Beit. Ent.	Berlin	ISSN 0005-805X
45(1995)2	S. 375-381	24.07.1995

Final instar Nymph of *Psilopsocus nebulosus* MOCKFORD (Psocoptera: Psilopsocidae), redescribed and compared with two wood-boring Species of the Genus

With 9 text figures

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Abstract

The nymph of *Psilopsocus nebulosus* MOCKFORD (from Philippines) is redescribed and compared with that of *Ps. mimulus* SMITHERS (from Australia) and an undescribed species of *Psilopsocus* (from South Africa). The morphological adaptations to the unusual wood-boring habit in these remarkable psocopterans are discussed.

Zusammenfassung

Das letzte Larvenstadium von *Psilopsocus nebulosus* MOCKFORD von den Philippinen wird beschrieben und verglichen mit der Art *Ps. mimulus* SMITHERS von Australien und einer unbeschriebenen Art der *Psilopsocus* von Südafrika. Die morphologischen Anpassungen in der ungewöhnlichen Holzwurmerscheinung dieser einzigartigen Psocoptera wird diskutiert.

Introduction

SMITHERS (in press) has confirmed that the nymph of *Psilopsocus mimulus* is extremely unusual in that it is a wood borer, the only member of the Order Psocoptera so far recorded as being so. It is highly modified for life in a tunnel but the adults live on bark and are not modified. An undescribed South African species of *Psilopsocus* has adaptations of the nymph similar to those of *Ps. mimulus* and it, too, is probably a wood-borer. Adults of the South African species are not known. It will be referred to in this paper as *Psilopsocus* sp. A.

MOCKFORD (1961) described the final instar nymph of *Ps. nebulosus* MOCKFORD from the Philippines. He mentioned that "the distal two-thirds of the abdomen is dark brown" but did not describe any unusual morphological features. The discovery of the wood-boring habit and adaptations to it in *Ps. mimulus* and MOCKFORD's comment on the abdomen of the Philippine species suggested that it, too, might also have a similar habit. Through the courtesy of Dr. P.P. PARILLO, of the Field Museum, Chicago, I have been able to examine and redescribe the specimen described by MOCKFORD and compare it with *Ps. mimulus*.

DOI: 10.21248/contrib.entomol.45.2.375-381

Redescription of final instar Nymph of *Psilopsocus nebulosus*

Coloration (after 48 years in alcohol). As described by MOCKFORD (1961) but colour pattern probably now less obvious because of long storage in alcohol. Black centripetal marks of ocellar triangle of developing adult visible through nymphal cuticle.

Morphology. Length of body: 3.0 mm. Body (fig. 1) a little extended because of long preservation in alcohol. Head with long, fine setae, porrect on anterior part of postclypeus and on top of head where the longest stand vertically on the epicranium. Eyes small. IO/D: 1.9; PO: 0.55. Length of flagellar segments (right side): f1: 0.3 mm.; f2: 0.27 mm. Antenna (right side) reaches about half way along body. Right antenna 13-segmented (normal), left antenna shorter, of only eight segments, the eighth being longer than usual for an apical segment (antenna abnormal, complete on specimen but not fully illustrated in figure). First flagellar segment, when the antenna is held back along the body, has the outer side smooth and pale with few fine setae. Inner side a little darker and more heavily sclerotized, appears to be somewhat rugose (antenna not removed from only known specimen). Mesothoracic wing buds reach about one quarter along side of abdomen. Length of fore wing bud: 1.17 mm. Femora short and broad. Tibiae shorter than expected considering slenderness of adult legs, broader near distal end than near proximal end. Hind tarsus with basal segment broader than distal segment. Measurements of hind leg: F: 0.5 mm; T: 0.7 mm; t1: 0.25 mm; t2: 0.18 mm; rt: 1.38:1. Abdomen broadly fusiform (figs. 1 and 7). Tergites from about sixth segment more heavily sclerotized than anterior tergites, as is sternum of final segment. Segmentation obliterated dorsally over posterior part of abdomen. This is probably the part of the abdomen referred to by MOCKFORD (1961) as "distal two-thirds of the abdomen is dark brown". Distal part of abdomen, where tergites are strongly sclerotized, with long, fine, backwardly projecting, mostly pointed, setae, a few blunt-ended. Integument in distal half of sclerotized area very finely rugose, with minute papillae. Anterior half of sclerotized area with smoother integument and with fewer setae. Epiproct (fig. 3) short, medially less heavily sclerotized than laterally, sparsely setose. Setae on only available specimen blunt-tipped, but several setae lost and some might be pointed. Paraproct (fig. 2) large, broad, heavily sclerotized all over, sparsely setose with mostly long setae; paraproct shaped so that when epiproct is folded down and the paraprocts folded inwards anal area would be covered. Epiproct and paraprocts with margins thickened, ensuring close approximation of edges when the anal region is covered. Posterior margin of paraprocts apparently with one large spine and small rounded cone near its base (paraproct of only specimen not dissected).

Material examined. 1 final instar nymph, E. slope of Mt. McKinley, Davao Prov., Mindanao, P.I. (Philippine Islands), Sept. 18.1946. H. Hoogstraal. Mossy forest, el. 6400'. C.H.M. This is the specimen on which MOCKFORD (1961) based his description.

Comparison of *Ps. nebulosus* Nymphs with those of other Species

MOCKFORD (1987) has provided a general account of psocopteran nymphs. The nymphs of *Ps. nebulosus*, *Ps. mimulus* and *Ps.* sp. A have features in common which differ strongly from those of other psocopterean nymphs and these features are, in *Ps. mimulus*, at least, certainly adaptations to its known wood-boring habit (SMITHERS, in press). The degree to which the adaptations in species of *Psilopsocus* differ from those of other psocopteran nymphs varies and

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a series of conditions can be traced through the three species in each feature. These are tabulated below for comparison.

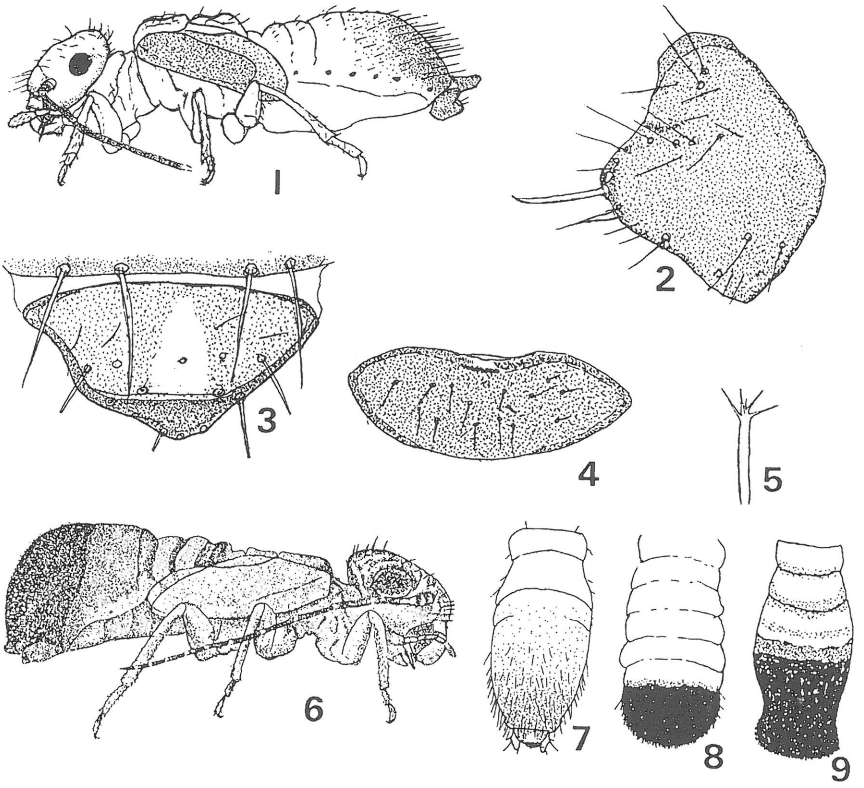

Fig. 1. *Psilopsocus nebulosus*, nymph. **Fig. 2.** same, right paraproct. **Fig. 3.** same, epiproct. **Fig. 4.** *Psilopsocus* sp. A, epiproct. **Fig. 5.** *Psilopsocus mimulus*, seta from posterior part of abdomen. **Fig. 6.** same, nymph. **Fig. 7.** *Psilopsocus nebulosus*, abdomen, dorsal. **Fig. 8.** *Psilopsocus* sp. A, abdomen, dorsal. **Fig. 9.** *Psilopsocus mimulus*, abdomen, dorsal.

Summary and Comparison of Characters in *Ps. nebulosus, Ps.* sp. A and *Ps. mimulus*

First flagellar segment

Ps. nebulosus. First flagellar segment not obviously curved to fit neatly against eye when antenna is held back along the body. Outer side apparently lightly sclerotized with few setae, inner side more heavily sclerotized, apparently with rugose surface (one available specimen not dissected).

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Ps. sp. A. First flagellar segment curved so as to fit against the curvature of compound eye. Outer side, when antenna is lying alongside head, lightly sclerotized with few setae, inner side more heavily sclerotized and rugose, apparently as in *Ps. nebulosus*, but specimen not dissected.

Ps. mimulus. Curved as in *Ps.* sp. A, differences between inner and outer sides of segment obvious (SMITHERS, in press, fig. 3).

Shape of abdomen

Ps. nebulosus. Somewhat fusiform, tapering behind (fig. 7), gently declivous in hind quarter (fig. 1).

Ps. sp. A. Parallel-sided when viewed from above (fig. 8), declivous near hind end, more steeply so than *Ps. nebulosus* but less so than *Ps. mimulus*.

Ps. mimulus. Almost parallel-sided, slightly narrowed just anterior to broadened hind end (fig. 9), very strongly declivous, almost truncate, apically (figs. 6 and 9).

Position of epiproct and paraprocts

Ps. nebulosus. More ventral than usual in psocopteran nymphs but visible from above (fig. 7).

Ps. sp. A. Ventrally placed, not visible from above (fig. 8).

Ps. mimulus. Ventrally placed, not visible from above (fig. 9).

Sclerotization of abdomen

Ps. nebulosus. Abdomen sclerotized dorsally towards hind end, not as densely as in other *Psilopsocus* species, segmentation obliterated dorsally over about hind half of abdomen (fig. 7). Sculpturation finely granular.

Ps. sp. A. Extremely heavily sclerotized near posterior end, segmentation dorsally obliterated on two posterior abdominal segments (fig. 8). Sculpturation finely granular.

Ps. mimulus. Extremely heavily sclerotized posteriorly, segmentation dorsally obliterated over about distal third of abdomen (fig. 9). Integument sculptured in characteristic, complex way around bases of setae on hind part of abdomen (SMITHERS, in press, fig. 1).

Form of setae on sclerotized part of abdomen

Ps. nebulosus. Setae long, finely pointed (fig. 1).

Ps. sp. A. Setae very short, but pointed, forming a dense pile, about as long as in *Ps. mimulus*.

Ps. mimulus. Setae very short, forming a dense pile. Some lateral, dispersed, setae apically

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pointed or blunt, but those on truncate, posterior part of abdomen apically divided into several conspicuous, divergent points (fig. 5).

Shape of epiproct

Ps. nebulosus. Somewhat triangular with rounded hind angle (fig. 3), a common shape in psocopteran nymphs.

Ps. sp. A. Narrowly transverse with smoothly rounded hind margin (fig. 4).

Ps. mimulus. Narrowly transverse, similar to that of *Ps.* sp. A. but with slightly sinuous hind margin and with a strongly sclerotized transverse ridge beyond which the epiproct is angled downwards (SMITHERS, in press, fig. 2).

Sclerotization of epiproct

Ps. nebulosus. Sclerotized laterally, weakly so in median area, margin thickened (fig. 3).

Ps. sp. A. Heavily sclerotized all over, margin thickened (fig. 4).

Ps. mimulus. Heavily sclerotized all over, extremely heavily sclerotized along a transverse band, beyond which epiproct bends down at an angle to basal part of epiproct (SMITHERS, in press, fig. 2) (see above).

Form of setae on epiproct

Ps. nebulosus. Short, probably all blunt (fig. 3) (some missing from only available specimen).

Ps. sp. A. Short, pointed (fig. 4).

Ps. mimulus. Short, those on anterior part of epiproct with apex divided as those on posterior part of abdomen (fig. 5).

Paraproct sclerotization and posterior margin

Ps. nebulosus. Well sclerotized but less strongly so than other species of genus. Hind margin with a spine and a small cone (fig. 2) (visible detail limited as only available specimen not dissected).

Ps. sp. A. Heavily sclerotized. Hind margin with two spines and a short cone (specimen not dissected, but paraproct clearly visible on whole specimen).

Ps. mimulus. Heavily sclerotized. Hind margin with two strong spines and a very well developed double cone which is a quarter of the length of the longer spine (SMITHERS, in press, fig. 4).

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Discussion

The three species of *Psilopsocus* dealt with in this paper show an interesting progression of nymphal characters towards increase in adaptation to life in a burrow with *Ps. nebulosus* being least modified (except for setae on epiproct, which are blunt instead of pointed) and *Ps. mimulus* showing the greatest level of specialisation. The manner in which the first flagellar segment of the antenna is curved in *Ps.* sp. A and *Ps. mimulus* is probably an adaptation to conditions in the confines of a burrow. The abdomen in *Ps. nebulosus* has retained a more or less fusiform shape similar to those of other psocopteran nymphs but it has sclerotized posterior terga. In *Ps.* sp. A and *Ps. mimulus* this process has proceeded further with the abdomen becoming cylindrical to make a better fit to the lumen of a tunnel. As the form of the abdomen has changed the posterior segments have become more densely sclerotized to form a plug, which would reduce likelihood of predators being able to attack the otherwise soft-bodied nymphs, which are, in effect, trapped within the burrow in a position from which it would be difficult to escape. Professor THORNTON (in lit.) has suggested that the plug-like modification of the abdomen in *Psilopsocus* might help to retain moisture in the tunnel. In *Ps. mimulus* the more truncate form of the end of the abdomen would increase further its effectiveness as a plug than it would be in *Ps.* sp. A or in *Ps. nebulosus*. In the case of *Ps. nebulosus* the setae on the hind part of the body are of the normal type found in most psocopteran nymphs, but a little longer than most and those of the epiproct are blunt. In the other two species they have become considerably shortened and form a dense pile. In the case of *Ps.* sp. A. they are shorter, stouter and probably more rigid than in *Ps. nebulosus*. In *Ps. mimulus* they are also short but have the added specialisation of divided ends. They appear to be glandular, as are those of many psocopteran nymphs, with debris adhering to them. Although the epiproct and paraprocts have moved towards the lower side of the end of the abdomen in *Ps. nebulosus*, in *Ps.* sp. A and *Ps. mimulus* the movement is complete so that they are invisible from above. At the same time they have become more heavily sclerotized overall with their edges reinforced by further sclerotization to form strong marginal ridges. In *Ps. nebulosus* the three plates are shaped so as to fit together but in the other two species the shapes are such that the fit is very close. In *Ps. mimulus* this is even more enhanced by the downward bending of the epiproct near its base, making the fit extremely tight. By becoming more ventral in position the epiproct and paraprocts do not form part of the posteriorly directed part of the "plug" which thus presents an undivided surface towards the entrance to the burrow. This arrangement of the three plates seals off the ventral surface of the hind end of the abdomen, adding to the effectiveness of the plug formed by the end of the abdomen.

It is interesting to note that the first instar nymph of *Ps. mimulus* (SMITHERS, in press) resembles the late instar nymph of *Ps. nebulosus* more than it does late instar nymphs of *Ps. mimulus* itself. The abdomen is more fusiform, its abdominal sclerotization is less extensive, its setae are less modified from the pointed, plesiomorphic condition and the integument of the hind part of the abdomen is not characteristically sculptured but simply granular. It is not known for certain whether the first instar nymph of *Ps. mimulus* is a wood borer. The few newly hatched nymphs which have so far been available in the laboratory did not show any sign of boring into wood before they died. It may be that they merely use existing crevices in bark as shelters and perhaps the nymph of *Ps. nebulosus* does the same.

There seems little doubt that *Ps.* sp. A is also a wood-borer as it has so many adaptations which are the same as those of *Ps. mimulus* although in some cases the modifications have not

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progressed quite as far as they have in *Ps. mimulus*. If *Ps. nebulosus* is a wood-borer it has clearly not reached the same level of specialisation for this habit as either of the other species. These three species show an instructive series within the genus illustrating the kind of changes which might have occurred during evolution from surface dweller to wood-borer, with associated specialisation of morphological features and changes of habit.
It is unfortunate that nymphs of the New Guinea and Malaysian species of *Psilopsocus* are not yet known.

Acknowledgements

I would like to thank my wife for collecting material of *Psilopsocus mimulus*, Dr. P.P. PARILLO of the Field Museum, Chicago, for the loan of the nymph of *Psilopsocus nebulosus* and Professors I.W.B. THORNTON and E.L. MOCKFORD for comments on a draft of this paper.

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