

Comparative study on the taxonomic relevance of gnathosomal structures in the family Zerconidae (Acari: Mesostigmata)

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Abstract. Taxonomic relevance of hypostomal, subcapitular, epistomal and cheliceral characters within the family Zerconidae is discussed with remarks on ontogeny, sexual-, individual- and interspecific variability of these characters. The general structure and chaetotaxy of the hypostome and subcapitulum is one of the most invariant among gnathosomal parts, only the shape of hypostomal, capitular and palp trochantral setae seem to have diagnostic relevance. A method is proposed for description of relative robustness of chelicerae. The importance of observation of subcapitular, hypostomal and cheliceral morphology is emphasized by the example of *Syskenozercon* and *Rotundozercon*. A more careful typified system of the epistome morphology (which was previously considered as a character of generic importance) in the known Zerconidae taxa is presented.

Keywords. Acari, Zerconidae, gnathosoma, ontogeny, sexual differences, taxonomic value.

INTRODUCTION

Taxonomic characterization of Zerconidae is based on quite a few structures in comparison with other Mesostigmata genera. The most frequently used characters are the idiosomal chaetotaxy, adenotaxy, sculpturing pattern (with dorsal cavities) and the shape of ventral shields and peritreme (see Ujvári, 2010, 2011), while legs and gnathosoma are rather neglected. Up to now, the descriptive paper of Athias-Henriot (1976) is the most detailed in respect to the former body parts and provides the most complete description of a Zerconidae species so far. However, early observations proposed that there is no significant variability in leg- and gnathosomal characters within Zerconidae (with the exception of the epistome which is a structure of very diverse shape, therefore is frequently illustrated in descriptive Zerconidae literature). These observations left their mark on the subsequent Zerconidae literature and served as a basis for nowadays trend, that zerconid species can sufficiently and satisfactorily be described on the basis of idiosomal characters.

The generalized description of gnathosomal structures and legs firstly appeared in the monograph of Halašková (1969a) and subsequently in the summarizing work of Błaszak (1974). Both authors assert that only the shape of tectum is diagnostic, and only in case of a couple of species

or at the level of genera (while Halašková also found that *Z. (Z.) arcuatus* possesses distinctive, special chelicerae).

Following the interpretation of the former authors, many information can be found on the epistomes (and rarely on the chelicerae) of different zerconid species and genera in the subsequent papers (e.g. Błaszak, 1981, 1984; Halašková, 1969b, 1977, 1979; Petrova, 1979; Solomon, 1984; Călugăr, 2001/2003), but nor legs, neither capitular structures were observed thenceforth.

The aim of this paper is to review selected gnathosomal structures of Zerconidae with special interest to individual and intraspecific morphological variability and with remarks on their appropriateness in taxonomic characterization.

MATERIAL AND METHODS

This study is based in part on the examination of the slide-mounted Zerconidae-material of the Soil Zoology Collection, Hungarian Natural History Museum (HNHM), Budapest and also on the data and illustrations of gnathosomal structures available in the literature. Original drawings were made with the aid of a drawing tube. Scanning micrographs were taken in the HNHM, Budapest, with a Hitachi S-2600N scanning electron mic-

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roscope (specimens investigated were sputter coated with gold-palladium).

Specimens of the following genera and subgenera were available for study in the HNHM (abbreviations used along the text in brackets): *Amerozircon* Halašková, 1969 (*A.*), *Aquilozircon* Halašková, 1979 (*Aq.*), *Aspar* Halašková, 1977 (*As.*), *Bakeras* Błaszak, 1984 (*Ba.*), *Błaszakzircon* Kemal & Koçak, 2008 (*Bn.*), *Boreozircon* Diaz-Aguilar & Ujvári, 2010 (*Bo.*), *Carpathozircon* Balan, 1991 (*Ca.*), *Echinozircon* Błaszak, 1975 (*E.*), *Eurozircon* Halašková, 1979 (*Eu.*), *Hypozercon* Błaszak, 1981 (*H.*), *Kaikiozircon* Halašková, 1979 (*K.*), *Koreozircon* Halašková, 1979 (*Ko.*), *Macrozircon* Błaszak, 1975 (*Ma.*), *Mesozircon* Błaszak, 1975 (*Me.*), *Microzircon* Błaszak, 1975 (*Mi.*), *Mixozircon* Halašková, 1963 (*M.*), *Parazircon* (*Parazircon*) Trägårdh, 1931 [*P. (P.)*], *Parazircon* (*Formosella*) Ujvári, 2011 [*P. (F.)*], *Prozercon* Sellnick, 1943 (*P.*), *Rotundozircon* Ujvári, 2011 (*R.*), *Skeironozircon* Halašková, 1977 (*S.*), *Zircon* (*Zircon*) C. L. Koch, 1836 (*Z.*), *Zirconella* (*Zirconella*) Willmann, 1953 [*Za. (Za.)*] and *Zirconella* (*Metzazircon*) Błaszak, 1975 [*Za. (M.)*].

Further useful information was found in the Zerconidae-literature on hypostome, chelicerae or epistome of the following genera: *Błaszakiella* Sikora & Skoracki, 2008 (*Bl.*), *Bledas* Halašková, 1977 (*B.*), *Caurozircon* Halašková, 1977 (*C.*), *Krantzas* Błaszak, 1981 (*Kr.*), *Lindquistas* Błaszak, 1981 (*L.*), *Monozercon* Błaszak, 1984 (*Mo.*) and *Syskenozircon* Athias-Henriot, 1976 (*Sy.*). Drawings about different structures of these genera were made after Athias-Henriot (1976), Błaszak (1981, 1984), Błaszak *et al.* (1997) Halašková (1969a, 1969b, 1977, 1979), Ma (2002), Petrova (1979), Sikora & Skoracki (2008) and Skorupski & Luxton (1996).

Unfortunately there is no reliable information on the gnathosomal structures of *Aleksozircon* Petrova, 1978, *Cosmozircon* Błaszak, 1981, *Indozircon* Błaszak, 1978, *Neozircon* Petrova, 1977, *Paleozircon* Błaszak, Cokendolpher & Polyak, 1995, *Parhozircon* Błaszak, 1981, *Xenozircon* Błaszak, 1976 and *Zircon* (*Icozircon*) Błaszak, 1979 therefore these taxa are not included in this evaluation.

OBSERVATIONS ON GNATHOSOMAL STRUCTURES OF ZERCONIDAE

Ventral region of gnathosoma (subcapitulum, hypostome and palp trochanter)

Basic organisation (Figs 1 a–b). Gnathosoma is a characteristic, highly specialized body region of mites. It is composed of the subcapitulum, the hypostome, the pedipalps, the chelicerae, the labrum and the epistome. Basally, the coxae of palps are connected to the idiosoma; their medial extension and coalescence of ventral portions forms the subcapitulum, the floor of the gnathosomal tube. The subcapitulum anteroventrally continues in the hypostome. A pair of chelicerae can be found between the palps, above the stome, these are the primary organs of food acquisition and usually are retractible. Below the chelicerae (but above the stome) sits the labrum. Dorsally, the gnathosoma is roofed by the epistome.

From a ventral view, the surface of subcapitulum, hypostome, palps and chelicerae are visible (Figs 1 a–b). Hypostome is prolonged anteromedially by the internal malae, and anterolaterally carries a pair of corniculi. The hypostome bears three pairs of hypostomal setae (*h1–3*), while the subcapitulum carries a single pair of capitular setae (*h4*). The situation of these setae is characteristic for the family Zerconidae: setae *h1* between the insertions of corniculi, *h2* posterior to *h1*, *h3* lateral to *h2*, *h4* posterior to *h3*. Basically these setae constitute two pairs of rows parallel to the body axis: rows *h1–h2* and *h3–h4*. A subcapitular groove is found along the central surface of the subcapitulum, which consists of several horizontal lines of phylliform cuticular structures. These phylliform structures are often hard to recognize by light microscopy, and usually it seems that the subcapitular groove is divided by transverse indentations (*Q*-lines, after Hirschmann 1959).

Ontogeny (Figs 2a–e). Larvae of Zerconidae bear only two pairs of hypostomal setae (Fig. 1 a), *h1* and *h2*, while the palp trochanter lacks both ventral setae. The remaining hypostomal and capitular setae (*h3*, *h4*) appear in protonymphal

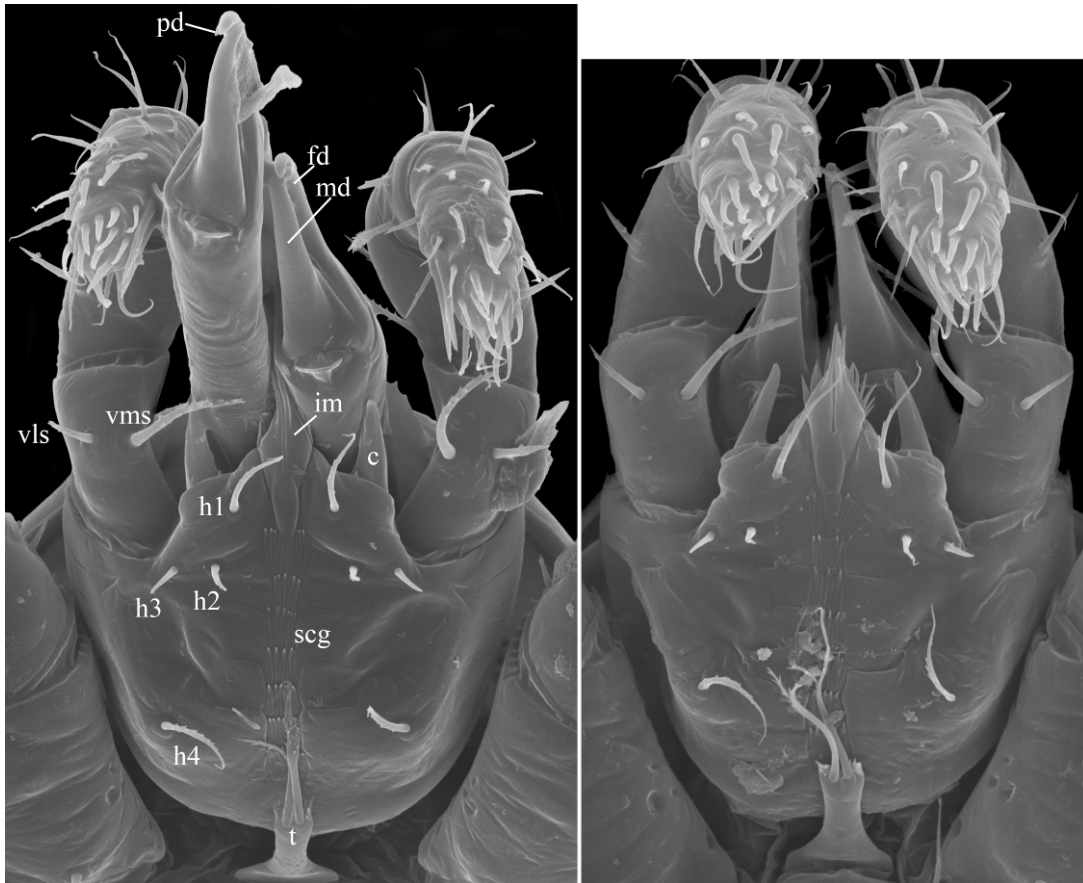


Figure 1. Ventral view of gnathosoma of *Z. (Z.) albanicus* Ujvári, 2010 (SEM photos): a = female, b = male

stage (Fig. 2 b) with one of the palp trochantral setae, the other pair of palp trochantral setae appears in deutonymphal stage (Fig. 2 c). Proportion of length of hypostomal and palp trochantral setae is approximately constant however the complexity of their shape develops during ontogeny. On protonymphs of each species observed setae *h1–4* and palp trochantral setae are simple, while setae *h4* become always serrate in adults of each genera. However both *h1* and ventrolateral palp-trochantral setae may become finely serrate in adult stage, which seems to be characteristic for species of larger size. The subcapitular groove and phylliform structures are hard to recognize on the ventral surface of larval gnathosoma. Distinct phylliform structures firstly appear in protonymphs, on caudoventral surface of subcapitulum, anterior *Q*-lines appear only in deutonymphs, and the series become complete only in adults. Corniculi and internal malae are basically similar in

each development stages however length of the bifurcate anterocentral appendices and complexity of marginal dentation of internal malae grows through the ontogeny.

Sexual differences (Figs 2 d–e₃, 3 a–f). Differences between female and male may occur only in the shape of proper hypostomal and palp trochantral setae (and evidently in size of gnathosoma). For example, ventrolateral palp trochantral setae and *h1* are smooth in male (Fig. 2 d) of *S. tricavus*, but finely serrate in female (Figs e_{1–3}).

Intraspecific variability (Figs 2 e_{1–3}). Number of *Q*-lines of subcapitular groove seems to be the only character of intraspecific variation of the ventral region of gnathosoma. According to Hirschmann (1959) and Karg (1993) 7 pairs of denticulate and a single pair of simple *Q*-line is characteristic for Zerconidae, however Halašková

(1969a) did not find the first, simple *Q*-line, instead she found that there is another, extra, denticulate *Q*-line between *Q*₄₋₅. Both conceptions suggest that basically 8 transverse *Q*-lines are to be found in the family. However, after the observation of many specimens it seems that this number shows variation even within a population, therefore it is quite an unstable character. For example females of *S. tricavus* usually have 6–8 *Q*-lines.

Interspecific variability (Figs 4 a–g). The most conspicuous difference among Zerconidae species and genera is the size of gnathosoma. Shape of corniculi and internal malae, position and proportion of length of setae *h1–4* are similar in almost each species and genera: corniculi horn-like; internal male with a pair of bifurcate antero-central appendices and with serrate margins; setae *h1* elongate, situated medial to insertions of corniculi; *h2* nearly as long as *h1*, positioned posterior to *h1*; *h3* shorter than *h2*, lying lateral to it; *h4* elongate, posteriorly to *h3*. However, it is most interesting, that *Syskenozercon* seems to be different from these standards, since, on the basis of Athias-Henriot's (1976) drawings it has smooth internal malae with not bifurcating appendices and setae *h2* and *h4* are significantly shorter than *h3* which is nearly as long as *h1*. *Sy. kosiri* seems to be the only species of the family which differs from the general zerconid type on the basis of the former hypostomal and subcapitular characters.

Shape of *h1–4* and ventral palp trochantral setae are characteristic at species level, but show only minute differences with only two recognized character states: smooth and serrate. This variation is found only in setae *h1* and ventrolateral palp trochantral setae. In general it seems that complexity and conspicuousness of serration of these setae grow with the size of setae. As the proportion of length of these setae is nearly constant in each Zerconidae (except *Syskenozercon*) and the size of these correlates positively with the size of idiosoma, the larger a species is, the larger gnathosomal setae it has, of which *h4* and ventromedial palp trochantral setae are the longest

and thickest, and always are serrate. Setae *h1* are also approximately as long as the formers, but slimmer. The ventrolateral palp trochantral setae are often also thick, even though shorter than the formers, therefore conspicuous serration of these setae often characterize larger species. The *h2–3* setae are slim, and shorter than the other subcapitular setae and seem to be smooth on most of the species.

As the number of *Q*-lines is a character of remarkable intraspecific variation, it is pointless to mention it in interspecific context, even if on the basis of the figures (e.g. Figs 4 b, c, f, g) it seems that some of the genera (e.g. *Mesozercon*, *Mixozzercon*, *Syskenozercon* and *Zerconella*) have characteristically less transverse lines, which may be due to the study of a single or very few specimens.

Taxonomic value. As a conclusion, the ventral region of gnathosoma bears very few useful characters to consider in taxonomy and classification of Zerconidae. The size of gnathosoma is in positive correlation with the size of idiosoma, shape of corniculi and internal malae, proportion of length of setae *h1–4* are mostly invariant (except for *Syskenozercon*), number of *Q*-lines crossing the subcapitular groove varies between 5 and 8 and cannot be used for discrimination of species or genera. The only relevant character is the shape of *h1–4* and palp trochantral setae, which present only a couple of character-combinations. Moreover, smoothness or pilosity of these setae is often not easy to detect by light microscopy, only scanning electronmicroscopy offers a reliable way, therefore the general usefulness of these characters is ambiguous.

Chelicerae

Basic organisation. The three-segmented chelicerae are well-developed, relatively slender in Zerconidae, and always possess a simple dorsal seta. Both digits bear a couple of large, recurved teeth, which suggest together with the slenderness

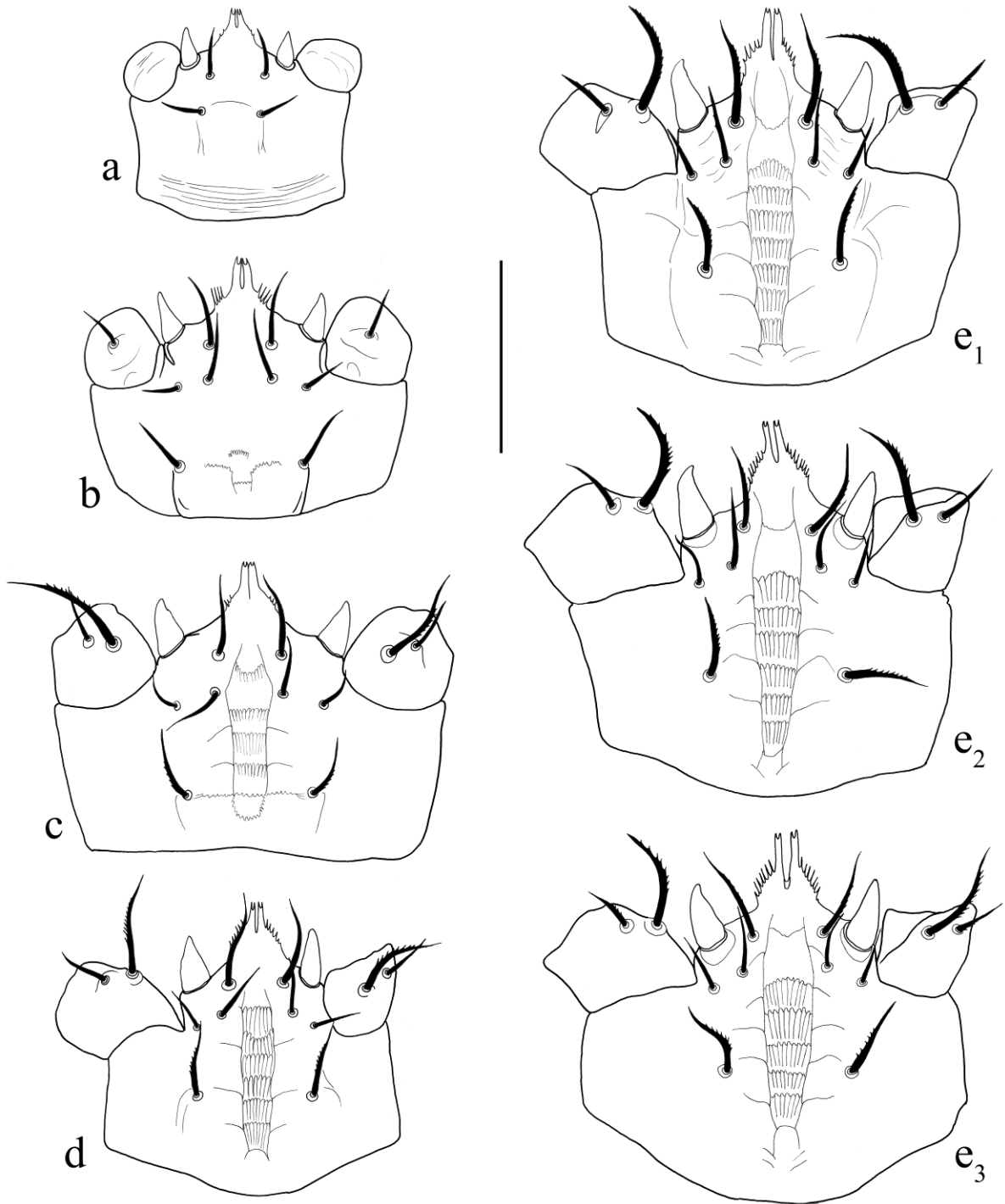


Figure 2. Ontogeny of ventral region of gnathosoma in *S. tricavus* Błaszak, 1982 (ventral view): a = larva, b = protonymph, c = deutonymph, d = adult male, e₁₋₃ = adult female

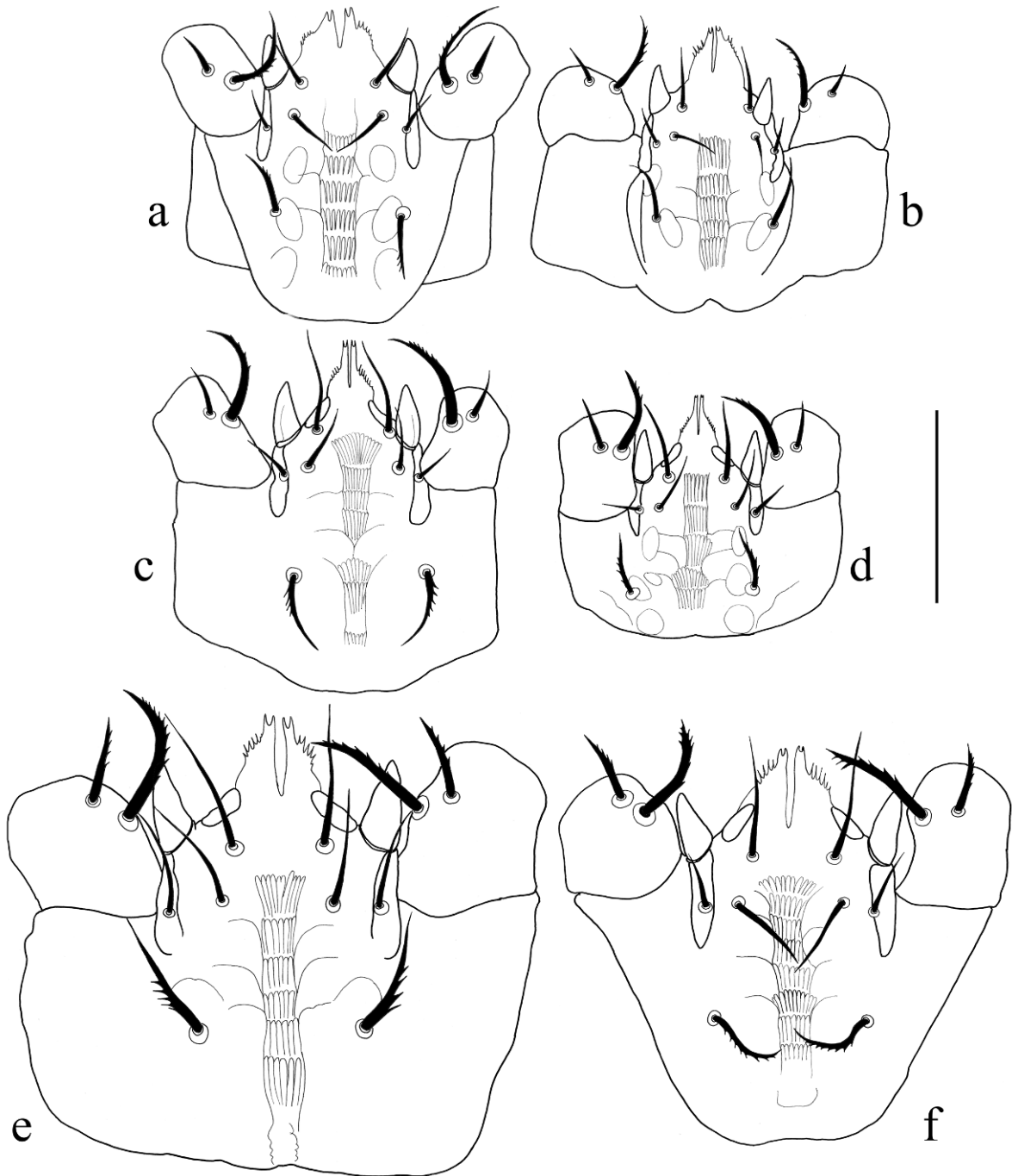


Figure 3. Ventral region of gnathosoma of different Zerconidae genera (both sexes, ventral view): a = *P. (F.) mirabilis* Ujvári, 2011, female, b = *P. (F.) mirabilis* Ujvári, 2011, male, c = *P. dominiaki* Błaszak, 1979, female, d = *P. dominiaki* Błaszak, 1979, male, e = *R. shuriken* Ujvári, 2011, female, f = *R. shuriken* Ujvári, 2011, male

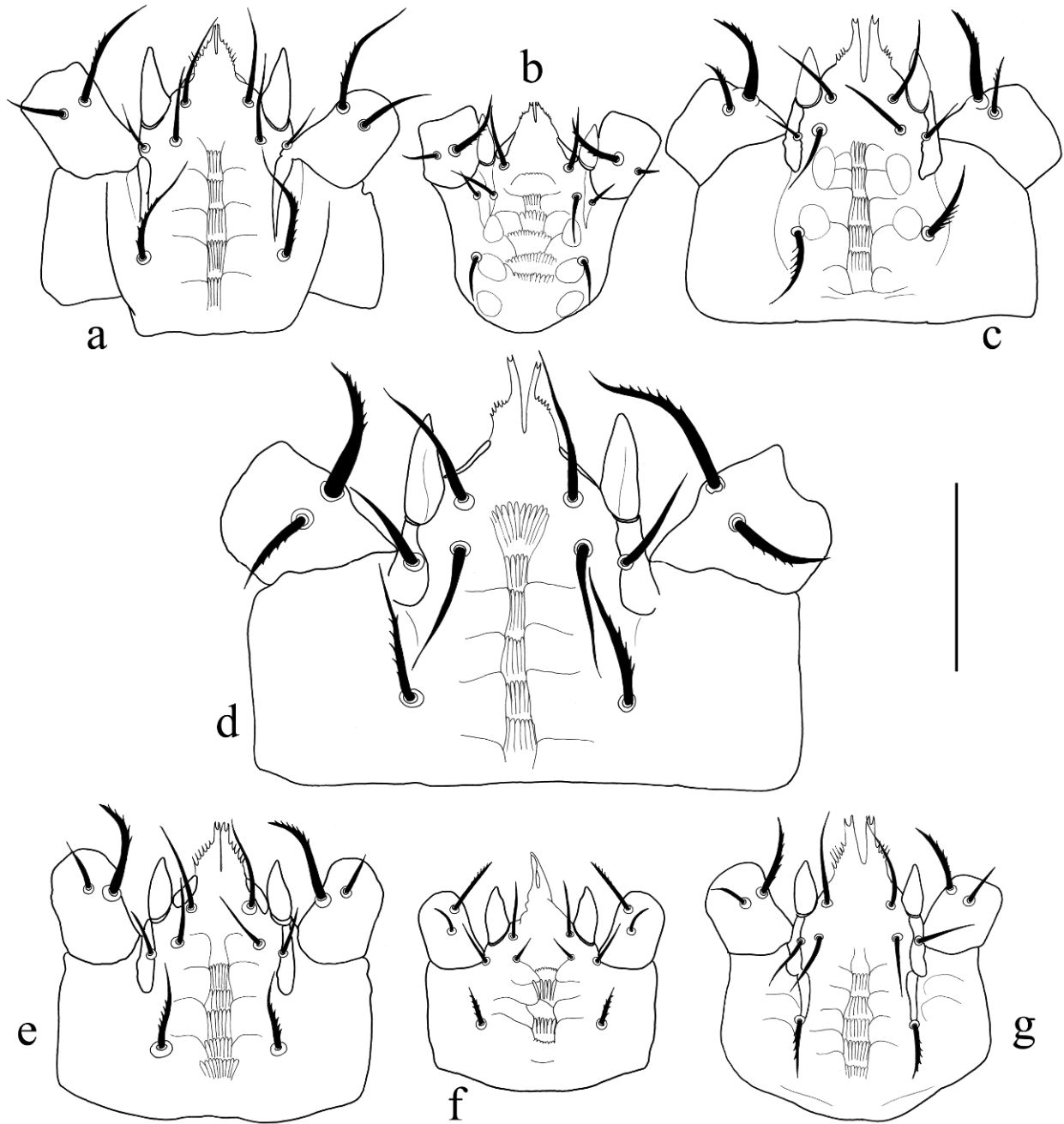


Figure 4. Ventral region of gnathosoma of different Zerconidae genera (females, ventral view): a = *Z. (Z.) serenus* Halašková, 1969, b = *Me. plumatus* (Aoki, 1966), c = *M. borealis* Diaz-Aguilar & Ujvári, d = *Z. (Z.) thulium* Athias-Henriot, 1980, e = *P. dramaensis* Ujvári, 2011, f = *Sy. kosiri* Athias-Henriot, 1976, g = *Za. (M.) lobata* Ujvári, 2010

that zerconid mites primarily feed on Nematodes (Karg, 1993). The movable digit has always fewer teeth than the fixed one. Movable digit of male does not bear any spermatophoral processes. As

Halašková (1969a) indicates, there is a small, vestigial, hyaline structure on the fixed digit of chelicerae, between the first and second tooth, lateral to the line of teeth, which is homologous

with pilus dentilis of other Mesostigmata. Unfortunately there are no SEM photos to support or disprove the presence of pilus dentilis in Zerconidae, however my personal observations suggest that this anterior knob is more likely homologous with cheliceral teeth.

Ontogeny (Figs 5 a–e). Chelicerae are well-developed and similar in each stage, only the length of segments and their robustness change during ontogeny. Dorsal seta is present in each stage.

Sexual differences (Figs 5 d–e, o–p, s_{1–2}, 6a_{1–2}, b). Both fixed and movable digits of chelicerae are shorter and more slender in males than in females. Besides, Călugăr (2004/2006) found that the terminal part of the fixed digit is bifurcated in males of *Prozercon* and *Zercon* species she investigated. This fact is supported herein by other species and genera, and seems to be a general feature in the family.

Intraspecific variability (Figs 5 n_{1–2}, s_{1–3}, t_{1–2}, 6a_{1–3}, d_{1–2}, e_{1–2}, f_{1–2}). There is considerable variation in length of digits, even within a population, as it was observed for example in *P. similis* females (Figs s_{1–3}), where length of movable digit varies between 23–28 µm (n = 15, mean = 25 µm, SD = 1.55 µm). Number of teeth on the movable digit of *P. similis* is 4 in general, and varies between 4–6, on the fixed digit this number is most often 5, and varies between 5–8.

Interspecific variability (Figs 5 e–v, 6 a–i). Shape and appearance of chelicerae is very similar in most of the Zerconidae genera and species. Minimum, maximum and average number of teeth of both digits show also similar values in most of the species. Comparing a typical *Zercon* (Figs 6 c–f) with a *Prozercon* (Figs 5 n–u) species, it seems that the major distinguishing feature of chelicerae is their size. Species of larger size possess larger chelicerae, which are similar in shape of digits and shape/number of large, recurved teeth to those of the smaller species. Therefore nor the number of teeth, neither the general appearance of the digits are characteristic for most of the Zerconidae genera and species.

There are however species which possess special chelicerae, different from those having the general type (Figs 5 e–v, 6 c–f). There is a type which bears large teeth on both digits, with a number of 4–6 on each (similarly to the general type), but the digits have a characteristic elongate, slim shape (Figs 6 h–i) in contrast to the more robust chelicerae observed in most of the genera. The elongate, slim cheliceral digits with large teeth are characteristic for a small group of *Zercon* species [including *Z. (Z.) lischanni* (Fig. 6 h) and *Z. (Z.) arcuatus* (Fig. 6 i)], supporting that these species are closely related and constitute a special group within the genus which is corroborated by the dorsal chaetotaxy and adenotaxy as well.

With respect to the chelicerae, the most extreme member of the family is the monotypic genus *Rotundozercon* (Figs 6 a–b). Its cheliceral digits are long, slim, and possess approximately twice as many teeth than that of any other species (where these structures were observed). Moreover, most of these teeth are extremely small. Besides the large terminal teeth, only a single large, revurved tooth can be found in females, on the proximal part of digits, but it seems to be absent in males. Behind the terminal hook of the movable digit, 8–10 very small teeth are sitting in a row, while 10–12 of these can be observed on the fixed digit. Terminal part of fixed digit possesses 3–5 longer teeth in a small area in both sexes (tripartite in males, in contrast to the general bifurcate form of other zerconids). According to the unique shape of chelicerae, *Rotundozercon* very likely has a special diet among Zerconidae.

Taxonomic value. Characterization and figures of chelicerae are lacking from most of the descriptive literature of Zerconidae. In contempt of the remarkable individual variability (experienced in size of cheliceral digits and number of teeth) and the paucity of interspecific differences, these structures may carry important informations, which can be useful for discrimination of species and even classification of higher level taxa. The instance of *R. shuriken*, *Z. (Z.) arcuatus* and *Z. (Z.) lischanni* supports that it is important to make

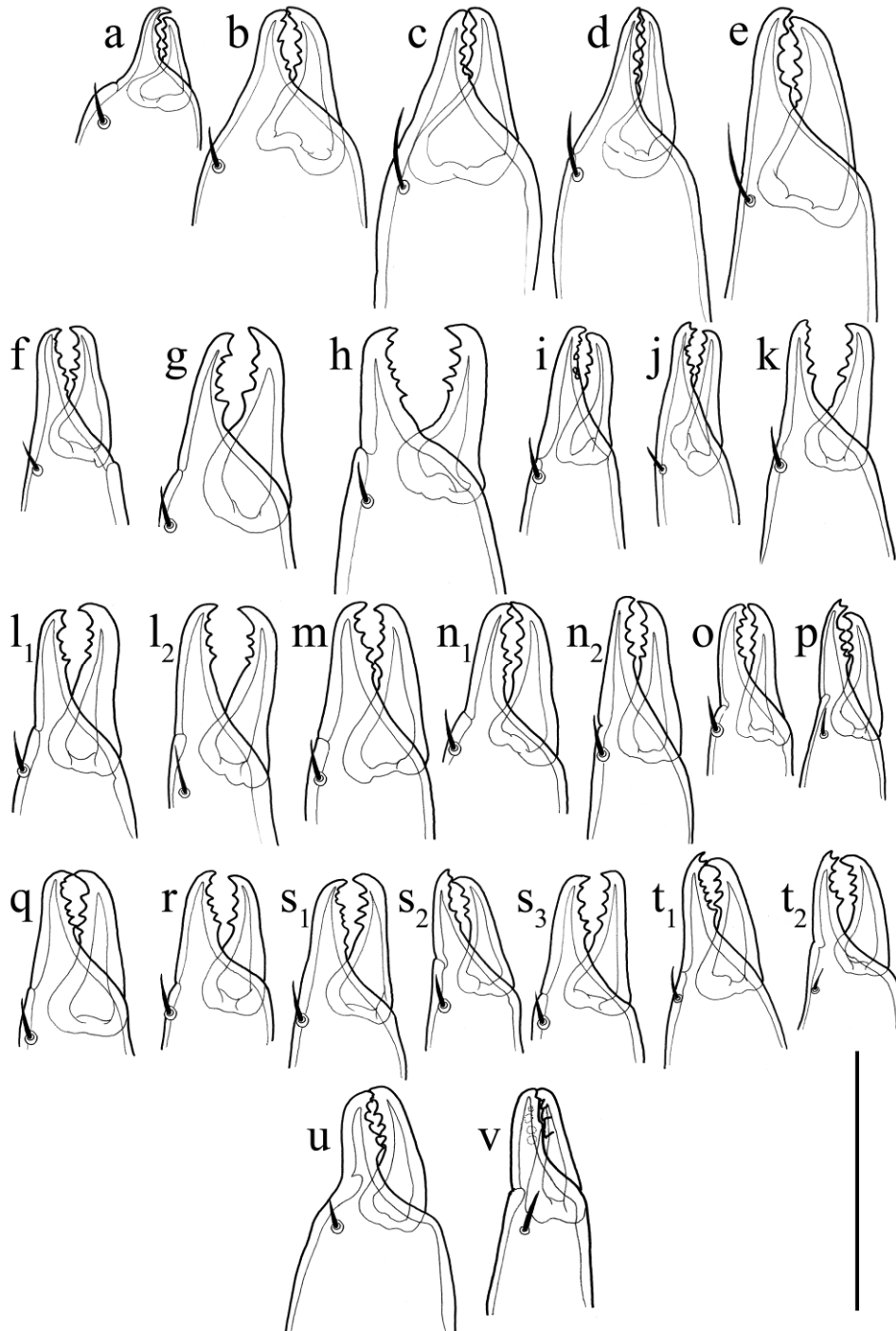


Figure 5. a–e: Ontogeny of chelicerae in *S. tricavus* Błazszak, 1982: a = larva, b = protonymph, c = deutonymph, d = adult male, e = adult female; f–v: chelicerae of different Zerconidae: f = *Bo. emendi* Diaz-Aguilar & Ujvári, 2010, female, g = *Ca. tuberculatus* (Kořir, 1974), female, h = *H. macleani* Błazszak, 1981, female, i = *Ko. bacatus* Halařková, 1979, female, j = *M. albertaensis* Diaz-Aguilar & Ujvári, 2010, female, k = *M. borealis* Diaz-Aguilar & Ujvári, 2010, female, l₁₋₂ = *P. (F.) mirabilis* Ujvári, 2011, female, m = *P. (P.) radiatus* (Berlese, 1910), female, n₁₋₂ = *P. carpathicus* Balan & Sergienko, 1991, female, o = *P. fimbriatus* (C. L. Koch, 1839), female, p = *P. fimbriatus* (C. L. Koch, 1839), male, q = *P. kochi* Sellnick, 1943, female, r = *P. kunsti* Halařková, 1963, female, s₁₋₃ = *P. similis* Balan, 1992, female, t₁₋₂ = *P. similis* Balan, 1992, male, u = *P. verruciger* Mařán & Fend'a, 2004, female, v = *Sy. kosiri* Athias-Henriot, 1976, female

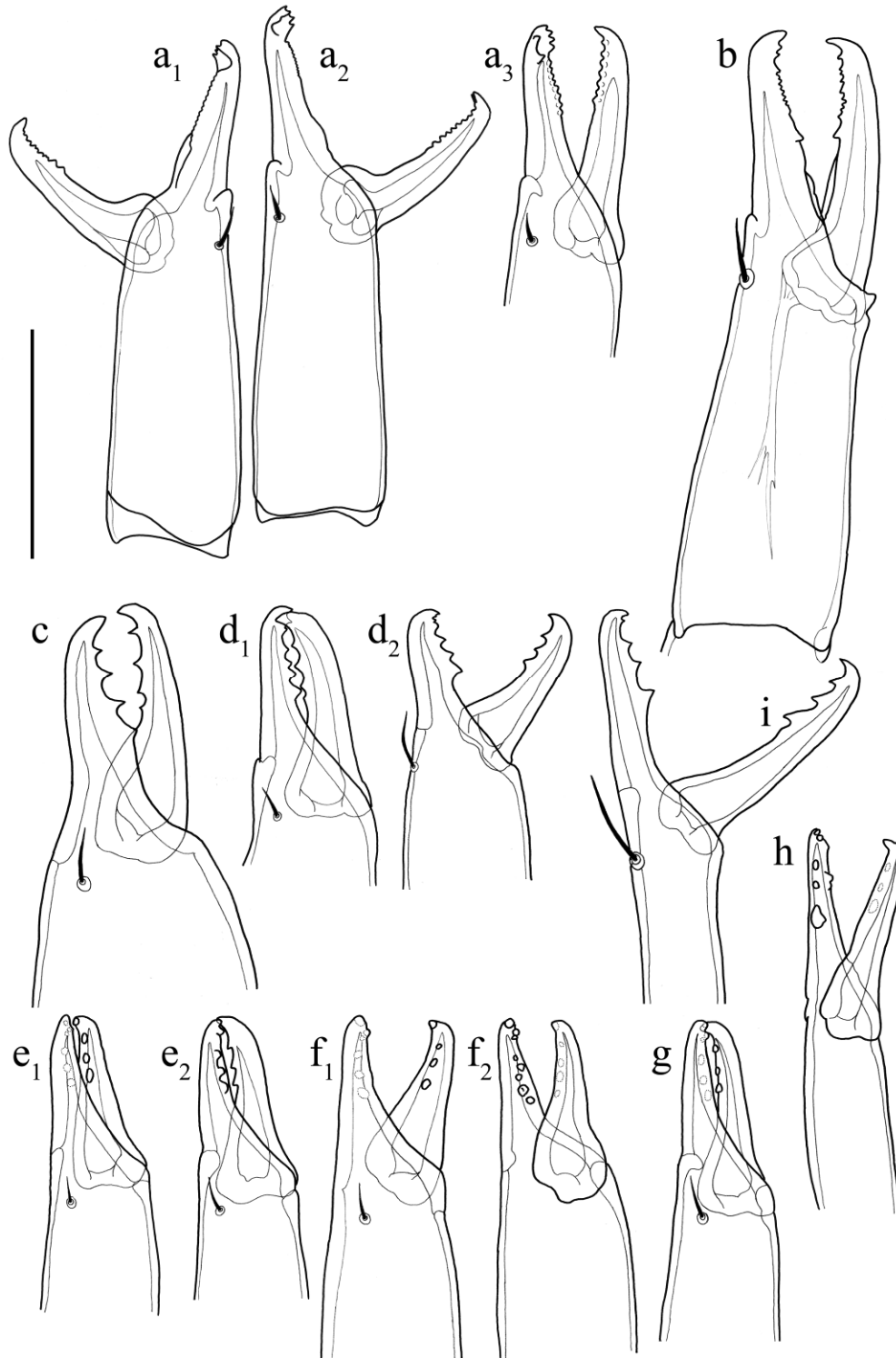


Figure 6. Chelicerae of different Zerconidae: a₁₋₃ = *R. shuriken* Ujvári, 2011, male, b = *R. shuriken* Ujvári, 2011, female, c = *Z. (Z.) tenerifensis* Moraza, 2006, female, d₁₋₂ = *Z. (Z.) triangularis* C. L. Koch, 1836, female, e₁₋₂ = *Z. (Z.) cretensis* Ujvári, 2008, female, f₁₋₂ = *Z. (Z.) schweizeri* Sellnick, 1944, female, g = *Z. (Z.) tsoi* Ujvári, 2011, female, h = *Z. (Z.) lischanni* Schweizer, 1961, female, i = *Z. (Z.) arcuatus* Trägårdh, 1931, female

an effort to observe and describe chelicerae of each new species of Zerconidae. For a correct description it would be necessary to give the following measurements: average length and largest width of movable digit of chelicerae (with standard deviation). On the basis of the proportion value calculated from former data, a relative robustness of chelicerae can be given, which may serve as a good morphometric character.

Epistome

Basic organisation. The epistome (or tectum) is a well developed, antermarginally serrate or spiny plate in Zerconidae which roofs the gnathosoma.

Ontogeny (Figs 7 a₁–x₃). Complete ontogeny of epistome was available to observe only on *Mixozircon*, *Parazircon*, *Skeironozircon* and *Zircon* species. It seems that there is no difference between genera in shape of epistome of proper stages, up to deutonymphs, the different, characteristic shapes appear only in adults (it was supported also by incomplete ontogenetic series of many other genera). In most of the specimens observed, there are four conspicuous, prolonged anterior processes on larvae, protonymphs and deutonymphs as well, of which the medial pair is longer than the lateral [sometimes one or three medial processes can be observed (Figs b₂, v₃)]. In species, where adults possess a single medial process besides the lateral pair, the two medial processes of deutonymphs seem to have a common 'root', as a single medial process with a wide basis and a deep distal incision between the two long tips.

Sexual differences (Figs 9 a–j). There is a great individual variation in shape of epistome of each Zerconidae species however no such differences were found so far which are characteristic for sexes.

Intraspecific variability (Figs 8 a₁–l₃). Epistome of different species was often described or figured earlier by proper authors (e. g. Halašková, 1969b and Petrova, 1979), but its strong individual variability was emphasized only by Ha-

lašková (1969a). Despite of her former observations, Halašková (1977) continued to give a general description of epistome of the new species found in North America, avoiding the fact of variability, therefore, based on her descriptions it may seem that some *Zircon* species characteristically have bifurcate medial process on epistome, others have tripartite medial process (suggesting that it a specific character). Unfortunately it is not true, and can be misleading if taken into account in identification.

Other authors regarded the shape of epistome as a character of generic distinction (e.g. Błaszak, 1984), which is a more careful way to take this feature into account in taxonomy. But omitting to observe this character on many specimens can also be misleading, even on generic level, as it is discussed below.

The most conspicuous target of intraspecific variation is the antero-central region of epistome. Looking at a couple of *Z. (Z.) triangularis* specimens (Figs. 8 a₁–s), it becomes obvious that its elongate, middle process may take various forms (even within a population), and its distal structure (simple, bifurcate or tripartite) is not characteristic for the species. Adults of *Mixozircon* species show similar variability, with an extreme form found in *M. albertaensis* (Fig. 8 b₁), where the base of the central part is wide, and its apical region is divided into three major serrate spines, of which the central is bifurcating. The variations observed are most interesting in *Z. (Z.) lischanni*: epistome of some specimens possesses a single, apically bifurcate medial process (Fig. 8 f₁), but on most of the specimens it bears two elongate medial processes besides the lateral pair which is atypical within the genus.

In some species/genera, the appearance of the two anterolateral processes is also a character of variability, as it can be observed in *Bakeras* and *Prozircon* species (Figs 8 j₁–l₃). Most often the expression of anterior serration of epistome varies within a population too: *Z. (Z.) clairae* serves as a fair example, regarding margins of the middle process of epistome, which may bear small, barely conspicuous (Fig. 7 d₃), or large, acuminous teeth (Fig. 7 d₂).

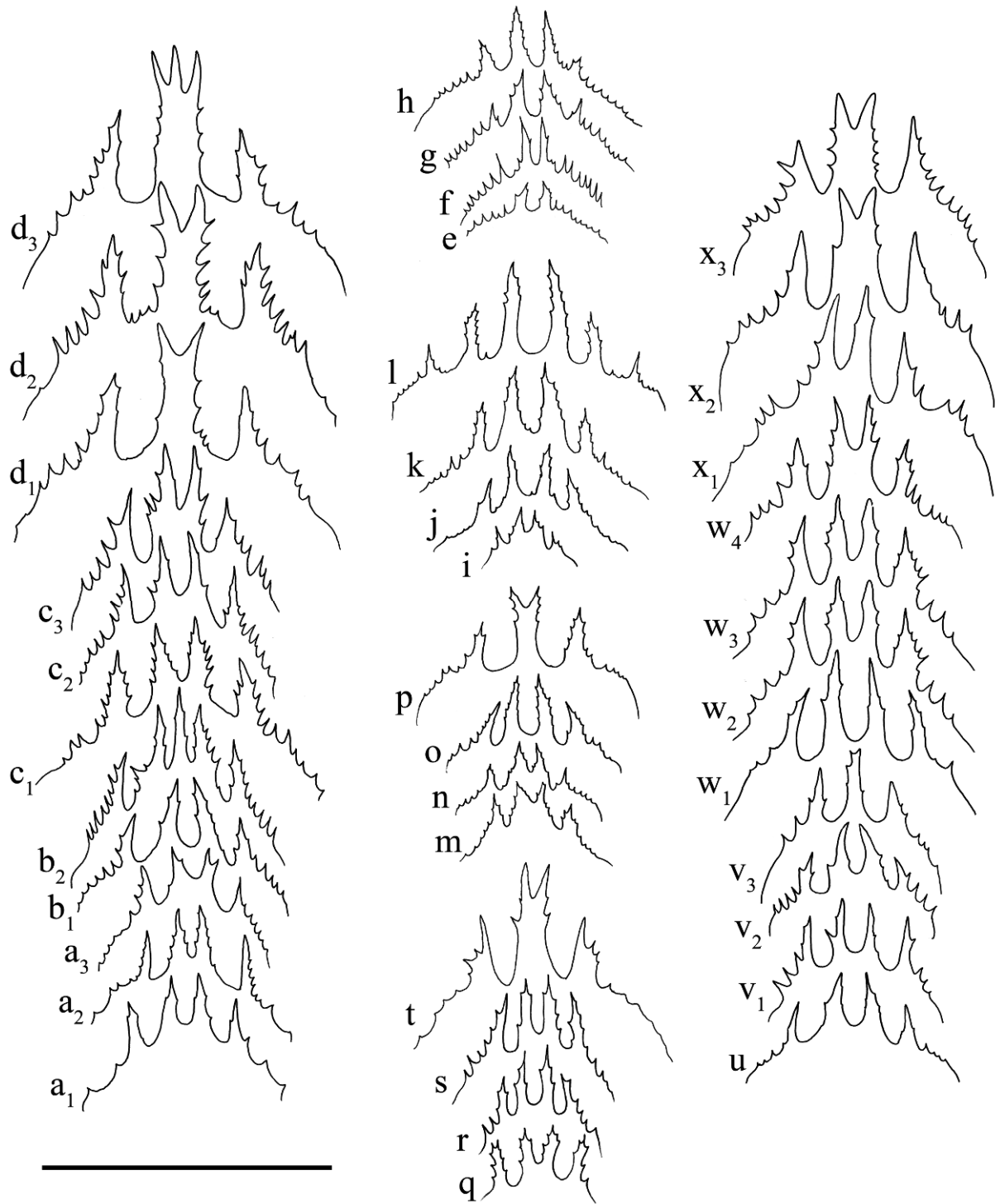


Figure 7. Ontogeny of epistome in different Zerconidae: a–d: *Z. (Z.) clirae* Halašková, 1977: a₁₋₃ = larva, b₁₋₂ = protonymph, c₁₋₃ = deutonymph, d₁₋₃ = adult female; e–h: *P. (F.) mirabilis* Ujvári, 2011: e = larva, f = protonymph, g = deutonymph, h = adult female; i–l: *S. tricavus* Błaszak, 1982: i = larva, j = protonymph, k = deutonymph, l = adult female; m–p: *M. albertaensis* Diaz-Aguilar & Ujvári, 2010: m = larva, n = protonymph, o = deutonymph, p = adult female; q–t: *Z. (Z.) carpathicus* Sellnick, 1958: q = larva, r = protonymph, s = deutonymph, t = adult female; u–x: *Z. (Z.) berlesei* Sellnick, 1958: u = larva, v₁₋₃ = protonymph, w₁₋₄ = deutonymph, x₁₋₃ = adult female

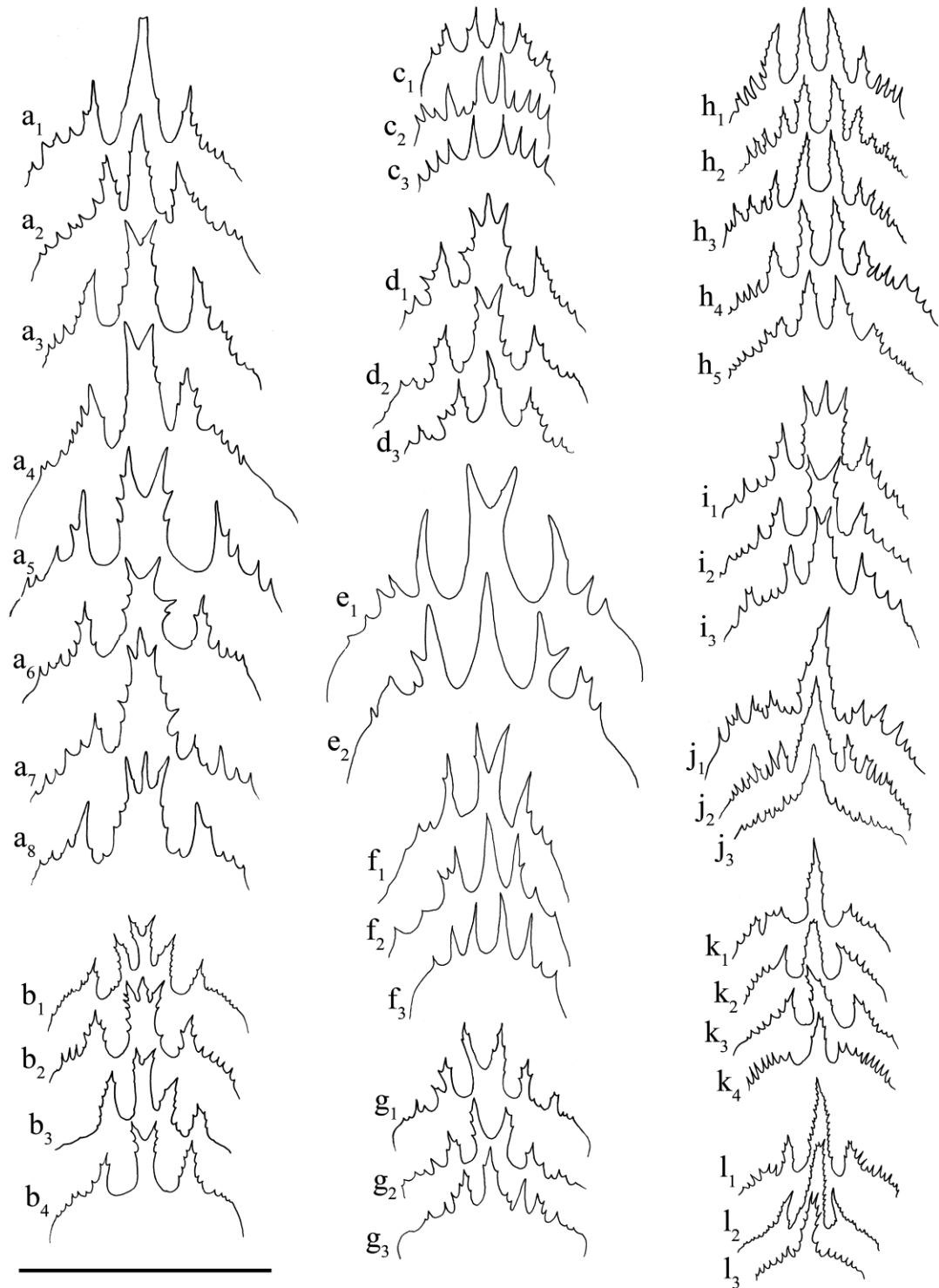


Figure 8. Intraspecific variation of epistome in different Zerconidae species (females): a₁₋₈ = *Z. (Z.) triangularis* C. L. Koch, 1836, b₁₋₄ = *M. albertaensis* Diaz-Aguilar & Ujvári, 2010, c₁₋₃ = *Z. (Z.) arcuatus* Trägårdh, 1931, d₁₋₃ = *Z. (Z.) peltatus* C. L. Koch, 1836; e₁₋₂ = *Z. (Z.) tenerifensis* Moraza, 2006, f₁₋₃ = *Z. (Z.) lischanni* Schweizer, 1961, g₁₋₃ = *Za. (M.) lobata* Ujvári, 2010, h₁₋₅ = *P. (P.) radiatus* (Berlese, 1910), i₁₋₃ = *Z. (Z.) spatulatus* C. L. Koch, 1839, j₁₋₃ = *Ba. opiparus* Błaszak, 1984, k₁₋₄ = *P. similis* Balan, 1992, l₁₋₃ = *P. tragardi* Halbert, 1923

Interspecific variability (Figs 9 k–ai, 10 a–ab, 11 a–al). As the epistome presents a wide spectrum of individual variability, it is difficult to determine interspecific or intergeneric differences.

Typical epistomes of *Zerconella* species (Figs 9k–o) are quite similar in appearance, each possess four large, serrate processes, of which the medial pair is significantly longer than the lateral pair. After a more careful examination, two major types can be distinguished within the former genus: the first type has less and smaller anterolateral spines, while the incision between their medial processes is reaching approximately half the distance between tips and bases of these (Figs 9 l–m); in the second type, there are more and longer anterolateral spines, while the incision between the medial processes reaches almost up to the bases of latter (Figs 9 k, n–o).

Species of the genus *Mixozircon* (Figs 9 p–t) are more similar to each other in shape of epistome: each possess a long, anteromedial process, which is often bifurcate, a pair of smaller anterolateral process with remarkable serration, and a couple of anterolateral spines lateral to the former structures. These characters are, however, similar to those found in most *Zircon* species.

Species of the genus *Caurozircon* (Figs 9 u–y) also possess a long anteromedial, and two, smaller, anterolateral processes, and the species seem to be different for the first sight based on the shape of the distal region of anteromedial process (simple or bifurcate), and the expression/length of anterolateral processes. Unfortunately there is no information about individual variability of epistome of these species, but considering that these characters vary in other genera these presumably are also useless for distinction of *Caurozircon* species as well.

Prozircon species (Figs 9 z–ai) bear a long, anterocentral process, which is densely serrate and its tip is often simple (rarely bifurcate or tripartite), besides two, significantly shorter anterolateral processes and many anterolateral spines

The largest Zerconidae genus, *Zircon*, is a bit different. While most of its species (Figs 10 a–ab) characteristically have an epistome similar to those of *Mixozircon*, some *Zircon* species are easy to distinguish. The epistome of one of the largest, *Z. (Z.) tenerifensis* (Figs 8e_{1–2}) is quite simple, lacks the fine serration, possesses only smooth processes and some larger spines (in contrast to the distinct serration observed in most *Zircon* species). Another group generally has an epistome atypical for the genus [*Z. (Z.) arcuatus* (Figs 8 c_{1–3}), *Z. (Z.) lischanni* (Figs 8 f_{1–3})], as its species usually have two anteromedial and two anterolateral processes (each simple), however a few specimens of those may possess only three anterior processes, similarly to the typical members of the genus. The case of *Z. (Z.) arcuatus* and *Z. (Z.) lischanni* is a perfect example to illustrate that such variability may exist on the level of individuals which was previously used for generic distinction.

As a matter of fact, it is quite hard to define correct groups on the basis of epistomal characters within Zerconidae. Considering the epistome types most frequently found in different species, the following four major morphotypes can be distinguished: *Prozircon*-, *Zircon*-, *Parazircon*- and *Rotundozircon*-type (named after the genus with the largest species-richness or widest distribution).

The *Prozircon*-type (Figs 11 a–i) possesses a single, apically tapering anteromedial process, the apex of which is usually undivided, and comprises mostly nearctic genera, such as *Bakeras*, *Krantzas*, *Macrozircon* etc. besides the palearctic *Prozircon*.

The *Zircon*-type (Figs 11 l–u) possesses a single, slender anteromedial process, which is apically nearly as wide as basally, and usually apically divided into 2–3 spines. It is the most the most widespread form among Zerconidae.

The *Parazircon*-type (Figs 11 v–ak) is similar to the common form possessed by the larvae, protonymphs and deutonymphs of each Zerconidae, bears four anterior processes, each

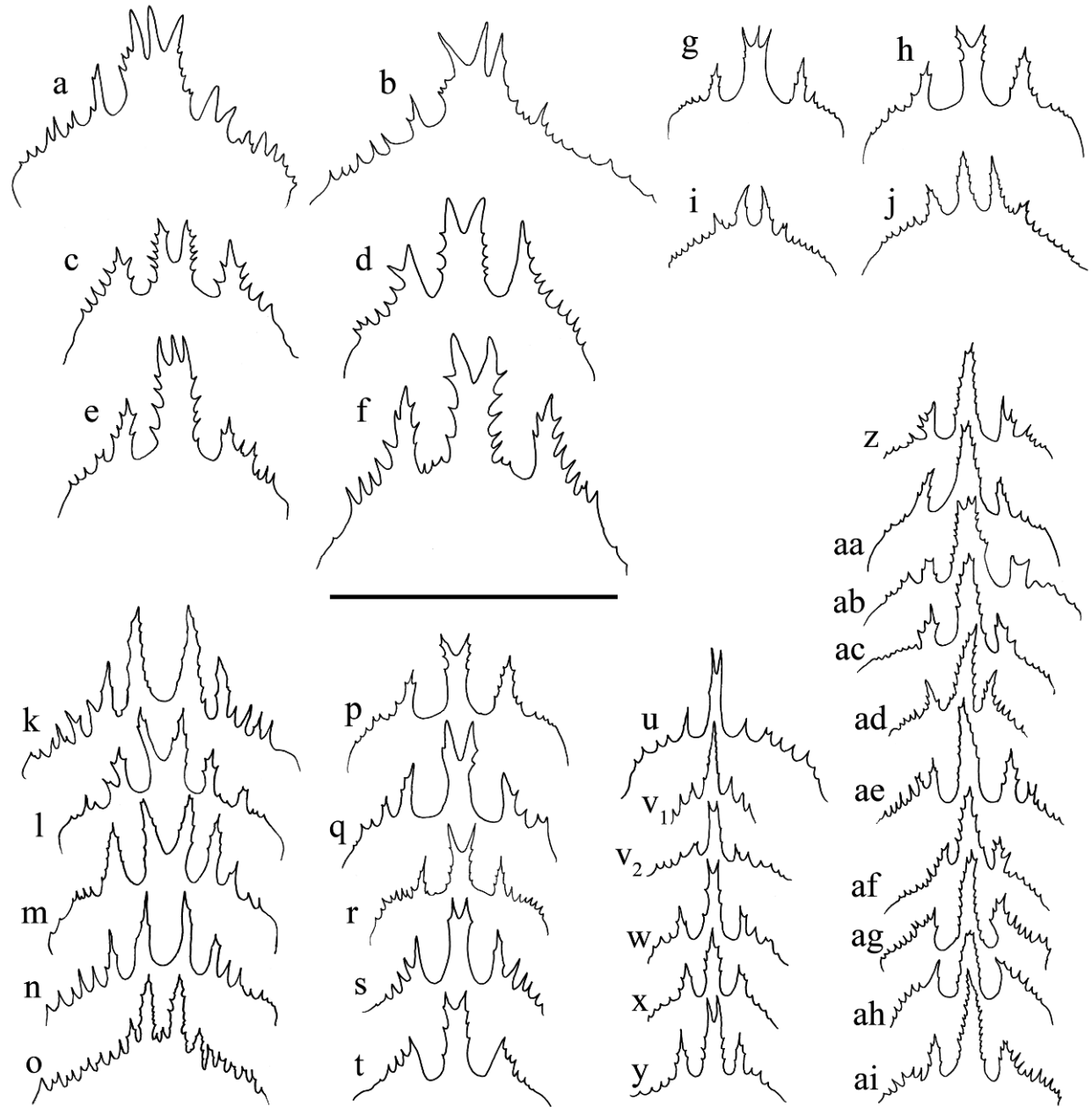


Figure 9. a–j: Comparison of epistomes of both sexes in different Zerconidae: a = *R. shuriken* Ujvári, 2011, male, b = *R. shuriken* Ujvári, 2011, female, c = *Z. (Z.) berlesei* Sellnick, 1958 male, d = *Z. (Z.) berlesei* Sellnick, 1958 female, e = *Z. (Z.) clairae* Halašková, 1977 male, f = *Z. (Z.) clairae* Halašková, 1977 female, g = *M. albertaensis* Diaz-Aguilar & Ujvári, 2010 male, h = *M. albertaensis* Diaz-Aguilar & Ujvári, 2010 female, i = *P. (F.) mirabilis* Ujvári, 2011, male, j = *P. (F.) mirabilis* Ujvári, 2011, female; k–aj: interspecific variation of epistome in different Zeconidae genera (females): k = *Za. (M.) athiasae* (Błaszak, 1975), l = *Za. (M.) lobata* Ujvári, 2010, m = *Za. (Za.) leitnerae* Willmann, 1953, n = *Za. (M.) mahunkai* (Halašková, 1979), o = *Za. (M.) rafalskii* (Błaszak, Kaczmarek & Lee, 1997), p = *M. albertaensis* Diaz-Aguilar & Ujvári, 2010, q = *M. borealis* Diaz-Aguilar & Ujvári, 2010, r = *M. jasoniana* Diaz-Aguilar & Ujvári, 2010, s = *M. sp.*, t = *M. sellnicki* (Schweizer, 1948), u = *C. duplexoides* Ma, 2002, v₁₋₂ = *C. duplex* Halašková, 1977, w = *C. similis* Petrova, 1979, x = *C. smirnovi* Petrova, 1979, y = *C. triplex* Petrova, 1979, z = *P. bulbiferus* Ujvári, 2011, aa = *P. cambriensis* Skorupski & Luxton, 1996, ab = *P. carpathofimbriatus* Mašán & Fend'a, 2004, ac = *P. fimbriatus* (C. L. Koch, 1839), ad = *P. graecus* Ujvári, 2011, ae = *P. kochi* Sellnick, 1943, af = *P. morazae* Ujvári, 2011, ag = *P. sellnicki* Halašková, 1963, ah = *P. similis* Balan, 1992, ai = *P. tragardi* Halbert, 1923

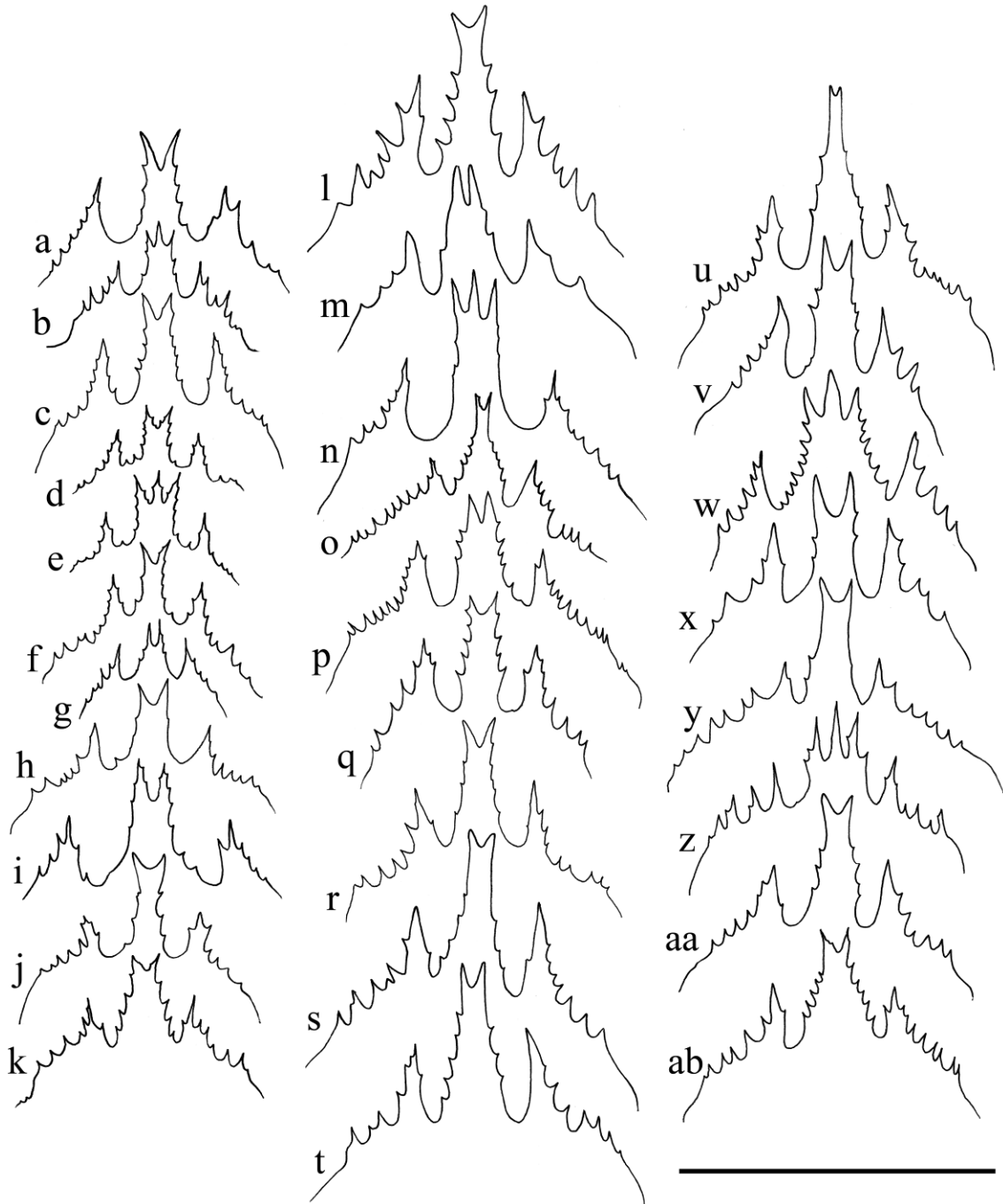


Figure 10. Interspecific variation of epistome within the subgenus *Zercon* (*Zercon*) C. L. Koch, 1836: a = *Z. (Z.) alaskaensis* Sellnick, 1958, b = *Z. (Z.) asaphus* Błaszak, 1976, c = *Z. (Z.) canadensis* Halašková, 1977, d = *Z. (Z.) carolinensis* Halašková, 1969, e = *Z. (Z.) columbianus* Berlese, 1910, f = *Z. (Z.) insolitus* Halašková, 1969, g = *Z. (Z.) kevani* Halašková, 1977, h = *Z. (Z.) lindquisti* Halašková, 1977, i = *Z. (Z.) michaeli* Halašková, 1977, j = *Z. (Z.) romagniolus* Sellnick, 1944, k = *Z. (Z.) szeptyckii* Błaszak, 1976, l = *Z. (Z.) baloghi* Sellnick, 1958, m = *Z. (Z.) berlesei* Sellnick, 1958, n = *Z. (Z.) clairae* Halašková, 1977, o = *Z. (Z.) comatus* Halašková, 1969, p = *Z. (Z.) cretensis* Ujvári, 2008, q = *Z. (Z.) gerhardi* Halašková, 1979, r = *Z. (Z.) schweizeri* Sellnick, 1944, s = *Z. (Z.) sylvii* Solomon, 1982, t = *Z. (Z.) vacuus* C. L. Koch, 1839, u = *Z. (Z.) gurensis* Mihelčič, 1962, v = *Z. (Z.) hungaricus* Sellnick, 1958, w = *Z. (Z.) kotschani* Ujvári, 2007, x = *Z. (Z.) montigenus* Błaszak, 1972, y = *Z. (Z.) phumatopilus* Athias-Henriot, 1961, z = *Z. (Z.) rafaljanus* Błaszak & Łaniecka, 2007, aa = *Z. (Z.) serenus* Halašková, 1969, ab = *Z. (Z.) tsoi* Ujvári, 2011

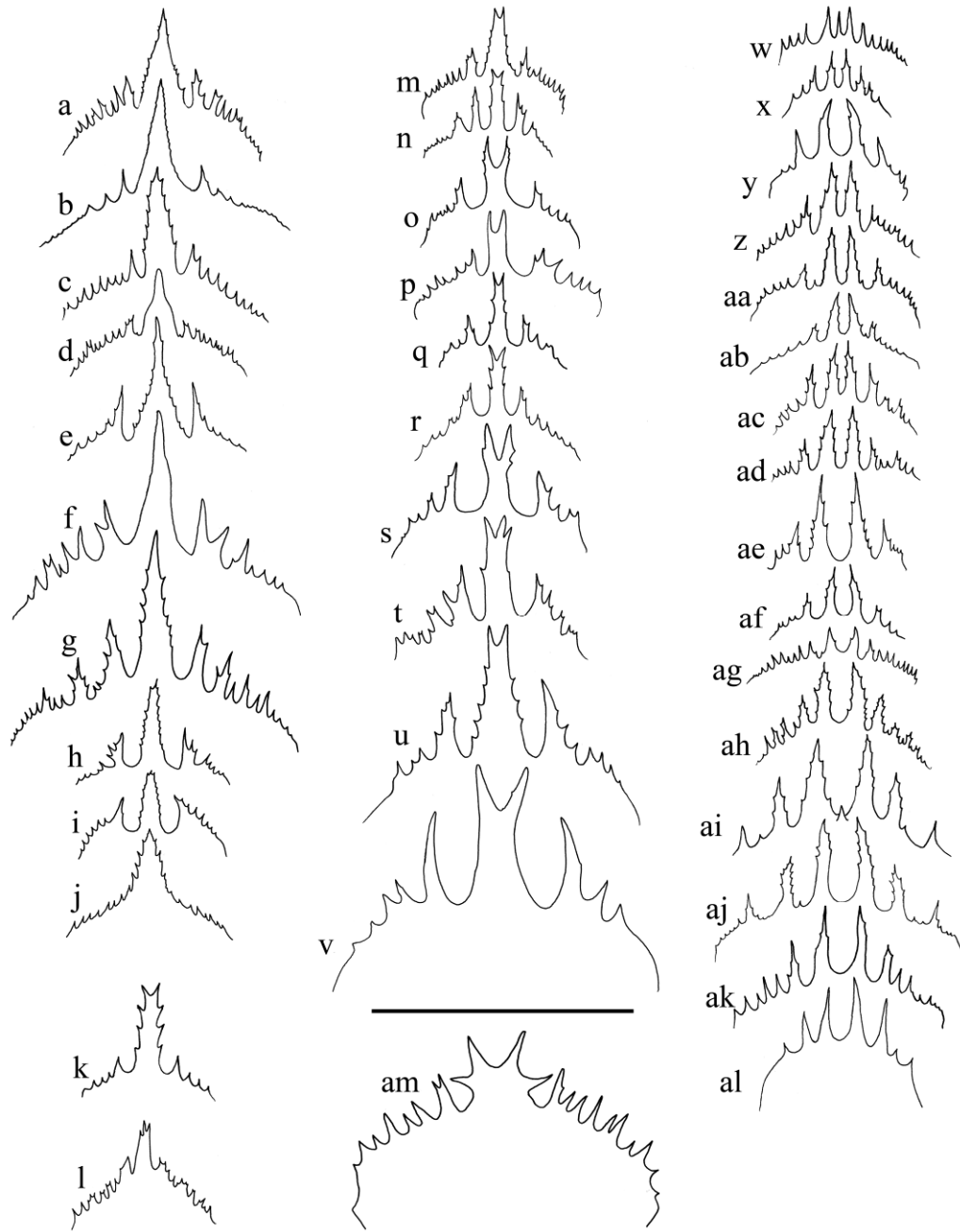


Figure 11. Epistomes of different Zerconidae genera (females): a-j: Prozercon-type: a = *Ba. opiparus* Błaszak, 1984, b = *Bl. americana* Sikora & Skoracki, 2008, c = *E. orientalis* Błaszak, 1975, d = *Kr. mirificus* Błaszak, 1981, e = *L. amythetes* Błaszak, 1981, f = *Ma. praecipuus* (Sellnick, 1958), g = *Ma. sp.*, h = *P. bulbiferus* Ujvári, 2011, i = *P. similis* Balan, 1992, j = *Cosmozercon setosus* Błaszak, 1981, k = *B. hesperius* Halašková, 1977, l = *Sy. kosiri* Athias-Henriot, 1976; m-v: Zercon-type: m = *A. suspiciosus* Halašková, 1969, n = *Bn. pulcher* (Błaszak, 1984), o = *Bo. emendi* Diaz-Aguilar & Ujvári, 2010, p = *Ca. tuberculatus* (Košir, 1974), q = *C. similis* Petrova, 1979, r = *H. macleani* Błaszak, 1981, s = *M. borealis* Diaz-Aguilar & Ujvári, 2010, t = *Mo. aciculatus* Błaszak, 1984, u = *Z. (Z.) vacuus* C. L. Koch, 1839, v = *Z. (Z.) tenerifensis* Moraza, 2006; w-al: Parazercon-type: w = *Aq. desuetus* Halašková, 1979, x = *As. anisotrichus* Halašková, 1977, y = *As. sp.*, z = *Eu. aquilonis* Halašková, 1979, aa = *Eu. pacificus* Halašková, 1979, ab = *K. mamillosus* Halašková, 1979, ac = *K. peregrinus* Halašková, 1979, ad = *Ko. bacatus* Halašková, 1979, ae = *Me. coreanus* Błaszak, 1975, af = *Me. plumatus* (Aoki, 1966), ag = *Mi. californicus* (Sellnick, 1958), ah = *P. (P.) radiatus* (Berlese, 1910), ai = *S. embersoni* Halašková, 1977, aj = *S. tricavus* Błaszak, 1982, ak = *Za. (M.) mahunkai* Halašková, 1979, al = *Z. (Z.) lischanni* Schweizer, 1961; Rotundozercon-type: am = *R. shuriken* Ujvári, 2011

apically tapering with undivided apex, and comprises mostly East Asian and North American genera, such as *Mesozercon*, *Parazercon*, *Eurozercon* and *Skeironozercon*. Moreover, this type of epistome is possessed by a small, European group of the genus *Zercon*.

The *Rotundozercon*-type (Fig. 11 al) is fairly unique by the single, wide, robust, anteromedial process, which is apically divided into 3–4 spines, and it is characteristic only for the monotypic Taiwanese genus.

Taxonomic value. Epistome is a structure showing greatest variability on the gnathosoma however, the remarkable intraspecific variability hardens the determination of its proper use as a valuable character. Rarely, it is applicable for distinction of species, but mostly the species are similar in shape of epistome within a genus. As it was discussed above, it is hard to distinguish even genera by their epistome, due to its variability. The most careful way to characterize Zerconidae is to classify their epistome according to the four general types mentioned above. Therefore the importance of this gnathosomal structure can be questioned regarding taxonomic characterization, but the special case of the group of *Zercon* comprising e.g. *Z. (Z.) arcuatus* and *Z. (Z.) lischanni* supports that it can be used successfully as an interesting distinctive feature. I suggest to discuss these characters in detail in describing new taxa. With due foresight for their variation observing a large amount of specimens is needed.

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