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Teratological data about Opiliones (Arachnida) from Bulgaria

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Teratology, anomalies, Opiliones, harvestmen, segmentation, macrosculpture, *Siro beschkovi*, *Paranemastoma radewi*, *Paranemastoma aurigerum aurigerum*, *Paranemastoma aurigerum ryla*, *Trogulus tricarinatus*, *Trogulus nepaeformis*, *Trogulus graecus*, *Dicranolasma giljarovi*, *Rilaena balcanica*, *Mitopus morio*, *Lacinius horridus*, *Phalangium opilio*, Bulgaria

Abstract. When studying 18 382 specimens of 12 species and subspecies of Opiliones in Bulgaria, morphological anomalies were established, which can conventionally be divided into three groups: (1) anomalies referring to the appendages structure; (2) anomalies of the abdominal segmentation; (3) anomalies in the macrosculpture.

The first group comprises the cases of reduced segment composition both of the pedipalps of some specimens *Rilaena balcanica* Šilhavý and *Mitopus morio* (Fabricius), and of the legs in *Trogulus tricarinatus* (Linnaeus), *T. nepaeformis* (Scopoli) and *T. graecus* Dahl. The second group comprises the case of partial atrophy of tergite 8, combined with an enlarged posterior part of tergite 7 towards the place of the missing part of tergite 8 in *Paranemastoma radewi* (Roewer) and the case of symphysomery in *Dicranolasma giljarovi* Šilhavý— sternites 4 and 5 are fused on the right. The third group comprises the cases of anomalies in the structure of the adenostyle in *Siro beschkovi* Mitov, the chelicera in *Phalangium opilio* Linnaeus and the frontal group of spines (= trident) in some *Lacinius horridus* (Panzer) specimens. Armament anomalies were observed in *Paranemastoma radewi* (Roewer), *P. aurigerum aurigerum* (Roewer) and *P. aurigerum ryla* (Roewer), in some cases manifested through the appearance of an additional tubercle, spine or a pair of tubercles, while in other cases through the disappearance of a tubercle, spine or a pair of tubercles. It was found that the appearance of a new tubercle (respectively a pair of tubercles) occurs in the places of the slit sensilla.

INTRODUCTION

There is teratological data about Opiliones in the work of Hansen & Soerensen (1904), Hadži (1928, 1931, 1935), Soerensen (1932), Kolosváry (1934), Pabst (1953), Cîrdei (1955), Rafalski (1958), Juberthie (1960, 1961, 1962, 1963a,b, 1964), Blaszak (1968).

The studying and the description of the anomalies is important, because they are a result of the influence of external and internal factors during the embryonic and postembryonal development and thus they are of interest to the embryology, the ecology, the evolutionary theory and the palaeontology. The anomalies are taxonomically important too, because they affect some of the important diagnostic characters in harvestmen.

The mentioned importance of the anomalies and the lack of such data on Opiliones from Bulgaria led us to pay special attention to the teratology of this group when the harvestmen in Bulgaria were studied.

Table 1. Survey of material. Numbers of individuals examined, anomal individuals (in parentheses) and percentage of anomalies.

species	♂♂	♀♀	juv.	total	%
Siro beschkovi Mitov, 1994	14 (1)	—	—	14 (1)	7.14
Trogulus tricarinatus (Linnaeus, 1758)	20	110 (2)	12	142 (2)	1.41
Trogulus nepaeformis (Scopoli, 1763)	101 (2)	34	3	138 (2)	1.45
Trogulus graecus Dahl, 1903	2	4 (1)	1	7 (1)	14.3
Dicranolasma giljarovi Šilhavý, 1966	28	20 (1)	27	75 (1)	1.33
Paranemastoma radewi (Roewer, 1926)	459 (3)	848 (17)	166 (2)	1473 (22)	1.49
Paranemastoma aurigerum aurigerum (Roewer, 1951)	43 (3)	54	35	132 (3)	2.27
Paranemastoma aurigerum ryla (Roewer, 1951)	229 (4)	293 (1)	12	534 (5)	0.94
Mitopus morio (Fabricius, 1779)	833	1400 (1)	1960 (1)	4193 (2)	0.047
Lacinius horridus (Panzer, 1794)	2494 (7)	2548 (12)	1902 (3)	6944 (22)	0.31
Phalangium opilio Linnaeus, 1758	889	1781 (1)	764	3434 (1)	0.029
Rilaena balcanica Šilhavý, 1965	263 (1)	305	728 (1)	1296 (2)	0.15

MATERIALS AND METHODS

The major part of the material was collected by pitfall traps, filled with formaline. Twelve taxons exhibiting morphological anomalies were found (Table 1). In the neighbourhood of the sites where anomalous specimens were collected are no industrial pollution sources.

The Scanning Electron Microscope (SEM) photographs were taken on SEM "Philips 515" (10–20 kV; mode: secondary electrons).

The terminology for the abdominal anomalies in this study is the same used for other arthropods (Balazuc, 1948; Ćurčić et al., 1991).

RESULTS

During the examination of specimens from all of the 47 species and subspecies of Opiliones in Bulgaria (except *Siro duricorius* (Joseph), *Nemastoma lugubre* (O. F. Müller, 1776) and *Eudasylobus beschkovi* Staręga, 1976), only in 12 species and subspecies morphologically anomalous individuals were found (Table 1). These morphological anomalies can be conventionally divided into three groups:

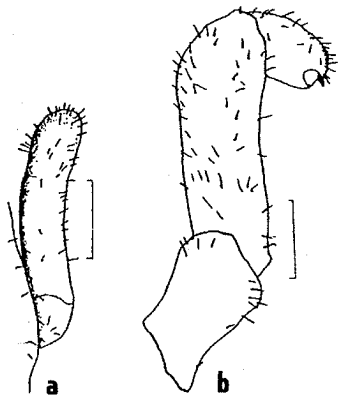

Fig. 1. Anomalous segmental composition of pedipalps: a—*Rilaena balcanica*, left pedipalp with two instead of five segments; b—*Mitopus morio*, right pedipalp with three instead of five segments. Scale lines: a—0.15 mm, b—0.11 mm.

Reduced segment number (composition) of the pedipalps

Out of the 1296 specimens of *Rilaena balcanica* one male and one juv. with anomalous pedipalps were found. In both cases the right pedipalp is composed of only two segments —a slightly developed trochanter and a femur; the claw is missing (Fig. 1 a). As a result the length of the male anomalous pedipalp is 1.72 mm, the length of the other pedipalp of this individual is 4.51 mm—definitive for this species (Staręga, 1976).

In the 4193 specimens studied of *Mitopus morio*, two specimens with anomalous pedipalps were found: the first specimen (juv.) is with the right pedipalp composed of three segments—trochanter, femur and the third segment is not clearly homologized (it may be the tarsus, the tibia or the patella), and bears a claw (Fig. 1b); the discrete segments are shorter than the corresponding segments of the normal pedipalp. The second specimen (female) is with the left pedipalp underdeveloped, shorter than a normal one and with the remains of a tarsus. The length of the anomalous pedipalp (excl. the tarsus) is 4.4 mm, the normal one (excl. the tarsus) is 7.1 mm long.

Reduced segment number (composition) of the legs

Out of a total number of 142 specimens of *Trogulus tricarinatus*, one female was found with anomalous second right leg—the tarsus is composed by one instead of two segments.

Fig. 2. Anomalous segmental composition of the tarsus in *Trogulus*. a—*T. nepaeformis* (leg II), b—*T. tricarinatus* (leg II), c—*T. nepaeformis* (leg III), tarsus with one instead of three segments; d—*T. graecus* (leg I), tarsus with one instead of two segments. Scale lines: a—0.44 mm; b—0.52 mm; c—0.33 mm; d—0.90 mm.

The tarsal joint (0.33 mm) is steadily fixed to the metatarsus, while the calcaneus is not formed (Fig. 2c); the normal tarsus is 1.12 mm. Another female shows a similar appearence of the tarsal joints on the I right leg; the anomalous tarsus is 0.3 mm, the normal one 0.4 mm long. A similar anomaly was observed by Pabst (1953) in *Trogulus nepaeformis*.

Out of 138 studied specimens of *Trogulus nepaeformis*, two males were aberrant: the first one with the tarsus of the second left leg one-jointed instead of two-jointed (Fig. 2a); the second one with the tarsus of the third right leg one-jointed instead of three-jointed (Fig. 2b). Pabst (1953) announced a similar case for *Trogulus nepaeformis*.

Out of seven specimens of *Trogulus graecus* one female with anomaly was found—the tarsus of the first left leg is one-jointed instead of two-jointed (Fig. 2d). Probably this anomaly is due to coalescence among the joints. Besides, the typical pigmentation for the first tarsal joint can be observed ventrally in the proximal end of the tarsus. It was found in two specimens of *Trogulus nepaeformis* that some of the legs possessed only stubs of metatarsus and tarsus. Most likely their absence was due to traumas. It is interesting to note that the distal part of these appendages is better pigmented. In one of the cases tibia of the third right leg is a little bit longer than that of the other leg—perhaps for compensation of the length in walking. Pabst (1953) described a similar case for *Trogulus nepaeformis*.

ANOMALIES OF THE ABDOMINAL SEGMENTATION

Out of the total of 1473 *Paranemastoma radewi* studied, one female (Fig. 3; Table 1) was found with a partial atrophy of tergite 8, combined with an enlarged posterior part of tergite 7 towards the place of the missing part of tergite 8. This combination of atrophy and tergite enlargement is a common phenomenon in Pseudoscorpiones (Ćurčić et al. 1991). Besides, in this case one can observe a deviation from the shape and asymmetry in the position of operculum anale and the tergite 9 (Fig. 3). The same specimen shows anomalous armament with an additional tubercle on Area V (Fig. 6j).

Out of the total 75 *Dicranolasma giljarovi* studied, one female was found with a case of symphysomery—sternites 4 and 5 are fused on the right (Fig. 3b).

Similar data about anomalies in the segmentation in Opiliones were given by Hansen and Soerensen (1904), Soerensen (1932), Hadži (1935), Pabst (1953) and Juberthie (1963b).

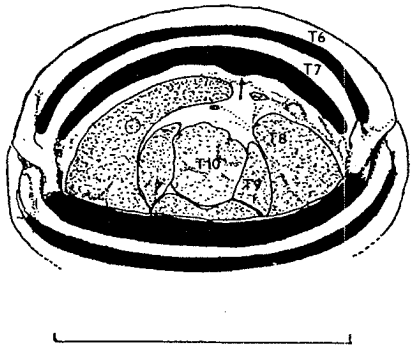

Fig. 3. Anomaly of the abdominal segmentation in *Paranemastoma radewi*. Partial atrophy of T 8 and compensatory enlargement of T 7 (arrowed), caudal, T = tergite. Scale line—2.2 mm.

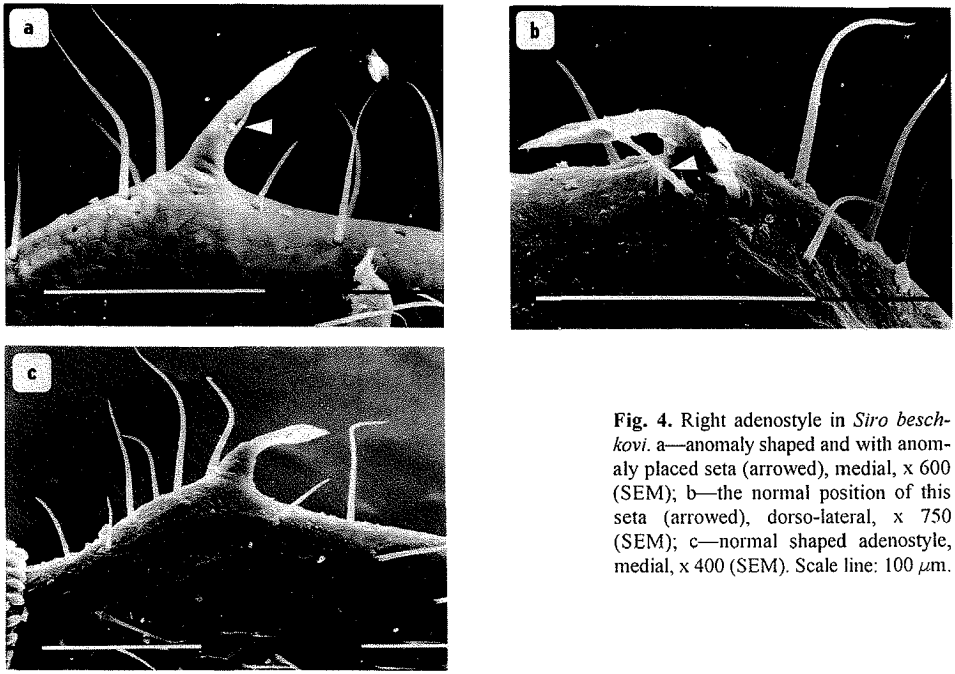

Fig. 4. Right adenostyle in *Siro beschkovi*. a—anomaly shaped and with anomaly placed seta (arrowed), medial, x 600 (SEM); b—the normal position of this seta (arrowed), dorso-lateral, x 750 (SEM); c—normal shaped adenostyle, medial, x 400 (SEM). Scale line: 100 μm.

ANOMALIES IN THE MACROSCULPTURE

The anomaly in adenostyle in only one of the legs of one specimen of *Siro beschkovi* (out of the total of 14 males studied) refers to this group of anomalies. It is manifested in the fact that one of the setae, normally situated at the adenostyle base, is on it in this case (Fig. 4a). In addition to this, the adenostyle shape significantly differs from the normal one (Fig. 4b,c). Rafalski (1958, Fig. 13) spoke about an abnormal seta near the adenostyle in *Siro carpaticus* Rafalski.

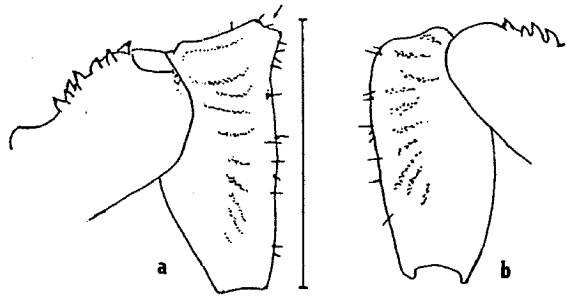

Fig. 5. Lateral view of chelicera in *Phalangium opilio* (without movable and fixed digit). a—right chelicera with anomalous appearance of apophysis (arrowed) on the distal segment; b—normal left chelicera. Scale line = 1.4 mm.

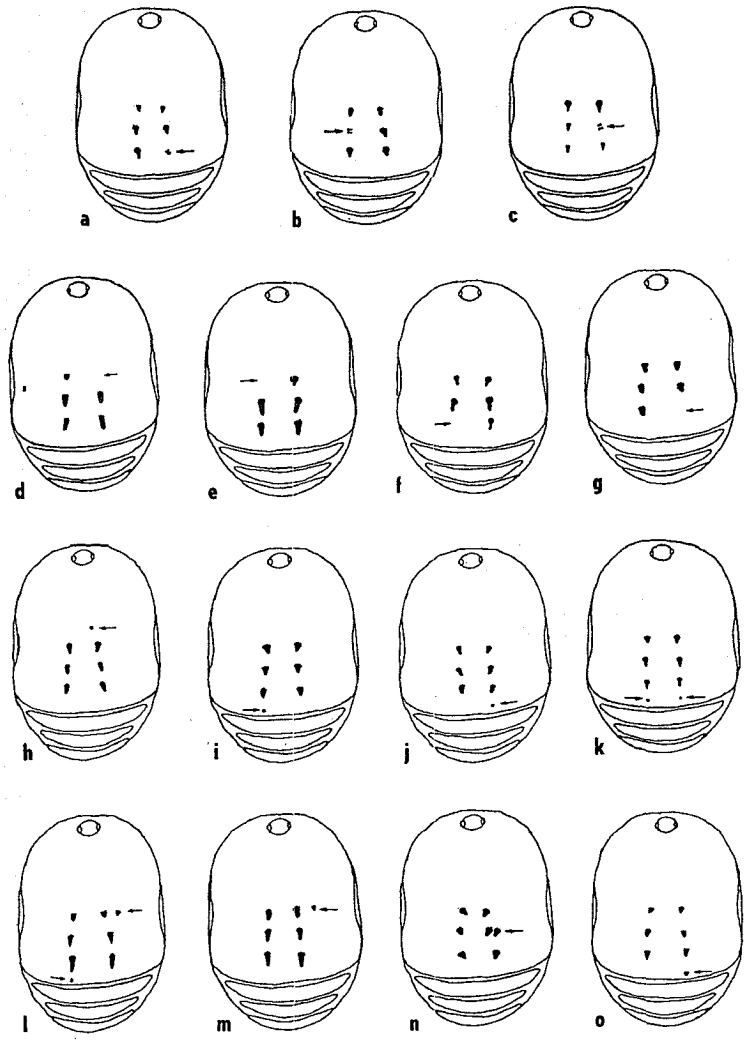

Fig. 6. Teratological variations in the armament of *Paranemastoma radevi*. a–c—tendency toward reduction of one of the spines on Areae III (b, c) and IV (a); d–g —full reduction of one of the spines on Areae II (d, e) and IV (f, g); h–k—formation of additional tubercles on Areae I (h) and V (i–k); l–o—formation of additional spines on Areae II (l, m), III (n) and V (o) [on this Area appears also an additional tubercle (l)]; all anomalies arrowed.

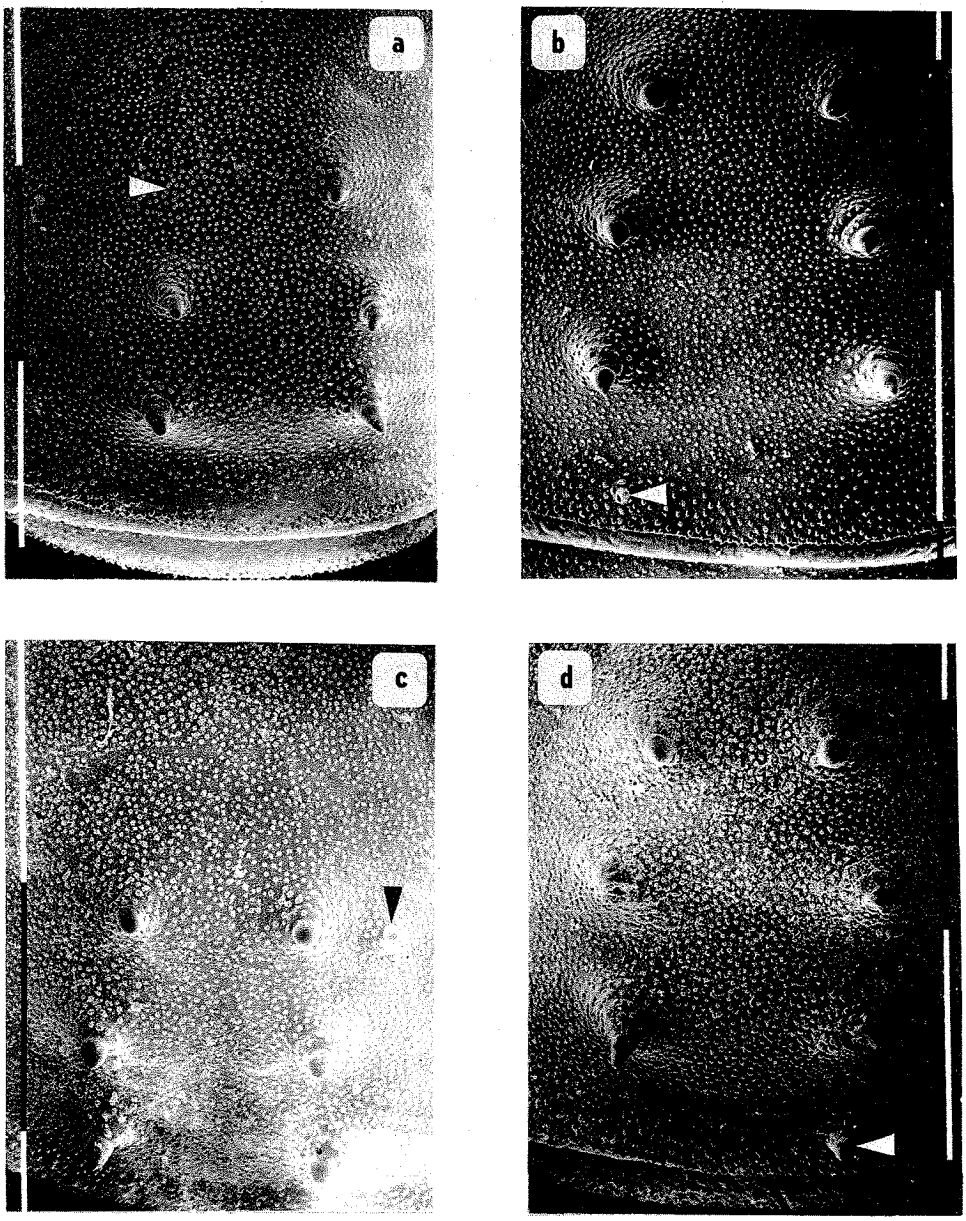

Fig. 7. Anomalous armament in *Paranemastoma radewi* a—fully reduced spine on Area II, x 34.4 (SEM); b—appearance of an additional tubercle on Area V, x 40 (SEM); c—appearance of an additional spine on Area II, x 44.4 (SEM); d—appearance of an additional spine on Area V, x 40 (SEM), dorsal. Scale line = 1 mm.

The case of the anomalous appearance of apophysis on the chelicera in a female *Phalangium opilio*, out of the 3434 specimens studied, belongs to this group too (Fig. 5). The frequency of this anomaly is 0.056 p.c. (referred to the number of females).

When analysing materials of *Paranemastoma* Redikorzev, many specimens were found in which the armament varied to a different degree from the normal one (Table 1, Figs 6–8). The analysis of the teratological variations in the armament of *Paranemastoma radewi* showed that out of the 1473 specimens studied, 21 cases (3 males, 16 females, 2 juv.) of anomalies in the armament were observed: 3 cases (females) of tendency towards reduction of one of the spines (Fig. 6a–c); 4 cases (3 females, 1 juv.) of full reduction of one of the spines (Figs 6d–g, 7a); formation of an additional tubercle—seven females (Figs 6h–j, 7b); formation of an additional pair of tubercles—one male (Fig. 6k); formation of an additional spine—five cases (two males, two females, one juv.) (Figs 6m–o, 7c–d); one complex case of formation of an additional spine and formation of an additional tubercle—one female (Fig. 6l).

Out of the 132 specimens of *Paranemastoma aurigerum aurigerum* studied, three males with anomalies in the armament were found: two males with fully reduced pair of tubercles on Area I (Fig. 8a) and one male with newly developed tubercle on Area V (Fig. 8b).

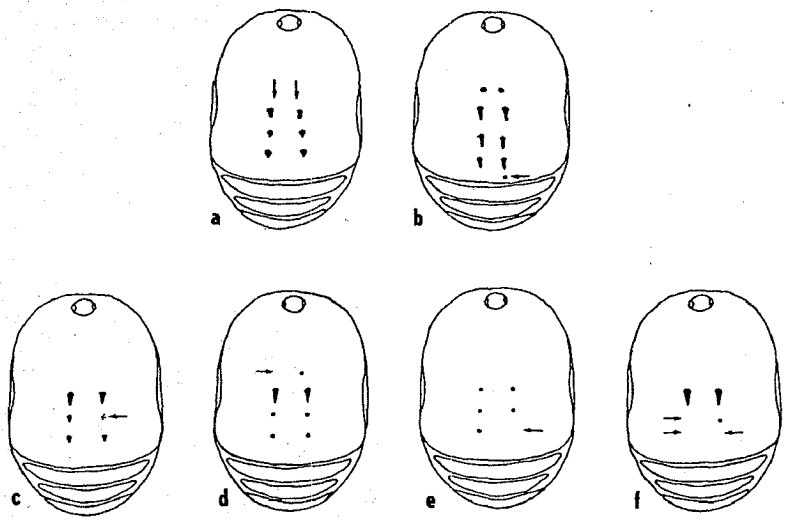

Fig. 8. Teratological variation in the armament of *Paranemastoma aurigerum aurigerum* (a–b) and *P. aurigerum ryla* (c–f). a—fully reducted pair of tubercles on Area I in *P. a. aurigerum*; b—newly developed tubercle on Area V in *P. a. aurigerum*; c—tendency towards reduction of one of the spines on Area III in *P. a. ryla*; d–f—fully reduced tubercles on Areae I (d), III (f) and IV (e,f) in *P. a. ryla*; (a, d—males).

Anomalies in the macrosculpture can be observed in *Paranemastoma aurigerum ryla*, too. Out of the 534 studied, five specimens (four males, one female) with anomalous armament were found: two males with tendency towards reduction of one of the spines (Fig. 8c); one male and one female with complete reduction of one of the tubercles (Fig. 8d,e); one male with simultaneous reduction of one tubercle on Area III and of the pair of tubercles on Area IV (Fig. 8f).

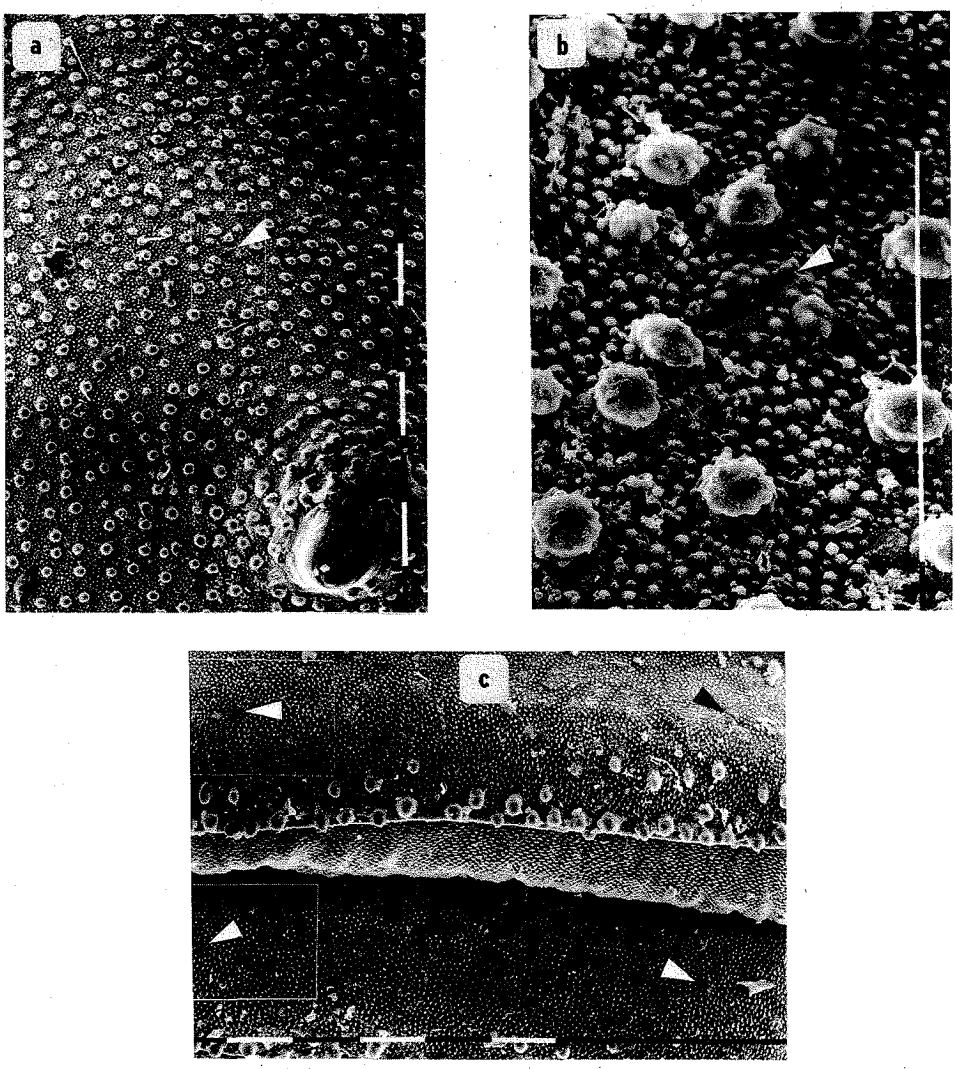

Fig. 9. *Paranemastoma radewi*, sculpture of the tergal cuticle. a—on Area I and Area II, slit sensilla (arrowed), x 130 (SEM); b—slit sensilla (arrowed), on Area I, x 810 (SEM); c—slit sensilla on T 7 (upper pair arrows) and T 8 (lower pair arrows), x 131 (SEM). Scale line: 100 μm.

This group of anomalies comprises the deviations from the normal structure of the frontal group of spines (= trident) in some *Lacinius horridus* specimens. Out of the 6944 specimens of *Lacinius horridus*, 22 specimens with deviations from the normal shape of the trident: three males, five females and one juv. specimens with one of the spines of the trident bifurcate (Fig. 10a), one juv. with two of the spines of the trident bifurcate (Fig. 10b), one female with the medial spine of the trident tridentate (Fig. 10c), two males and two females with two of the spines of the trident coalescent at their base (Fig. 10d, e), two males and four females with one spine of the trident underdeveloped (Fig. 10f) and one juv. (Fig. 10g) with oddly shaped left spine of the trident were found.

DISCUSSION AND CONCLUSIONS

1. The anomalies referring to the first group—the cases of reduced segment number (composition) and underdevelopment of the appendages, may be a result of adversely temperature influence during the embryonic development stage (cf. Juberthie 1964), a traumatic variation, partial regeneration (cf. Hadži, 1928, 1931) or asymmetry deviation (Ćurčić et al., 1981).

2. Anomalies of the abdominal segmentation may be a result of the malfunction of the hormonal system, the influences of environmental factors and the genetic factors of metamerization (Ćurčić et al., 1991).

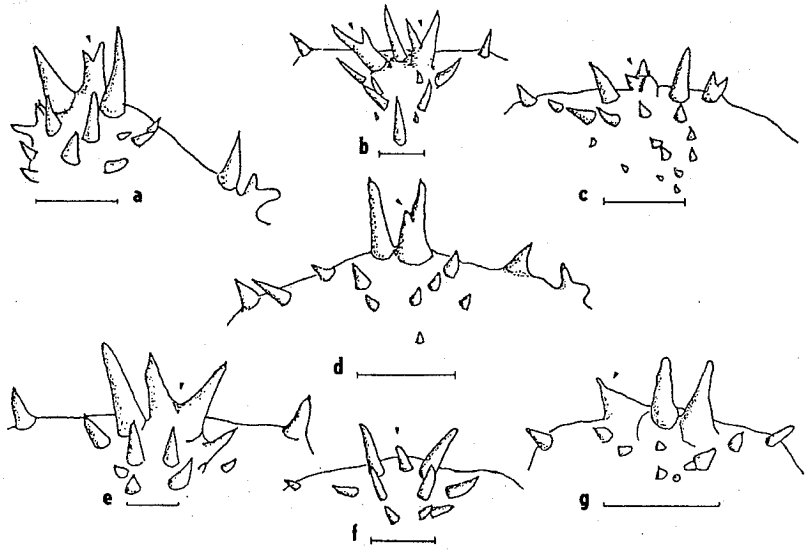

Fig. 10. Anomalies in the structure of the trident in *Lacinius horridus*. a—bifurcation of the medial spine (arrowed), dorso–lateral, scale = 0.5 mm: b—bifurcation of the lateral spines (arrowed), scale = 0.25 mm; c—tridentate medial spine (arrowed), scale = 0.4 mm; d, e—coalescence of a lateral with the medial spine (arrowed), scale d = 0.3 mm; e = 0.25 mm; f—underdeveloped medial spine (arrowed). scale = 0.4 mm; g—oddly shaped left lateral spine (arrowed), scale = 0.5 mm.

3. Generally, the causes for the anomalies in the macrosculpture can be hormone-based and in *Paranemastoma* also a manifestation of atavism or a tendency towards the armament reduction. If the appearance or disappearance of a spine (spines) or tubercle (tubercles) reflects on the value of the specific surface of the organism, then this phenomenon can have a direct relation to the thermodynamics of the metabolism in this Opiliones, because the specific metabolism intensity is proportional to the specific surface and depends on factors acting on the boundary surface between the organism and its environment (Schmidt-Nielsen, 1987; Florov, 1988).

A more detailed analysis of the macro- and microsculpture of *Paranemastoma* showed that the appearance of a new tubercle (respectively a spine) occurs in the places of the slit sensilla (⌀ 33 μm) (Fig. 9).

It is possible that a part of the deviations of the normal structure of the trident in *Lacinius horridus*, added to this group of anomalies (see Figs 10a,b,f), to present just normal intraspecific variations of the armament like these anomalies and variations, described by Cîrdei (1959) and Cîrdei and Bulimar (1968) for the spikes of the supracheliceral lamellae in *Phalangium opilio.*

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