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THE POSTEMBRYONIC DEVELOPMENT OF THE THORACIC CHAETOTAXY OF *PROTAPHORURA ARMATA* AND *P. FURCIFERA* (COLLEMBOLA: ONYCHIURIDAE)

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ABSTRACT

Developmental stages of thoracic chaetotaxy of *Protaphorura armata* (Tullberg, 1869) sensu Gisin, 1952, 1960, and of *P. furcifera* (Börner, 1901) are analysed. The chaetotaxy of the first juvenile stage is identical in both species and oligochaetose, it closely resembles the chaetotaxy found in most Hypogastruridae. The plurichaetose condition, typical of the genus *Protaphorura*, is developed by a gradual orderly appearance of supplementary setae, among which the primary setae still can be recognized.

INTRODUCTION

In systematic studies of Collembola, chaetotaxy has played an increasingly important part in the delimitation of species, since Yosii in 1961 published the first detailed account of collembolan chaetotaxy (e.g. Thibaud, 1970, 1972, and Szeptycki, 1972). The basic condition for a fruitful chaetotactic analysis is obviously that the setae have a fixed localization, and are more or less limited in number. This last condition is violated in groups demonstrating the phenomenon called plurichaetosis by Yosii, 1961. This phenomenon, occurring polyphyletically in different lineages of Collembola, implies the appearance of supernumerary setae in addition to those considered primitive, as is testified by their single presence in related groups. The use of chaetotaxy as a taxonomic character in the subfamily Onychiurinae has been limited just because of plurichaetosis. In the present study I have tried to discriminate between the setae belonging to the primitive chaetotaxy, and those of the secondary haircover. Using two easily separable, but otherwise fairly closely related species of the genus *Protaphorura*, viz. *P. armata* (Tullberg, 1869) sensu Gisin, 1952, 1960, and *P. furcifera* (Börner,

1901), I studied the postembryonic ontogeny of the chaetotaxy, assuming that the first instar would possess the most primitive chaetotaxy, following it during the various developmental stages, in order to segregate the setae of the adult stage.

It is hoped that knowledge of the "ontogenetic age" of the components of the chaetotaxy will make chaetotactical studies practical, thereby perhaps enabling the assessment of relationships, but also permitting a more profound analysis of the variability, both within and between populations, of these protean species.

MATERIAL AND METHODS

Protaphorura armata (Tullberg, 1869) sensu Gisin, 1952, 1960, and *P. furcifera* (Börner, 1901) were obtained by means of Berlese-techniques from soil samples taken in damp grassland near Molenwijk, a suburb of Amsterdam. Some of the animals were kept for breeding, the others were mounted in Marc André II, after clearing with isopropanol and chloral-lactophenol.

The Collembola were collectively cultured in plastic boxes on a plaster of Paris and charcoal mixture. The cultures were kept at a constant temperature of 18°C and a relative humidity of 100%. Yeast pellets were given as food. The animals were kept in total darkness except when examined (Hale, 1965a).

The number of instars was tentatively established for both species separately after measurements of the length of the head capsule (Hale, 1965b). The results were afterwards corroborated by the steps into which the development of the chaetotactic pattern could be divided. Specimens at the point of ecdysis were particularly useful to assure the transition from one stage to another.

Primary sexual characteristics were not particularly useful, as they became apparent only in the later stages: the specimens could be sexed in *P. armata* from the 5th instar, and in *P. furcifera* from the 4th. The material studied was in perfect agreement with the description in Gisin, 1960. In particular, the pseudocelli arrangement was almost completely stable in all instars, with the exception of five specimens (roughly 1%) showing some asymmetry.

RESULTS

In total, 250 specimens of *P. armata*, and 163 of *P. furcifera*, were examined.

For both species, the chaetotaxy of the first instar is identical, as shown in fig. 1a and 2a. The fact that no previous postembryonic instar existed was indicated by the study of the reared animals. The setae of the first instar present an oligochaetose arrangement; they are denominated according to current usage (cf. Cassagnau, 1974). Since the rows are very irregular, the nomenclature used can of course only be conjectural. Setae, appearing in the subsequent instars could not with any confidence be attributed to the basal scheme of the Poduromorpha; therefore these "secondary" setae are simply numbered consecutively in their order of appearance.

Most secondary setae may arise in one out of two subsequent instars, characteristic for each particular seta, as is shown in tables I and II. Most asymmetries could be explained by the appearance of a seta in one side, whereas the opposite seta lags behind.

After instar 6 in *furcifera*, and instar 5 in *armata* the number of secondary setae remains essentially constant; only incidentally and very irregularly a few additional setae appear, but it was not possible to correlate these with an instar.

Thorax I

The single seta, which is apparent in the first instar, is labelled x_3, since its homology with one of the three transverse rows present in subsequent segments is not clear (Cassagnau, 1974). Both in *armata* and *furcifera* in the course of the first five instars two irregular transverse rows are formed in this segment. It is interesting to note that seta 9, the one which Gisin labelled i, and the presence of which was frequently used by him as a taxonomic character, appears in instar 3 of *armata*, but only in instar 5 of *furcifera*.

Thorax II

The first instar shows the following chaetotaxy. In the front row (a) setae a_3 and a_5 are lacking, and a_4 is placed a little backwards. In the middle row (m) only m_5 and m_7 are left. In all Poduro-

morpha this is the row in which most deviations from the basic pattern take place, and from which most setae disappear (Cassagnau, 1974). Seta m_1 is closest to the sensillum which is present in many families of the Poduromorpha, and seems to form a pair with it in the first stages. The posterior row is complete with the exception of a seta p_5. It was not possible to discriminate setae sensuales.

In the subsequent four or five instars 16 secondary setae appear; the primary setae retain their position, except a_4 which moves slightly backwards. The order of appearance of the secondary setae takes place in a very regular way, as shown in the figures and in the tables; the variation in the chaetotactic development is so slight that usually it was possible to distinguish the instar entirely on the basis of the chaetotaxy.

Neither was it possible to discover any regularity in the pattern of the secondary chaetotaxy, nor in the way in which this pattern arose. It can only be said that most secondary setae are to be found in the lateral part of the segment, whereas the space in front of p_3 and p_4 remains remarkably open; this may be caused by the distribution of the muscular insertions.

Thorax III

The primary and the adult chaetotaxy of thorax III basically resembles that of thorax II, but is not that constant. It is not possible to determine the instar after the development of the chaetotaxy, as could be done in thorax II. For these reasons the chaetotaxy of thorax III will be left out of consideration here.

DISCUSSION

The primitive chaetotaxy, as well as the adult setal pattern of the two Onychiurids studied show an outstanding conformity. Yet, the similarity in adult patterns is reached along different ways. In general terms, there is fairly close agreement in the adult thoracic chaetotaxy of the species of *Protaphorura*, and the closely related genus *Onychiurus* as well. The few available data on the chaetotaxy of the first instars (e.g. Yosii, 1961: *Onychiurus folsomi* (Schäffer, 1900)) on the other hand suggest another, parallel set of affinities.

It is interesting to note that it seems to be a rule, at least in the Poduromorpha, that primary juveniles of oligochaetose species bear their complete chaetotaxy (e.g. Gruia, 1974: *Neanura tatricola* Gisin, 1960). This is in interesting contrast with the studied plurichaetose species, in which the chaetotaxy is gradually completed.

The large difference between the young and adult stages can lead to various confusions. Therefore the remark of Yosii (1961) that there is a possibility of confusing one of the earlier instars with an adult of a new species, should be taken quite seriously. This problem becomes even more important when we take into consideration that a specimen with well-developed sexual characters can have a chaetotaxy that differs from a full-grown specimen (e.g. as in *furcifera*).

As mentioned, the difference in chaetotaxy between *armata* and *furcifera* is one in the sequence of appearance of the setae, except for some minor details. Although not specially studied, there seems to be no difference between males and females. The material examined was not large enough to confirm this with certainty.

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TABLE I

ORDER OF APPEARANCE OF THE SECONDARY SETAE IN THE FIRST FIVE INSTARS OF *PROTAPHORURA ARMATA*

(-: seta absent, ±: seta often but not always present, +: seta always present)

	instar	I	II	III	IV	V
	seta #					
Thorax I	1	-	+	+	+	+
	2	-	+	+	+	+
	3	-	+	+	+	+
	4	-	+	+	+	+
	5	-	-	±	+	+
	6	-	-	-	±	+
	7	-	-	-	±	+
	8	-	-	-	-	±
	9	-	-	-	-	±
Thorax II	1	-	+	+	+	+
	2	-	+	+	+	+
	3	-	+	+	+	+
	4	-	+	+	+	+
	5	-	-	±	+	+
	6	-	-	±	+	+
	7	-	-	+	+	+
	8	-	-	-	+	+
	9	-	-	-	+	+
	10	-	-	-	±	+
	11	-	-	-	±	±
	12	-	-	-	±	±
	13	-	-	-	±	+
	14	-	-	-	-	±
	15	-	-	-	-	±
	16	-	-	-	-	±

TABLE II

ORDER OF APPEARANCE OF THE SECONDARY SETAE IN THE FIRST SIX INSTARS OF *PROTAPHORURA FURCIFERA*

(-: seta absent, ±: seta often, but not always present, +: seta always present)

	instar	I	II	III	IV	V	VI
	seta #						
Thorax I	1	-	+	+	+	+	+
	2	-	+	+	+	+	+
	3	-	+	+	+	+	+
	4	-	+	+	+	+	+
	5	-	-	±	+	+	+
	6	-	-	+	+	+	+
	7	-	-	±	+	+	+
	8	-	-	-	±	+	+
	9	-	-	-	-	±	+
	10	-	-	-	-	±	+
	11	-	-	-	-	-	±
Thorax II	1	-	+	+	+	+	+
	2	-	+	+	+	+	+
	3	-	+	+	+	+	+
	4	-	-	±	+	+	+
	5	-	-	±	±	+	+
	6	-	-	+	+	+	+
	7	-	-	±	±	+	+
	8	-	-	+	+	+	+
	9	-	-	-	+	+	+
	10	-	-	-	-	±	+
	11	-	-	-	-	±	±
	12	-	-	-	-	±	±
	13	-	-	-	-	±	+
	14	-	-	-	-	±	±
	15	-	-	-	-	+	+
	16	-	-	-	-	-	+

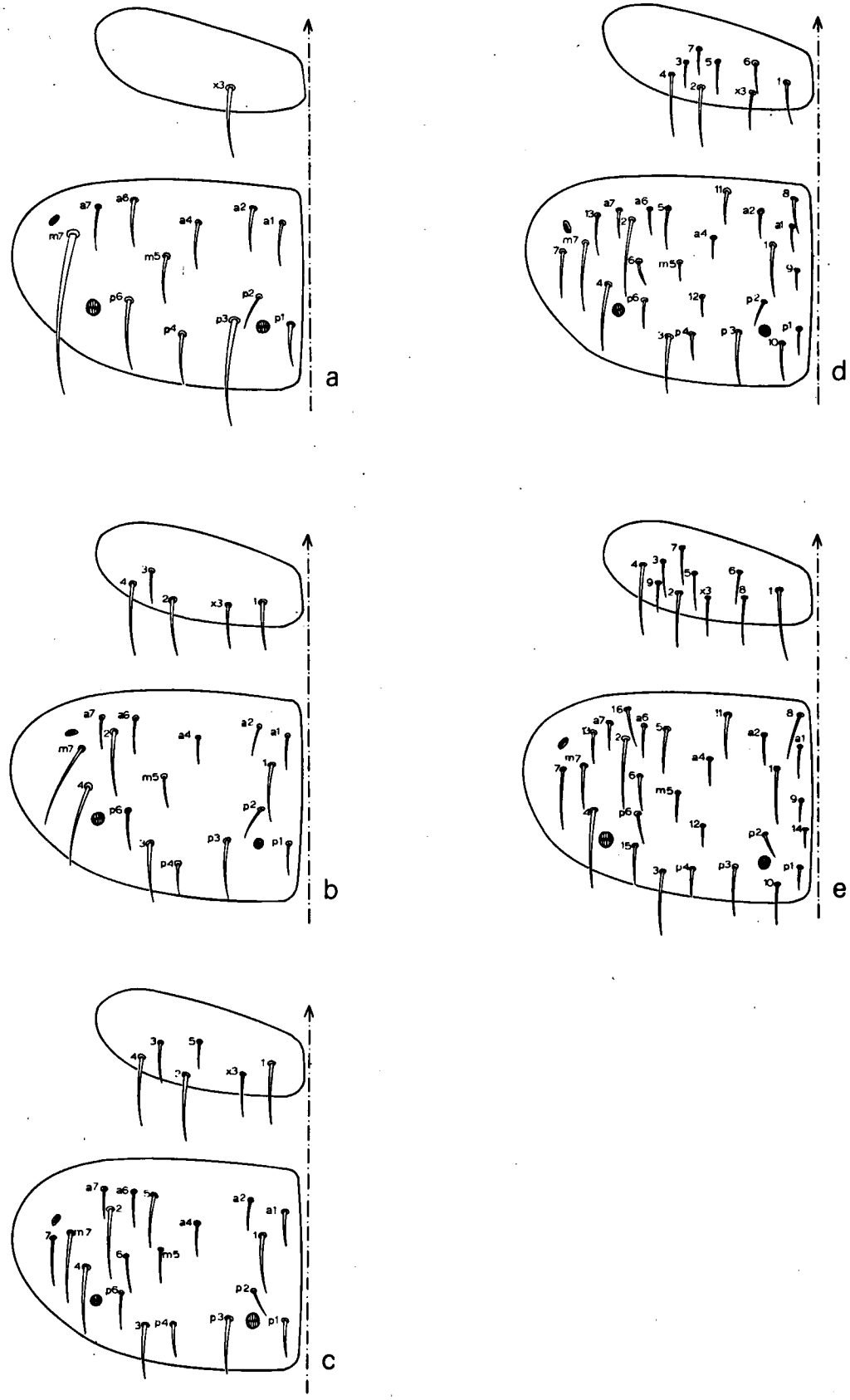

Fig. 1. *Protaphorura armata* (Tullberg, 1869) sensu Gisin, 1952, 1960: dorsal chaetotaxy of thoracic segments I and II in the first five instars, a-e.

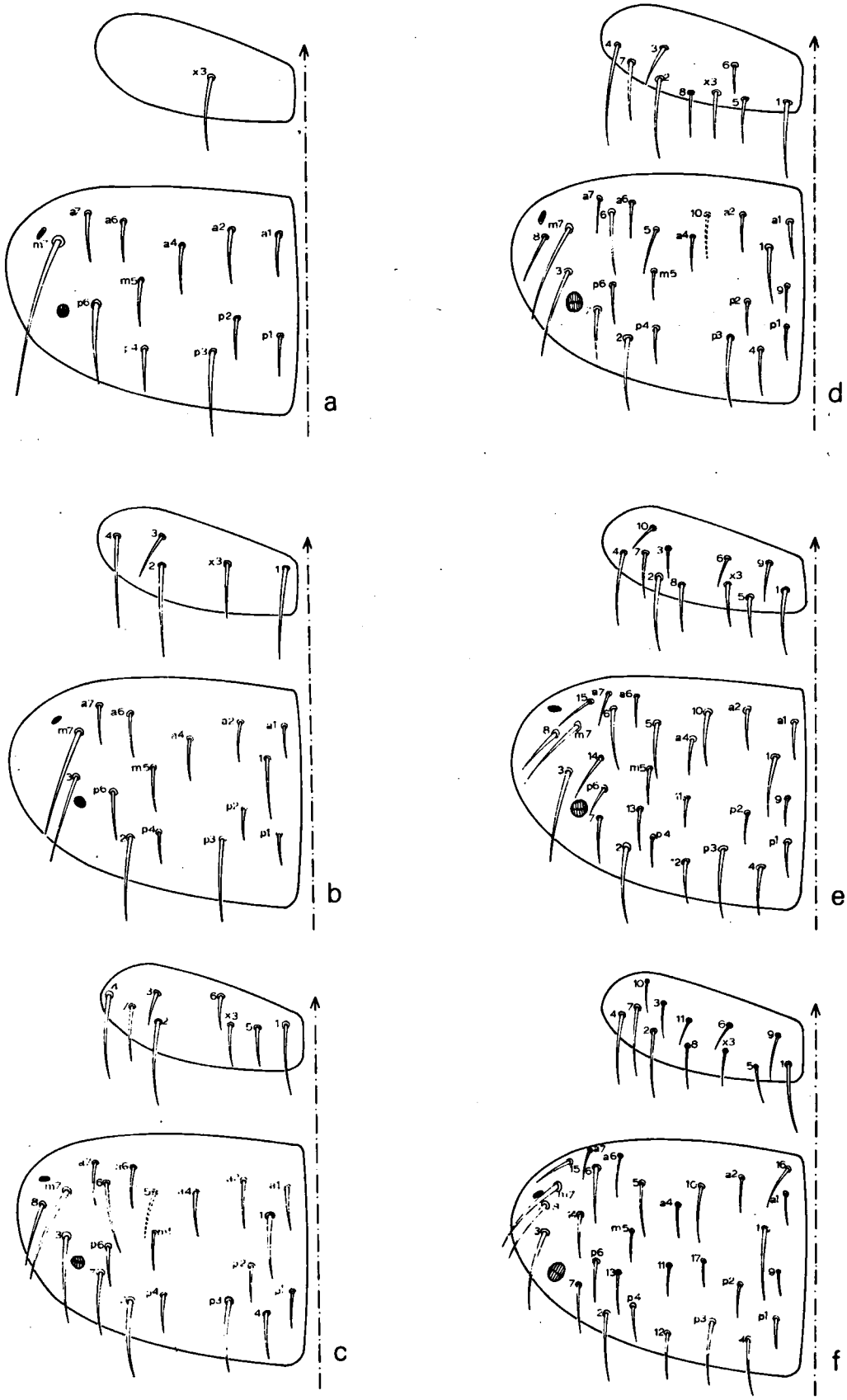

Fig. 2. *Protaphorura furcifera* (Börner, 1901): dorsal chaetotaxy of thoracic segments I and II in the first six instars, a-f.