

American Museum Novitates

PUBLISHED BY THE AMERICAN MUSEUM OF NATURAL HISTORY
CENTRAL PARK WEST AT 79TH STREET, NEW YORK 24, N.Y.

NUMBER 2259

AUGUST 18, 1966

Systematics of the Larvae of North American Panurgine Bees (Hymenoptera, Apoidea)

BY JEROME G. ROZEN, JR.¹

In a comprehensive study of bee larvae of the world, Michener (1953) examined firsthand the larval representatives of three genera belonging to the andrenid subfamily Panurginae, all of which were from North America. Although larvae of additional species and genera have been described since, a treatment of these forms as a subfamily has not been worthwhile because of insufficient material. However, because of recent efforts of specialists on bees, particularly in the United States, our collections of mature bee larvae have now increased appreciably in size, and as a consequence a preliminary systematic review of the North American representatives is given here. Larvae from other areas are considered in the key and in the description of the subfamily, so as to make the paper as inclusive as possible. It is hoped that such preliminary studies will result in the collection and careful preservation of more larvae. Future investigations on a worldwide basis will then be possible.

Eight genera of panurgine bees are found in North America, and the mature larvae of five of them (*Pseudopanurgus*, *Panurginus*, *Nomadopsis*, *Calliopsis*, and *Perdita*) are treated here. The mature larvae of the widespread *Psaenythea* and of the rare and monotypic *Xenopanurgus* have not been discovered; the immature stages of these two may well prove helpful in shedding light on the phylogeny of the Panurginae. The un-

¹Curator, Department of Entomology, the American Museum of Natural History.

known larva of *Hypomacrotera* will presumably agree closely with the larvae of *Calliopsis* and *Nomadopsis* as judged by the similarities of the imagoes.

Much of the research for this paper was supported by National Science Foundation Grant G-14854. The following people kindly provided specimens for this study: Dr. G. E. Bohart, Entomology Research Division, United States Department of Agriculture, University of Utah, Logan; Dr. Paul D. Hurd, Jr., University of California, Berkeley; and Dr. Charles D. Michener, the University of Kansas, Lawrence. I wish to acknowledge the expert assistance of Mrs. Marjorie Statham Favreau who collected many of the specimens used herein. Mrs. Rose Ismay was responsible for the meticulous typing of the manuscript. The literature search on panurgine larvae was facilitated by the Bibliography of Apoid Biology directed by Dr. Michener. Except where stated otherwise, the larvae used in this investigation are in the collection of the American Museum of Natural History.

PHYLOGENETIC-TAXONOMIC CONSIDERATIONS

On the basis of adult features, the Panurginae are unquestionably monophyletic (Rozen, 1951), and our current understanding of the adults of the Andrenidae indicates that the Panurginae and the Andreninae arose from a common, presumably andrenine-like ancestor. The present study does not contradict the monophyletic nature of the Panurginae, but the larvae of all bees are too poorly known at the present for an interpretation as to the ancestry of the Panurginae and the Andreninae.

Though preliminary, this investigation suggests that species within a genus are quite homogeneous with respect to larval features. Furthermore, with the exception of *Nomadopsis* and *Calliopsis*, the larval differences among genera are quite distinct though at times difficult to express verbally. As a result there seems, at least at our present imperfect knowledge of the group, little difficulty in identifying larvae to genus. However, in spite of the distinctness of the genera, the generic characteristics are disappointing in that they do not permit an evaluation of intergeneric relationships. For example, although *Perdita* larvae are quite distinct and easily recognizable, we cannot affiliate them more closely with one or another of the other panurgine genera. Larvae of *Nomadopsis* and *Calliopsis* are quite similar, as are the adults, and therefore these genera represent the only obvious case in which presumed generic relationships are evident in the larval stages. The difficulty in deducing relationships can probably be explained on the basis of our fragmentary

understanding of the group; that is, too few genera are known as larvae and we cannot determine which features are primitive and which are derived.

DESCRIPTION OF THE PANURGINAE BASED ON THE MATURE LARVAE

The family Andrenidae as now understood (Rozen, 1965a) consists of three subfamilies: the Andreninae, the Panurginae, and the monotypic Eueherbstiinae; the immature stages of the last are unknown. The larvae of the Panurginae can be distinguished from those of the Andreninae on the basis of the dorsolateral abdominal tubercles. Those of the Panurginae, with the possible exception of *Panurgus dentipes* Latreille (Rozen and Rozen, in press), are conical (a condition that is also found in various South American genera; Claude-Joseph, 1926), whereas in the Andreninae the tubercles are transverse, nearly meeting on the mid-dorsal line. In other respects the larvae of the two subfamilies seem quite alike, though dissimilarities may become evident after the Andreninae are studied in greater detail. The significance of the fact that conical abdominal tubercles, a seemingly specialized condition, are also characteristic of the halictid subfamilies Nomiinae and Dufoureae cannot be assessed at the present time.

The following description includes not only the North American forms, but also *Panurgus dentipes* and *Melitturga clavicornis* (Latreille), both of which I have examined firsthand (Rozen, 1965a; Rozen and Rozen, in press).

HEAD: Integument with scattered sensilla; dorsal surface of labrum non-spiculate; epipharynx usually, if not invariably, spiculate; hypopharynx usually more or less spiculate; maxillae spiculate dorsally; mandibles lightly pigmented. Tentorium complete or incomplete; anterior and posterior arms well developed; tentorial pits moderately developed and invariably present; posterior pits at juncture of posterior thickening of head capsule and hypostomal ridge; posterior thickening of head capsule well developed; hypostomal ridge well developed; pleurostomal ridge usually well developed; epistomal ridge invariably evident below anterior tentorial pits; ridge absent mesiad of pits except in *Panurginus*; longitudinal thickening of head capsule at most weakly developed; vertex not projecting to projecting strongly and without paired tubercles. Antennal prominence projecting only very slightly to very strongly; antennal papilla short to very short and usually bearing three sensilla. Labrum protruding variable amount, with two small to moderately large tubercles. Mandible moderate in length, not massive,

moderate to narrow in adoral width at base, and gradually tapering to point; dorsal inner apical edge dentate; ventral inner apical edge dentate or not; cusp slightly to moderately produced and with teeth; apical concavity not sharply defined. Maxillae moderately produced and moderately fused with labium; that is, more extensively combined with labium than those of cocoon-spinning bee larvae but not so fused as is characteristic of most of larvae of the Nomadinae; however, degree of development of maxillae somewhat variable; maxillary apex rounded and at most directed only slightly mesiad, in which case apex not spiculate; galea absent; palpus short, rarely longer than basal diameter, but basal diameter often rather great; sclerotized cardo and stipes absent. Hypopharynx produced either somewhat less or slightly farther than labium; hypopharyngeal groove usually present but in some cases absent (*Panurgus* and some *Perdita*). Labium recessed as compared with cocoon-spinning bee larvae so that its apex rarely projects even slightly farther (some *Perdita*) than maxillary palpi as seen in lateral view; labium in some cases inconspicuously divided into prementum and postmentum; salivary opening a curved slit without projecting lips; labial palpi invariably shorter than maxillary palpi and in a few cases scarcely evident.

BODY: Form moderately slender; intrasegmental lines either not evident or inconspicuous; dorsolateral tubercles present on most body segments; those on abdomen conical (with possible exception of *Panurgus*) rather than transverse, with apex more or less rounded; lateral body tubercles absent. Integument with spiculated areas, without sclerites, and without conspicuous setae except for apex of dorsal tubercles in *Perdita*. Spiracles moderate in size; atrium smooth or with faint ridges but without spines and denticles; atrium projecting above body wall or not; peritreme present; primary tracheal opening with collar; subatrium often unusually long, not divided into outer and inner parts. Tenth abdominal segment in some cases with dorsal median projection; anus apical in position except in *Perdita* in which it is situated posteroventrally.

The following key refers to all panurgine larvae that I have studied, including the European *Melitturga clavicornis* (Rozen, 1965a) and *Panurgus dentipes* (Rozen and Rozen, in press).

KEY TO THE MATURE LARVAE OF THE PANURGINAE

1. Mandible (figs. 3, 13) with large subapical tooth on dorsal inner edge in addition to smaller teeth; apexes (figs. 1, 11) of first pair of dorsal thoracic tubercles directed somewhat cephalad..... 2
- Mandible (figs. 36, 45) with teeth on dorsal inner edge subequal in size; apexes (figs. 17, 34, 41) of first pair of dorsal thoracic tubercles directed dorsally (except in *Calliopsis andreniformis*)..... 3
- 2(1). Most dorsal abdominal tubercles (Rozen, 1965a, fig. 6) beset with pig-

- mented spicules; mandible (Rozen, 1965a, figs. 9, 10, 13) with very large tooth below cuspal teeth *Melitturga clavicornis* (Latreille)
- Dorsal body tubercles (figs. 1, 11) without spicules; mandible (figs. 2, 13) without large tooth in region of cusp though with numerous small cuspal teeth *Pseudopanurgus* Cockerell
- 3(1). Tenth abdominal segment (figs. 41, 47) with elongate, median, postero-dorsal tubercle; anus (figs. 41, 47) posteroventral in position; most dorsal body tubercles (fig. 47) bearing minute, robust setae apically *Perdita* Smith
- Tenth abdominal segment (figs. 17, 29) without distinct, median, poster-dorsal tubercle (very small protrusion present on *Nomadopsis helianthi* = *euphorbiae*, Rozen, 1958, fig. 61); anus (fig. 17) in normal posterior position; dorsal body tubercles (figs. 17, 29) without conspicuous setae 4
- 4(3). Epistomal ridge (figs. 18, 19) present between anterior tentorial pits as seen in cleared head capsule; maxillary palpus (figs. 19, 23, 26) elongate, curving downward and bearing large spicules; labroclypeal region short as seen in lateral view (figs. 19, 23) *Panurginus* Nylander
- Epistomal ridge (figs. 30, 31) absent between anterior tentorial pits; maxillary palpus non-spiculate; maxillary palpus either short (fig. 31) and directed forward or moderately elongate and directed somewhat downward; if the latter (*Panurgus dentipes*), then labroclypeal region abnormally elongate as seen in lateral view 5
- 5(4). Maxillary palpus (Rozen and Rozen, in press, fig. 4) more elongate, directed somewhat ventrally; labroclypeal area elongate so that apex of labrum extending far beyond labiomaxillary region as seen in lateral view (Rozen and Rozen, in press, fig. 4); subatrium normal in length (Rozen and Rozen, in press, fig. 2) *Panurgus dentipes* Latreille
- Maxillary palpus (fig. 31) short, directed parallel to long axis of maxilla; labroclypeal region short so that apex of labrum extending only short distance beyond labiomaxillary region as seen in lateral view (fig. 31); subatrium elongate (fig. 37) *Calliopsis* Smith
- Nomadopsis* Ashmead

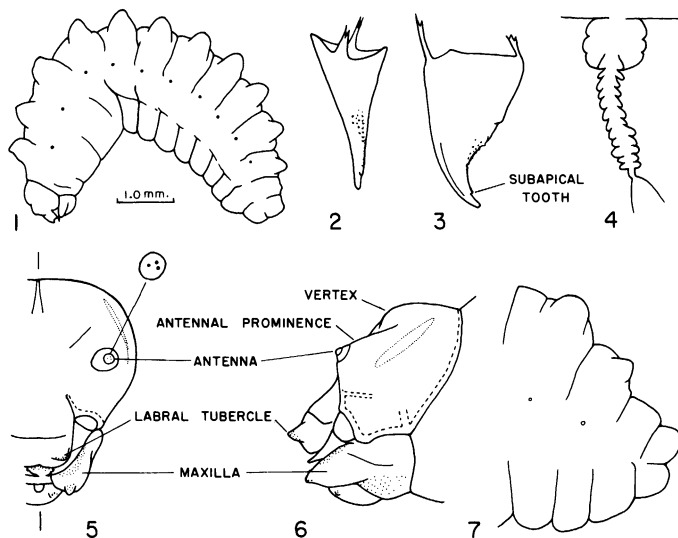
PSEUDOPANURGUS COCKERELL

The larvae of at least the two major subgenera can be distinguished from those of other known North American panurgine genera on the basis of the distinct subapical mandibular tooth (figs. 3, 13). Although the European *Melitturga clavicornis* (Rozen, 1965a) also possesses such a tooth, the larvae of the two taxa are quite distinct, as indicated in the key. The strongly projecting dorsal body tubercles (figs. 1, 11), the produced vertex (figs. 6, 9, 16), the large antennal prominences, the conical antennae, the large labral tubercles and maxillae, and the often dorsally produced tenth abdominal segment (fig. 10) are a unique combination of characters and impart distinctive facies to *Pseudopanurgus* larvae.

Pseudopanurgus (Heterosarus) boylei (Cockerell)

Figures 1-7

This species was called *perlaevis* (Cockerell) by Rozen (1965b), but Timberlake (*in litt.*) now believes it to be *boylei*.



FIGS. 1-7. *Pseudopanurgus boylei* (Cockerell). 1. Live, postdefecating larva, lateral view. 2, 3. Left mandible, inner and ventral views. 4. Spiracle. 5, 6. Head, frontal and lateral views. 7. Terminal part of abdomen of predefecating larva, lateral view.

Scale refers to figure 1.

HEAD (FIGS. 5, 6); Integument without setae though with scattered sensilla; antennae, palpi, and labral tubercles very faintly but distinctly pigmented; vertex strongly produced on each side above antenna; antennae arising from projecting prominences. Tentorium incomplete; anterior tentorial arms moderately slender; posterior tentorial arms more robust but short; posterior thickening of head capsule well developed; hypostomal ridge well developed; pleurostomal ridge well developed; epistomal ridge below anterior tentorial pits thin but distinct, mesiad of pits absent; parietal bands evident. Antenna a low convexity on top of prominent disc; antenna with three sensilla. Labrum bearing two prominent tubercles. Mandible (figs. 2, 3) slender; upper margin with subapical tooth, posterior to which are numerous fine serrations; lower apical margin not serrate; cusp not strongly produced but dentate. Maxilla

large, projecting well beyond labium; apex perhaps very slightly bent mesiad; palpus very large, directed forward; integument spiculate on dorsal surface and on palpus. Hypopharynx spiculate; hypopharyngeal groove distinct. Labium moderately projecting, not divided into prementum and postmentum (the posterior spiculated area on the labio-maxillary region, fig. 6, is lateral in position, does not extend to ventral part of head, and consequently is not the postmentum; its anatomical homologies are uncertain though it may correspond to the maxillary conjunctiva); labial palpus greatly reduced. Salivary opening a curved slit.

BODY: Color somewhat yellowish, somewhat spiculate, particularly immediately behind head; tenth abdominal segment not spiculate ventrally. Dorsal tubercles (figs. 1, 7) extremely prominent; abdominal ones conical and with smooth, rounded apexes; terminal segment (fig. 7) with postero-dorsal median tubercle low, scarcely noticeable. Spiracles small; atrium (fig. 4) not projecting above body wall; atrial wall without teeth but grooved; peritreme very thin; primary tracheal opening with collar; subatrium moderate in length.

MATERIAL STUDIED: Two postdefecating, one predefecating larvae, Southwestern Research Station, near Portal, Cochise County, Arizona, September 1, 1962 (J. G. Rozen, M. Statham, S. Hessel); one postdefecating larva, same except September 6, 1962. Associated adults identified by P. H. Timberlake.

Pseudopanurgus Species A

Figure 8

HEAD: As described for *Pseudopanurgus boylei* except for following: tentorium complete; mandible with subapical tooth as well as other teeth longer and more sharply pointed and with fine serrations apicad of subapical tooth; maxilla with spiculations reduced; hypopharynx faintly spiculate; posterior part of labiomaxillary region with spicules scattered and small, scarcely noticeable.

BODY: As described for *P. boylei* except for following: color of postdefecating form unknown; spiculations reduced; dorsal tubercles (fig. 8) more sharply pointed than in *boylei*; ninth abdominal segment with distinct tubercles; terminal segment with conspicuous median posterodorsal tubercle.

MATERIAL STUDIED: Three predefecating larvae, Southwestern Research Station, near Portal, Cochise County, Arizona, September 8, 1962 (J. G. Rozen and M. Statham); one predefecating larva, same except September 7, 1962.

It is questionable how valid some of these characters are taxonomically.

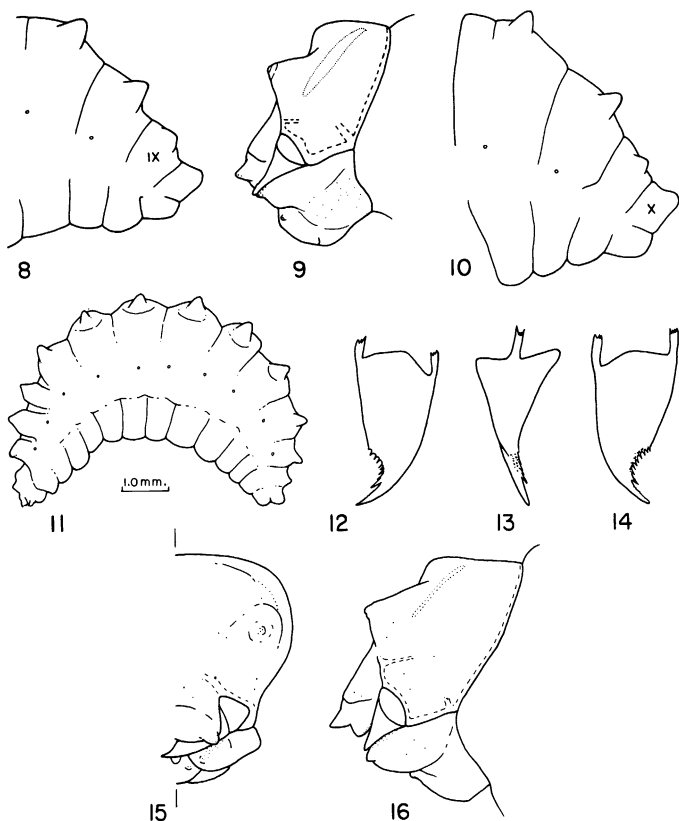


FIG. 8. *Pseudopanurgus* species A, terminal part of abdomen of predefecating larva, lateral view.

FIGS. 9, 10. *Pseudopanurgus aethiops* (Cresson). 9. Head, lateral view. 10. Terminal part of abdomen of predefecating larva, lateral view.

FIGS. 11-16. *Pseudopanurgus* species B. 11. Predefecating larva, lateral view. 12-14. Left mandible, dorsal, inner, and ventral views. 15, 16. Head, frontal and lateral views.

Scale refers to figure 11.

The condition of the tentorium may depend upon how close the larva is to molting (only one head capsule was cleared with this species). Also there seems to be some variation in the extent of expression of the mandibular serrations. However, the reduction in spiculation, the more sharply pointed dorsal tubercles, and the production of the median tubercle of the last segment are believed to be of diagnostic value in the separating of *boylei* from species A.

Pseudopanurgus (Pseudopanurgus) aethiops (Cresson)

Figures 9, 10

HEAD (FIG. 9): As described for *Pseudopanurgus boylei* except for following: vertical and antennal protuberances even more produced than in *boylei*; tentorium complete; maxilla with but few scattered spicules dorsally; hypopharynx feebly spiculate; spiculations on posterior part of labiomaxillary region minute, scarcely visible; labium divided into prementum and postmentum by inconspicuous fold; palpus small but larger than in *boylei*.

BODY: As described for *P. boylei* except for following: color of postdefecating form unknown; dorsal tubercles (fig. 10) smaller in relation to body size and more sharply pointed than in *boylei*; terminal segment with posterodorsal median tubercle large.

MATERIAL STUDIED: One predefecating larva, Southwestern Research Station, near Portal, Cochise County, Arizona, September 4, 1962 (J. G. Rozen, M. Statham, S. Hessel). Associated adults determined by P. H. Timberlake.

Pseudopanurgus (Pseudopanurgus) Species B

Figures 11-16

This is an undescribed species belonging to the subgenus *Pseudopanurgus*.

HEAD (FIGS. 15, 16): As described for *Pseudopanurgus boylei* except for following: vertical prominences slightly more developed than in *boylei*; tentorium complete; epistomal ridge slightly visible mesiad of anterior tentorial pits; mandible (figs. 12-14) as described for species A; maxilla with spiculations reduced; hypopharynx faintly spiculate; labiomaxillary region with spicules apparently absent.

BODY: As described for *P. boylei* except for following: color of postdefecating form unknown; spiculations reduced; dorsal tubercles (fig. 11) more sharply pointed than in *boylei*; ninth abdominal segment with distinct dorsal tubercles; terminal segment with posterodorsal median tubercle more conspicuous.

MATERIAL STUDIED: Two predefecating larvae, 1 mile north of Rodeo, Hidalgo County, New Mexico, August 28, 1964 (J. G. Rozen); one predefecating larva, same except August 24, 1964. Associated adults are in the collection of the American Museum of Natural History.

These larvae are nearly identical to those of species A.

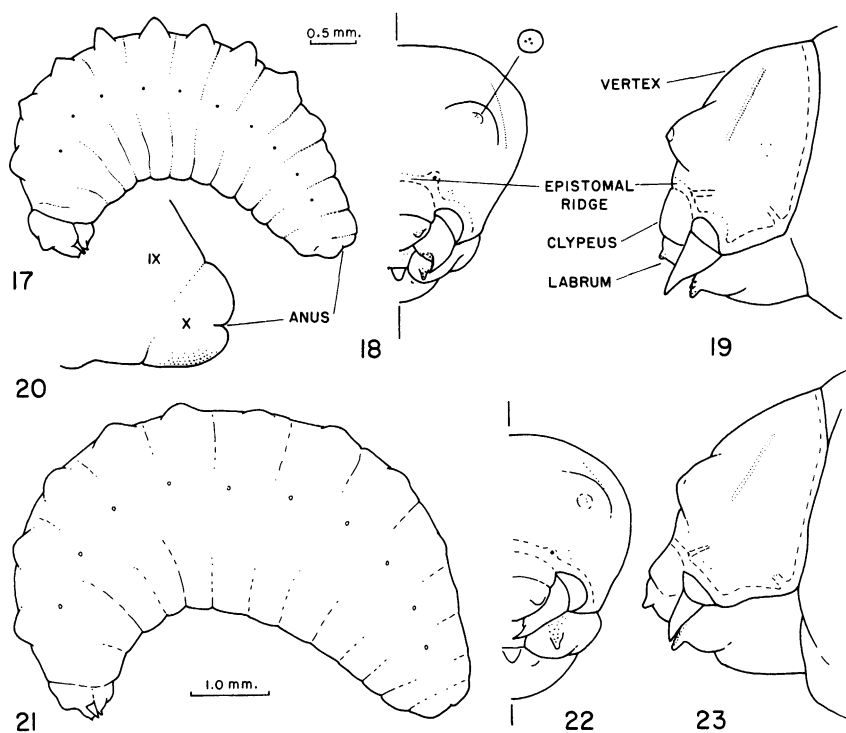
PANURGINUS NYLANDER

The known North American larvae of this Holarctic genus can be distinguished from those of other North American panurgines by the complete epistomal ridge (figs. 18, 19) and the down-curving, spiculate, maxillary palpi. The combination of the low vertex and the strongly projecting antennal prominences is not encountered in other genera, nor is the greatly recessed labium found in other North America forms. The low dorsal body tubercles (fig. 17) that decrease in size posteriorly along the body also provide a quick way to recognize these larvae at a glance. Although the European *Panurgus dentipes* (Rozen and Rozen, in press) share some of these characters, its very long labroclypeal region in contrast to the unusually short one of *Panurginus* permits easy separation of these two taxa.

Panurginus potentillae (Crawford)

Figures 17-20

HEAD (FIGS. 18, 19): Integument with scattered sensilla and setae; maxillary palpi, labral tubercles faintly pigmented; parietal bands unpigmented; vertex produced only modestly on each side above antennae; antennae arising from projecting prominences. Tentorium complete; posterior arms more robust than anterior arms; posterior thickening of head capsule moderately well developed though fading out near dorsal median line; hypostomal ridge well developed and broad; pleurostomal ridge broad but poorly developed, scarcely evident except near mandibular articulations; epistomal ridge broad but not well developed and represented both below and mesiad of anterior tentorial pits; anterior tentorial pits situated in short dorsal extensions of ridge; parietal bands evident. Antenna a low convexity; antenna with three sensilla. Labrum bearing two moderately small tubercles. Mandible slender; upper apical edge serrate and without enlarged subapical tooth as in *Pseudopanurgus*; lower apical edge with serrations somewhat finer than on upper edge; cusp moderately produced and dentate; in general, mandible like that of *Panurginus melanocephalus* (Cockerell) (Michener, 1953, figs. 86, 87). Maxilla moderately large and projecting well beyond recessed labium; apex directed somewhat mesiad; palpus large and curved downward in lateral view; few large spicules found dorsally near apex. Hypopharynx either not spiculate or spicules poorly developed; hypopharyngeal groove present. Labium, unlike that of other panurgine genera, greatly reduced and receding, projecting only about as far as base of mandible; as a consequence, maxillae unusually close together as seen in frontal view; labium not divided into prementum and postmentum; palpus represented



FIGS. 17-20. *Panurginus potentillae* (Crawford). 17. Live, postdefecating larva, lateral view. 18, 19. Head, frontal and lateral views. 20. Tip of abdomen, predefecating larva, lateral view.

FIGS. 21-23. *Panurginus melanocephalus* (Cockerell). 21. Postdefecating larva, lateral view. 22, 23. Head, frontal and lateral views.

Scales refer to figures 17 and 21.

only by vague swellings with several sensilla. Salivary opening a curved slit.

BODY: Color whitish, spiculate in various places, especially just behind head and on ventral surface of tenth abdominal segment (seen best in predefecating larva, fig. 20); spicules not pigmented. On postdefecating larva (fig. 17), three pairs of thoracic and first five pairs of abdominal dorsal tubercles low but well defined; prothoracic pair slightly larger than those of mesothorax and metathorax but somewhat smaller than those of first five abdominal segments; posterior thoracic segments nearly or actually without dorsal tubercles; on predefecating larvae only thoracic and first two pairs of abdominal tubercles distinct, other tubercles represented at most by low mounds; tubercles non-spiculate, with micro-

scopic setae on apex, but setae short and fine and not conspicuous as in *Perdita*; terminal abdominal segment small and not bearing postero-dorsal median tubercle. Spiracles small; atrium projecting above body wall and provided with rim; atrial wall smooth; primary tracheal opening with collar; subatrium elongate; in general, spiracle as in *Panurginus melanocephalus* (Michener, 1953, fig. 88) except for rim and for fact that atrium more spherical and wider than deep.

MATERIAL STUDIED: Four postdefecating and three predefecating larvae, Closter, Bergen County, New Jersey, June 1, 1963 (J. G. Rozen). Adults determined by the author.

Panurginus melanocephalus (Cockerell)

Figures 21-23

The following description is based upon the same specimens used by Michener (1953).

HEAD (FIGS. 22, 23): As described for *Panurginus potentillae* except for following: antennal prominences not quite so projecting.

BODY: As described for *P. potentillae* except for following: body form (fig. 21) not so robust anteriorly and not tapering so pronouncedly posteriorly; body size larger, about 6.0 mm.; color not known; spicules of tenth abdominal segment apparently absent; though larva bloated, dorsal tubercles apparently not projecting so strongly; spiracle in some cases with rim (contrary to fig. 88 in Michener, 1953).

MATERIAL STUDIED: Three postdefecating larvae, Berkeley, Contra Costa County, California, June 28, 1952 (J. W. MacSwain), in the collection of the California Insect Survey.

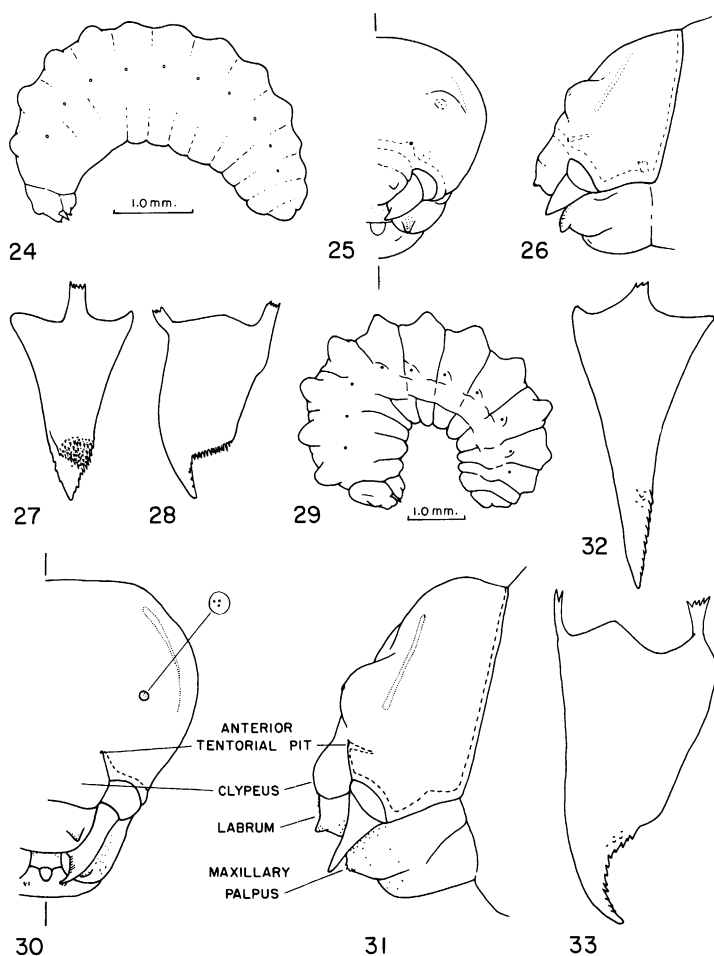
Panurginus Species A

Figures 24-28

HEAD (FIGS. 25, 26): As described for *Panurginus potentillae* except for following: antennal prominences not projecting so strongly; mandible (figs. 27, 28) somewhat more robust and with longer teeth.

BODY: As described for *P. potentillae* except for following: body form (fig. 24) not so robust anteriorly and not tapering so strongly posteriorly; body size, about 5.0 mm.; color not known; spicules on tenth abdominal segment apparently absent; dorsal tubercles slightly larger basally; spiracles perhaps lacking collar.

MATERIAL STUDIED: Seven larvae, Preston Spring, Cub River Canyon, Franklin County, Idaho, May 6, 1949 (G. E. Bohart), in the collection of G. E. Bohart.



FIGS. 24-28. *Panurginus* species A. 24. Postdefecating larva, lateral view. 25, 26. Head, frontal and lateral views. 27, 28. Left mandible, inner and ventral views.

FIGS. 29-33. *Calliopsis crypta* Shinn. 29. Live, postdefecating larva, lateral view. 30, 31. Head, frontal and lateral views. 32, 33. Left mandible, inner and ventral views.

Scales refer to figures 24 and 29.

CALLIOPSIS SMITH

Larvae of *Calliopsis* can be recognized best on the basis of the characters given in the key. They possess a somewhat reduced maxillary palpus (fig. 31) and a rather broadly fused labiomaxillary region; the body

tubercles are rounded, moderately low but distinct. However, *Calliopsis* does not have striking features such as are encountered in some of the other genera. All forms treated here belong to the subgenus *Calliopsis*, and they are indistinguishable from *Nomadopsis* larvae.

Calliopsis (Calliopsis) crypta Shinn

Figures 29–33

HEAD (FIGS. 30, 31): Integument with a few scattered setae; palpi, labral tubercles at most very faintly pigmented; parietal bands pigmented; vertex produced on each side above antennae but not so much so as in *Pseudopanurgus*; antennae arising from moderate prominences. Tentorium complete; anterior arms moderately thick; posterior arms somewhat thicker; posterior thickening of head capsule well developed; hypostomal ridge well developed; pleurostomal ridge well developed; epistomal ridge below anterior tentorial pits thin but distinct; ridge absent mesiad of pits; parietal band evident. Antenna a moderately low convexity with three sensilla. Labrum bearing two prominent tubercles. Mandible (figs. 32, 33) slender; upper apical edge serrate and without large sub-apical tooth; lower edge not serrate; cusp poorly produced, with only a few small teeth. Maxilla moderate in size, slightly exceeding labium; apex not directed adorally; each palpus large in diameter but not long, directed forward; integument spiculate on dorsal surface. Hypopharynx with a few spicules; hypopharyngeal groove present. Labium moderately recessed, apparently not divided into prementum and postmentum; palpus scarcely visible. Salivary opening a curved slit.

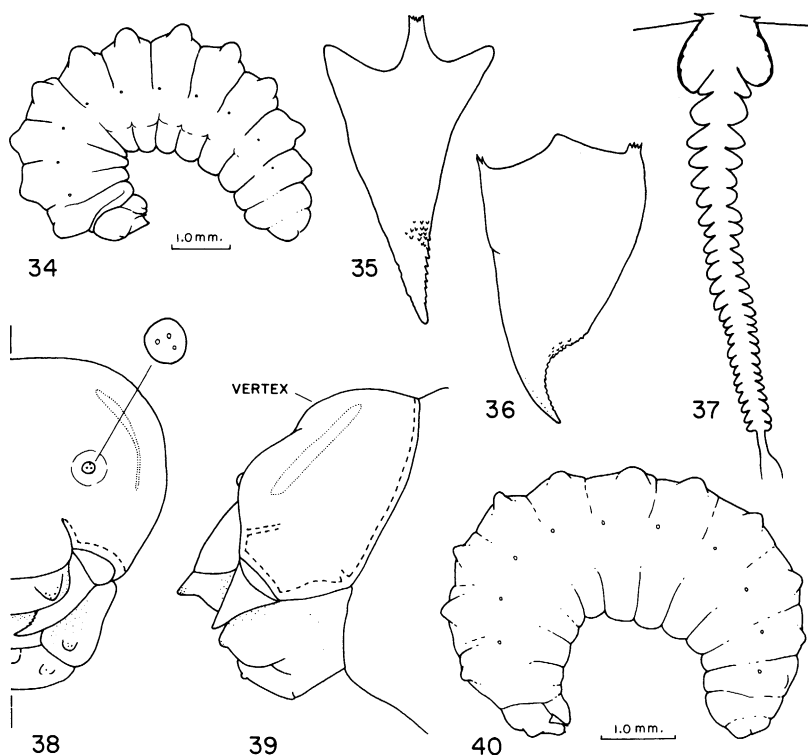
BODY: Integument cream color, with spiculated areas; tenth abdominal segment not spiculate ventrally. Dorsal tubercles (fig. 29) moderate in size, non-spiculate, but minutely wrinkled apically; terminal segment without posterodorsal median tubercle. Spiracles moderate in size; atrium scarcely projecting above body wall; atrial wall without teeth and without ridges; peritreme flat; tracheal opening with collar; subatrium long, like that of *rozeni*? (fig. 37).

MATERIAL STUDIED: Two hibernating larvae, Southwestern Research Station, near Portal, Cochise County, Arizona, collected live September 16, 1962, preserved March 1, 1963, from nest of female paratype (J. G. Rozen). Associated adults identified by Alvin F. Shinn.

Calliopsis (Calliopsis) rozeni Shinn?

Figures 34–39

The larva described below was collected before I realized that two similar appearing species were flying at the Southwestern Research



FIGS. 34–39. *Calliopsis rozeni* Shinn?. 34. Live, postdefecating larva, lateral view. 35, 36. Left mandible, inner and ventral views. 37. Spiracle. 38, 39. Head, frontal and lateral views.

FIG. 40. *Calliopsis andreniformis* Smith, postdefecating larva, lateral view. Scales refer to figures 34 and 40.

Station in the early fall of 1962. Consequently it was not associated with an adult. However, the larva is amply distinct from that of *Calliopsis crypta*, and therefore it almost certainly represents *C. rozeni*, the only other species commonly found at the Station. It can be distinguished from both *C. crypta* and *andreniformis* because it possesses a mandible with a serrated lower apical edge.

HEAD (FIGS. 38, 39): As described for *C. crypta* except for following: parietal bands unpigmented; as seen in lateral view (fig. 39), vertex more gradually rounded; antennal prominences somewhat larger and antennae with greater diameter; mandible less attenuate than that of *crypta* and with lower apical edge serrate; labium projecting moderately, feebly divided into prementum and postmentum.

BODY: As described for *C. crypta* except for following: dorsal tubercles not so acute; atrium projecting slightly farther above body wall; atrial wall with ridges; peritreme slightly convex.

MATERIAL STUDIED: One postdefecating larva, Southwestern Research Station, near Portal, Cochise County, Arizona, September 9, 1962 (M. Satham).

Calliopsis (Calliopsis) andreniformis Smith

Figure 40

Michener (1953) compared the larva of this species with that of *Nomadopsis fracta* Rozen.

HEAD (MICHENER, 1953, FIGS. 101, 102): As described for *C. crypta* except for following: antenna with greater diameter; mandibular cusp (Michener, 1953, figs. 103, 104) with more teeth; labium more strongly developed.

BODY: Dorsal tubercles (fig. 40) less pronounced than in *C. crypta* and *rozeni*?; contrary to Michener (1953), atrium projecting slightly above body wall.

MATERIAL STUDIED: Twelve postdefecating larvae, 11 miles east of Brookville, Jefferson County, Pennsylvania, August 11, 1964 (A. Moldenke). Associated adults determined by the author.

NOMADOPSIS ASHMEAD

The larvae of *Nomadopsis* can be recognized most easily by the features presented in the key. They cannot, however, be distinguished as a group from those of *Calliopsis*. Although none are described here, *Nomadopsis* larvae have been more extensively studied (Rozen, 1958, 1963) than those of any other panurgine genera, in that all of the subgroups are known as larvae, as follows: in the subgenus *Nomadopsis*: *zonalis sierrae* Rozen, *edwardsii* (Cresson), *linsleyi* Rozen, *puellae* (Cockerell); in the subgenus *Macronomadopsis*: *anthidia anthidia* (Fowler), *anthidia lutea* Rozen, *micheneri* Rozen, *filiolum* Rozen; in the subgenus *Micronomadopsis*: *fracta* Rozen, *barbata* Timberlake, *helianthi* (Swenk and Cockerell) [as *euphorbiae* (Cockerell)], *hesperia equina* (Cockerell), *scutellaris scutellaris* (Fowler); and in species of uncertain position: *boharti* Rozen. All three species groups of *Micronomadopsis* are represented.

PERDITA SMITH

The large median tubercle (figs. 41, 52) on the dorsum of the tenth abdominal segment and the setiferous dorsal body tubercles are found in larvae of *Perdita* but not in those of other known panurgine genera.

Furthermore, the low vertex (fig. 43), reduced antennal prominences, small labrum, and enlarged labium are unique in this genus. Unfortunately larvae of but two of the numerous subgenera have been collected.

Perdita (Perdita) zebrata zebrata Cresson

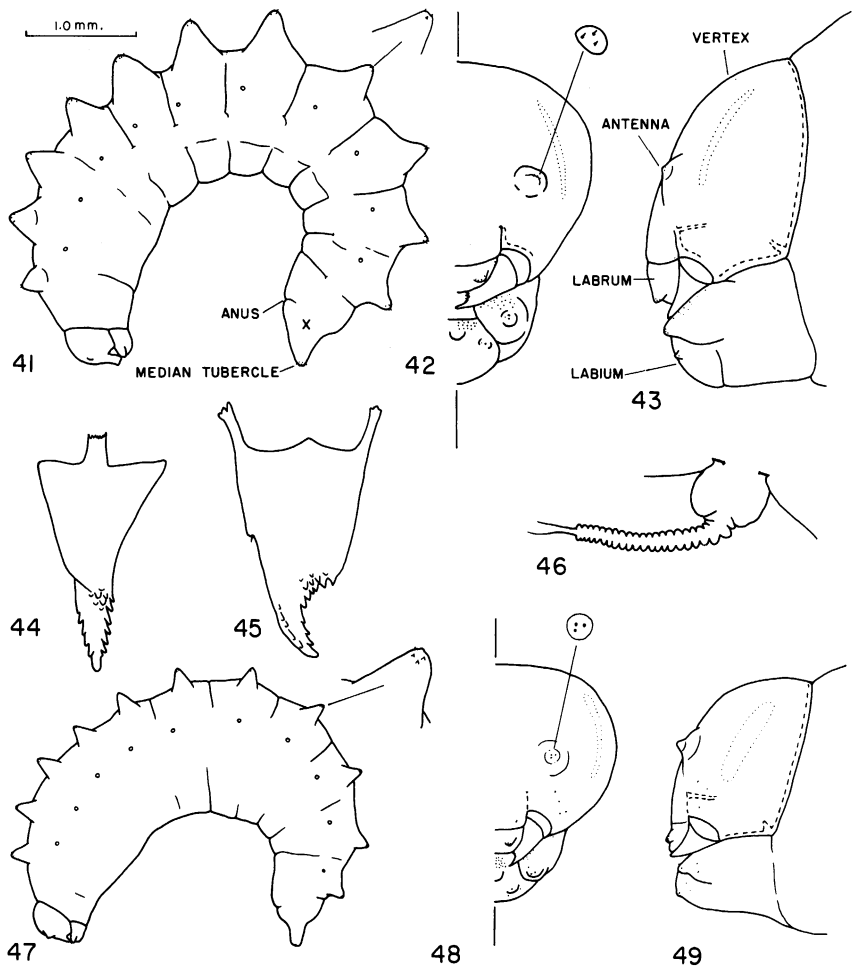
Figures 41-46

The larva of this species was described briefly by Custer (1929) and compared with the larvae of *Perdita opuntiae* and *Nomadopsis australior* (Cockerell).

HEAD (FIGS. 42, 43): Integument with scattered short setae; antennae, palpi, and labral tubercles very faintly pigmented; vertex not produced on each side, therefore unlike that of other panurgine genera; antennae arising from very low prominences. Tentorium incomplete; anterior tentorial arms slender; posterior arms somewhat more robust; posterior thickening of head capsule well developed; hypostomal ridge well developed; pleurostomal ridge faint, evident only toward anterior tentorial pits; epistomal ridge slender but evident below anterior tentorial pits; ridge absent mesiad of pits; parietal bands present but faint. Antenna a low convexity with three sensilla. Labrum small, scarcely exceeding labiomaxillary region, and therefore unlike that of other panurgines; labral tubercles small. Mandible (figs. 44, 45) moderately slender; upper apical edge with numerous large teeth; lower apical edge with teeth somewhat smaller; cusp moderately produced and dentate. Maxilla moderate in size, projecting but little beyond protuberant labium; apex slightly bent adorally; each palpus large, directed forward; integument spiculate dorsally. Hypopharynx spiculate; hypopharyngeal groove absent.¹ Labium projecting, divided into prementum and postmentum; labial palpi moderately small, smaller than maxillary palpi. Salivary opening a curved slit.

BODY: Integument whitish; spiculated areas reduced; tenth abdominal segment not spiculate. Dorsal tubercles (fig. 41) prominent, conical, and with apex non-spiculate but bearing one to four minute, robust setae on small mounds; terminal segment produced into long median tubercle posterodorsally; tubercle moderately long and with minute setae apically;

¹ The hypopharyngeal groove, as seen on cleared specimens, is apparently lost in all *Perdita* except *P. maculigera maculipennis*. On *Perdita zebrata zebrata* there is a sulcus that seems in nearly the same position of the hypopharyngeal groove of other panurgines. That this structure is not the hypopharyngeal groove is indicated by the fact that the hypopharynx, identified by its spiculate surface, lies below the sulcus.



FIGS. 41-46. *Peridita zebrata zebrata* Cresson. 41. Live, postdefecating larva, lateral view. 42, 43. Head, frontal and lateral views. 44, 45. Left mandible, inner and ventral views. 46. Spiracle.

FIGS. 47-49. *Peridita lenis* Timberlake. 47. Postdefecating larva, lateral view. 48, 49. Head, frontal and lateral views.

Scale refers to figures 41 and 47.

not as in other panurgine genera, anus posteroventral in position. Spiracles (fig. 46) moderate in size; atrium projecting well above body wall; atrial wall smooth though with faint grooves; peritreme narrow; primary tracheal opening with collar; subatrium elongate.

MATERIAL STUDIED: Two postdefecating larvae, Fallon, Prairie County,

Montana, August 8, 1962 (J. G. and B. L. Rozen). Adults taken at nesting site determined by P. H. Timberlake.

Perdita (Perdita) lenis Timberlake

Figures 47-49

HEAD (FIGS. 48, 49): As described for *P. zebrata zebrata* except for following: antennae, palpi, and labral tubercles apparently unpigmented; antennae more protuberant; mandible with upper apical edge having teeth somewhat smaller; lower edge with teeth much smaller than those on upper edge; cusp moderately produced and dentate; labium apparently not divided into prementum and postmentum.

BODY: As described for *P. zebrata zebrata* except for following: dorsal tubercles smaller (fig. 47); atrial wall smooth.

MATERIAL STUDIED: One postdefecating larva, east of Portal, Cochise County, Arizona, September 16, 1955 (G. E. Bohart), in the collection of G. E. Bohart. Adults determined by G. E. Bohart.

Perdita (Perdita) confusa Timberlake?

Figure 50

The following larvae were excavated from an area where numerous adult *P. confusa* were flying and where a pupa of *confusa* had been found. The identification of these specimens must be considered tentative, however, because other species of *Perdita* occurred in the region.

HEAD: As described for *P. zebrata zebrata* except for following: antennae, palpi, and labral tubercles apparently unpigmented; mandible as described for *P. lenis*; maxillary integument either not spiculate or with spiculated area reduced; labium perhaps weakly divided into prementum and postmentum.

BODY: As described for *P. zebrata zebrata* except for following: dorsal tubercles (fig. 50) not so pronounced as in other *Perdita* discussed here; posterodorsal median tubercle of terminal segment short, but longer than in *Nomadopsis helianthi* and *Pseudopanurgus*; spiracles with atrial wall smooth.

MATERIAL STUDIED: Two postdefecating larvae, 16 miles northeast of Douglas, Cochise County, Arizona, August 24, 1962 (J. G. Rozen, M. Statham, S. Hessel). Associated adults identified by P. H. Timberlake.

Perdita (Perdita) maculigera maculipennis Graenicher

The following description is based on the same specimens employed by Michener and Ordway (1963) in their treatment of the larva.

HEAD (MICHENER AND ORDWAY, 1963, FIGS. 4, 5): As described for *P. zebrata zebrata* except for following: integument unpigmented; anten-

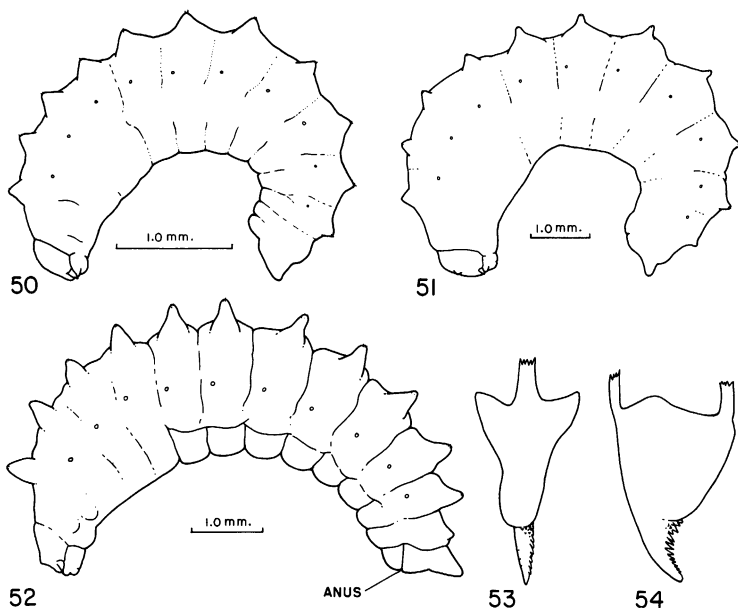


FIG. 50. *Perdita confusa* Timberlake?. Postdefecating larva, lateral view.

FIG. 51. *Perdita sexmaculata* Cockerell?. Postdefecating larva, lateral view.

FIGS. 52-54. *Perdita lingualis* Cockerell. 52. Postdefecating larva, lateral view. 53, 54. Left mandible, inner and ventral views.

Scales refer to figures 50-52.

nal prominences somewhat higher; tentorium complete; teeth on mandibular cusp, more numerous; hypopharynx spiculate (not shown in illustration); hypopharyngeal groove distinct, not as in other known *Perdita*.

BODY (MICHENER AND ORDWAY, 1963, FIG. 3): As described for *P. zebrata zebrata* except for following: posterodorsal tubercles, including tubercle of tenth abdominal segment, more pronounced and with apical setae larger; atrial wall (Michener and Ordway, 1963, fig. 8) apparently smooth.

MATERIAL STUDIED: Numerous postdefecating larvae, Lawrence, Douglas County, Kansas, August 20, 1957 (C. D. Michener). Adults identified by P. H. Timberlake.

Perdita (Perdita) sexmaculata Cockerell?

Figure 51

These larvae were uncovered from a nesting area where numerous

adults of *P. sexmaculata* were found burrowing in subsequent years. It seems fairly certain, therefore, that the larvae belong to this species.

HEAD: As described for *P. zebrata zebrata* except hypopharynx spiculate.

BODY: As described for *P. zebrata zebrata* except for following: dorsal tubercles (fig. 51) somewhat smaller and with apices somewhat more constricted; median tubercles of terminal segment slightly shorter.

MATERIAL STUDIED: Six postdefecating larvae, 3 miles east of Apache, Cochise County, Arizona, September 22, 1963 (J. G. Rozen). Associated adults determined by P. H. Timberlake.

Perdita (Cockerellia) lingualis Cockerell

Figures 52-54

The specimens used in the following comparison are the same as those studied by Michener (1963). As Michener illustrated a predefecating larva, the postdefecating form is figured (fig. 52) here.

HEAD (MICHENER, 1963, FIGS. 3, 4): As described for *P. zebrata zebrata* except for following: head capsule more darkly pigmented; antennal prominences somewhat more pronounced; mandible (figs. 53, 54) more slender apically and ventral inner edge without teeth; maxillae finely and sparsely spiculate dorsomedially (not shown in Michener, 1963, fig. 4); hypopharynx with only few indistinct spicules.

BODY: As described for *P. zebrata zebrata* except for following: dorsal tubercles (fig. 52; and Michener, 1963, fig. 2) arising more abruptly; tubercles of ninth abdominal segment evident; anal slit, especially on postdefecating larva, abnormally elongate (fig. 52); atrial wall smooth.

MATERIAL STUDIED: Nine predefecating and three postdefecating larvae, Lawrence, Douglas County, Kansas, September 1, 1955 (C. D. Michener), in the collection of the University of Kansas.

REFERENCES CITED

- CLAUDE-JOSEPH, F. [H. JANVIER]
1926. Recherches biologiques sur les hyménoptères du Chili (mellifères). Ann. Sci. Nat., Zool., ser. 10, vol. 9, pp. 113-268, figs. 1-97.
- CUSTER, CLARENCE P.
1929. Habits of *Perdita zebrata* with description of larva. Canadian Ent., vol. 61, pp. 49-51.
- MICHENER, CHARLES D.
1953. Comparative morphological and systematic studies of bee larvae with a key to the families of hymenopterous larvae. Univ. Kansas Sci. Bull., vol. 35, pp. 987-1102, figs. 1-287.
1963. Observations on the bionomics of a colonial bee of the genus *Perdita* (Hymenoptera: Apoidea, Panurginae). Jour. Kansas Ent. Soc., vol. 36, pp. 114-118, 2 figs.

MICHENER, CHARLES D., AND ELLEN ORDWAY

1963. The life history of *Perdita maculigera maculipennis* (Hymenoptera: Andrenidae). Jour. Kansas Ent. Soc., vol. 36, pp. 34-45, figs. 1-10.

ROZEN, JEROME G., JR.

1951. A preliminary comparative study of the male genitalia of Andrenidae (Hymenoptera, Apoidea). Jour. Kansas Ent. Soc., vol. 24, pp. 142-150, figs. 1-17.
1958. Monographic study of the genus *Nomadopsis* Ashmead (Hymenoptera: Andrenidae). Univ. California Publ. Ent., vol. 15, pp. 1-202, 218 text figs., 17 maps.
1963. Notes on the biology of *Nomadopsis*, with descriptions of four new species (Apoidea, Andrenidae). Amer. Mus. Novitates, no. 2142, pp. 1-17, figs. 1-20.
- 1965a. The biology and immature stages of *Melitturga clavicornis* (Latreille) and of *Sphecodes albilabris* (Kirby) and the recognition of the Oxaeidae at the family level (Hymenoptera, Apoidea). *Ibid.*, no. 2224, pp. 1-18, figs. 1-22.
- 1965b. Biological notes on the cuckoo bee genera *Holcopasites* and *Neolarra* (Hymenoptera: Apoidea). Jour. New York Ent. Soc., vol. 73, pp. 87-91, figs. 1-4.

ROZEN, JEROME G., JR., AND BARBARA L. ROZEN

- [In press.] Mature larvae of the Old World bee genus *Panurgus* (Hymenoptera, Apoidea). Jour. New York Ent. Soc.