

**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).

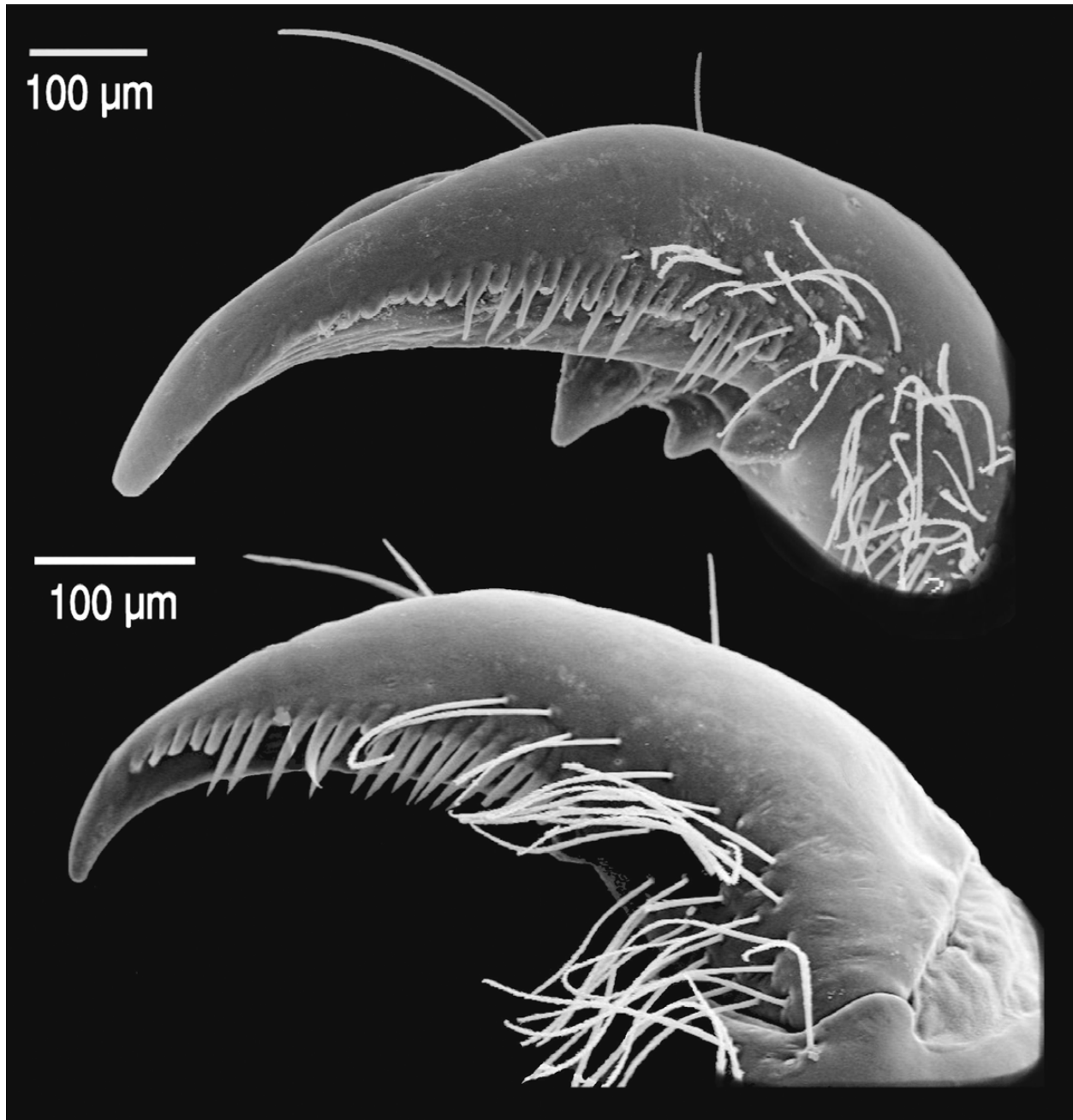
### **Pedipalps**

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 Scorpipinae (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 ventro-median (*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-

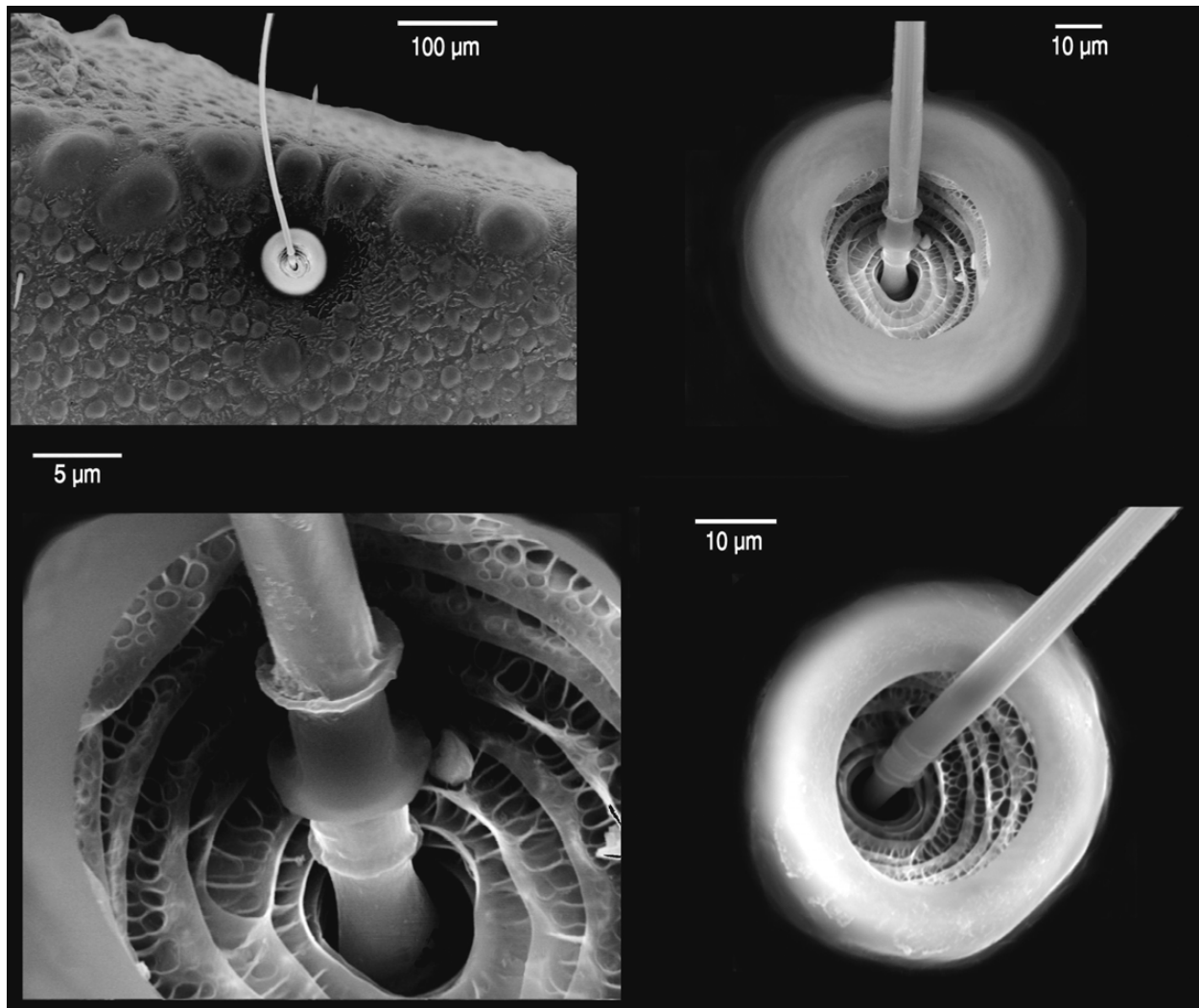


**Figure 9:** Cheliceral movable finger, ventral view, showing well developed serrula. **Top.** *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey. **Bottom.** *C. gruberi*, **sp. nov.**, juvenile male, Antalya, Turkey.

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

The **chelar 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.

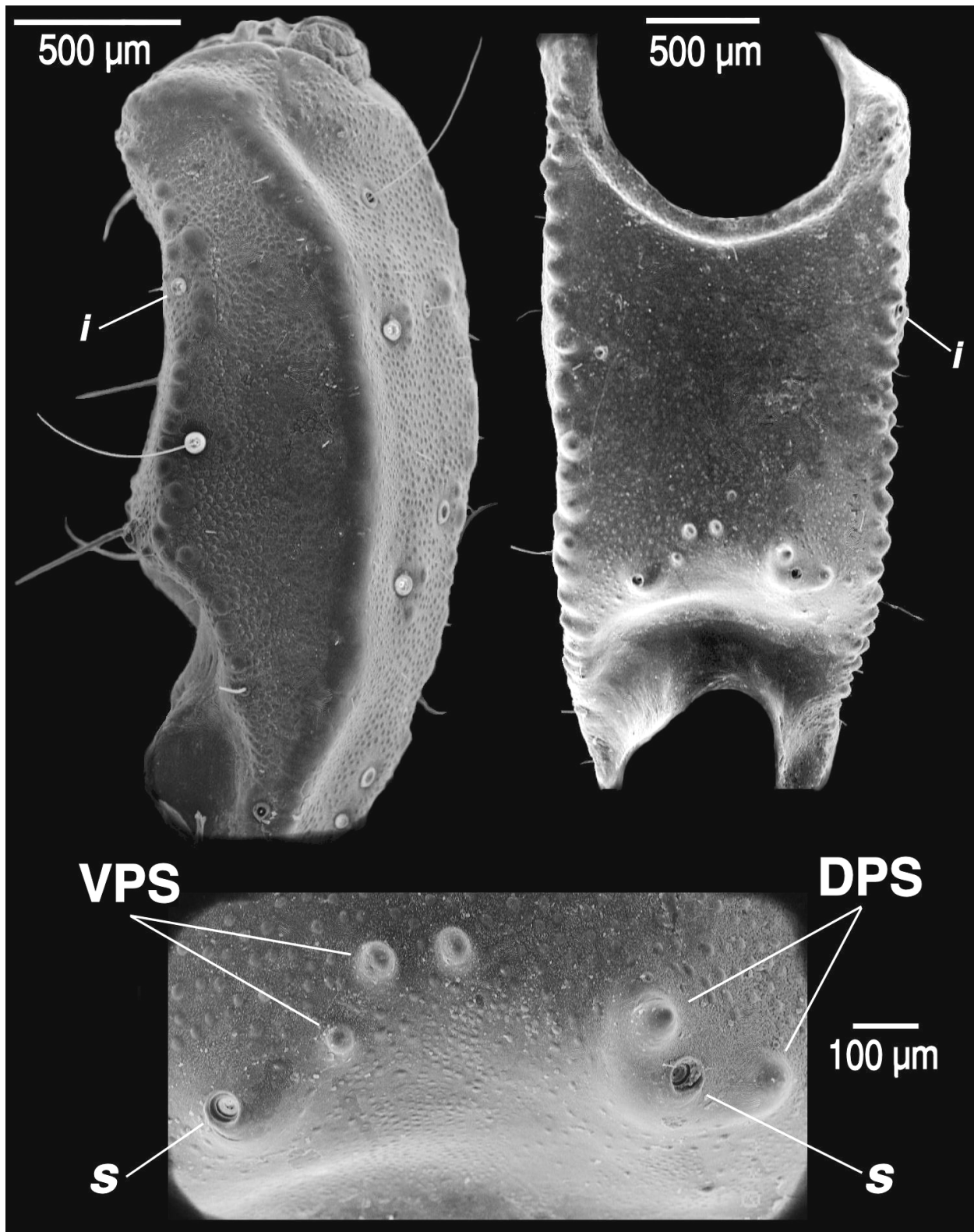
more proximally in basal groups. The last *MD* group in either finger is not accompanied by an *ID*. All *MD* denticle groups terminate with a slightly enlarged *OD* denticle, except for the basal *MD* group which terminates with increasingly smaller *MD* denticles. The most distal *MD* denticle group 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*:

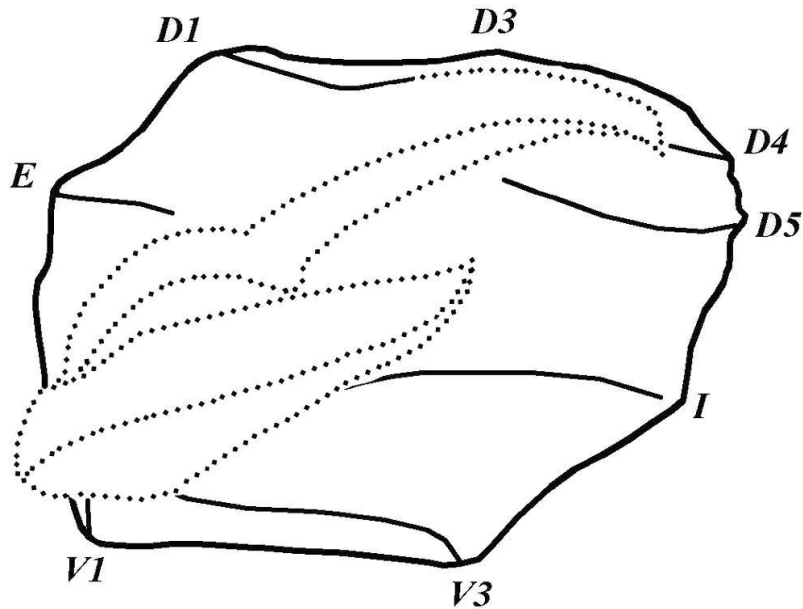
“... The mobile finger of the chelae ... there are seven rows of granules on its blade, distinctly separated from

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 anteriorly; 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* = ventro-external carina, *V3* = ventrointernal carina, *E* = external carina, *I* = internal carina. Diagram based on male *C. nordmanni*.

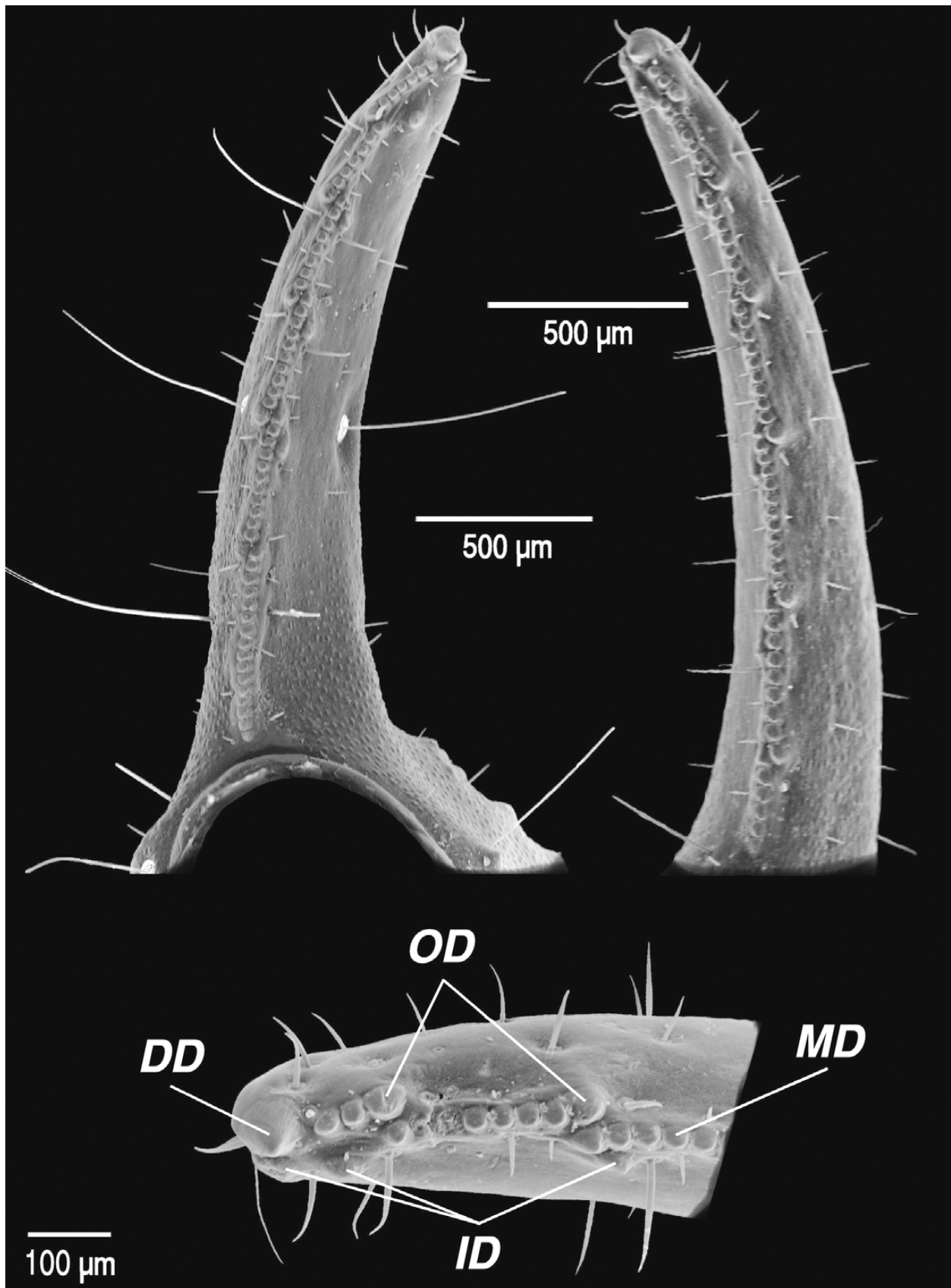
(1971: fig. 10) illustrated the movable finger dentition for a male of *C. nordmanni* from Birula's original collection (ZISP 1395).

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* (Kovářik 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*.

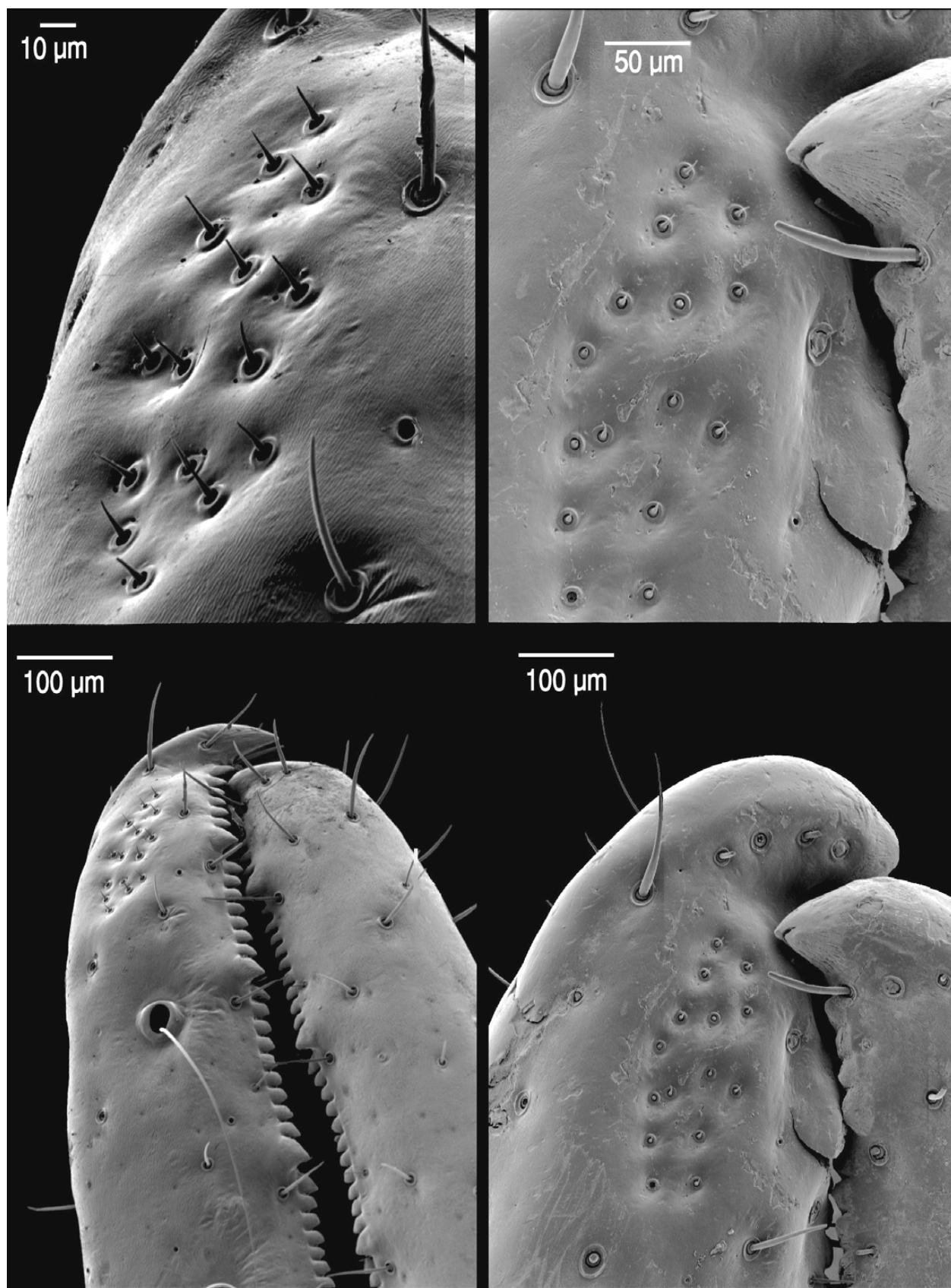
### Legs

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*<sub>3</sub> 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.