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A scanning electron microscopic study of the setae of some chernetid pseudoscorpions

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Summary

A scanning electron microscope was used to examine the setae on the tergites of six species of chernetid pseudoscorpions: *Lamprochernes nodosus* (Schrank), *Pselaphochernes scorpioides* (Hermann), *Allochernes wideri* (C. L. Koch), *A. dubius* (Cambridge), *Toxochernes panzeri* (C. L. Koch) and *Chernes cimicoides* (Fabricius). Setae in all these species have an axial spine distally and a shorter frontal spine located basally, in addition to a varying number of other spines.

Statistical comparisons of the characteristic number of spines on the setae were carried out. On the basis of seta shape and spine numbers, *L. nodosus* (Lamprochernetinae) stands clearly apart from the other five species studied here, and these latter (all Chernetinae) may be divided into two groups with *P. scorpioides* and *A. dubius* in one group and *A. wideri, T. panzeri* and *C. cimicoides* in the other.

Introduction

Our present knowledge of the relationships among the pseudoscorpions is scarce and the systematics is still a matter of discussion.

In the family Chernetidae the structure of the body setae is used, among other characters, to distinguish between the subfamilies Lamprochernetinae and Chernetinae, and additionally they are used as characters at the generic level (Beier, 1932, 1963; Evans and Browning, 1954; Thydsen Meinertz, 1962).

Beier (1963) described the vestitural setae from the Lamprochernetinae as long, pointed and finely spinulate, in contrast to those of the Chernetinae which are short, distinctly spined and more or less club-shaped.

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Muchmore (1972) has objected to this, since he points out that these differences are not fundamental. Based on the structure of the setae as well as on other characters he claims that *Lamprochernes* in Lamprochernetinae is more closely related to *Allochernes* and *Pselaphochernes* in Chernetinae than implied by Beier (1963).

However, structural descriptions of the setae of the genera in Lamprochernetinae and Chernetinae are usually arbitrary and incomplete. Consequently the present work was undertaken to study the fine structure of available species from these two subfamilies.

Materials and Methods

The investigation was carried out on the adults of six species representing five different genera. The subfamily Lamprochernetinae was represented by *Lamprochernes nodosus* (Schrank) (7♀♀) and the subfamily Chernetinae by *Pselaphochernes scorpioides* (Hermann) (1♂, 4♀♀), *Allochernes wideri* (C. L. Koch) (2♂♂, 6♀♀), *Allochernes dubius* (Cambridge) (1♂, 4♀♀), *Toxochernes panzeri* (C. L. Koch) (2♂♂, 8♀♀), and *Chernes cimicoides* (Fabricius) (2♂♂, 3♀♀). The numbers of specimens investigated are in brackets. All specimens were captured in different locations in southern Norway as given by Klausen (1975, 1977).

The animals were cleaned before dehydration by treatment with weak hydrochloric acid (Larsson & Myhrberg, 1976, and pers. comm.). Dehydration was carried out in graded solutions of acetone. Two changes in 100% acetone were used. To minimize artifacts the specimens were dried in a Polaron critical point drying apparatus. The specimens were then coated with carbon and gold/palladium in an Edwards evaporation unit and examined in a Philips PSEM 500 scanning electron microscope operated at 25 kV and secondary electron registration. Stereoscopic picture pairs were made at 10° difference in specimen tilt angle.

Only setae from the posterior border of the abdominal tergites were examined. The spines on the setae were counted on four specimens from each of the six species (Table 1). To ensure an unbiased selection of setae a number was assigned to each of the first 10 tergites of each specimen, and the setae from two tergites selected at random were examined.

On a few setae the number of spines could not be established with certainty, and these setae were excluded from the counts. The eleventh and last tergite was usually stuck in the silverpasta on the specimen chuck and therefore not included in the investigation.

To test any differences or similarities in spine frequencies in the setae of the different species we used Spearman's Rank Correlation Coefficient:

$$R = 1 - \frac{6 \Sigma d^2}{n^3 - n}$$

where d = rank difference and n = number of ranks.

The data were also subjected to a chi-square test.

Results

The setae are not radially symmetrical. In the following account the side seen when viewing the animals dorsally is called the frontal side. The side facing the abdomen is called the reverse side.

No difference could be observed between males and females, except for *Lamprochernes nodosus* where only females were available.

Several features are common to all six species. All setae are distinctly spined. All had a single spine situated basally on the frontal side of the seta, more or less separated from the remaining spines (Plate 6, b). There is always one spine placed axially and distally (Plate 6, a).

In *Lamprochernes nodosus* (Plate 1) the setae are slim and considerably longer than in the other species. The total number of spines was invariably 5 in all the specimens examined. Apart from the basal and axial spines there is a third on the reverse side, and finally there are two spines located diametrically opposite each other on the sides of the seta a little below the third spine. The setae have some faint ridges running longitudinally, but are otherwise smooth.

The setae of the other five species differ from those of *L. nodosus* in their general shape and in having a greater number of spines. In addition to the axial and basal spines they all have a number of spines encircling the axial one, resembling a coronet. Moreover, they all have a varying number of longitudinal ribs running from each spine (except for the axial one) down to the base of the seta. Not all the ribs continue uninterrupted all the way down the seta; on the reverse side some of them join before reaching the base (Plate 5).

Based on the general morphology of the setae and the number of spines, the specimens investigated may be divided into two groups. *Allochernes wideri, Toxochernes panzeri* and *Chernes cimicoides* constitute one group, while *Allochernes dubius* and *Pselaphochernes scorpioides* constitute the other group.

spines per seta:	5	7	8	9	10	11	12	13	
L. nodosus	12-20	0	0	0	0	0	0	0	range
	60	0	0	0	0	0	0	0	Total count
P. scorpioides	0	0-1	0-5	3-8	6-11	1-5	0-1	0	range
	0	1	11	24	32	11	2	0	Total count
A. wideri	0	0-1	7-17	5-12	0-1	0	0	0	range
	0	2	42	37	1	0	0	0	Total count
A. dubius	0	0	0-1	0-8	7-14	3-12	0-3	0-1	range
	0	0	1	11	40	24	4	1	Total count
T. panzeri	0	0-1	6-19	2-17	0-1	0	0	0	range
	0	1	42	48	1	0	0	0	Total count
C. cimicoides	0	0-1	10-27	1-14	0-1	0	0	0	range
	0	2	64	32	1	0	0	0	Total count

Table 1: Total count and range in the number of setae with respective number of spines from four specimens of each species

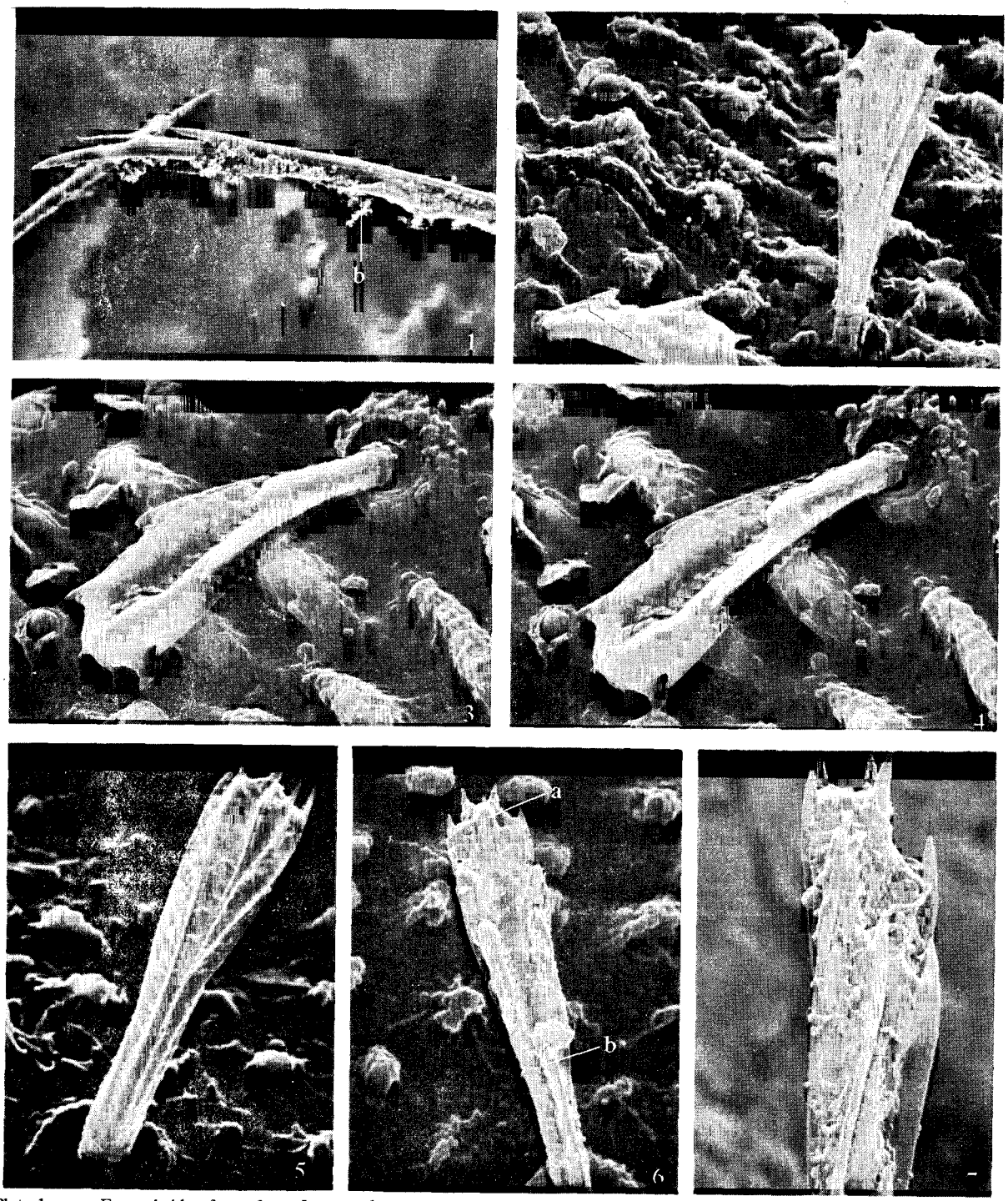
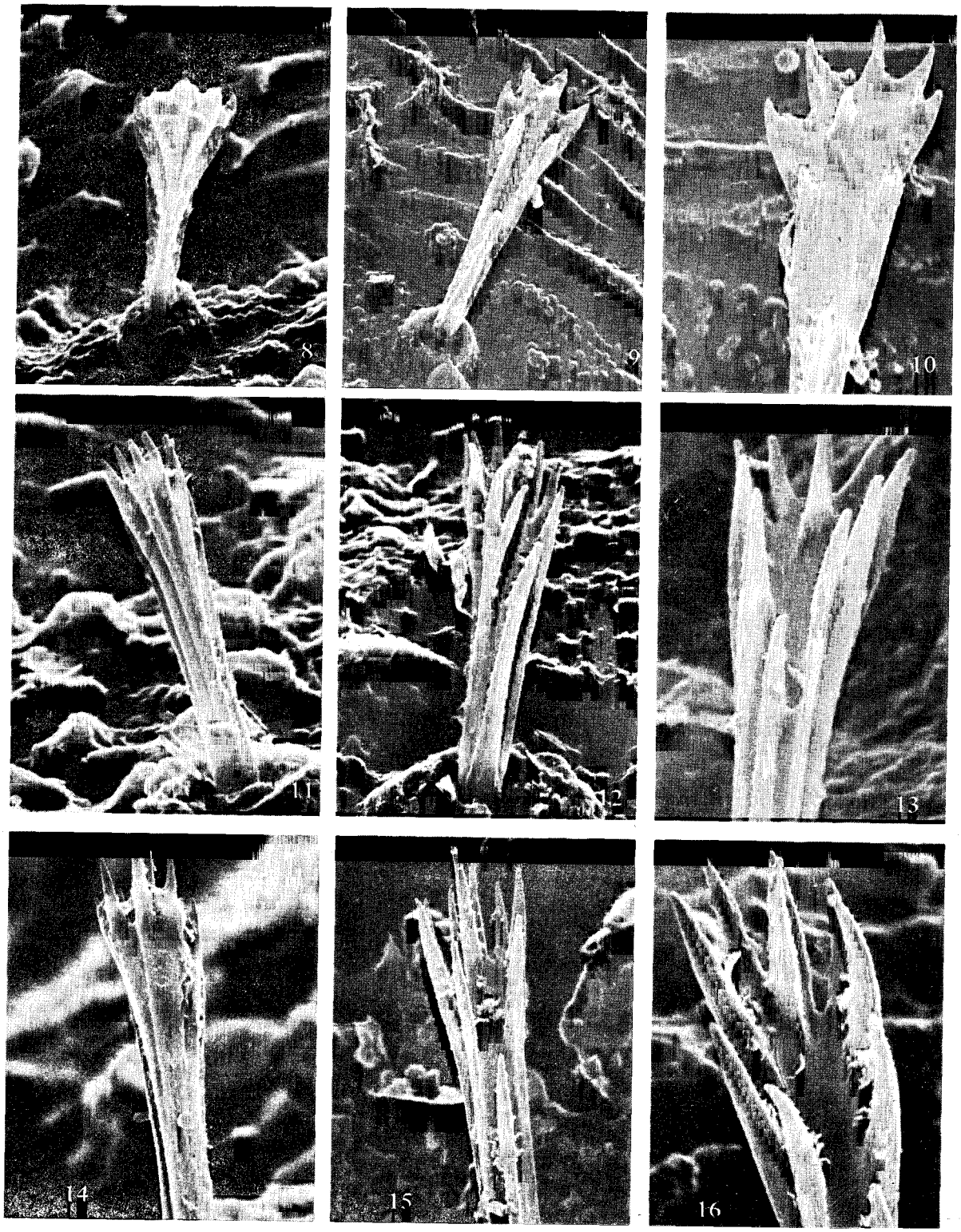


Plate 1: Frontal side of seta from *Lamprochernes nodosus* x 1,250, b = frontal spine.

Plates 2-4: Setae from *Allochernes wideri.* **2** Reverse side. Note the deep longitudinal furrows. x 1,250. **3** and **4** Stereopair of frontal side, x 2,500.

Plates 5-7: Setae from *Toxochernes panzeri.* **5** Reverse side, x 1,250; **6** Frontal side, x 1,250, b = frontal spine, a = axial spine; **7** Frontal side, x 2,500.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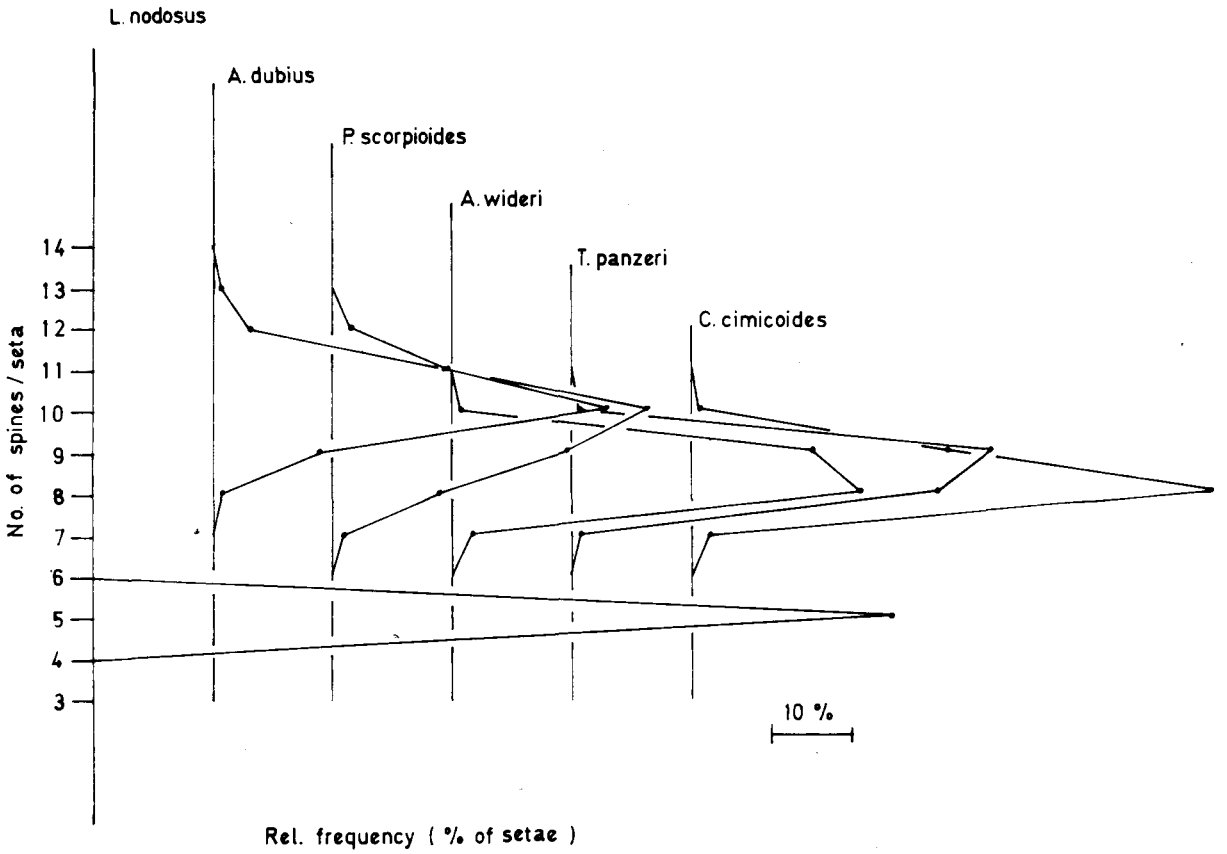

Fig. 1: Relative frequency of setae (in %) with different numbers of spines counted on four specimens of each species.

The setae of *A. wideri* (Plates 2, 3, 4), *T. panzeri* (Plates 5, 6, 7) and *C. cimicoides* (Plates 8, 9, 10) differ only slightly from one another. The difference is due to the shape of the tips of their setae. This is a result of the extent to which the spines are distally spread, making them more or less club-shaped. In *A. wideri* and *C. cimicoides* the tips of the setae are more club-shaped than in *T. panzeri.*

Most setae from these three species have 8 or 9 spines (Table 1, Fig. 1).

A. dubius (Plates 11, 12, 13) and *P. scorpioides* (Plates 14, 15, 16) have slim setae with spines more parallel to each other than in the other species, and the axial spine is usually more prominent. Most setae have 9, 10 and 11 spines (Table 1, Fig. 1). Both species have a kind of striated pattern on the surface, most conspicuous on the frontal side among the spines (Plate 16). The resemblance to a human fingerprint pattern is striking. This character seems to be lacking in the other species investigated, though this

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Plates 8-10: Setae from *Chernes cimicoides.* **8** Reverse side, x 1,250; **9** Frontal side, x 1,250; **10** Frontal side, x 2,500.

Plates 11-13: Setae from *Allochernes dubius.* **11** Reverse side, x 1,250; **12** Frontal side, x 1,250; **13** Frontal side, x 2,500.

Plates 14-16: Setae from *Pselaphochernes scorpioides.* **14** Reverse side, x 1,250; **15** Frontal side, x 1,250; **16** Frontal side. Note the fingerprint pattern. x 2,500.

	A. wideri	*A. dubius*	*T. panzeri*	*C. cimicoides*
P. scorpioides	0.186	0.795	0.429	0.186
A. wideri		−0.188	0.75	1.0
A. dubius			0.018	−0.188
T. panzeri				0.75

Table 2: Spine frequencies of five species tested against each other using Spearman's Rank Correlation Coefficient

is somewhat uncertain since the area between the spines could not be seen clearly on all setae from the five species due to contamination.

When all species except *L. nodosus* are tested against each other using Spearman's Rank Correlation Coefficient the results shown in Table 2 are obtained. The correlation is fair between *P. scorpioides* and *A. dubius* and between each of the three species *A. wideri, T. panzeri,* and *C. cimicoides.* On the other hand, when either of the two species *P. scorpioides* and *A. dubius* is tested against each of the three remaining species a poor correlation results.

When the spine frequencies are subjected to a chi-square test, the χ^2-values shown in Table 3 are found. The figures in brackets are the critical χ^2-values when probability of chance is less than 0.01 with respective degrees of freedom. All chi-square values have been corrected for small sample size.

These tests showed no significant differences between *P. scorpioides* and *A. dubius* and no significant difference between each of the three species *A. wideri, T. panzeri* and *C. cimicoides.* Additionally, when either of the two species *P. scorpioides* and *A. dubius* are compared against each of the three remaining species a significant difference is obtained. The chi-square tests seem to confirm the trend given by Spearman's R.C.C.

Spearman's R.C.C. and the chi-square confirm the opinion based on the general morphology of the setae, namely that *P. scorpioides* and *A. dubius* constitute one group, while *A. wideri, T. panzeri* and *C. cimicoides* constitute another. This can be illustrated by a dendrogram based on the correlation coefficients and worked out by methods described in Sokal and Michener (1958) (Fig. 2).

Discussion

It was necessary to clean the animals before the SEM study. A substance was found on many of the spines in uncleaned animals. By treatment in weak hydrochloric acid this substance was efficiently removed, as reported by Larsson and Myhrberg (1976).

On the basis of seta shape and spine numbers *Lamprochernes nodosus* stands clearly apart from the other five species. This is slightly at variance with the opinion held by Muchmore (1972) who states that the setae of *L. nodosus* differ from those of *Allochernes* and *Pselaphochernes* only in being longer and thinner and in having smaller spines.

	A. wideri	*A. dubius*	*T. panzeri*	*C. cimicoides*
P. scorpioides	56.200 (15.086)	15.909 (16.812)	60.986 (15.086)	72.719 (15.086)
A. wideri		110.229 (16.812)	0.887 (11.345)	3.198 (11.345)
A. dubius			118.336 (16.812)	127.729 (16.812)
T. panzeri				7.226 (11.345)

Table 3: Chi-square values (corrected for small sample size) of spine frequencies of five species

However, *L. nodosus* shares common features with the other species in having one axial and one frontal spine. The axial spine is no doubt a direct continuation of the stem of the seta and therefore nothing but the pointed tip of the same. This is probably also the case with the five species of Chernetinae. If so, these spines are homologous characters, and thus more fundamental qualities than any other character of the setae. This view is confirmed by the description by Muchmore (1973) of *Muchrochernes hirsutus* (Banks). This species has long pointed tergal setae which are completely bare of spines except for one spine placed halfway along the shaft of the seta. This spine probably corresponds with the frontal spine and the pointed tip with the axial spine in our descriptions.

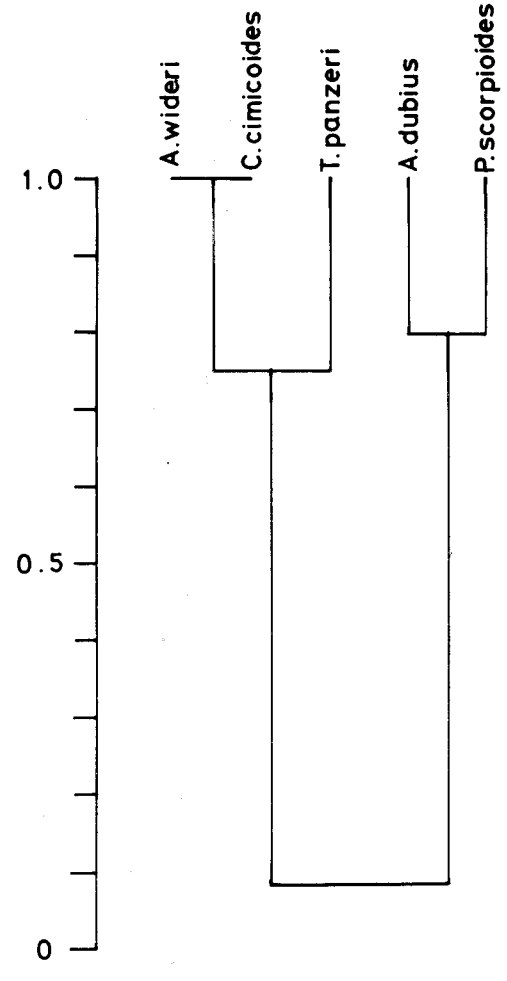

Fig. 2: Dendrogram showing the relationships of setae of the five species in Chernetinae based on correlation coefficients.

As stated earlier *L. nodosus* and the five species in Chernetinae fall into three groups, a) *L. nodosus,* b) *P. scorpioides* and *A. dubius*, and c) *A. wideri, T. panzeri* and *C. cimicoides.* The divergent position of *Allochernes dubius* inside the genus *Allochernes* based upon the shape of the setae and their spine numbers corresponds with work done by other authors, though their investigations are based on different morphological characters. Beier (1932) originally placed the species in his subgenus *Toxochernes* (later raised to generic level). This was based upon erroneous interpretation of palpal characters as pointed out by Lohmander (1939) who concluded that the species was a true *Allochernes.* This was accepted by Beier (1963) in his later work. However, the species differs from the type species of the genus, *A. wideri*, in having tactile setae on the last tergite. Besides *A. peregrinus* (Lohmander), *A. dubius* is the only European species in the genus which has tactile setae on the last tergite, according to Beier (1963).

Lohmander (1939) states that *A. dubius* differs both from *A. wideri* and *T. panzeri* in several respects, most importantly in the male genitalia. Unfortunately he does not discuss the matter further, but refers to a future work on the genitalia which was never published as far as we know.

According to Legg (1971) the five genera dealt with fall into three groups, i) *Chernes, Dendrochernes* and *Toxochernes*, ii) *Lamprochernes*, and iii) *Allochernes* and *Pselaphochernes.* Concerning *A. wideri* and *A. dubius* he found no significant difference in the male genitalia except for the number of setae on the genital opercula, which was higher in *A. wideri.* The female genitalia differed in the shape of the spermathecae and the number of setae on the anterior genital opercula.

Our investigation on the tergal setae suggests a closer relationship between *P. scorpioides* and *A. dubius* than between the latter and *A. wideri.* The setae of *A. wideri* seem to be similar to those of *T. panzeri* and *C. cimicoides.* Judged from other characters stated by Beier (1932, 1963) *P. scorpioides* seems to be more similar to *A. dubius* than to *A. wideri. P. scorpioides* has trichobothria on the eleventh tergite, which are also present in *A. dubius* but absent in *A.*

wideri. The number of setae on the tergites is within the same range as in *A. dubius* but considerably smaller than in *A. wideri.* The length of the body is approximately the same as in *A. dubius* and distinctly smaller than in *A. wideri.* Most other characters are either overlapping or similar in the three species.

Furthermore, Legg's (1971) work suggests several characters in the male and female genitalia of *P. scorpioides* which are similar to *A. dubius* but different from *A. wideri.* The number of setae on the genital opercula is almost the same as in *A. dubius* but different from that of *A. wideri.* The female has a darkly tanned region on the posterior margin of the posterior operculum like that of *A. dubius.* The shape of the spermathecae is similar in *P. scorpioides* and *A. dubius* but different from that of *A. wideri.*

Judged by Legg's drawings the outline of the lateral diverticula of the male ejaculatory canals is similar in *P. scorpioides* and *A. dubius* but different from *A. wideri.*

All characters viewed together seem to support the result of our investigation.

The most conclusive difference between *P. scorpioides* and *A. dubius* is the trichobothria on the podomeres of the third and fourth leg, present in the former but absent in the latter species. This is shown by Gabbutt (1972) to be a constant character occurring in all post-embryonic stages.

Further investigation on more specimens and characters which are perhaps more fundamental than setae will probably reveal the true relationships between the species in these groups.

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