

SYSTEMATIC VALUE OF LOSSES OF SOME NOTOGASTRAL SETAE IN ADULT  
SPHAEROZETINAE  
(ACARI : ORIBATIDA : CERATOZETIDAE) IN THE LIGHT  
OF ONTOGENETIC STUDIES

BY Stanisław SENICZAK<sup>1</sup>, Valerie M. BEHAN-PELLETIER<sup>2</sup>  
and Torstein SOLHØY<sup>3</sup>

PHYLOGENY  
SPHAEROZETINAE

ABSTRACT : The morphology of adult and juvenile stages of 11 species of the ceratozetid subfamily Sphaerozetinae was investigated in order to explain systematic relationships of genera and species. The genera *Ghilarovizetes*, *Melanozetes* and *Fuscozetes* form well-defined "Melanozetes group" which differs morphologically from *Edwardzetes* and *Sphaerozetes*. The losses of some notogastral setae in adult of "Melanozetes group" were established and a hypothetical development of this group of mites is proposed.

PHYLOGENÈSE  
SPHAEROZETINAE

RÉSUMÉ : La morphologie de l'adulte et des différents stades de jeunesse d'onze espèces ceratozetidiennes de la sous-famille Sphaerozetinae a été recherchée pour reconnaître la parenté entre les genres. Les genres *Ghilarovizetes*, *Melanozetes* et *Fuscozetes* forment un groupe bien défini — « Melanozetes group » — qui se distingue par sa morphologie des genres *Edwardzetes* et *Sphaerozetes*. On a établi l'ordre de perte de quelques poils notogastriques chez les adultes du « Melanozetes group » et on propose un développement hypothétique pour ce groupe.

INTRODUCTION

Adult of the ceratozetid subfamily Sphaerozetinae have similar body shape, medium size (0,45-0,75 mm) and brown colour. The cuticle is well sclerotized, forming a skeleton which protects the mite's body against physical damage and water loss. The exoskeleton is further protected by many outgrowths such as lamellae, with or without translamellae, tutoria, pedotecta, pteromorphs, teeth, carinae etc., which make the mites bigger and presumably less appetizing to predators.

The subfamily Sphaerozetinae was established mainly on the basis of character states of the adult

exoskeleton (SHALDYBINA, 1966), which however, can vary extensively. The rostrum in most representatives of this subfamily is rounded, but in some species it is protected by two lateral teeth. Lamellae are usually broad with well developed cusps, but are sometimes narrow, or have insignificant cusps. Sensillus head is often clavate and barbed, but in some species is fusiform. Tutorium varies from short to long and pointed, and a tutorial cusp may be present or absent. Pedotecta are well-developed. The infracapitulum lacks a tectum on the mentum (inappropriately called "ceratozetoid-type" of infracapitulum by many authors, as *Punctoribates* and *Minunthozetes* which are members of the

1. Department of Animal Ecology, Academy of Technology and Agriculture, ul. H. Sawickiej 28, PI-85 084. Bydgoszcz, Poland.

2. Biosystematics Research Centre, Agricultural Canada, Ottawa, Canada K1A 0C6.

3. Department of Animal Ecology, Museum of Zoology, University of Bergen, Muséplass 3, N- 5014 Bergen, Norway.

Ceratozetoides, have a tectum on the mentum). Pteromorphs are well-developed and lack a line of dehiscence (hinge). Notogastral porose areas, especially adalar (Aa), are clearly evident. The adult bears 10 to 15 pairs of notogastral setae.

The Sphaerozetinae are the most interesting subfamily in the Ceratozetidae if we consider the range of notogastral setation expressed in adult representatives. The subfamily includes species with 15, 14, 13, 12, 11 or even 10 pairs of notogastral setae, and the setation can sometimes be unpaired. Therefore, it is possible to observe the tendency for, and order of, reduction of notogastral setae in this group of mites. Such observations may help in explaining the systematic relationships of genera and species in the Sphaerozetinae and in closely related groups of mites.

Notogastral setal losses in adult oribatids are poorly understood, based on published reports in the literature. Still problematical is the homology of different setae on the adult notogaster, as the opinions of different authors vary on the development of both hysterosomal segments and setation during ontogeny.

According to GRANDJEAN (1934) the hysterosoma of the larva is formed of 6 segments which bear pairs of setae and slit sense organs. All postlarval segments are added terminally, i.e., adanal segment (AD) in the protonymph, anal segment (AN) in the deutonymph, and peranal segment (PA) in the tritonymph, 9 segments in total. This GRANDJEAN considered the holotrichous (and most primitive) condition in oribatid mites; the current notation for this holotrichous condition are given in Table 1. GRANDJEAN (1934) noted that the holotrichous condition is comparatively rare in oribatid mites, other than in primitive groups. GRANDJEAN noted in 1934 and subsequently that the application of his theories on notogastral setal homologies to higher oribatids is very difficult, as when setae are lost, e.g., the *d* series in the adult, other notogastral setae take a more centrodorsal position to fill up the sensory space. He considered a unideficient setation to entail loss of setae *f*<sub>1</sub>, and for deficiencies of 2 to 5 pairs of setae developed a multideficient notation (GRANDJEAN, 1934, 1949). For deficiencies greater than 5 pairs of setae, GRANDJEAN (1951a) developed

the "Dometorina" nomenclature. Probable homologie among GRANDJEAN's notogastral setal nomenclatures have been outlined by R. A. NORTON (BALOGH and BALOGH, 1988) based on GRANDJEAN's body of work, and are used in Table 1. SHALDYBINA (1972) tried to explain the development of opisthosomal segments and setation in ceratozetoid mites during ontogeny. Her observations on the morphology of juvenile and adult stages of 26 species in this superfamily led her to the conclusion that the hysterosoma of the larva is composed of 8 segments: C and with 3 pairs of setae — *c*<sub>1</sub>, *c*<sub>2</sub>, *c*<sub>3</sub> and the slit sense organ *ia*; D with 2 pairs of setae *da* and *la*; E with setae *dm* and *lm* and slit sense organ *im*; F with 2 pairs of setae *dp* and *lp*; H with 1 pair of setae *H*<sub>1</sub> and slit sense organ *ip*; OP with 2 pairs of setae *OP*<sub>1</sub> and *OP*<sub>2</sub>, and PP without setation. Addition of setae in the protonymph and deutonymph follows the scheme of ZACHVATKIN (1953), who considered that postlarval segments are added subterminally, hypothesis discussed and refuted by GRIFFITHS *et al.* (1990). SHALDYBINA's (1972) notation system for notogastral setae is given in Table 1.

The Ceratozetoidea are in the group of taxa which GRANDJEAN (1949) noted are unideficient as nymphs and bi- or multideficient as adults. Although GRANDJEAN did not study notogastral setal loss in the Ceratozetoidea directly, a review of his papers on the other higher oribatid taxa (e.g., 1951b, 1958, 1967, 1968) shows that based on studies of immature oribatid mites he viewed as most probable the loss of particular setae as outlined in Table 1.

SHALDYBINA (1972, 1975) appreciated the systematic value of losses of notogastral setae in adult Sphaerozetinae and used these losses to separate genera such as *Ghilarovizetes*, *Melanozetes* and *Fuscozetes*. SHALDYBINA (1972) in her study on the Ceratozetoidea accepted GRANDJEAN's hypothesis on the loss of certain setae, but disagreed with others. An outline her hypotheses on probable notogastral setal loss in the Sphaerozetinae is given in Table 1. It is sometimes difficult to compare her probable losses with those of GRANDJEAN as her "unideficient" notation although similar to that of GRANDJEAN, is not completely homologous.

TABLE 1 : Losses of some setae in adults of higher oribatids after GRANDJEAN (1934, 1939, 1949) and SHALDYBINA (1972)

Notogastral setae present (+) or absent (—)

GRANDJEAN :

Holotrichous notation	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	D <sub>3</sub>	D <sub>1</sub>	D <sub>2</sub>	E <sub>1</sub>	E <sub>2</sub>	F <sub>1</sub>	F <sub>2</sub>	H <sub>1</sub>	H <sub>2</sub>	H <sub>3</sub>	p <sub>1</sub>	p <sub>2</sub>	p <sub>3</sub>	Representative taxa
15 setal pairs (unideficient)	c <sub>1</sub>	c <sub>2</sub>	c <sub>3</sub>	la	da	dm	dp	lm	—	lp	h <sub>1</sub>	h <sub>2</sub>	h <sub>3</sub>	p <sub>1</sub>	p <sub>2</sub>	p <sub>3</sub>	
14 setal pairs	+	+	—	+	+	+	+	+	—	+	+	+	+	+	+	+	
13 setal pairs	—	+	—	+	+	+	+	+	—	+	+	+	+	+	+	+	
11 setal pairs	+	+	—	+	—	—	—	+	—	+	+	+	+	+	+	+	
10 setal pairs	—	+	—	+	—	—	—	+	—	+	+	+	+	+	+	+	

SHALDYBINA :

Holotrichous notation	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	—	D <sub>1</sub>	D <sub>2</sub>	E <sub>1</sub>	E <sub>2</sub>	F <sub>1</sub>	F <sub>2</sub>	PN <sub>1</sub>	PN <sub>2</sub>	H <sub>1</sub>	H <sub>2</sub>	OP <sub>1</sub>	OP <sub>2</sub>	Representative taxa	
15 setal pairs (unideficient)	c <sub>1</sub>	c <sub>2</sub>	c <sub>3</sub>	—	da	la	dm	lm	dp	lp	pn <sub>1</sub>	pn <sub>2</sub>	h <sub>1</sub>	h <sub>2</sub>	OP <sub>1</sub>	OP <sub>2</sub>	<i>Ghilarovizetes</i>	
14 setal pairs	—	+	+	—	+	+	+	+	+	+	+	+	+	+	+	+		<i>Melanozetes</i>
11 setal pairs	—	+	+	—	+	+	—	—	+	—	+	+	+	+	+	+		<i>Shaerozetes</i>
10-11 setal pairs	—	+/+	—	+	+	—	—	—	+	+	+	—	+	+	+	+		<i>Fuscozetes</i>
10 setal pairs	—	+	—	—	+	+	—	—	+	—	+	+	+	+	+	+		<i>Edwardzetes</i>

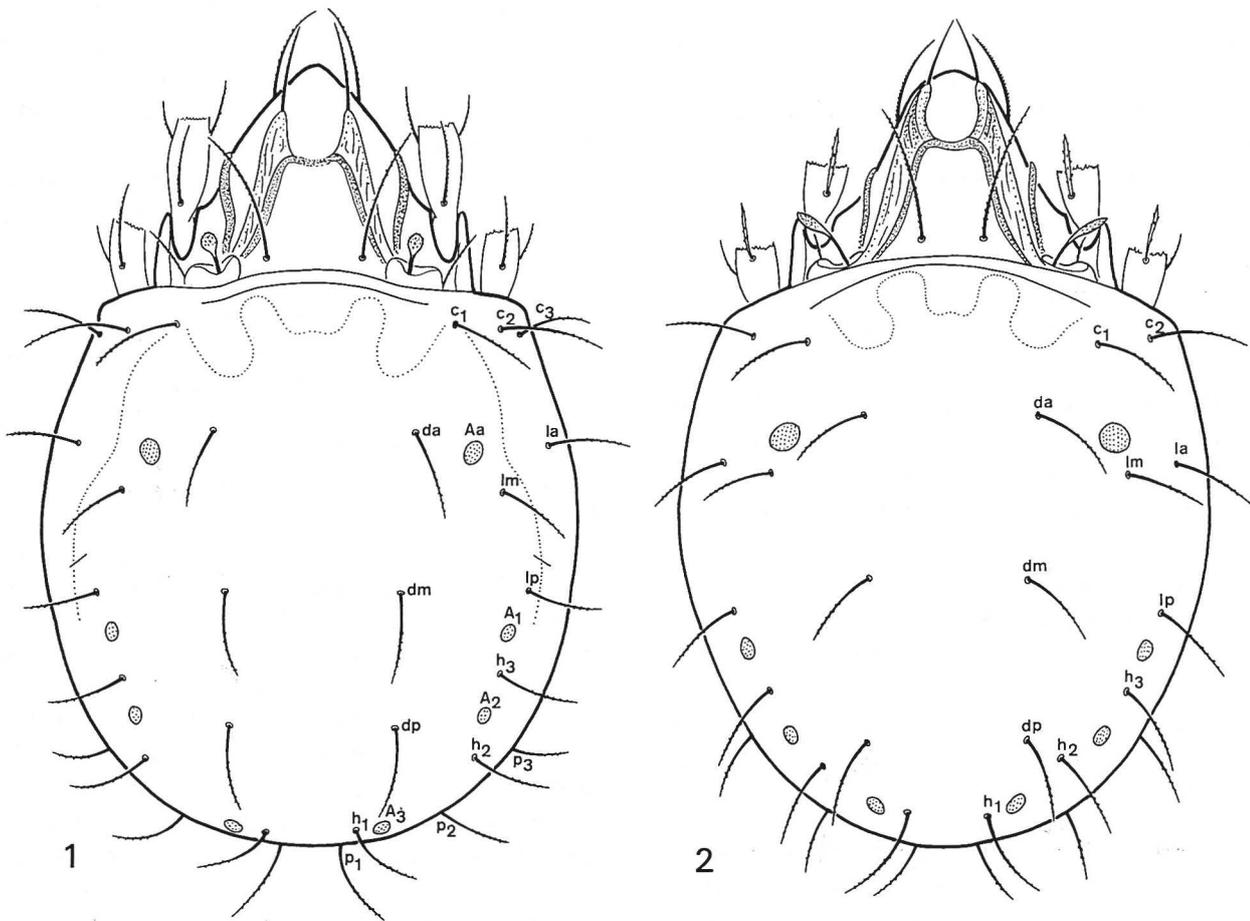


FIG. 1 : *Ghilarovizetes longisetosus* (Hammer), adult, dorsal aspect ( × 149).

FIG. 2 : *Melanozetes meridianus* Sellnick, adult, dorsal aspect ( × 171.5).

These differing points of view on notogastral setal losses in the adult have stimulated us to reanalyze this problem on the basis of an examination of the Sphaerozetinae. We examined adults and immatures of representative species of all genera in this subfamily to see if it is possible to correlate adult notogastral setal reductions with other morphological character states.

#### MATERIAL AND METHODS

Adult and immature stages of the following 11 species of the subfamily Sphaerozetinae were examined for this study: *Edwardzetes edwardsii* Nicolet, *Fuscozetes fuscipes* (C. L. Koch), *F. setosus* (C. L. Koch), *Fuscozetes* sp. 2, *Ghilarovizetes longisetosus* (Hammer), New Comb., *Melanozetes meridianus* Sellnick, *M. mollicomus* (C. L. Koch), *M. sellnicki* (Hammer), New Comb., *Sphaerozetes arcticus* Hammer, *S. firthensis* Behan-Pelletier and *S. piriformis* (Nicolet).

These mites were collected from the following sites and plant communities:

Poland, Karkonosze National Park near Szklarska Poreba, *Pinetum mughi sudeticum*: *Edwardzetes edwardsii*, *Melanozetes meridianus* and *Sphaerozetes piriformis*;

Poland, Preserve Cisy Staropolskie in Tuchola Forest, *Arrhenatheretum elatoralis*: *Fuscozetes fuscipes* and *Melanozetes mollicomus*;

Poland, Tatry National Park near Zakopane, *Pinetum mughi carpathicum*: *Fuscozetes setosus* and *Fuscozetes* sp. 2;

Canada, Yukon, British Mountains, *Carex*, *Equisetum*, *Salix*, moss: *Ghilarovizetes longisetosus* and *Sphaerozetes arcticus*;

Canada, Yukon, Ogilvie Mountains, *Geum glacialis*, *Saxifraga oppositifolia*, moss: *Sphaerozetes firthensis*.

We present illustrations of the dorsal aspect of adult representatives of the following species: *Ghilarovizetes longisetosus* (Fig. 1), *Melanozetes meridianus* (Fig. 2), *Fuscozetes setosus*, with details of the different patterns of notogastral setation

(Fig. 3, 4), *Fuscozetes* sp. 2 (Fig. 5), *F. fuscipes* (Fig. 6), *Edwardzetes edwardsii* (Fig. 7) and *Sphaerozetes piriformis* (Fig. 8), to show the order of losses in the process of reduction of notogastral setae; and illustrations of the juvenile stages of the above species other than *Fuscozetes* sp. 2 and *F. fuscipes* (Figs. 9-15) to show the humeral sclerites and lateroabdominal shield, both important morphological characters for this study. Terminology used follows that of GRANDJEAN (see TRAVÉ and VACHON, 1975 for many references).

#### RESULTS

##### ADULT

The Sphaerozetinae include species with a great diversity in number of notogastral setae in the adult. SHALDYBINA (1975) recognized the following 5 genera in this subfamily: *Ghilarovizetes* Shaldybina, *Melanozetes* Hull, *Fuscozetes* Sellnick, *Edwardzetes* Berlese and *Sphaerozetes* Berlese. Detailed observation of the adults of these genera led us to the conclusion that *Ghilarovizetes*, *Melanozetes* and *Fuscozetes* are morphologically very similar, differing primarily in the number of notogastral setae. *Ghilarovizetes*, represented by *G. longisetosus*, has an unidifferentiated notogastral setation, with 15 pairs of setae (Fig. 1). Members of *Melanozetes*, represented here by *M. meridianus*, *M. mollicomus* and *M. sellnicki*, have one pair of setae less (14 pairs), with  $c_3$  lost. In adults of *Fuscozetes*, represented by *F. setosus* (Figs. 3, 4), *Fuscozetes* sp. 2 (Fig. 5) and *F. fuscipes* (Fig. 6), setae  $c_1$  are lost in addition, and setae of the  $d$  series are subject to loss. According to GRANDJEAN (1939, 1949) the first setae of the  $c$  series subject to reduction is  $c_3$ , whereas SHALDYBINA (1972) considers that the setal pair lost is  $c_1$ . On the basis of a comparison of the position of  $c_1$  and  $c_3$  in *G. longisetosus*, anterior of porose area  $Aa$ , and on the anterolateral margin of the notogaster, respectively, with the position of the  $c$  setae in *Melanozetes*, it is most probable that  $c_3$  is lost in members of this genus.

*Fuscozetes* is a very interesting genus with regard to our interpretation of notogastral setal loss. In *F.*

TABLE 2 : The losses of some setae *d*-serie in the adult of *Fuscozetes setosus* in the population from Tatry Mountain.

Number of notogastral setae	Loss of setae	Number of individuals
26		50
25	one seta of <i>da</i>	115
24	a pair of <i>da</i>	612
23	a pair of <i>da</i> and one setae of <i>dm</i>	41
22	pairs of <i>da</i> and <i>dm</i>	76

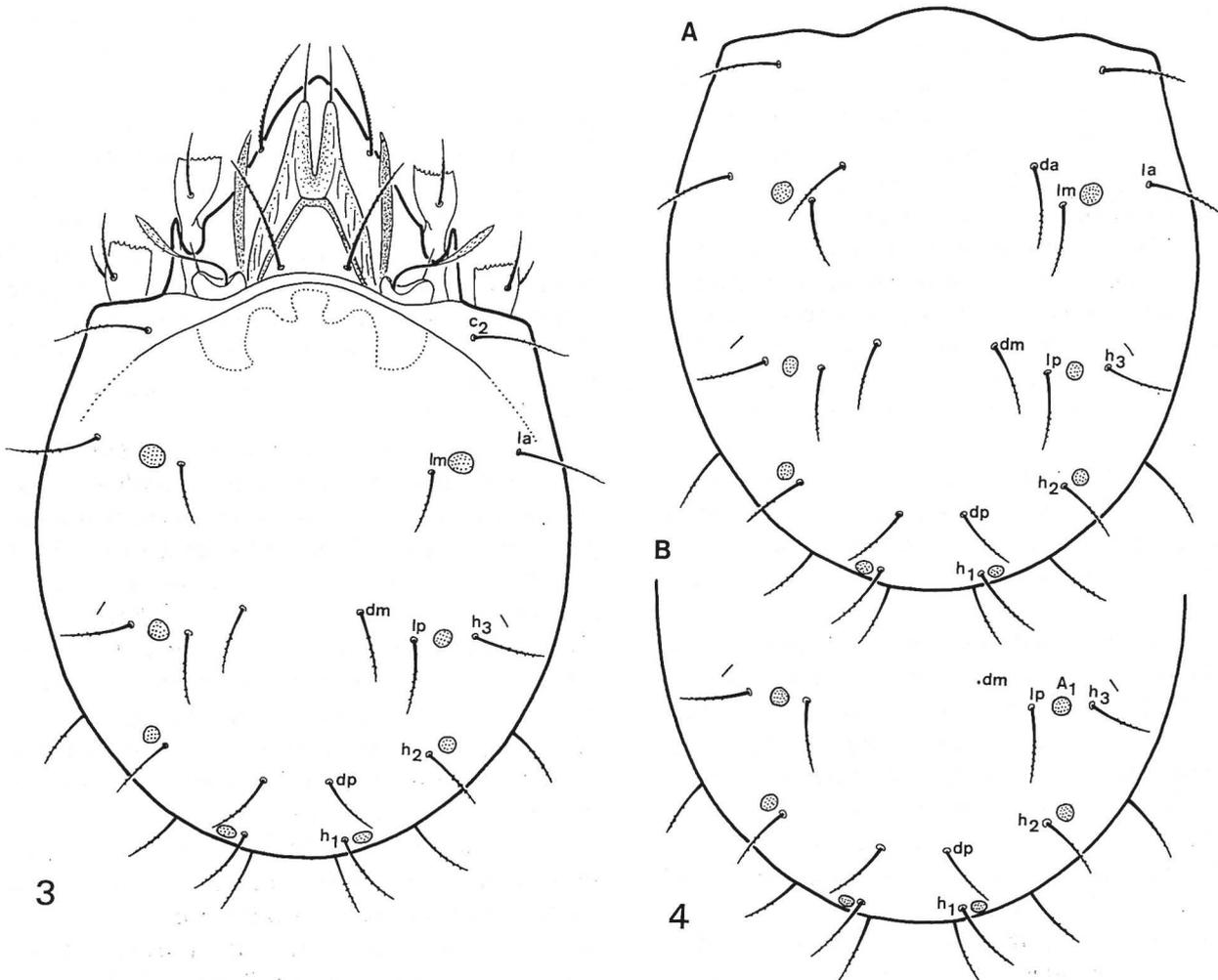


FIG. 3 : *Fuscozetes setosus* (C. L. Koch), adult, dorsal aspect ( × 164.84).

FIG. 4 : The notogastral setation of adult in *Fuscozetes setosus* (C. L. Koch) : A — with all *d* series setae, B — with setae *da* and *dm* lost.

*setosus* 11 to 13 pairs of notogastral setae are present, and setation is quite fluid in this species. Most specimens from the Tatry Mountains population have 12 pairs of notogastral setae with *da* lost (Fig. 3, Table 2). However, many specimens had all setae of the *d* series present (Fig. 4 A), or only one pair (*dp*), with setae *da* and *dm* lost (Fig. 4 B). Specimens with intermediate patterns of notogastral setation were also present, with only one seta of the pair *da* or *dm* lost (Table 2). In many specimens the setal alveoli were still visible although setae *da* or *dm* were lost (Fig. 4 A).

It is clear that the process of reduction of the *d* series setae begins with *da* and continues to *dm*, because if only one of setal pair *da* is lost, setae *dm* are always present on the notogaster. Alternatively if only one of setal pair *dm* is lost, setae *da* are also lost (Table 2). In the specimens of *F. setosus* examined, lability of notogastral setae applied to *da* and *dm* only; setae *dp* were constant, and present in all adults of the specimens discussed.

In other species of *Fuscozetes* examined, i.e., *Fuscozetes* sp. 2 and *F. fuscipes*, setae of the *d* series are absent (10 pairs of notogastral setae). But in *Fuscozetes* sp. 2 alveoli of setae *dp* are clearly visible. Therefore we can conclude that *Fuscozetes* species with 10 pairs of setae on the notogaster are closely related to *Fuscozetes* species with some or all of the *d* series setae. On the basis of their variability in *F. setosus*, loss of setae *da* and *dm* would appear to have no systematic value, but loss of setae *dp* is important character state which can be used to separate species.

On the other hand loss of setae  $c_3$  and  $c_1$  appear to be stable for any group of species and we consider them to have greater systematic value than losses in the *d* series, and therefore, useful to separate genera. Within the Sphaerozetinae, therefore, the diagnosis for *Ghilarovizetes* is NG15, for *Melanozetes* NG14 (loss of  $c_3$ ), for *Fuscozetes* NG10-13 (loss of  $c_1$  in addition to  $c_3$ , and loss of some or all of *d* series setae).

In comparison with their position in *Ghilarovizetes* and *Melanozetes* a distinct centrodorsal migration of setae *lm*, *lp* and  $h_3$  is visible in *Fuscozetes*. These setae take a more centrodorsal position even when all *d* series setae are present on the notogaster

(Fig. 4 A), with the result that *lm* are positioned mediad of porose areas *Aa*, *lp* are positioned mediad of porose areas  $A_1$ , and  $h_3$  is laterad of  $A_1$ , rather than being midway between  $A_1$  and  $A_2$  as in *Melanozetes*. As *lm*, *lp* and  $h_3$  have already shifted their position in specimens of *F. setosus* with 13 pairs of notogastral setae, loss of setae *da* and *dm* has no further visible effect on the position of these or other notogastral setae (Figs. 3, 4). However, in *Fuscozetes* sp. 2 and *F. fuscipes*, with loss of setae *dp*, setae  $h_1$  take a more centrodorsal position (Figs. 5, 6). It should be noted that in *Fuscozetes* sp. 2 setae  $h_1$  take this position even with the alveoli for *dp* still present.

SHALDYBINA (1972) interpreted setal loss in *Fuscozetes* to involve setae *dm*, *lm* and  $pn_2$  (NG10 or NG11), on the basis of a comparison of setal position and subsequent loss, between genera. There is much validity in her argument if we ignore movement of lateral notogastral setae to more centrodorsal positions. However it is clear from the data of *F. setosus* given above, that movement of lateral setae does occur, and it may even anticipate actual loss of *d* series setae. The above observations show clearly that losses of notogastral setae in adult Sphaerozetinae occur in the order postulated by GRANDJEAN (1939, 1949).

If we consider the loss of some, and the movement of other notogastral setae in *Ghilarovizetes*, *Melanozetes*, and *Fuscozetes* it is evident that these genera are closely related and form a well-defined "*Melanozetes* group". In this group we hypothesise the most primitive genus to be *Ghilarovizetes* with a unideficient notogastral setation. *Melanozetes* and *Fuscozetes* share the apomorphy of loss of setae  $c_3$ . Species of *Fuscozetes*, in turn, express loss of setae  $c_1$ , and often setae of the *d* series. Genera in this group also share the apomorphy of a distinct ventral carina on femora I to IV.

Transformations in other characters are evident in this group of genera but may not parallel notogastral setal losses. In *Ghilarovizetes longisetosus* the sensillus is short with a clavate head, whereas in *Melanozetes meridianus* and *Fuscozetes setosus* the sensillus is much longer with a slender head. However, in *Fuscozetes* sp. 2 the sensillus is again short. In *G. longisetosus* lamellae are well

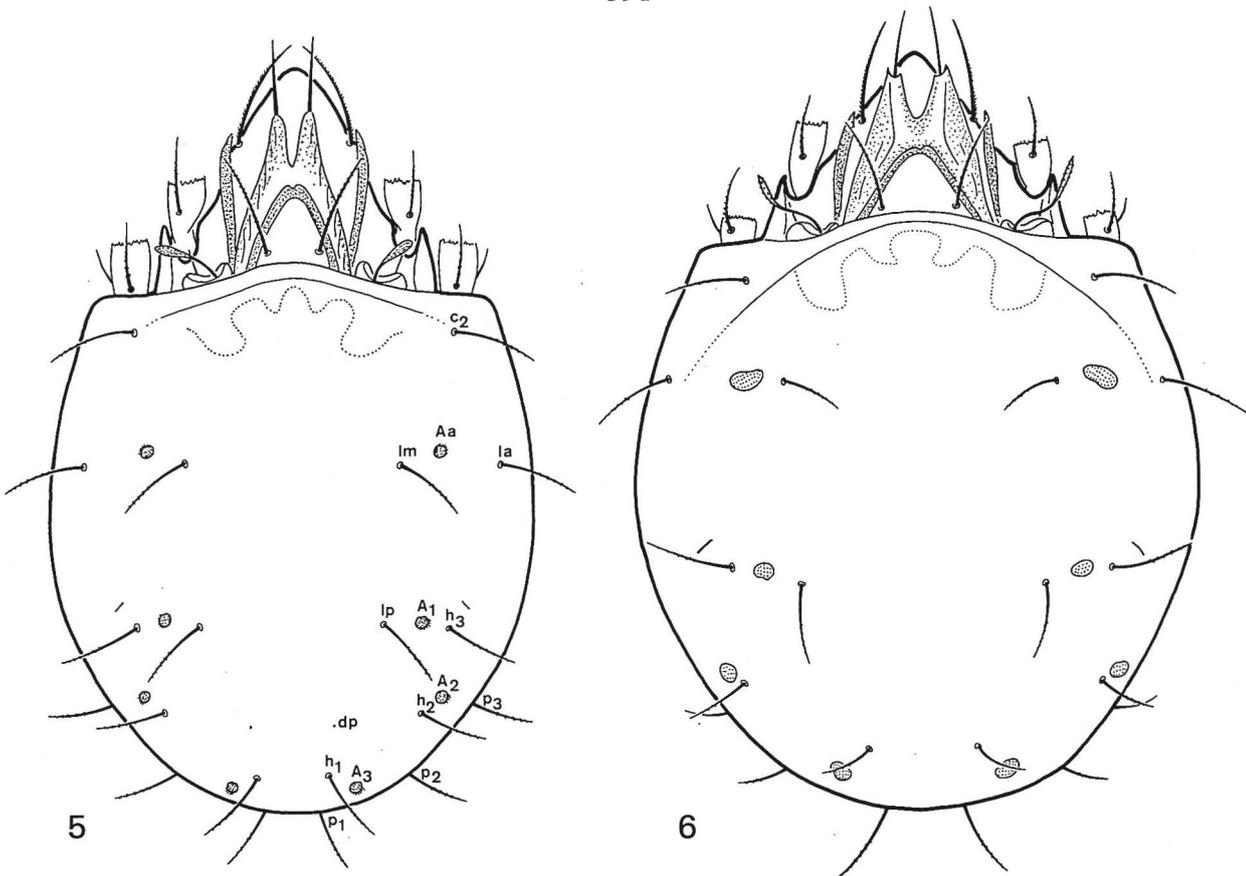


FIG. 5 : *Fuscozetes* sp. 2, adult, dorsal aspect ( × 133.92).

FIG. 6 : *Fuscozetes fuscipes* (C. L. Koch), adult, dorsal aspect ( × 133.44).

developed but the translamella is indistinct. In *M. meridianus* the translamella is clearly visible, and in *Fuscozetes* it is short and broad, and in some species in this genus the lamellae are virtually connected.

Although the adult notogastral setation of *Edwardzetes edwardsii* is similar to that of *Fuscozetes* sp. 2 and *F. fuscipes*, the shapes of the rostrum and lamellae differ. Adults of *E. edwardsii* have 2 small lateral teeth on the rostrum, whereas the rostrum is rounded in all members of the “*Melanozetes* group” (Figs. 1, 2, 3, 5, 6, 7). In *E. edwardsii* lamellae are narrow and without a translamella or cusps. In addition, there is no distinct ventral carina on femora I to IV in *E. edwardsii*, whereas this carina is well developed in the “*Melanozetes* group”.

Adults of *Sphaerozetes* differ both from those of

the “*Melanozetes* group” and from *E. edwardsii*. Setae  $c_1$  and  $c_2$  are present on the notogaster in *Sphaerozetes* but  $d$  series setae are absent; a pattern unique to the Sphaerozetinae (Fig. 8). Other morphological character states by which adult *Sphaerozetes* differ from those of the “*Melanozetes* group” are: in *Sphaerozetes* the rostrum is protected by 2 distinct lateral teeth, whereas this part of the body is rounded in the “*Melanozetes* group”. Porose area  $Aa$  and  $A_3$  are elongated in *Sphaerozetes*, whereas these porose areas are rounded in the “*Melanozetes* group” and there are no distinct ventral carina on femora I to IV in *Sphaerozetes*.

#### JUVENILES

The observations we have carried out on notogastral setal losses in adults of Sphaerozetinae genera, and the relationships between genera we

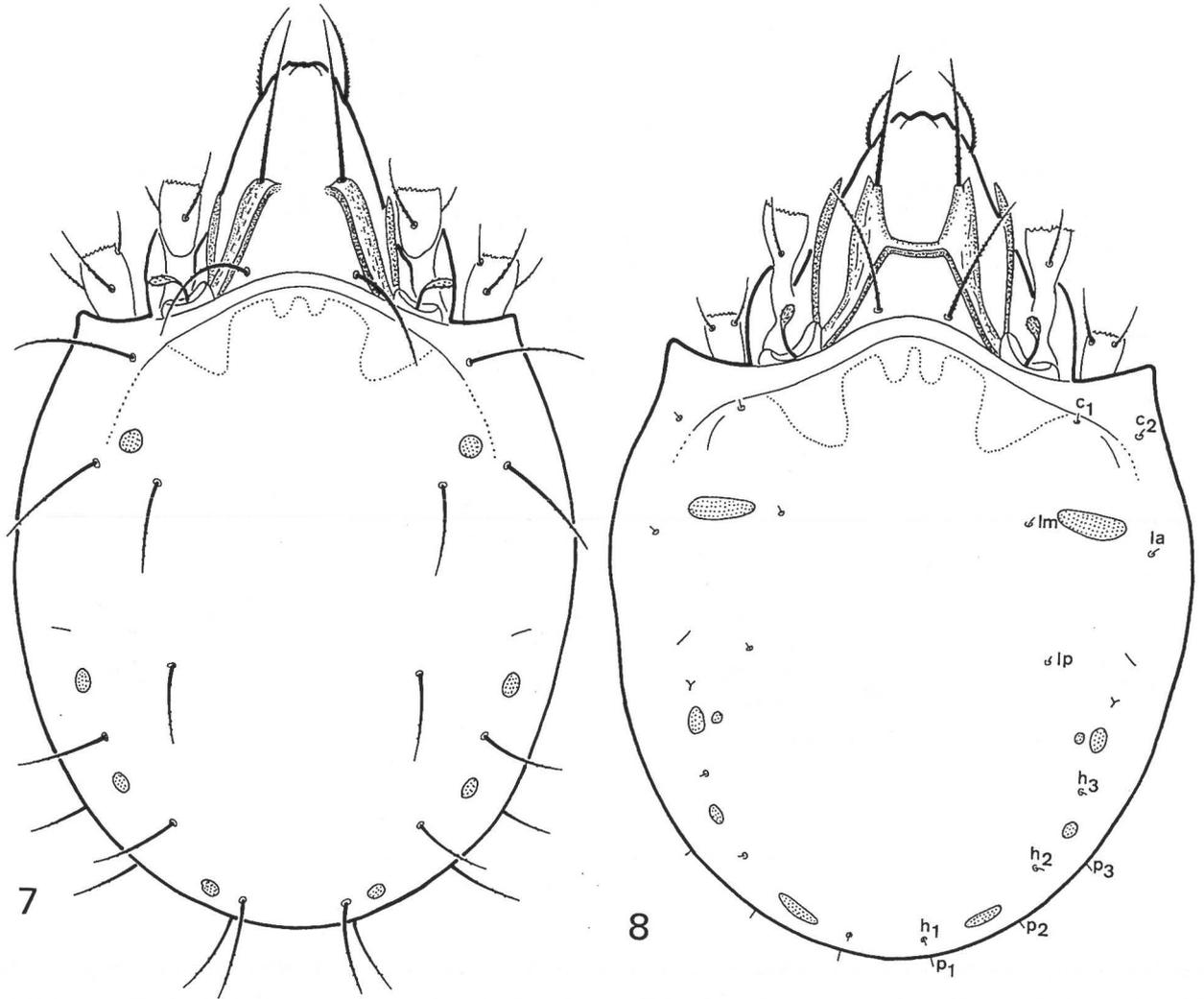


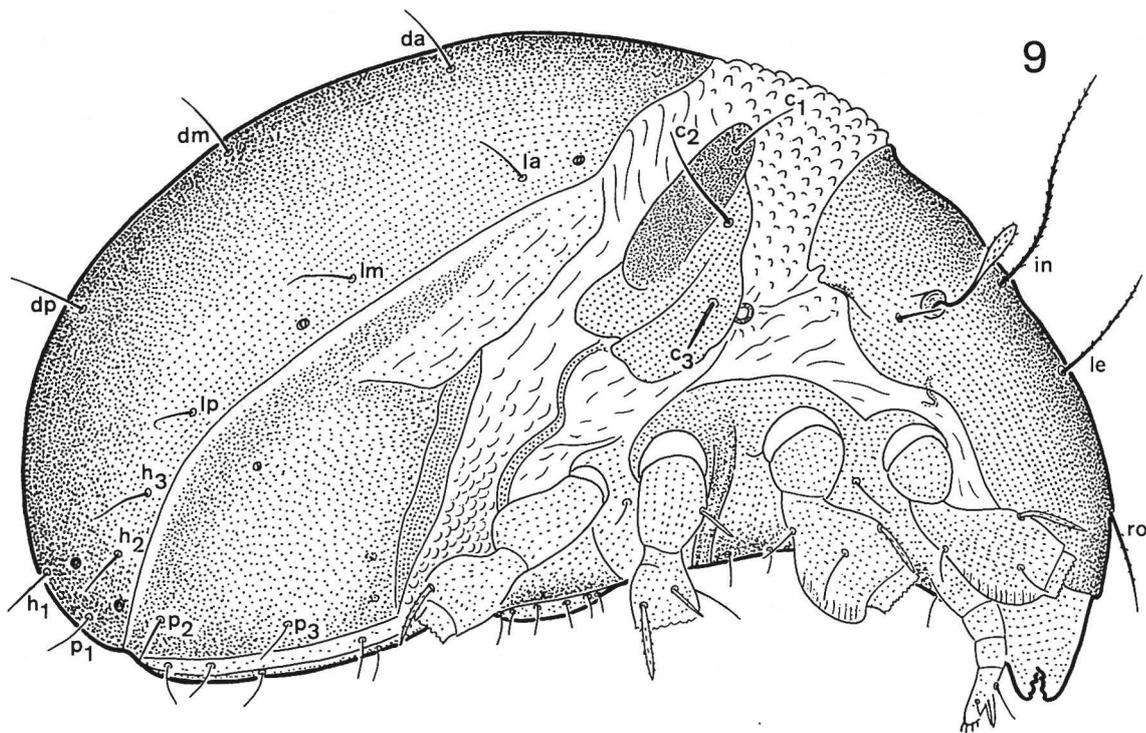
FIG. 7 : *Edwardzetes edwardsii* Nicolet, adult, dorsal aspect ( × 148.77).  
 FIG. 8 : *Sphaerozetes piriformis* (Nicolet), adult, dorsal aspect ( × 164.73).

have proposed are supported by observations on the morphology of the juvenile stages as well. In comparing the larvae and nymphs of *Ghilarovizetes*, *Melanozetes*, and *Fuscozetes* we see that the humeral region and the shape of the lateroabdominal shield differ between genera. In *G. longisetosus* the humeral macrosclerite is large, reaches the opening of the humeral organ and bears all *c* series setae (Fig. 9). In juvenile *Melanozetes meridianus* the humeral macrosclerite is smaller and does not reach the humeral organ opening. It bears only setae *c*<sub>1</sub>, and other *c* series are borne on their own microsclerites (Fig. 10). In the larva of some *Fuscozetes* (*F. setosus* and *Fuscozetes* sp. 2) setae *c*<sub>1</sub> are still borne

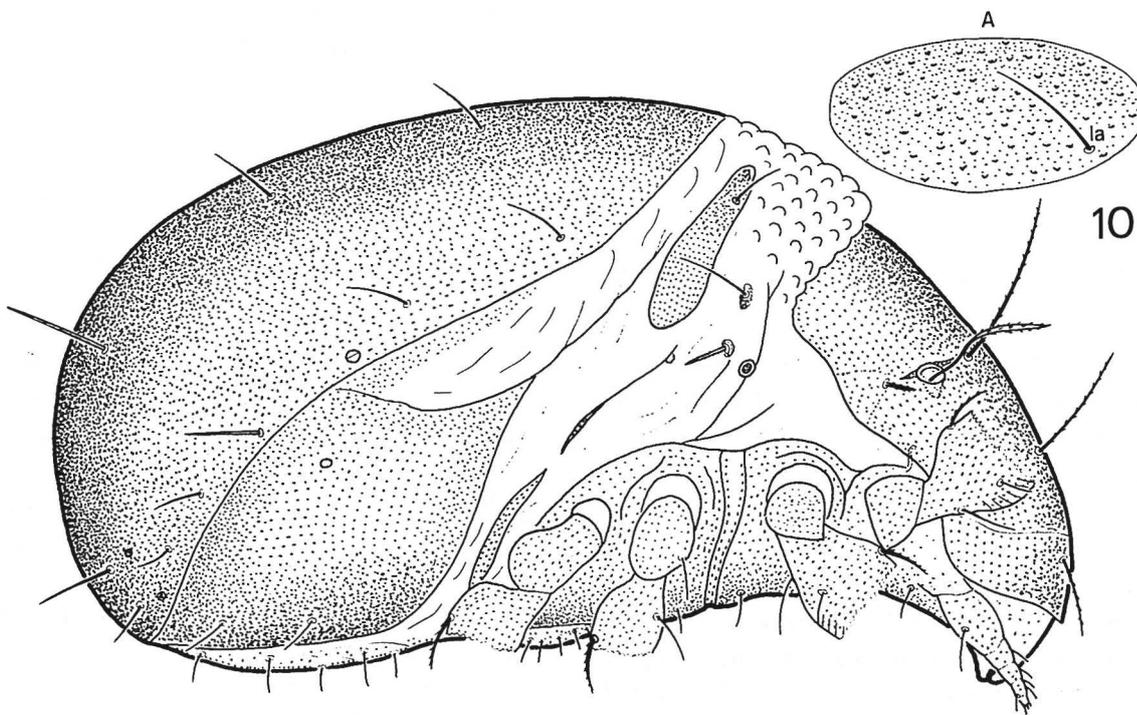
on the humeral macrosclerite (Fig. 11); but in the larva of *F. fuscipes* and in all nymphs of this genus there are no setae on the humeral macrosclerite, and all *c* series setae are borne on their own microsclerites (Fig. 12).

In *G. longisetosus* the large and well sclerotized lateroabdominal shield is positioned between the lateral border of the pygidial shield and the adanal region (Fig. 9). In *M. meridianus* the lateroabdominal shield is reduced in size but its shape is still rhomboidal, as in *G. longisetosus* (Fig. 10). In *F. setosus* this shield is distinctly smaller and its shape is oval (Fig. 12).

In the larvae of *Fuscozetes* the gastronotal shield



9



10

FIG. 9 : *Ghilarovizetes longisetosus* (Hammer), tritonymph, lateral aspect ( × 140.5).

FIG. 10 : *Melanozetes meridianus* Sellnick, tritonymph, lateral aspect ( × 231.4). A — fragment of notagaster.

is divided into two (*F. setosus* and *Fuscozetes* sp. 2) or more pieces (*F. fuscipes*), but in all nymphal stages this shield is uniform in the species studied.

Although the juvenile stages of *Fuscozetes* are more morphologically differentiated than those of *Melanozetes*, generic character states are evident. Thus the juvenile stages of these two genera can be distinguished from each other by the following :

LARVA :— shape of the gastronotal shield : uniform in *Melanozetes* ; divided into 2 or more sections in *Fuscozetes* ;

NYPHS :— setation of the humeral macrosclerite : this sclerite bears setae  $c_1$  in *Melanozetes* ; and no setae in *Fuscozetes* ;

ALL JUVENILES :— relative length of setae  $le$  :  $le$  longer than  $ro$  in *Melanozetes* ; shorter than  $ro$  in *Fuscozetes* ;

— location of humeral organ opening : situated in front of seta  $c_3$  in *Melanozetes* ; near the posterolateral corner of the aspis in *Fuscozetes* (Figs. 10, 11, 12) ;

— shape of the lateroabdominal shield : large and rhomboidal in *Melanozetes* ; smaller and oval in *Fuscozetes* ;

— ornamentation of the notogastral shield : punctated in *Melanozetes* (Fig. 10 A) ; with a light network in *Fuscozetes* (Fig. 12 A).

Larva of *E. edwardsii* are similar to those of *F. setosus* and *Fuscozetes* sp. 2 because the gastronotal shield is divided into 2 parts — frontal and pygidial (Fig. 13). However, all juvenile stages of *E. edwardsii* differ from those of *Fuscozetes* by the following :

— presence of setae  $c_1$  on the humeral macrosclerite :  $c_1$  situated on the border of the humeral macrosclerite in *E. edwardsii* ; humeral macrosclerite generally bare in *Fuscozetes*, except that  $c_1$  borne it in some larvae (*F. setosus*, *Fuscozetes* sp. 2) ;

— relative length of setae  $le$  :  $le$  as long as  $ro$  in *E. edwardsii* ; shorter than  $ro$  in *Fuscozetes* ;

— location of the humeral organ opening : opening on the lateral side of seta  $c_3$  with small tubercles posteriad of it, in *E. edwardsii* (Figs. 13, 14) ; opening near posterolateral corner of aspis in *Fuscozetes* (Figs. 11, 12) ;

— presence of distinct lateroabdominal shield : absent in *E. edwardsii*, only dark pigmentation present ; well-developed in *Fuscozetes* ;

— ornamentation of the gastronotal shield : punctated in *E. edwardsii* ; with light network pattern in *Fuscozetes* ;

— ventral carina on femora I to IV : absent in *E. edwardsii* ; present in *Fuscozetes*.

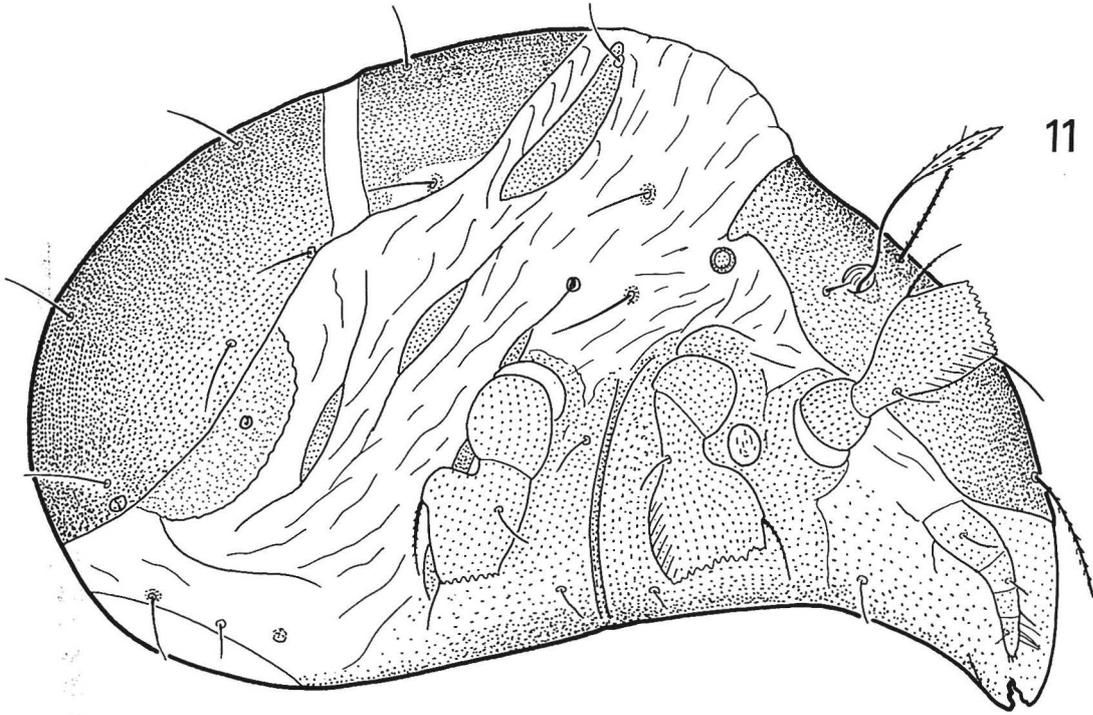
On the basis of the morphological differences between juvenile stages of *E. edwardsii* and *Fuscozetes* we do not consider these taxa closely related, even though there are some similarities in the morphology of the larval stages.

Juvenile stages of *Sphaerozetes* differ from those of the “*Melanozetes* group” mainly by the distinctly shorter gastronotal setae, bigger humeral organ opening, with small tubercles posteriad of it, as in *E. edwardsii*, and the lack of a distinct lateroabdominal shield (Fig. 15). Because *Sphaerozetes* and *Edwardzetes* share the character states of presence of tubercles posteriad of the humeral organ and the lack of a distinct lateroabdominal shield we consider them to be distinct from the “*Melanozetes* group” of genera.

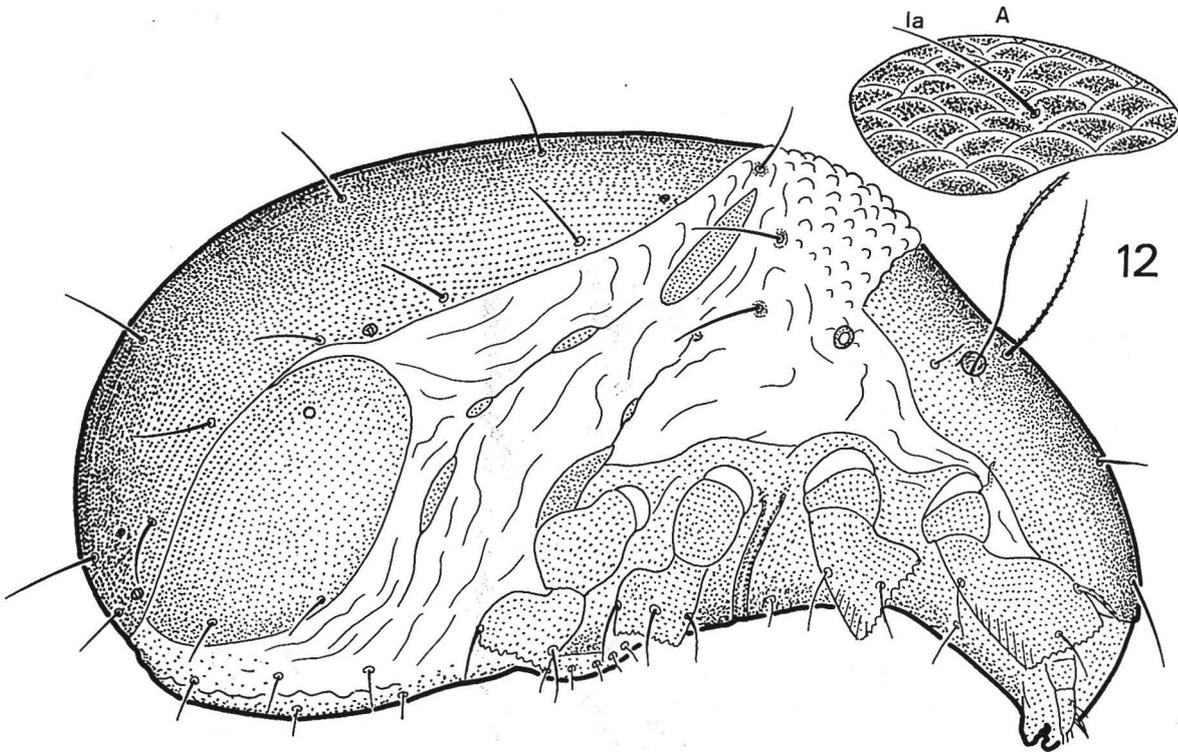
#### DISCUSSION

The notogastral setation of many groups of moss mites is still poorly known. The taxonomy of these mites is based mainly on non-setal characters such as, the shape of the prodorsum and notogaster, presence and shape of lamella and translamella, presence and shape of pteromorphs, shape of tatoria, pedotecta, teeth, tubercles, furrows etc. As the exoskeleton of most oribatid mites is well sclerotized and there are many characters to consider, it is possible to divide these mites into many taxonomic groups. But such groups may be artificial, especially if we do not know the systematic value of the character states being used for dividing the mites into groups.

A systematic problems of this types is evident in the Ceratozetidae. SHALDYBINA (1966, 1975) divided this group of mites into 3 subfamilies on the basis of adult features such as : mobility of the



11



12

FIG. 11 : *Fuscozetes setosus* (C. L. Koch), larva, lateral aspect (  $\times 439.96$  ).

FIG. 12 : *Fuscozetes setosus* (C. L. Koch), tritonymph, lateral aspect (  $\times 225.08$  ). A — fragment of notogaster.

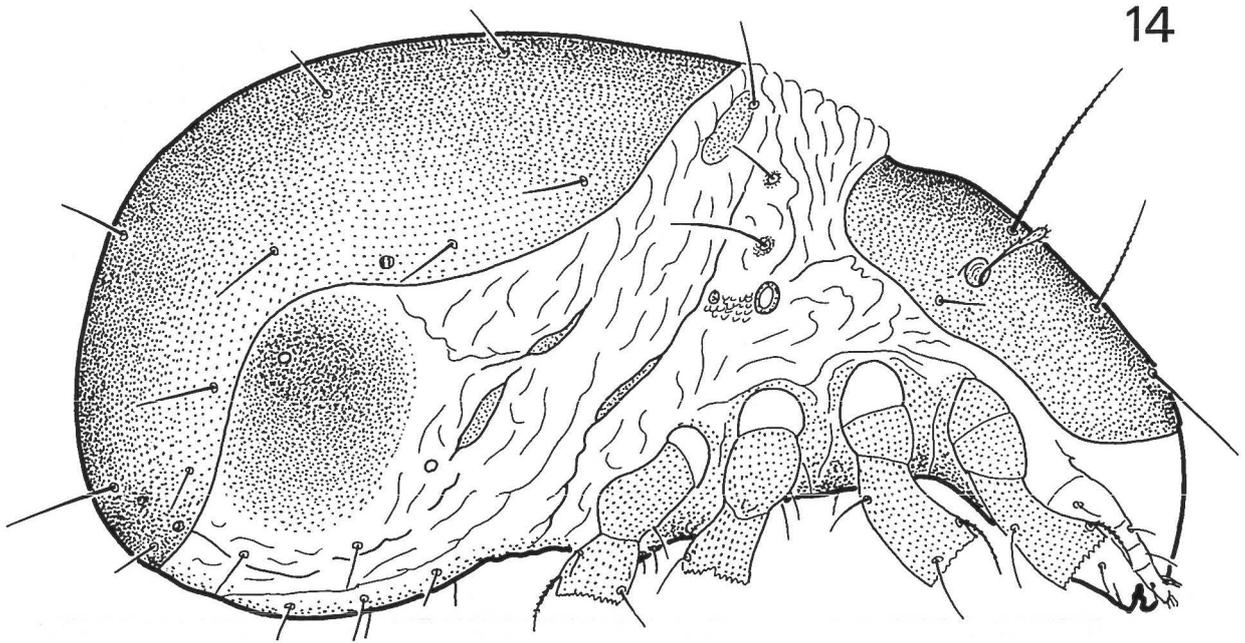
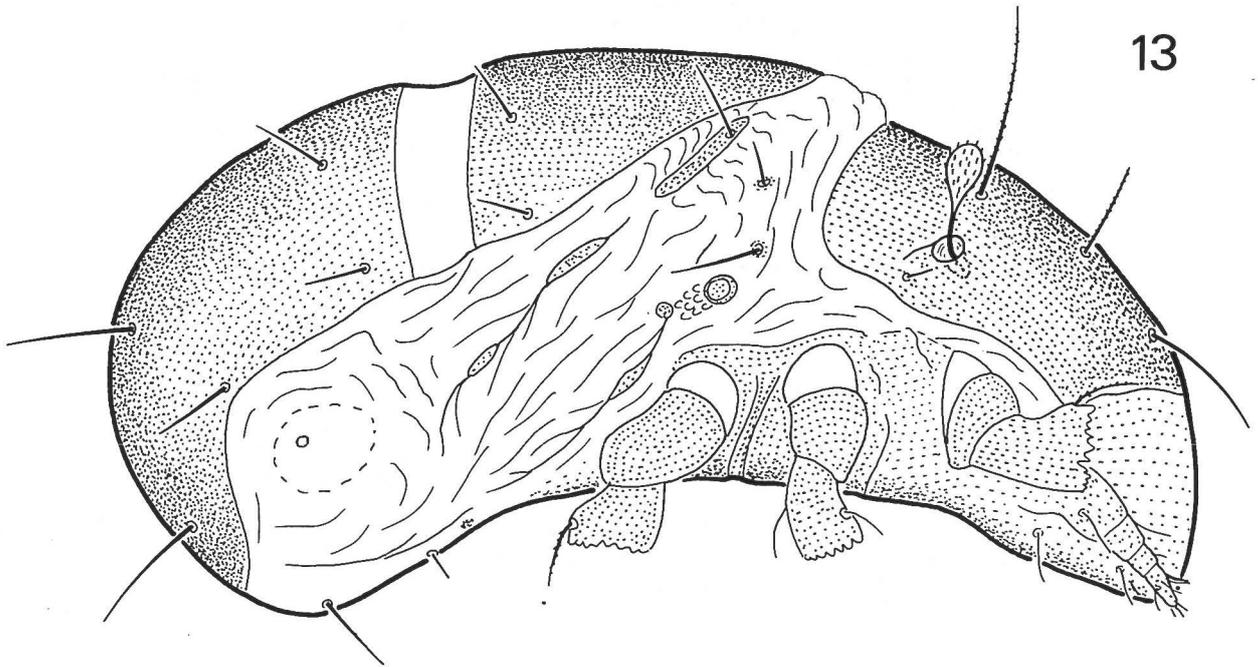


FIG. 13 : *Edwardzetes edwardsii* Nicolet, larva, lateral aspect (  $\times 416.1$  ).  
FIG. 14 : *Edwardzetes edwardsii* Nicolet, tritonymph, lateral aspect (  $\times 229.22$  ).

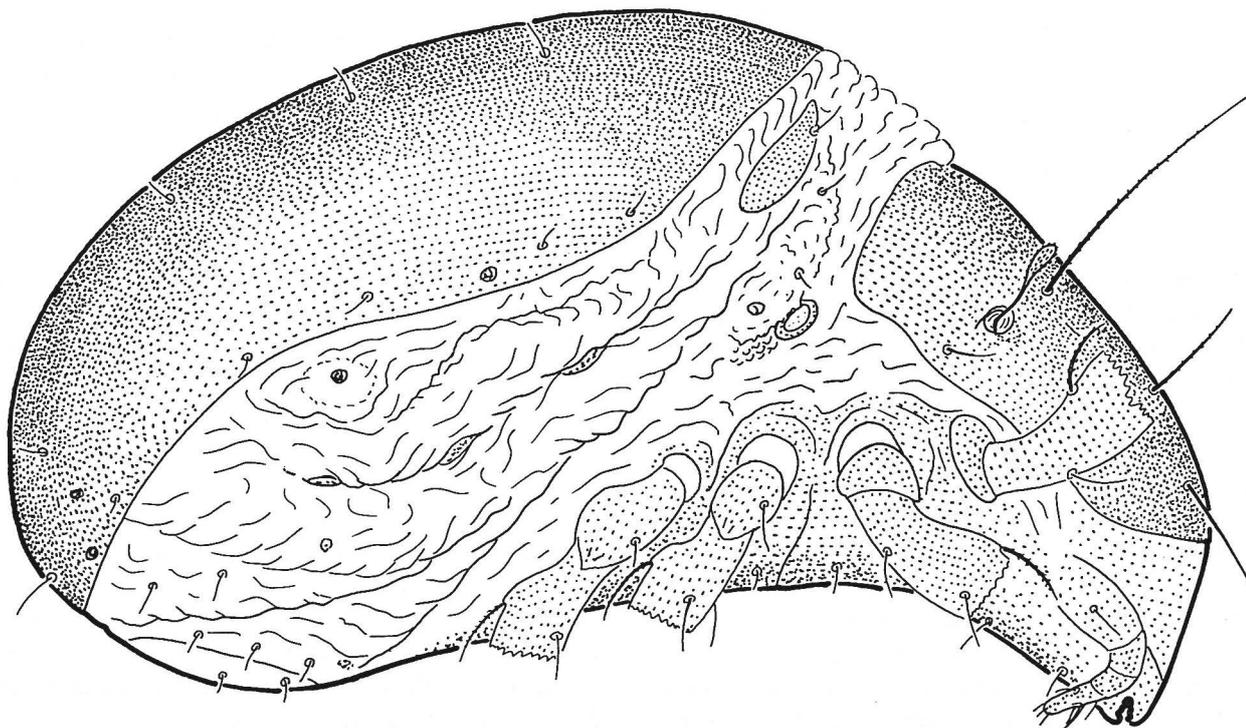


FIG. 15 : *Sphaerozetes piriformis* (Nicolet), tritonymph, lateral aspect (  $\times 253.08$  ).

pteromorphs, shape of tutorium, rostrum, lamella, and translamella, number of notogastral setae etc. In the Sphaerozetinae and Ceratozetinae she considered the notogastral setation as the most important systematic character, whereas in the Trichoribatinae she considered exoskeleton characters as more important for separating genera and species. We consider that in related genera, such as those in the Ceratozetidae, if a particular character state is useful for defining relationships in one subfamily, it may also be useful in another.

In the present research we have emphasized notogastral setation, as according to GRANJEAN's various publications (e.g., 1939, 1949) losses of some notogastral setae can provide information on the phylogeny of moss mites. Using representative species of all genera of the Sphaerozetinae it was an easy task to demonstrate the successive losses of notogastral setae from the unidifferent pattern (NG15) in *Ghilarovizetes* to the 10 setal pair pattern in some species of *Fuscozetes*. As we have shown

the process of reduction of some notogastral setae in adults of the "*Melanozetes* group" follows a pattern proposed by GRANJEAN (1934-1939), starting with loss of setae  $c_3$  in *Melanozetes*. Following loss of setae  $c_1$  in *Fuscozetes*,  $d$  series setae are exposed to reduction. We can easily observe loss of  $da$  and  $dm$  in *F. setosus* as these setae are labile in this species, and alveoli are often still visible, although setae are lost. With the examination of almost 900 specimens in this species we have established that the reduction starts with  $da$  and continues to include  $dm$ . Because of the lability of these setae, the notogastral setation often was unpaired in this species. Setae  $dp$ , however, were constant in all specimens of *F. setosus* examined, and loss of these setae is only expressed in *Fuscozetes* sp. 2 and *F. fuscipes*.

We consider loss of setae  $c_3$  and  $c_1$  to have greater systematic value than of  $d$  series setae, and we, therefore, use these character states to separate the *Fuscozetes*/*Melanozetes* lineage from *Ghilarovi-*

zetes. At least within Sphaerozetinae loss of setae *da* and *dm* appears to have no systematic value, and only loss of setae *dp* can be used to separate species based on our results.

Our observations on the loss of some notogastral setae contradict those of SHALDYBINA (1972). She considered that the setae that are situated close to porose areas and the opisthosomal gland retain their position during phylogeny to protect these important organs. Therefore, she hypothesized that during phylogeny setae *da* and *la* move closer to porose area *Aa*, setae *h<sub>3</sub>* and *dp* (in GRANDJEAN's terminology) move closer to porose area *A<sub>1</sub>*, setae *h<sub>2</sub>* move closer to porose area *A<sub>2</sub>*, and setae *h<sub>1</sub>* to *A<sub>3</sub>*. In contrast our observations suggest that when setae of the *d* series are lost or subject to reduction, as in *Fuscozetes* there is a distinct movement of setae *lm*, *lp* and *h<sub>3</sub>* in comparison with the position of these setae in *Melanozetes*. Setae *lm* and *lp* take a more centrodorsal position with *lm* mediad of porose area *Aa*, *lp* mediad of porose area *A<sub>1</sub>*, whereas *h<sub>3</sub>* moves anterolaterally and is positioned laterad of porose area *A<sub>1</sub>* rather than between *A<sub>1</sub>* and *A<sub>2</sub>*. In some adults of *F. setosus* these setae have moved to their "new" positions even though the *d* series setae are still retained (Fig. 4 A). With loss of setae *dp* setae *h<sub>1</sub>* take a more anterior position. We have also noted that porose area *A<sub>1</sub>* has a more centrodorsal position in *Fuscozetes* than in *Melanozetes* (Figs. 2, 3, 5). Although setae *lm* and *lp* take a more centrodorsal position with loss of the *d* series setae in *Edwardzetes* and *Sphaerozetes*, setae *h<sub>3</sub>* retain their position between porose areas *A<sub>1</sub>* and *A<sub>2</sub>*. This may be associated with porose area *A<sub>1</sub>* remaining in a laterad position in these genera. The above data from *Fuscozetes*, *Edwardzetes* and *Sphaerozetes* suggest that loss of *d* series setae can have differing effects on the remaining notogastral setae.

In the light of the present study SHALDYBINA's hypothesis on the movement of some notogastral setae in adult Ceratoretidae cannot be accepted. Her hypothesis on the loss of setae *lm* and *h<sub>2</sub>* (GRANDJEAN's terminology) in *Fuscozetes* and *lm* and *lp* in *Edwardzetes* and *Sphaerozetes* even though she considers *da* and *dm* retained, we also consider unacceptable.

The systematic value of loss of setae *c<sub>3</sub>* and *c<sub>1</sub>* in the "Melanozetes group" is supported by morphological features of the juvenile stages. In juvenile stages of *Ghilarovizetes* the humeral macrosclerite is large and bears all *c* series setae. In *Melanozetes* this sclerite is smaller and bears only setae *c<sub>1</sub>*, other *c* series setae are borne on microsclerites (SENICZAK, in press, a). In *Fuscozetes* the humeral macrosclerite is smaller still and setae *c<sub>1</sub>* is borne on this sclerite only in the larvae of some species (SHALDYBINA, 1977, SENICZAK in press, b).

Our observations on loss of some notogastral setae in adult Sphaerozetinae may be useful not only for hypothesizing systematic relationships in this subfamily but also among other genera and species in the Ceratoretidae. Presence or absence of setae of the *c* series is a very easy character to recognize and we consider it to be a better criterion for dividing the mites into groups than some of the exoskeleton features, as it appears to clearly reflect the phylogeny of these mites. When exoskeleton features are emphasized in Sphaerozetinae some difficulties appear in the differentiation of some genera, especially *Melanozetes* and *Fuscozetes* (BEHAN-PELLETIER, 1985, 1986). Knowing the morphology of larvae and nymphs we can separate these genera in the juvenile stages also.

The great lability of setae *da* and *dm* in *F. setosus* and the loss of setae *dp* within *Fuscozetes* mediate against the use of these characters as important criteria for dividing the mites into groups. We encounter this problem in the Trichoribatinae for example where genera such as *Latilamellobates* and *Svalbardia* have the same pattern of notogastral setation, and differ from genera such as *Trichoribatates* and *Oromurcia*, only in the absence of setae *dp*. If we consider the Trichoribatinae and Sphaerozetinae to be closely related subfamilies we must reevaluate the real systematic value of the presence or absence of setae *dp* in Trichoribatinae on the basis of the above examination of sphaerozetine taxa.

Knowing the morphology of both adult and immatures of representative species of all Sphaerozetinae genera we have hypothesized on the relationships among genera, and consider that a distinct "Melanozetes group" is clearly defined, with

*Ghilarovizetes* as the most primitive genus in the group and *Fuscozetes* the most derived. Adults and juvenile stages of *E. edwardsii* and *Sphaerozetes* differ from those of the “*Melanozetes* group” in the absence of distinct carina on femora I to IV. Adults differ by having lateral teeth on the rostrum in contrast to the rounded rostrum in the “*Melanozetes* group”. Juveniles differ by having no distinct lateroabdominal shield, whereas this shield is well developed in the “*Melanozetes* group”. Although both *Edwardzetes* and *Sphaerozetes* lack *d* series setae, porose area  $A_1$  is not moved centro-dorsally and setae  $h_3$  retain a position midway between  $A_1$  and  $A_2$ , as in *Melanozetes* and *Ghilarovizetes*. In addition *Sphaerozetes* retains setae  $c_1$ .

#### CONCLUSIONS

1. Species of *Ghilarovizetes*, *Melanozetes* and *Fuscozetes* form a well-defined “*Melanozetes* group” within Sphaerozetinae, which demonstrates the successive losses of some notogastral setae in the adult.
2. Losses of some notogastral setae in the adult appear in the following order :  $c_3$ ,  $c_1$ , *da*, *dm*, *dp* or  $c_3$ , *da*, *dm*, *dp*.
3. Loss of setae  $c_3$ , in *Melanozetes* and  $c_1$  in *Fuscozetes* has great systematic value and can be used to separate genera.
4. Loss of setae *da* and *dm* has no systematic value because of their lability (e.g., in *F. setosus*), but loss of setae *dp* can be used to separate species.
5. Juvenile stages of genera in the “*Melanozetes* group” differ in the shape of the humeral macrosclerite and the shape of the lateroabdominal shield.

#### REFERENCES

- BALOGH (J.) and BALOGH (P.), 1988. — Oribatid mites of the Neotropical Region. 1. — Akadémiai Kiado, Budapest, 335 pp.
- BEHAN-PELLETIER (V. M.), 1985. — Ceratozetidae of the Western North American Arctic. — *Can. Ent.*, 117 : 1287-1366.
- BEHAN-PELLETIER (V. M.), 1986. — Ceratozetidae (Acari : Oribatei) of the Western North American Subarctic. — *Can. Ent.*, 118 : 991-1057.
- GRANDJEAN (F.), 1934. — La notation des poils gastro-notiques et des poils doreaux du propodosoma chez les Oribates (Acariens). — *Bull. Soc. zool. France*, 40 : 12-44.
- GRANDJEAN (F.), 1939. — Les segments post-larvaires de l'hysterosoma chez les Oribates (Acariens). — *Bull. Soc. zool. France*, 65 : 273-284.
- GRANDJEAN (F.), 1947. — Les Enarthronota (Acariens). Première série. — *Ann. Sci. natur. Zool.*, 8 : 213-248.
- GRANDJEAN (F.), 1949. — Formules anales, gastro-notiques génitales et aggénitales du développement numérique des poils chez les Oribates. — *Bull. Soc. zool. France*, 74 : 201-225.
- GRANDJEAN (F.), 1951a. — Sur deux espèces du genre *Dometorina* n. g. et les mœurs de *D. plantivaga* (Berl.) (Acariens, Oribates). — *Bull. Soc. zool. France*, 75 : 224-242.
- GRANDJEAN (F.), 1951b. — Étude sur les Zetorchestidae (Acariens, Oribates). — *Mém. Mus. nat. Hist. natur. (n. s.), sér. A, Zool.*, 4 : 1-50.
- GRANDJEAN (F.), 1958. — *Charassobates cavernosus* Grandjean 1929 (Acarien, Oribate). — *Mém. Mus. nat. Hist. natur. (n. s.), sér. A, Zool.*, 16 : 121-140.
- GRANDJEAN (F.), 1967. — Les Staurobatidae n. fam. (Oribates). — *Acarologia*, 8 : 696-727.
- GRANDJEAN (F.), 1968. — *Schusteria littorea* n. g., n. sp. et les Selenoribatidae (Oribates). — *Acarologia*, 10 : 116-150.
- GRIFFITHS (D.A.), ATYEO (W.T.), NORTON (R.A.) and LYNCH (C.A.), 1990. — The idiosomal chaetotaxy of astigmatid mites. — *J. Zool., Lond.* 220 : 1-32.
- SENICZAK (S.), in press a. — Morphology of juvenile stages of moss mites of subfamily Sphaerozetinae (Acarida, Oribatida). — I. — *Ann. Zool., Warsaw*.
- SENICZAK (S.), in press b. — Morphology of juvenile stages of moss mites of subfamily Sphaerozetinae (Acarida, Oribatida). — II. — *Ann. Zool., Warsaw*.
- SHALDYBINA (E. S.), 1966. — Postembrionalnoje razvite pancirnyh klescej nadsemejsta Ceratozetoidea Balog 1961 i ih sistema. — *Piervoje akaro?LB?giceskije sovescane*, 225-226 pp.
- SHALDYBINA (E. S.), 1968. — K biologii *Sphaerozetes orbicularis* (Koch) (Oribatei, Ceratozetidae). — *Zoo?LB?. ?Z?urn.*, 47 : 541-547.
- SHALDYBINA (E. S.), 1972. Nekotoryje osobennosti morfo?LB?ogii ceratozetoid (Oribatei). — *Ucenyje zapiski Gor. gosud. ped. instituta, Gorki*, 130 : 35-66.
- SHALDYBINA (E. S.), 1975. — Semejstvo Ceratozetidae. — *In* : *Opredelitel obitajuscih v pocve klescej. Sarcopti-*

- formes. Edit. Ghilarov (M. S.) and Krivoluckij (D. A.), Nauka, Moscow, 276-303 pp.
- SHALDYBINA (E. S.), 1977. — Novyj vid roda *Fuscozetes* (Oribatei, Ceratozetidae). — Zool. Žurn., 56 : 709- 713.
- TRAVÉ (J.) and VACHON (M.), 1975. — François GRAND-  
JEAN 1882-1975 (Notice biographique et bibliographique). — *Acarologia*, 17 : 1- 19.
- ZAKHVATKIN (A. A.), 1953. — Sbornik naucnyh rabot, Moscow.

*Paru en Février 1991.*