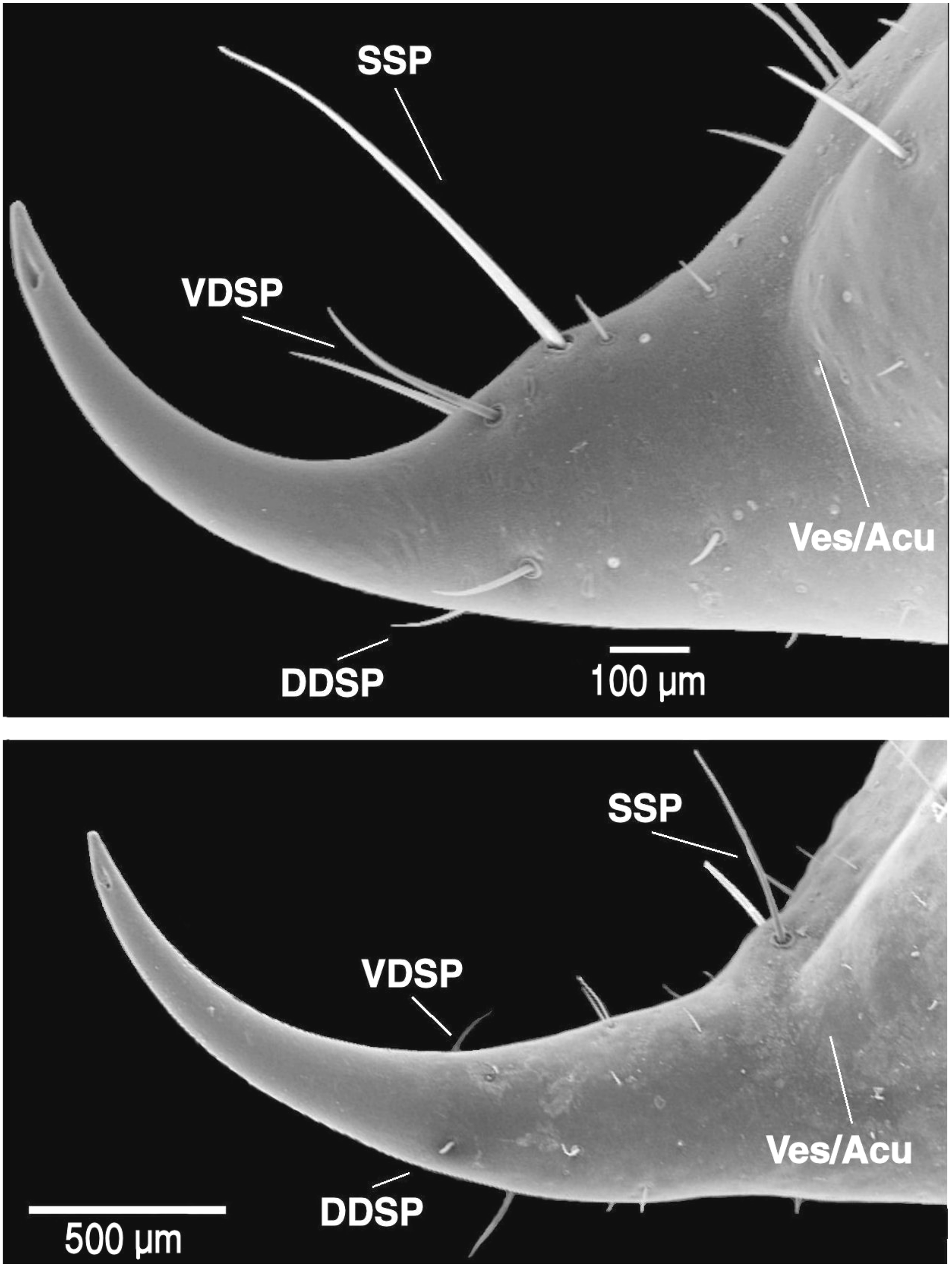


Figure 21: Close-up of the telson of *Calchas* showing two different placements of the subaculear setal pair (SSP) with respect to the vesicle/aculeus juncture. **Top.** *Calchas birulai*, **sp. nov.**, female, Nemrut Dağı, Turkey, SSP placed on aculeus base, distal of the juncture. **Bottom.** *C. gruberi*,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

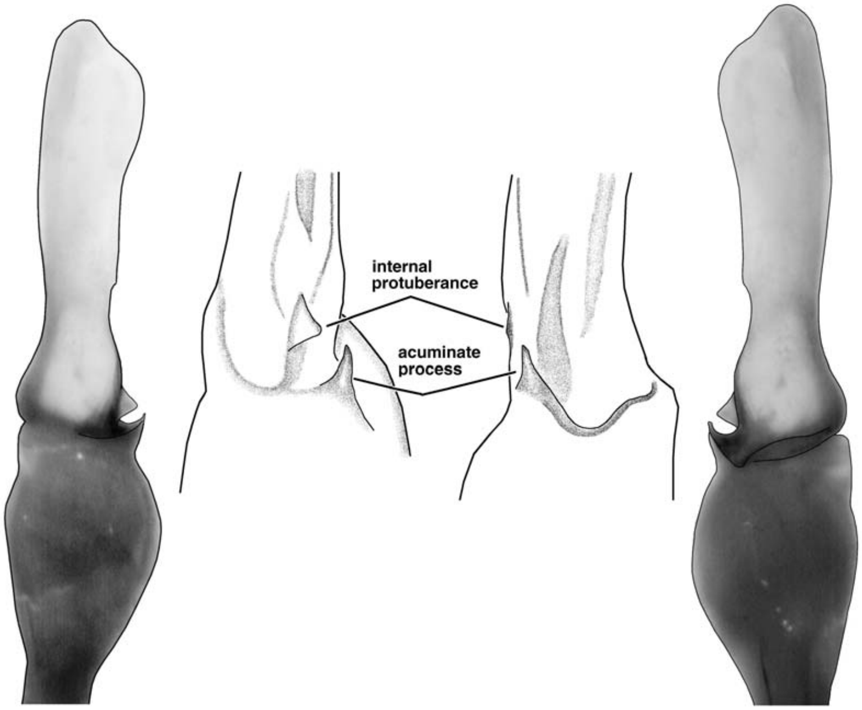


Figure 22: Right hemispermatophore of *Calchas birulai*, **sp. nov.**, Kavurma Köyü, Turkey. **Left.** Dorsal view. **Right.** Ventral view. **Central, Left.** Close-up of capsular area, interodorsal view, internal protuberance visible, though angled slightly outward towards figure plane. **Central, 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

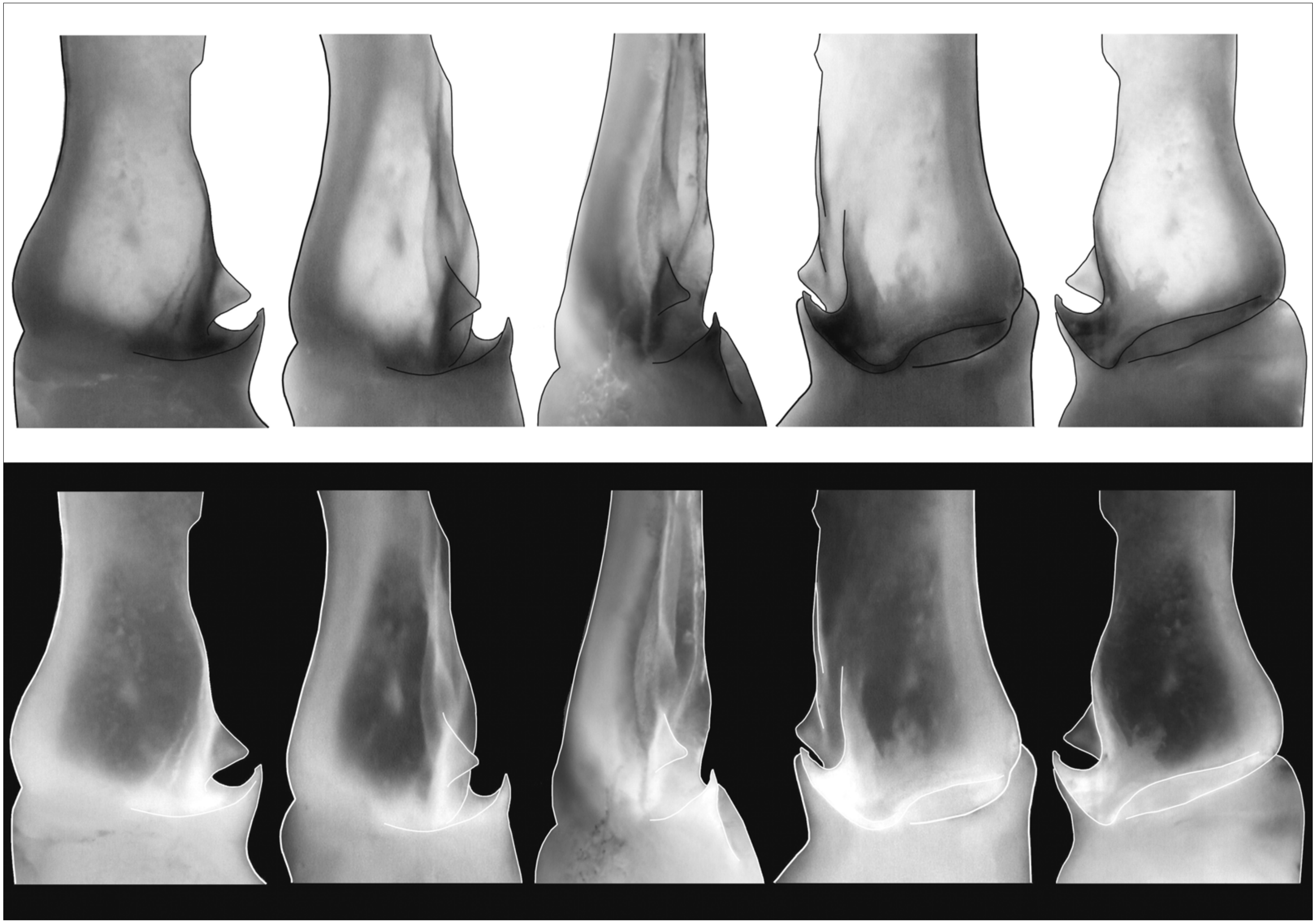


Figure 23: Right hemispermatophore of *Calchas birulai*, **sp. nov.**, Kavurma Köyü, Turkey. Close-up of capsular area (left to right), dorsal, dorsointernal, interodorsal, ventrointernal, and ventral. Reverse video images on bottom.

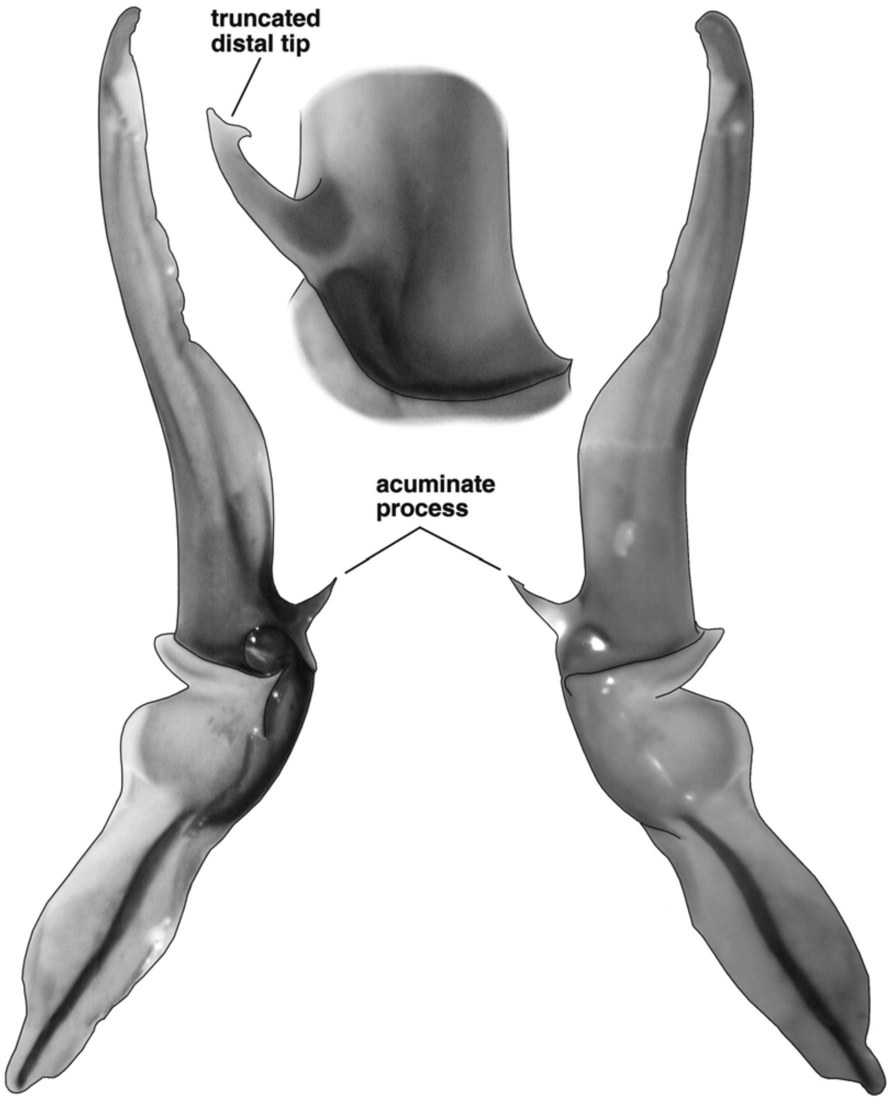


Figure 24: Right hemispermatophore of *Iurus dufoureius*, Antalya, Turkey. Dorsal and ventral views, and close-up of capsular area from a internoventral view. Note the significantly developed acuminate process with a truncated distal tip visible from the internal and ventral perspectives.

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

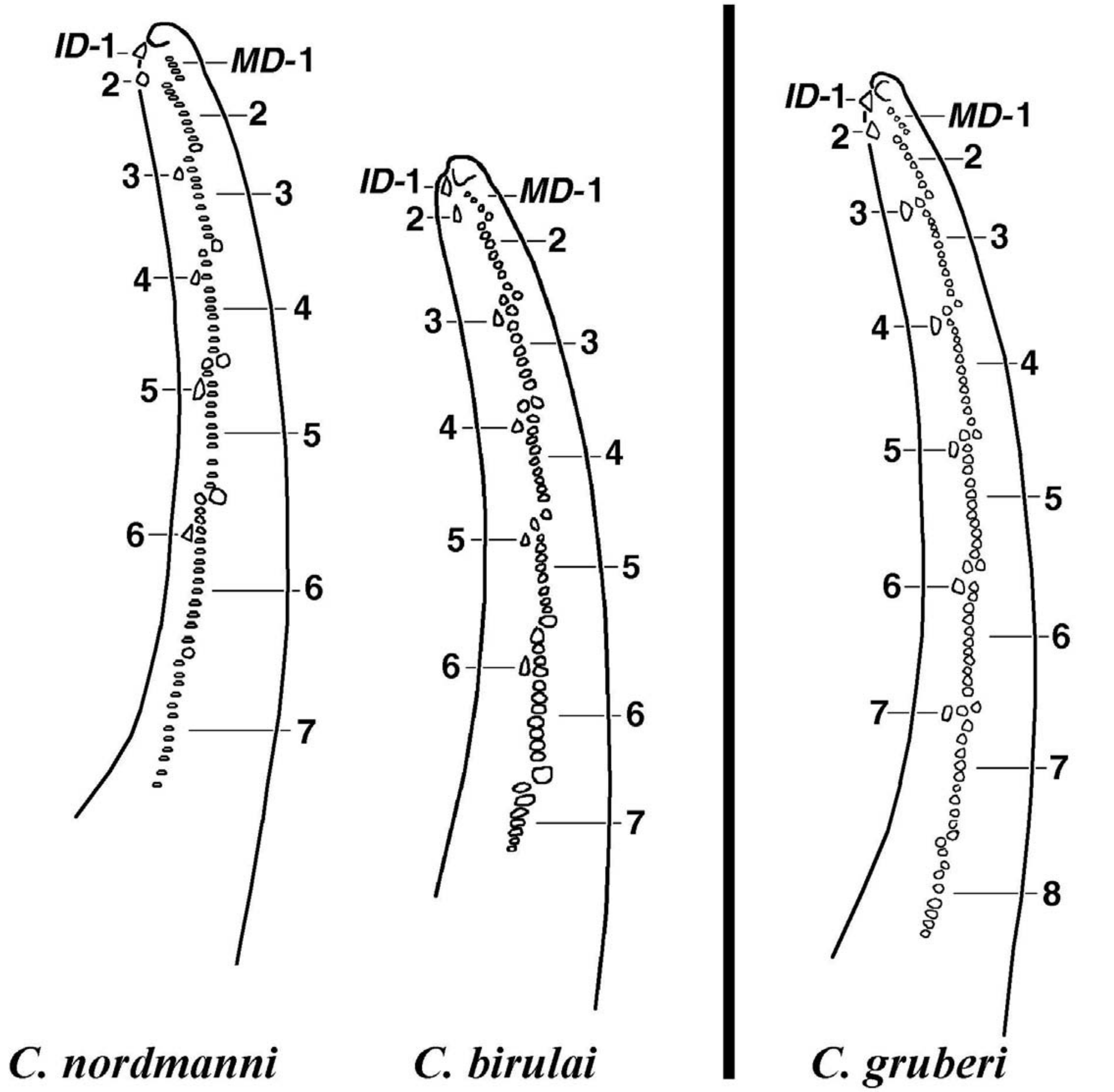


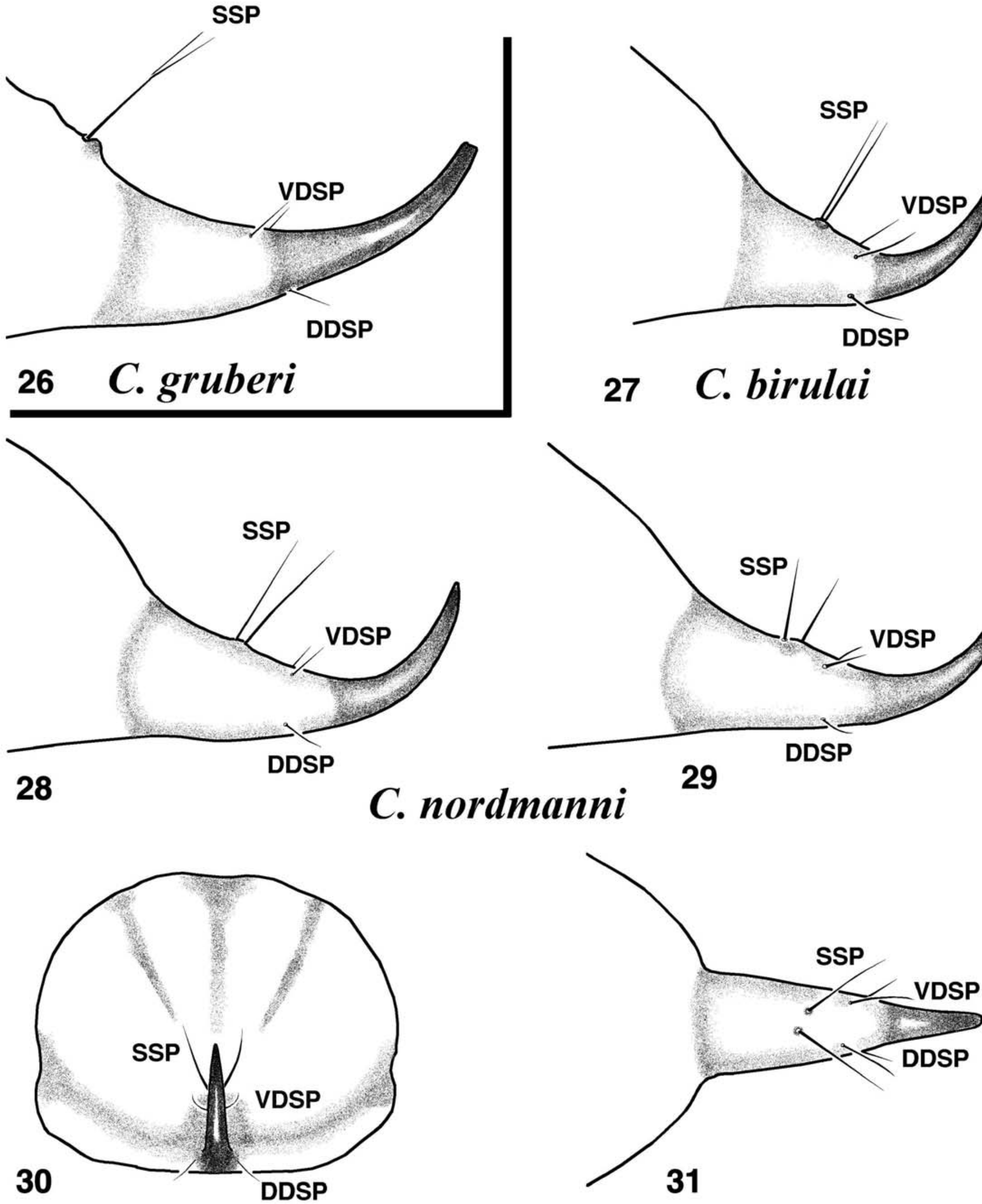
Figure 25: Chelal movable finger of *Calchas* species showing dentition. Note differences in the number of inner denticles (*ID*) and median denticle (*MD*) groups between the species: *C. nordmanni*, female, Tortum, Turkey, and *C. birulai*, **sp. nov.**, male holotype, Mardin, Turkey, with six *ID*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

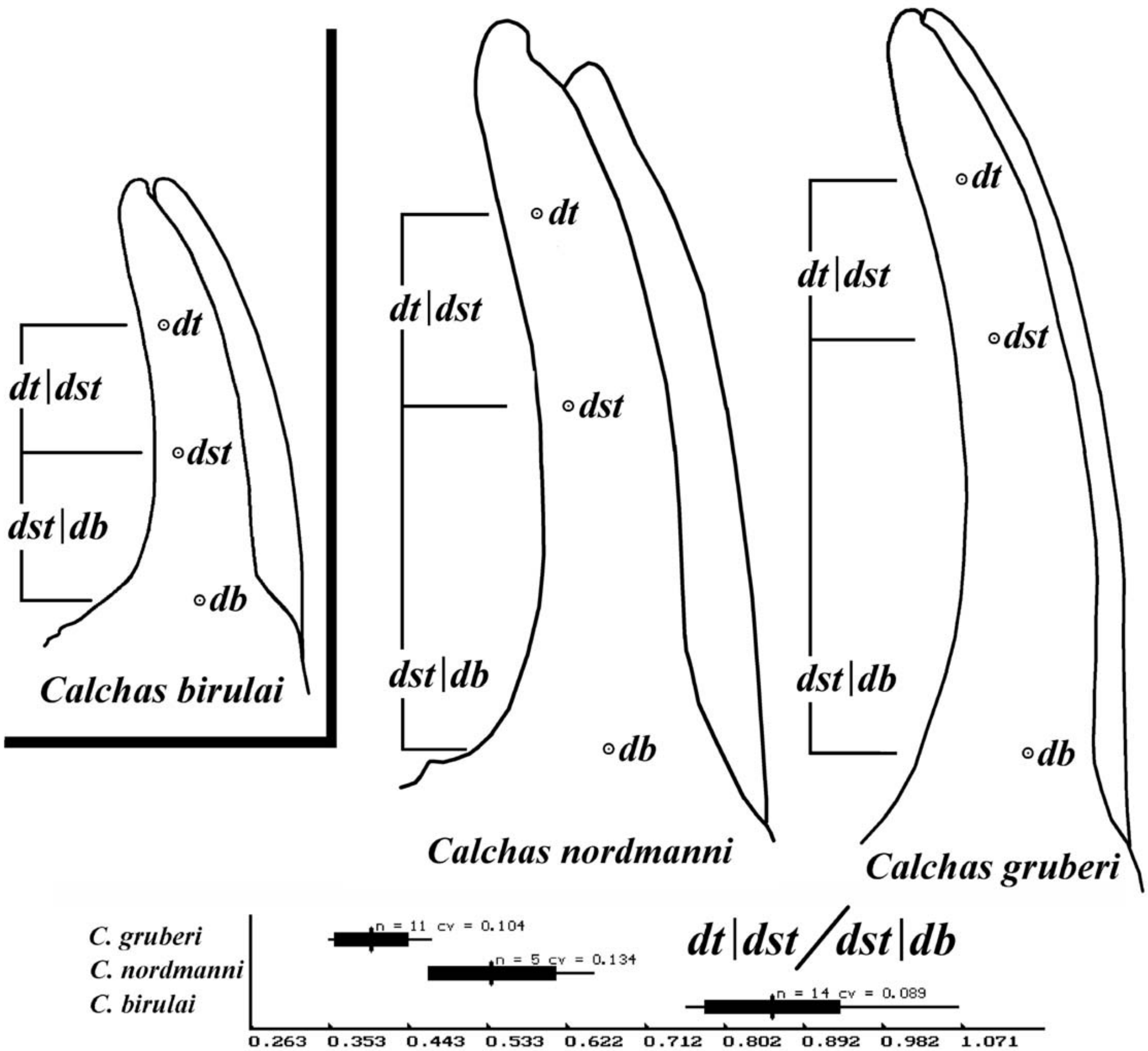


Figure 32: Relative position of chelal trichobothrium *dst* in *Calchas* with respect to trichobothria *dt* and *db*. Trichobothrium *dst* mean position indicated by open circle based on 30 samples (other fixed finger trichobothria not shown). Method of measurement: *dt|dst* = distance between *dt* and *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 mid-point, 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

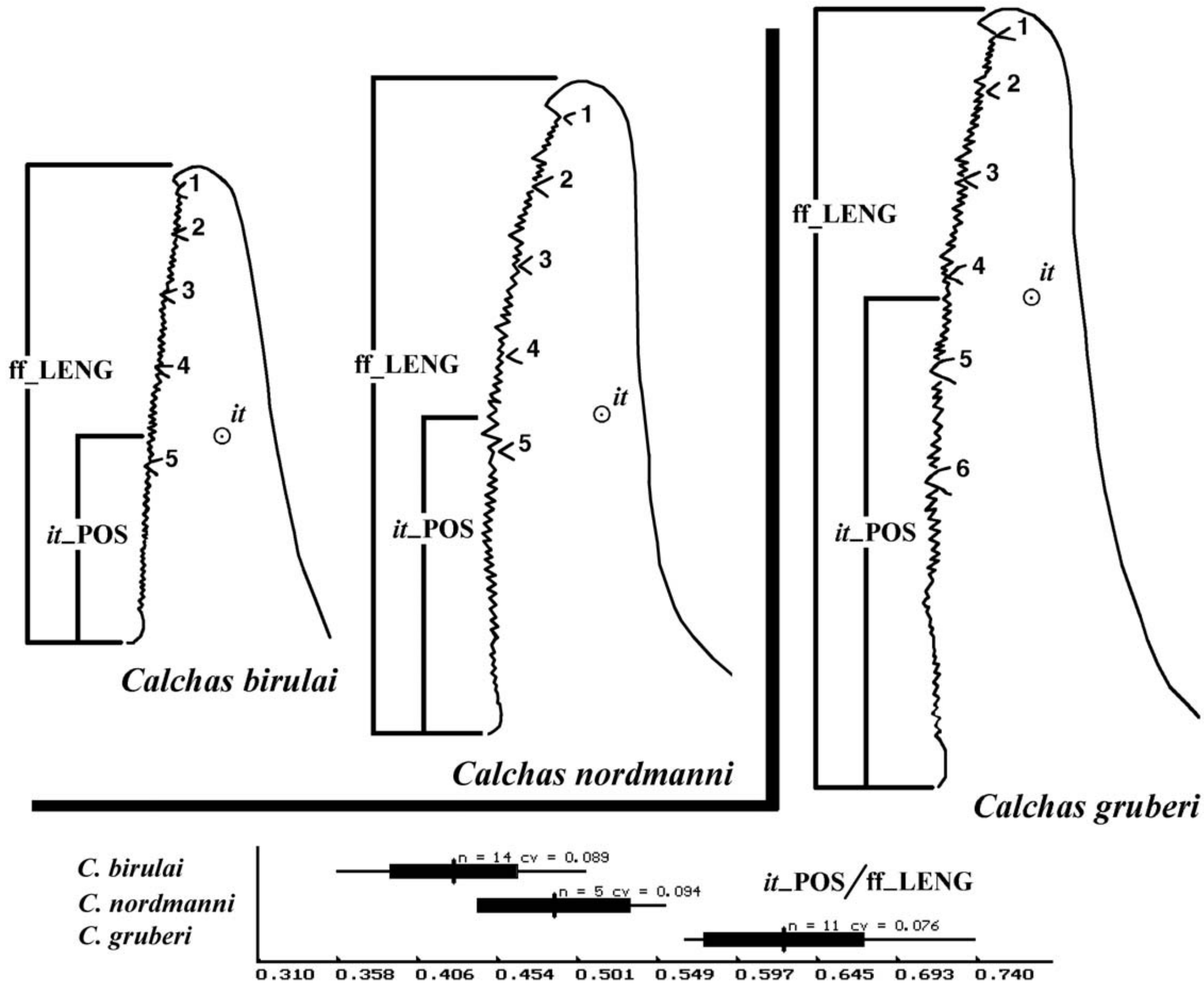


Figure 33: Relative position of chelal trichobothrium *it* in *Calchas* based on its location with respect to the fixed finger length. Trichobothrium *it* mean position indicated by open circle based on 30 samples. Method of measurement: ff_LENG = fixed finger length, *it*_POS = *it* position. Histogram 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-

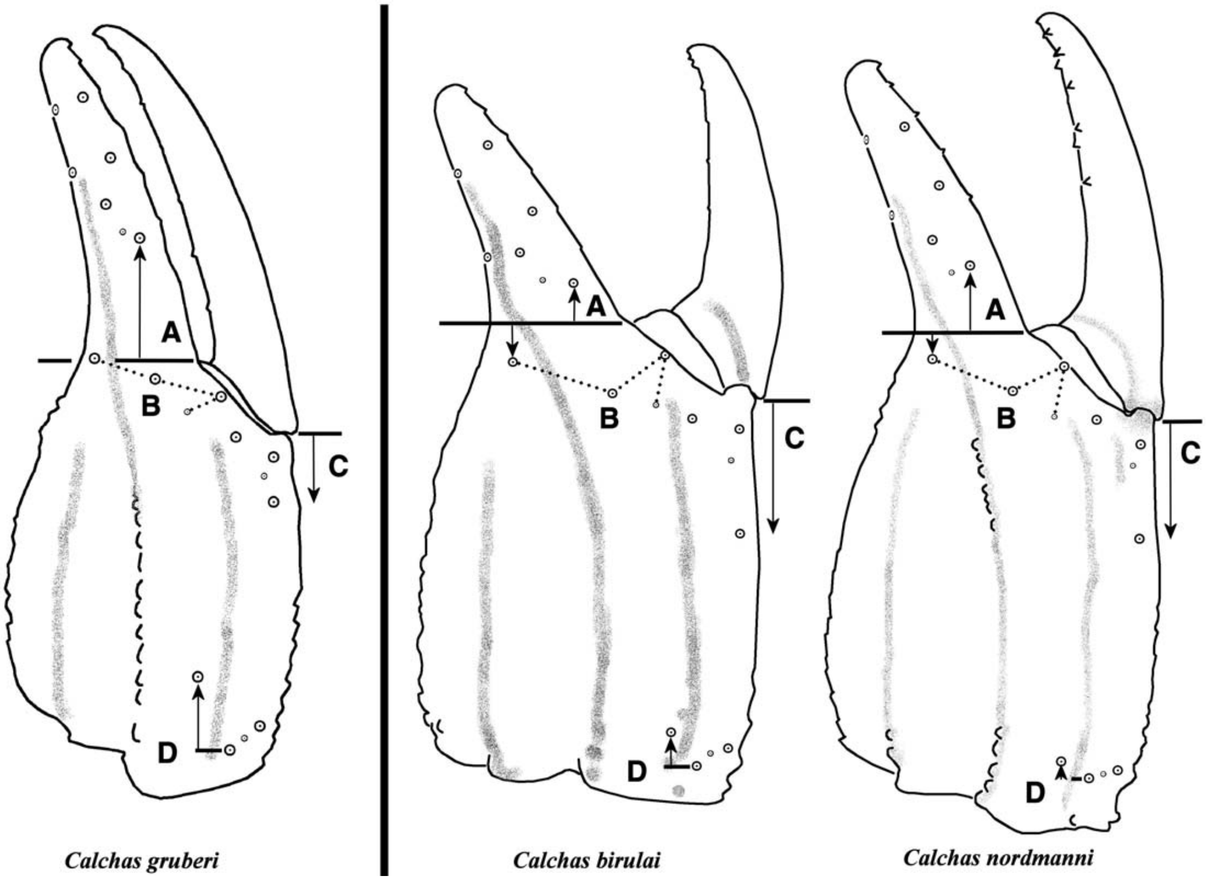


Figure 34: External surface of the chela highlighting trichobothria positional differences in *Calchas* species. Four specific areas (A–D) are delineated showing major trichobothrial location differences between species *C. gruberi* as compared to *C. birulai* and *C. nordmanni*. **A:** in *C. gruberi* 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,

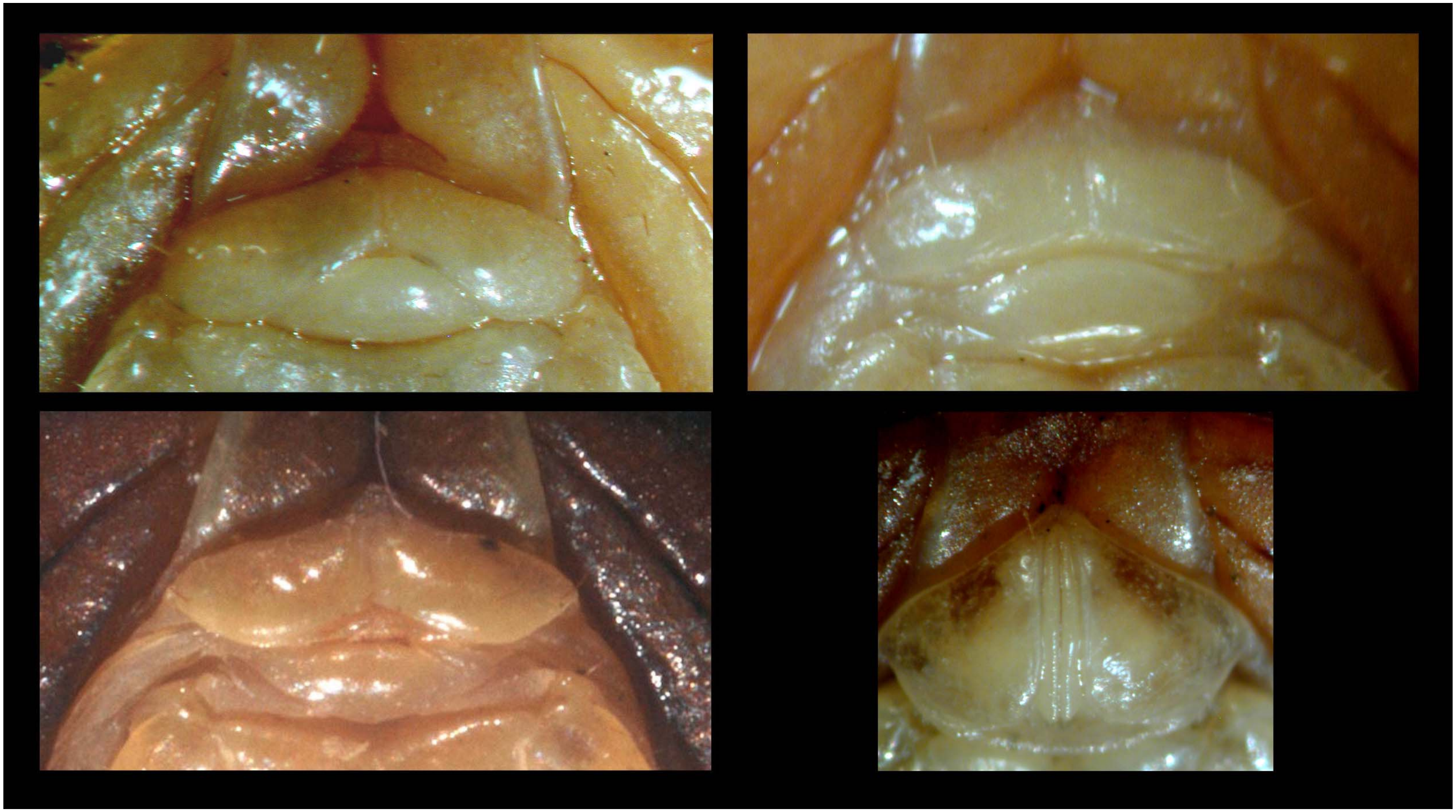


Figure 35: Sternopectinal area in *Calchas* species showing the genital operculum, prepectinal plate (in female), and genital papillae (in male). Note, in the male, the large long subtriangular shaped genital operculum with separated sclerites exposing significant genital papillae, as compared to the 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.

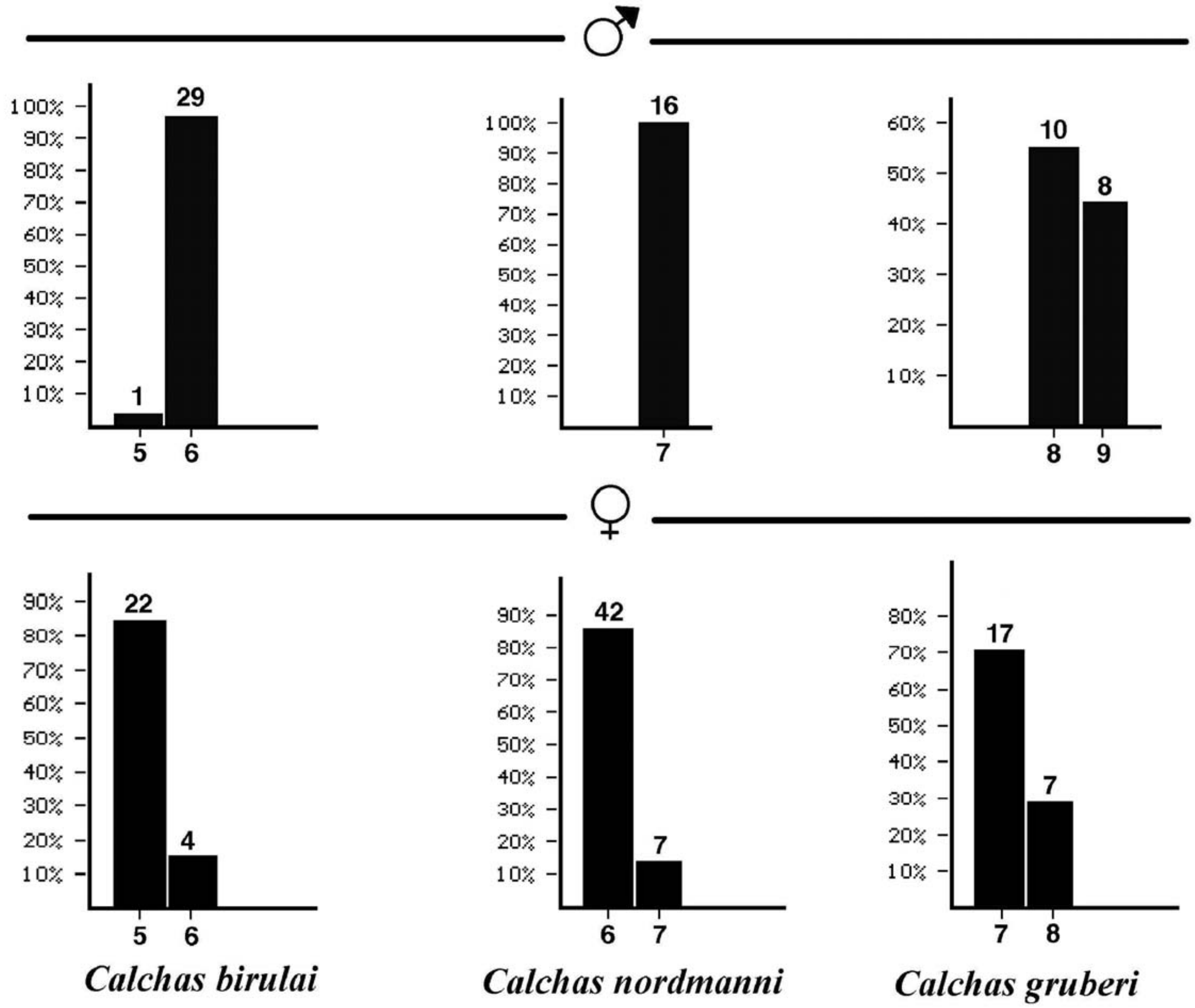


Figure 36: Distribution of pectinal tooth counts in genus *Calchas* based on 82 specimens (32 males and 50 females). Number of teeth on bottom, number of samples on top. Data is based on material examined and Birula (1900, 1905, 1911, and 1912).

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-

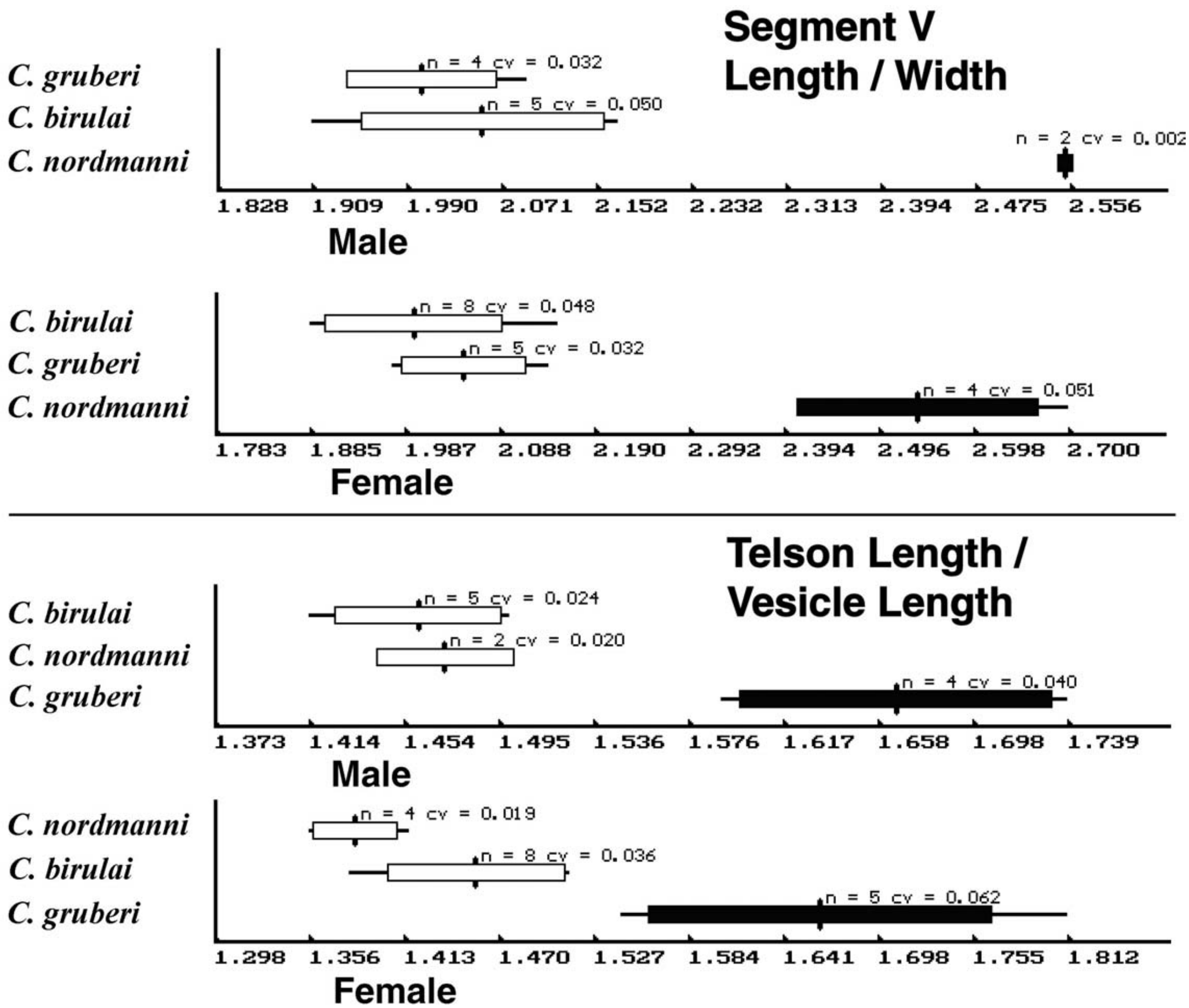


Figure 37: Key morphometric ratio differences in species of *Calchas* based on 28 sets of measurements. **Top.** Metasomal segment V proportions (length/width) show that metasomal segment V is considerably more slender in *C. nordmanni* than in the other two species, exhibiting considerable standard 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,

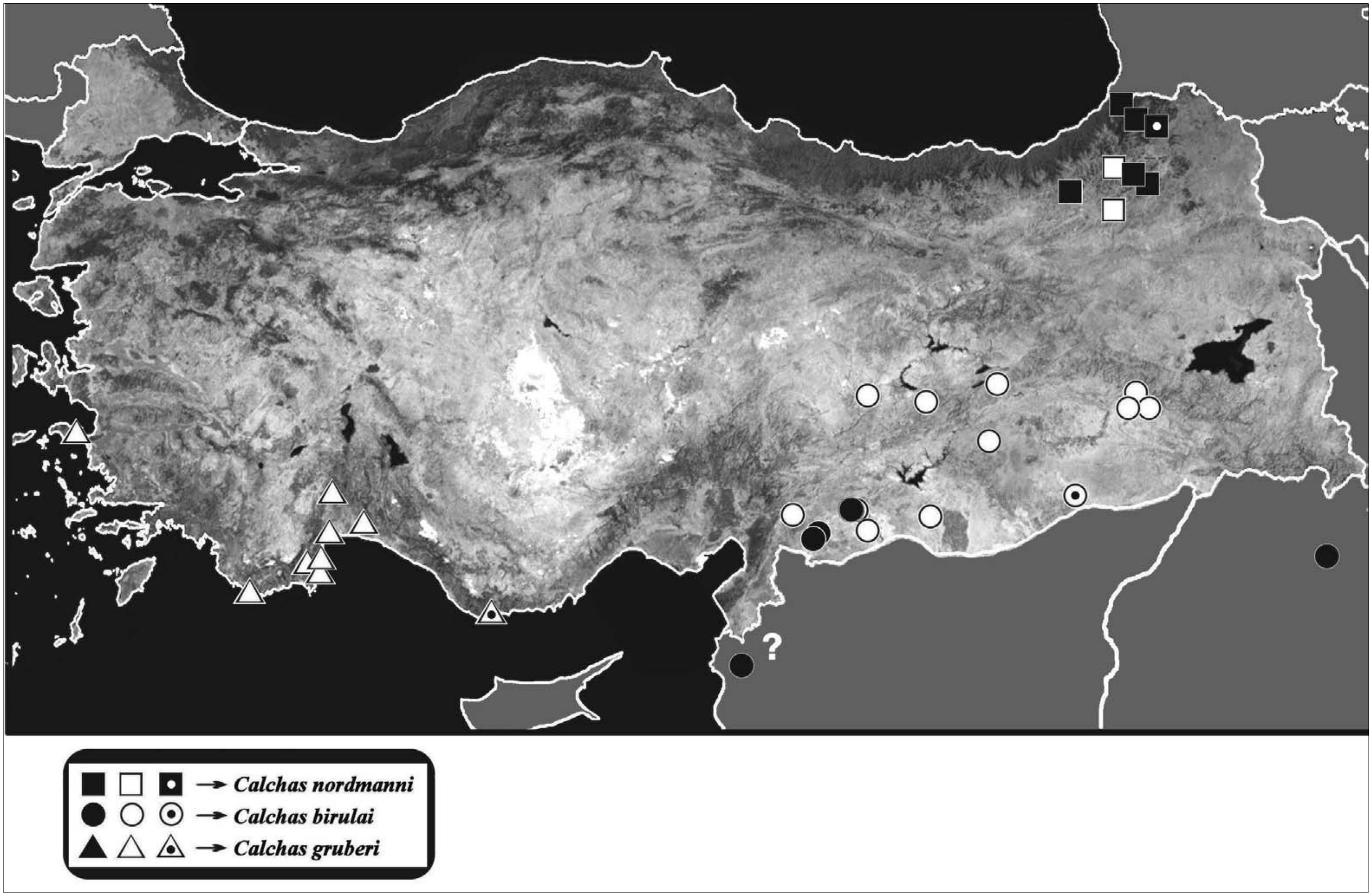


Figure 38: Distribution of all reported instances of genus *Calchas*. Open icons depict localities examined in this study; closed icons depict remainder of published localities; icons with enclosed dot indicate type locality. Note *C. birulai* localities from northern Iraq and possibly Syria (? = not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

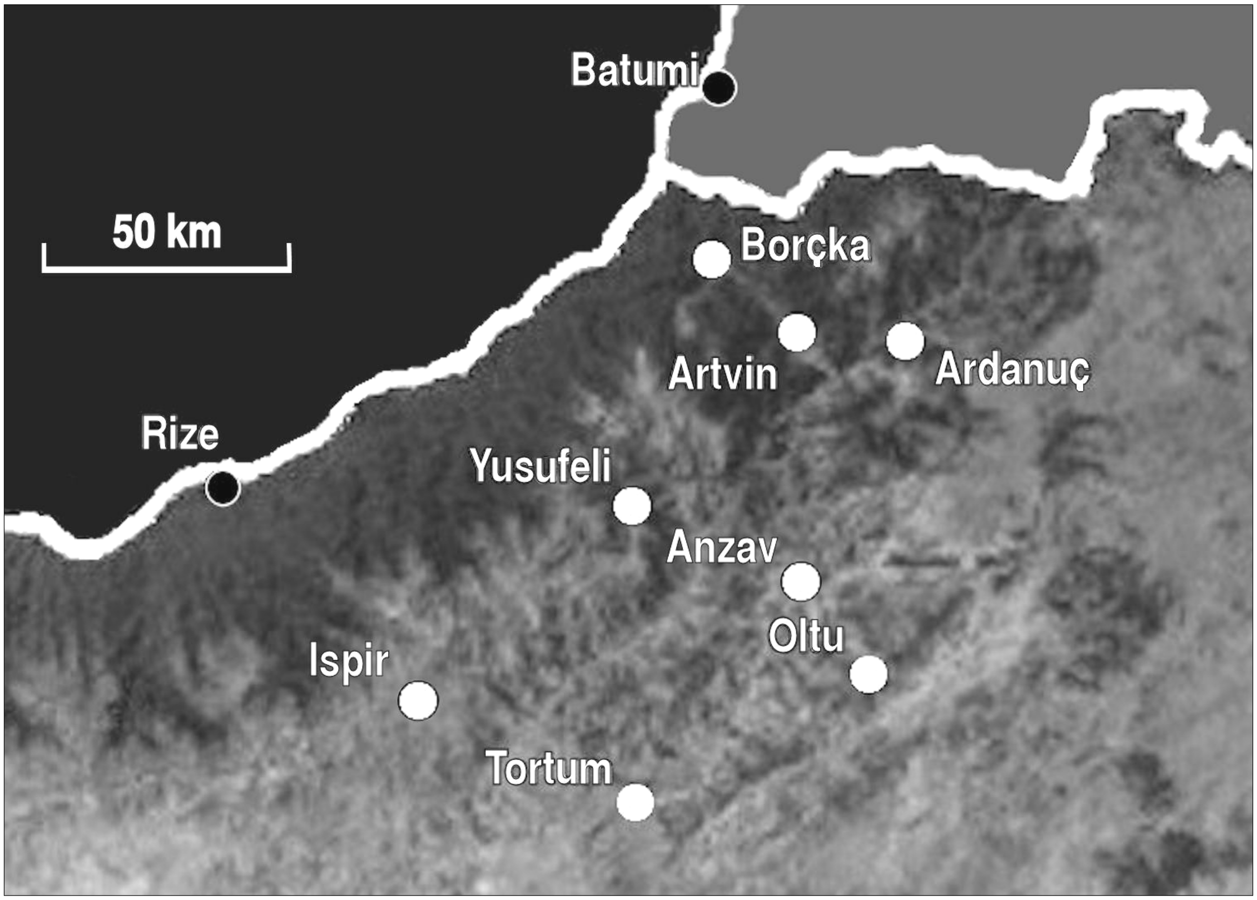


Figure 39: Large-scale range of *Calchas nordmanni*, white circles. See general *Calchas* map in Fig. 38.

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