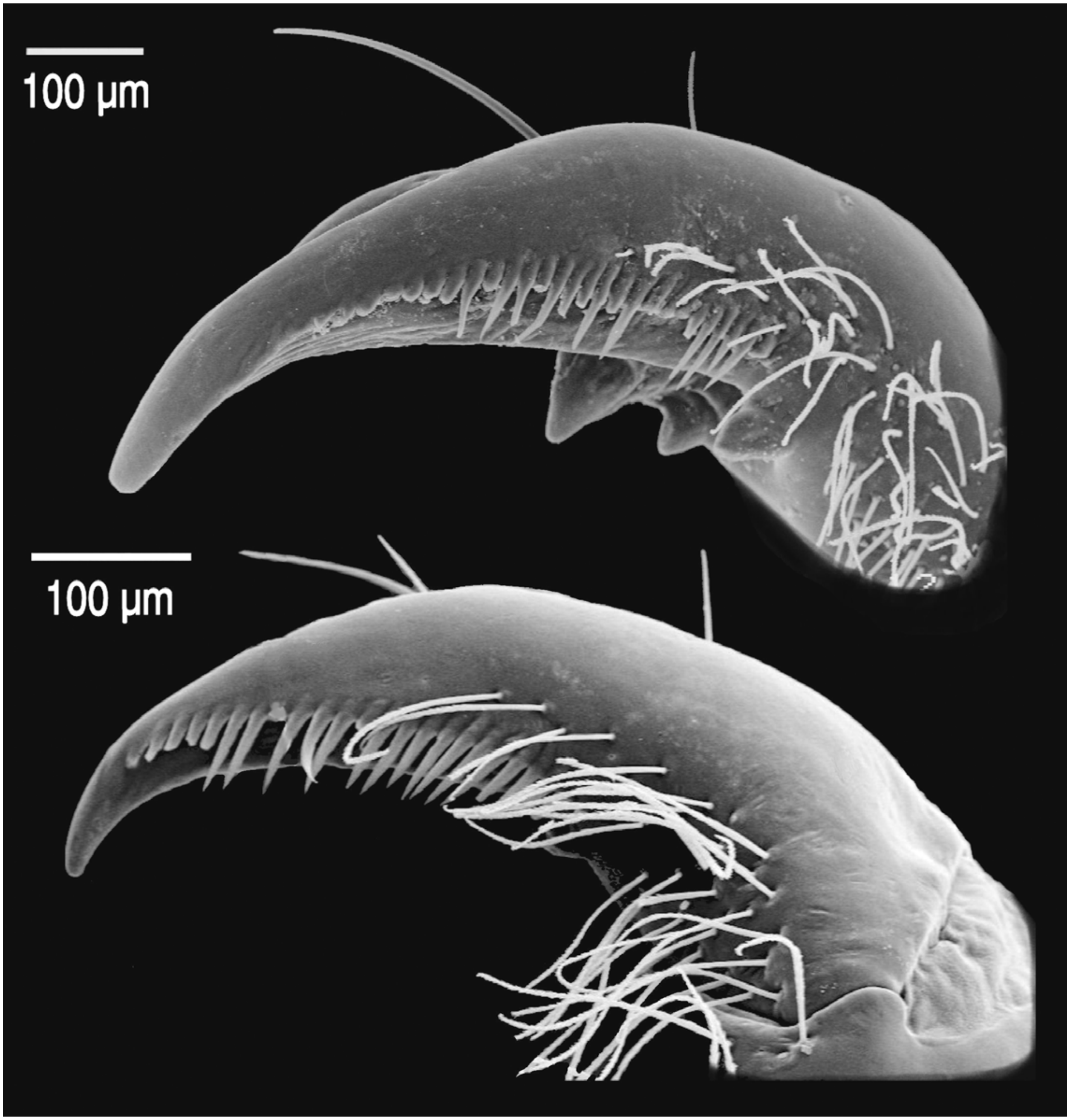


Figure 9: Cheliceral movable finger, ventral view, showing well developed serrula. **Top.** *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey. **Bottom.** *C. gruberi*, **sp. nov.**, juvenile male, Antalya, Turkey.

boctonidae, the "ten-carinae" configuration is present, a demonstrated synapomorphy (state=1).

The **chelal finger dentition** is very distinctive in *Calchas* and is used in part to separate its species. The fixed and movable finger dentition is shown in Fig. 13 for *C. birulai*, **sp. nov**. Common to all *Calchas* species, and considered a symplesiomorphy for superfamily Iuroidea, are the oblique imbricated median denticle (*MD*) groups, occurring in the three other parvorders, Pseudochactida, Buthida, and Chaerilida. Interestingly, the *MD* denticle groups in sister family Caraboctonidae, though oblique, are not imbricating, considered a synapomorphy by Fet & Soleglad (2008: character 5, state=1). In Fig. 13, we see the distribution of inner (*ID*) and outer (*OD*) denticles. As common to most scorpions two *ID*s are grouped at the movable finger distal tip close to the distal denticle (*DD*), the remaining *ID*s positioned at the beginning of *MD* groups distally and moving slightly

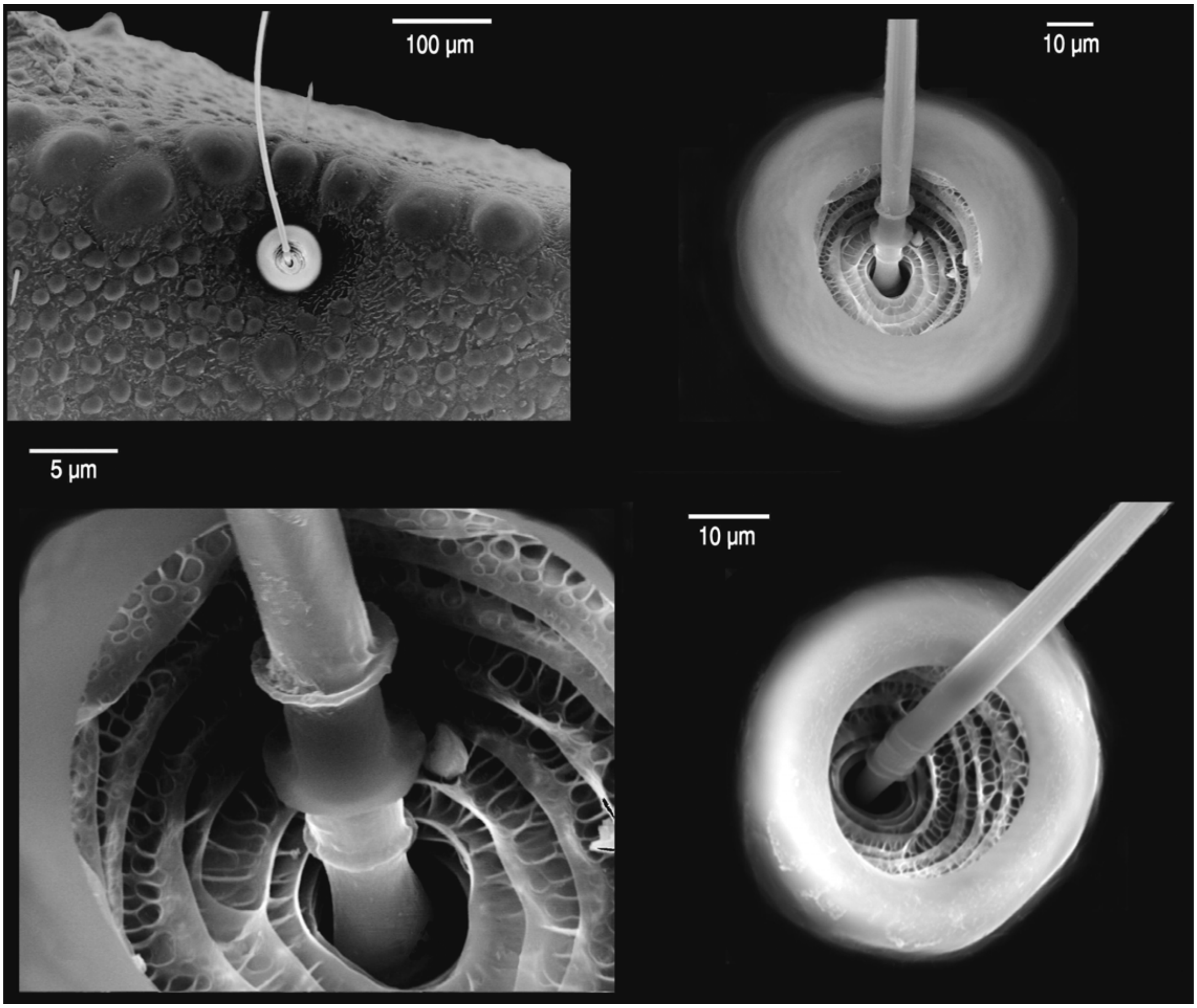


Figure 10: Close-up of trichobothrium areola and bristle base, *Calchas gruberi*, **sp. nov. Top and Bottom Left.** Adult female, Antalya, Turkey, showing patellar trichobothrium with bristle partially raised from areola. **Bottom Right.** Adult female, Antalya, Turkey, showing normal setting of bristle.

more proximally in basal groups. The last *MD* group in either finger is not accompanied by an *ID*. All *MD* denticle groups terminate with a slightly enlarged *OD* denticle, except for the basal *MD* group which terminates with increasingly smaller *MD* denticles. The most distal *MD* denticle group is much shorter on the movable finger, exhibiting roughly half the number of denticles than found on the fixed finger. This overall *MD*, *ID* and *OD* distribution as just described is found in all three *Calchas* species, only the number of *ID* and *MD* denticle groups is species specific, as described in detail below under species descriptions.

Birula (1917a) discusses the chelal dentition in detail for *C. nordmanni*:

> "… The mobile finger of the chelae … there are seven rows of granules on its blade, distinctly separated from one another and set slightly obliquely towards the blade; at the fingertip, the granule rows shorten gradually, the last two rows being very short and isolated from the others; each row begins and ends with a larger granule, the other granules diminishing anteriad; one row overlaps the other at its end with the distal tip on the outside; … one large granule is situated on the inside near the end of each row except on the first, basal and last two rows; at the fingertip there are 2–3 denticles. The genus *Calchas* differs from most Chactidae also in that the rows of granules are situated not in succession along the blade but, as in genus *Chaerilus*, at an angle to the blade. …".

Birula's observation with respect to *Chaerilus* is very prophetic since we hypothesize above the primitive nature of the *MD* configuration; and recently, Fet & Soleglad (2008) used *Chaerilus* as the outgroup in their cladistic analysis of superfamily Iuroidea. Vachon

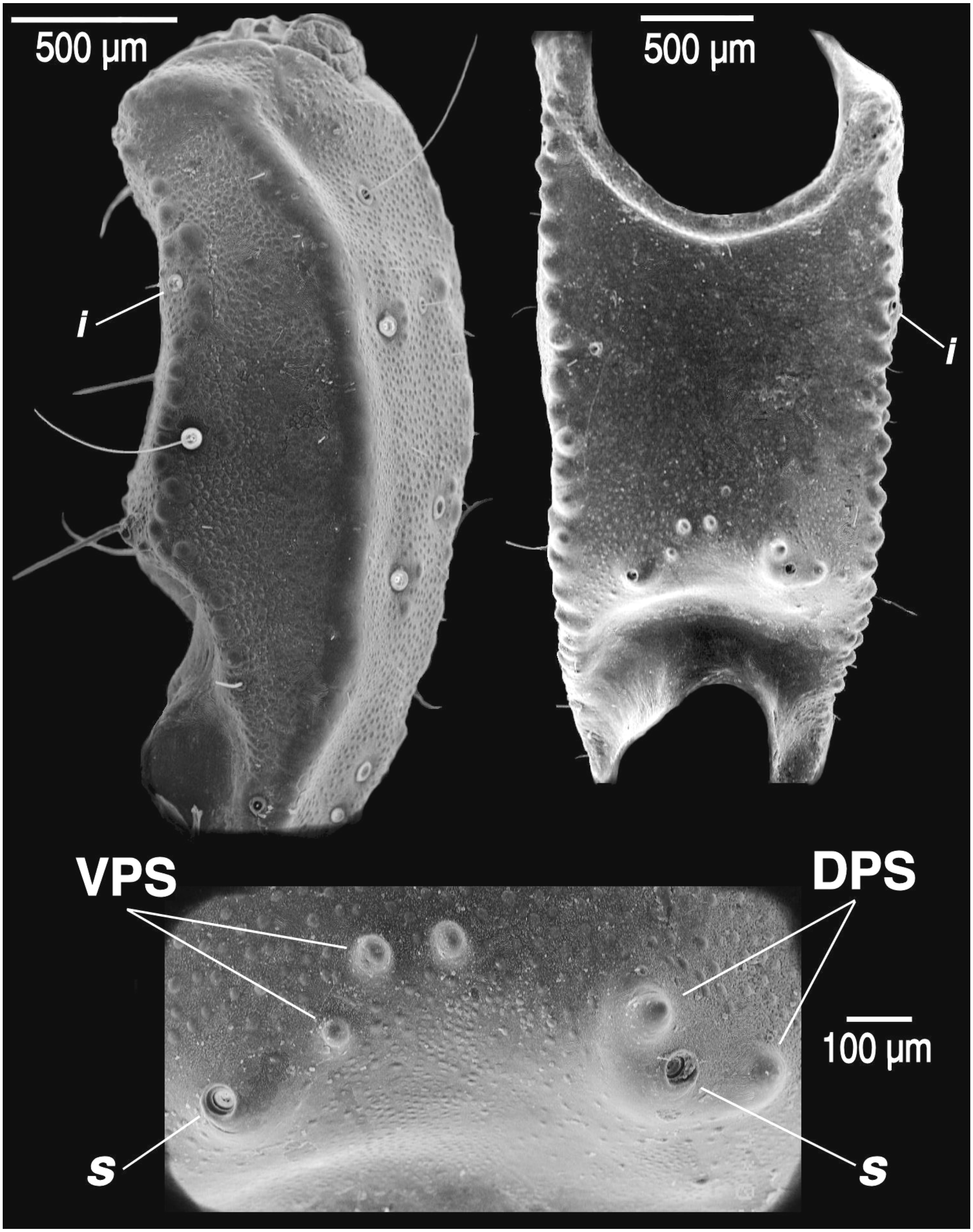


Figure 11: Pedipalp right patella showing Dorsal (DPS) and Ventral (VPS) Patellar Spurs. *Calchas gruberi*, **sp. nov. Top.** Dorsal view (left), juvenile male, Antalya, Turkey, showing doubled DPS and accompanying setae. Internal view (right, dorsal edge indicated by trichobothrium *i*), female, Antalya, Turkey, showing doubled DPS and VPS plus accompanying setal areolae. **Bottom.** Close-up of internal base of patella showing spurs and setal areolae (*s*).

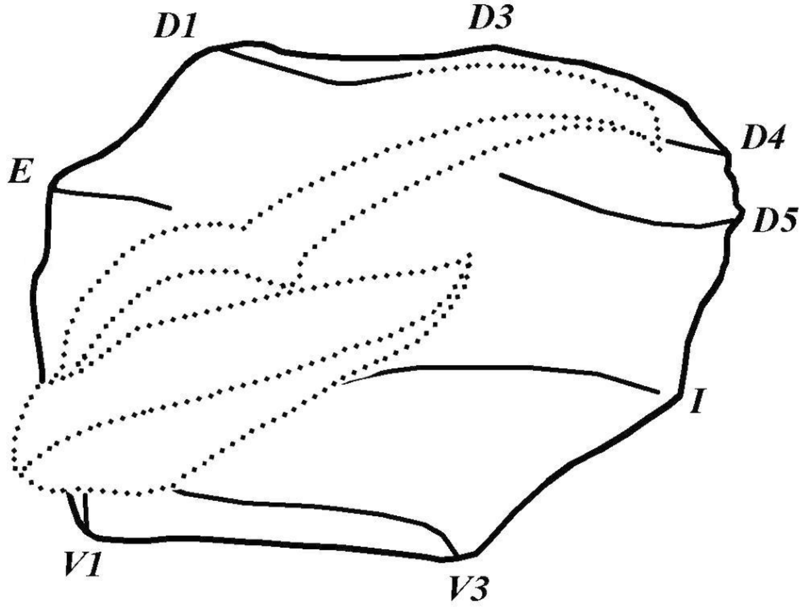


Figure 12: Diagrammatic view of pedipalp chela from the finger's perspective showing the eight primary carinae in genus *Calchas*. This carinal arrangement complies with the "8-carinae" configuration, note the absence of the *V2* (ventromedian) and *D2* (subdigital) carinae. Dotted portions indicate fixed and movable fingers and socket areas. *D1* = digital carina, *D3* = dorsosecondary carina; *D4* = dorsomarginal carina, *D5* = dorsointernal carina, *V1* = ventroexternal carina, *V3* = ventrointernal carina, *E* = external carina, *I* = internal carina. Diagram based on male *C. nordmanni*.

(1971: fig. 10) illustrated the movable finger dentition for a male of *C. nordmanni* from Birula's original collection (ZISP 1395).

Fet et al. (2006a) first reported the occurrence of a very unique array of minute sensilla located on the extreme distal external tip of the chelal fixed finger, termed the **constellation array**. Based on current investigations, this array is assumed to be present in one form or another in all Recent scorpions, Fet et al. (2006a) having examined all four parvorders and six superfamilies. To emphasize its taxonomic value, Fet et al. (2006c) further studied the constellation array of the vaejovid subfamily Smeringurinae, representing all genera and many of its species. In that study, the number of sensilla was quite small, three found in *Paravaejovis* and two in the other three genera, thus implying a consistency within genera. Fet et al. (2006a: figs. 6–7) published the first illustrations of the constellation array of *Calchas*, two specimens identified now as *C. gruberi*, **sp. nov.** In both of these specimens (replicated in our Fig. 14), the number of sensilla is quite large, numbering 15. However, in Fig. 15, the constellation array is illustrated for *C. birulai*, **sp. nov**., which only exhibits eight sensilla, considerably less than that seen in *C. gruberi*. The large difference in sensilla numbers in *Calchas* species (i.e., two so far available for SEM) was a surprise to us, reducing this character to species level. This sensory structure is also being analyzed in *Iurus* (Kovařík et al., in progress), and hopefully, a specimen of *C. nordmanni* will be available for similar analysis. At that time, possibly we can address evolution of this structure within the iurids. We predict, based on other character partitioning within the three *Calchas* species, that the constellation array of *C. nordmanni* will be similar, if not identical, to that seen in *C. birulai*.

Legs

In Fig. 16 the **tibial spur** is illustrated for leg III of *C. birulai*. This is the only known Recent scorpion in parvorder Iurida with a tibial spur. In other Recent scorpions, it is found in primitive parvorders Pseudochactida and Buthida (with many exceptions, primarily in the "Tityus" group). Tibial spur is also present in the Cretaceous *Palaeoburmesebuthus* (Santiago-Blay et al., 2004; fig. 11), as well as in earlier Paleozoic scorpions such as *Compsoscorpius* (Jeram, 1994a: text-fig. 5-D) and *Pulmonoscorpius* (Jeram, 1994b). Not only is the structure found in *Calchas* termed a "tibial spur"; i.e., located at the distal base of the leg tibia next to the basitarsus, but it is only found on the third and fourth legs, just as in Pseudochactida and Buthida. So it seems that we must conclude it is a homologous structure since it is structured the same, located on the same area of the tibia, and found on the same legs. The occurrence of a tibial spur in *Calchas* is probably one of most interesting evolutionary "oddities" known in Recent scorpions, and already noticed by Birula (1900, 1917a, 1917b). In the recent cladistic analysis of Iuroidea (Fet & Soleglad, 2008: character 21, state=1), the tibial spur in *Calchas* was classified as autapomorphic, the outgroup *Chaerilus* lacking such structure, implying that its occurrence is independent of the other occurrences in other parvorders (which were *not* represented in this analysis). In another analysis, Soleglad & Fet (2003b: character 59, state=0) concluded, due to considerable homoplasy (i.e., the character's CI and RI = 0.286 and 0.500, respectively),

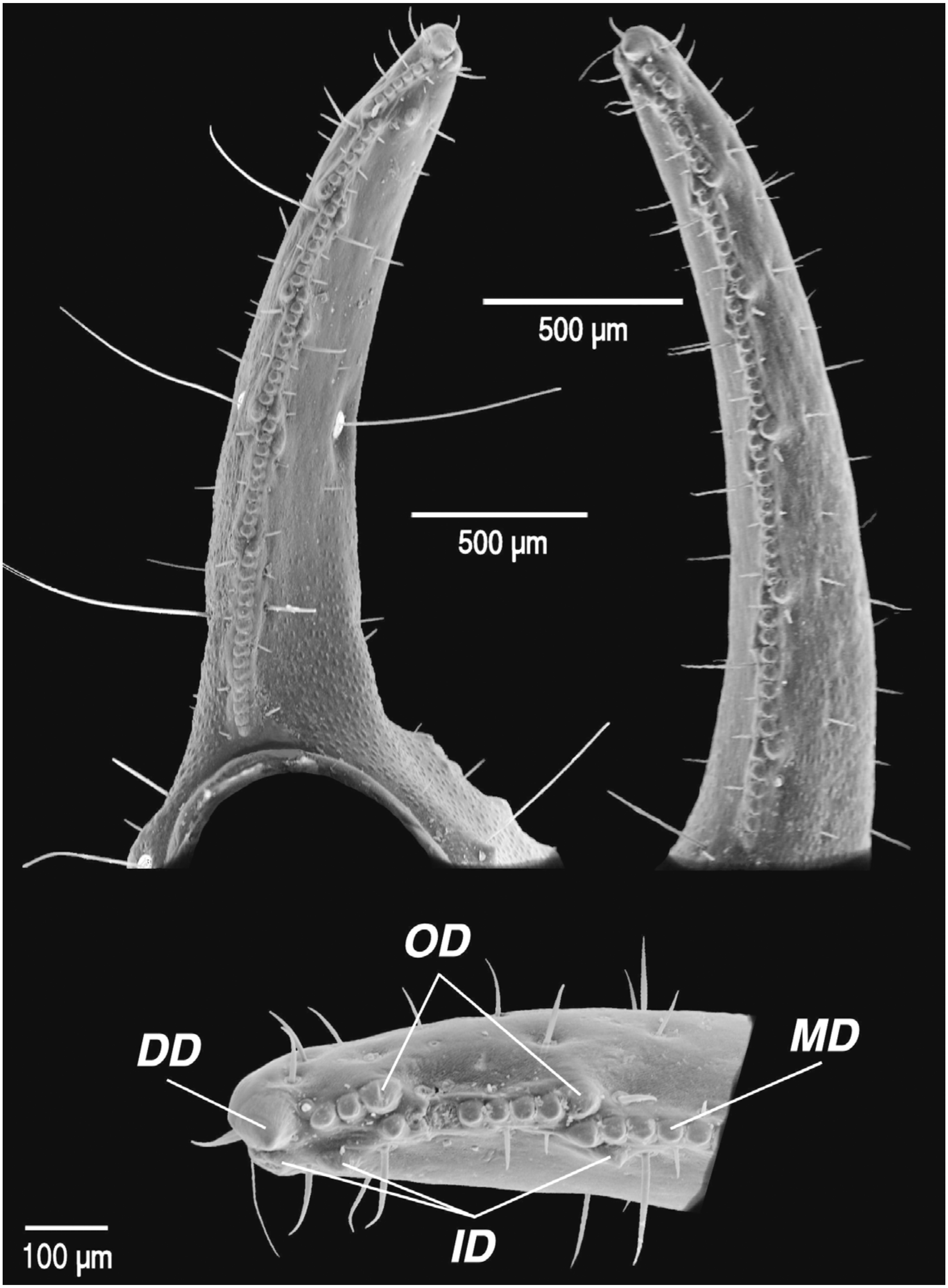


Figure 13: Chelal finger dentition (fixed left, movable right), *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey. Note that the median denticle (*MD*) groups are oblique and slightly imbricated. Also visible, in part, are trichobothria *ib*, *it*, *et*, *est*, *esb*, *eb*, and Et_3 on fixed finger. Bottom figure shows close-up of movable finger distal aspect with distal denticle (*DD*), median denticles (*MD*), outer denticles (*OD*), and inner denticles (*ID*) identified.

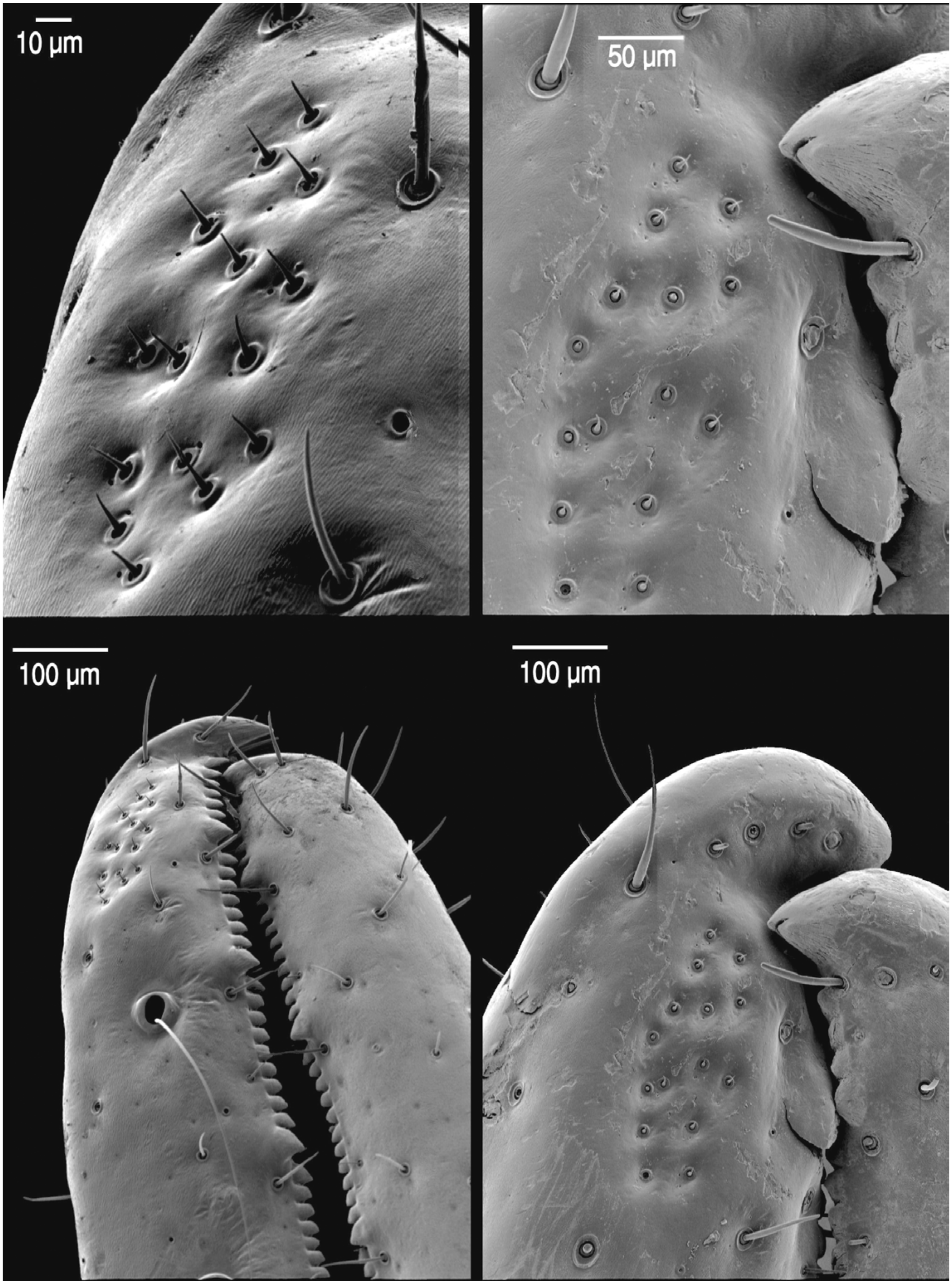


Figure 14: Constellation array in *Calchas gruberi*, **sp. nov.**, showing 15 sensilla. **Left.** Juvenile male, Antalya, Turkey. **Right.** Adult male, Antalya, Turkey.

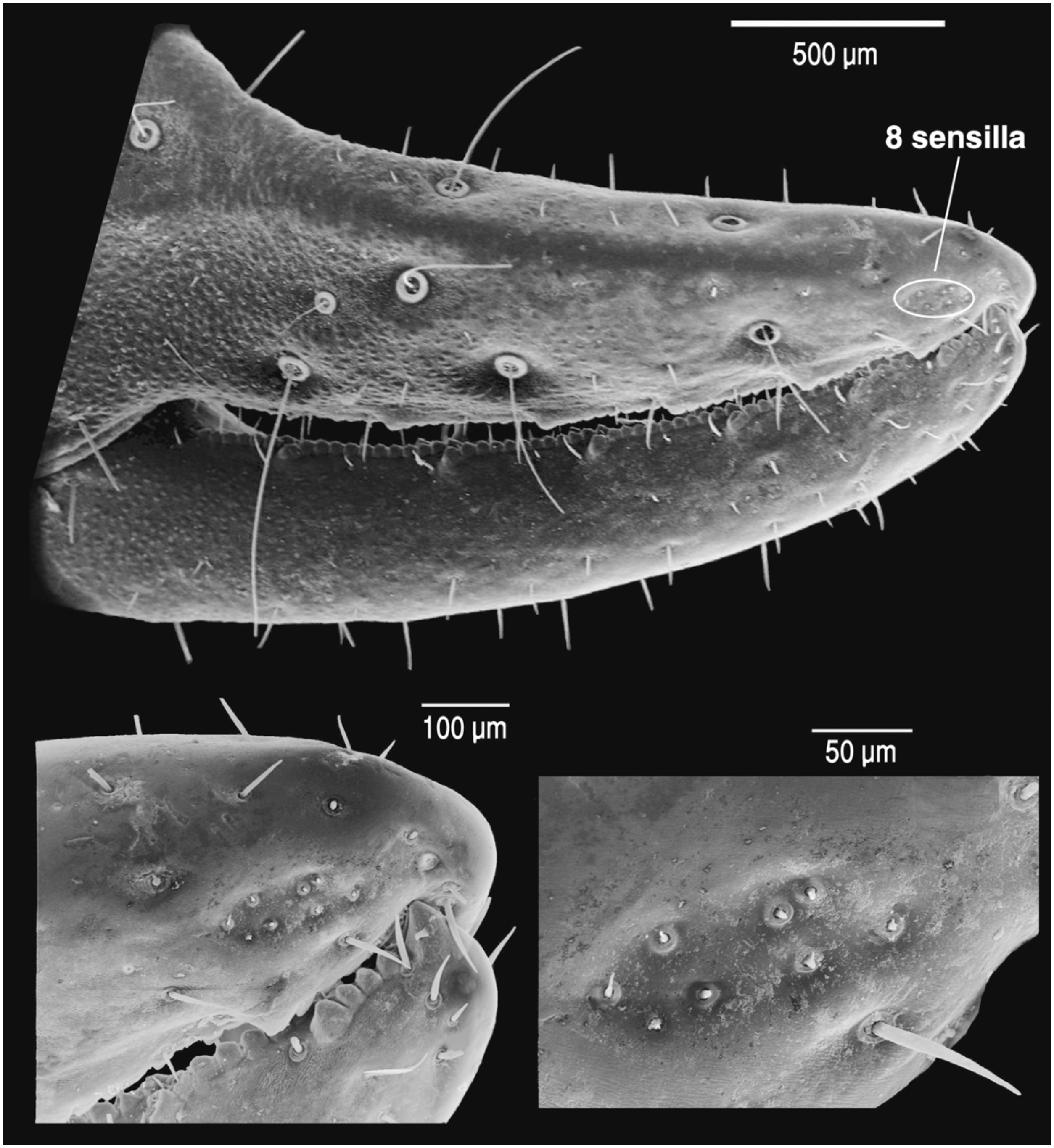


Figure 15: External view of pedipalp chela showing constellation array of *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey. Note that this species exhibits eight sensilla, considerably less than that found in *C. gruberi*, **sp. nov.**, which has 15 sensilla (see Fig. 14). Also visible are eight fixed finger trichobothria, *eb–et* and *db–dt*, showing the pattern representative of *C. birulai*.

that the presence/absence of the tibial spur did not warrant consideration as a "fundamental character" and therefore its distribution was not discussed. This subject is currently being revisited (Soleglad et al., in progress).

Calchas is also equipped with a pair of **pedal spurs** located on the ventral surface at the juncture of the basitarsus and tarsus (see Fig. 18). These spurs are typical of Recent scorpions; they are smooth, neither exhibiting spinelets as in *Hadrurus* and *Hoffmannihadrurus* (family Caraboctonidae), nor showing morphometric differences between the spurs as seen in some environmentally adapted scorpions such as psammophiles.

Fet et al. (2004) presented a detailed analysis of the iuroid leg tarsus. In this important study, it was shown that all six iuroid genera had some form of **spinule**

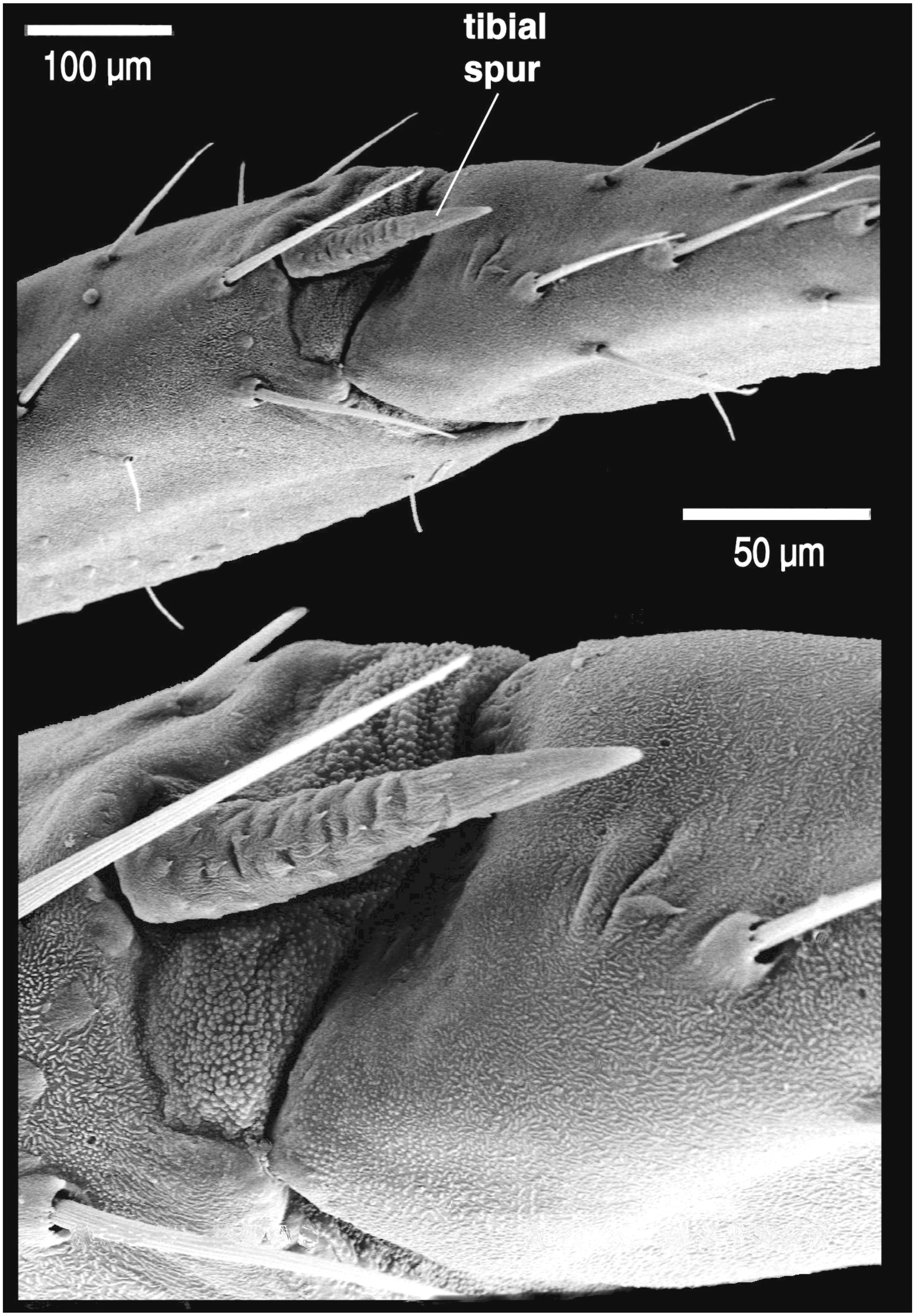


Figure 16: Leg III tibial spur. *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey.

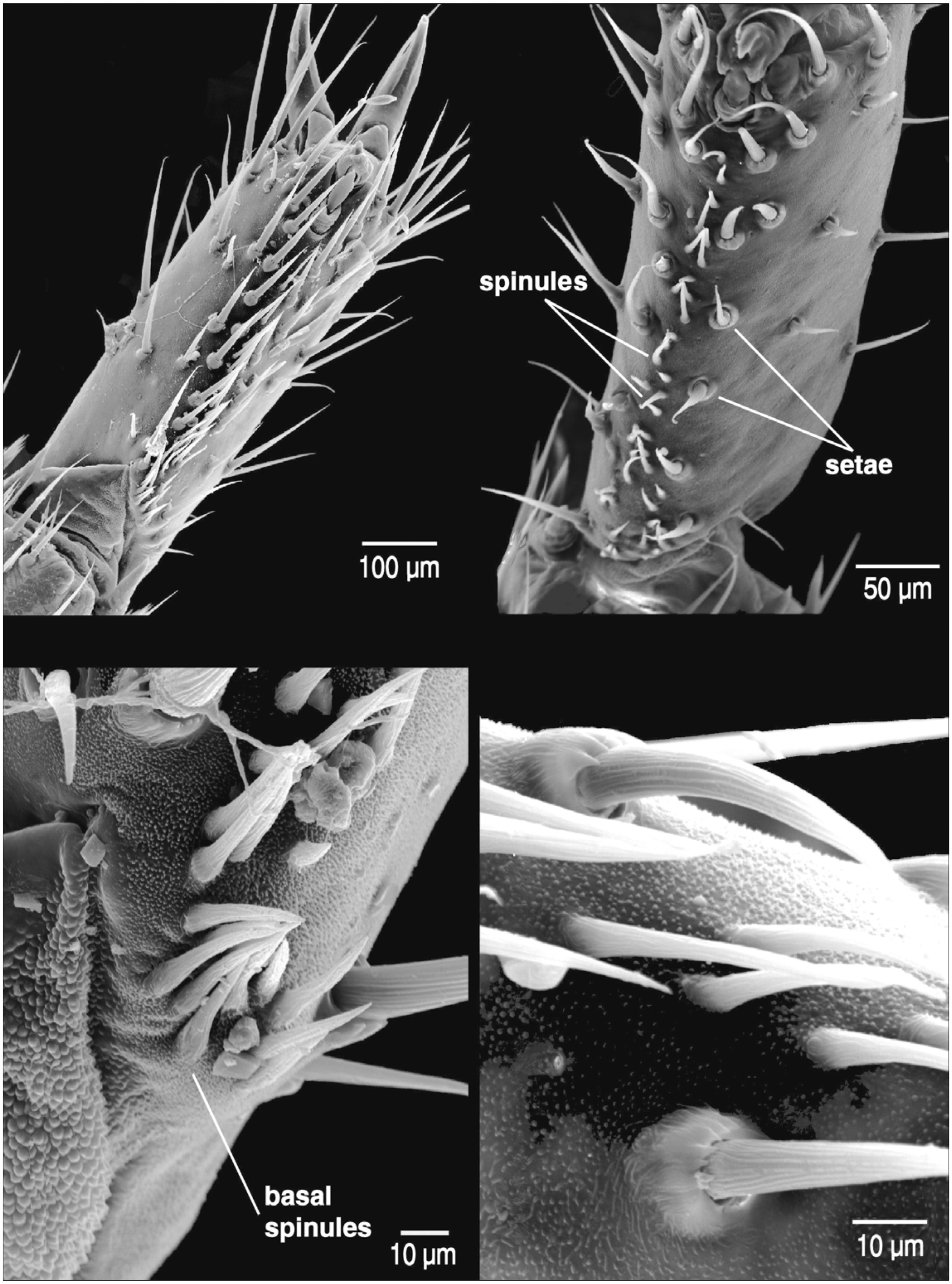


Figure 17: Leg tarsus spination in *Calchas gruberi*, **sp. nov.**, ventral surface, juvenile male, Antalya, Turkey.

clusters on the ventral surface of the **leg tarsus**. The variety and overall manifestation of this spination, however, is considerable across the six genera, which we summarize here:

(a) in *Calchas* (Fig. 17) the spinules, in juveniles, occur in irregularly configured clusters extending medially the entire length of the tarsus; in adults, the spinules are reduced in number, only occurring at the tarsus base;
(b) in *Iurus*, the individual spinules are exceptionally small and form actual clusters of dense spinules in a medial line along the tarsus, terminating in a pair of enlarged clusters;
(c) in *Caraboctonus* and *Hadruroides*, we see a similar clustered configuration as in *Iurus*;
(d) in *Hadrurus* and *Hoffmannihadrurus*, the spinule clusters are "fused" into a striated structure resembling a large spinule. Fet et al. (2004) hypothesized that these tarsal structures with their striations emanating from the base are the remnants of fused spinule clusters.

Soleglad & Fet (2003b: character 57, state=3) and Fet & Soleglad (2008: character 4, state=1) demonstrated that the ventral aspect of the tarsus with heavy spination is a synapomorphy for superfamily Iuroidea.

The leg tarsus of *Calchas* is covered ventrally with numerous **large socketed setae**, essentially obscuring the underlying spination discussed above (Fig. 18). It is interesting to point out that some of these setal sockets are armed with small pointed spines circling the setal base. A similar armed setal socket is illustrated for *Chaerilus* (Soleglad & Fet, 2003b: figs. 13–14).

In Figure 19 we illustrate a curious **"rosette"-like structure** in *Calchas* emanating from the extreme distal edge of the basitarsus, illustrated here for two specimens of *C. gruberi*. This structure is formed as a cluster of five to seven highly tapered acuminate denticle-like substructures with conspicuous striations occurring vertically along their shaft. Their length is shorter than that of a pedal spur. In Figure 19, a conspicuous slit sensilla is seen next to the "rosette", aligned vertically.

Birula (1917a) writes concerning the leg of *C. nordmanni*:

> "…on the third and fourth pairs of legs, in contrast to other Chactidae, well developed spurs are present; there are two spines on all legs near the base of the tarsus … ventrally bears four rows of bristles arranged in a series, two on each side …".

Vachon (1971: figs. 11–12) illustrates leg IV of a male *C. nordmanni*, showing the two pedal and tibial spurs as well as the dense setation of the ventral surface of the tarsus. Note that this figure does not show spinule clusters that most probably occurred on the tarsus base.

Metasoma and telson

The **metasomal** structure of *Calchas* is typical of many Iurida scorpions. Segments I–IV become narrower and longer beginning from the basal segment, segment IV usually the narrowest and longest of the four segments. Segment V is considerably longer than segment IV, 1.50 to 1.70 times longer. Segments I–IV exhibit dorsal, dorsolateral, lateral, ventrolateral, and ventromedian carinal pairs, the lateral being complete on segment I, and decreasing in size to obsolete on segments II–IV. These carinae are well developed and usually granulate, or crenulate to serrate. The dorsal and dorsolateral carinae terminate in a slightly enlarge dentical. The dorsolateral carinae of segment IV are not flared distally, but terminate at the condyle. Segment V has dorsolateral, lateral, ventrolateral, and ventromedian carinae, the latter singular. The lateral carinae are present on the anterior two-thirds of the segment. As with the other carinae, segment V carinae are granulate to serrate. The single ventromedian carina is straight, not exhibiting any form of bifurcation. The distal portion of the metasoma of species *C. birulai*, **sp. nov.** (Figs. 49, 50), and *C. gruberi*, **sp. nov.** (Figs. 66, 67), is illustrated below in the species level descriptions.

The **telson** in *Calchas* is unique within its species, exhibiting both conspicuous morphometric proportion differences as well as an unusual positioning of the subaculear setal pair (SSP) in some of its species. In Figure 20, showing *C. birulai*, **sp. nov.**, and *C. gruberi*, **sp. nov.**, we see that the vesicle in the former is considerably more elongated, with a shorter, abruptly curving aculeus. In *C. gruberi*, **sp. nov.**, the vesicle is more globular and the aculeus longer and less abruptly curved. In Figure 21, we see that in *C. gruberi* and *C. birulai* the SSP is not found at the same location. In *C. gruberi*, the SSP is located at the vesicle/aculeus juncture, as in most scorpions, in *C. birulai*, it is placed on the base of the aculeus. Below, when we discuss the species of *Calchas*, we will see that the SSP position in *C. nordmanni* is also on the aculeus base, as in *C. birulai*.

We consider the enlarged setal pair found on the aculeus base in *C. nordmanni* and *C. birulai* to be homologous to the pair found in *C. gruberi* for the following reasons:

- the SSP are enlarged setae, emanating from a raised area of the cuticle caused, in part, by the enlarged areolae (quite visible in Fig. 21)
- this raised area, depending on its size, can form a subaculear tubercle as found in some scorpions

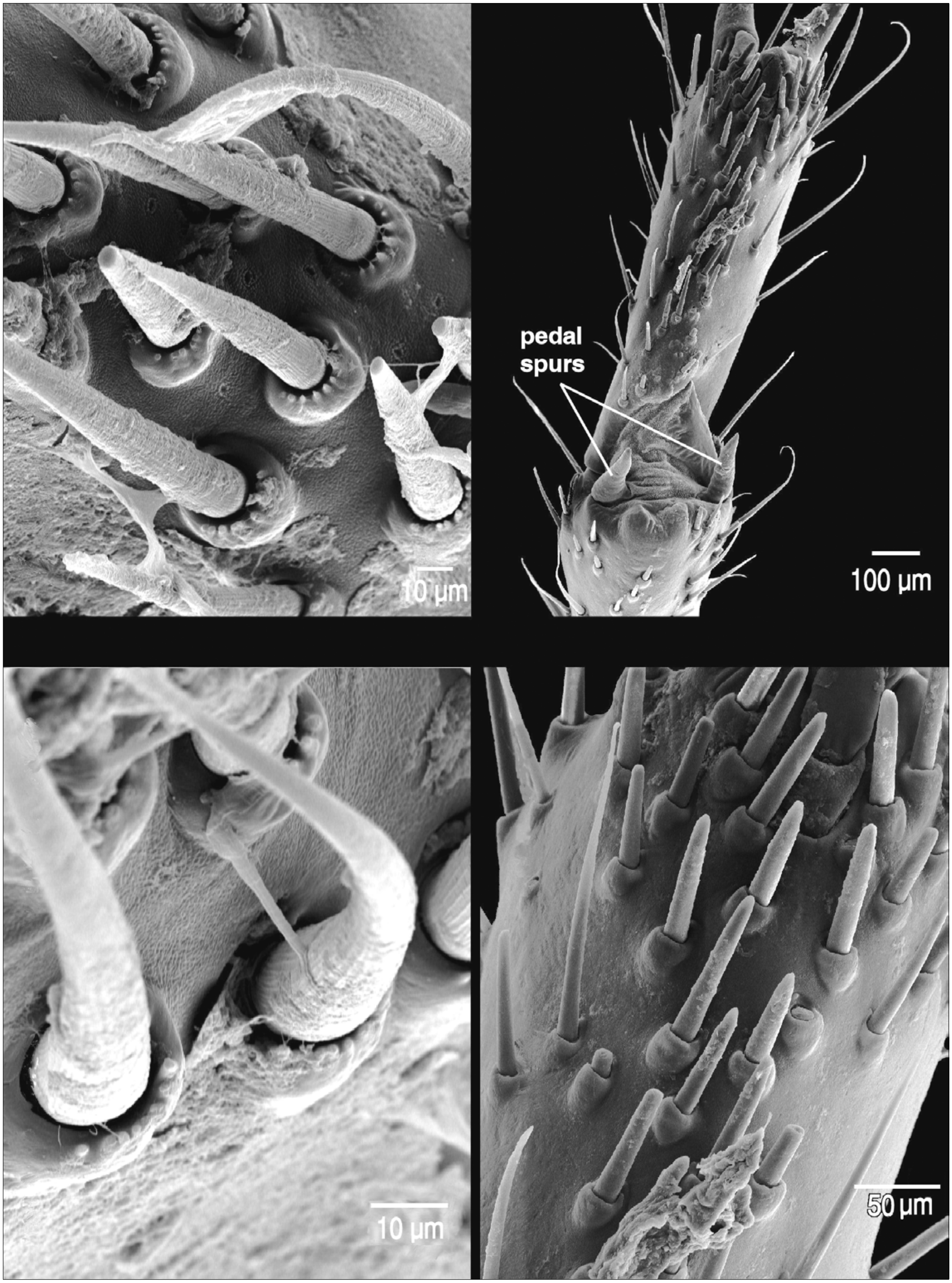


Figure 18: Leg tarsus setation in *Calchas gruberi*, **sp. nov.**, ventral surface. **Left.** Adult male, Antalya, Turkey. **Right.** Adult female, Antalya, Turkey, pedal spurs indicated.

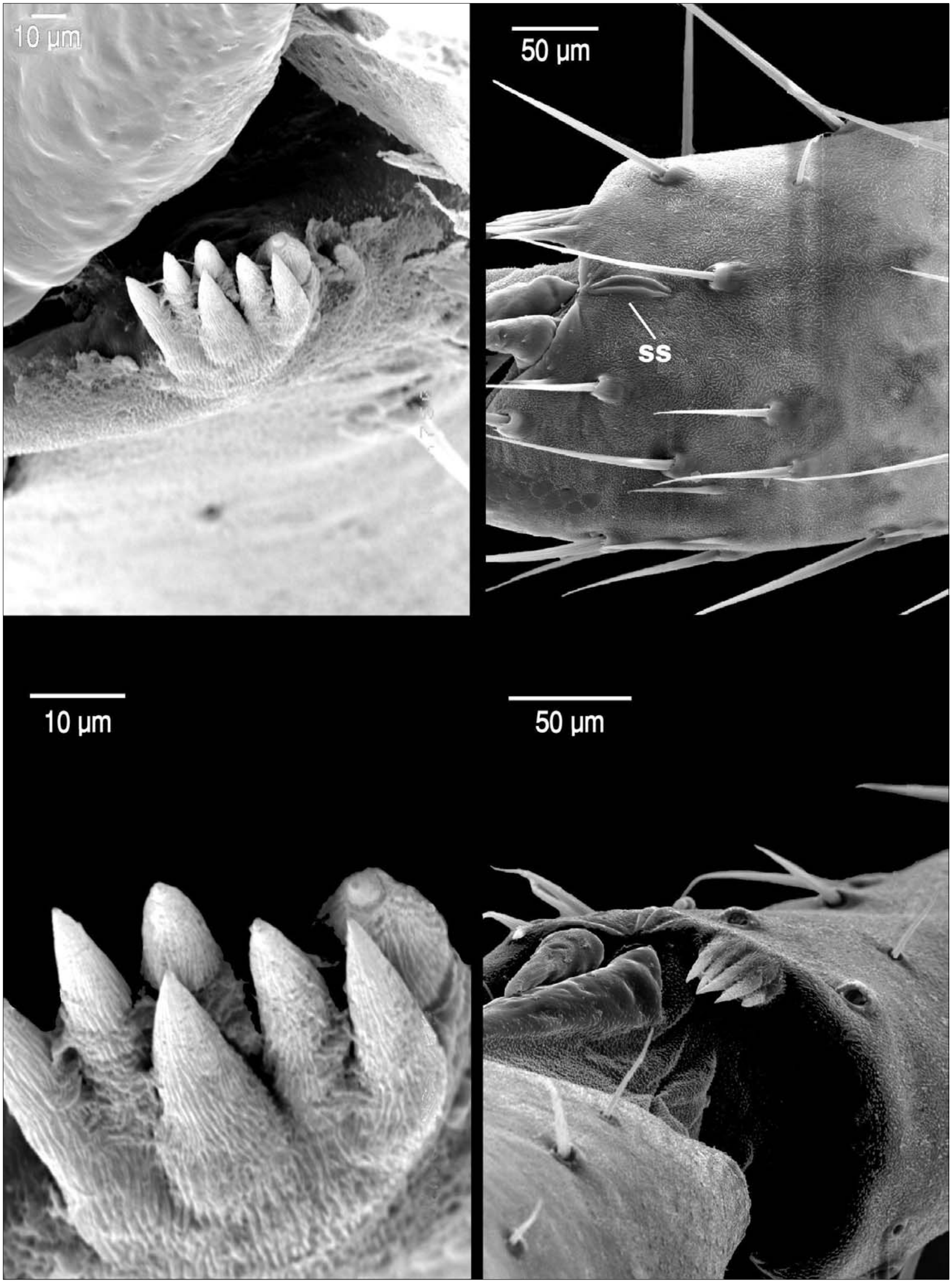


Figure 19: Distal aspect of leg basitarsus in *Calchas gruberi,* **sp. nov.**, Antalya, Turkey. **Left.** Adult male, showing "rosette" structure with seven denticles. **Right-Bottom.** Juvenile male, "rosette" with five denticles. **Right-Top.** Slit sensilla (indicated by *ss*) and "rosette".

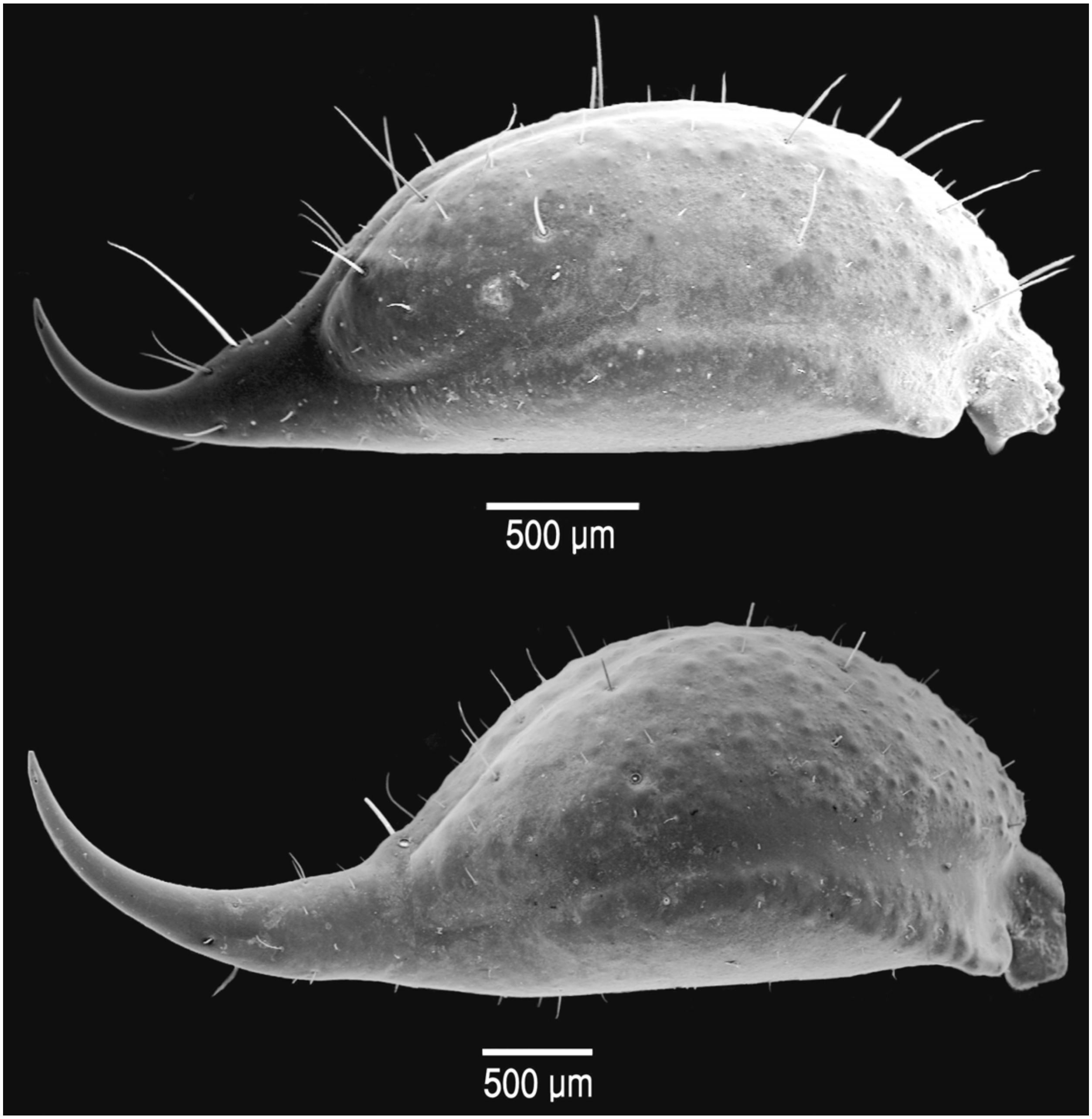


Figure 20: Telson, lateral view, of *Calchas* species. **Top.** *C. birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey. **Bottom.** *C. gruberi*, **sp. nov.**, female, Antalya, Turkey.

- the enlarged setae and raised area are not found on the vesicle/aculeus juncture in *C. nordmanni* and *C. birulai* further implying that the SSP has moved forward onto the aculeus
- the ventral distal setal pair (VDSP) is more distal on the aculeus essentially adjacent to the dorsal distal setal pair (DDSP) in *C. nordmanni* and *C. birulai*; in *C. gruberi*, the VDSP is proximal to DDSP, common to many scorpions, concluding that the VDSP has moved distally as well, probably caused by the forward movement of the SSP (see Fet et al., 2006b, on their discussion of the LAS (Laterobasal Aculear Serrations) in the family Vaejovidae where DDSP and VDSP are further discussed)

The unique telson of *C. nordmanni* was also discussed in great detail by Birula (1917a: fig. 13):

> "… dorsally the telson … has two smooth, shallow, longitudinal grooves which distinctly separate the base of the sting from the surface of the telson, laterally on the end; only at the base of the vesicle … the sting,

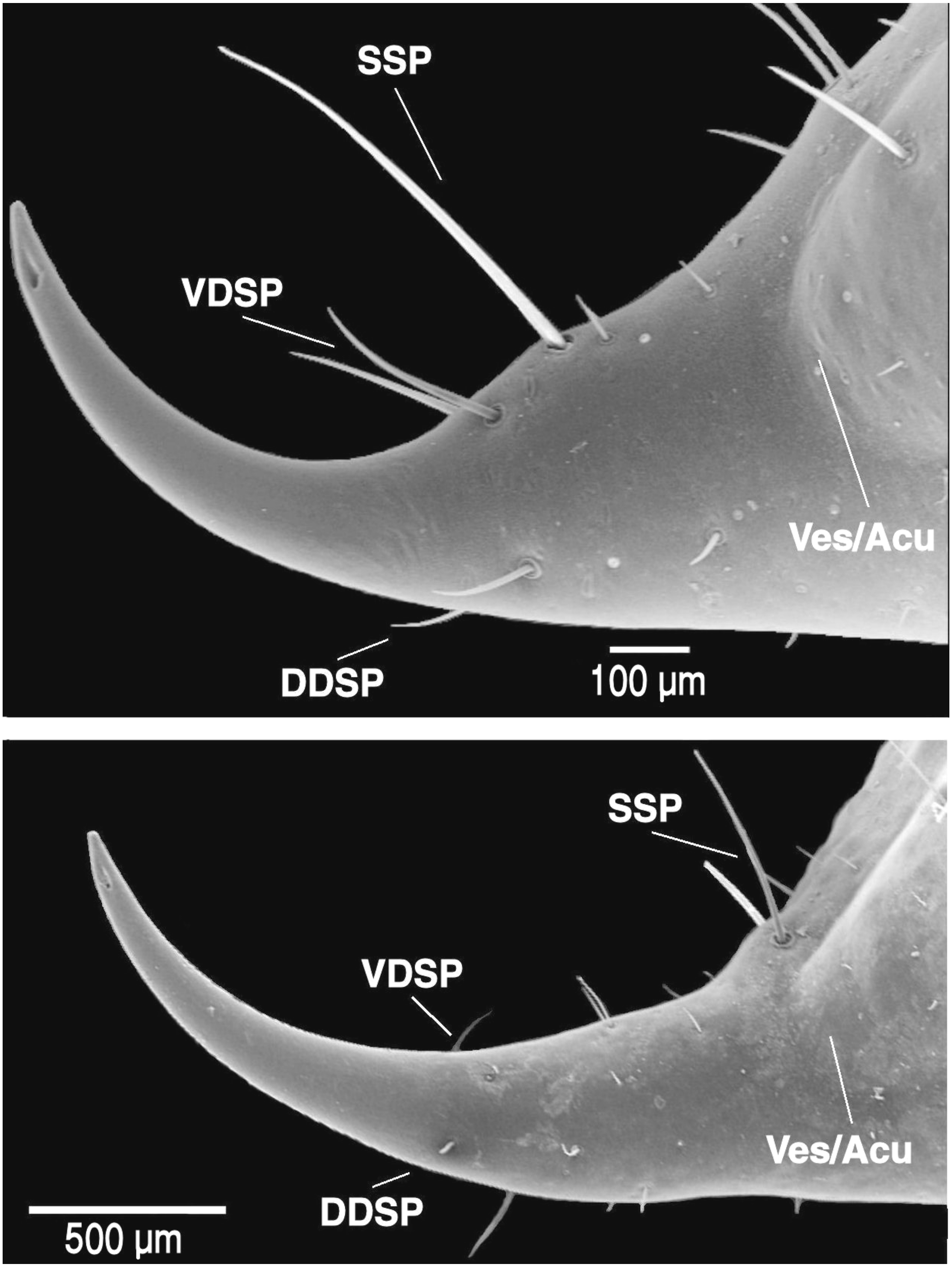


Figure 21: Close-up of the telson of *Calchas* showing two different placements of the subaculear setal pair (SSP) with respect to the vesicle/aculeus juncture. **Top.** *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey, SSP placed on aculeus base, distal of the juncture. **Bottom.** *C. gruberi*, **sp. nov.**, female, Anamur, Turkey, SSP placed at juncture. Ves/Acu = vesicle/aculeus juncture, VDSP = ventral distal setal pair, DDSP = dorsal distal setal pair.

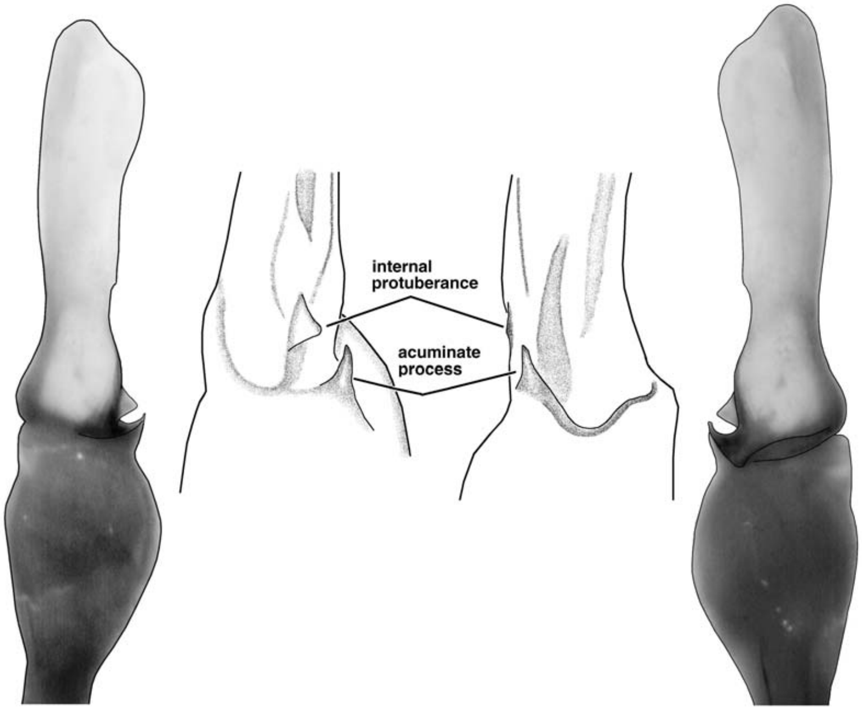


Figure 22: Right hemispermatophore of *Calchas birulai*, **sp. nov.**, Kavurma Köyü, Turkey. **Left.** Dorsal view. **Right.** Ventral view. **Central, Left.** Close-up of capsular area, interodorsal view, internal protuberance visible, though angled slightly outward towards figure plane. **Central, Right.** Internal view, internal protuberance barely visible, angled directly into figure plane. Note that the truncated nature of the acuminate process distal tip is visible in this view.

> thickened at the base in the shape of a knot, and curved only terminally …”.

It is important to note here that the unusual placement of the subaculear setal pair (SSP) on the aculeus base is quite clear in Birula’s figures of *C. nordmanni*.

Hemispermatophore

The description of the *Calchas* hemispermatophore is presented here for the first time, based on the analysis of species *C. birulai*, **sp. nov.**, as illustrated in Figs. 22 and 23. It should also be noted that the hemispermatophore of the type specimen is illustrated below in Fig. 55 under the description for that species. In general, most of the *Calchas* specimens examined were not adequately preserved internally. Therefore, hemispermatophores when located were not affixed to the distal aspect of the mesosoma, thus the trunk was not usually intact. However, the lamina and capsular area, which exhibited some sclerotization, were preserved well enough to study their structure.

The *Calchas* hemispermatophore is classified as lamelliform, a hypothesized synapomorphy for the parvorder Iurida (Soleglad & Fet, 2003b, fig. 114, character 73, state=3). The lamelliform hemispermatophore is composed of three basic parts: the lamina, capsular area, and the trunk (see Soleglad & Fet, 2008: fig. 40, for some of the more basic terminology). The lamina overall structure is simplistic, its external and internal edges are straight, parallel, and forming a somewhat spatulate structure, terminating in a blunt distal tip angled towards its base in an external to internal direction. The distal tip is slightly thickened on the external edge exhibiting minor sclerotization and pigmentation, most noticeable on the ventral surface. The lamina base lacks a basal constriction but a slight angled expansion is visible on the internal edge just proximally of the lamina midpoint. A very delicate sclerotization is found on the internal lamina base edge extending to this expansion. At the lamina internal base edge, is a marginally pigmented, slightly sclerotized thin triangular-shaped protuberance. This **internal protuberance**, though located on the internal aspect of the lamellar base, is positioned closer to the dorsal surface, its view being partially blocked when viewed from the ventral aspect (see close-ups of the capsular area exhibiting six views in Figs. 22 and 23). The capsular area is formed at the extreme base of the lamina, formed by two swallow troughs, termed the dorsal and ventral troughs. These troughs are formed by delicate sclerotization and are roughly equal in position from a vertical perspective. Emanating from the capsular area internal area is a highly pigmented sclerotized **acuminate process** terminating in a delicately truncated point. This acuminate process curves sharply in a distal direction, its edges formed as extensions from the sclerotized portions of the two troughs. A truncal flexure, of medium development, is found on the external edge, separating the trunk from the lamina-capsular area. The trunk is somewhat elongated, roughly half the length of the hemispermatophore. It lacks any

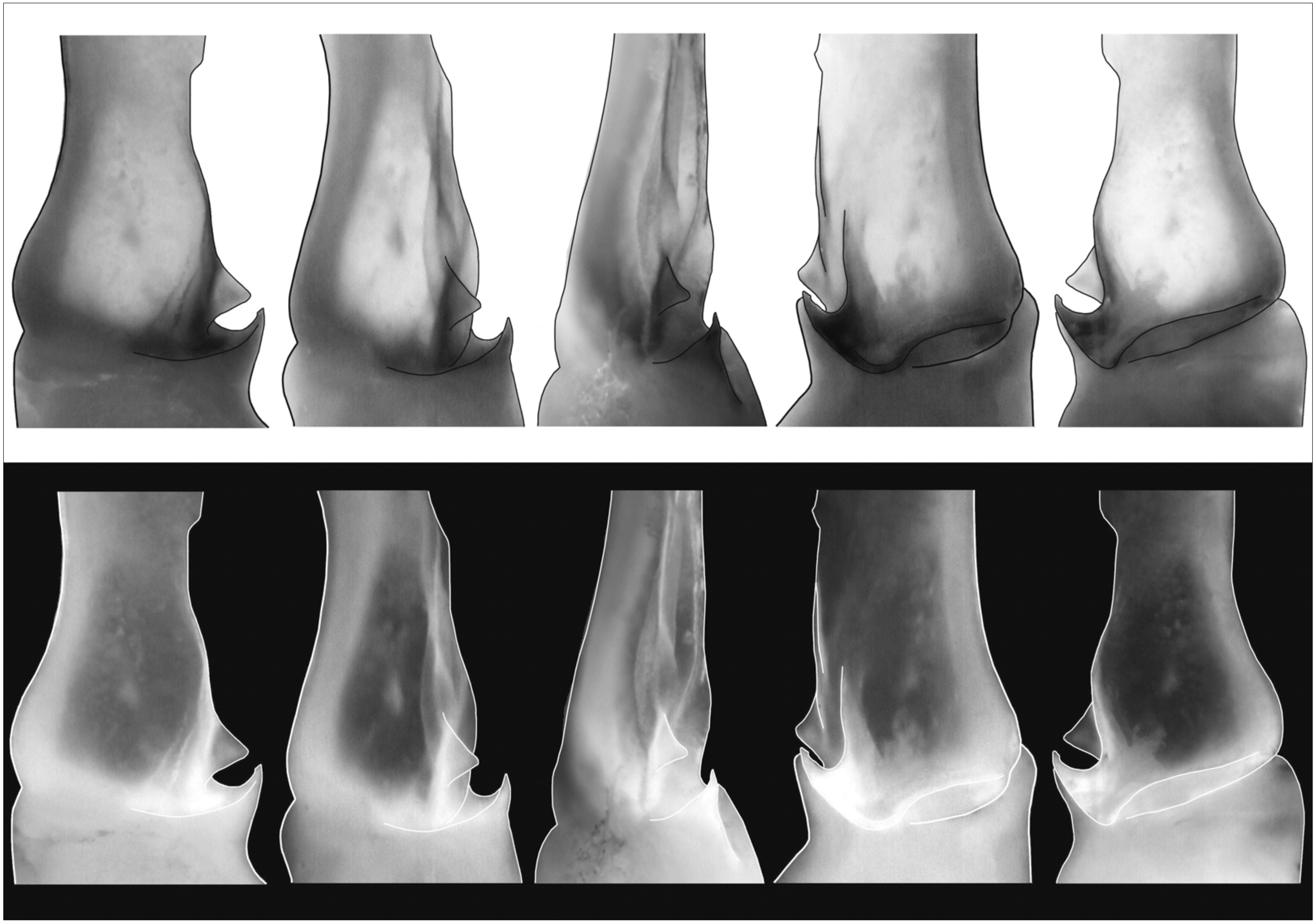


Figure 23: Right hemispermatophore of *Calchas birulai*, **sp. nov.**, Kavurma Köyü, Turkey. Close-up of capsular area (left to right), dorsal, dorsointernal, interodorsal, ventrointernal, and ventral. Reverse video images on bottom.

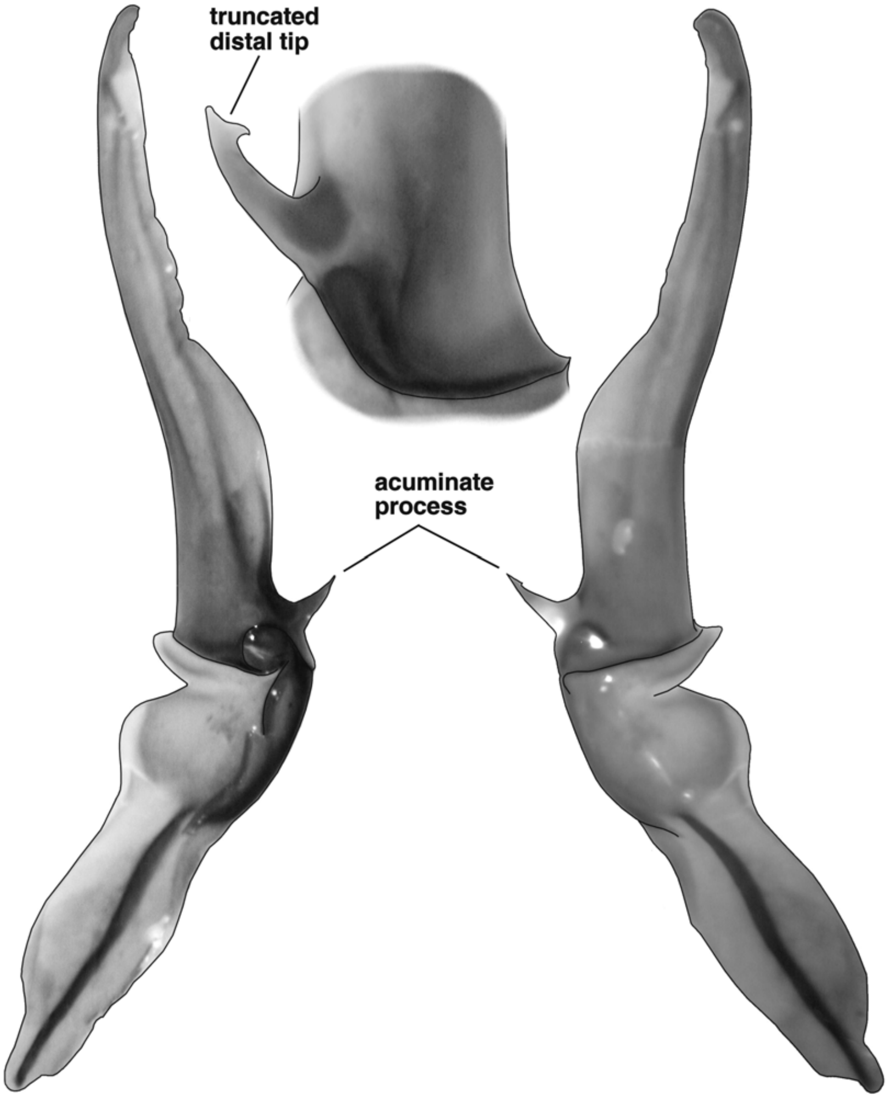


Figure 24: Right hemispermatophore of *Iurus dufoureius*, Antalya, Turkey. Dorsal and ventral views, and close-up of capsular area from a internoventral view. Note the significantly developed acuminate process with a truncated distal tip visible from the internal and ventral perspectives.

noticeable sclerotization and tapers considerably towards its “foot”.

Comparisons to *Iurus*. In Figure 24, we show the hemispermatophore of *Iurus dufoureius*, dorsal and ventral views, plus a close-up of the capsular area (first illustrated in Francke & Soleglad, 1981: figs. 53–56). A much more in-depth analysis of this structure in *Iurus* will be given in another paper in this series (Kovařík et al., in progress); here, it is presented only for comparison with *Calchas*.

In *Iurus*, the overall basic structure of the hemispermatophore appears quite different from that seen in *Calchas*: the lamina in *Iurus* is quite elongate and tapers considerably distally, whereas in *Calchas*, the lamina is more spatulate in shape, the external and internal edges essentially parallel; the lamina in *Iurus* is more sclerotized and pigmented with a well defined back and a irregularly shaped internal edge. In *Calchas*, the lamina is lightly sclerotized with little pigment; the basal third of the lamina in *Iurus* protrudes internally in a highly rounded expansion as it extends to the capsular area; in *Calchas* a slight narrow expansion is visible at lamina midpoint; *Iurus* lacks the subtle triangular-shaped internal protuberance seen in *Calchas*; *Iurus* exhibits a curious sclerotized pigmented structure emanating from the capsular area dorsointernal aspect, folding over onto the internal area of the trunk, roughly one-third the trunk’s length; *Calchas* lacks this structure; both *Iurus* and *Calchas* have a truncal flexure, highly developed in the former and moderately developed in the latter; finally, both *Iurus* and *Calchas* exhibit a highly sclerotized pigmented acuminate process protruding from the internal edge of the capsular area, terminating in a truncated point. We hypothesize here that this acuminate process with its truncated point is homologous in these genera and therefore is a likely synapomorphy for family Iuridae.

Key to species of *Calchas*

Below we present a key to the three species of *Calchas*. Though small, we propose it is phylogenetic since we believe that *C. nordmanni* and *C. birulai* are sister species; i.e., *Calchas* = (*C. gruberi* + (*C. nordmanni* + *C. birulai*)). This relationship is currently being analyzed from a cladistic perspective (Soleglad et al., in progress).

1 - Six and five internal denticles (*ID*) and seven and six median denticle (*MD*) groups found on the chelal movable and fixed fingers, respectively (Fig. 25); trichobothrium *it* positioned on basal half of fixed finger (Fig. 33); subaculear setal pair (SSP) of telson located on base of aculeus, distally of vesicle/aculeus juncture (Figs. 27–31); telson vesicle relatively long with respect to the telson, ratio telson_L/vesicle_L = 1.38–1.47 (Fig. 37) …………… ……………………………..….. **2**

■ - Seven and six internal denticles (*ID*) and eight and seven median denticle (*MD*) groups found on the chelal movable and fixed fingers, respectively (Fig. 25); trichobothrium *it* positioned on distal third of fixed finger (Fig. 33); subaculear setal pair (SSP) of telson located at vesicle/aculeus juncture (Fig. 26); telson vesicle relatively short with respect to the telson, ratio telson_L/vesicle_L = 1.67 (Fig. 37)…..***C. gruberi*, sp. nov.**

2 - Metasomal segment V approximately twice as long as wide, ratio L/W = 2.00–2.06 (Fig. 37); chelal fixed finger relatively short, considerably shorter than palm, ratio palm_L/fixed finger_L = 1.33–1.44; trichobothrium *dst* approximately mid-distance between *dt* and *db*, ratio *dt*|*dst* / *dst*|*db* = 0.75–1.10 (Fig. 32); pectinal tooth counts 6 male, 5 female (Fig. 36)….. ***C. birulai*, sp. nov.**

■ - Metasomal segment V approximately two and one-half times longer than wide, ratio L/W = 2.54–2.55 (Fig. 37); chelal fixed finger relatively medium in length, equal to or slightly shorter than palm, ratio palm_L/ fixF_L = 1.10–1.20; trichobothrium *dst* distal of mid-point between *dt* and *db*, ratio *dt*|*dst* / *dst*|*db* = 0.46–0.64 (Fig. 32); pectinal tooth counts 7 male, 6 female (Fig. 36) ……………...……….. ***C. nordmanni* Birula, 1899**.

Major Structural Differences in *Calchas* Species

We discuss here in detail the morphological differences exhibited between the three species of *Calchas*. In general, these differences separate *C. gruberi* from the two closely related species *C. nordmanni* and *C. birulai*, although the latter two are differentiated as well. The differences between these two species groups are considerable, involving chelal finger dentition, the telson structure, and several differences in trichobothrial positions.

Chelal finger dentition

C. gruberi can be distinguished from *C. birulai* and *C. nordmanni* by the number of inner denticles (*ID*) and median denticle (*MD*) groups found on the chelal fingers. In Fig. 25, we see that *C. gruberi* has one additional *ID* and *MD* group on the movable finger than the other two species, seven and eight respectively. This difference of one *ID* and *MD* group is also seen in the fixed finger where *C. gruberi* exhibits six *ID* and seven *MD* groups, compared to five *ID* and six *MD* groups in *C. birulai* and *C. nordmanni*. The overall structure of the *MD* groups is the same in the three species, however, as described above for the genus. *MD* group-1 on the movable finger is quite small, involving 3–4 denticles and the most basal *MD* group is not accompanied by an *ID* denticle nor is terminated with an outer denticle (*OD*).

As to be expected, since *C. gruberi* has an additional *MD* denticle group, the number of *MD* denticles (this excludes the terminating *OD* denticle) is the largest in this species. Based on two movable finger counts per species, we see that *C. birulai* has the least number of *MD* denticles, with *C. nordmanni* intermediate in this count:

C. birulai (54 MD) < *C. nordmanni* (70) < *C. gruberi* (77)

Telson structure

The telson in *C. gruberi* is constructed differently than in *C. nordmanni* and *C. birulai*, involving both major setal placement and the overall proportions of the vesicle and aculeus. In Figs. 26–31, *C. gruberi* is contrasted with several views of *C. nordmanni* and *C. birulai*. Of particular interest is the placement of the subaculear setal pair (SSP). In *C. gruberi*, the SSP is positioned at the vesicle/aculeus juncture, a typical location in many scorpions. In *C. nordmanni* and *C. birulai*, the SSP is located well on the aculeus, definitely distally of the vesicle/aculeus juncture. Now, it must be mentioned here that for this distinction to have significance in a cladistic sense, the two sets of setal pairs must be homologous. Elsewhere in this paper we put forth an argument showing that the SSP seen in these two species groups are indeed homologous.

The overall proportions of the two major telson components, the vesicle and aculeus, are different in the two species groups. *C. gruberi* has a bulbous telson (Fig. 20) with a relatively long aculeus with a wide curve. In *C. nordmanni* and *C. birulai* we see a more elongated vesicle (Fig. 20), rapidly extending into the short aculeus which curves abruptly distally. We calculated a ratio using the telson and vesicle length which effectively also models the aculeus length (i.e., aculeus length = telson length – vesicle length). As depicted in Fig. 37 (based on

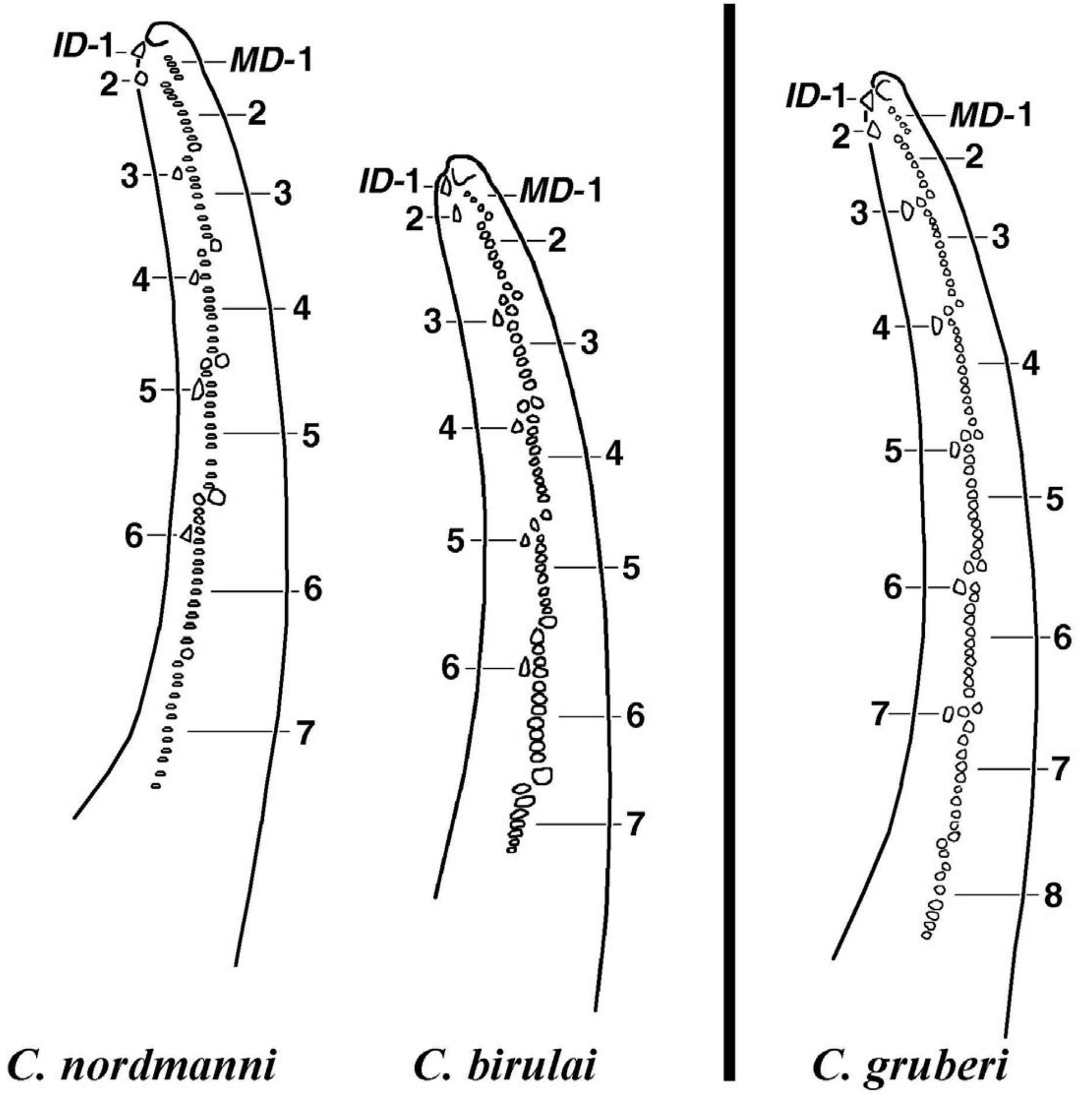


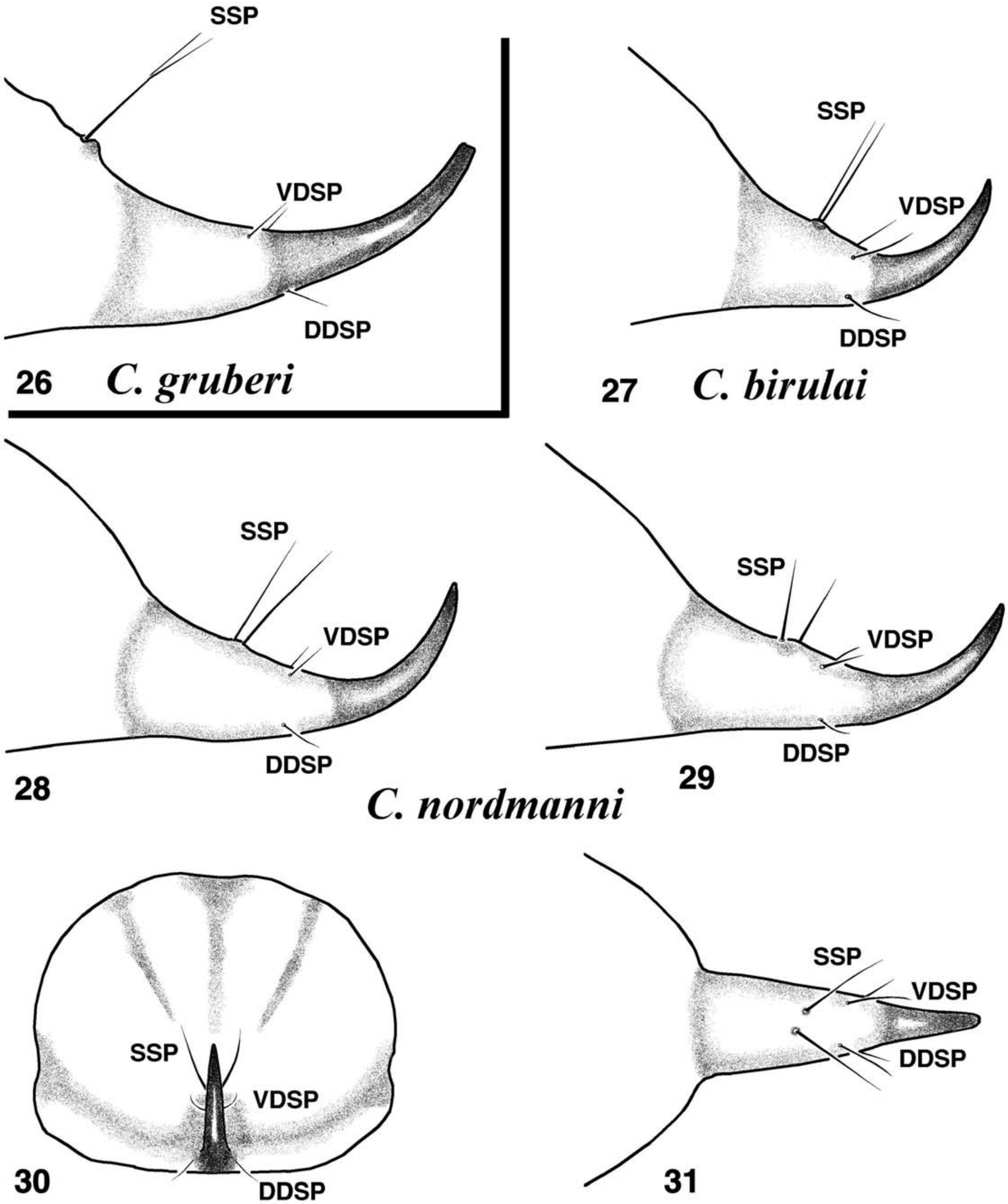
Figure 25: Chelal movable finger of *Calchas* species showing dentition. Note differences in the number of inner denticles (*ID*) and median denticle (*MD*) groups between the species: *C. nordmanni*, female, Tortum, Turkey, and *C. birulai*, **sp. nov.**, male holotype, Mardin, Turkey, with six *ID* and seven *MD* groups as compared to *C. gruberi*, **sp. nov.**, female holotype, Mamure Kalesi, Anamur, Turkey, with seven *ID* and eight *MD* groups.

28 samples), *C. gruberi* exhibits standard deviation as well as absolute range separation from the other two species. Its larger ratio value implies a relatively smaller vesicle (thus a relatively longer aculeus). The mean value differences between *C. gruberi* and the other two species (combined) are 13.8 % male and 16.2 % female.

Trichobothria patterns

Another important set of species level diagnostic characters is the location of trichobothria on the chela. Figures 32–34 illustrate several positional based characters that are adequate in separating all three species of *Calchas*. For actual identification of individual trichobothria in *Calchas*, refer to Soleglad et al. (2009: fig. 1).

Trichobothrium *dst* position. The relative positions of fixed finger trichobothria *dt*, *dst*, and *db* provide an excellent diagnostic character for *C. birulai*. *C. birulai* has by far the shortest fixed finger of the three species and this trichobothria-based character emphasizes this morphometric. In *C. birulai*, *dst* is located



Figures 26–31: Subaculear setal pair (SSP) in genus *Calchas*, lateral view unless otherwise noted (note, only the SSP, VDSP, and DDSP setal pairs are shown). Conspicuous in these illustrations is the aculear placement of the SSP in species *C. nordmanni* and *C. birulai*. In *C. gruberi*, the SSP is located at the vesicle/aculeus juncture, common to most scorpions. **26.** *C. gruberi*, **sp. nov.**, female, Mamure Kalesi, Anamur, Turkey. **27.** *C. birulai*, **sp. nov.**, male holotype, Mardin, Turkey. **28.** *C. nordmanni*, female, Tortum, Turkey. **29.** *C. nordmanni*, male, Turkey. **30.** *C. nordmanni*, female, Tortum, Turkey, viewed from the aculeus. **31.** *C. nordmanni*, male, Tortum, Turkey, ventral view. VDSP = ventral distal setal pair, DDSP = dorsal distal setal pair.

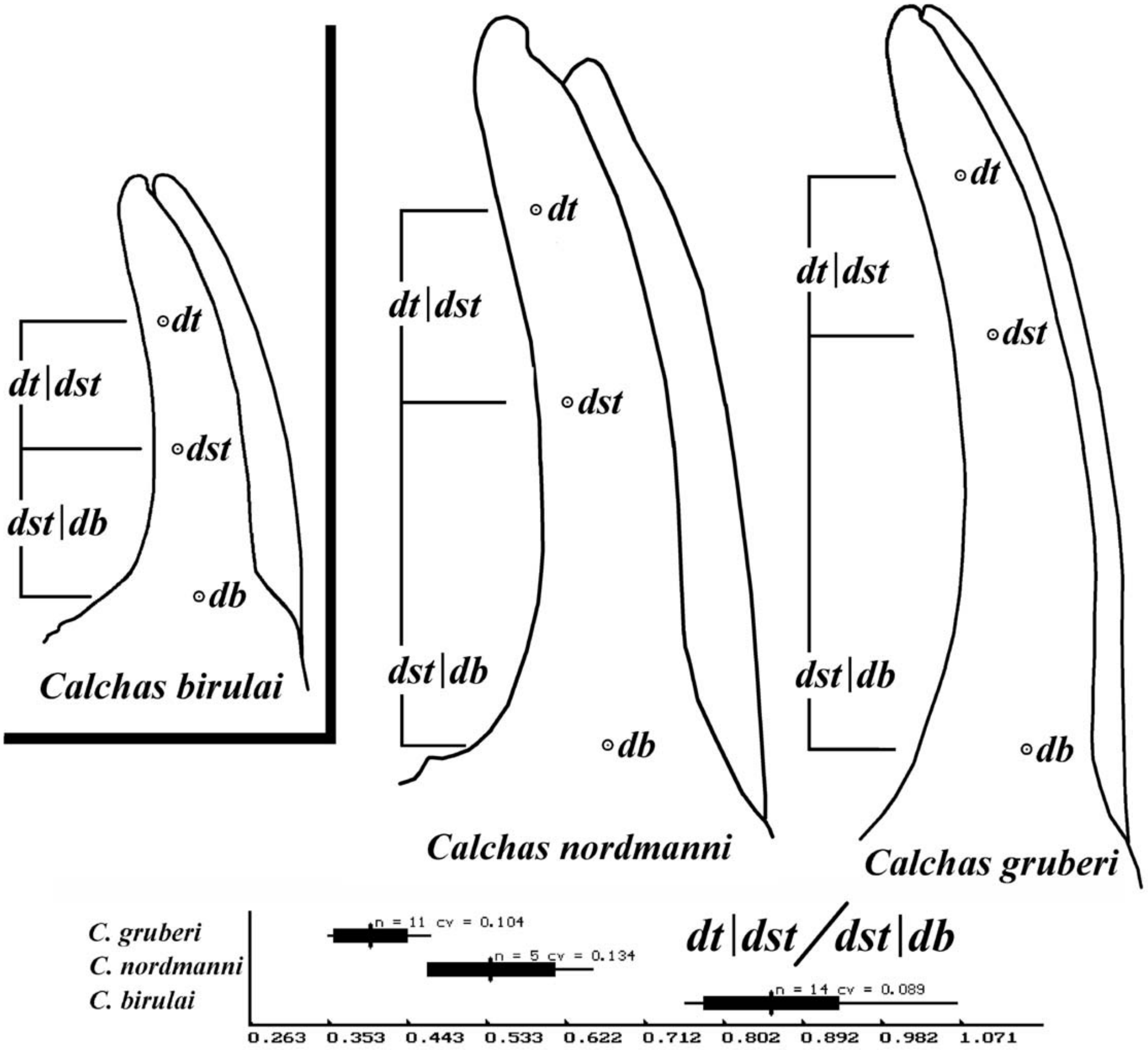


Figure 32: Relative position of chelal trichobothrium *dst* in *Calchas* with respect to trichobothria *dt* and *db*. Trichobothrium *dst* mean position indicated by open circle based on 30 samples (other fixed finger trichobothria not shown). Method of measurement: *dt*|*dst* = distance between *dt* and *dst*, *dst*|*db* = distance between *dst* and *db*. Histogram of morphometric ratio shows mean (vertical bar), minimum, maximum, and standard error (black rectangle) ranges. We see two significant *dst* positional differences in these species: In *C. birulai*, trichobothrium *dst* is approximately at midpoint between *dt* and *db* whereas in *C. nordmanni* and *C. gruberi*, *dst* is considerably distal of midpoint, most exaggerated in *C. gruberi*.

approximately equidistant between *dt* and *db*, slightly closer to the former (Fig. 32). In *C. nordmanni* and *C. gruberi*, *dst* is located significantly distal of the midpoint between *dt* and *db*, the most exaggerated in the latter species. The histogram shown in Fig. 32 also illustrates this character from a statistical perspective. Here we see, based on 30 samples, that when the distance between *dt* and *dst* (denoted as *dt*|*dst*) is divided by the distance between *dst* and *db*, there is significant standard error separation between *C. birulai* and the other two species, exhibiting a 59 %|113.7 % difference between the mean values, *C. nordmanni* and *C. gruberi*, respectively.

Trichobothrium *it* position. The relative position of trichobothrium *it* on the fixed finger provides an excellent diagnostic character for *C. gruberi*. In *C. gruberi*, trichobothrium *it* is located on the distal third of the fixed finger (Fig. 33). In *C. nordmanni* and *C. birulai*, *it* is located approximately at the finger midpoint, the most exaggerated in latter species where it is definitely proximal of the finger midpoint. The histogram shown in Fig.33 also illustrates this character from a statistical perspective. Here we see, based on 30 samples, that when the distance from the fixed finger base to trichobothrium *it* is divided by the length of the

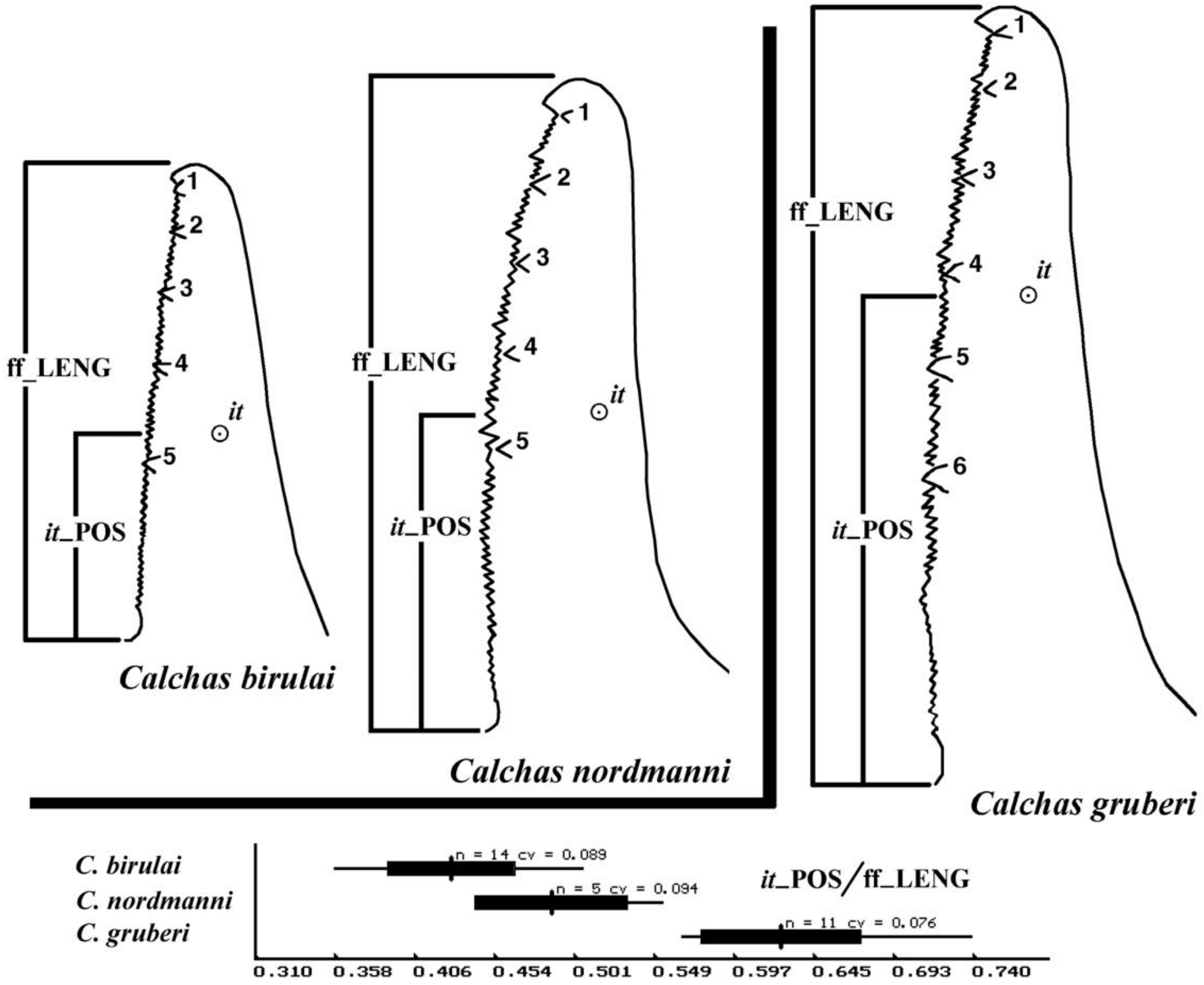
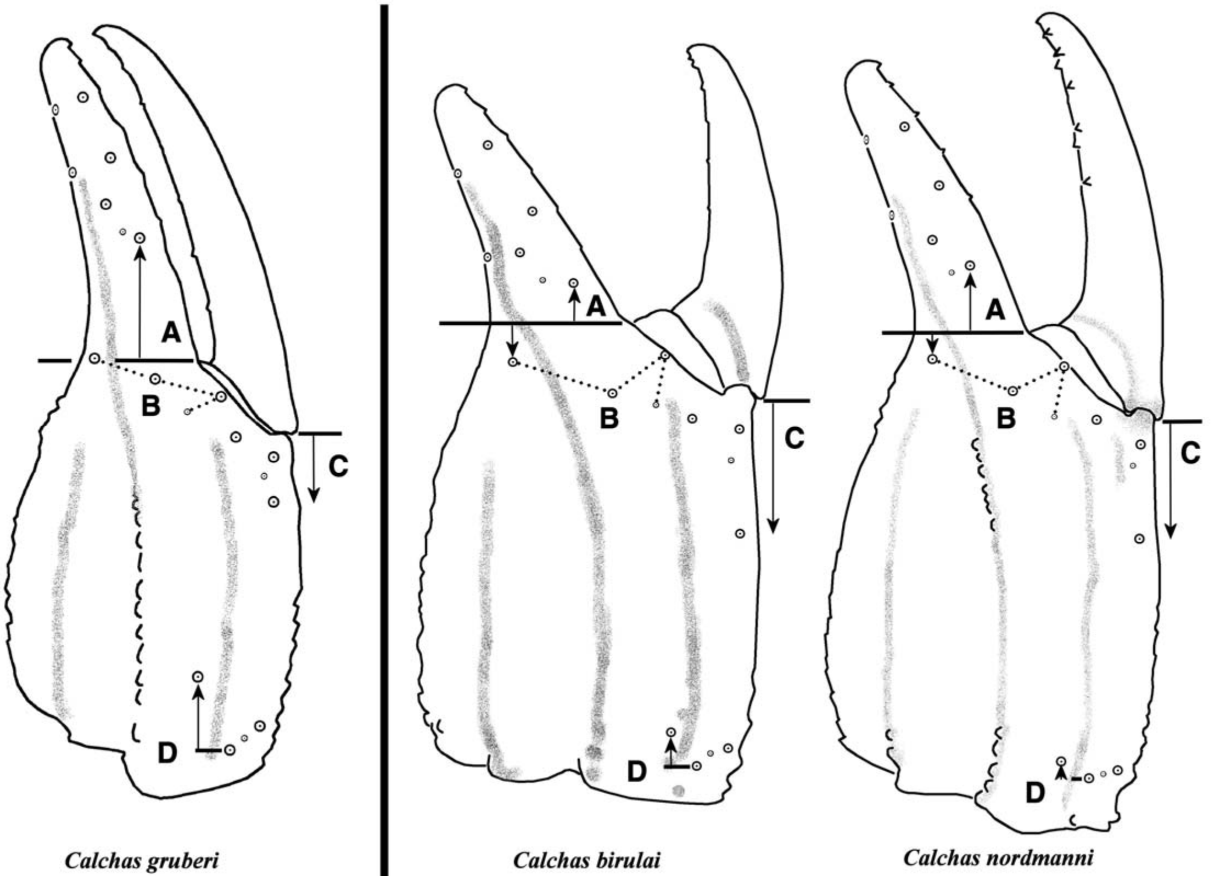


Figure 33: Relative position of chelal trichobothrium *it* in *Calchas* based on its location with respect to the fixed finger length. Trichobothrium *it* mean position indicated by open circle based on 30 samples. Method of measurement: ff_LENG = fixed finger length, *it*_POS = *it* position. Histogram of morphometric ratio shows mean (vertical bar), minimum, maximum, and standard error (black rectangle) ranges. We see two significant *it* positional differences in these species: In *C. birulai* and *C. nordmanni*, trichobothrium *it* is approximately at finger midpoint or proximal, most exaggerated in *C. birulai*, whereas in *C. gruberi* trichobothrium *it* is considerably distal of finger midpoint.

fixed finger, there is significant standard error separation between *C. gruberi* and the other two species, exhibiting a 28.3 %|45.9 % difference between the mean values, *C. nordmanni* and *C. birulai*, respectively. Also apparent in Fig.33 is the position of trichobothrium *it* with respect to *ID* denticles. In *C. gruberi*, *it* is positioned closer to *ID*-4 whereas in the other two species, *it* is closer to *ID*-5.

Chelal external trichobothria positions. Figure 34 contrasts *C. gruberi* with the other two species, showing several trichobothria position-based characters. The trichobothrial position differences are divided into four areas as indicated on the chela, **A**–**D**. In the area denoted by **A,** we see in *C. gruberi* that trichobothrium *eb* is located at the finger midpoint whereas in the other two species *eb* is much more basal. In addition, the other external finger trichobothria, *esb*, *est* and *et*, are also more distally placed on the finger. Area **B** denotes the patterns formed by trichobothria db-Et_5-Et_3 and Et_3-Et_4. In *C. gruberi*, the first pattern is formed in essentially a straight line with trichobothrium *db* located at the extreme fixed finger base, whereas in *C. birulai* and *C. nordmanni*, these trichobothria form a wide V-shaped pattern, with Et_5 located significantly more proximally, and *db* located below the finger base on the distal aspect of the palm. In the second pattern, Et_4 in *C. gruberi* is angled more dorsally than Et_3, whereas in the other two species it is situated essentially proximal to Et_3. In the areas denoted by **C** and **D** we see that trichobothria *Db* and *Dt* are located more distally in *C. gruberi* than in the other two species.

In conclusion it is clear in *C. gruberi*, that in general, many of the chelal external trichobothria dis-



Calchas gruberi   *Calchas birulai*   *Calchas nordmanni*

Figure 34: External surface of the chela highlighting trichobothria positional differences in *Calchas* species. Four specific areas (A–D) are delineated showing major trichobothrial location differences between species *C. gruberi* as compared to *C. birulai* and *C. nordmanni*. **A:** in *C. gruberi* trichobothrium *eb* is placed considerably more distally on finger than in the other two species. **B:** in *C. gruberi* the pattern formed by trichobothria Et_3–Et_5–*db* essentially forms a straight line with *db* more distally placed, situated parallel to the finger juncture; in addition, trichobothrium Et_4 is located considerably dorsally of Et_3. **C & D:** in *C. gruberi* trichobothrium *Dt* and *Db* are positioned considerably more distally than in the other two species.

cussed above are located both more distally and dorsally on the chela palm and fixed finger, consistent with *C. gruberi*'s distal placement of trichobothrium *it*. Accompanying, and possibly one of the reasons for this shift in trichobothria, is the relatively longer fixed finger seen in *C. gruberi* than in the other two species (see morphometrics discussion below).

Prepectinal plate

In Figure 35, we show photographs of the female prepectinal plate of all three species. We see that the prepectinal plate in *C. gruberi* is not as relatively large as in the other two species. In particular, its length is less, definitely smaller than the genital operculum, whereas in *C. nordmanni* and *C. birulai* the prepectinal plate is more medially inflated, its depth approaching that of the genital operculum.

Pectinal tooth counts

Figure 36 shows the distribution of pectinal tooth counts for all three species, male and female. Data are based on 82 specimens, including 23 specimens of *C. nordmanni* analyzed by Birula (1900, 1905, 1911, 1912). Of particular interest in this data, besides the differences between the three species, is the small range exhibited by both genders, not exceeding two values. Also apparent is the dominance of a single count per species and gender, usually occurring in 80 or more percent (the *C. gruberi* male is the only exception with numbers ranging somewhat evenly across two values). *C. birulai*, the smallest species of the three, has the smallest pectinal tooth counts, the female usually with only five teeth. *C. gruberi*, another small species, has the largest pectinal tooth counts in the genus, with some males exhibiting as many as nine teeth. *C. nordmanni* tooth counts are intermediate between the other two species. Finally,

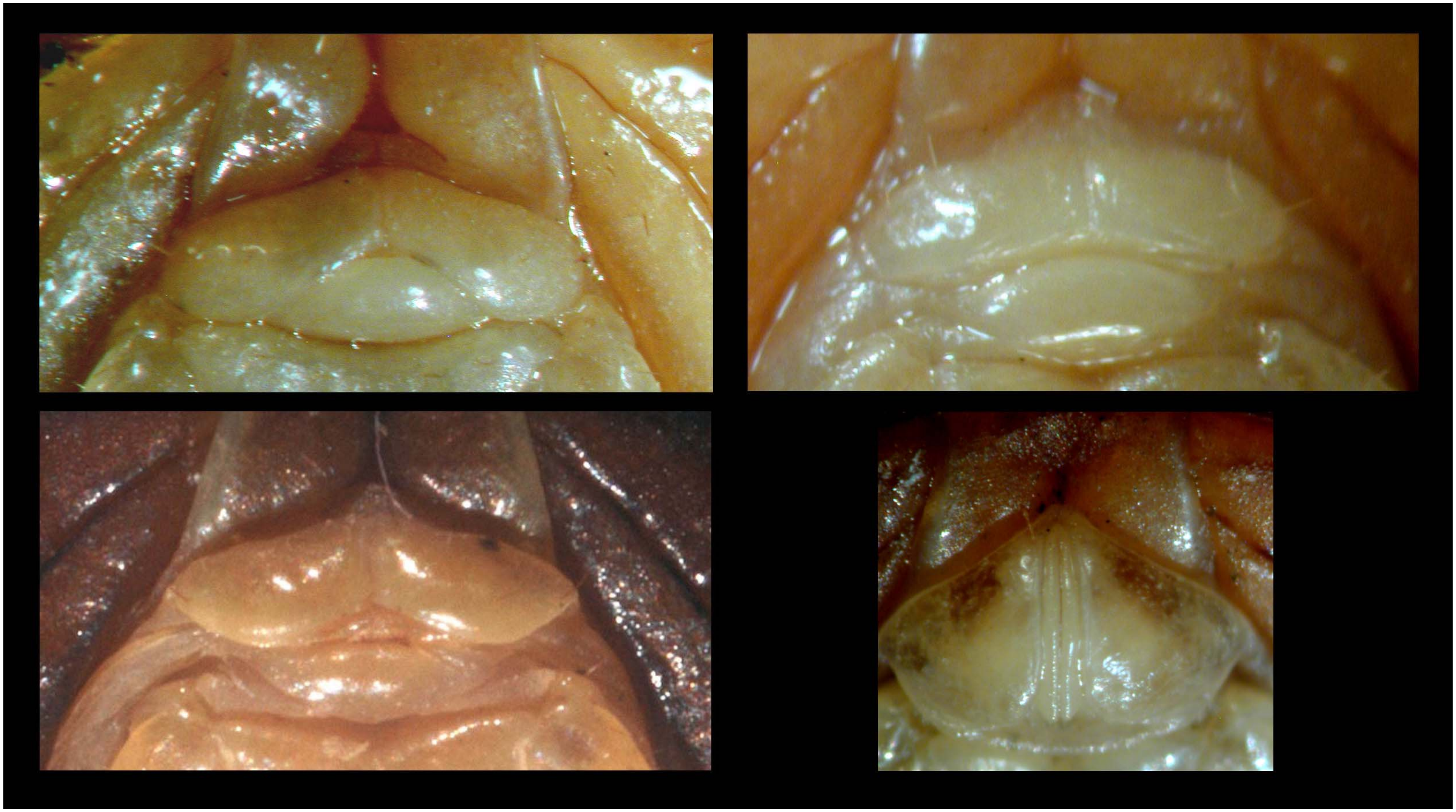


Figure 35: Sternopectinal area in *Calchas* species showing the genital operculum, prepectinal plate (in female), and genital papillae (in male). Note, in the male, the large long subtriangular shaped genital operculum with separated sclerites exposing significant genital papillae, as compared to the female, we see a narrow operculum with fused sclerites. **Top-Left.** *C. nordmanni*, female, Tortum, Turkey. **Top-Right.** *C. birulai*, **sp. nov.**, female, Mardin, Turkey. **Bottom-Left.** *C. gruberi*, **sp. nov.**, female, 12 km S. Akseki, Turkey. **Bottom-Right.** *C. nordmanni*, male, Turkey.

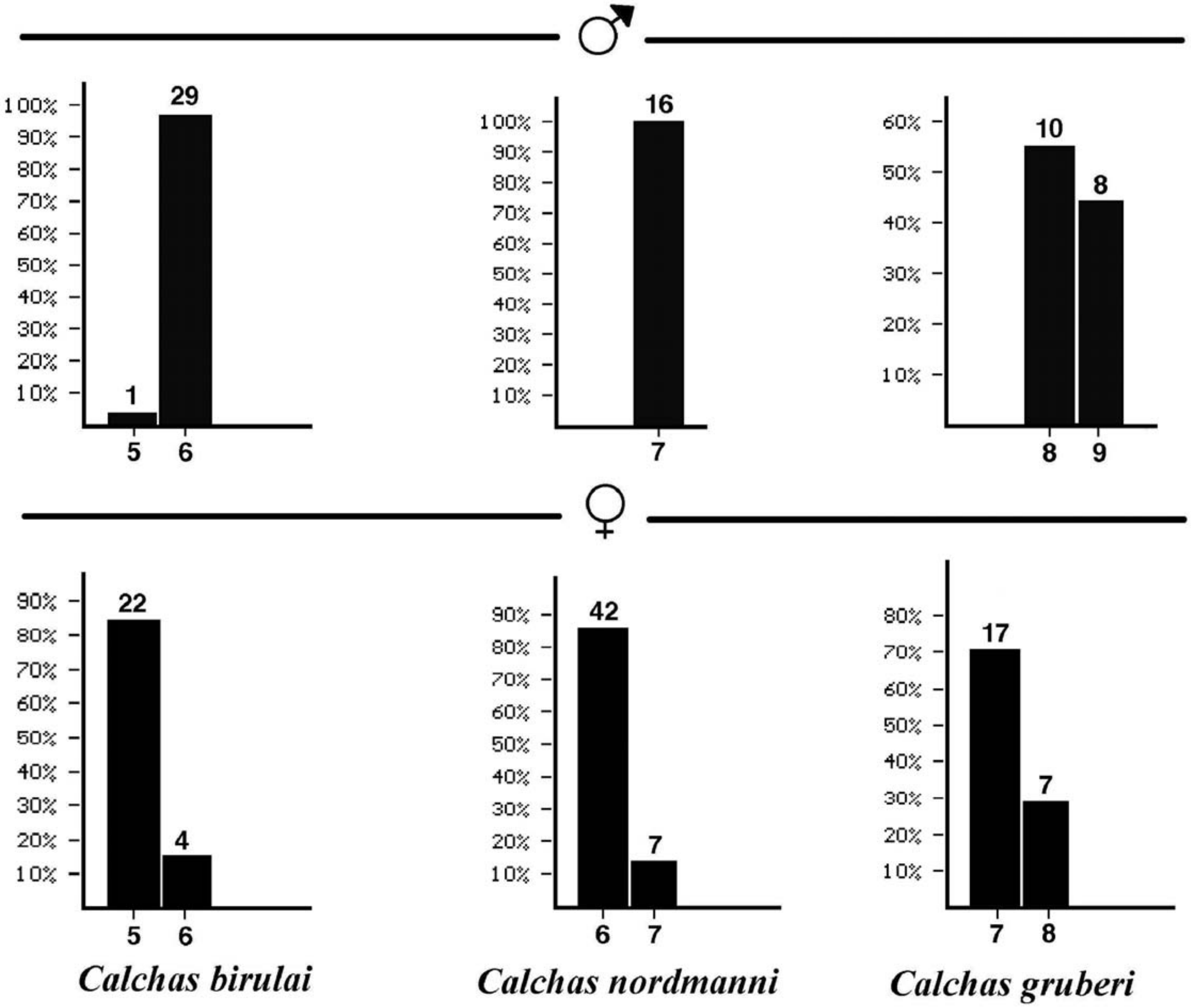


Figure 36: Distribution of pectinal tooth counts in genus *Calchas* based on 82 specimens (32 males and 50 females). Number of teeth on bottom, number of samples on top. Data is based on material examined and Birula (1900, 1905, 1911, and 1912).

based on mean values, the male of each species has one more tooth than the female.

Morphometrics

We calculated all possible morphometrics from twelve measurement sets (Table 3) comparing each species to the other. This particular analysis included 27 measurements per set, thus 26 ratio comparison per measurement pair, a total of 351 ratios. Since, as reported elsewhere in this paper, sexual dimorphism involving morphmetrics is essentially negligible in *Calchas*, we combined both genders in this comparison. Table 2 shows salient results of these calculations, highlighting eight major measurements that dominated in these ratio calculations.

From Table 2, it is clear that *C. gruberi* has a more slender chela than the other two species; that is, its palm is relatively smaller when compared to the finger lengths. In Table 2 we see that both *C. birulai* and *C. nordmanni* significantly dominated in ratios involving the chelal width, depth, and palm length: for chelal width both *C. birulai* and *C. nordmanni* dominated in all (out of 26) ratio calculations; for palm length, in 25 and 24, respectively; and for chelal depth, 24 and 23, respectively. Also apparent in these three chela measurements is the overall dominance in *C. birulai*, in 20 or more ratios. In support of the relatively slender chelae in *C. gruberi*, we see that the movable and fixed finger lengths dominated in 26 and 24 cases with *C. birulai*, and in 19 and 19 with *C. nordmanni*, a relatively longer fingered species than *C. birulai*. For *C. birulai* and *C. nordmanni* comparisons, the fingers are relatively longer in *C. nordmanni*, dominating in 24 and 25 ratio calculations for the movable and fixed fingers, respectively. These results are consistent with the fixed finger trichobothrial-based ratios discussed above.

	C. gruberi	*C. nordmanni*	*C. birulai*
Chelal Width	• | 0 | 0	**26** | • | 3	**26 | 23** | •
Chelal Depth	• | 0 | 0	**23** | • | 4	**24 | 22** | •
Palm Length	• | 0 | 0	**24** | • | 4	**25 | 21** | •
Movable Finger Length	**• | 19 | 24**	7 | • |**24**	2 | 2 | •
Fixed Finger Length	**• | 19 | 26**	7 | • |**25**	0 | 1 | •
Metasomal Segment V Length	• | 1 | 10	**25** | • | **26**	**15** | 0 | •
Metasomal Segment V Width	**• | 26 | 18**	0 | • | 0	8 | **26** | •
Vesicle Length	• | 1 | 3	**25** | • | **17**	**23** | 9 | •

Table 2: Summary of major measurements which show dominance in morphometric ratio calculations across the three species of *Calchas* where all possible ratios are calculated. Each species is compared to the other two species, thus two sets of data per species. Each value states the number of ratios the measurement dominated for that species when compared to the other species; e.g., for "chelal width" *C. gruberi* did not dominate in any ratio calculations whereas *C. nordmanni* dominated in 26 ratios when compared to *C. gruberi* and only in 3 when compared to *C. birulai*. From this we can conclude that chelal width in *C. birulai* is clearly relatively wider than in the other two species, since it dominated in a large majority of the ratios. Shaded areas indicate the species that dominated in that measurement against both other species. Note that genders are combined in these calculations.

As discussed elsewhere in this paper, we see the dominance of *C. nordmanni*'s slender metasomal segment V when compared to the other two species: for the length, *C. nordmanni* dominated in 25 to 26 ratio comparisons whereas for the width, *C. gruberi* and *C. birulai* dominated in all 26 ratio comparisons, each endorsing the relatively slender segment V exhibited in *C. nordmanni*. The metasomal segment V of *C. nordmanni* is considerably thinner than that of the other two species. In the histogram shown in Fig. 37, we see that segment V is roughly two and a half times longer than wide. In *C. gruberi*, **sp. nov.**, and *C. birulai*, **sp. nov.**, this segment is only two times longer than wide. Also of interest, we see only negligible differences between the two genders in all three species, unusual in scorpions where normally the male's metasoma is noticeably thinner.

Species Descriptions

Calchas nordmanni Birula, 1899

(Figs. 25, 28–41; Tables 2, 3)

Calchas nordmanni Birula, 1899: XV.

Syntypes. 2 ♀ subad. (ZISP 942), TURKEY, *Artvin Province,* Ardanuç District, Ardanuç, in houses, 5(17) July 1898, K. M. Deryugin leg.

REFERENCES (selected; see Sissom & Fet, 2000: 418–419 for the full list of secondary references; all references before 1980 apply **only** to *Calchas nordmanni*):

Calchas nordmanni: Birula, 1899: XV; Birula, 1900: 252–255; Birula, 1905: 130–131; Birula, 1911: 175–177, figs. 2–3; Birula, 1912: 124–125; Birula, 1917a: 138–153, figs. 11–15; Birula, 1917b: 143–159, pl. II, figs. 1–9, pl. IV, figs. 1–2; Vachon, 1971: 406–408, figs. 1–12; Vachon, 1974, figs. 166, 180, 196–198, 212–215; Kinzelbach, 1980: 169–174 (in part), figs. 3–4, 5 (map localities 1–13); Francke & Soleglad, 1981: 245–248 (in part), figs. 1–4; Kinzelbach, 1982: 58 (in part); Kinzelbach, 1985: Map IV (in part); Lourenço, 1998: 140, fig. 4; Crucitti, 1999: 87 (in part); Kovařík, 1999: 40, 42 (in part); Fet & Braunwalder, 2000: 18 (in part); Sissom & Fet, 2000: 418–419 (in part); Crucitti & Cicuzza, 2001: fig. 7 (in part); Crucitti & Vignoli, 2002: 458–459; Graham & Fet, 2006: 6; Kaltsas et al., 2008: 227 (in part); Kamenz & Prendini, 2008: 43 (in part), pl. 62.

Paraiurus nordmanni: Vachon & Kinzelbach, 1987: 99, 102, fig. 6 (in part).

Diagnosis. Medium-sized scorpion with heavy chelae, 45–52 mm in length, pectinal tooth counts, 7 male and 6–7 (6) female. Coloration variable, adult specimens are dorsally red brown or dark brown with darker, almost black, pedipalpal and metasomal carinae; the legs and telson are lighter, yellow, yellow brown or brown. Telson vesicle elongated, with short, abruptly curved aculeus; subaculear setal pair (SSP) located on aculeus base. Six and five inner denticles (*ID*) and seven and six median denticle (*MD*) groups on the movable and fixed fingers, respectively. Fixed finger of chela same length as palm, trichobothrium *it* located at fixed finger midpoint. Trichobothrium *dst* located distally of mid-

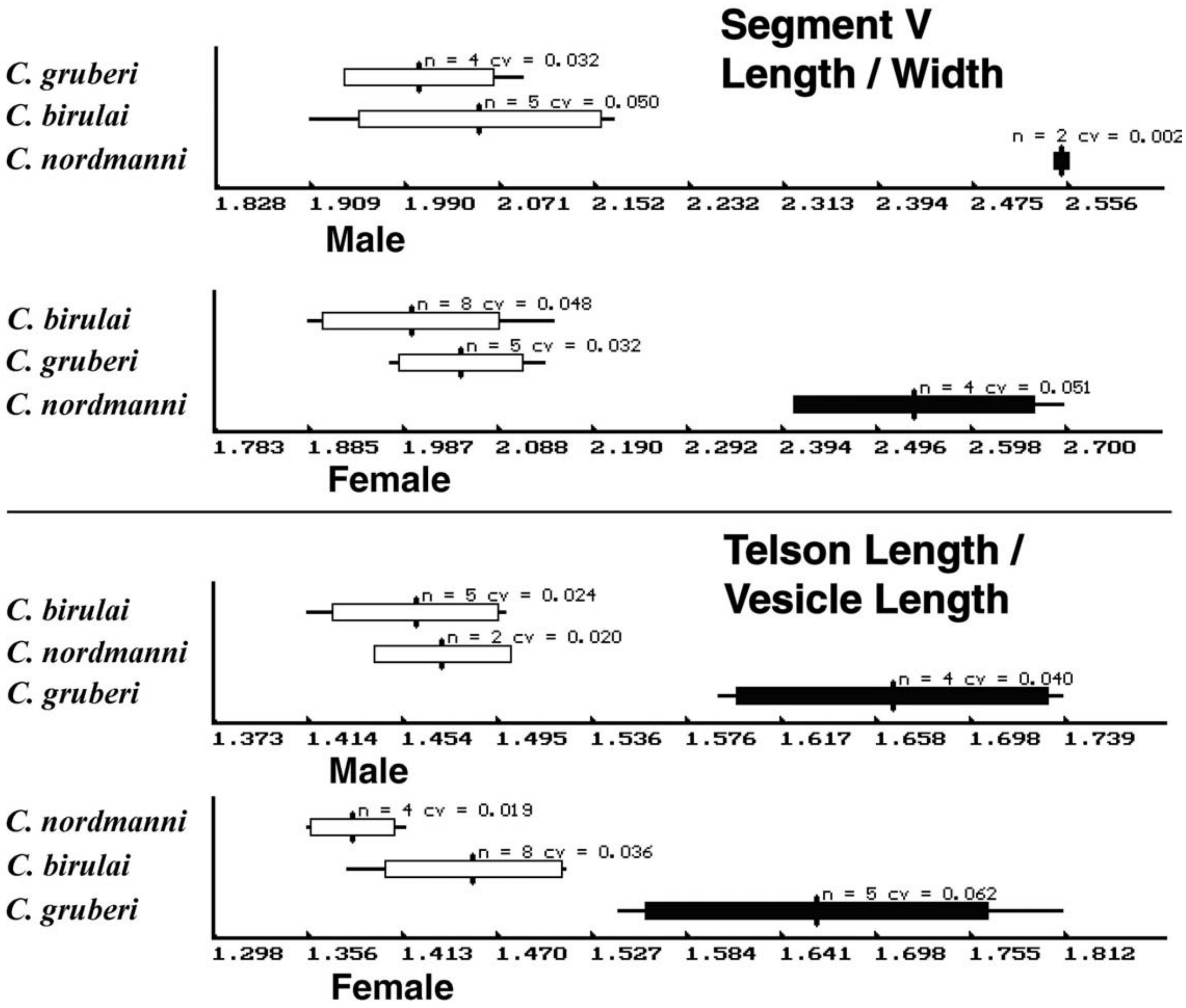


Figure 37: Key morphometric ratio differences in species of *Calchas* based on 28 sets of measurements. **Top.** Metasomal segment V proportions (length/width) show that metasomal segment V is considerably more slender in *C. nordmanni* than in the other two species, exhibiting considerable standard error as well as absolute range separation. Differences in mean values between *C. nordmanni* and the other two species, male|female, is as follows: *C. birulai* = 24.2 %|27.1 %, *C. gruberi* = 27.4 %|23.8 %. **Bottom.** Telson proportions (telson length / vesicle length) show that species *C. nordmanni* and *C. birulai* have a longer vesicle than that seen in *C. gruberi*. The mean value differences between *C. gruberi* and the other two species (combined) is 13.8 % male and 16.2 % female. Also of interest in both sets of ratios, we see that the differences between the genders across species are negligible.

point between *dt* and *db*. Metasomal segment V 2.5 times longer than wide.

Distribution. TURKEY: northeast (Artvin and Erzurum Provinces) (see maps in Figs. 38, 39).

Material examined: (2 ♂, 5 ♀, 3 juv.): TURKEY, *Artvin/Erzurum Provinces*: 3 ♀, 1 juv. (FKCP), “Demirkent, Tortum” [i.e., between Demirkent (Artvin Province, Yusufeli District, 40.885°N 41.738°E) and Tortum (Erzurum Province, Tortum District, 40.298°N, 41.548°E)], 3 June 1992, J. Bradka & R. Nergr leg.; *Erzurum Province*: 1 ♀, 1 ♂ subad. (NMM 0203), Tortum, April 1970, C. Kosswig leg.; 2 ♀ juv. (ZMUH A39/71), Yusufeli, 40.817°N, 41.55°E, 30 April 1971, C. Kosswig leg.; 1 ♀ (FKCP), Tortum, 7 June 1992, M. Kaftan & R. Nergr leg. *No specific locality:* 1 ♂ (MNHN RS 5171), “Turkey, FANY”, 1965, M. Tsabar leg. [*Note*: FANY could be an acronym of the First Aid Nursing Yeomanry, a British women's ambulance unit].

Other specimens/localities (material not examined): TURKEY, *Artvin Province:* 2 ♀ subad. **syntypes** (ZISP 942), Ardanuç, 41.128°N, 42.059°E, in houses, 5(17) July 1898, K. M. Deryugin leg.; 2 ♀ ad., 1 ♂ ad., 2 ♂ juv., 4 ♀ juv. (ZISP 1394, only one specimen exists,

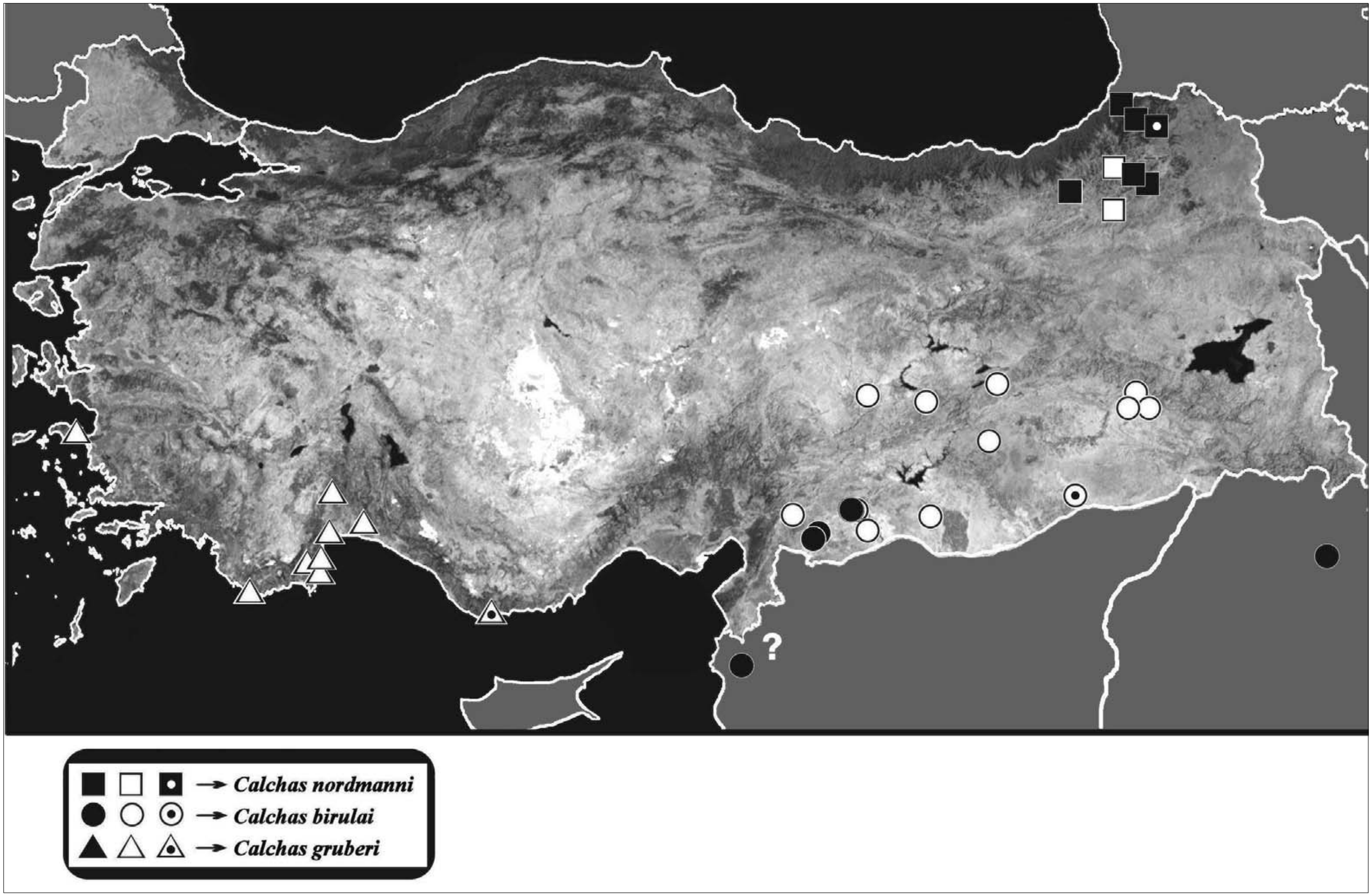


Figure 38: Distribution of all reported instances of genus *Calchas*. Open icons depict localities examined in this study; closed icons depict remainder of published localities; icons with enclosed dot indicate type locality. Note *C. birulai* localities from northern Iraq and possibly Syria (? = not confirmed).

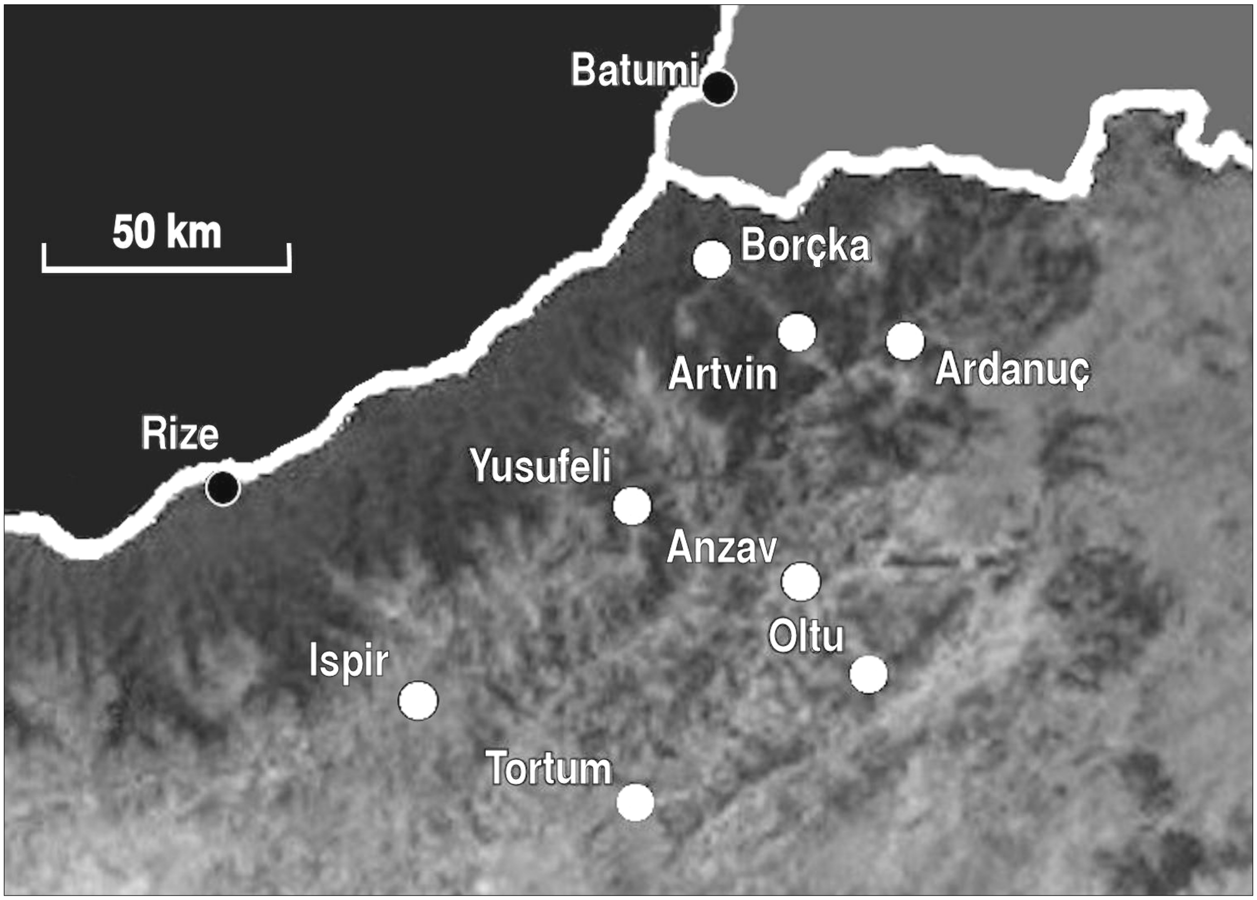


Figure 39: Large-scale range of *Calchas nordmanni*, white circles. See general *Calchas* map in Fig. 38.

others not found), Lomashen (Lomasheni) near Artvin, 41.182°N, 41.819°E, 10(23) June 1909, P. V. Nesterov leg.; 1 ♂ ad. (ZISP 1395), Lomashen near Artvin, July 1911, Yu. N. Voronov leg.; 1 ♀ ad., 1 ♀ subad., 1 ♀ juv. (GNM 243, only two specimens exist), Khakhauch, Keniya Mts., left bank of Çoruh River, SE Artvin, July 1911, Yu. N. Voronov leg.; 3 ♀ juv., 1 ♂ juv., 1 ♀ pull. (GNM 211), Svetibar [Svetibari] near Artvin, July 1911, Yu. N. Voronov leg.; 1 ♀ ad. (formerly in ZISP, not found), Çoruh River, near Borçka, 41.3625°N, 41.68°E, 15 (28) May 1910, P. V. Nesterov leg.; 1 ♀ ad., 2 ♀ juv., 1 ♂ juv. (formerly in ZISP, not found), near Artvin, 29 May (11 June) 1912, B. Lindholm leg.; 1 ♀ (AMNH [LP 2246]), Ardanuç [reported as "Ardanug"], 26 August 2001, A. Karataş leg. (Kamenz & Prendini, 2008). *Erzurum Province*: 1 ♂ ad. (GNM 212), N of Oltu, border post Erük [now Örik], 30 May (12 June) 1904, E. König leg.; 1 ♀ juv. (GNM 519), Oltu District, Anzov [now Anzav], 24 August (6 September) 1905, E. König leg.; 1 ♂ juv. (ZISP 1393), Oltu District, near Oltu, 40.55°N, 41.983°E, 12 (25) August 1910, P. Nesterov leg.; 1 specimen (ZSRO 1052), Ispir, rock and castle within the town, left bank of Çoruh Nehri, 40.483° N, 40.995°E, site no. VO-1988/328, 26–27 July 1988, R. Kinzelbach leg. *Artvin/Erzurum Provinces*: Çoruh River, near Artvin, and between Artvin and Yusufeli, July–August 1999 [P. Crucitti & V. Vignoli leg.], depository and specimen data unspecified (Crucitti & Vignoli, 2002).

Identification of *C. nordmanni*. Two syntypes (ZISP 942) and other existing specimens studied by A. A. Birula in 1899–1917 (ZISP, GNM) were not available for this study. We, however, examined 10 specimens of *C. nordmanni*, including eight from the area between Demirkent and Tortum. This area (see map in Fig. 39) is close to the localities originally listed by Birula (1899, 1900, 1912, 1917a, 1917b), and is well removed from the known ranges of *C. birulai* **sp. nov.** and *C. gruberi* **sp. nov.** Morphology of our specimens is consistent with the detailed illustrations and description provided by Vachon (1971), based on a single male specimen from Lomashen near Artvin, which belongs to the original Birula collection (ZISP 1395). In particular, our specimens match the movable finger dentition of six *ID* and seven *MD* denticle groups (Fig. 25); the trichobothrial pattern also matches, trichobothrium *dst* located much closer to *dt* than *db*. See full trichobothrial pattern for

Figure 40: *Calchas nordmanni*, dorsal view (specimens dried). **Left.** Adult female (43 mm), Demirkent – Tortum, Turkey. **Right.** Adult female (45 mm), Demirkent – Tortum, Turkey.

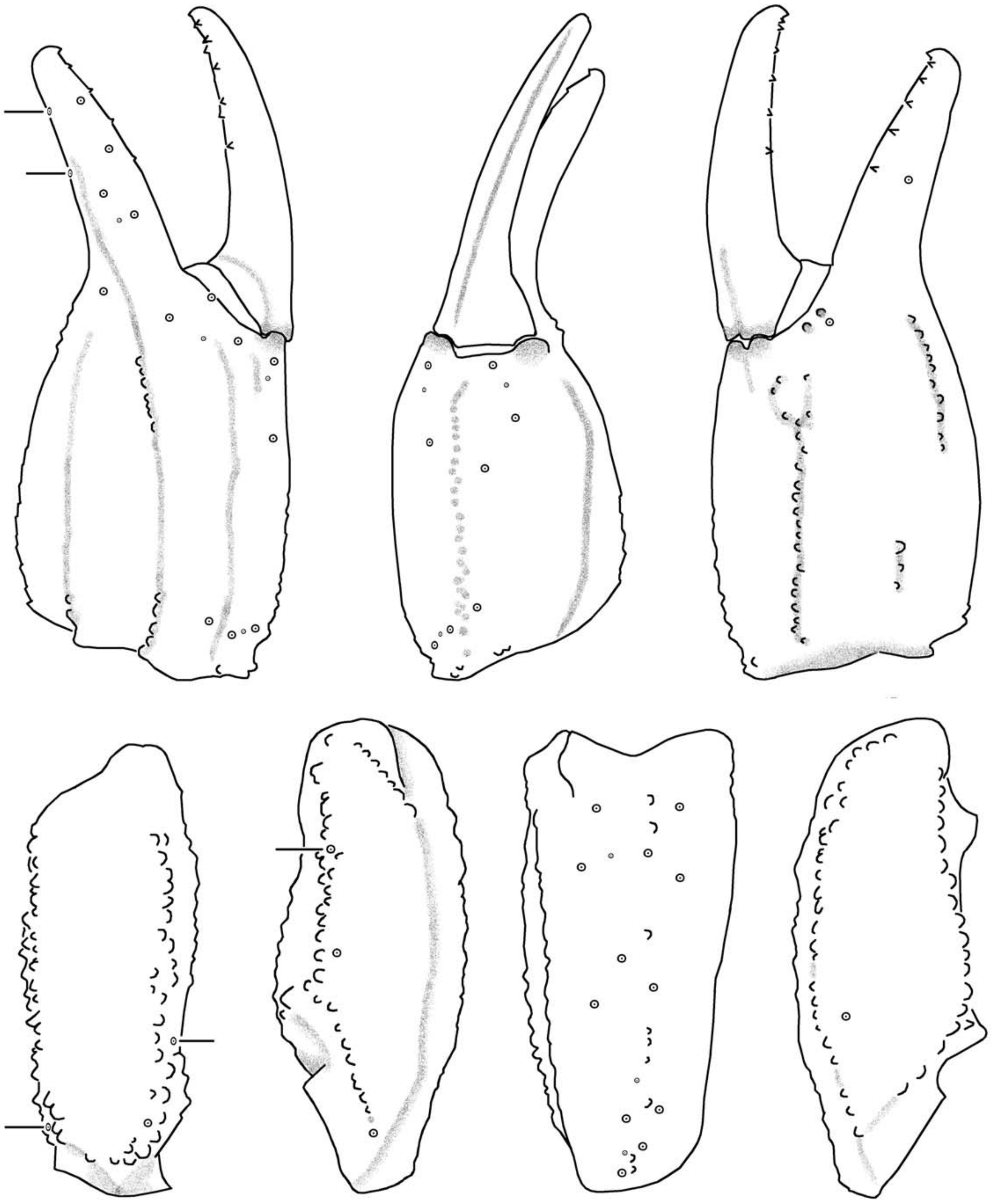


Figure 41: Trichobothrial pattern of *Calchas nordmanni* Birula, female, Tortum, Turkey.

this species in Figure 41. The overall telson structure is consistent with Birula's (1917a: fig. 13; 1917b: Pl. II, figs. 6–7) description (Figs. 28–31), and the coloration and patterns seen in two studied females (Fig. 40) is as described by Birula (1917a, 1917b). Finally, the pectinal tooth counts, male and female, are consistent with those reported by Birula (1917a, 1917b) (Fig. 36).

Calchas birulai Fet, Soleglad et Kovařík, sp. nov.

(Figs. 4–5, 8–9, 13, 15, 16, 20–23, 25, 27, 32–38, 42–58; Tables 2, 3)

REFERENCES:

Calchas nordmanni: Kinzelbach, 1980: 169–174 (in part), fig. 5 (map localities 14–15); Francke & Soleglad, 1981: 245–248 (in part), fig. 20; Kinzelbach, 1982: 58 (in part); Kinzelbach, 1985: Map IV (in part); Kovařík, 1997: 184; Crucitti, 1999: 87 (in part); Kovařík, 1999: 40, 42 (in part); Fet & Braunwalder, 2000: 18 (in part); Sissom & Fet, 2000: 418–419 (in part); Crucitti & Cicuzza, 2001: fig. 7 (in part); Soleglad & Fet, 2003b: 7 (in part), Karataş & Çolak, 2005: 4; Fet & Soleglad, 2008: 256 (in part), fig. 5; Kaltsas et al., 2008: 227 (in part); Kamenz & Prendini, 2008: 43 (in part); Soleglad et al., 2009: 2 (in part).

Paraiurus nordmanni: Vachon & Kinzelbach, 1987: 99, 102, fig. 6 (in part).

Holotype: ♂ (NMW 0843), TURKEY, *Mardin Province*: Mardin, 6 May 1966, J. Eiselt et al. leg. **Paratypes** (11 ♂, 14 ♀, 4 juv.), see list below.

Diagnosis. Small-sized scorpion with heavy chelae, 25–28 mm in length, pectinal tooth counts, 5–6 (6) male and 5–6 (5) female. Coloration yellow-orange with little pigmented patterns. Telson with short, abruptly curved aculeus; subaculear setal pair (SSP) located on aculeus base. Six and five inner denticles (*ID*) and seven and six median denticle (*MD*) groups on the movable and fixed fingers, respectively. Fixed finger of chela shorter than palm, trichobothrium *it* located proximally of fixed finger midpoint. Trichobothrium *dst* is equidistant between *dt* and *db*. Metasomal segment V two times longer than wide.

Distribution. TURKEY: southeast (Adıyaman, Diyarbakır, Gaziantep, Malatya, Mardin, Şanlıurfa, and Siirt Provinces). IRAQ: north (Arbil Province). ?SYRIA (unconfirmed sighting, see Introduction) (see maps in Figs. 38, 42).

Etymology. Species name is a patronym honoring the famous Russian scorpiologist, Alexei Andreevich Byalynitskii-Birula (A. A. Birula) (1864–1937), formerly of the Zoological Institute, St. Petersburg, Russia, the discoverer of *Calchas*.

MALE. Description based on holotype male from Mardin, Turkey. Measurements of the holotype plus three other specimens are presented in Table 3. See Figure 43 for a dorsal view of the male holotype.

COLORATION. Basic color of carapace, mesosoma, metasoma, pedipalps yellow-orange; telson and legs yellow; carinae of pedipalps and metasoma, and leg condyles reddish; chelal finger dentition and telson aculeus a dark brown. No variegated patterns present.

CARAPACE (Fig. 44). Anterior edge with a small median indentation, five small irregularly placed setae visible; interocular area somewhat rough with scatter granulation, though smooth around the immediate area of the median eyes; posterior lateral aspects covered with medium to large granules. Anterior and lateral edges next to lateral eyes with small but conspicuous pointed granules. Mediolateral ocular carinae present and granular, extending to the lateral eyes; lateral eyes number two, the posterior eye slightly larger. Median eyes and tubercle somewhat small, positioned considerably anterior of middle with the following length and width formulas: 100|335 (anterior edge to medium tubercle middle |carapace length) and 40|250 (width of median tubercle including eyes|width of carapace at that point).

MESOSOMA (Fig. 46). Tergites I–II granulated on extreme posterior edge, III–VI with heavier granulation, primarily on posterior half; tergite VII covered with coarse granules with two pairs of granulate carinae. Sternites III–VI smooth and lustrous, VII surface rough; on segment VII, one pair of irregularly granulated lateral carinae and one median pair essentially obsolete with some traces present posteriorly. Stigmata (Fig. 46) are short sub-oval in shape, angled 45 degrees in an anterointernal direction.

METASOMA (Figs. 49–50). Segments I–IV: dorsal and dorsolateral carinae crenulate; dorsal (I–IV) and dorsolateral (I–III) carinae terminate with spine; lateral carinae crenulate on I, present on one-half of II, on 30 % of III, and absent on IV; ventrolateral and ventromedian carinae crenulate. Dorsolateral carinae of segment IV terminate at articulation condyle. Segment V: dorsolateral carinae crenulate; lateral carinae crenulate for two-thirds of posterior aspect; ventrolateral and single ventromedian carinae crenulate; ventromedian carina not bifurcated, terminating in straight line (Fig. 50). Intercarinal areas of segments I–IV essentially smooth ventrally, with scattered granulation laterally; segment V

	Calchas birulai				*Calchas gruberi*					*Calchas nordmanni*		
	Mardin, Turkey		Ergani, Turkey		Mamure Kalesi, Anamur, Turkey		Belkis, Turkey		Samos Isl. Greece	Tortum, Turkey		Turkey
	Male Type	Female	Male	Female	Female Type	Male	Male	Female	Male	Female	Male	Male
Total length	27.00	25.90	24.60	28.00	31.90	26.25	26.60	28.75	27.40	35.75	31.65	34.20
Carapace length	3.35	3.30	3.15	3.55	4.20	3.25	3.45	3.75	3.35	5.35	4.20	4.45
Mesosoma length	8.50	10.00	7.90	10.30	10.40	9.45	8.95	9.75	9.45	9.45	10.30	8.95
Metasoma length	11.05	9.15	9.85	10.40	12.40	9.80	10.20	10.90	10.60	15.40	12.65	15.35
Segment I length/width	1.30/2.05	1.15/1.80	1.15/1.85	1.45/1.90	1.55/2.35	1.30/1.85	1.25/2.10	1.35/2.25	1.30/2.10	1.90/2.65	1.45/2.20	1.85/2.50
Segment II length/width	1.70/1.80	1.35/1.65	1.45/1.70	1.60/1.80	1.85/2.25	1.45/1.80	1.45/1.90	1.55/2.05	1.60/2.05	2.20/2.45	1.85/2.10	2.30/2.40
Segment III length/width	1.85/1.75	1.55/1.60	1.65/1.70	1.65/1.75	2.00/2.20	1.60/1.80	1.60/1.90	1.75/2.00	1.70/1.90	2.45/2.40	2.05/2.00	2.50/2.35
Segment IV length/width	2.40/1.70	1.95/1.45	2.10/1.60	2.15/1.70	2.65/2.20	2.10/1.75	2.25/1.90	2.40/1.95	2.40/1.85	3.30/2.30	2.70/1.95	3.35/2.15
Segment V length/width	3.80/1.75	3.15/1.55	3.50/1.65	3.55/1.65	4.35/2.10	3.35/1.60	3.65/1.85	3.85/1.95	3.60/1.85	5.55/2.30	4.60/1.80	5.35/2.10
Telson length	4.10	3.45	3.70	3.75	4.90	3.75	4.00	4.35	4.00	5.55	4.50*	5.45
Vesicle length	2.90	2.50	2.50	2.50	3.00	2.30	2.30	2.40	2.35	4.00	3.10	3.65
width/depth	1.90/1.55	1.75/1.25	1.70/1.35	1.70/1.35	2.30/1.80	1.75/1.25	1.80/1.30	1.95/1.40	1.85/1.25	2.45/2.00	1.95/1.45	2.30/1.80
Aculeus length	1.20	0.95	1.20	1.25	1.90	1.45	1.70	1.95	1.65	1.55	1.40	1.80
Pedipalp length	11.75	11.00	10.70	11.80	15.30	10.95	11.55	12.95	11.70	17.75	13.75	15.05
Femur length/width	2.95/1.15	2.75/1.10	2.70/1.05	2.85/1.20	3.55/1.60	2.75/1.15	2.90/1.15	3.15/1.25	2.95/1.15	4.40/1.80	3.35/1.40	3.75/1.45
Patella length/width	2.90/1.25	2.80/1.20	2.60/1.10	2.95/1.20	3.55/1.35	2.85/1.15	3.00/1.15	3.30/2.25	2.95/1.25	4.40/1.90	3.45/1.40	3.55/1.60
Chela length	5.90	5.45	5.40	6.00	8.20	5.35	5.65	6.50	5.80	8.95	6.95	7.75
Palm length	3.15	2.95	2.85	3.15	3.25	2.50	2.65	2.75	2.55	4.55	3.40	3.75
width/depth	2.20/2.65	2.00/2.40	2.15/2.45	2.25/2.75	2.20/2.65	1.60/1.95	1.90/2.20	1.85/2.40	1.85/2.20	3.15/3.65	2.35/2.75	2.80/3.55
Fixed finger length	2.40	2.10	2.00	2.30	3.35	2.50	2.65	3.00	2.70	3.75	2.90	3.40
Movable finger length	3.25	2.95	2.85	3.25	4.30	3.15	3.40	3.95	3.50	4.95	3.95	4.50
Pectines teeth	6-6	5-5	6-6	5-5	7-7	8-8	8-8	7-7	9-9	6-6	7-7	7-7
middle lamellae	4-4	2-2	3-3	3-2	3-3	4-4	5-4	3-5	6-6	3-3	5-5	5-5
Sternum length/width	0.85/1.35	1.05/1.30	0.85/1.15	1.15/1.40	1.15/1.35	1.05/1.35	0.95/1.25	1.05/1.25	0.80/1.05	1.30/1.70	1.15/1.30	1.15/1.35

Table 3: Morphometrics (mm) of *Calchas birulai*, **sp. nov.**, *C. gruberi*, **sp. nov.**, and *C. nordmanni*.

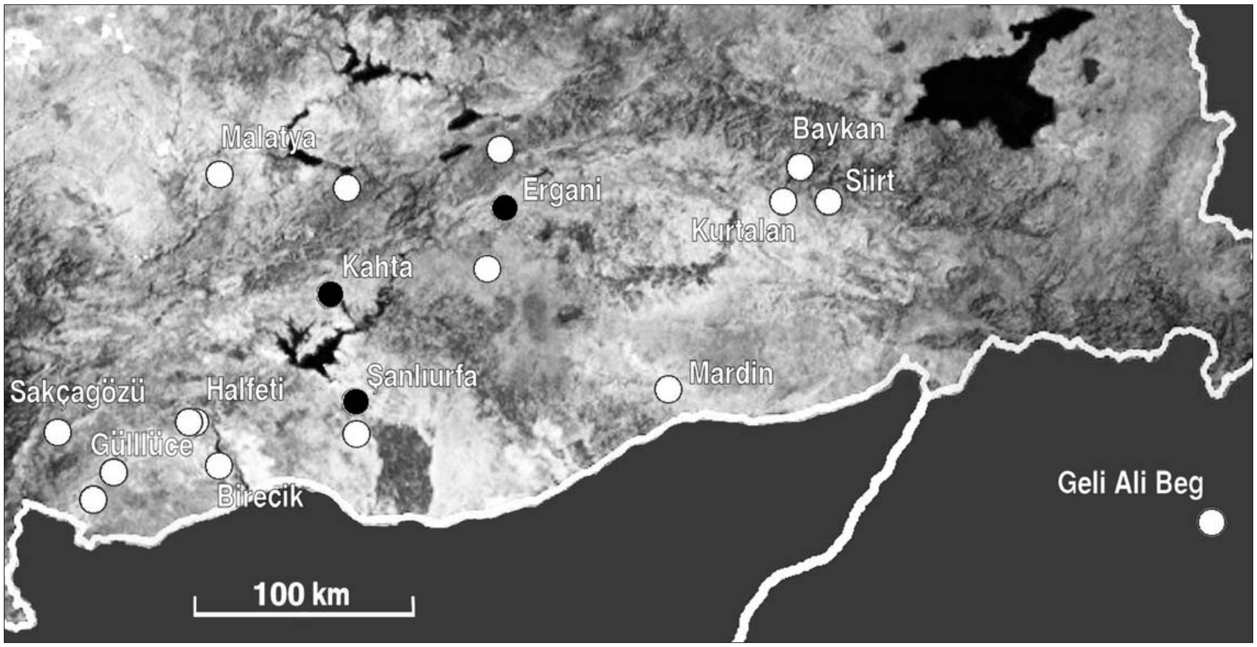


Figure 42: Large-scale range of confirmed localities of *Calchas birulai*, **sp. nov.** (open circles). See general *Calchas* map in Fig. 38.

with heavy granulation on ventral surface. Metasoma essentially void of setation.

TELSON (Figs. 49–50, 51, paratype female from Mardin). Elongated vesicle with short abruptly curved aculeus. Vesicle ventral surface covered with medium sized granules, heavier basally; scattered setae located on ventral surface of vesicle; subaculear setal pair (SSP) located on base of aculeus, distal of vesicle/aculeus juncture.

PECTINES (Fig. 47). Well-developed segments exhibiting length|width formula 340|190 (length taken at anterior lamellae|width at widest point including teeth). Sclerite construction complex, three anterior lamellae and 4/4 middle lamellae; fulcra of medium development. Teeth number 6/6. Sensory areas developed along most of tooth inner length on all teeth, including basal tooth. Small white setae found on anterior lamellae and distal pectinal tooth. Basal piece large, with deep indentation along anterior edge, length|width formula 80|115.

PREPECTINAL PLATE (Fig. 47). Not present in male (see discussion on female below).

GENITAL OPERCULUM (Fig. 47). Sclerites large, subtriangular, approximately as wide as long, separated for most of length. Conspicuous genital papillae present between the sclerites, but not extending beyond the posterior edge (see discussion on female below).

STERNUM (Fig. 47). Type 2, posterior emargination present, well-defined convex lateral lobes, apex visible but not conspicuous; wider than long, length|width formula 85|135; sclerite tapers anteriorly, posterior-width|anterior-width formula 135|108.

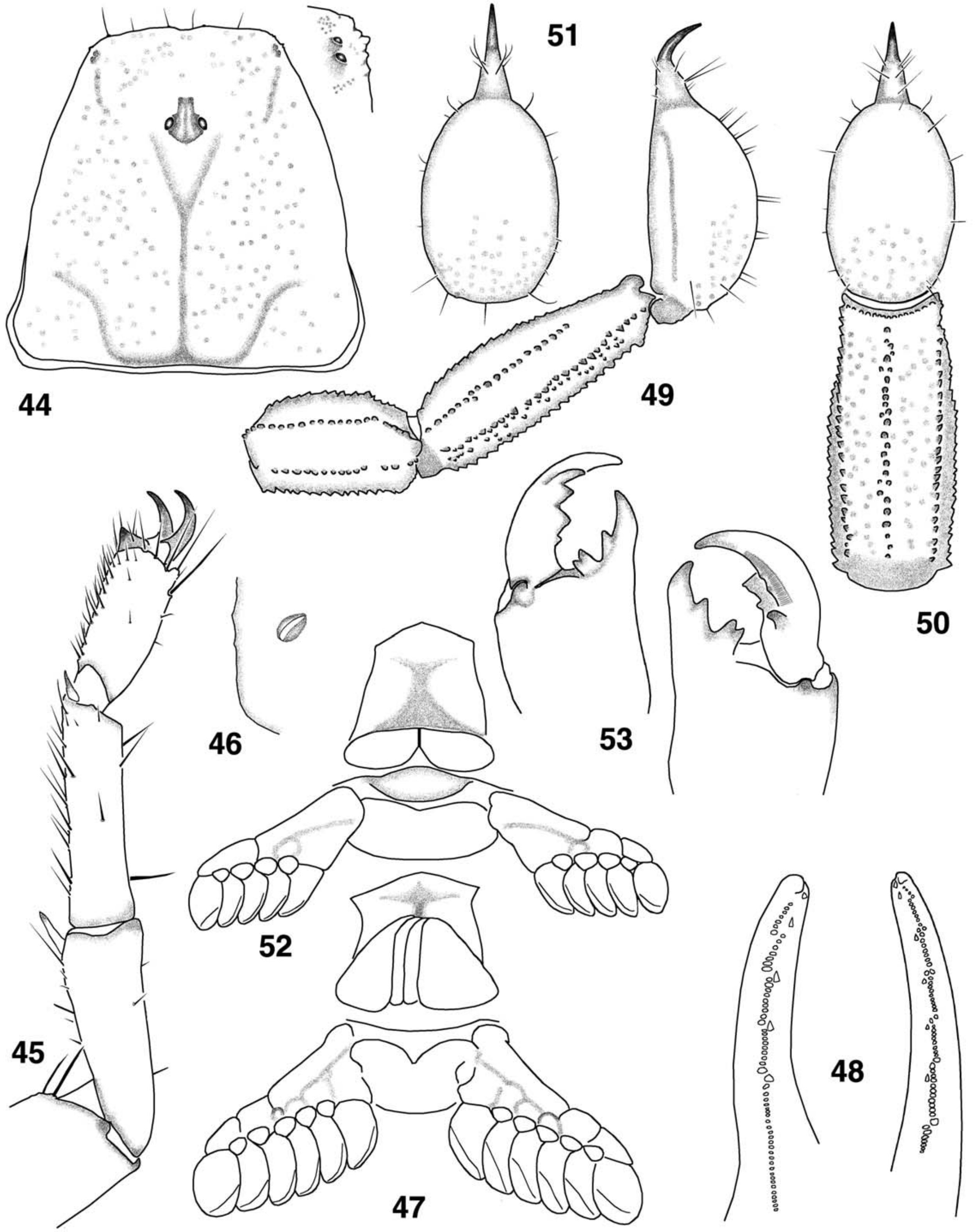
CHELICERAE (Fig. 53, female). Movable finger dorsal edge with one large subdistal (*sd*) denticle; ventral edge with two small pigmented crenulations (*va*) on the distal half, and one large pigmented accessory denticle at finger base; ventral edge with heavy setal brush covering well-developed serrula with over 20 contiguous tines, terminating just before distal tip. Ventral distal denticle (*vd*) considerably longer than dorsal (*dd*). Fixed finger with four denticles, median (*m*) and basal (*b*) denticles conjoined on common trunk; no ventral accessory denticles present.

PEDIPALPS (Figs. 48, 54). Short fingered, strong chelae, heavily carinated, no scalloping on chelal fingers, thus not exhibiting sexual dimorphism in this structure. **Femur:** Dorsointernal and ventrointernal carinae serrate, dorsoexternal carina crenulate, ventroexternal rounded. Dorsal and internal surfaces sparsely granulate, ventral smooth, and external surface with line of serrate granules. **Patella:** Dorsointernal and ventrointernal carinae serrate, dorsoexternal granulate, ventroexternal rough rounded, and exteromedian carina granulate. Dorsal, ventral, and external surfaces smooth; external surface with granulate exteromedian carina; internal surface smooth except for weakly developed doubled

Figure 43: *Calchas birulai*, **sp. nov.**, male holotype (NMW), Mardin, Turkey, dorsal view (27 mm).

DPS and single VPS. **Chelal carinae:** Complies with the "8-carinae configuration". Digital (*D1*) carina strong, smooth to granulate; dorsosecondary (*D3*) present on basal half only, smooth; dorsomarginal (*D4*) rounded, continuous, with granules; dorsointernal (*D5*) weak, sparsely granulated; ventroexternal (*V1*) strong and granulated proximally, terminating at external condyle of movable finger; ventrointernal (*V3*) strong and smooth, continuous to internal condyle; external (*E*) strong, continuous, essentially smooth except for proximal one-fifth which is granulate; internal (I) weak, rounded, not continuous, with small granules. **Chelal finger dentition (Fig. 48):** median denticle (MD) row groups oblique and slighting imbricating, numbering 6/6 and 7/7 on fixed and movable fingers; 5/5 and 6/6 internal denticles (*ID*) and 5/5 and 6/6 outer denticles (*OD*) on fixed and movable fingers, respectively. No accessory denticles present. Number of *MD* denticles on movable finger is 55. **Trichobothrial patterns (Fig. 54):** Type C, orthobothriotaxic. See discussion of trichobothria differences between *Calchas* species which highlights the pattern of this male type.

LEGS (Fig. 45). Both pedal spurs present on all legs; tibial spurs present on legs III and IV. Tarsus covered heavily with large socketed setae on ventral surface.



Figures 44–53: *Calchas birulai*, **sp. nov. 44–50.** Male holotype (NMW), Mardin, Turkey. **44.** Carapace showing close-up of lateral eyes. **45.** Leg IV (left, ventral view), showing the tibial spur. **46.** Stigma IV. **47.** Sternum, genital operculum, and pectines. **48.** Chelal fixed and movable finger dentition. **49.** Telson and metasomal segments IV–V, lateral view. **50.** Metasomal segment V and telson, ventral view. **51–52.** Female paratype (NMW), Mardin, Turkey. **51.** Telson, ventral view. **52.** Sternum, genital operculum, prepectinal plate, and pectines. **53.** Female paratype (HNHM), Kavurma Köyü, Diyarbakır Province, Turkey. Chelicerae, ventral and dorsal views.

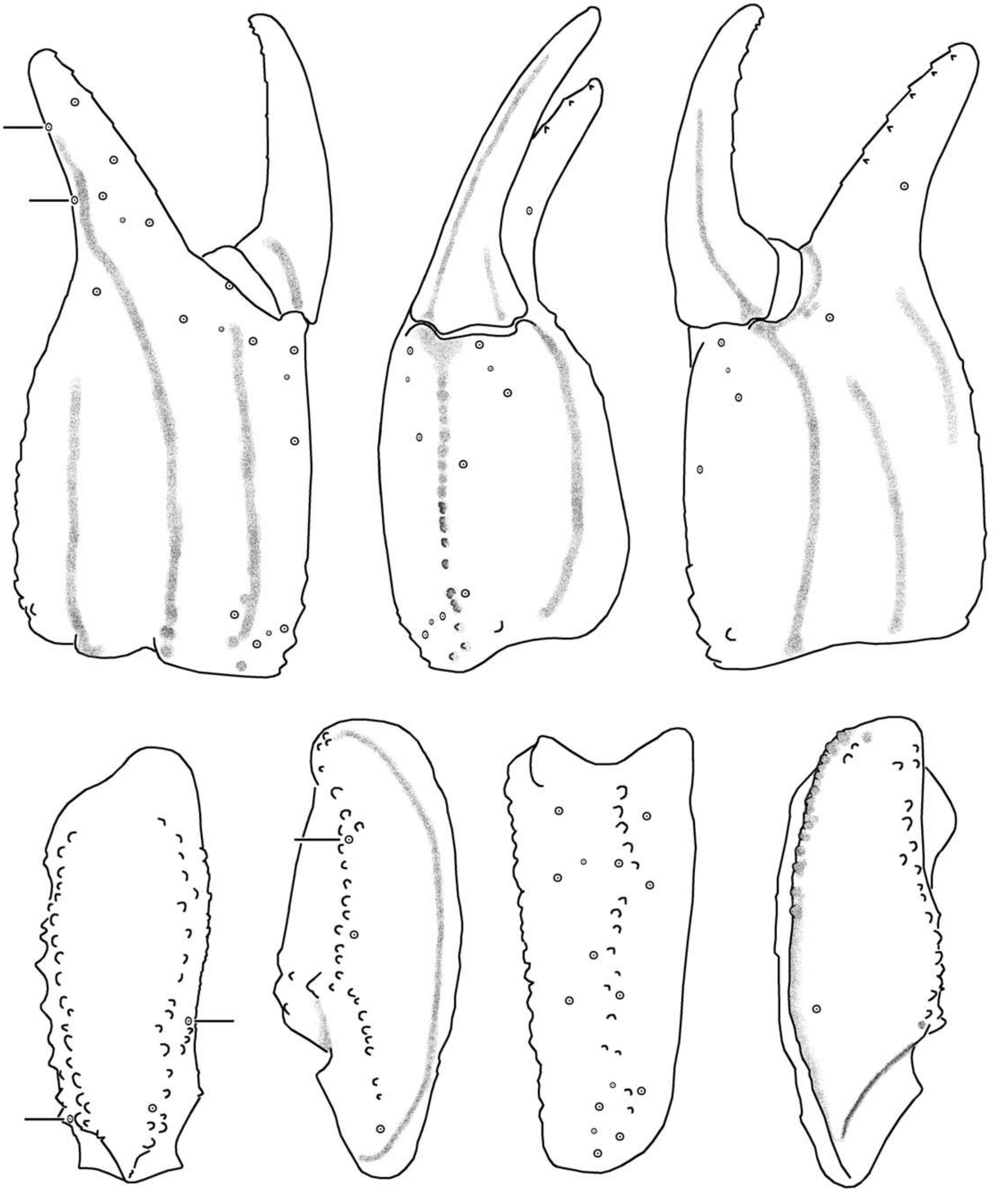


Figure 54: Trichobothrial pattern of *Calchas birulai*, **sp. nov.**, male holotype (NMW), Mardin, Turkey.

HEMISPERMATOPHORE (FIG. 55). In Figure 55 the right hemispermatophore ventral view is illustrated. It is consistent with the *C. birulai* hemispermatophore described in detail elsewhere. The overall structure is simplistic with a straight, parallel, and somewhat wide lamina terminating in a blunt, slightly tapered distal tip. The distal tip is thickened on the external edge exhibiting a slight sclerotization. The lamina base lacks a basal constriction but a slight angled expansion is visible just proximally of the lamina midpoint. At the

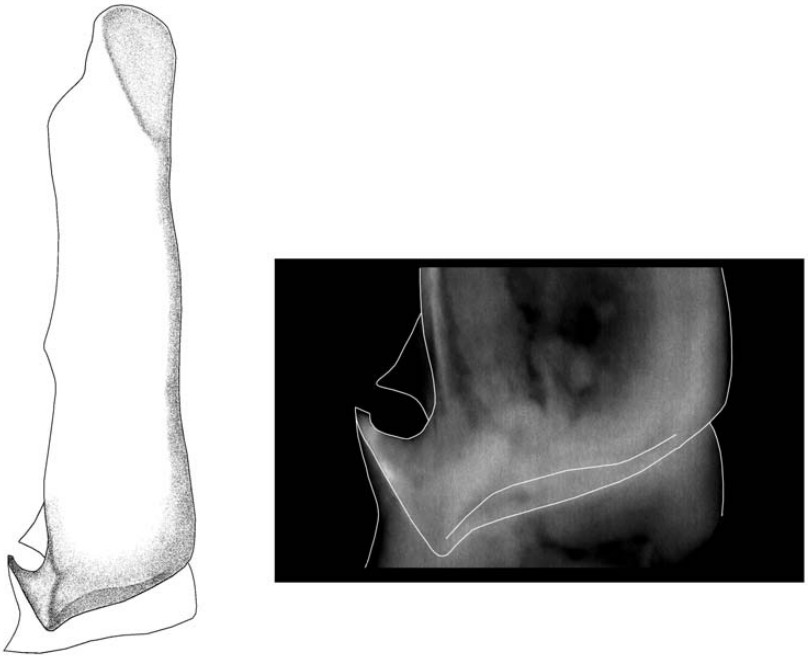


Figure 55: Right hemispermatophore of *Calchas birulai*, **sp. nov.**, male holotype (NMW), Mardin, Turkey. Ventral view and close-up of capsular area showing the truncated distal tip of the acuminate process.

lamina base is a nonpigmented, slightly sclerotized thin pointed internal protuberance. Emanating from the internal aspect of the capsular area is a highly pigmented sclerotized acuminate process terminating in a delicately truncated point.

Female Paratype (Mardin, Turkey, Figs. 51–53). Adult females are approximately the same size as the male, 24.60–27.00 [2] for males, compared to 25.90–28.00 [2] for females. The genders do not exhibit any significant morphometric differences except for the carapace length, which is relatively larger in the female; the female carapace length dominated in every possible ratio calculation. Pectinal tooth counts in the male exceed the female by one tooth over 80 % of the samples, male 5–6 (5.97) [30], female 5–6 (5.15) [26] (see histograms in Fig. 36). The genital operculum of the male is dramatically different from that in the female (Figs. 47, 52). The sclerites, subtriangular in shape, are as long as or longer than wide in the male, whereas in the female the sclerites are short and wide, more than twice as wide as long. Whereas the sclerites are fused medially in the female, they are separated their entire length in the male, exposing significantly developed genital papillae. The prepectinal plate, so conspicuous in the female, is absent in males (Figs. 47, 52). Figures 56–58 show dorsal and ventral views of both male and female specimens, and a locality area (Birecik, Turkey) for this species.

Type material. **Holotype:** ♂ (NMW 0843), TURKEY, *Mardin Province*: Mardin, 37.30°N, 40.733°E, 6 May 1966, J. Eiselt et al. leg. **Paratypes** (11 ♂, 14 ♀, 4 juv.): TURKEY, *Adıyaman Province*: 1 ♀ (FKCP), Nemrut Dağı, 40 km N Kahta, 37.982°N, 38.741°E, 3 July 1993, V. Šejna leg. *Diyarbakır Province*: 1 ♂, 1 ♀ (HNHM), Kavurma Köyü, 10 km NE Ergani, 1400 m a.s.l., 38.267°N, 39.767°E, 27 April 1989, G. Fabian, G. Ronkay & L. Ronkay leg. *Gaziantep Province*: 1 ♀ (NMW 0844), Sakçagözü, 37.198°N, 36.927°E, 26 April 1966, J. Eiselt et al. leg. *Malatya Province*: 1 ♀ (FKCP), Malatya, 38.067°N, 38.0167°E, June 1992, M. Kaftan leg.; 1 ♂ (FKCP), near Birecik, ca. 15–20 km from Syrian border (see Fig. 58), 37°01.185'N, 37°59.348'E, 500 m a.s.l. (collected together with *Compsobuthus matthiesseni* and *Mesobuthus eupeus*), 20 October 2008, A. Funk leg. *Mardin Province*: 3 ♂ 3 ♀ (NMW 0843), Mardin, 6 May 1966, J. Eiselt et al. leg. *Şanlıurfa Province*: 3 ♂ 2 ♀ (NMW 0840), 20 km S Urfa (now Şanlıurfa), 37.15°N, 38.80°E, 1 May 1966, J. Eiselt et al. leg.; 1 ♀ (MNHN RS 6452), Birecik [label: "Bilejdik"], 37.025°N, 37.977°E, 23 April 1971, J. Garzoni leg.; 1 ♂ subad., 2 ♀ subad., 1 ♂ juv., 1 ♀ juv. (HNHM), Halfeti, 37.25°N, 37.867°E, 1990, G. Ronkay leg.; 1 ♂ subad., 2 ♂ juv. (HNHM), Halfeti, valley of Euphrates, 500 m a.s.l., 15–22 April 1990, B. Herzig & G. Ronkay leg. *Siirt Province*: 1 ♂ (NMW 0842), road Siirt–Kurtalan, 16 May 1966, J. Eiselt et al. leg.; 1 ♀ (NMW 0846), Baykan (between Siirt and Bitlis), 38.165°N, 41.780°E, 15 May 1966, J. Eiselt et al. leg.; 1 ♀ (ZMUH A37/72), Siirt, 37.933°N, 41.95°E, 18 June 1972, C. Kosswig leg.

Note: see Eiselt (1967) for detailed itinerary and map of the NMW expedition to southeastern Turkey in 1966.

Additional specimens/localities (not examined): TURKEY: *Adıyaman Province*: 1 specimen (ZSRO 1181),

Figure 56: *Calchas birulai*, **sp. nov.**, dorsal and ventral views. Adult female paratype (FKCP) (24 mm), Nemrut Dağı, Turkey.

Figure 57: *Calchas birulai*, **sp. nov.**, dorsal and ventral views. Adult male paratype (FKCP) (22 mm), Birecik, Turkey.

Figure 58: Turkey, Gaziantep Province, Birecik, 500 m, a.s. l., 37°01.185'N, 37°59.348'E, ca. 15–20 km from the Syrian border. Collection locality of adult male paratype (FKCP) of *Calchas birulai*, **sp. nov.** (see Fig. 57), together with *Compsobuthus matthiesseni* and *Mesobuthus eupeus*.

Nemrut Dağı between summit and Horik, 37.93–37.97°N, 38.70–38.73°E site no. VO-1982/52d, 28 September 1982, R. Kinzelbach leg. *Gaziantep Province*: 1 ♂, 1 ♀ (ZDNU 2003/524/1-2), Şahinbey District, Güllüce Village, lower slopes of Mt. Ellezi, 13 September 2003; 1 ♂ (ZDNU 2003/573/1), 1 ♀ (ZDNU 2003/573/2), Şahinbey District, Güllüce Village, 36.983°N, 37.267°E, 21 September 2003 (Karataş & Çolak, 2005); 1 ♂ (AMNH [LP 4333]), Şehitkamil District, Incesu Köyü, 7 May 2005, E. Aydin [Yağmur] leg. (reported as “Antep-Sehitkamil: Incesu Köyü” by Kamenz & Prendini, 2008); 2 specimens (ZSRO 1101), Rumkale, 37.265°N, 37.874°E, 28 April 1987, M. Kasparek leg. *Sanlıurfa Province*: 1 specimen (ZSRO 0358, formerly NMM 0500), Karaçadağ Mts. near Siverek, 1200 m a.s.l., 37.691°N, 39.654°E, 18 April 1981, W. Heinz leg. (Kinzelbach, 1982: 58). IRAQ (north). *Arbil (Erbil, Hawler) Province*. 1 specimen, Geli Ali Beg waterfall, 36.6305°N, 44.4475°E, 21 April 1958, C. Kosswig leg. (ZMUH, no. 9/1958) (R. Kinzelbach, pers. comm., May 2009).

***Calchas gruberi* Fet, Soleglad et Kovařík, sp. nov.**

(Figs. 3, 5–7, 9–11, 14, 17–21, 25–26, 32–38, 59–75; Tables 2–3)

REFERENCES:

Calchas nordmanni: Kinzelbach, 1980: 169–174 (in part), figs. 1–2, 5 (map locality 16); Kinzelbach, 1982: 58 (in part); Kinzelbach, 1985: Map IV (in part); Crucitti, 1999: 87 (in part); Kovařík, 1999: 40, 42 (in part); Fet & Braunwalder, 2000: 18 (in part); Sissom & Fet, 2000: 418–419 (in part); Crucitti & Cicuzza, 2001: fig. 7 (in part); Stathi & Mylonas, 2001: 290, 293; Soleglad & Fet, 2003a: 5, fig. 2; Soleglad & Fet, 2003b: 7 (in part), figs. 19, 23, 52, 96; Fet et al., 2004: 24, figs. 1–4, 41–42 (Megisti listed in error; should be Anamur, NMW 0841); Fet et al., 2006a: 269–271, figs. 6–7; Fet & Soleglad, 2008: 256 (in part); Kaltsas et al., 2008: 227 (in part); Soleglad et al., 2009: 2 (in part), fig. 1.

Paraiurus nordmanni: Vachon & Kinzelbach, 1987: 99, 102, fig. 6 (in part); Sissom, 1988: 272.

Holotype: ♀ (NMW 0847), TURKEY, *Mersin Province*: Mamure Kalesi, Anamur, under stones, 15 May 1969 (F. Ressl). **Paratypes** (6 ♂, 10 ♀, 4 juv.): see list below.

Note: the type locality, Mamure Kalesi, is a famous waterfront Roman fortress, further strengthened by the Ottomans. It is located on Cape Anamur, the southernmost point of the Anatolian Peninsula.

Diagnosis. Small-sized scorpion with medium chelae, 26–36 mm in length, pectinal tooth counts 8–9 (8) male and 7–8 (7) female. Coloration variable, from yellow-orange with little patterns to dark brown and variegated patterns. Telson with bulbous vesicle, with long, wide curved aculeus; subaculear setal pair (SSP) located at vesicle/aculeus juncture. Seven and six inner denticles (*ID*) and eight and seven median denticle (*MD*) groups on the movable and fixed fingers, respectively. Fixed finger of chela longer than palm, trichobothrium *it* located on distal third of fixed finger. Metasomal segment V two times longer than wide.

Distribution. TURKEY: south (Antalya and Mersin Provinces). GREECE: Samos Island, Megisti Island. (see maps in Figs. 38, 59).

Etymology. The species name is a patronym honoring our colleague Dr. Jürgen Gruber, the prominent opilionologist and a veteran curator of Arachnida in 3.Zoologische Abteilung, Naturhistorisches Museum Wien, Austria.

FEMALE. Description based on holotype female from Mamure Kalesi, Anamur, Turkey. Measurements of this holotype plus four paratypes are presented in Table 3. See Figure 60 for a dorsal view of the female holotype.

COLORATION. Basic color of carapace, tergites, metasoma, telson, pedipalps, and legs yellow-orange; carinae of pedipalps and metasoma, and cheliceral dentition a light red; chelal finger dentition and telson aculeus a dark reddish-brown; leg condyles red; sternites and pectines pale yellow. No variegated patterns present.

CARAPACE (Fig. 61). Anterior edge with a small median indentation, equipped with four small irregularly placed setae (others may be broken off); interocular area somewhat rough with scattered granulation, though smooth around the immediate area of the median eyes; posterior lateral aspects covered with medium to large granules. Mediolateral ocular carinae present, extending to the lateral eyes; lateral eyes number two, the posterior eye a little larger. Median eyes and tubercle somewhat small, positioned considerably anterior of middle with the following length and width formulas: 118|420 and 54|338.

MESOSOMA (Fig. 62). Tergites I–III lightly granulated, IV–VI with heavier granulation, primarily on posterior half; tergite VII covered with coarse granules with two pairs of granulate carinae. Sternites III–VI smooth and lustrous, VII covered with small granules; two pair of weak, vestigial carinae present on segment VII. Stigmata (Fig. 62) are short sub-oval in shape, angled 45° in an anterointernal direction.

METASOMA (Figs. 66–67). Segments I–IV: dorsal and dorsolateral carinae crenulate; dorsal (I–IV) and dorsolateral (I–III) carinae terminate with spine, smaller on dorsolateral; lateral carinae crenulate on I and obsolete on II–IV; ventrolateral and ventromedian carinae crenulate. Dorsolateral carinae of segment IV terminate at articulation condyle. Segment V: dorsolateral carinae crenulate; lateral carinae irregularly granulated for two-thirds of posterior aspect; ventrolateral and single ventromedian carinae crenulate; ventromedian carina not bifurcated, terminating in straight line (Fig. 67). Intercarinal areas essentially smooth on I–III, scattered with granulation ventrally on IV–V. Metasoma essentially void of setation.

TELSON (Figs. 66–67, 68, paratype male from Anamur). Bulbous vesicle with long widely curved aculeus. Vesicle surface covered ventrally with medium sized granules, heavier basally; scattered setae located on ventral surface of vesicle; subaculear setal pair (SSP) located at vesicle/aculeus juncture.

PECTINES (Fig. 64). Well-developed segments exhibiting length|width formula 400|160 (length taken at anterior lamellae|width at widest point including teeth). Sclerite construction complex, three anterior lamellae and 3/3 middle lamellae; fulcra of medium development. Teeth number 7/7. Sensory areas developed along most of tooth inner length on all teeth, including basal tooth. Delicate thin, white setae found on anterior lamellae and distal pectinal tooth. Basal piece large, with deep indentation along anterior edge, length|width formula 80|100.

PREPECTINAL PLATE (Fig. 64). Conspicuous lustrous plate, approximately as wide as a gential operculum sclerite; length/width ratio 230/550.

GENITAL OPERCULUM (Fig. 64). Sclerites much wider than long, fused medially. Posterior medial area contracts anteriorly. Genital papillae absent (see discussion on male below).

STERNUM (Fig. 64). Type 2, posterior emargination present, well-defined convex lateral lobes, apex visible but not conspicuous; slightly wider than long, length|width formula 115|135; sclerite tapers anteriorly, posterior-width|anterior-width formula 135|93.

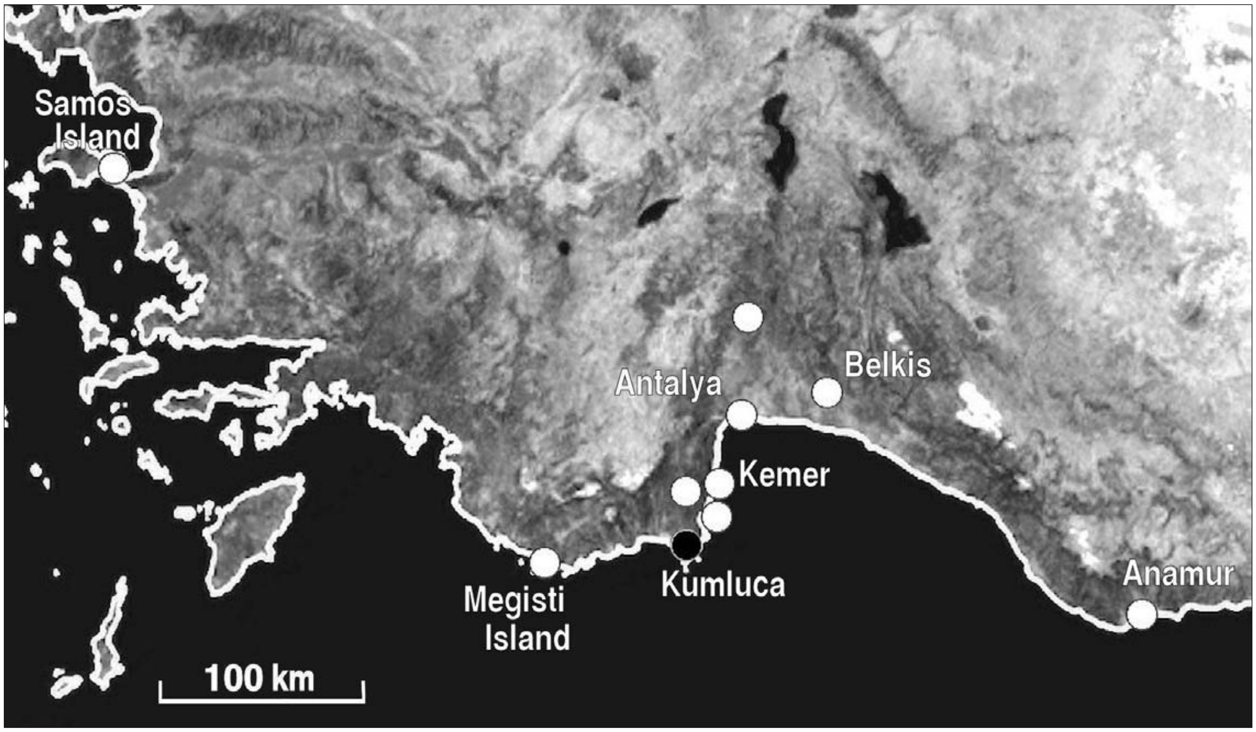


Figure 59: Large-scale range of *Calchas gruberi*, **sp. nov.** (open circles). See general *Calchas* map in Fig. 38.

CHELICERAE (Fig. 69, paratype male from Anamur). Movable finger dorsal edge with one large subdistal (*sd*) denticle; ventral edge with three small crenulations (*va*), two pigmented, on the distal half, and one large pigmented accessory denticle at finger base; ventral edge with heavy setal brush covering well-developed serrula with over 20 contiguous tines, terminating just before distal tip. Ventral distal denticle (*vd*) considerably longer than dorsal (*dd*). Fixed finger with four denticles, median (*m*) and basal (*b*) denticles conjoined on common trunk; no ventral accessory denticles present.

PEDIPALPS (Figs. 65, 71). Moderately chelate, heavily carinate species, no scalloping on chelal fingers, thus not exhibiting sexual dimorphism in this structure. **Femur:** Dorsointernal carina serrate, dorsoexternal and ventrointerior carinae crenulate, ventroexternal rounded. Dorsal, ventral, and external surfaces rough, internal surface granulated. **Patella:** Dorsointernal, dorsoexternal, and ventrointernal carinae crenulate, ventroexternal carina granulate, exteromedian carina irregularly crenulate. Dorsal and ventral surfaces rough; external surface with exteromedian carina; internal surface smooth except for weakly developed doubled DPS and VPS. **Chelal carinae:** Complies with the “8-carinae configuration”. Digital (*D1*) carina strong, smooth to granulate; dorsosecondary (*D3*) present on basal half only, covered with large granules; dorsomarginal (*D4*) strong, round, continuous, with large granules; dorsointernal (*D5*) weak, sparsely granulated; ventroexternal (*V1*) strong and granulated, terminating at external condyle of movable finger; ventrointernal (*V3*) medium development, continuous to internal condyle, covered with small granules; external (*E*) strong, continuous, and granulated; internal (*I*) weak, rounded, not continuous, with small granules. **Chelal finger dentition (Figs. 65):** median denticle (MD) row groups oblique and slightly imbricating, numbering 7 and 8; 6/6 and 7/7 internal denticles (*ID*) and 6/6 and 7/7 outer denticles (*OD*) on fixed and movable fingers, respectively. No accessory denticles present. Number of *MD* denticles on movable finger is 76. **Trichobothrial patterns (Fig. 71):** Type C, orthobothriotaxic. See discussion of trichobothria differences between *Calchas* species which highlights the pattern of this female type.

LEGS (Figs. 62). Both pedal spurs present on all legs; tibial spurs present on legs III and IV. Tarsus covered heavily with large socketed setae on ventral surface.

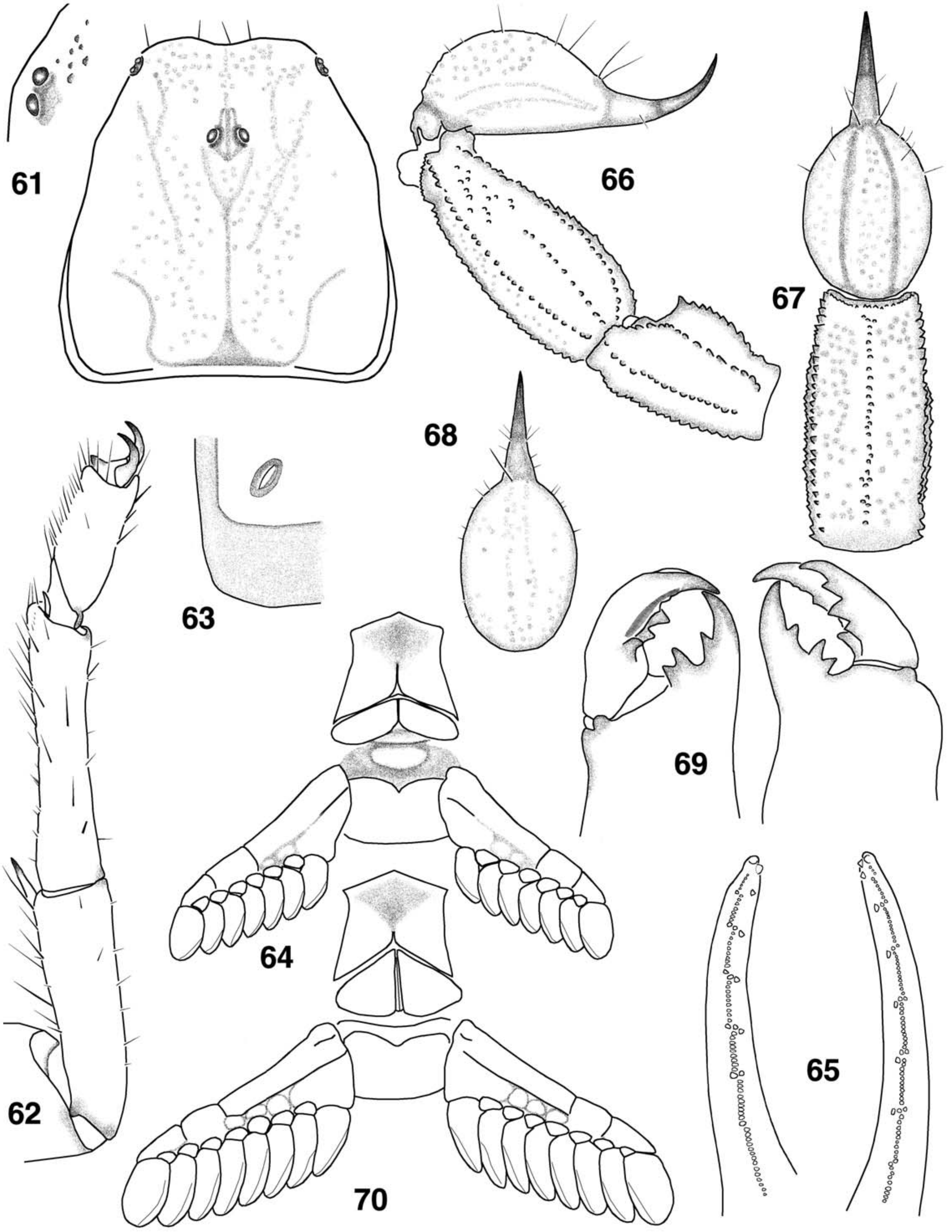
HEMISPERMATOPHORE. Unknown, not found in available males.

Male Paratype (Figs. 68–70, from Anamur). Adult males are approximately the same size as the female, 26.60–27.40 [3] for males, compared to 28.75–31.90 [2] for females. The genders do not exhibit any significant morphometric differences: for example, metasomal segments (L/W), where gender differences are commonly found, mean-value differences ranged only

Figure 60: *Calchas gruberi*, **sp. nov.**, female holotype (NMW), dorsal view (32 mm), Mamure Kalesi, Anamur, Turkey.

0.8–2.4 %. Only the chelal palm showed mean-value differences exceeding ten percent; chela length / palm width 14.9 % and chela length / palm length 12 % (in both cases, based on the female with the longer chela). Pectinal tooth counts in the male exceed the female by one tooth, male 8–9 (8.44) [18], female 7–8 (7.29) [24] (see histograms in Fig. 36). Note that one of the males with nine pectinal teeth is from the Greek island of Samos, off the western coast of Turkey, somewhat removed from the primary range of *C. gruberi* (see maps in Figs. 38, 59). The genital operculum of the male is dramatically different from that in the female (Figs. 64, 70). The sclerites, subtriangular in shape, are as long as or longer than wide in the male whereas in the female, the sclerites are short and wide, more than twice as wide as long. Whereas the sclerites are fused medially in the female, they are separated their entire length in the male, exposing significantly developed genital papillae. The prepectinal plate, so conspicuous in the female, is absent in males (Figs. 64, 70). Figures 72–73 show dorsal and ventral views of two dark colored *C. gruberi* female specimens: one from Antalya (dry, Fig. 72) another from Akseki (live specimen, Fig. 73) as well as the locality area where the latter specimen was collected; and Figures 74–75 show dorsal and ventral views of light colored female and male specimens from Kemer, Turkey.

Type material. TURKEY. **Holotype**: 1 ♀ (NMW 0847), *Mersin Province*: Mamure Kalesi, Anamur, 36.078°N, 32.834°E, under stones, 15 May 1969, F. Ressl leg. **Paratypes** (6 ♂, 10 ♀, 4 juv.): *Mersin Province*: 2 ♀ (NMW 0847), Mamure Kalesi, Anamur, under stones, 15 May 1969, F. Ressl leg.; 1 ♂, 1 ♂ juv. (partially dismembered and used for SEM) (NMW 0841), 15 km by road W of Anamur, 36.078°N, 32.817°E, 18 May



Figures 61–70: *Calchas gruberi*, **sp. nov. 61–67.** Female holotype (NMW), Mamure Kalesi, Anamur, Turkey. **61.** Carapace showing close-up of lateral eyes. **62.** Leg IV (left, ventral view), showing the tibial spur. **63.** Stigma III. **64.** Sternum, genital operculum, prepectinal plate, and pectines. **65.** Chelal fixed and movable finger dentition. **66.** Telson and metasomal segments IV–V, lateral view. **67.** Metasomal segment V and telson, ventral view. **68–70**. Male paratype (NMW), Anamur, Turkey. **68.** Telson, ventral view. **69.** Chelicerae, vental and dorsal views. **70.** Sternum, genital operculum, and pectines (note lack of prepectinal plate conspicuous in female).

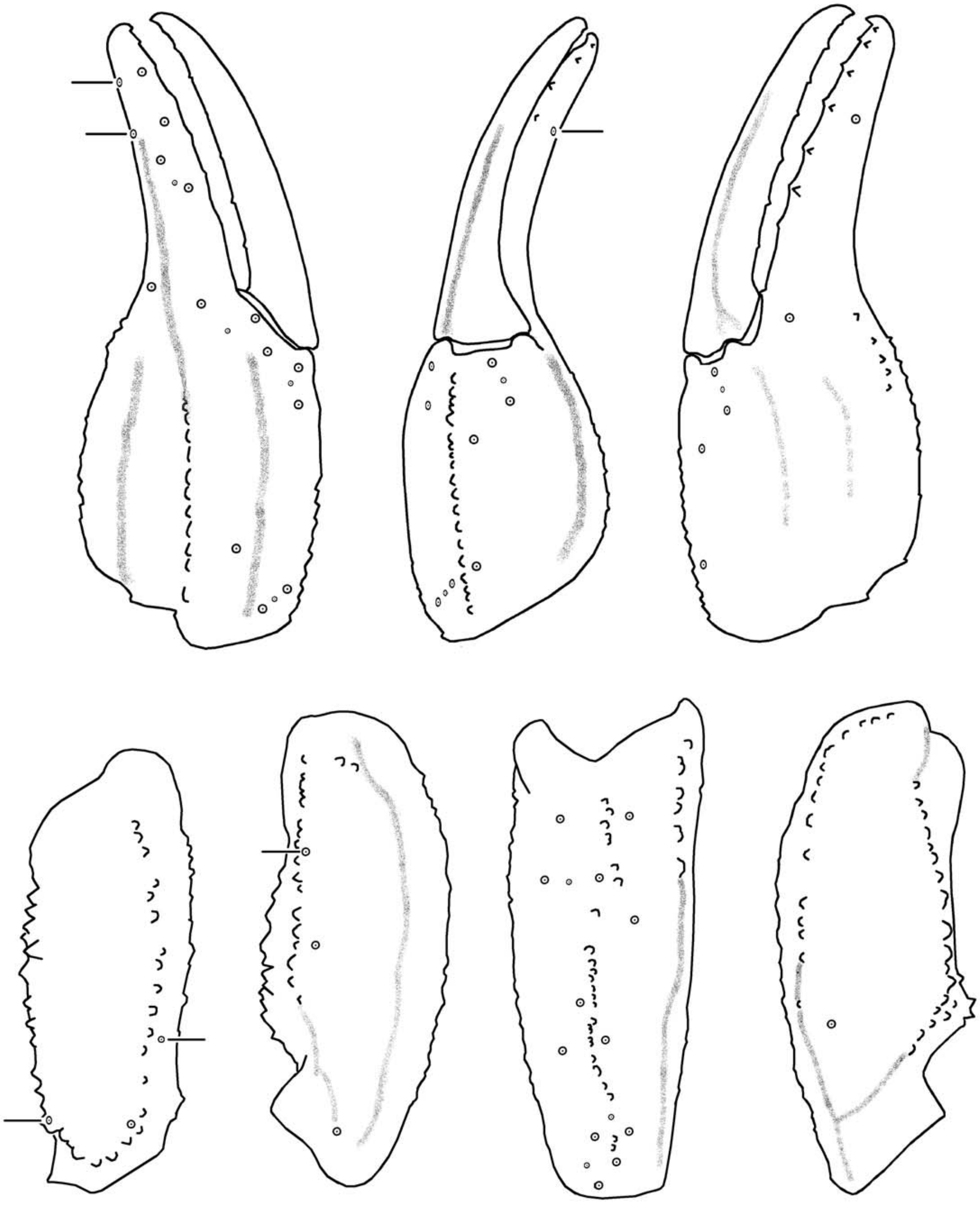


Figure 71: Trichobothrial pattern of *Calchas gruberi*, **sp. nov.**, female holotype (NMW), Mamure Kalesi, Anamur, Turkey.

1969, G. Pretzmann leg. *Antalya Province*: 1 ♂, 1 ♀ (NMW 0848), Belkıs (Aspendos), 36.939°N, 31.172°E, near ruins, under stones, 16 May 1965, F. Ressl leg.; 1 ♂, 1 ♀ (NMW 0838/VF; specimens partially dismembered and used for SEM), mountains N of Antalya, 36.913°N, 30.69°E, 19 May 1969, J. Koller & F. Ressl leg. (together with *Iurus*); 1 juv. (damaged) (MNHN RS 7024), Olympos, 36.403°N, 30.474°E, 30 July 1974; 1

Figure 72: *Calchas gruberi*, **sp. nov.**, dorsal and ventral views. Adult female paratype (FKCP), Antalya, Turkey.

Figure 73: Adult female paratype (FKCP) of *Calchas gruberi*, **sp. nov.**, (top) and collection locality, 12 km S. Akseki, Turkey (bottom).

Figure 74: *Calchas gruberi*, **sp. nov.**, dorsal and ventral views. Adult paratype female (FKCP) (34 mm), Kemer, Turkey.

Figure 75: *Calchas gruberi*, **sp. nov.**, dorsal and ventral views. Adult paratype male (FKCP) (36 mm), Kemer, Turkey.

Figure 76: Part of scorpion collection in Naturhistorisches Museum Wien (NMW), curated by Dr. Jürgen Gruber (1999).

♀, near Antalya, 1994 (FKCP); 2 ♀, 1 juv. (FKCP), 12 km S of Akseki, 11–12 May 2006, F. Kovařík leg.; 3 ♂, 2 ♀, 1 juv. (FKCP), Kemer, May 2009; 1 ♀ (NMM 0250), 15 km NE of Kumluca, 36.546°N, 30.283°E, 12 August 1972, R. Kinzelbach leg. (Kinzelbach, 1982: 58; the same specimen was reported as "20 km N of Kumluca, 12 August 1972" by Kinzelbach, 1980).

Note: see Pretzmann (1972) for a detailed itinerary and map of the NMW expedition to Turkey in 1969.

Other material examined: GREECE, 1 ♀ juv. (NMHC 81.1.7.9/VF; specimen dismembered and partially used for DNA studies), Megisti (=Kastelorizo) Island, 36.149°N, 29.594°E, I. Stathi leg.; 1 ♂ (FMNH), Samos Island, 37.757°N, 26.977°E, Mt. Spiliani, 2 km N Pithagorion, S slope, 23 April 1979, A. Riedel leg.

Note: we do not include Greek island specimens, identified here as *C. gruberi*, in the type series of *C. gruberi*; a further detailed study of Samos and Megisti populations is warranted.

Other specimens/localities (material not examined): TURKEY, *Antalya Province*: 1 specimen (NMW 0845), 46 km by road N of Antalya, 865 m, mountain pass, 21 May 1969, G. Pretzmann leg. GREECE, Megisti (=Kastelorizo) Island (Stathi & Mylonas, 2001: "big population").

Biogeography

Kaltsas et al. (2008: 238) mentioned that "the biogeography of the monotypic genus *Calchas* still remains a mystery to scientists." We are glad to offer here a window to this mystery.

Figures 38, 39, 42, and 59 present the current ranges of three species described and discussed in the present paper, based on all known records. The observed disjunction follows modern ecological barriers. The ecologically diverse territory of the Anatolian Peninsula (historical Asia Minor) is divided into a number of biogeographic provinces or regions. Three disjunct species of *Calchas* tend to fall under three separate regions as described for the Anatolian scorpiofauna by Crucitti & Cicuzza (2001).

Already the range of *Calchas nordmanni* depicted by Kinzelbach (1985) and Vachon & Kinzelbach (1987: 99, fig. 6) reflected three widely disjunct populations; additional records expanded boundaries of their ranges, but the disjunction remains. The geographic range of *Calchas nordmanni* Birula, 1899 (*sensu stricto*) is limited to Çoruh River valley (Black Sea watershed) in northeastern Turkey, i.e. mainly in the very east of Black Sea Region; it does not cross the mountain ranges stretching between Erzurum and Kars. The geographic range of *Calchas birulai* **sp. nov**. covers a large area in southeastern Turkey, across Gaziantep, Adıyaman, Malatya, Sanlıurfa, Diyarbakır, Mardin, and Siirt Provinces, and reaches to northern Iraq. This range covers the entire East Anatolian Region as defined by Crucitti & Cicuzza (2001). *C. nordmanni* and *C. birulai* are clearly separated by the high mountain ranges of Güneydoğu Toroslar, Hakkari, Munzur, and Bingöl. The geographic range of *Calchas gruberi* **sp. nov**. at this moment is limited to a small portion of southern Turkey along the Mediterranean coast, from Kumluca to Anamur, within the Mediterranean Region. On the east, it is well separated by the Taurus Mountains from the range of *C. birulai*. The populations from Greek islands (Samos and Megisti) are currently also assigned to *C. gruberi* but should be a subject of a more detailed study, with a possible clarification of Samos locality.

The disjunct distribution of *Calchas*, therefore, appears to be a textbook illustration of allopatric speciation, with three species that seem to occupy different ecological regions. Although it is hard to speculate about the timing of this disjunction, it does not have to be very recent (i.e. Pleistocene). Modern evolution of scorpiofauna in the Aegean-Anatolian area, at species level and below, was traced in the recent DNA-based studies of Greek researchers (Parmakelis et al., 2006a, 2006b). It is believed to have been influenced by tectonic fragmentation for both a widespread *Mesobuthus gibbosus* (Buthidae) and a more localized *Iurus dufoureius* (Iuridae). It is generally accepted that the Aegean-Anatolian area was represented by a single landmass (Agäis) in the Upper to Middle Miocene (23–12 Mya), with the subsequent fragmentation due to tectonic events of 12–5 Mya (Stathi & Mylonas, 2001).

Hrbek et al. (2004) in their detailed DNA-based work on historical biogeography of Central Anatolian fish, conclude that "geologically complex areas of the Near East contain many phylogenetically deeply divergent lineages, some showing reproductive isolation, that are otherwise morphologically difficult to differentiate. We suggest this is most likely due to fragmentation of previously contiguous areas into a parapatric series of ecologically equivalent regions." The case of *Calchas* seems to be more straightforward: there are three distinct morphospecies in three ecologically different regions.

Acknowledgments

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Figure 77: Peter Jäger (left), holding a jar with Ragnar Kinzelbach's scorpion specimens, and a local volunteer in Naturhistorisches Museum Mainz (NMM) (1999).

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