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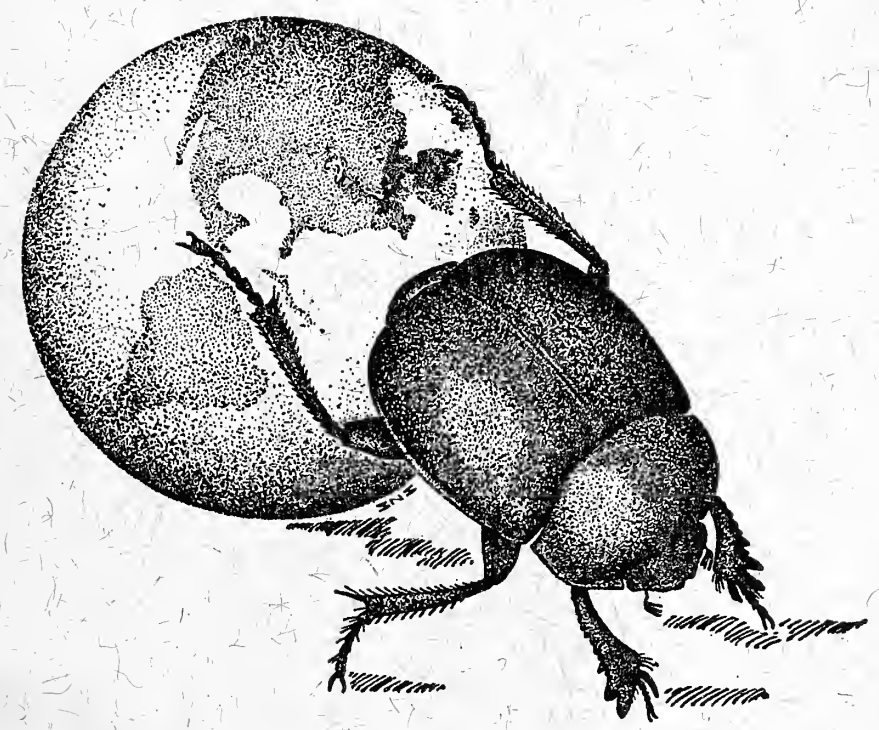

Devoted to Entomology in General

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New York Entomological Society

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Journal of the New York Entomological Society

VOLUME LXXIV MARCH 31, 1966 No. 1

CONTENTS

Musculature and Nervous System of the Thorax, of the Sound Mechanism, and of a Typical Pregenital Abdominal Segment of the Male of the Annual Cicada, *Tibicen chloromera* (Walker) (Homoptera: Cicadidae)[1]

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Abstract: The musculature and innervation of the thorax, sound mechanism, and the fourth abdominal segment of the male annual cicada, *Tibicen chloromera* (Walker) are described.

The ventral nerve cord consists of a subesophageal ganglion, prothoracic ganglion, and a thoracic–abdominal ganglionic mass. There are no ganglia present in any of the abdominal segments. The prothoracic ganglion supplies innervation to some of the muscles of the cervical area and the muscles of the prothorax. The thoracic–abdominal ganglionic mass provides innervation to the posterior tergo-sternal muscles of the prothorax, the muscles of the prothorax, the muscles of the mesothorax, metathorax, and all of the abdominal segments. The abdominal segments are innervated by lateral nerve branches which arise from a pair of nerves that originate from the posterior portion of the thoracic–abdominal ganglionic mass located in the mesothorax. No median nerves are visible between the subesophageal ganglion, prothoracic ganglion, and the thoracic–abdominal ganglionic mass. The median nerves are probably included within the interganglionic connectives.

The members of the family Cicadidae are among the largest insects classified in the order Homoptera. Their periodic occurrences in large numbers and the shrill "song" produced by the males have probably aroused the curiosity of man since the beginning of time. Despite their large size and the interest they have received by virtue of their sound-producing apparatus, cicadas have been somewhat neglected by morphologists. This study was undertaken as a contribution to our knowledge of the musculature and innervation of the thorax, of the sound mechanism, and of a typical pregenital abdominal segment of the male of the annual cicada, *Tibicen chloromera* (Walker).

A study of the nerve patterns in insects may be approached with at least two different objectives in mind. From a physiological or histological standpoint, a knowledge of nerve and muscle arrangements is a necessary prerequisite for precise investigations. From a morphological standpoint, a knowledge of the hexapod nervous system is essential in establishing nerve and muscle homologies and thereby provide additional information on the course of phylogenetic development. This paper is an attempt in the latter direction with the full understanding that detailed investigations of many more forms are necessary in order to establish the course of phylogenetic development.

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[1] Paper of the Jour. Series, N. J. Agric. Expt. Station, Rutgers–The State University of New Jersey, Dept. Ent. and Econ. Zool.

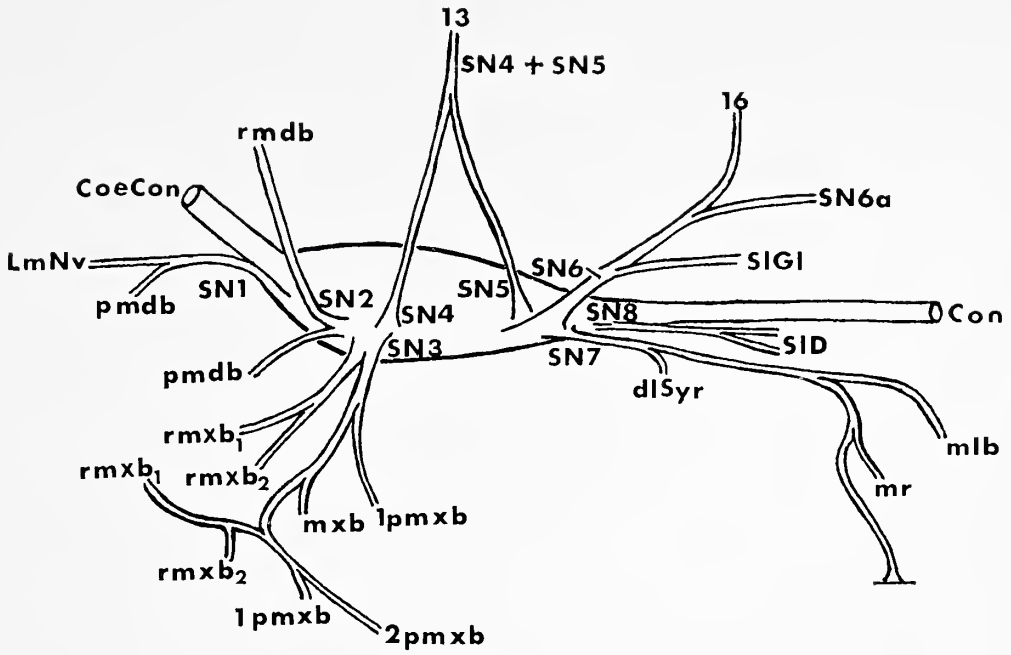

Figure 1A

Fig. 1A. Lateral view of the subesophageal ganglion of the male annual cicada *Tibicen chloromera* (Walker).

The concept of an underlying homology of segmental musculature has provided important evidence on the evolution of the insect thorax and appendages. This concept is based on the assumption that at sometime in the past history of the Hexapoda, the abdominal somites, as leg-bearing segments, had essentially the same structure as the primitive thoracic and gnathal segments. If we assume that the innervation pattern as well as the musculature was homologous in each ancestral segment then the nerve configuration manifested in insects today is a variation of the ancestral pattern. Moreover, since the inherent purpose of the nervous system is to transmit nerve impulses, selective pressure on the nerve pattern would be less than on the structures innervated (Schmitt, 1959). This assumption should not be interpreted to imply that the nervous systems of insects have remained static in the course of phylogenetic development, but rather that through investigations of the segmental innervation patterns of insects and by establishing criteria of homology of nerves through the utilization of primitive muscle groups and nerve junctions, a knowledge of the course of the phylogenetic development of the nervous system should be possible.

Unfortunately, only a very few comparative morphological investigations have been presented in the literature concerning the establishment of nerve homologies in insects. The writer hopes that this paper will be a significant addition to the existing studies and serve to cultivate further interest regarding the concept of a basic plan of segmental innervation.

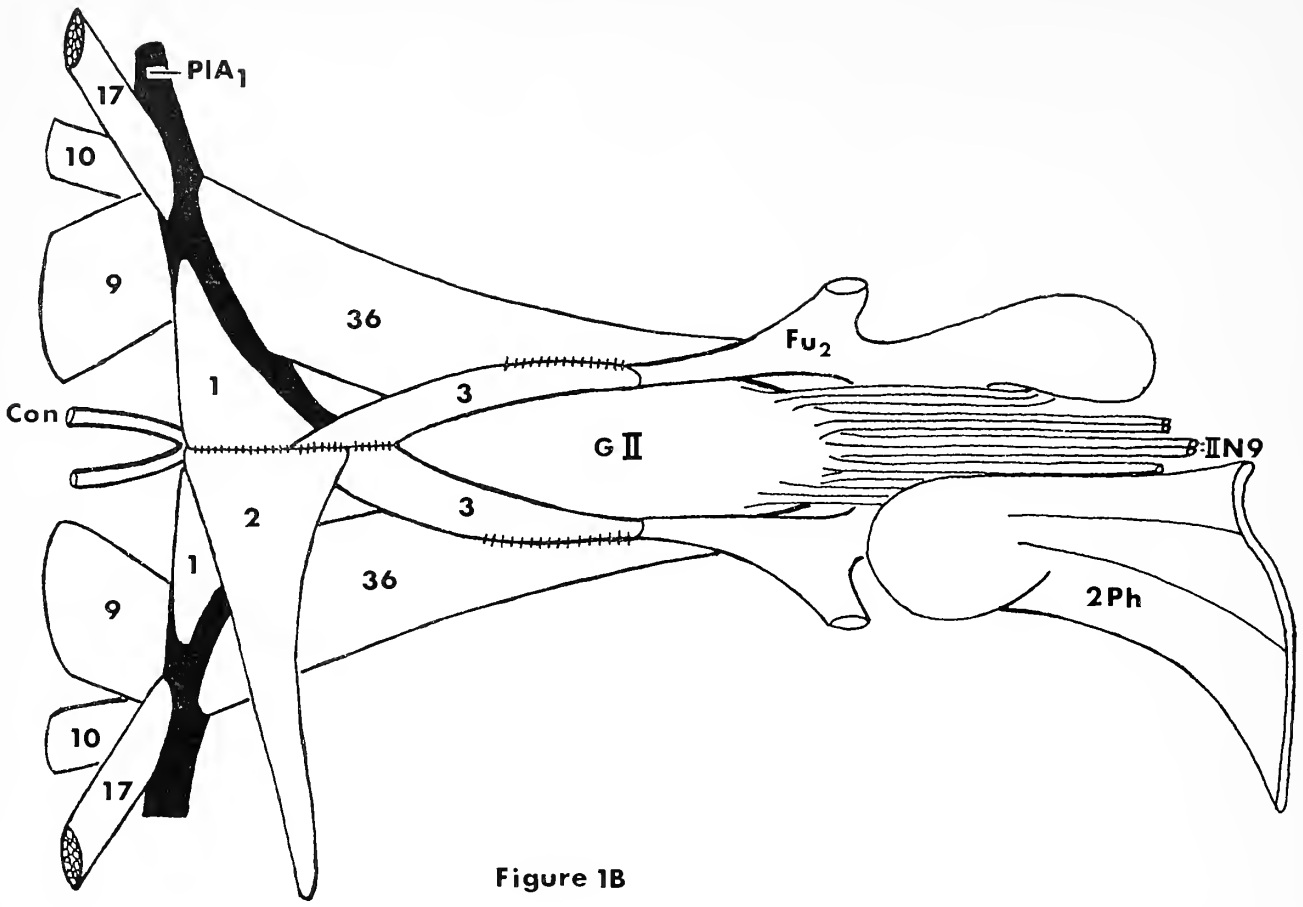

FIG. 1B. Dorsal view of ventral muscles that cover the prothoracic ganglion and anterior portion of the thoracic–abdominal ganglionic mass of the male annual cicada *Tibicen chloromera* (Walker).

OBJECTIVES

1. Determine the musculature of the thorax of the male of the annual cicada, *Tibicen chloromera* (Walker) and compare this musculature to that of *Huechys sanguinea* var. *philaemata* as described by Maki (1938) and to that of *Cicada* (= *Tibicen*) *plebeia* as described by Berlese (1909).
2. Describe the ventral nerve cord of *Tibicen* and compare its configuration to the ventral nerve cords previously described in the family Cicadidae.
3. Determine and describe the cervicothoracic nervous system of the male of *Tibicen chloromera* (Walker) and, if feasible, to establish criteria of homology.
4. Determine the musculature of the first abdominal segment of *Tibicen* which contains the sound mechanism and compare this musculature to that described by Maki (1938) for *Huechys* and to that of *Cicada* (= *Tibicen*) *plebeia* as described by Berlese (1909).
5. Determine the innervation of the first abdominal segment of the male of *Tibicen chloromera* (Walker).
6. Determine the musculature of a typical pregenital abdominal segment of

Table 1. Ventral muscles covering the prothoracic and thoracic–abdominal ganglia of *Tibicen chloromera* (Walker).

Muscle number	Origin	Insertion
1	Pleural arm of prothorax	Zygomatic with muscles 2 and 3 over the prothoracic ganglion and the anterior portion of thoracic–abdominal ganglionic mass.
2	Anterior margin of episternum ventral to tergo-pleural 40	Zygomatic with muscles 1 and 3 over the prothoracic ganglion and the anterior portion of thoracic–abdominal ganglionic mass.
3	Anterior mesofurcal arm	Zygomatic with muscles 1 and 2 over the prothoracic ganglion and the anterior portion of thoracic–abdominal ganglionic mass.

Tibicen and compare this musculature to that described by Maki (1938) for *Huechys*.

7. Determine the innervation of a typical pregenital abdominal segment of *Tibicen* and, if feasible, to establish criteria of homology.

REVIEW OF LITERATURE

The literature will be reviewed under five major headings corresponding to their order of presentation in this paper.

1. THE VENTRAL NERVE CORD

Comparatively little is known concerning the general nerve configuration in the families of the order Homoptera. The principal writers reporting on the ventral nerve cord of cicadas are: Binet (1894), Dufour (1833), Hilton (1939), and Myers (1928). It may be stated that within the family Cicadidae a high degree of specialization has taken place as far as the nervous system is concerned (Myers, 1928). The chief evidence of this specialization is the fact that all abdominal ganglia have become consolidated within the large thoracic–abdominal ganglionic mass located in the mesothorax.

Binet (1894) described the subintestinal nervous system of *Cicada orni*. By microscopic sections of the thoracic–abdominal ganglionic mass, Binet was able to distinguish the abdominal ganglia by the absence of crural lobes correlated with the absence of legs in corresponding segments (Myers, 1928).

Dufour (1833), in an earlier publication, described the ventral nerve cord in *Cicada orni* as having a cephalic ganglion and two thoracic ganglia. The thoracic ganglia are nearly fused, forming one oblong body which is covered dorsally by a mass of muscles which occupy the lower wall of the thorax. Dufour states that the anterior thoracic ganglion gives rise to four pairs of principal nerves, while the posterior ganglion gives rise to six pairs of nerves. The nerve cords

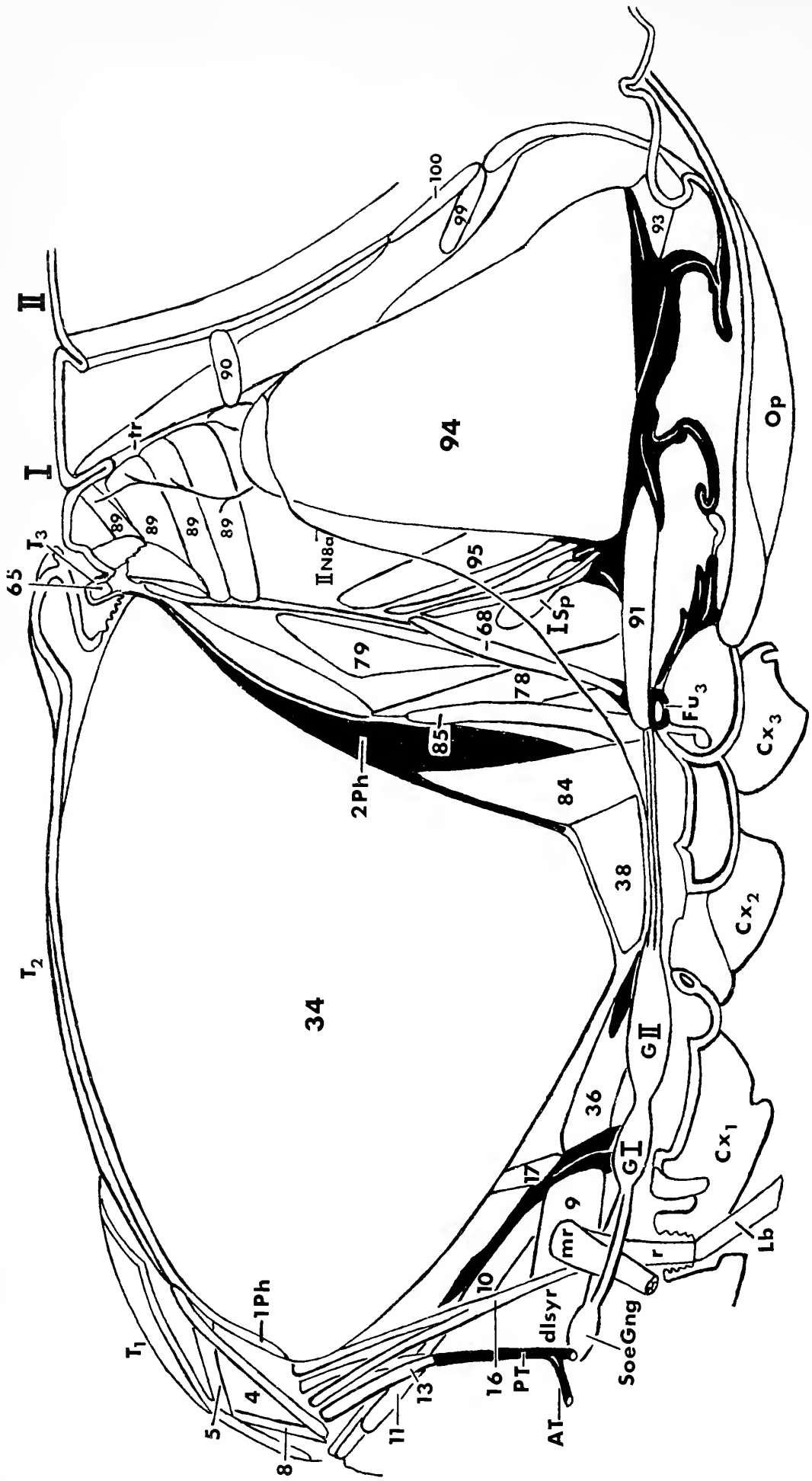

FIG. 2. First stage dissection showing muscles of the cervix, thorax, and first abdominal segment and the ventral nerve cord in longitudinal section in the male annual cicada *Tibicen chloromera* (Walker).

which innervate the abdominal segments are adherent at their origin but separate before finally dividing in the abdominal cavity. Dufour did not describe the subesophageal ganglion which, according to Myers (1928), may have been mistaken for the brain.

Hilton (1939) described the central nervous system for both the immature and adult stages of a cicada. Unfortunately, no mention is made of the species studied. There were two ganglia in both the immature and mature cicada other than the superesophageal ganglion. Hilton further stated that there are many large, long nerves issuing from the caudal portion of the large thoracic–abdominal ganglion.

Myers (1928) described the brain and ventral nerve cord of *Melampsalta sericea*. The round subesophageal ganglion is connected to the first ganglionic mass by a pair of long, stout, well-separated interganglionic connectives. The first ganglionic mass lies largely in the prothorax. Two short, very stout interganglionic connectives join the first ganglionic mass to the second thoracic mass which lies wholly within the mesothorax. Myers states that the second thoracic mass is much longer than broad and displays signs of a two fold origin. However, from the standpoint of gross anatomy, the abdominal ganglia cannot be distinguished. Nerves that innervate typical abdominal segments superficially appear to arise as a single cord as they leave the second thoracic mass. Later the single cord splits into two nerves as it enters the abdomen.

2. THORACIC MUSCULATURE

The thoracic musculature of two species of cicadas have been described by Berlese (1909) and Maki (1938). Berlese (1909) described in some detail the thoracic musculature of *Cicada* (=*Tibicen*) *plebeia*. Muscles are identified in figures by Roman or Arabic numerals while descriptions of muscle origins and insertions are included in the text. An attempt is made to homologize the thoracic musculature of several species of insects. Unfortunately, with respect to *Cicada* (= *Tibicen*) *plebeia*, it appears many of the muscles that originate on the furcal and pleural arms and attach to the coxae and trochantine are omitted.

Maki (1938) presents a very detailed description of the thoracic muscles of *Huechys sanguinea* var. *philaemata*. Muscles are identified by their position and function; however, in tables and figures, Arabic numerals are utilized for muscle numbers. Muscle origins and insertions are described in the text.

In his study of Hemiptera, Maki presents the thoracic musculature of *Eurostus validus*, *Sigara substriata*, *Cicadella ferruginea*, *Macrohomotoma gladiatum*, and *Huechys sanguinea* var. *philaemata*. Maki includes in his tables the musculature of *Nezara viridula* by Malouf (1933), *Cicada plebeia* by Berlese (1909), and *Psylla mali* by Weber (1929).

Snodgrass (1927 and 1935), illustrates a portion of the thoracic musculature of *Tibicina* (= *Magicicada*) *septendecim* as an example of indirect wing muscles.

TABLE 2. Prothoracic musculature of *Tibicen chloromera* (Walker).

Muscle	Muscle number	Origin (or attachment)	Insertion (or attachment)
Dorsal muscles			
Median dorsal	4	Posterior edge of head	First phragma
Median dorsal	5	Dorsolaterally on middle of tergum	First phragma
Lateral dorsal	6	Dorsolaterally on middle of tergum	Anterolateral region of first phragma
Lateral dorsal	7	Dorsolaterally on middle of tergum	Anterior edge of first phragma
Anterior dorsal	8	Posterior edge of head	Dorsolateral midportion of tergum
Ventral muscles			
Internal ventral	9	Posterior tentorial arm	Sternal apophyses
External ventral	10	Posterior end of cervical sclerite	Pleural arm of prothorax
Tergo-sternal muscles			
Anterior intersegmental	11	Posterior edge of head	Ventrolateral cervical sclerite
Anterior intersegmental	12	Posterior edge of head	Ventrolateral cervical sclerite
Anterior intersegmental	13	Anterior dorsolateral region of tergum	Posterior tentorial arm
Anterior intersegmental	14	Dorsolateral region of tergum	Posterior tentorial arm
Anterior intersegmental	15	Anterior dorsolateral region of tergum	Ventrolateral cervical sclerite
Anterior intersegmental	16	Dorsolateral region of tergum	Base of tentorium
Posterior tergo-sternal	17	Anterolateral portion of mesotergum	Pleural arm of prothorax
Tergo-pleural muscles			
Anterior tergo-pleural	18	Dorsolateral portion of posterior edge of head	Base of prothoracic pleural arm
Anterior tergo-pleural	19	Dorsolateral portion of posterior edge of head	Base of prothoracic pleural arm
Ordinary tergo-pleural	20	Middle of lateral region of tergum	Pleural arm of prothorax
Coxal muscles			
Tergal promotor	21	Dorsolateral region of tergum	Anterior rim of coxa
Tergal promotor	22	Lateral region of tergum	Apodeme of trochantin
Sternal promotor	23	Profurca	Anterior basal rim of coxa
Tergal remotor	24	Middle dorsolateral region of tergum	Remotor apodeme of coxa
Tergal remotor	25	Oblique ridge at middle of lateral region of tergum	Remotor apodeme of coxa
Tergal remotor	26	Tergum external to 25	Posterior basal rim of coxa
Tergal remotor	27	Lateral region of tergum beneath 26	Posterior basal rim of coxa
Sternal remotor	28	Profurca	Posterior basal rim of coxa
Tergal abductor	29	Midportion of dorsolateral region of tergum	Apodeme anterolateral basal rim of coxa
Pleural abductor	30	Pleural arm of prothorax	Anterior basal rim of coxa
Pleural abductor	31	Pleural arm of prothorax	Anterior basal rim of coxa
Trochanteral muscles			
Tergal depressor	32	Midlateral region of tergum	Depressor apodeme of trochanter
Pleural depressor	33	Pleural arm of prothorax	Depressor apodeme of trochanter

The muscles illustrated in the mesothorax are the longitudinal dorsal, oblique dorsal, anterior tergo-sternal, and posterior tergo-sternal. The metathoracic depressor muscles of the trochanter and the coxal part of the depressor muscle of the trochanter are also included.

The above muscles are homologous to those of *Cicada* (= *Tibicen*) *plebeia* (Berlese, 1909), *Huechys sanguinea* var. *philaemata* (Maki, 1938), and *Tibicen chloromera* with respect to their origins and insertions.

3. THE CERVICOTHORACIC NERVOUS SYSTEM

Detailed descriptions of the thoracic nervous system have not appeared in the literature for any member of the family Cicadidae nor for any insect in the order Homoptera. Moreover, the literature contains only a relatively few studies regarding the thoracic nervous systems of insects. One reason for this lack of information is due to the time-consuming nature and patience necessary for such research. Therefore, the majority of nerve studies have been restricted to anatomical facts and descriptions of nerve cord configurations. The principal writers who have contributed detailed information on thoracic nervous systems of insects are: Holste (1910) on *Dytiscus marginalis*, Johansson (1957) on *Oncopeltus fasciatus*, Maki (1936) on *Chauliodes formosanus*, Marquardt (1939) on *Carausius morosus*, Matsuda (1956) on *Agulla adnixa* and *Blattella germanica*, Nüesch (1957) on *Telea polyphemus*, Pipa and Cook (1959) on *Periplaneta americana*, Schmitt (1959) on *Dissosteira carolina*, and Wittig (1955) on *Perla abdominalis*.

Schmitt (1962) states that an additional reason for the lag of nerve topography studies in insects is due to the difficulty in relating the findings on one group to those on another group. Furthermore, Maki (1936) and Pipa and Cook (1959) state that there exists a remarkable degree of variability in nerve distribution patterns of different individuals of the same insect species. However, Pipa and Cook (1959) also state that the existence of a fundamental plan in the peripheral distribution of thoracic nerves in widely separated insects is evident. Wittig (1955) describes the innervation pattern in the thorax of the larva and adult of *Perla abdominalis*. She presents a comparison of the innervation fields of the thoracic nerves of *Perla abdominalis* with those of *Chauliodes formosanus* as reported by Maki (1936), *Carausius morosus* as reported by Marquardt (1939), and *Dytiscus marginalis* as reported by Holste (1910) and establishes the existence of nerve homologies in these widely separated insects.

Pipa and Cook (1959) state that the pattern of nerve distribution in *Periplaneta americana* essentially agrees with that found in other insects which have been investigated. A similar indication in *Periplaneta americana* was made by Nijenhuis and Dresden (1955).

Schmitt (1959) describes the cervicothoracic nervous system of *Dissosteira carolina* and presents several areas of nerve homology with respect to *Chauliodes*

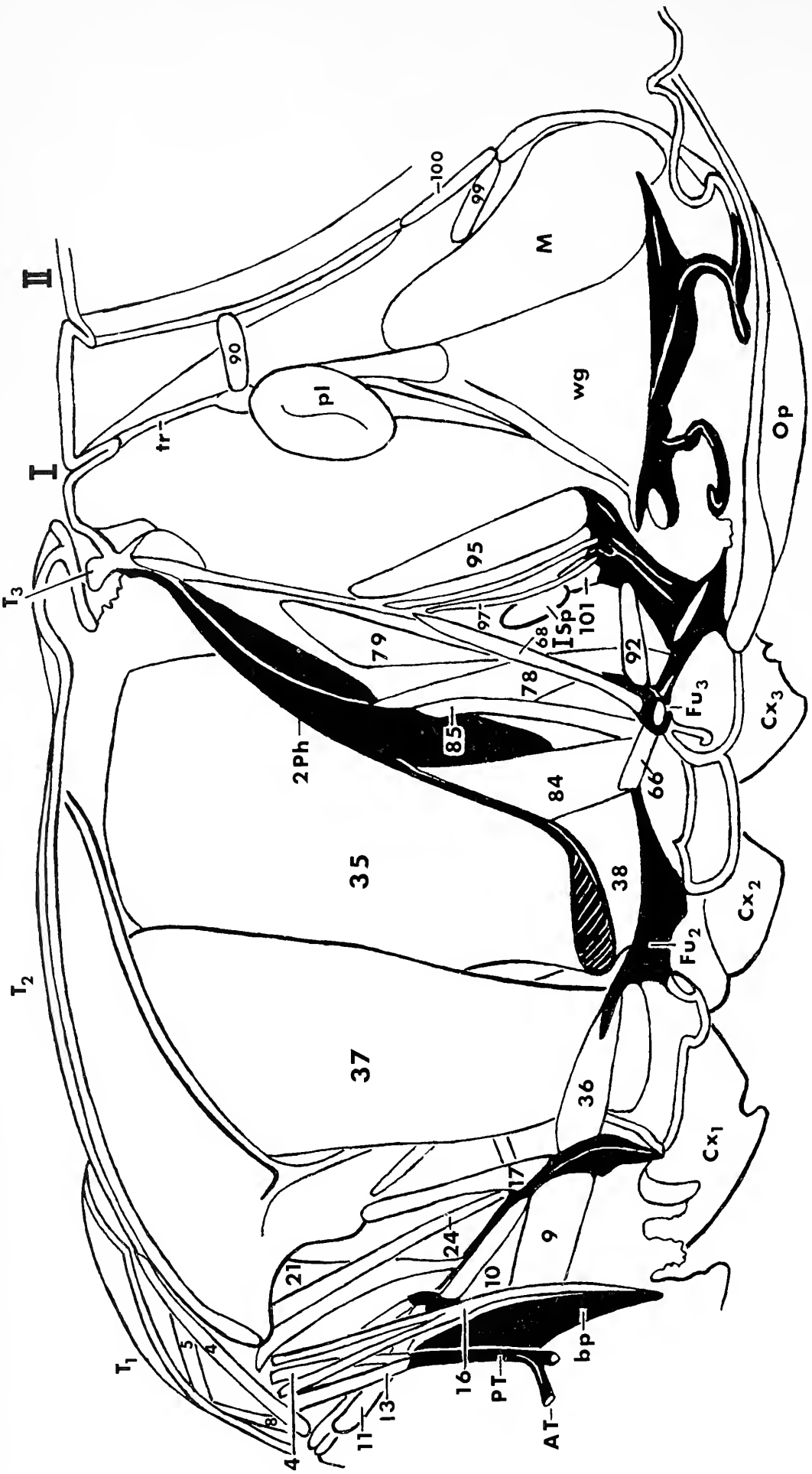

FIG. 3. Second stage dissection showing muscles of the cervix, thorax, and first abdominal segment in longitudinal section in the male annual cicada *Tibicen chloromera* (Walker).

formosanus as reported by Maki (1936). However, he states that the pterothoracic dorsal nerves pass beneath the ventral longitudinal muscles and differ in this respect from the prothoracic dorsal nerves of *Dissosteira* and all the thoracic dorsal nerves of *Chauliodes*. Schmitt compared the nerves of the prothoracic muscles of *Dissosteira* with those of the pterothorax and concluded that there is evidence of a loss of anterior prothoracic musculature as a result of the evolution of the cervix. The cephalic muscles of the cervical sclerites and the ventral lateral neck muscles are derived from this anterior prothoracic musculature. Schmitt also includes a comparative study of the anterior ganglionic connectives of the dorsal nerves of *Dissosteira*, *Periplaneta*, and *Orchelimum* and indicates that the anterior ganglionic connectives of the dorsal nerves may have a wider distribution than in Orthoptera but are not recognizable because of juxtaposition with the connectives of the ventral nerve cord. Schmitt describes the median nerves and the innervation of the spiracular muscles in *Dissosteira* and mentions that the transverse nerves, dorsal nerves, and the innervation of the spiracular muscles of *Chauliodes* as described by Maki (1936) present a pattern identical with that in *Dissosteira*. There appears to be no essential differences in the innervation pattern of the thoracic spiracles as compared with the innervation pattern of the abdominal spiracles in both *Chauliodes* and *Dissosteira*. Schmitt concludes that the nerves to the thoracic spiracles agree sufficiently with the nerve pattern of the abdominal spiracles to indicate that the thoracic spiracles may be homologous with the abdominal spiracles.

Schmitt (1962), in a later paper, despite unfortunate differences in nomenclature applied by different workers, presents additional information establishing the presence of nerve homologies in several insects. Schmitt utilizes the dorsal longitudinal muscles as a starting point since these muscles are homologous both in the thorax and abdomen of insects. Usually, from a descriptive standpoint it is quite simple to identify the dorsal nerves to these muscles. Schmitt arranges in tabular form the names and designations used by various authors for the nerves to the thoracic dorsal longitudinal muscles, designations of the anterior ganglionic connectives, designations of the subesophageal nerves to the protergal muscles, and a comparison of thoracic nerve designations used by various authors with those utilized by Maki for *Chauliodes*. The wing nerves, median and transverse nerves, innervation of the ventral muscles and spinosternal musculature, and a discussion of the prothoracic nervous system in various insects is also presented.

4. The musculature and innervation of the sound mechanism

The majority of investigations appearing in the literature concerning the sound mechanism of cicadas describes the construction of the sound apparatus and the mechanics of sound production. Myers (1928) presents a summary of the studies pertaining to the sound-producing apparatus as well as including his

TABLE 3. Mesothoracic musculature of *Tibicen chloromera* (Walker).

Muscle	Muscle number	Origin (or attachment)	Insertion (or attachment)
Dorsal muscles			
Median dorsal	34	Anterior median portion of tergum	Median area of second phragma
Lateral dorsal	35	Middle of dorsolateral portion of tergum	Lateral portion of second phragma
Ventral muscles			
Longitudinal ventral	36	Profurcal arm	Anterior mesofurcal arm
Tergo-Sternal muscles			
Anterior tergo-sternal	37	Anterior portion of dorsolateral region of tergum	Ventrolateral sternal region
Posterior tergo-sternal	38	Ventral portion of second phragma	Posterior mesofurcal arm
Tergo-Pleural muscles			
Tergo-pleural	39	Anterolateral margin of tergum	Anterior margin of episternum
Tergo-pleural	40	Lateral margin of tergum	Anterior margin of episternum
Tergo-pleural	41	Lateral margin of tergum	Mesothoracic pleural arm
Tergo-pleural	42	Lateral margin of tergum	Prothoracic pleural arm
Tergo-pleural	43	Lateral margin of tergum	Wing process
Tergo-pleural	44	Lateral margin of tergum	Base of mesothoracic pleural arm
Pleural-axillary	45	Episternum	Third axillary sclerite
Pleural-axillary	46	Episternum	Third axillary sclerite
Pleuro-subalar	47	Posterior margin of epimeron	Subalar sclerite
Sterno-Pleural muscles			
Sterno-basalar	48	Anterodorsal portion of episternum	Ventrolateral sternal region
Furco-entopleural	49	Furcal arm of mesothorax	Pleural arm of mesothorax
Coxal muscles			
Tergal promotor	50	Anterolateral region of tergum	Trochantin
Trochantino-basalar	51	Laterodorsal margin of episternum	Trochantin
Trochantino-basalar	52	Anterolateral margin of episternum	Trochantin
Sternal promotor	53	Base of mesofurcal arm	Anterior basal rim of coxa
Tergal remotor	54	Anterolateral region of tergum	Posterior basal rim of coxa
Tergal remotor	55	Posterior dorsolateral region of tergum	By a tendon to posterior basal rim of coxa
Coxo-subalar	56	Posterior basal rim of coxa	Subalar sclerite
Sternal remotor	57	Posterior mesofurcal arm	Posterior basal rim of coxa
Sternal remotor	58	Mesofurcal arm	Posterior basal rim of coxa
Sternal adductor	59	Mesofurca	Mesal basal edge of coxa
Coxo-basalar	60	Dorsal margin of episternum	Anterolateral basal rim of coxa
Trochanteral muscles			
Tergal depressor	61	Anterolateral portion of tergum	Depressor apodeme of trochanter
Trochantero-basalar	62	Dorsal margin of episternum	Depressor apodeme of trochanter
Sternal depressor	63	Mesofurcal arm	Depressor apodeme of trochanter
Muscles of the spiracle			
Occlusor	64	Subspiracularum	Ventral portion of atrial chamber

own findings based on *Melampsalta sericea* and *Melampsalta muta*, two species of cicadas found in New Zealand.

Complete studies regarding the musculature of the first abdominal segment which contains the sound-producing apparatus have been described for *Cicada* (= *Tibicen*) *plebeia* by Berlese (1909) and for *Huechys sanguinea* var. *philaemata* by Maki (1938). Berlese utilizes both Roman and Arabic numerals for muscle identification in his figures while descriptions of muscle attachments are included in the text. Berlese (1909) shows the structure of the sound mechanism in his figures 879 to 882. Berlese considers the sclerotized V-shaped structure, yAd_2 in his figure 880, as the furca of the second abdominal sternite. However, Carlet (1876), Vogel (1923) and Myers (1928) who have given this structure the most attention, ascribe it to the first abdominal segment. Maki (1938) shows the musculature of the sound mechanism in his figure 24 and utilizes Arabic numerals for muscle numbers. Maki presents in tabular form the muscles of the first six abdominal segments with their muscle numbers. Descriptions of the muscle attachments are not included in the text.

A complete presentation of the innervation pattern of the first abdominal segment of cicadas has not appeared in the literature. However, the auditory or tymbal nerves which innervate the large tymbal muscles have been mentioned by various writers since Binet (1894). Swinton (1880) traced the auditory nerve from the thoracic ganglionic mass, presumably in the mesothorax, to the abdomen and around the tymbal muscle. The auditory nerve then forms a ganglion which enters a groove. According to Vogel (1923) the auditory nerve arises in the ventral nerve strands and rises, running parallel with the body wall, in a sclerotized groove and passes dorsally to the sense organ, where its fibers run into the base of each sense cell. Myers (1928), in poorly preserved material, found a distinct nerve emerging on each side of the last thoracic–ganglionic mass and running parallel to a sclerotized ridge leading up to the auditory capsule. Myers (1928) states that it is very improbable that the auditory nerve should arise from the abdominal strands, as Vogel (1923) states.

Investigations utilizing electric stimulation of the auditory or tymbal nerve and the sympathetic nerve have appeared in the literature. Pringle (1954) concluded that the frequency of tymbal movements resulting from the contractions of the tymbal muscle exceeds the rhythm of tymbal nerve stimulation. Pringle also reported that an isolated tymbal muscle does not give multiplied rhythmic reactions when stimulated but functions the same as a common skeletal muscle. Hagiwara and Watanabe (1956) found that at a certain intensity and frequency of nerve stimulation, repetitive potentials up to ten or more resulted from each stimulus in the tymbal muscle, tymbal nerve, and motor neuron. Voskresenskaya and Svidersky (1960) investigated the electrical activity of the tymbal muscle, the tymbal nerve, and the sympathetic nerve during and

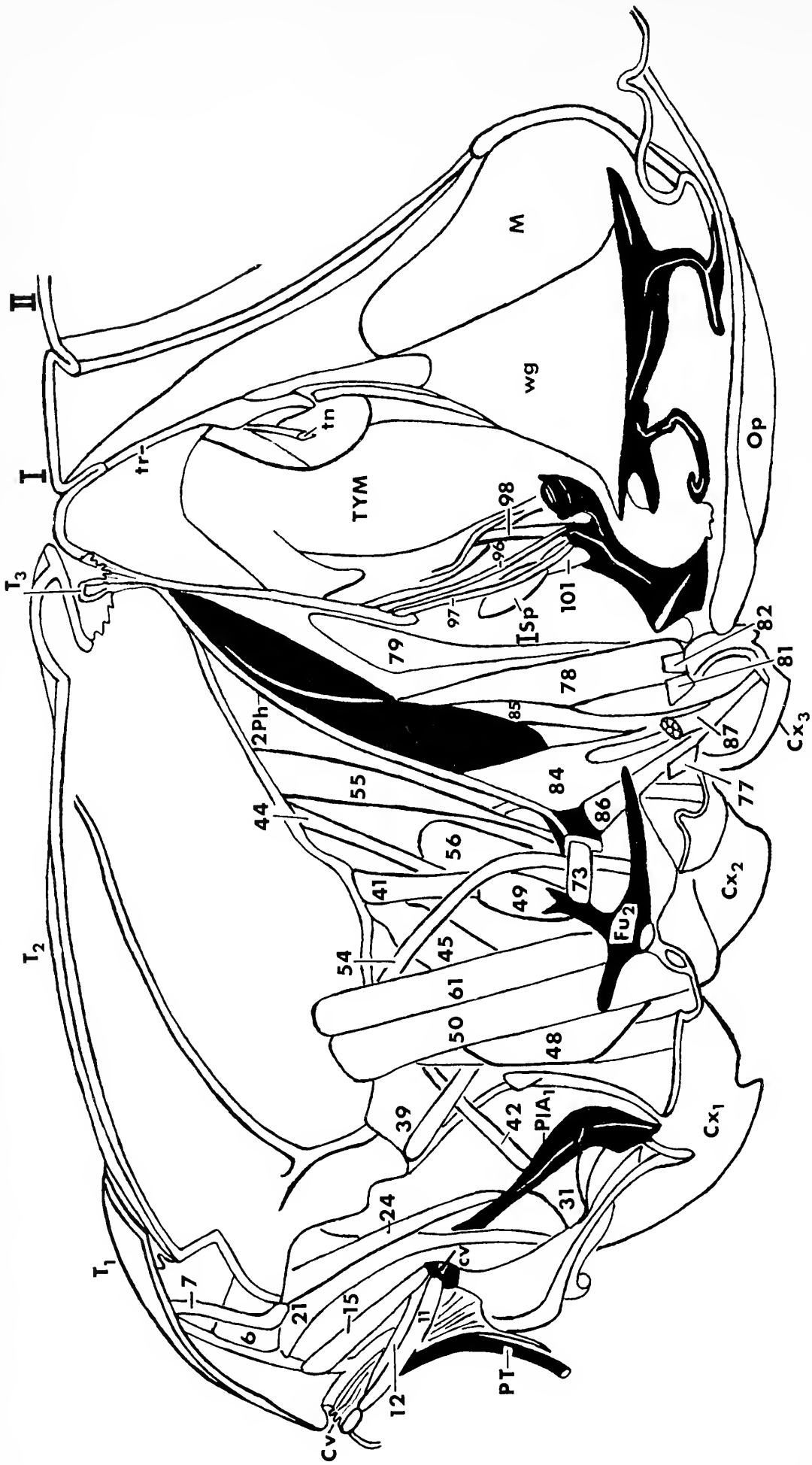

FIG. 4. Third stage dissection showing muscles of cervix, thorax, and first abdominal segment in longitudinal section in the male annual cicada *Tibicen chloromera* (Walker).

after electric stimulation and concluded that the sympathetic nervous system is essential to normal sound production in cicadas.

5. The musculature and innervation of the fourth abdominal segment

The musculature of the pregenital abdominal segments of male cicadas have been described by Maki (1938) for *Huechys sanguinea* var. *philaemata* and by Berlese (1909) for *Cicada* (= *Tibicen*) *plebeia*. Maki in his figure 24 shows the musculature of the first three abdominal segments and utilizes Arabic numerals for muscle numbers. Maki presents the muscles of the first six abdominal segments and their muscle numbers in a table on page 168 where he compares the musculature of *Erostus validus*, *Sigara substriata*, *Huechys sanguinea* var. *philaemata*, *Cicadella ferruginea*, and *Macrohomotoma gladiatum*. Maki does not describe the muscle attachments for *Huechys* in his text; however, they are clearly shown in his figure 24. Berlese (1909) describes the musculature of the first three abdominal segments in *Cicada* (= *Tibicen*) *plebeia* and utilizes both Roman and Arabic numerals for muscle identification. Descriptions of the muscle attachments are included in the text.

No studies dealing with the innervation of a pregenital abdominal segment of a male cicada have been found in the literature. Moreover, the literature contains only a few studies on the abdominal nervous system of insects.

In recent years some interest has been shown regarding the establishment of basic segmental nerve pattern within the Hexapoda. Schmitt (1954) describes the nervous system of the pregenital abdominal segments of *Dissosteira carolina*, *Acheta assimilis*, *Periplaneta americana*, and *Diapheromera femorata*. Schmitt utilizes various points of nerve homology or "landmarks" in presenting the innervation pattern of the above insects. The innervation of the ventral diaphragm in *Dissosteira* is also described. Libby (1959) describes the musculature and innervation of the second and third abdominal segments of the cecropia larva and concludes that the dorsal, ventral, and transverse nerve roots arising from each segmental ganglion of the cecropia larva seem homologous with those described by Schmitt (1954) for the pregenital segments of certain Orthoptera. Libby concludes, by utilizing the points of nerve homology set forth by Schmitt, that the homogeneity of the innervation pattern in such widely separated orders as Orthoptera and Lepidoptera lend further support to the concept of a basic segmental nerve pattern within the Hexapoda. Libby (1961) describes the musculature and innervation in the fourth abdominal segment of the adult male cecropia moth *Hyalophora cecropia* and compares his finding with the pregenital abdominal segments of *Chauliodes formosanus*, as described by Maki (1936), *Acheta assimilis*, as described by Schmitt (1954), and the larva of *Hyalophora*, as described by Libby (1959).

Schmitt (1963) describes the abdominal nervous system in the nymph of *Pteronarcys proteus* and the adult of *Pteronarcys californica* and concludes that

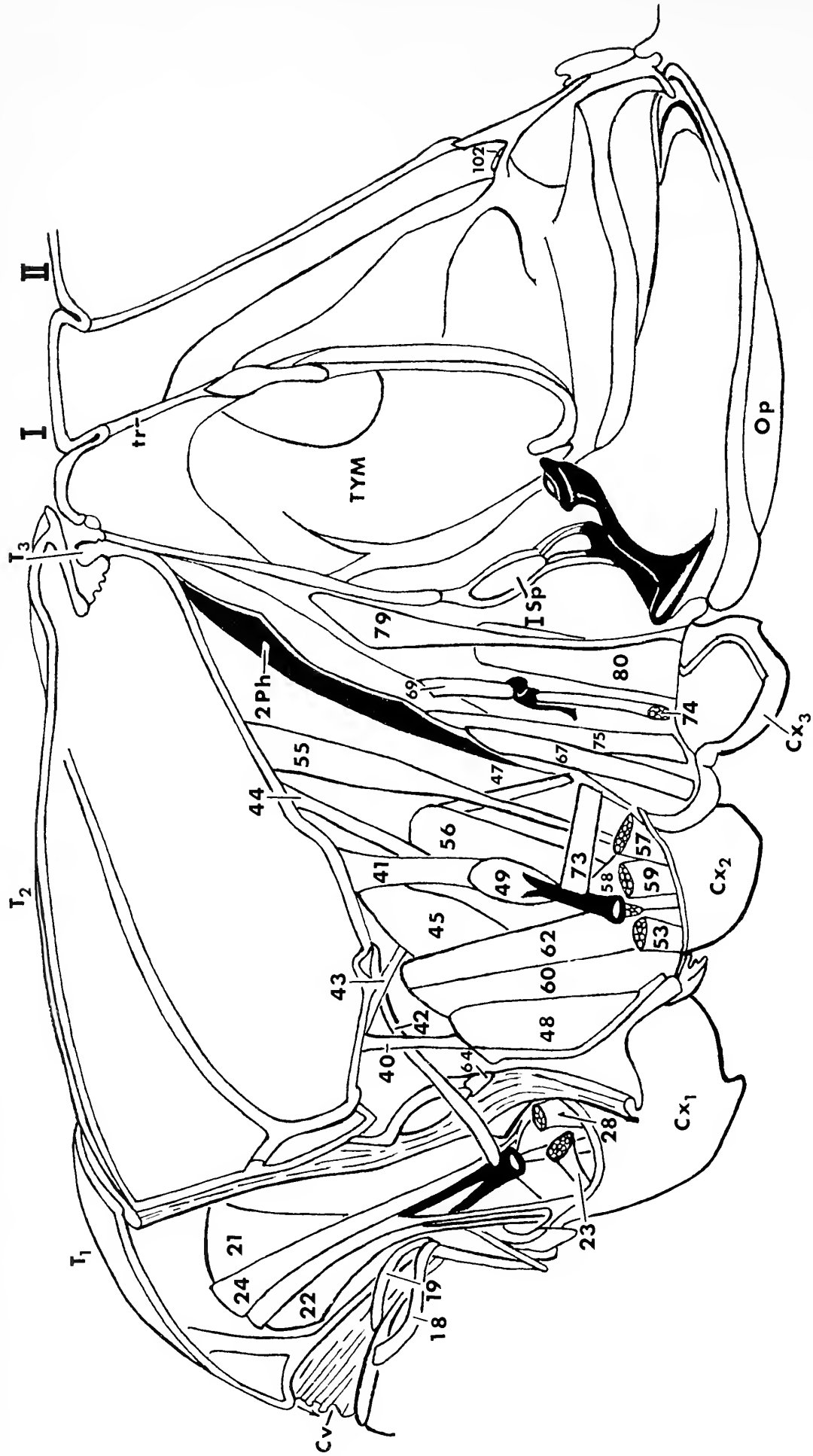

FIG. 5. Fourth stage dissection showing muscles of the cervix, thorax, and first abdominal segment in longitudinal section in the male annual cicada *Tibicen chloromera* (Walker).

the ganglia of segments 3 and 4 have coalesced and only the first three segments contain both dorsal and ventral nerves. The transverse nerves of segments 4, 5, and 6 arise from the ganglia of the immediately following segments. No occlusor or dilator muscles of the spiracles could be found in the two above-mentioned species of *Pteronarcys*. Schmitt also describes the muscles and nerves of the genital segments.

Schmitt (1964) describes the nerve pattern of the pregenital abdominal segments of *Neoconocephalis exiliscanorus* and *Ceutophilus gracilipes gracilipes*, two Orthoptera classified in the family Tettigoniidae. The segmental nerve patterns of these two insects were comparable and conformed to the patterns described in the Acrididae, the Gryllidae, and the Blattidae, as described by Schmitt (1954), and in *Carausius* (Phasmidae) as described by Marquardt (1939). Similarities in the nerve patterns to *Hyalophora cecropia* as described by Libby (1959 and 1961) and by Beckel (1958) and in some degree to the Plecoptera and the Megaloptera were noted. No innervation to the alary muscles could be found in *Neoconocephalus* or *Ceutophilus*.

Schmitt (1965) presents a comparative study on the transverse nerves of the pregenital abdominal segments of insects. By comparing the segmental innervation patterns of *Periplaneta*, *Neoconocephalus*, *Hyalophora*, *Chauliodes*, *Pteronarycs*, *Acroneurai*, *Apis*, and *Tibicen*, Schmitt concludes that, in those insects which apparently lack median and transverse nerves, these nerves are incorporated in the longitudinal connectives and lateral segmental nerves.

MATERIALS AND METHODS

Insect Material Used in the This Study.—The male of the annual cicada, *Tibicen chloromera* (Walker), was selected for this study in order to provide information concerning the musculature and nervous system of the thorax, sound mechanism, and a typical pregenital abdominal segment. The annual cicada's large size and ready availability make them especially attractive subjects for such investigation.

Nomenclature.—Nomenclature used in this study involve primarily the musculature and nervous system. Various methods of nomenclature have been devised for each of these organ systems.

Nomenclature of the musculature is based on the general outline set forth by Maki (1938) in his work on *Huechys sanguinea* var. *philaemata*. Muscles are named according to their position, attachment, or function and are assigned Arabic numerals which serve as muscle numbers in figures.

Effective nerve nomenclature requires not only that it describe the nerves in question, but also that it can be applied or adapted to as many nervous systems as possible in order to demonstrate nerve homologies. However, before a standard terminology can be devised, it is essential to have a relatively thorough knowledge of the musculature and nervous systems of many different insect

TABLE 4. Metathoracic Musculature of *Tibicen chloromera* (Walker)

Muscle	Muscle Number	Origin (or attachment)	Insertion (or attachment)
Dorsal muscles			
Median dorsal	65	Dorsal portion of second phragma	Dorsal portion of third phragma
Ventral muscles			
Longitudinal ventral	66	Posterior mesothoracic furcal arm	Metafurcal arm
Tergo-Sternal muscles			
Anterior tergo-sternal	67	Anterior dorsolateral region of tergum	Ventrolateral sternal region
Posterior tergo-sternal	68	Anterolateral edge of first abdominal tergum	Metafurcal arm
Tergo-Pleural muscles			
Tergo-pleural	69	Lateral portion of tergum	Pleural arm of metathorax
Tergo-pleural	70	Lateral portion of tergum	Dorsal border of episternum
Pleuro-axillary	71	Pleural ridge	Third axillary sclerite
Pleuro-axillary	72	Pleural ridge	Third axillary sclerite
Sterno-Pleural muscles			
Sterno-pleural	73	Mesofurcal arm	Anterior end of metathoracic episternum
Furco-entopleural	74	Metafurcal arm	Pleural arm of metathorax
Coxal muscles			
Tergal promotor	75	Anterior dorsolateral region of tergum	Trochantin
Pleural promotor	76	Anterior portion of episternum	Anterior basal rim of coxa
Sternal promotor	77	Metafurcal arm	Anterior basal rim of coxa
Tergal remotor	78	Mid dorsolateral region of tergum	Posterior basal rim of coxa
Tergal remotor	79	Posterior dorsolateral region of tergum	Posterior basal rim of coxa by a tendon
Coxo-subalar	80	Lateral basal rim of coxa	Subalare
Sternal remotor	81	Metafurcal arm	Posterior basal rim of coxa
Sternal remotor	82	Metafurcal arm	Posterior basal rim of coxa
Pleural abductor	83	Anterior region of episternum lateral to 75	Anterolateral basal rim of coxa
Trochanteral muscles			
Tergal depressor	84	Second phragma	Depressor apodeme of trochanter
Tergal depressor	85	Anterior portion of dorsolateral region of tergum	Depressor apodeme of trochanter
Pleural depressor	86	Episternum	Depressor apodeme of trochanter
Sternal depressor	87	Metafurcal arm	Depressor apodeme of trochanter
Muscles of the spiracle			
Occlusor	88	Ridge between mesothorax and metathorax	Ventral end of spiracle

species. Several systematic methods of nerve terminology have been devised and each have their advantages and disadvantages.

The method of nerve designation utilized in this paper is similar to that used by Whittig (1955) in her work on *Perla abdominalis* Burm. Ganglia, except for the subesophageal ganglion, are assigned Roman numerals. Nerve roots arising from each ganglion are designated by the Roman numeral of the ganglion followed

by the letter N and an Arabic numeral. Lower case letters following Arabic numerals are used to identify nerve branches. Prime (′) and double prime (″) designations are utilized where it appears necessary for better understanding of nerve branch description.

Methods of Illustration.—Illustrations in this paper representing nerves and muscles are of two types. One type, the semiperspective illustration, is an attempt to represent as clearly as possible the various stages of dissection. Each stage is illustrated separately and in series beginning with the median muscle groups and progressing to the body wall. In illustrations that combine two consecutive stages of dissection, the lower half of the figure represents the earlier stage.

The second type of illustration used in this study are diagrams indicating the spatial relationships of nerves. The right side of the insect is illustrated and viewed in a laterad aspect. Muscle innervations are designated by Arabic numerals which represent muscle numbers. Where two nerves cross, the laterad nerve is interrupted. Nerves which terminate in the integument are indicated by a short line drawn across the nerve.

An explanation of abbreviated designations may be found under "Abbreviations used in the Figures" at the conclusion of this paper.

RESULTS AND DISCUSSION

1. THE VENTRAL NERVE CORD

General: The ventral nerve cord of insects is the postcephalic portion of the nervous system which lies beneath the alimentary canal and extends posteriorly through the thorax and abdomen. This portion of the central nervous system contains the subesophageal ganglion, thoracic ganglia, and abdominal ganglia arranged metamerically and joined by paired longitudinal connectives. However, modifications of the above generalized ventral nerve cord exists in a number of insect orders and is evidenced by the reduction in number or complete absence of ganglia in abdominal segments. Snodgrass (1935) states that there is a tendency for the ganglia of the ventral nerve cord to migrate anteriorly and unite with each other. This process is referred to as condensation. The forward migration and fusion of ganglia results in the shortening and external disappearance of connectives and commissures.

A dorsal view of the ventral nerve cord in the male cicada, *Tibicen chloromera* (Walker) is illustrated in Fig. 9 and consists of a subesophageal ganglion, prothoracic ganglion, and a thoracic–abdominal ganglionic mass. There are no ganglia in any of the abdominal segments. All abdominal segments are innervated by nerves originating from the posterior portion of the thoracic–abdominal ganglionic mass located in the mesothorax.

The subesophageal ganglion is the anterior ganglion of the ventral nerve cord.

TABLE 5. Comparison of prothoracic musculature of *Tibicen chloromera*, *Huechys sanguinea* var. *philaemata* (Maki, 1938), and *Cicada* (= *Tibicen*) *plebeia* (Berlese, 1909).

Muscle groups	*Tibicen chloromera*	*Huechys sanguinea* var. *philaemata* (Maki, 1938)	*Cicada* (= *Tibicen*) *plebeia* (Berlese, 1909)
Dorsal muscles			
Median dorsal	4	1	140
Median dorsal	5	2	CIX
Lateral dorsal	6	3	110
Lateral dorsal	7	–	CXII
Anterior dorsal	8	4	CXXXVI
Anterior dorsal	–	–	CXXXV
Ventral muscles			
Internal ventral	9	5	136
External ventral	10	6	CXXXI
Tergo-Sternal muscles			
Anterior intersegmental	11	7	147
Anterior internal tergo-sternal	12	–	–
Anterior internal tergo-sternal	13	8	CXXXV
Anterior internal tergo-sternal	14	–	–
Anterior internal tergo-sternal	15	9	CXXXVa
Anterior internal tergo-sternal	–	10	144
Anterior internal tergo-sternal	16	11	–
Posterior tergo-sternal	17	12	112
Tergo-Pleural muscles			
Anterior tergo-pleural	18	13	–
Anterior tergo-pleural	19	–	–
Ordinary tergo-pleural	20	14	–
Coxal muscles			
Tergal promotor	21	15	113
Tergal promotor	22	16	–
Sternal promotor	23	17	–
Tergal remotor	24	18	116
Tergal remotor	25	19	–
Tergal remotor	26	20	–
Tergal remotor	27	21	–
Sternal remotor	28	–	–
Tergal abductor	29	22	–
Pleural abductor	30	23	–
Pleural abductor	31	24	–
Trochanteral muscles			
Tergal depressor	32	25	115
Pleural depressor	33	26	–

In *Tibicen chloromera* eight pairs of nerves arise from the ganglion and innervate the salivary glands and lateral salivary gland ducts, muscles associated with the feeding apparatus, and some muscles of the cervical area.

The prothoracic ganglion and the anterior portion of the thoracic–abdominal ganglionic mass are covered dorsally by ventral muscles (Fig. 1B). Dufour (1833) mentions similar ventral muscles in *Cicada orni*.

An invagination of the first abdominal sternite serves as a muscle attachment for the large tympanal muscles. A sternal canal is located within this invagination. Two pairs of nerves, IIN8 and IIN9, pass through the sternal canal.

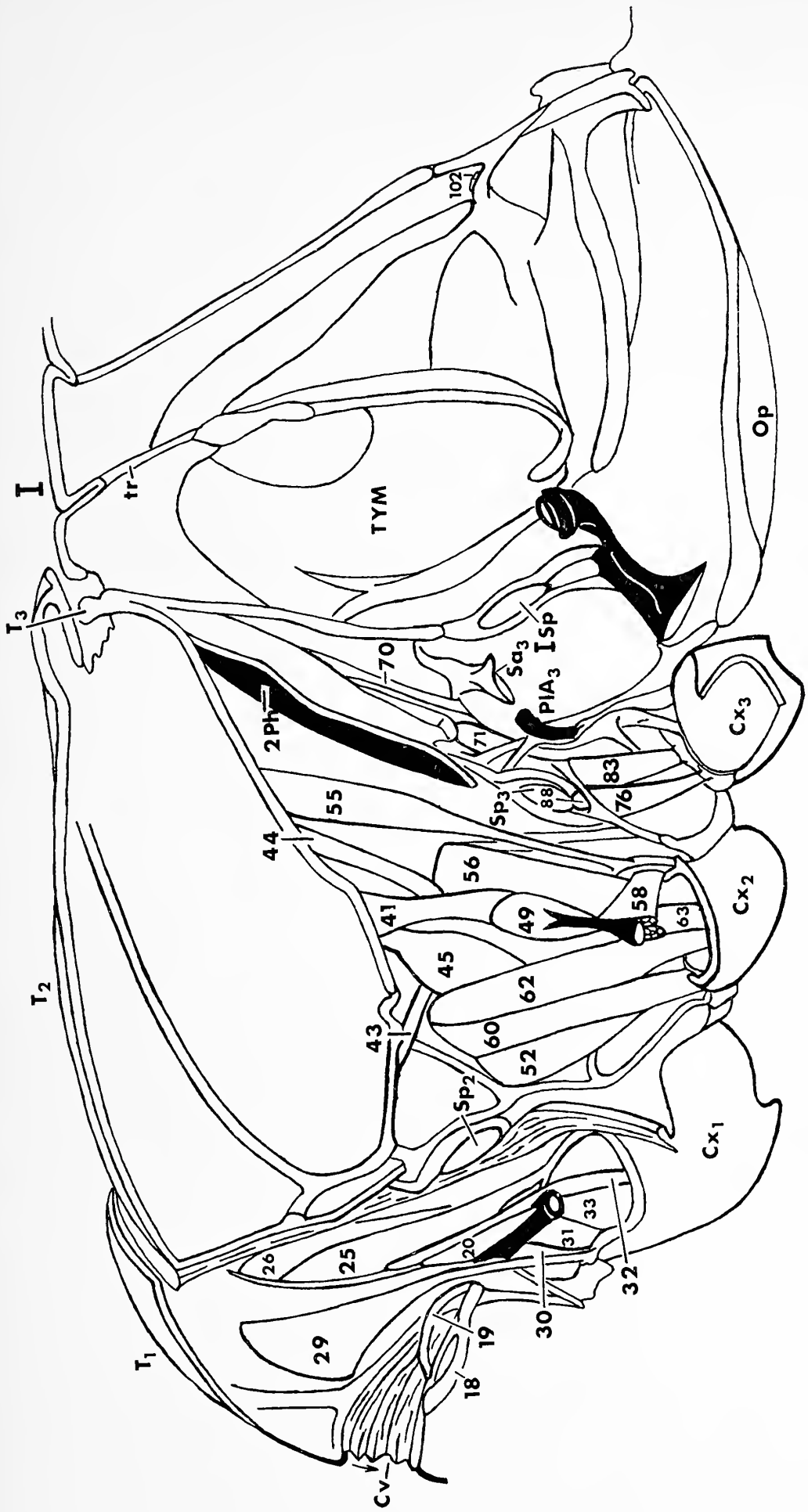

Fig. 6. Fifth stage dissection showing muscles of the cervix, thorax, and first abdominal segment in longitudinal section in the male annual cicada *Tibicen chloromera* (Walker).

One pair of nerves, IIN8, innervates the posterior muscles of the first abdominal segment while the other pair of nerves, IIN9, innervates the remaining abdominal segments.

No median nerve is visible between the subesophageal ganglion, prothoracic ganglion, and thoracic–abdominal ganglionic mass. However, the median nerve is probably included within the interganglionic connectives.

Spiracular muscles in the thoracic segments are innervated by nerves which arise from the dorsolateral portion of the prothoracic ganglion and thoracic–abdominal ganglionic mass. Spiracular muscles in pregenital abdominal segments are innervated by a nerve branch from the dorsal nerve.

The ventral nerve cord of the male *Tibicen chloromera* (Walker) is not restricted to a definitive positional relationship in the thorax by spinae or muscles that attach to these structures. Schmitt (1959) described an opposite situation in the thorax of *Dissosteira*, where possible future evolution of the ventral nerve cord towards condensation will require drastic skeletal and muscle system changes.

Subesophageal Ganglion: The anterior portion of the subesophageal ganglion is covered by the tentorial bridge (TB, Fig. 9). A pair of short, stout circumesophageal connectives link the subesophageal ganglion to the brain.

A lateral view of the subesophageal ganglion is shown in Fig. 1A. Eight pairs of nerves arise from the ganglion, five pairs of nerves from the lateroventral surface, and three pairs from the ventral area.

The first pair of nerves, SN1, arise from the anterior medioventral surface of the ganglion in close association with the ventral portions of the circumesophageal connectives. SN1 nerves divide into labral nerves (LmNv) and nerves which innervate the protractor muscles of the mandibular bristles (pmdb).

The second pair of nerves, SN2, are mandibular nerves and arise from the anterior lateroventral surface of the ganglion. The SN2 nerve divides soon after leaving the ganglion into a dorsal branch that innervates the retractor muscle of the mandibular bristle (rmdb) and a ventral branch that innervates the protractor muscles of the mandibular bristles.

The third pair of nerves, SN3, are maxillary nerves and arise from the lateroventral surface of the ganglion. The SN3 nerve bifurcates into anterior and posterior nerve branches. The anterior branches innervate the internal ($rmxb_1$) and the external ($rmxb_2$) retractor muscles of the maxillary bristles. Posterior nerve branches innervate both internal and external retractor muscles of the maxillary bristles, protractor muscles of the maxillary bristles (1pmxb and 2pmxb), and provide nerve branches which enter the base of the maxillary bristles, mxb (Fig. 1A).

The fourth, SN4, and fifth, SN5, pairs of nerves arise from the mediolateral and posterolateral areas, respectively, of the subesophageal ganglion and co-

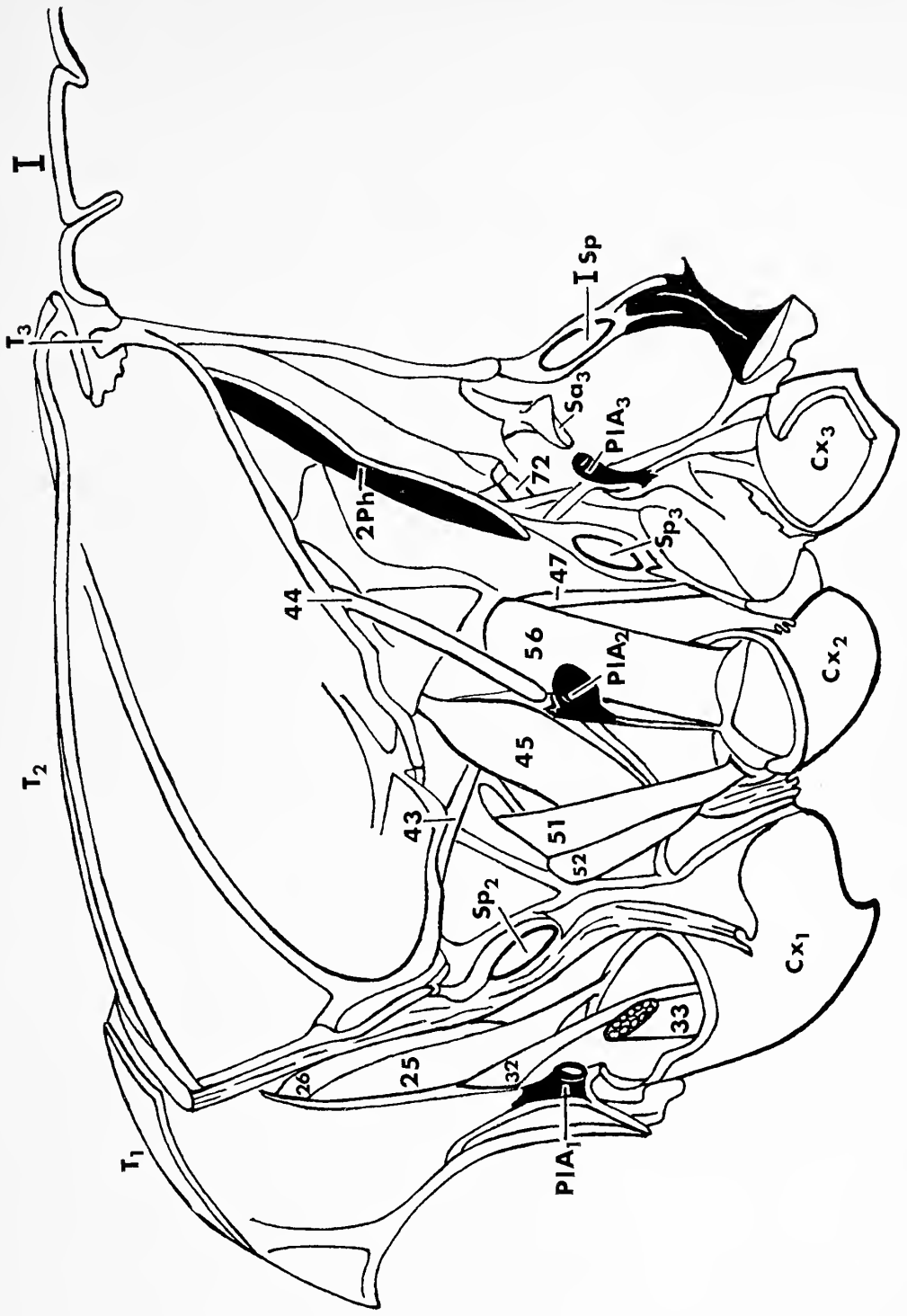

Fig. 7. Sixth stage dissection showing muscles of the thorax in longitudinal section in the male annual cicada *Tibicen chloromera* (Walker).

alesce to form the first cervical nerve SN4 + SN5. The SN4 + SN5 nerves extend dorsally and innervate the anterior internal tergo-sternal muscle 13.

The sixth pair of nerves, SN6, arises from the posterior lateroventral surface of the ganglion and innervates the salivary glands (S1G1) and the anterior internal tergo-sternal muscle 16. The latter nerves are the second cervical nerves. A nerve branch from SN6, and SN6a, proceeds in a posterior direction and coalesces with the SN9 + IN1 nerve.

The seventh pair of nerves, SN7, are the labial nerves and arise from the posterior medioventral surface of the ganglion ventrad to SN6. Nerve SN7 pro-

vides nerve branches to the dilator muscles of the salivary syringe (dlSyr) and the lateral muscles of the sclerotized rod (mr) before entering the labium. Johansson (1957) shows a similar innervation pattern for the labial nerve in the milkweed bug *Oncopeltus fasciatus* (Dallas). The labial nerves innervate the dilator muscles of the salivary syringe before entering the base of the labium.

The eighth pair of nerves, SN8, arises from the posterior medioventral surfaces of the ganglion in close association with the interganglionic connectives and innervates the salivary ducts (S1D).

A pair of large nerves, SN9, arises laterally from each interganglionic connective and coalesce with the IN1 nerves which arise from the anterior surface of the prothoracic ganglion. IN1 nerves can easily be separated from the interganglionic connectives to their origin on the prothoracic ganglion.

A pair of long, sturdy, well-separated interganglionic connectives link the subesophageal ganglion to the prothoracic ganglion. The interganglionic connectives pass laterally around the muscles of the sclerotized rod. The sclerotized rod is an extension of the labium and appears to have a stronger association with the prothorax than with the head since it hangs freely from the cervical membrane.

Prothoracic Ganglion: The prothoracic ganglion lies wholly within the prothorax and is situated between the sternal apophyses. Three pairs of ventral muscles (1, 2, and 3) cover the entire ganglion dorsally (Fig. 1B).

Four pairs of nerves arise from the anterior portion of the prothoracic ganglion (Fig. 9). The anterior pair of nerves (IN1) proceed anteriorly and join nerves SN9 which branch from the interganglionic connectives. Nerves IN2, IN3, and IN4 pass under the internal ventral longitudinal muscles (9) and innervate muscles of the cervix, prothorax, and prothoracic leg muscles. (A detailed description of the innervation pattern is presented under the section entitled "The Cervicothoracic Nervous System.")

A pair of large nerves, IIN1, issues from the interganglionic connectives between the prothoracic ganglion and thoracic–abdominal ganglionic mass (Fig. 9). The IIN1 nerves pass over the IIN2 nerves originating from the thoracic–abdominal ganglionic mass and then pass under the longitudinal ventral muscles 36 of the mesothorax. Nerve IIN1 innervates the longitudinal ventral muscles 36, median dorsal muscles 34, and lateral dorsal muscles 35 of the mesothorax.

A pair of fine, short nerves, IN5, arise on each side of the middorsal portion of the prothoracic ganglion and innervates the ventral muscles 1 which cover the ganglion.

Two pairs of fine nerves, IN6 and IN7, arise from the middorsal area of the prothoracic ganglion and coalesce with nerve IN8 arising from the dorsal surface of the interganglionic connective between the prothoracic ganglion and thoracic–abdominal ganglionic mass.

A pair of very short, stout interganglionic connectives links the prothoracic ganglion to the large thoracic–abdominal ganglionic mass.

Thoracic–Abdominal Ganglionic Mass: The thoracic–abdominal ganglionic mass is the terminal ganglion of the ventral nerve cord and is located above the basisternum of the mesothorax. With the exception of the IIN2a nerves which innervate the posterior tergo-sternal muscles 17 of the prothorax, nerves originating from the thoracic–abdominal ganglionic mass innervate muscles of the mesothorax, metathorax, sound mechanism, and abdominal segments.

Eight pairs of lateral nerve roots arise from the thoracic–abdominal ganglionic mass: one pair anteriorly, IIN2; two pairs laterally, IIN3 and IIN4; and five pairs posteriorly, IIN5, IIN6, IIN7, IIN8, and IIN9 (Fig. 9). Nerves IIN2, IIN3, and IIN4 pass under the longitudinal ventral muscles 36 while the remaining nerve roots extend posteriorly and pass over the mesofurca. IIN2 is the anterior wing nerve while IIN3 and IIN4 innervate muscles in the mesothorax. Nerves IIN5 and IIN6 pass under the posterior arms of the mesofurca and innervate muscles of the metathoracic segment with the exception of nerve branch IIN6a′ which innervates the posterior tergo-pleural muscle 38 of the mesothorax. The IIN5 nerve is the dorsal nerve since it innervates the dorsal muscles 65. Ventral muscles are innervated by a nerve branch from IIN10 + IIN11. Nerve IIN6 provides a nerve branch IIN6a which is the posterior wing nerve. Nerves IIN7 supply innervation to the muscles located in the anterior portion of the first abdominal segment and the membrane forming the large abdominal air chamber. Nerves IIN8 provide nerve branches IIN8a to the large tympanal muscles before passing through the sternal canal to innervate the muscles located in the posterior portion of the first abdominal segment. The IIN9 nerves pass through the sternal canal and innervate muscles of the remaining pregenital abdominal segments by providing a lateral nerve branch to each consecutive segment. Two pairs of fine nerves (IIN10 and IIN11) arise dorsolaterally from the thoracic–abdominal ganglionic mass (Fig. 9). The IIN11 nerve divides soon after leaving the ganglion and provides a fine nerve branch IIN11a which coalesces with nerve IIN5. Nerves IIN10 and IIN11 are connected by a fine nerve designated as IIN10 + IIN11. It appears that both the IIN10 and IIN11 nerves are responsible for innervation of the occlusor muscle (88) of the metathoracic spiracle and ventral muscle 3.

Discussion: Unfortunately, only the gross anatomy of the central nervous system of cicadas has been described in the literature. Therefore, comparisons of ventral nerve cords in order to establish areas of homology are limited to their general configuration.

Hilton (1939) in his Figure 190–1 presents an unlabeled drawing of the central nervous system of an unnamed adult cicada showing the brain and two ganglia of the ventral nerve cord. If it is assumed that the anterior ganglion is the

TABLE 6. Comparison of mesothoracic musculature of *Tibicen chloromera, Huechys sanguinea* var. *philaemata* (Maki, 1938), and *Cicada* (= *Tibicen*) *plebeia* (Berlese, 1909).

Muscle groups	*Tibicen chloromera*	*Huechys sanguinea* var. *philaemata* (Maki, 1938)	*Cicada* (= *Tibicen*) *plebeia* (Berlese, 1909)
Dorsal muscles			
Median dorsal	34	27	70
Median dorsal	–	–	69
Lateral dorsal	35	28	71
Ventral muscles			
Longitudinal ventral	36	29	105 + 106
Spino-furcal ventrals	–	–	104
Tergo-Sternal muscles			
Anterior tergo-sternal	37	30	LXXVIII
Posterior tergo-sternal	38	31	73
Tergo-Pleural muscles			
Tergo-pleural	39	32	XCI
Tergo-pleural	40	33	86
Tergo-pleural	41	34	–
Tergo-pleural	42	–	–
Tergo-pleural	43	–	–
Tergo-pleural	44	–	–
Pleuro-axillary	45	35	XCIII
Pleuro-axillary	46	36	XCII
Pleuro-subalar	47	37	–
Sterno-Pleural muscles			
Sterno-basalar	48	38	91
Furco-entopleural	49	39	100
Coxal muscles			
Tergal promotor	50	40	74?
Trochantino-basalar	51	–	79 + 80
Trochantino-basalar	52	–	–
Sternal promotor	53	41	–
Tergal remotor	54	42	LXXXII
Tergal remotor	55	43	75
Coxo-subalar	56	44	84
Sternal remotor	57	45	–
Sternal remotor	58	–	–
Sternal adductor	59	–	–
Pleural abductor	–	46	–
Coxo-basalar	60	47	82
Trochanteral muscles			
Tergal depressor	61	48	76
Trochantero-basalar	62	49	81
Sternal depressor	63	50	–
Muscles of the spiracle			
Occlusor	64	51	–

subesophageal ganglion, then the remaining ganglionic mass contains all of the thoracic and abdominal ganglia.

Dufour (1833), describing the ventral nerve cord in *Cicada orni*, states that the central nervous system consists of a cephalic ganglion and two thoracic ganglia. No mention is made of the subesophageal ganglion, which, according to Myers (1928), Dufour may have confused with the brain. Dufour does

mention that the cephalic ganglion is produced by a fusion of two hemispheroid lobes and the cleft which separates the two lobes is only superficial. Dufour continues by describing the thoracic ganglia as not being separate and distinct but nearly fused into one. However, with difficulty, a light demarcation of an anterior ganglion can be observed.

Myers (1928) states that the ventral nerve cord in *Melampsalta sericea* consists of a subesophageal ganglion, prothoracic ganglion, and thoracic–abdominal ganglionic mass, each separated by visible interganglionic connectives.

Berlese (1909), in his Figure 697, presents a diagram of the brain and the subesophageal ganglion of *Cicada* (= *Tibicen*) *plebeia*, and shows that the subesophageal ganglion is separated from the brain by a pair of stout circumesophageal connectives. The remainder of the ventral nerve cord is not described.

Snodgrass (1935), in his Figure 237, presents a longitudinal section of *Tibicina* (= *Magicicada*) *septendecim* showing two thoracic ganglia, one in the prothorax and the other in the mesothorax. The subesophageal ganglion is not illustrated.

If the above investigations are correct, then there appears to be some diversity in the family Cicadidae regarding the number of ganglia in the ventral nerve cord. *Cicada orni* is the most specialized with a central nervous system composed of a cephalic ganglion and two very closely associated thoracic ganglia while in *Melampsalta sericea* and *Tibicen chloromera* there is a subesophageal ganglion and two separate thoracic ganglia.

There also appears to be a diversity in the number of principal lateral nerve roots arising from the thoracic ganglia. Dufour (1833) mentions that the anterior thoracic ganglion in *Cicada orni* gives rise to four pairs of principal nerves while six pairs of nerves issue from the posterior thoracic ganglion. Hilton (1939), in his Figure 190–1, of the central nervous systems of an unnamed species of cicada, shows three principal nerves arising from the anterior lobe of the thoracic–abdominal ganglionic mass while the posterior lobe possesses three pairs of lateral nerves and a single caudal nerve.

Tibicen chloromera has three pairs of principal lateral nerve roots (not counting the IN1 nerve which adheres to the interganglionic connective) arising from the prothoracic ganglion. One nerve, IIN1, appears to arise from the interganglionic connective between the prothoracic ganglion and thoracic–abdominal ganglionic mass, and eight principal pairs of nerves arise from the thoracic–abdominal ganglionic mass.

2. THORACIC MUSCULATURE

General: The thoracic musculature of the male cicada, *Tibicen chloromera* (Walker) is illustrated in Figs. 1B to 8. Figs. 2 to 8 represent stage dissections which proceed from the interior muscle groups to the exterior muscle groups on the body wall. Arabic numerals are utilized for muscle numbers. Thoracic

TABLE 7. Comparison of metathoracic musculature of *Tibicen chloromera, Huechys sanguinea* var. *philaemata* (Maki, 1938), and *Cicada* (= *Tibicen*) *plebeia* (Berlese, 1909).

Muscle groups	*Tibicen chloromera*	*Huechys sanguinea* var. *philaemata* (Maki, 1938)	*Cicada* (= *Tibicen*) *plebeia* (Berlese, 1909)
Dorsal muscles			
Median dorsal	65	52	37
Ventral muscles			
Longitudinal ventral	66	53	68
Tergo-Sternal muscles			
Anterior tergo-sternal	67	54	XXXVI
Posterior tergo-sternal	68	55	XXXVII
Tergo-Pleural muscles			
Tergo-pleural	69	56	–
Tergo-pleural	70	–	–
Pleuro-axillary	71	57	56
Pleuro-axillary	72	58	–
Sterno-Pleural muscles			
Sterno-pleural	73	59	–
Furco-entopleural	74	60	65
Coxal muscles			
Tergal promotor	75	61	42?
Pleural promotor	76	62	48 + 49
Sternal promotor	77	63	–
Tergal remotor	78	64	44
Tergal remotor	79	65	43
Coxo-subalar	80	66	XLIX
Sternal remotor	81	67	61
Sternal remotor	82	–	–
Pleural abductor	83	68	–
Trochanteral muscles			
Tergal depressor	84	69	XLV
Tergal depressor	85	70	46
Pleural depressor	86	71	–
Sternal depressor	87	72	–
Muscles of the spiracle			
Occlusor	88	73	–

muscles are listed with their muscle numbers, origins, and insertions in Tables 1 to 4. A comparison of the thoracic musculature of *Tibicen chloromera*, *Huechys sanguinea* var. *philaemata* described by Maki (1938) and *Cicada* (= *Tibicen*) *plebeia* described by Berlese (1909) is presented in Tables 5 to 7.

Ventral Muscles Which Cover the Thoracic Ganglia: The prothoracic ganglion and the anterior portion of the thoracic–abdominal ganglionic mass are covered dorsally by three pairs of muscles (Fig. 1B). The muscle numbers, origins, and insertions of the three muscles groups are described in Table 1. Ventral muscles 1, 2, and 3 are mutually joined by zygomatic connections. Muscles 1 and 3 are quite sturdy, while muscle 2 is broad at its zygomatic junction and compressed dorsoventrally. Muscle 3 is joined laterally to ventral longitudinal muscle 36 for a portion of its length.

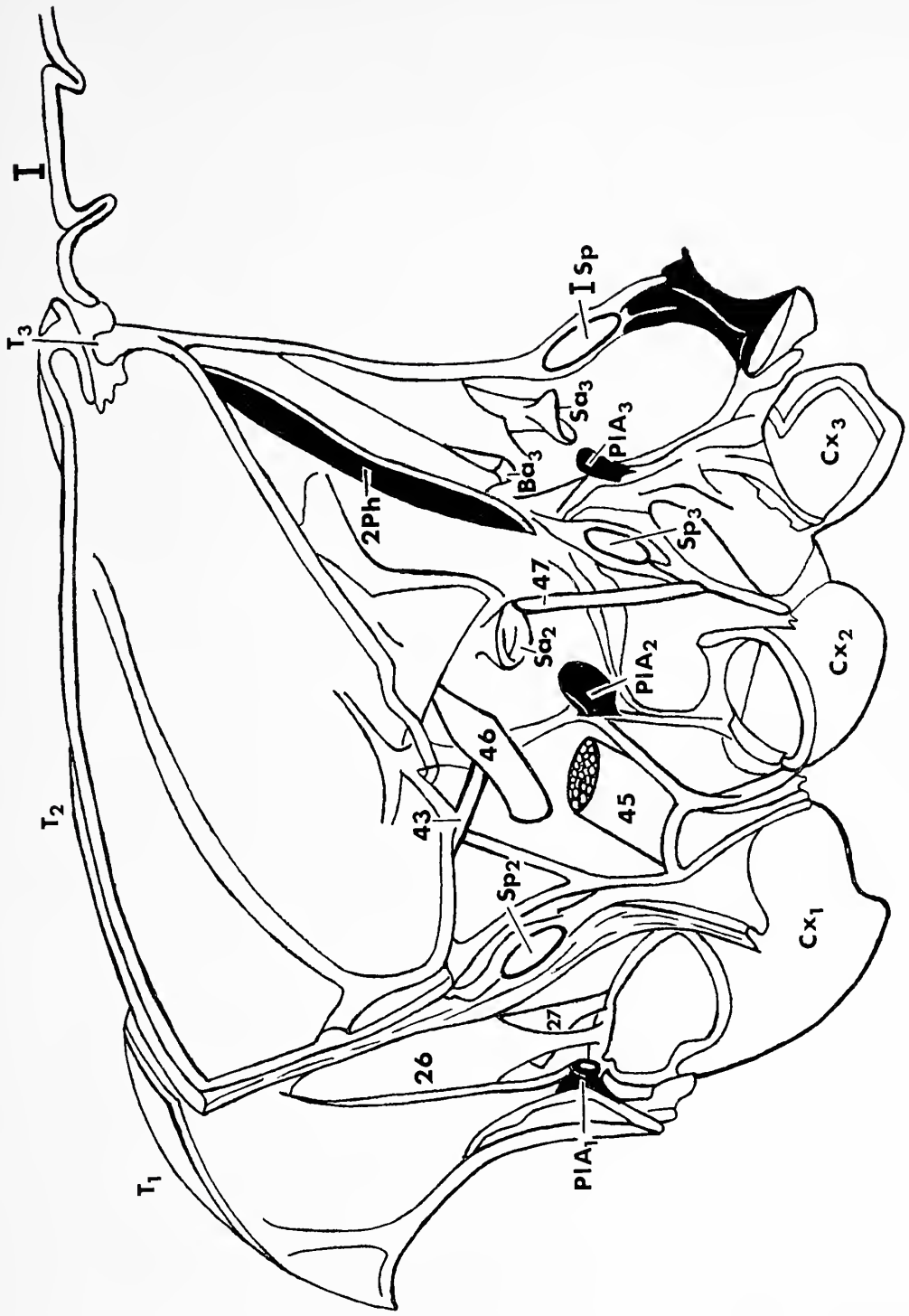

Fig. 8. Seventh stage dissection showing muscles of the thorax in longitudinal section in the male annual cicada *Tibicen chloromera* (Walker).

Prothoracic Musculature: The prothoracic muscles in *Tibicen chloromera* are fundamentally homologous to *Huechys sanguinea* var. *philaemata* (Table 5). The lateral dorsal 7, anterior internal tergo-sternals 12 and 14, anterior tergo-pleural 19, and sternal remotor 28 muscles in *Tibicen chloromera* were not reported in *Huechys sanguinea* var. *philaemata.*

The anterior internal tergo-sternal muscle 10 reported by Maki (1938) and muscle 144 by Berlese (1909) are absent in *Tibicen chloromera.* This muscle arises on the tergum and attaches to the ventrolateral cervical sclerite. However, the anterior tergo-sternal muscles 12 in *Tibicen chloromera,* which has its origin

on the posterior end of the head and attaches to the ventrolateral cervical sclerite, is probably the homologue.

Berlese (1909) did not report the presence of tergo-pleural, sternal promotor, sternal remotor, tergal abductor, pleural abductor or pleural depressor muscles in the prothorax of *Cicada* (= *Tibicen*) *plebeia*. The anterior internal tergo-sternal 14, anterior tergo-pleural 19, and sternal remotor 28 muscles in *Tibicen chloromera* do not have counterparts in the other two species of cicadas.

Mesothoracic Musculature: The mesothorax is the largest division of the thorax and necessarily so, since it contains the very large dorsal longitudinal (34) and oblique dorsal (35) muscles. The dorsal longitudinal muscles serve as depressors of the wings while the oblique dorsal muscles are probably wing elevators (Snodgrass, 1927 and 1935).

The tergo-pleurals 42, 43, and 44, trochantino-basalar 52, sternal remotor 58, and sternal adductor 59 muscles in *Tibicen chloromera* have not been reported in *Huechys sanguinea* var. *philaemata* by Maki (1938) or in *Cicada* (= *Tibicen*) *plebeia* by Berlese (1909). The trochantino-basalar muscle 51 in *Tibicen chloromera* is present in *Cicada* (= *Tibicen*) *plebeia* (79 + 80) but not in *Huechys sanguinea* var. *philaemata*. The pleural abductor of the coxa, Maki's muscle number 46 in *Huechys sanguinea* var. *philaemata*, was not described by Berlese (1909) in *Cicada* (= *Tibicen*) *plebeia* nor is it present in *Tibicen chloromera*.

Berlese (1909) includes median dorsal 69 and spino-furcal ventral 104 muscles in *Cicada* (= *Tibicen*) *plebeia*. Both of the above muscles are not present in the two other species of cicadas (Table 6). Berlese (1909) did not report the presence of pleural-subalar, sternal promotor, sternal remotor, sternal adductor, sternal depressor, or spiracular muscles.

Metathoracic Musculature: The metathorax is extremely short, especially dorsally, where the entire notum is reduced to a narrow band behind the scutellum of the mesonotum.

The metathoracic musculature in *Tibicen chloromera* is homologous to that of *Huechys sanguinea* var. *philaemata*, with the exception of the tergo-pleural muscle 70 and the sternal remotor muscle 82. Berlese (1909) did not report the presence of tergo-pleural, sternal-pleural, sternal promotor, pleural abductor, pleural depressor, sternal depressor, and spiracular muscles. However, all of the above mentioned muscles were reported by Maki (1938) in *Huechys sanguinea* var. *philaemata* and are present in *Tibicen chloromera*.

3. THE CERVICOTHORACIC NERVOUS SYSTEM

General: A dorsal view of the ventral nerve cord in the male of *Tibicen chloromera* (Walker) is shown in Fig. 9. A general description of the thoracic nervous system is presented under the section entitled "The Ventral Nerve Cord."

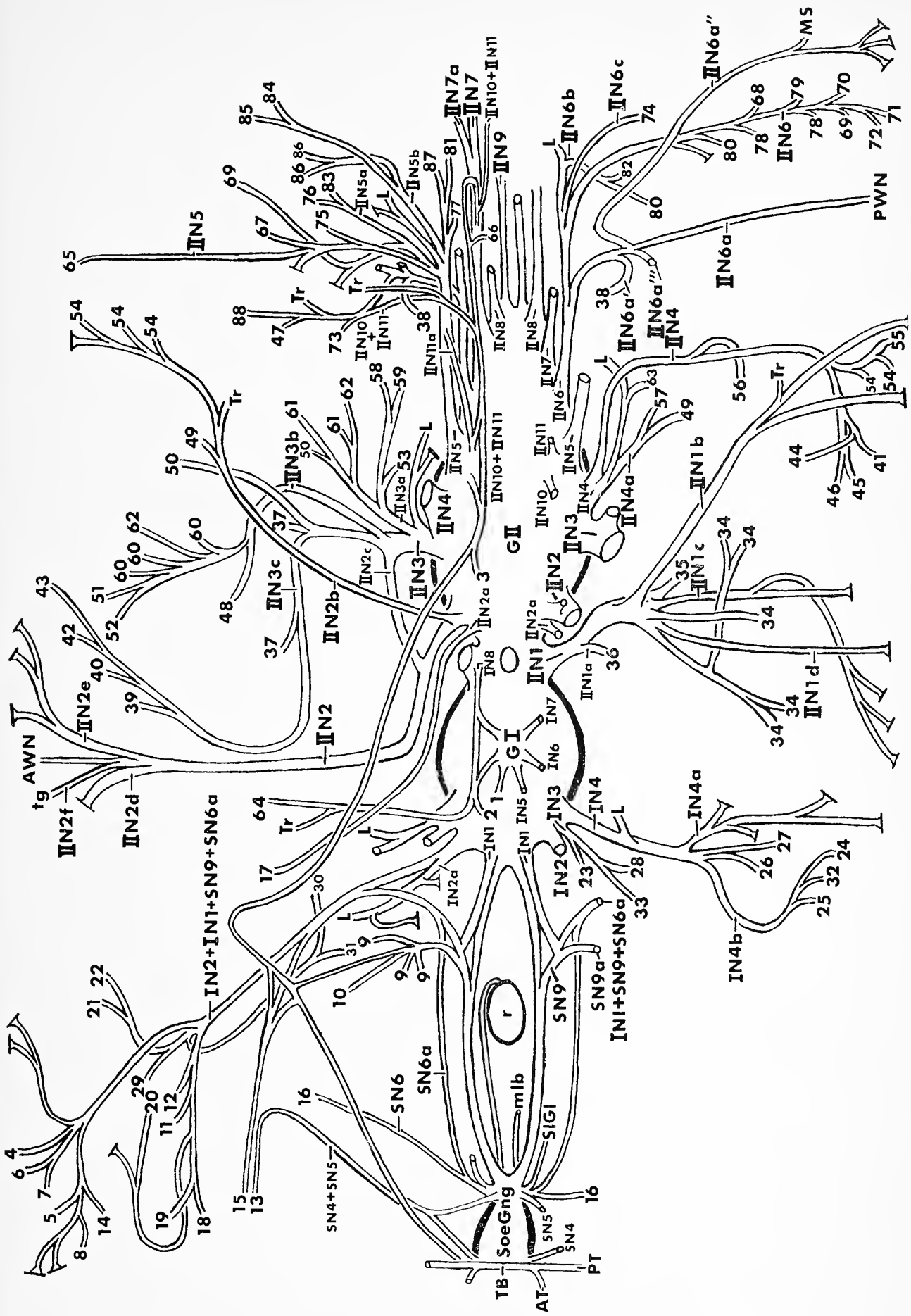

Fig. 9. Dorsal view of the ventral nerve cord of the male annual cicada *Tibicen chloromera* (Walker) from the head to the first abdominal segment.

The Cervix and the Prothorax: The narrowed membranous region between the head and prothorax of insects is called the cervix or neck and is presumably derived from portions of both the labial and prothoracic segments. Muscles contained within the cervical region are believed to have evolved from both the labial and prothoracic segments. Therefore, the concept that the muscles of a segment are innervated from the ganglion of that segment suggests that each muscle of the cervix can be assigned either to the labial or prothoracic segment by determining the segment of innervation.

Three pairs of nerves from the subesophageal ganglion innervate muscles located in the cervical region: SN4 + SN5, SN6 (Fig. 9), and SN7 (Fig. 1A). Nerve SN4 + SN5 innervates the anterior intersegmental muscle 13 and nerve SN6 innervates the anterior intersegmental muscle 16. The SN7 nerve innervates the muscles of the sclerotized rod, mr, and muscles within the labium, mlb (Fig. 1A). The sclerotized rod is an extension of the labium and hangs freely from the cervical membrane.

A nerve branch from SN6, designated as SN6a in figs. 1A and 9, may be associated with the innervation of the anterior intersegmental muscle 15 and possibly other muscles in the cervicoprothoracic area. A precise determination could not be made since the SN6a nerve joins with a nerve formed by the coalescence of nerves SN9 and IN1. The resulting nerve, IN1 + SN9 + SN6a, then coalesces with the IN2 nerve to form nerve IN2 + IN1 +SN9 +SN6a which innervates muscles associated with the cervical sclerites, dorsal muscles, and muscles located in the anterior portion of the prothorax.

The SN9 nerves issue from the interganglionic connectives between the subesophageal ganglion and prothoracic ganglion. Nerve branch SN9a innervates the internal ventral muscle 9 and external ventral muscle 10 before joining the IIN10 + IIN11 nerve originating from the thoracic–abdominal ganglionic mass (Fig. 9). Nerve SN9 then coalesces with nerve IN1 and later receives the SN6a nerve before joining nerve IN2 originating from the prothoracic ganglion.

The IN1 nerves arise from the anterior portions of the prothoracic ganglion adjacent to the interganglionic connectives. Nerves IN1 proceed anteriorly in close association with the interganglionic connectives before coalescing with the SN9 nerves.

The IN2 nerves issue from the anterolateral area of the prothoracic ganglion and pass under the internal ventral muscles 9. The first nerve branch, IIN2a, provides two sensory nerve branches to the integument, then passes around the tergal promotor muscle of the coxa 21 and over the anterior basal rim of the prothoracic coxa into the leg. After IN2 coalesces with nerve IN1 + SN9 + SN6a to produce nerve IN2 + IN1 + SN9 + SN6a, a nerve branch is formed which combines with nerve branches from nerve IIN10 + IIN11 to innervate the anterior intersegmental muscle 15. Nerve IN2 + IN1 + SN9 + SN6a then

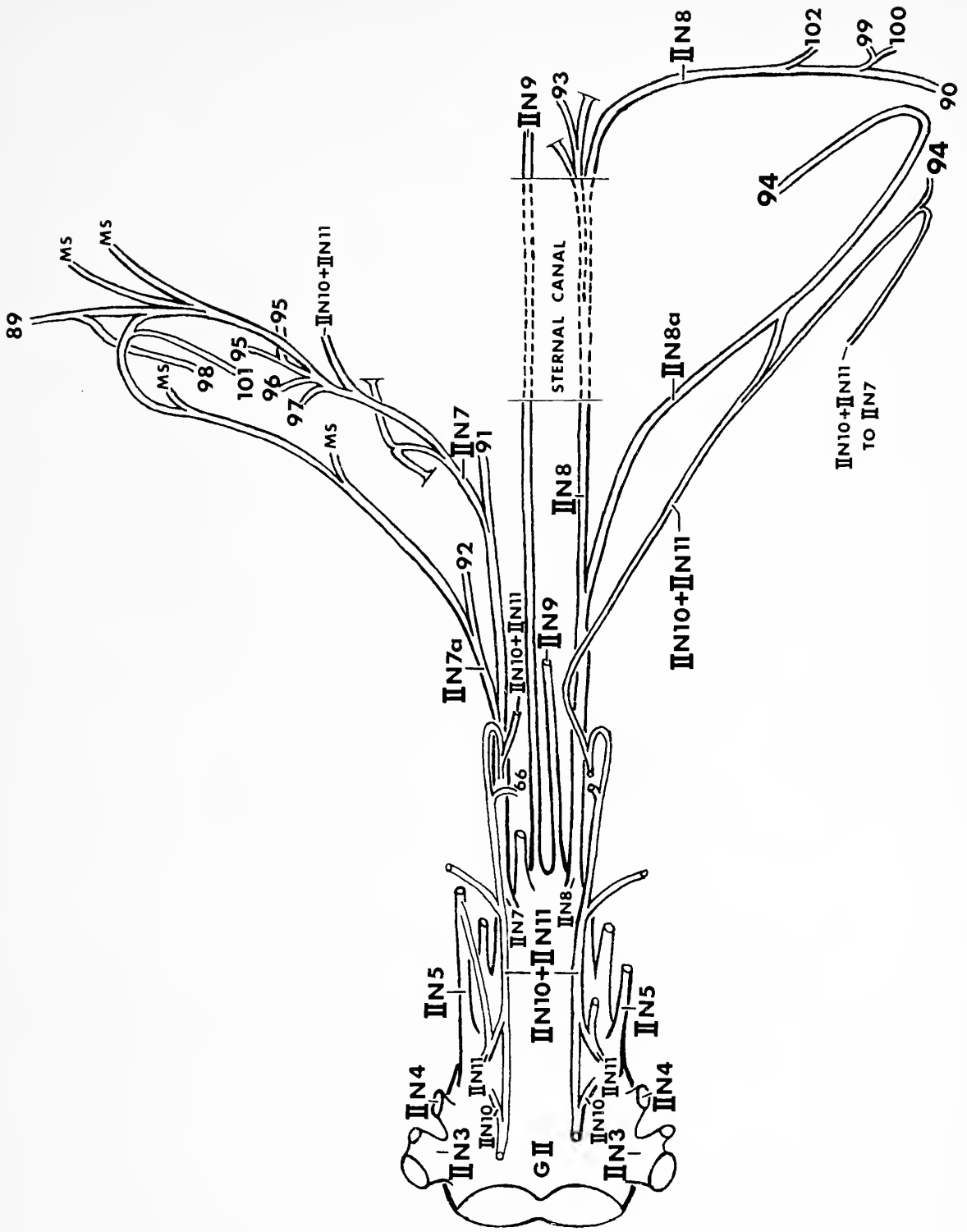

Fig. 10. Dorsal view of the ventral nerve cord of the male annual cicada, *Tibicen chloromera* (Walker), from nerve root IIN3 of the thoracic–abdominal ganglionic mass to the second abdominal segment and showing the innervation pattern of the first abdominal segment.

ramifies into three nerve branches. One nerve branch proceeds anteriorly and innervates the anterior intersegmental muscles 11 and 12, the ordinary tergo-pleural muscle 20, and the anterior tergo-pleural muscles 18 and 19. The lateral nerve branch bifurcates into a ventral branch which innervates the pleural abductors 30 and 31 and a dorsal branch which innervates the tergal abductor

muscle 29 and the tergal promotor muscles 21 and 22. The remaining nerve branch proceeds dorsally and innervates the anterior intersegmental muscle 14, anterior dorsal muscle 8, median dorsal muscle 5, lateral dorsal muscles 6 and 7, and median dorsal muscle 4.

The IN3 nerves arise from the anterolateral portion of the prothoracic ganglion, pass under the anterior edge of the prothoracic pleural apophysis, and innervate the sternal promotor 23, pleural depressor 33, and sternal remotor 28 muscles.

Nerve IN4 arises from the anterolateral portion of the prothoracic ganglion posterior to IN3 and proceeds in a lateral direction passing under the prothoracic pleural apophysis. IN4 provides a nerve branch into the leg before dividing into nerve branches IN4a and IN4b. IN4a is a sensory nerve and provides nerve branches to the posterolateral protergal area. Nerve IN4a innervates tergal remotor muscles 24, 25, 26, and 27 and the tergal depressor muscle 32.

Nerve IN5 is very short and issues from the mediodorsal area of the prothoracic ganglion and innervates ventral muscle 1.

Nerves IN6 and IN7 arise from the mediodorsal portion of the ganglion posterior to nerve IN5 and coalesce with nerve IN8 which arises from the dorsal area of the interganglionic connective between the prothoracic ganglion and thoracic–abdominal ganglionic mass (Fig. 9). It appears that nerves IN6, IN7, and IN8 are responsible for the innervation of ventral muscle 2 and the occlusor muscle 64 of the mesothorax.

The posterior tergo-sternal muscle 17 of the prothorax is innervated by nerve branch IIN2a which arises from the anterolateral area of the thoracic–abdominal ganglionic mass. Nerve IIN2a passes under nerve IIN1 and proceeds lateral to the longitudinal ventral muscle 36 and along the posterior edge of the prothoracic pleural arm to the posterior tergo-sternal muscle 17.

Mesothorax: The mesothorax is the largest thoracic segment in the male of the annual cicada, *Tibicen chloromera* (Walker). Innervation of the mesothoracic segment, with the exception of the posterior tergo-sternal muscle 38 and the occlusor muscle 64, is achieved by five pairs of nerves: IIN1, IIN2, IIN3, IIN4, and IIN10 + IIN11.

The large IIN1 nerves arise from the short interganglionic connectives between the prothoracic ganglion and thoracic–abdominal ganglionic mass GII (Fig. 9). Nerve IIN1 passes over nerve IIN2 and provides nerve branch IIN1a to the longitudinal ventral muscle 36.

Nerve IIN1a bifurcates into two nerve branches. One nerve branch enters muscle 36 along its mesal surface while the remaining nerve branch enters the lateral surface of the muscle 36. The IIN2 nerve passes laterad to the longitudinal ventral muscle 36 and ramifies into six nerve branches along the ventral edge of the median dorsal muscle 34. The large median dorsal muscle 34 is innervated by three nerve branches while the lateral dorsal muscle 35 is in-

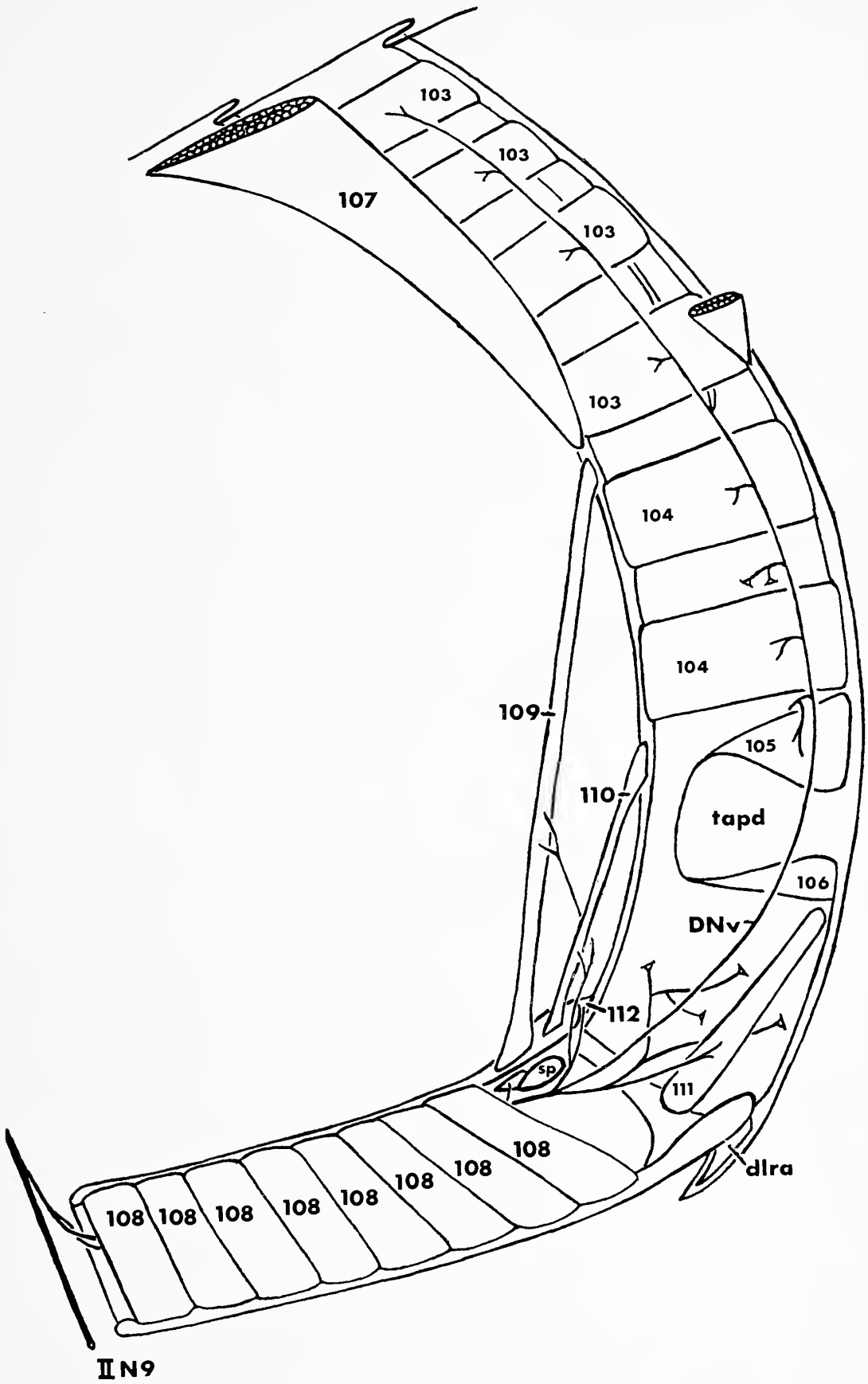

Fig. 11. Posterolateral view of the nerves and muscles of the right side of the fourth abdominal segment of the male of *Tibicen chloromera* (Walker). First stage of dissection.

nervated by a single nerve branch which passes between the median dorsal muscle 35 and the anterior tergo-sternal muscle 37. The remaining nerve branches (IIN1b, IIN1c, and IIN1d) are sensory nerves and terminate in the integument of the mesotergum (Fig. 9). Nerve branch IIN1b passes obliquely between the anterior tergo-sternal muscle 37 and the median dorsal muscle 34 and continues mesad to the furco-entopleural muscle 49 and tergal remotor muscle 54. Nerve IIN1b provides a nerve branch to the trachea between muscle 54 and 55 before terminating in the integument in the posterior portion of the mesotergum. IIN1c passes mesad to median dorsal muscle 34 and divides into two nerve branches. One nerve branch continues dorsally and terminates in the middorsal region of the mesotergum while the other nerve branch passes between the latter nerve and muscle 34 and terminates in the integument in the anterodorsal region of the mesotergum. Nerve IIN1d passes obliquely over the anterior tergo-sternal muscle 37 then proceeds along the posterior edge of muscle 37 and terminates in the integument of the middorsal region of the mesotergum.

Nerve IIN2 arises from the anterolateral surface of the thoracic–abdominal ganglionic mass. Two nerve branches, IIN2a and IIN2b, issue from the base of nerve IIN2. The IIN2 nerve passes under the ventral longitudinal muscle 36, and provides a nerve branch IIN2c to nerve IIN3 (Fig. 9). Nerve IIN2 proceeds anterodorsally along the posterior edge of the profurcal arm and then passes laterad to the anterior tergo-sternal muscle 37. The IIN2 nerve divides into three nerve branches, IIN2d, IIN2e, and IIN2f, prior to entering the forewing. Nerve branch IIN2d enters the integument below the tegula of the mesothorax. Nerve branch IIN2e terminates in the integument in the region of the third axillary sclerites and nerve branch IIN2f enters the mesothoracic tegula. Nerve IIN2 is the anterior wing nerve (AWN, Fig. 9) and enters the base of the mesothoracic wing. Nerve branch IIN2a innervates the posterior tergo-sternal muscle 17 of the prothorax. Nerve branch IIN2b passes under the ventral longitudinal muscle 36, proceeds around the posterior edge of the anterior tergo-sternal muscle 37, and innervates the furco-entopleural muscle 49 and the tergal remotor muscle 54, before terminating in the integument along the lateral edge of the mesotergum.

Nerve IIN3 is a large nerve and arises from the lateral surface of the thoracic–abdominal ganglionic mass. The first nerve branch passes under the nerve IIN4 and bifurcates into two nerve branches. One nerve branch enters the integument while the remaining nerve branch passes over the anterior basal aim of the mesothoracic coxa and enters the leg. Nerve branch IIN3a innervates the sternal promotor of the coxa 53, sternal remotor of the coxa 58, sternal adductor of the coxa 59, tergal depressor 61, trochantero-basalar 62, and the tergal promotor of the coxa 50. Nerve IIN3 is then connected to IIN2 by way of nerve branch IIN2c. The next nerve branch, IIN3b, innervates the sterno-basalar muscle 48,

the trochantero-basalar muscle 62, the trochantino-basalar muscles 51 and 52, and the coxo-basalar muscle 60.

Nerve IIN3 then ramifies into three nerve branches, one innervating the anterior tergo-sternal muscle 37, another which innervates the tergal promotor muscle 50, and a nerve branch designated as IIN3c (Fig. 9). Nerve branch IIN3c innervates the anterior tergo-sternal muscle 37 and the tergo-pleural muscles 39, 40, 42, and 43.

Nerve IIN4 issues from the lateral surface of the thoracic–abdominal ganglionic mass posterior to IIN3 and proceeds posteriorly and ramifies into three nerve branches (Fig. 9). One nerve branch innervates the sternal depressor muscle of the coxa 63 before passing over the posterior basal rim of the coxa and into the mesothoracic leg. Nerve branch IIN4a innervates the furco-entopleural muscle 49 and the sternal remotor muscle 57. Nerve IIN4 passes around the posterior edge of the sternal remotor muscle 57 and provides a nerve branch to the coxo-subalar muscle 56. Nerve IIN4 continues dorsally and innervates the tergo-pleural muscles 41 and 44, the pleuro-axillary muscles 45 and 46, and the tergal remotor muscles 54 and 55.

The posterior tergo-sternal muscle 38 of the mesothorax is innervated by nerve branch IIN6a′. Nerve branch IIN6a is the posterior wing nerve (PWN, Fig. 9). It is noteworthy that the posterior tergo-sternal muscle 17 of the prothorax is innervated by a nerve branch IIN2a of the anterior wing nerve IIN2.

The pleuro-subalar muscle 47 is innervated by a nerve branch formed by the coalescence of IIN10 + IIN11 and nerve branch IIN6a‴.

Ventral muscle 3 is innervated by a nerve branch from the IIN10 + IIN11 nerve (Fig. 9).

Metathorax: The metathorax is the shortest thoracic segment in the male of the annual cicada, *Tibicen chloromera* (Walker). The entire notum is reduced to a narrow band behind the scutellum of the mesonotum (Fig. 2). Innervation of the metathoracic segment is achieved by three pairs of nerves: IIN5, IIN6, and IIN10 + IIN11 (Fig. 9).

Nerve IIN5 arises from the lateroposterior surface of the thoracic–abdominal ganglionic mass and passes mesad to the mesofurca. After receiving nerve branch IIN11a, nerve IIN5 continues posteriorly and ramifies into five nerve branches (Fig. 9). The anterior nerve branch, IIN5, is the dorsal nerve and innervates the tergal promotor muscle 75, the anterior tergo-sternal muscle 67, and terminates in the median dorsal muscles 65. The next nerve branch originates at the base of IIN5 and bifurcates into a nerve branch which enters the integument and nerve branch IIN5a which innervates the pleural promotor muscle 76 and the pleural abductor muscle 83. A nerve branch originating between IIN5 and IIN5b provides a nerve to the integument before passing over the anterior basal rim of the metathoracic coxa and into the leg. Nerve

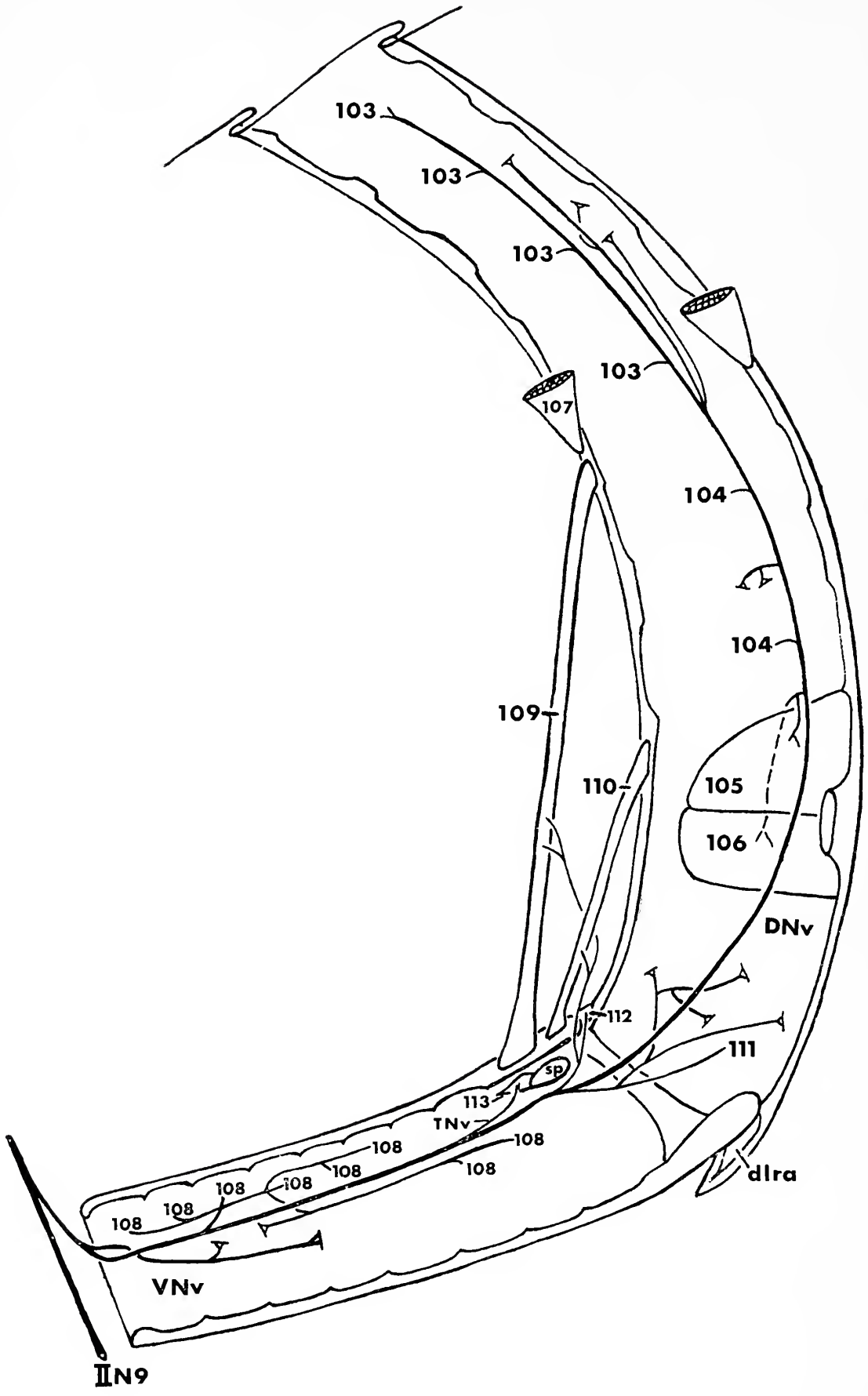

FIG. 12. Posterolateral view of the nerves and muscles of the right side of the fourth abdominal segment of the male of *Tibicen chloromera* (Walker). Second stage of dissection.

branch IIN5b passes under the posterior mesofurcal arm and provides a nerve branch to the pleural depressor muscle 86 before innervating the tergal depressor muscles 84 and 85. The remaining nerve branch innervates the sternal promotor muscle 77, the sternal depressor muscle 87, and the sternal remotor muscle 81.

Nerve IIN6 passes under the posterior mesofurcal arm and forms nerve branch IIN6a which passes around the posterior tergo-sternal muscle 38 of the mesothorax providing the nerve branch, IIN6a′ to muscle 38. Nerve branch IIN6a″ passes around the tergal depressor muscle 84 and proceeds along the posterior edge of the second phragma (2 Ph) and provides a nerve branch to the membranous sac of the abdominal air chamber (MS) before terminating in the integument along the posterolateral edge of the metatergum (Fig. 9). Nerve branch IIN6a‴ coalesces with nerve IIN10 + IIN11. Nerve IIN6a is the posterior wing nerve and passes along the anterior edge of the second phragma and enters the base of the metathoracic wing. Nerve IIN6 passes under the posterior metafurcal arm and proceeds dorsally along the posterior edge of the tergal remotor muscle 79. Nerve IIN6 provides a nerve branch which enters the integument of the epimeron before innervating the following muscles: coxo-subalar 80, posterior tergo-sternal 68, tergal remotors 78 and 79, tergo-pleural 69 and 70, and the pleural-axillary muscles 71 and 72. Nerve IIN6b provides a nerve branch to the metathoracic leg before innervating the sternal remotor muscles 82 and the coxo-subalar muscle 80. Nerve branch IIN6c innervates the furco-entopleural muscle 74.

Nerves IIN10 and IIN11 arise from the posterior dorsolateral surface of the thoracic abdominal ganglionic mass and coalesce to form nerve IIN10 + IIN11. The anterior branch of nerve IIN10 + IIN11 passes mesad to the ventral muscle 3 and provides a nerve branch to muscle 3 prior to passing mesad to the profurcal arm and the posterior tergo-sternal muscle 17 of the prothorax. Nerve IIN10 + IIN11 continues anteriorly passing over the large trachea of the mesothoracic spiracle and provides two nerve branches which coalesce with a nerve branch from IN2 + IN1 + SN9 + SN6a that innervates the anterior internal tergo-sternal muscle 15 of the prothorax. A nerve branch from SN9a also joins nerve IIN10 + IIN11. The pattern of axon distribution resulting from this fusion requires histological clarification. However, it appears that the anterior intersegmental muscle 15, which attaches to the anterior dorsolateral region of the protergum and the ventrolateral cervical sclerite, does, in part, receive its innervation from nerve IIN10 + IIN11. The IIN10 + IIN11 nerve continues anteriorly and passes under the tentorial bridge.

Nerve IIN11 provides a short nerve branch, IIN11a, that coalesces with nerve IIN5.

The posterior branch of IIN10 + IIN11 passes dorsally over the caudal portion of the thoracic–abdominal ganglionic mass and bifurcates into a dorsal branch and ventral branch. The dorsal branch divides forming two

nerve branches. One nerve branch passes mesad to IIN6a′ and enters the large trachea originating from the metathoracic spiracle. The second nerve branch passes laterad to IIN6a′ and coalesces with IIN6a‴ to innervate the sterno-pleural muscle 73, the pleuro-subalar muscle 47 of the mesothorax, and the occlusor muscle 88 of the metathoracic spiracle. The ventral branch, IIN10 + IIN11, continues posteriorly and innervates the longitudinal ventral muscle 66, then forms a loop which proceeds anteriorly and provides a nerve branch which coalesces with nerve IIN7. The IIN10 + IIN11 nerve proceeds in a posterior direction and enters the first abdominal segment which contains the sound mechanism. Further description of the innervation pattern of the IIN10 + IIN11 nerve is presented under the section entitled "The Musculature and Innervation of the Sound Mechanism."

Nerve IIN7 innervates the muscles located in the anterior portion of the first abdominal segment while nerve IIN8 innervates the muscles located in the posterior portion of the first abdominal segment. The IIN9 nerves innervate the remaining pregenital abdominal segments by providing a pair of lateral nerve roots to each consecutive segment.

Discussion: The thoracic nervous system in the male of the annual cicada, *Tibicen chloromera* (Walker), presents a perplexing enigma regarding the determination of nerve homologies. This problem is due to the coalescence of the mesothoracic, metathoracic, and abdominal ganglia into a single ganglionic mass located in the mesothorax. Condensation of the ventral nerve cord has presumably resulted in the coalescence of lateral nerve branches thereby producing apparent variations in the nerve distribution pattern in *Tibicen* when compared to nerve patterns described in other insects.

Schmitt (1962) suggests utilization of the dorsal longitudinal muscles as a starting point in establishing nerve homologies. The dorsal longitudinal muscles are innervated by the dorsal nerves of each consecutive segment. Therefore, from a descriptive standpoint, it is usually easy to identify the dorsal nerve as it issues from its ganglion. However, Nüesch (1954) has shown that some of the axons which supply the dorsal longitudinal muscles also originate from the immediately anterior ganglion.

The dorsal muscles of the prothorax in *Tibicen* is innervated by nerve IN2 + IN1 + SN9 + SN6a. Nerve SN9 may be the anterior ganglionic connective of the dorsal nerve and has adhered to the interganglionic connective. However, it cannot be determined without recourse to histological examination if nerve IN1 or nerve IN2 is the prothoracic dorsal nerve.

The dorsal longitudinal muscles of the mesothorax are innervated by the IIN1 nerves which arise from the very short interganglionic connectives between the prothoracic ganglion and the thoracic–abdominal ganglion mass. Anterior ganglionic connectives are not visible in *Tibicen*. Nüesch (1954) has demonstrated in *Telea* that motor axons from the prothoracic ganglion pass through

the anterior ganglionic connectives to the mesothoracic dorsal nerve. Anterior ganglionic connectives are not visible in *Chauliodes*, as described by Maki (1936), nor in *Agulla*, as described by Matsuda (1956). However, Schmitt (1962) proposes that if the findings of Nüesch regarding the innervation of the dorsal longitudinal muscles are applicable to other Neopterygota, it is probable that the fibers of the anterior ganglionic connectives are also present in *Chauliodes* and *Agulla*, but are incorporated in the interganglionic connectives to their connection with the dorsal nerves.

Nerve IIN5 in *Tibicen* is the dorsal nerve of the metathorax and provides innervation to muscles located in the anterior portion of this segment and the dorsal longitudinal muscles.

In the Neopterygota, wing nerves may also be useful in establishing nerve homologies. The wing nerve enters the wing cavity and is associated with sensory structures at the base of the wing. In *Tibicen* there are two wing nerves. The anterior wing nerve IIN2 arises from the anterolateral surface of the thoracic–abdominal ganglionic mass. Two nerve branches arise from the base of the anterior wing nerve (IIN2a and IIN2b) and a third nerve branch IIN2c coalesces with nerve IIN3 (Fig. 9). Nerve IIN2 then continues as a completely independent nerve providing sensory nerve branches to the integument below the tegula, the tegula, and the integument in the region of the third axillary sclerites before entering the wing cavity. Maki (1936) describes a similar condition in *Chauliodes*, where a separate nerve which he labeled "fourth root" arises from the mesothoracic ganglion and passes directly into the wing. In *Dissosteira*, Schmitt (1959) found that in addition to innervating the dorsal muscles of the mesothorax, the dorsal nerve also provides an anterior nerve branch which enters the tegmen anteriorly and a posterior branch, entering the same wing posteriorly. In *Agulla*, Matsuda (1956) also found that a branch of the dorsal nerve enters the wing. It appears that the wing nerves of *Tibicen* and *Chauliodes* are homologous to the wing nerves of *Dissosteira* and *Agulla* despite their association with dorsal nerves in the latter two insects. The posterior wing nerve in *Tibicen* arises as a nerve branch, IIN6a, from nerve IIN6 (Fig. 9). Nerve IIN6a provides three nerve branches, IIN6a′, IIN6a″, IIN6a‴, before continuing as a separate nerve and passing directly into the metathoracic wing cavity.

It is interesting to note that the thoracic legs receive their innervation from two pairs of nerves, one entering the coxae anteriorly and the other posteriorly. The prothoracic legs are innervated by nerve branches from nerves IN2 and IN4 and the mesothoracic legs by nerve branches from IIN3 and IIN4 while nerve branches from IIN5 and IIN6 enter the metathoracic legs.

In *Tibicen* no median nerves are visible between the subesophageal ganglion and the prothoracic ganglion nor between the prothoracic ganglion and the thoracic–abdominal ganglionic mass. However, the median nerves may be

included within the interganglionic connectives. The transverse or lateral nerves to the occlusor muscles of the mesothoracic spiracles arise from the dorsal surface of the prothoracic ganglion. The mesothoracic occlusor muscle 64 is innervated by a nerve resulting from the coalescence of nerves IN6, IN7, and IN8 (Fig. 9). Case (1957) has shown that in the cockroach the axons to muscles of a thoracic spiracle leave the anterior ganglion by way of the median nerve, passing to the transverse nerve and then to the muscles. Hoyle (1959) has reported a similar axon path in the thorax of *Schistocerca gregaria*. It appears then that the nerve formed by the coalescence of IN6, IN7, and IN8 is in part the transverse nerve since it terminates in the occlusor muscle of the mesothoracic spiracle. In many instances the transverse nerves from the prothoracic ganglion coalesce with the mesothoracic dorsal nerves. This was found to be true in *Agulla* and *Blattella* by Matsuda, in *Carausiaus* by Marquardt (1939), in *Chauliodes* by Maki (1936), in *Dissosteira* by Schmitt (1959), in *Periplaneta* by Pipa and Cook (1959), in *Perla* by Wittig (1955), and in *Telea* by Nüesch (1957). Schmitt (1962) mentions that no explanation has been offered for the coalescence of dorsal nerves to the transverse nerves and presumably the transverse nerves provide other functions in addition to exercising control over the spiracles.

The IIN10 + IIN11 nerves may contain axons of a transverse nerve, since a nerve branch from IIN10 + IIN11 coalesces with nerve branch IIN6a‴ and the resulting nerve terminates in the occlusor muscle 88 of the metathoracic spiracle.

4. THE MUSCULATURE AND INNERVATION OF THE SOUND MECHANISM

General: The musculature of the sound mechanism of *Tibicen chloromera* (Walker) is shown in Figs. 2 to 4 and a list of these muscles with their muscle numbers and attachments is presented in Table 8. Fig. 10 shows that the innervation of the first abdominal segment is achieved by nerves IIN7, IIN8, and IIN10 + IIN11. Nerve branch IIN8a is the auditory or tymbal nerve since it innervates the large tergo-sternal muscle 94 or tymbal muscle of the sound mechanism. Nerve IIN10 + IIN11 provides nerve branches to IIN8a and the tymbal muscle.

The Musculature of the Sound Mechanism: The musculature of the sound mechanism of *Tibicen chloromera* (Walker) is contained within the first abdominal segment. The tergo-sternal muscle 94 (Fig. 2), or tymbal muscle, is the largest muscle of the sound mechanism and has its attachments on the basal portion of the first abdominal sternum and a sclerotized terminal plate which attaches to the tymbal by a tendon. The tymbal muscles and the tymbals are the essential elements of the sound-producing apparatus (Myers, 1928).

The first abdominal sternite has become modified into a sclerotized V-shaped structure which provides attachments and support for the large tymbal muscles.

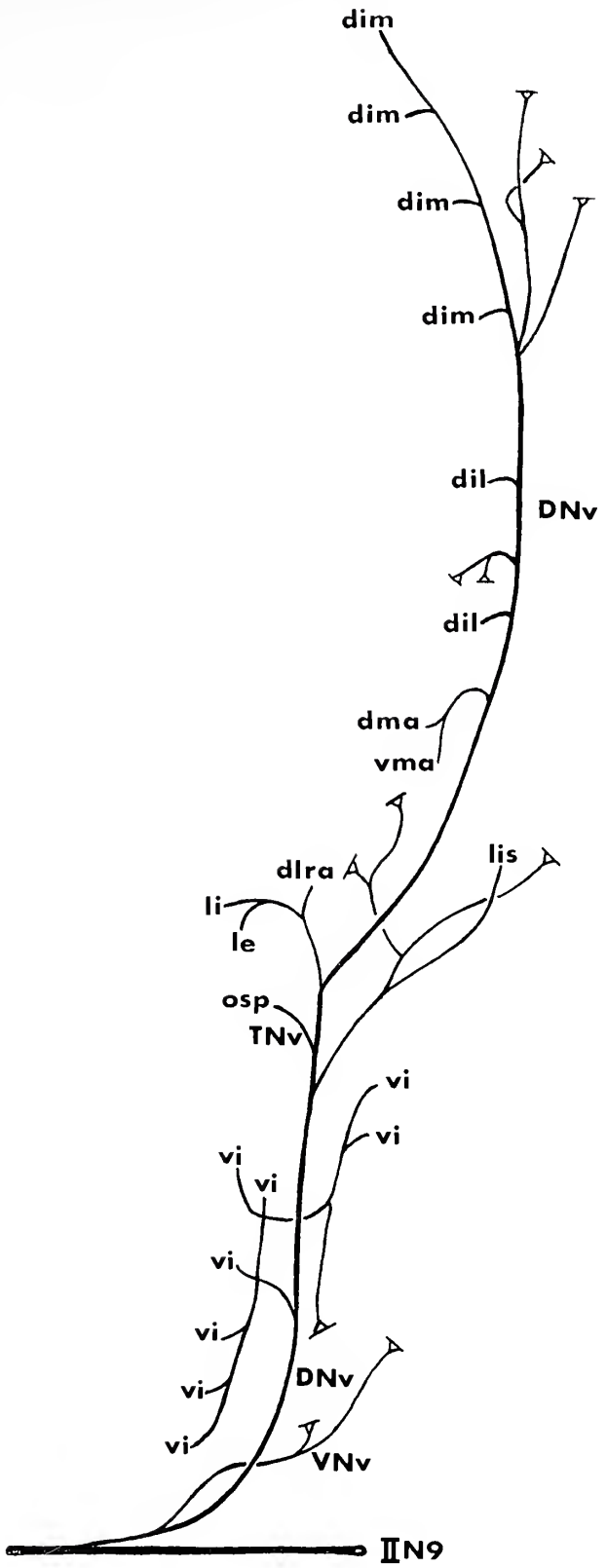

Fig. 13. Diagram of the nerve pattern of the right side of the fourth abdominal segment of the male of *Tibicen chloromera* (Walker) viewed mesally.

Carlet (1876), Vogel (1923), and Myers (1928) have established that this sclerotized V-shaped structure is a modification of the first abdominal sternum. A sternal canal is present within the base of this structure and provides a passageway for two pairs of nerves, IIN8 and IIN9. The "wings" or "arms"

TABLE 8. Musculature of the sound mechanism of *Tibicen chloromera* (Walker).

Muscle	Muscle number	Origin (or attachment)	Insertion (or attachment)
Dorsal muscle	89	Anterior intersegmental fold	Tergal ridge
Dorsal muscle	90	Tergal ridge	Posterior intersegmental fold
Ventral muscle	91	Metafurca	Anterior edge of first abdominal sternite
Ventral muscle	92	Metafurca	Lateral apodemal arm of anterior edge of sternum
Ventral muscle	93	Posterior edge of first abdominal sternum	Posterior intersegmental fold
Tergo-sternal muscle (Tymbal muscles)	94	Basal portion of first abdominal sternum	Terminal plate which attaches to tymbal by a tendon
Tergo-sternal muscle	95	Anterolateral edge of tergum	Lateral apodemal arm of anterior edge of sternum
Tergo-sternal muscle	96	Anterolateral edge of tergum ventrad to 95	Lateral apodemal arm of anterior edge of sternum
Tergo-sternal muscle	97	Anterolateral edge of tergum ventrad to 96	Lateral apodemal arm of anterior edge of sternum
Tergo-sternal muscle	98	Anteroventral edge of tymbal	Lateral apodemal arm of anterior edge of sternum
Tergo-sternal muscle	99	Tergum along lateral edge of mirror	Lateral apodemal arm of posterior edge of sternum
Tergo-sternal muscle	100	Posterior intersegmental fold	Lateral apodemal arm of posterior edge of sternum
Occlusor of spiracle	101	Lateral apodemal arm of posterior edge of sternum	Ventral end of spiracle
Occlusor of spiracle	102	Lateral apodemal arm of posterior edge of sternum	Base of spiracle

of the sclerotized V-shaped structure attach to the tergal ridge of the first abdominal segment.

A comparison of the musculature of the sound mechanism of *Tibicen chloromera* with *Huechys sanguinea* var. *philaemata* described by Maki (1938) and *Cicada* (= *Tibicen*) *plebeia* described by Berlese (1909) is presented in Table 9. The musculature of *Tibicen* differs from that found in the two other species of cicadas compared in Table 9 by the presence of tergo-sternal muscles 96, 97, and 98. Maki's ventral muscle 76 in *Huechys* was not described by Berlese (1909) in *Cicada* (= *Tibicen*) *plebeia*; however, it is present in *Tibicen chloromera*. In *Tibicen*, the dorsal muscles 89 and 90 have attachments on the tergal ridge (tr) of the first abdominal segment (Fig. 2). Berlese (1909) shows in his figure 542 similar points of attachments for the dorsal muscles 37 and 28–29 in *Cicada* (= *Tibicen*) *plebeia*. However, the dorsal muscle 74 of *Huechys sanguinea* var. *philaemata*, as shown by Maki (1938) in his figure 24, has its attachment on the anterior and posterior intersegmental folds of the first abdominal segment.

Innervation of the Sound Mechanism: The innervation of the sound mechanism is shown in Fig. 10. Nerves IIN7, IIN8, and IIN10 + IIN11 provide innervation to the muscles of the first abdominal segment which contains the

sound mechanism. Nerve IIN7 issues from the posterior portion of the thoracic–abdominal ganglionic mass and proceeds posteriorly and passes over the mesofurca. Nerve IIN7 receives a nerve branch from the IIN10 + IIN11 nerve before forming the nerve branch IIN7a. Branch IIN7a provides innervation to the ventral muscle 92, the membranous sac of the abdominal air chamber, and occlusor muscle of the first abdominal spiracle 101 before coalescing with the dorsal nerve IIN7. Nerve IIN7 is the anterior dorsal nerve of the first abdominal segment since it terminates in the dorsal muscles 89. Nerve IIN7 provides a nerve branch to the ventral muscle 91 and passes under muscle 91, around the posterior arm of the metafurca, and continues along the anterior edge of the first abdominal segment. Nerve IIN7 provides a sensory nerve branch to the integument and coalesces with nerve IIN10 + IIN11 before innervating the tergo-sternal muscles 95, 96, and 97. Nerve IIN7 then provides a nerve branch to the membranous sac surrounding the tymbal muscle 94 and coalesces with nerve branch IIN7a before providing a nerve branch to the tergo-sternal muscle 98 and dorsal muscle 89 (Fig. 10).

Nerve IIN8 issues from the posterior portion of the thoracic–abdominal ganglionic mass and proceeds posteriorly over the mesofurca. Nerve IIN8 then divides into a dorsal nerve branch IIN8a which terminates in the tergo-sternal muscle 94, and a ventral nerve IIN8 which passes between the ventral muscles 91 and enters the sternal canal. Nerve branch IIN8a is the auditory nerve and proceeds dorsally and for a portion of its length adheres to the IIN8a nerve from the opposite side. Nerve branch IIN8a then receives a nerve branch from the IIN10 + IIN11 nerve and proceeds in a dorso-oblique path over the mesal surface of the large tergo-sternal muscle 94. Nerve IIN8a then passes around the dorso-posterior edge of muscle 94 and enters this muscle along its lateral surface. Nerve IIN8 passes through the sternal canal and provides nerve branches to the integument and ventral muscle 93. Nerve IIN8 then passes along the posterior edge of the first abdominal segment and provides nerve branches to the occlusor muscle of the spiracle 102, tergo-sternal muscles 99 and 100, and the dorsal muscle 90. Nerve IIN8 is the posterior dorsal nerve since it terminates in the dorsal muscle 90 located in the posterior portion of the first abdominal segment.

The IIN10 + IIN11 nerve enters the first abdominal segment after supplying a nerve branch to nerve IIN7 and proceeds posteriorly in a dorso-oblique path and provides a nerve branch which coalesces with nerve IIN8a. The IIN10 + IIN11 nerve continues dorsolaterally and provides a short nerve branch to the tymbal muscle 94 before it loops in an anterior direction and coalesces with nerve IIN7 (Fig. 10). The IIN10 + IIN11 nerve is the sympathetic nerve of Voskresenskaya and Svidersky (1960), who report that without the innervation of the sympathetic nerve the sound-producing system cannot function normally. Therefore, both the auditory nerve, IIN8a, and the sympathetic unpaired nerve,

TABLE 9. Comparison of the musculature of the sound mechanism of *Tibicen chloromera*, with *Huechys sanguinea* var. *philaemata* (Maki, 1938) and *Cicada* (= *Tibicen*) *plebeia* (Berlese, 1909).

Muscles	*Tibicen chloromera*	*Huechys sanguinea* var. *philaemata* (Maki, 1938)	*Cicada* (= *Tibicen*) *plebeia* (Berlese, 1909)
Dorsal muscles	89	–	37
Dorsal muscles	90	–	28–29
Dorsal muscle	–	74	–
Ventral muscle	91	75	35
Ventral muscle	92	76	–
Ventral muscle	93	–	14 + 15
Tergo-sternal muscle	94	77	XXVI
Tergo-sternal muscle	95	78	–
Tergo-sternal muscle	96	–	–
Tergo-sternal muscle	97	–	–
Tergo-sternal muscle	98	–	–
Tergo-sternal muscle	99	–	XVII
Tergo-sternal muscle	100	83	XVII
First interpleural muscle	–	–	LIII
Occlusor of spiracle	101	79	–
Occlusor of spiracle	102	85	–

IIN10 + IIN11, are necessary for the rhythmic "singing" of the cicada. It is interesting to note that Hagiwara and Watanabe (1956) concluded that the paired tymbal muscles receive alternate impulses from the ganglion, and this alternate activity of the two tymbals may give a double sound vibration frequency.

5. THE MUSCULATURE AND INNERVATION OF THE FOURTH ABDOMINAL SEGMENT

General: The abdominal musculature of adult and larval insects conforms to a simple fundamental pattern which is repeated with only minor variations in each of the pregenital segments (Snodgrass, 1935). The major groups of abdominal muscles found in insects are the dorsal muscles, ventral muscles, lateral muscles, transverse muscles, and spiracular muscles. The dorsal and ventral muscles in most insects occur in two layers and thereby form dorsal internal and external muscles and ventral internal and external muscles. In the male of *Tibicen chloromera* (Walker) the dorsal external and ventral external muscles are absent. The writer observed a similar condition in all of the typical pregenital abdominal segments. Another common form of diversification affecting dorsal and ventral muscles includes a more or less distinguishable grouping of the muscles into median and lateral sets (Snodgrass, 1935). In *Tibicen* the dorsal muscles can be classified into dorsal internal median and dorsal internal lateral muscle groups; however, the ventral internal muscles cannot be classified into median and lateral sets since there are no ventral transverse muscles or a wide separation between the ventral internal muscles.

The musculature of the fourth abdominal segment of the male of the annual cicada, *Tibicen chloromera* (Walker) is shown in Figs. 11 and 12 and a list of the muscles with their muscle numbers and attachments is presented in Table 10.

The innervation of the abdominal musculature with the exception of the muscles of the first abdominal segment is achieved by nerves IIN9. The IIN9 nerves provide a pair of lateral nerve branches to each consecutive pregenital abdominal segment. Figs. 11 and 12 show the innervation of the fourth abdominal segment.

The Musculature of the Fourth Abdominal Segment: The musculature of the fourth abdominal segment of the male of *Tibicen chloromera* (Walker) can be classified into dorsal, ventral, lateral, and spiracular muscles (Table 10). The dorsal muscles are subdivided into dorsal internal median (103) and dorsal internal lateral (104) muscles, dorsal (105) and ventral (106) muscles of the apodeme, and dorsal transverse muscles (107). The dorsal internal median and dorsal internal lateral muscles have their attachments on the anterior and posterior intersegmental folds while the dorsal and ventral muscles of the apodeme have their attachments on the anterior edge of the apodeme and the posterior intersegmental fold. It is interesting to note that there is a complete absence of dorsal external muscles in the pregenital abdominal segments. The usual location of the dorsal external muscles is the posterior portion of the abdominal segment with their attachments on the posterior margin of the tergum and the posterior intersegmental fold. In this position the dorsal external muscles serve as protractors of the abdomen. It appears that the protraction of the abdomen in *Tibicen* is achieved by the contraction of the dorsal and ventral muscles of the tergal apodeme. The dorsal transverse muscle, 107, has its attachments along the lateral edge of the dorsal vessel and the anterolateral intersegmental fold of the tergum.

Eight closely associated sets of ventral internal muscles, 108, are present in *Tibicen*. The ventral internal muscles cannot be grouped into specific median and lateral muscle sets.

Four pairs of lateral muscles are present in *Tibicen*: lateral internal 109, lateral external 110, lateral intrasegmental 111, and the dilator of the abdomen 112 (Figs. 11 and 12). The lateral internal and external muscles are tergo-sternal muscles and have their attachments on the anterior intersegmental fold of the tergum and the internal surface of the anterior sternal apodeme. The lateral intrasegmental muscle is tergo-sternal in its attachments and is located in the posterior portion of the segment. The dilator of the abdomen is attached to the anterolateral edge of the tergum and the external surface of the anterior sternal apodeme.

The spiracle of the fourth abdominal segment is located in the anterolateral corner of the sternum. The occlusor muscle of the spiracle has its attachments

on the anterolateral portion of the sternum adjacent to the sternal apodeme and to the ventral edge of the spiracle.

Maki (1938) in his figure 24 shows the musculature of the third abdominal segment of *Huechys sanguinea* var. *philaemata*. The musculature of the fourth abdominal segment of *Tibicen chloromera* (Walker) is homologous to the third segment of *Huechys sanguinea* var. *philaemata* with the exception of the dorsal internal lateral muscles 104, the lateral intrasegmental muscle 111, and the dilator of the abdomen 112 of *Tibicen* (Table 11).

The Innervation of the Fourth Abdominal Segment: The innervation of the fourth abdominal segment is achieved by a pair of lateral nerve branches which arise from the IIN9 nerves. The IIN9 nerves issue from the posterior end of the thoracic–abdominal ganglionic mass and pass over the mesofurca and metafurca and between the ventral muscles into the sternal canal. After the IIN9 nerves pass through the sternal canal they provide a pair of lateral nerve branches to the second and remaining pregenital abdominal segments. The lateral nerve branch from nerve IIN9 divides into a dorsal nerve and ventral nerve prior to passing under the ventral internal muscles of the fourth abdominal segment. The innervation of the fourth abdominal segment is shown in Figs. 11 and 12. The ventral nerve (VNv) passes under the dorsal nerve (DNv) and terminates in the integument beneath the ventral internal muscles 108 (Fig. 12). The dorsal nerve provides a nerve branch to the ventral internal muscles which are innervated along their external surface.

The dorsal nerve proceeds laterally and provides a nerve (TNv) to the occlusor muscle of the spiracle 113 (Fig. 13). Case (1957) presents experimental evidence that the median and transverse nerves provide a neural pathway connecting the spiracular mechanism with the central nervous system. Schmitt (1965) presents a comparative morphological study on the transverse nerves in the abdominal nervous system of insects and concludes that, in insects which apparently lack median and transverse nerves, these nerves have become incorporated in the longitudinal connectives and lateral segmental nerves. In the majority of insects reviewed by Schmitt, the transverse nerve also innervates the alary muscles. In *Tibicen chloromera* (Walker) the writer could not determine the innervation of the alary muscles; however, it appears reasonable to conclude that the innervation of the occlusor muscle of the spiracle of *Tibicen* is accomplished by fibers of the transverse nerve which have become incorporated in the dorsal nerve.

After providing a nerve branch to the occlusor muscle of the spiracle, the dorsal nerve ramifies into three nerve branches. The anterior nerve branch innervates the lateral internal muscle 109, lateral external muscle 110, and the dilator of the abdomen 112. The posterior nerve branch divides into a sensory nerve which terminates in the integument and a nerve branch which innervates the lateral intrasegmental muscle 111 (Figs. 11 and 12).

Table 10. The musculature of the fourth abdominal segment of *Tibicen chloromera* (Walker).

Muscle	Muscle number	Origin (or attachment)	Insertion (or attachment)
Dorsal muscles			
Dorsal internal median muscles	103	Anterior intersegmental fold	Posterior intersegmental fold
Dorsal internal lateral muscles	104	Anterior intersegmental fold	Posterior intersegmental fold
Dorsal muscle of apodeme	105	Anterior edge of tergal apodeme	Posterior intersegmental fold
Ventral muscle of apodeme	106	Anterior edge of tergal apodeme	Posterior intersegmental fold
Dorsal transverse muscle	107	Anterior intersegmental fold	Lateral edge of the dorsal vessel
Ventral muscles			
Ventral internal muscles	108	Anterior intersegmental fold	Posterior intersegmental fold
Lateral muscles			
Lateral internal muscle	109	Anterior intersegmental fold of tergum	Internal surface of sternal apodeme
Lateral external muscle	110	Anterior intersegmental fold of tergum	Internal surface of sternal apodeme
Lateral intrasegmental muscle	111	Posterolateral portion of tergum	Lateral edge of sternum
Dilator of the abdomen	112	Lateral edge of tergum	External surface of sternal apodeme
Muscles of the spiracle			
Occlusor	113	Anterolateral portion of sternum adjacent to the sternal apodeme.	Ventral edge of spiracle

The dorsal nerve proceeds dorsally in an oblique-posterior direction over the tergal apodeme and supplies a nerve branch to the dorsal and ventral muscles (104 and 105) of the apodeme (Figs. 11 and 12). The dorsal nerve continues dorsally along the posterior portion of the tergum and passes over the dorsal internal lateral muscles 104 and provides nerve branches to these muscles. The dorsal nerve then divides into three nerve branches; two nerve branches pass laterally under the dorsal internal median muscles and terminate in the integument while the dorsal nerve passes mesally over the dorsal internal median muscles supplying these muscles with nerve branches. The dorsal nerve terminates in the first set of dorsal internal median muscles (Fig. 11).

The segmental nerve pattern in the male cicada, *Tibicen chloromera* (Walker), is notably abbreviated when compared to the innervation pattern of some families of Orthoptera, as described by Schmitt (1954), *Chauliodes formosanus* as described by Maki (1936), the larva and adult of *Hyalophora cecropa* as described by Libby (1959 and 1961), and in *Pteronarchys* as described by Schmitt (1963). The abbreviated nerve pattern in *Tibicen* is largely due to the absence of the dorsal and ventral external muscles and by the condensation

TABLE 11. A comparison of the musculature of the fourth abdominal segment of *Tibicen chloromera* (Walker) to the musculature of the third abdominal segment of *Huechys sanguinea* var. *philaemata* described by Maki (1938).

Muscle groups	*Tibicen chloromera*	*Huechys sanguinea* var. *philaemata* (Maki, 1938)
Dorsal muscles		
Dorsal internal median muscles	103	86
Dorsal internal lateral muscles	104	–
Dorsal muscle of apodeme	105	87
Ventral muscle of apodeme	106	88
Dorsal transverse muscle	107	89
Ventral muscles		
Ventral internal muscles	108	90
Lateral muscles		
Lateral internal muscle	109	91
Lateral external muscle	110	92
Lateral intrasegmental muscle	111	–
Dilator of the abdomen	112	–
Muscles of the spiracle		
Occlusors of the spiracle	113	93

of the ventral nerve cord which has resulted in the formation of a thoracic–abdominal ganglionic mass located in the mesothorax. With the condensation of the ventral nerve cord, the motor axons which supply the innervation to the typical pregenital abdominal segments have become incorporated within a single pair of nerves, IIN9. The IIN9 nerves supply a pair of lateral nerve branches to each consecutive abdominal segment after which there are no nerve connections between segments.

The innervation pattern of the fourth abdominal segment of *Tibicen* is shown in Fig. 13. The dorsal nerve supplies innervation to the dorsal and ventral internal longitudinal muscles which are considered primitive muscle groups of the segmental musculature and are therefore useful in the establishment of a criteria of nerve homology. Schmitt (1954) shows that the dorsal and ventral internal muscles of *Dissosteira*, *Acheta*, and *Periplaneta* are innervated by nerve branches from the dorsal nerve. Libby (1959 and 1961) shows a similar innervation of the same muscle groups in the larva and adult of *Hyalophora*.

Further investigations of insects possessing a thoracic–abdominal ganglionic mass located in the thorax must be conducted before significant comparisons can be made with the segmental nerve pattern of *Tibicen*.

SUMMARY AND CONCLUSIONS

The musculature and innervation of the thorax, of the sound mechanism, and of a typical pregenital abdominal segment of the male of the annual cicada, *Tibicen chloromera* (Walker) are described. The musculature of the thorax and

abdominal segments of *Tibicen* is essentially homologous to the musculature of the male cicada *Heuchys sanguinea* var. *philaemata* as described by Maki (1938).

The ventral nerve cord consists of a subesophageal ganglion, prothoracic ganglion, and a thoracic–abdominal ganglionic mass. There are no ganglia present in any of the abdominal segments. The abdominal segments are innervated by lateral nerve branches arising from a pair of nerves that originate from the posterior portion of the thoracic–abdominal ganglionic mass located in the mesothorax. Eight pairs of nerves arise from the subesophageal ganglion and supply innervation to the muscles associated with the feeding apparatus, the salivary glands, the lateral ducts of the salivary glands, and some of the muscles of the cervical area.

The prothoracic ganglion and the anterior portion of the thoracic–abdominal ganglionic mass are covered dorsally by ventral muscles. The prothoracic ganglion supplies innervation to some of the muscles of the cervical area and the muscles of the prothorax. The thoracic–abdominal ganglionic mass provides innervation to the posterior tergo-sternal muscles of the prothorax, the muscles of the mesothorax, metathorax, and all the abdominal segments. No median nerves are visible between the subesophageal ganglion, prothoracic ganglion, and the thoracic–abdominal ganglionic mass. However, the median nerves are probably included within the interganglionic connectives. Spiracular muscles of the thoracic segments are innervated by nerves which arise from the dorsolateral area of the prothoracic ganglion and the thoracic–abdominal ganglionic mass. The nerves to the spiracular muscles are apparently the transverse nerves of the "ventral sympathetic nervous system."

The sound mechanism is contained within the first abdominal segment. An invagination of the first abdominal sternite serves as an area for attachment and support for the large tymbal muscles. A sternal canal is located within the sternal invagination and permits the passage of two pairs of nerves. One pair of nerves innervates the muscles in the posterior portion of the first abdominal segment while the remaining pair of nerves provides innervation to the remaining abdominal segments.

Each typical pregenital abdominal segment is innervated by a pair of lateral nerve branches which arises from a single pair of nerves originating from the posterior end of the thoracic–abdominal ganglionic mass and pass through the sternal canal. There are no nerve connections between the typical pregenital abdominal segments once the lateral nerves enter their respective segments. A single nerve branch from the dorsal nerve innervates the occlusor muscle of the spiracle of the fourth abdominal segment. It appears that the innervation of the occlusor muscle of the spiracle is achieved by fibers of the transverse nerve which have become incorporated in the lateral nerve branches to the abdominal segments.

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ABBREVIATIONS USED ON THE FIGURES

AT—Anterior tentorial arm
AWN—Anterior wing nerve
Ba_3—Metathoracic basalare
bp—Bristle plate
CoeCon—Circumesophageal connective
Con—Connective
Cv—Cervix
cv—Cervical sclerite
Cx_1—Coxa of the prothoracic leg
Cx_2—Coxa of the mesothoracic leg
Cx_3—Coxa of the metathoracic leg

dil—Dorsal internal lateral muscle
dim—Dorsal internal median muscle
dlra—Dilator muscle of the abdomen
dlSyr—Dilator muscle of the salivary syringe
dma—Dorsal muscle of the tergal apodeme
DNv—Dorsal nerve
Fu_2—Mesofurca
Fu_3—Metafurca
GI—Prothoracic ganglion
GII—Thoracic–abdominal ganglionic mass
L—Leg
Lb—Labium
le—Lateral external muscle
li—Lateral internal muscle
lis—Lateral intrasegmental muscle
LmNv—Labral nerve
M—Mirror of the sound mechanism
mlb—Muscles of labium
mr—Muscles of the rod
MS—Membranous sac of the sound mechanism
mxb—Maxillary bristle
Op—Operculum
osp—Occlusor muscle of the spiracle
pl—Tymbal muscle plate
PlA_1—Prothoracic pleural arm
PlA_2—Mesothoracic pleural arm
PlA_3—Metathoracic pleural arm
pmdb—Protractor muscle of the mandibular bristle
PT—Posterior tentorial arm
PWN—Posterior wing nerve
r—Rod
rmdb—Retractor muscle of the mandibular bristle
$rmxb_1$—Internal retractor muscle of the maxillary bristle
$rmxb_2$—External retractor muscle of the maxillary bristle
Sa_2—Subalare of the mesothorax
Sa_3—Subalare of the metathorax
SLD—Salivary duct
SLGL—Salivary gland
SoeGng—Subesophageal ganglion
Sp_2—Mesothoracic spiracle
Sp_3—Metathoracic spiracle
sp—Fourth abdominal spiracle
T_1—Prothoracic tergum
T_2—Mesothoracic tergum
T_3—Metathoracic tergum
tapd—Tergal apodeme
TB—Tentorial bridge
tg—Tegula
tn—Tendon between tymbal plate and tymbal
TNv—Transverse nerve

Tr—Trachea
tr—Tergal ridge
TYM—Tymbal
Vi—Ventral internal muscles
Vma—Ventral muscle of the tergal apodeme
Vnv—Ventral nerve
wg—Wing of sclerotized V-shaped structure of first abdominal segment
1Ph—First phragma
2Ph—Second phragma
I—First abdominal segment
ISp—First abdominal spiracle
II—Second abdominal segment
1pmxb—Protractor muscle of the maxillary bristle
2pmxb—Protractor muscle of the maxillary bristle

Spiders from Powdermill Nature Reserve

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Abstract: This paper is a list of 150 species of spiders collected during a 2-week study of the fauna of Powdermill Nature Reserve in Pennsylvania.

Local and regional faunal lists are the backbone of ecological and zoogeographical studies. Such lists provide the detailed information on local faunas necessary for syntheses of a broader scope. The spider fauna of Pennsylvania has been sadly neglected. Distribution maps in recent taxonomic revisions almost invariably show a lack of locality records from this state. There has been only one list of Pennsylvania spiders published during the last half century (Truman, 1942): a list of spiders from Presque Isle, Erie County. This present paper is also a local faunal list.

The Powdermill Nature Reserve of Carnegie Museum is an area of about 1,500 acres in the Ligonier Valley of Westmoreland County, Pennsylvania. The reserve includes a variety of woodland and open (chiefly old field) habitats. This collection was primarily made during a 2-week study in June and July, 1965, with a few additional specimens collected at other times of the year. This list must, of necessity, be regarded as preliminary. With the exception of duplicates retained by the author, the specimens are deposited in Carnegie Museum.

The collection consists of over 1,000 specimens of mature spiders, representing about 150 species. The list from Presque Isle also includes about 150 species, but the two lists have only half their species in common. These lists, along with scattered reports, bring the published number of Pennsylvania species between 200 and 250. Judging by the fauna of New York state, there should eventually be more than 500 species of Pennsylvania spiders.

I wish to thank C. J. Goodnight, of Western Michigan University, for identification of the opilionids; W. Ivie, of the American Museum of Natural History, for identification of the erigonids; and W. J. Gertsch, Curator of Spiders at the American Museum of Natural History, for identification of *Clubiona* and for help with some of the difficult species. I am also indebted to M. Graham Netting, Director of Carnegie Museum, for making my fieldwork at Powdermill Nature Reserve possible.

ORDER ARANEIDA

Suborder MYGALOMORPHAE

ANTRODIAETIDAE

Antrodiaetus unicolor (Hentz)

Suborder ARANEAMORPHAE

AMAUROBIIDAE

Amaurobius bennetti (Blackwall)

DICTYNIDAE

Dictyna cruciata Emerton
Dictyna foliacea (Hentz)
Dictyna frondea (Hentz)
Dictyna sublata (Hentz)
Lathys foxi Marx

ULOBORIDAE

Hyptiotes sp. (immature)

SEGESTERIIDAE

Ariadna bicolor (Hentz)

TETRAGNATHIDAE

Leucauge venusta (Walckenaer)
Mimognatha foxi (McCook)
Pachygnatha autumnalis Keyserling
Tetragnatha elongata Walckenaer
Tetragnatha straminea Emerton
Tetragnatha versicolor Walckenaer

THERIDIIDAE

Achaearanea globosum (Hentz)
Achaearanea tepidariorum (Koch)
Ancylorrhanis hirsutum (Emerton)
Asagena americana Emerton
Crustulina altera Gertsch and Archer
Ctenium frontata (Banks)
Ctenium pumilis (Emerton)
Dipoena nigra (Emerton)
Enoplognatha tecta (Keyserling)
Euryopis funebris (Hentz)
Steatoda borealis (Hentz)
Teutana triangulosa (Walckenaer)
Theridion albidum Banks
Theridion differens Emerton
Theridion frondeum Emerton
Theridion lyricum Walckenaer
Theridion murarium Emerton
Theridion sexpunctatum Emerton
Theridion spirale Emerton
Theridula opulenta Walckenaer

ERIGONIDAE

Ceraticelus bulbosus (Emerton)
Ceraticelus fissiceps (Cambridge)
Ceraticelus laetabilis (Cambridge)
Ceratinopsidis formosa (Banks)
Ceratinopsis interpres (Cambridge)
Ceratinopsis nigriceps Emerton
Collinsia oxypaederotipus (Crosby)
Cornicularia minuatus Emerton
Cornicularia vigilax (Blackwall)
Eperigone maculata (Banks)
Erigone autumnalis Emerton
Grammonota trivittata ? Banks
Hypselisthes florens (Cambridge)
Maso sarcocuom (Crosby and Bishop)
Maso sundevalli (Westring)
Origanates rostratus (Emerton)
Scylaceus pallida (Emerton)

LINYPHIIDAE

Bathyphantes albiventris (Banks)
Lepthyphantes subalpina (Emerton)
Linyphia waldea Chamberlin and Ivie
Meioneta fabra (Keyserling)
Pityohyphantes costatus Hentz
Tennesseellum formica (Emerton)

ARANEIDAE

Araneinae

Acacesia hamata (Hentz)
Acanthepeira stellata (Walckenaer)

Araneus attestor Petrunkevitch
Araneus cornutus Clerck
Araneus marmoreus Clerck
Araneus solitarius (Emerton)
Araneus trifolium (Hentz)
Araniella displicata (Hentz)
Cyclosa conica (Pallos)
Cyclosa turbinata (Walckenaer)
Eustala anastera (Walckenaer)
Mangora gibberosa (Hentz)
Mastophora bisaccata ? (Emerton) (immature)
Neoscona arabesca (Walckenaer)
Singa praetensis Emerton
Singa sp. aff. *variabilis*

Argiopinae

Argiope trifasciata (Forskal)
Gea heptagon (Hentz)

Gasteracanthinae

Micrathena gracilis (Walckenaer)
Micrathena sagittata (Walckenaer)

Theridiosomatinae

Theridiosomma radiosum McCook

AGELENIDAE

Agelenopsis pennsylvanica (Koch)
Cicurina arcuata Keyserling
Cicurina brevis (Emerton)
Cicurina idahoana Chamberlin
Cicurina pallida Keyserling
Coras medicinalis (Hentz)
Wadotes sp. (immature)

HAHNIIDAE

Antistea brunnea ? (Emerton) (immature)
Hahnia cinerea Emerton

OXYOPIDAE

Oxyopes salticus (Hentz)

PISAURIDAE

Dolomedes scriptus Hentz
Dolomedes tenebrosus Hentz
Dolomedes triton sexpunctatus Hentz
Dolomedes urinator Walckenaer
Dolomedes vittatus Walckenaer
Pisaurina brevipes (Emerton)
Pisaurina mira (Walckenaer)
Pisaurina mira var. *subinflata*

LYCOSIDAE

Arctosa virgo (Chamberlin)
Lycosa frondicola Emerton
Lycosa gulosa Walckenaer
Lycosa helluo Walckenaer
Lycosa rabida Walckenaer
Pardosa distincta (Blackwall)
Pardosa lapidicina Emerton
Pardosa milvina Hentz
Pardosa moesta Banks
Pardosa saxatilis (Hentz)
Pirata insularis Emerton
Pirata maculatus Emerton
Pirata minutus Emerton
Pirata montanus Emerton
Schizocosa avida (Walckenaer)
Schizocosa crassipes (Walckenaer)
Schizocosa saltatrix (Hentz)

GNAPHOSIDAE

Drassyllus fallens Chamberlin
Sosticus insularis (Banks)
Zelotes duplex Chamberlin

ANYPHAENIDAE

Anyphaenella saltabunda (Hentz)

CLUBIONIDAE

Castianeira sp. (immature)
Chiracanthium inclusum (Hentz)
Clubiona abboti Koch
Clubiona kastoni Gertsch
Clubiona obesa Hentz
Clubionoides pallens (Hentz)

THOMISIDAE

Misuminae

Misumenoides formosipes (Walckenaer)
Misumenops asperatus (Hentz)
Misumenops oblongus (Keyserling)
Xysticus elegans Keyserling
Xysticus ferox (Hentz)
Xysticus fraternus Banks
Xysticus funestus (Keyserling)
Xysticus triguttatus Keyserling

Philodrominae

Philodromus placidus Banks
Philodromus rufus Walckenaer
Thanatus sp. (immature)

Tibellus maritimus (Menge)
Tibellus oblongus (Walckenaer)

SALTICIDAE

Evarcha hoyi (Peckham)
Habrocestum pulex (Hentz)
Habronattus decorus (Balckwall)
Hasarius adansoni (Audouin)
Icius harti Emerton
Maevia inclemens (Walckenaer)
Marpissa lineata (Koch)
Marpissa undata (DeGeer)
Metaphidippus galathea (Walckenaer)
Neon nelli Peckham
Paraphidippus marginata (Walckenaer)
Peckhamia scorpiona (Hentz)
Phidippus clarus Keyserling
Phidippus princeps (Peckham)
Phlegra fasciata (Hahn)
Salticus scenicus (Linnaeus)
Sittacus floridanus Gertsch and Mulaik
Synemosyna formica Hentz
Zygoballus bettini Peckham

ORDER OPILIONIDA

Leiobunum nigropalpi Wood
Leiobunum ventricosum Wood
Leiobunum verrucosum Wood

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Recent Publications

The Natural History of Mosquitoes. Marston Bates, Harper and Row, New York, $2.45 (paper) 378 pp., 1965.

A Systematic Revision of the Amenidae (Diptera: Calliphoridae), R. W. Crosskey, Bull. Brit. Mus. (Nat. Hist.), Entomology, **16:** 2, about $5.00, 107 pp., 1965.

The Culicoides of New York State (Diptera: Ceratopogonidae), Bull. # 399. Hugo Jamnback, New York State Museum and Science, $1.00, 154 pp., 24 plates, 1965.

Microlepidoptera of Juan Fernandez Island. J. F. Gates Clarke, Proc. U. S. Nat. Museum **117** No. 3508, Smithsonian Institution, Washington, D. C., 106 pp., 1965.

A Revision of the Nodini and A Key to the Genera of Eumolpidae of Africa (Coleoptera: Eumolidae), B. J. Selman, Bull. Brit. Mus. (Nat. Hist.), Entomology, **16**, No. 2, about $1.90 (paper), 31 pp., 1965.

Review of the Genus Cerceris in America North of Mexico (Hymenoptera: Sphecidae), Herman A. Scullen, Proc. U. S. Nat. Museum, **116**, No. 3506, Smithsonian Institution, Washington, D. C., 2121 pp., 1965.

Defensive Secretion of a Caterpillar (Papilio). Thomas Eisener, and Yvonne C. Meinwald, Science, **150**, Dec. 1965, pp. 1733–1738, illus.

Origin and Structural Function of the Basal Cells of the Larval Midgut in the Mosquito, *Aedes aegypti* Linnaeus[1]

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Abstract: This study of a series of midgut whole mounts of larval and pupal *Aedes aegypti* shows that basal or regenerative cells first appear as a distinct cell type in the mosquito midgut at about the ninth hour of larval life. These cells seldom take part in forming the epithelial lining of the larval midgut. After their appearance, frequent mitotic divisions occur in the basal cells throughout the larval instars resulting in the presence of a large number of these cells in the prepupal midgut. During metamorphosis in the pupal stage, the basal cells remain to form the epithelial layer of the imaginal midgut.

Relatively little is known about the cytological development of the midgut in the mosquito, *Aedes aegypti* Linnaeus. Christophers' (1960) description of the *Aedes* digestive tract indicates that the midgut has received little attention from cytologists. Among the three types of cells comprising the larval midgut of *Aedes*, the regenerative or basal cells remained somewhat of a mystery as to their origin. Christophers stated that the origin of the basal cells is unknown. Berger (1938) reported finding regenerative cells in the larval midgut of the mosquito *Culex pipiens* but offered no explanation as to their origin. The fairly constant size, active divisions, and increasingly larger numbers of these cells during the larval stages indicate that they must perform some function other than to replace epithelial cells in the larval midgut. The question regarding the origin of the basal cells as well as the fact that such a large number of these cells is present in the later larval instars indicated the need for further cytological study of the midgut of *A. aegypti*. While the investigation is principally concerned with the larval midgut, pupal and adult midguts were also studied to determine the origin and structural function of the basal or regenerative cells.

MATERIALS AND METHODS

The *Aedes* larvae used in this study were obtained from the colony maintained in this laboratory (O'Brien, 1965). Beginning about 6 hours after hatching and at intervals of from 1 to 4 hours throughout the larval and pupal stages, the midguts were dissected from the specimens. They were then prepared as whole mounts, stained with the Feulgen reaction and counterstained with Orange G. The dissections, the fixation, and the staining procedure were performed on depression slides to eliminate loss or damage to the tissue (O'Brien, 1965).

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[1] A portion of the author's dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Fordham University. The author wishes to acknowledge the assistance and encouragement given him during this study by Prof. C. A. Berger, S.J., of the Fordham Biological Laboratory. This work was supported in part by an Educational Assistance Grant from the Arthur J. Schmitt Foundation.

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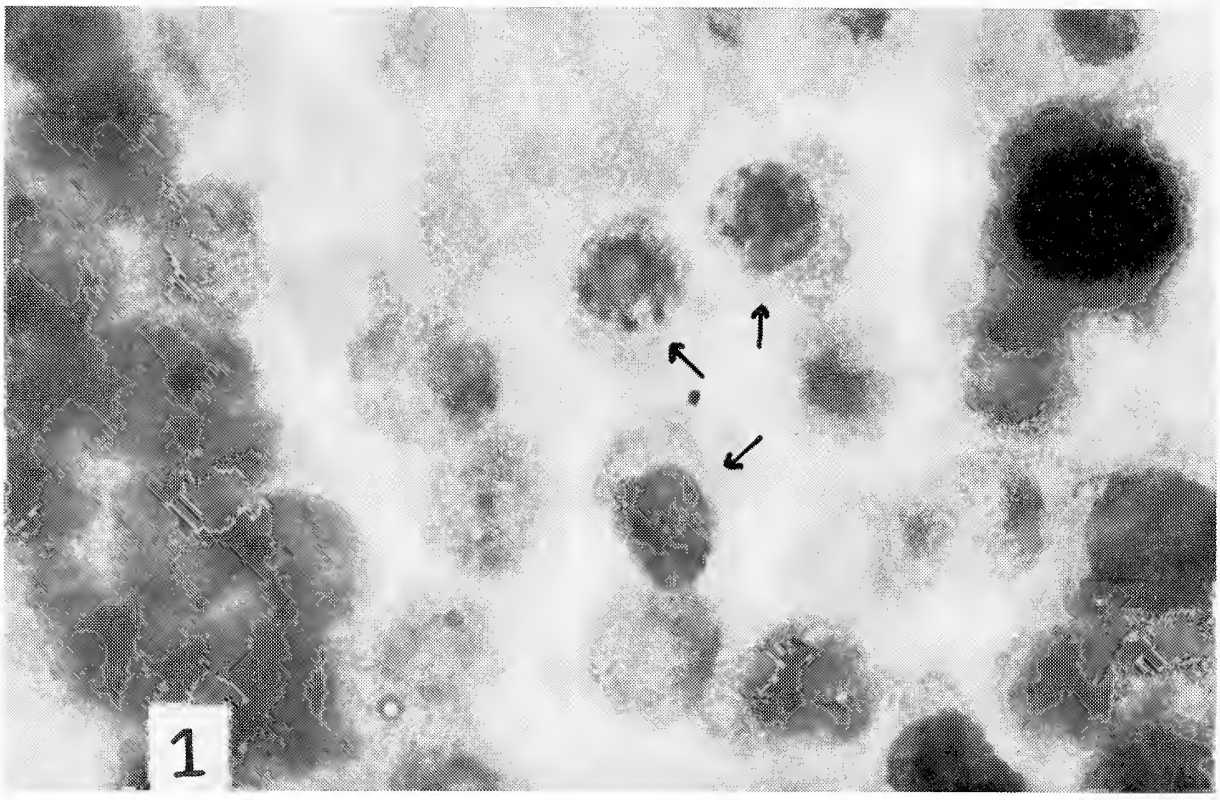

FIG. 1. Photomicrograph of portion of stomach area of 17-hour larva showing three potential regenerative cells (arrows). × 1,290.

RESULTS

In 6-hour larval midguts, only two cell types are present, the longitudinal and circular rows of muscle cells and larger cells forming the epithelial lining of the midgut. At about the twelfth hour of larval life, growth of the midgut has resulted in an increase in size of the epithelial cells, making the epithelial cells easily distinguishable from the smaller regenerative cells which have appeared by this time. Examination of whole mounts of midguts between 6 and 12 hours old shows that at about 9 hours, some of the original midgut epithelial cells are undergoing mitotic division. Such a division gives rise to two cells that are smaller than the neighboring cells. These smaller cells are regenerative cells. Up to this time, the midgut wall is only two cell layers thick, the outer cells being the rows of muscle cells and the inner layer the epithelial cells. The division of some of the initial epithelial cells results in the formation of the smaller cells that lie on the basement membrane, at the bases of the epithelial cells—hence the term "basal" cells.

Study of the cells of the midguts obtained from larvae between 6 and 9 hours old reveals the presence of large, uniformly sized epithelial cells resting on the basement membrane. A few of these cells exhibit nuclei that appear to be in early prophase of mitotic division, while the neighboring cells contain normal "resting" nuclei. Since all the cells are of about the same size, the cells appearing to be in early prophase must be the potential basal cells (Fig. 1). The origin of the basal cells from epithelial cells was confirmed when mitosis was observed

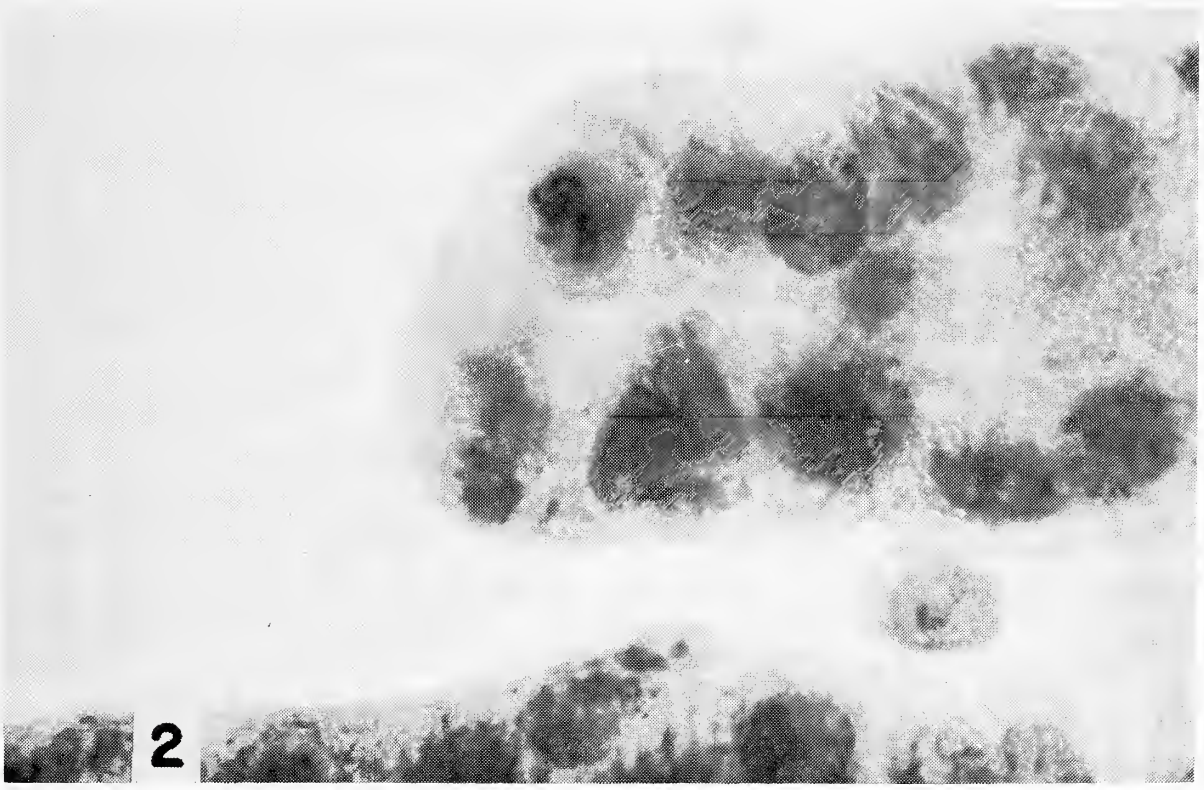

Fig. 2. Photomicrograph of portion of a pouch of gastric ceca of 24-hour larva showing one of the primordial epithelial cells in mitotic prophase. × 1,290.

in epithelial cells of the gastric ceca (Fig. 2) where regenerative cells appear at a later stage and in fewer numbers than in the stomach area of the midgut.

All divisions of the basal cells are normal mitotic divisions, exhibiting the somatic pairing of homologous chromosomes characteristic of dipteran cells (Figs. 2, 3, 4).

After the basal cells appear in the midgut, their number increases rapidly by repeated divisions. These cells lie at the bases of the large primordial epithelial cells which continue to grow larger during the larval instars and never divide after about 24 hours of larval life. By the fourth instar, the regenerative cells form almost a complete layer of cells, intermediate in size between the large primordial epithelial cells and the smaller muscle cells, against the basement membrane. The number of basal cells found in the gastric ceca is considerably smaller than in the stomach area of the midgut.

Examination of the pupal midgut shows that the regenerative cells form the new epithelial lining of the imaginal midgut. During the larval instars, few of the basal cells help to form the epithelial layer of the midgut. But, after the onset of pupation, the primordial epithelial cells quickly separate from the basement membrane, are sloughed off into the lumen of the midgut, and begin to disintegrate. The basal cells that have been increasing in number throughout larval life continue their divisions and soon form the epithelial lining of the imaginal midgut. Since the adult midgut contains no structure similar to the pouches of the larval gastric ceca, the basal cells that formed in the region of

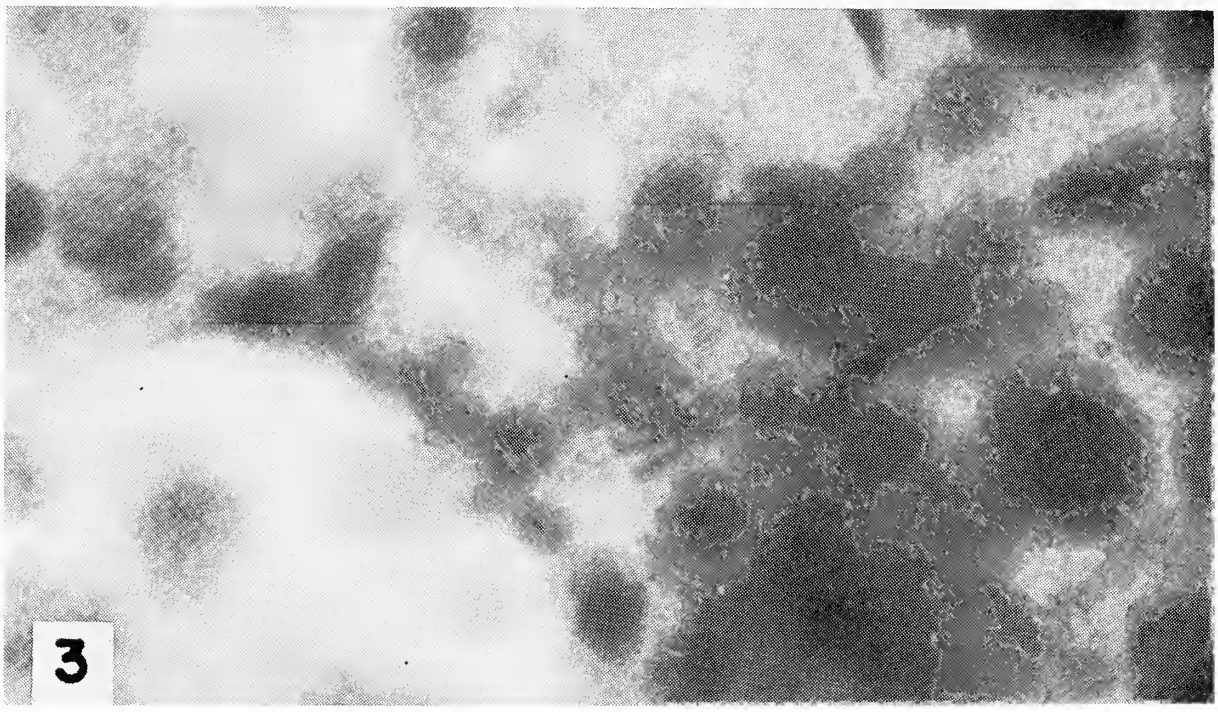

FIG. 3. Photomicrograph of portion of gastric ceca of 17-hour larva showing a large epithelial cell in mitotic prophase. × 1,290.

the gastric ceca during the larval instars combine with the cells of the cardiac region and those of the anterior portion of the stomach area to form the epithelium of the anterior region of the adult midgut.

DISCUSSION

The results of this study indicate the need for revising some statements based upon earlier findings. Berger (1938) reported that the cells comprising the epithelial lining of the larval mosquito midgut (the "primordial" epithelial cells) never undergo mitotic division but rather only increase in size during larval life. The basal cells were thought to function primarily as replacement cells for the worn-out epithelial cells in the larval midgut. But the findings here presented show that the early first-instar midgut contains only muscle cells and primordial epithelial cells and that very few of the basal cells function as replacement cells in the larval instars. Therefore, it seems that some of the primordial epithelial cells in the young larva become potential basal or regenerative cells soon after hatching. Once larval feeding and growth begin, these potential basal cells cease functioning as epithelial cells, undergo mitotic division, and become basal cells. In the process of this transformation, their places in the epithelial layer are taken by the nearby primordial epithelial cells which do not divide, but rather enlarge to fill the space left in the epithelial lining. Thus, some of the primordial epithelial cells do undergo division, but only during the early hours of larval life. The factor determining the time of transformation from primordial epithelial cells to potential basal cells is not known.

Since so few of the basal cells in the larval midgut function as replacement

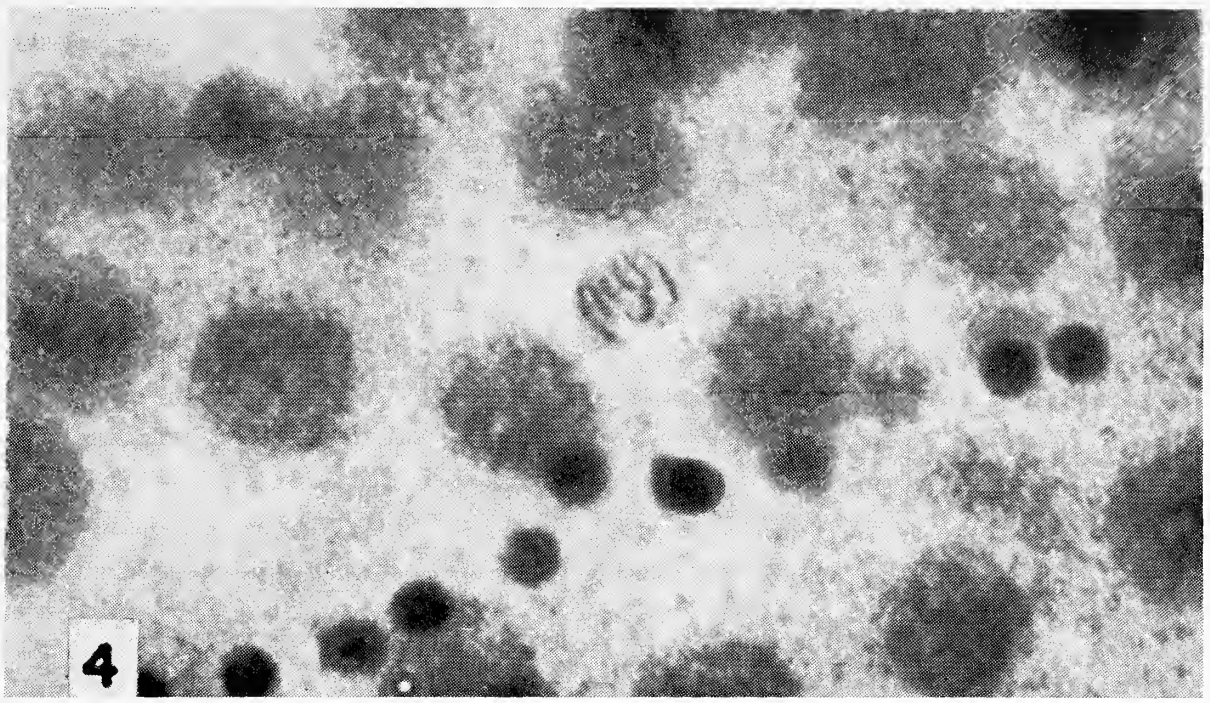

Fig. 4. Photomicrograph of portion of stomach area of 24-hour larva showing a basal cell in mitotic prophase. × 1,290.

cells in the epithelial coat, the main role of these cells must be to form the epithelial lining of the imaginal midgut. Therefore, the formation of the adult midgut does not take place principally in the pupa. Both the muscular coat for the midgut, basically that present in the prepupa (O'Brien, 1965), and the epithelial lining of the imaginal midgut, derived from the basal cells of the larval midgut, have been steadily developing throughout the larval stages.

SUMMARY

Regenerative or basal cells in the larval midgut of *A. aegypti* first appear about 9 hours after hatching.

The basal cells generally take no part in forming the epithelial lining of the larval midgut.

After their appearance in the early larval midgut, the basal cells undergo frequent mitotic divisions, resulting in the presence of a large number of basal cells in the prepupa.

Early in the pupal stage, the primordial epithelial cells of the larval midgut are sloughed off into the midgut lumen and the basal cells remain to form the epithelial lining of the imaginal midgut.

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BOOK REVIEWS

TWO BOOKS FOR YOUNG NATURALISTS

Monarch Butterflies. Alice L. Hopf. Illustrated by Peter Burchard. Thomas Y. Crowell Company, 1965, 135 pp., price $3.75.

Fireflies in Nature and the Laboratory. Lynn and Gray Poole. Illustrated by Christine Sapieha. Thomas Y. Crowell Company, 1965, 149 pp., price $3.95.

These two little books are valuable additions to the young naturalist's library. Mrs. Hopf's book will have greater appeal, probably, since it is based on personal experiences and transmits the author's enthusiasm for field work and dedication to the Monarch Butterfly. The Poole book brings together a large amount of information about luminescence which might be difficult for the young person to ferret out by himself. It is of broader scope than its title implies. Both books will arouse the reader's interest in getting outdoors and "swinging a net."

Monarch Butterflies describes the work that has been done in tagging butterflies for the purpose of gathering information on flight and migration and offers practical suggestions for the young collector who would like to cooperate in this scientific study. It discusses the collecting, rearing, and photographing of Monarchs and gives detailed and practical suggestions which are applicable to many other species of insects. In touching briefly upon the studies that have been made to test the Monarch's protection against predation it shows the reader how he, too, may make observations which might be of value.

Fireflies includes a discussion of the vocabulary of luminescence and describes luminous dinoflagellates, annelid worms, molluscs, mycetophilids, bacteria, and fungi. The chapters about the early research on luminous organisms, and the various authors' accounts of them, may not hold the readers' interest, but those on recent and current work and on the methods of collecting fireflies, shipping them to scientists, and exchanging them with other young collectors for natural history specimens from their particular area will certainly elicit an enthusiastic response. The black and white illustrations are enchanting. Unfortunately the book is marred by poor editing: scientific names are sometimes italicized, sometimes not; genus names are sometimes capitalized, sometimes not; and the arachnid daddylonglegs is called an insect.

The price of these books seems high for text that is scarcely more than magazine article length. But the books are attractive; they are printed in large, clear type; and they seem to have been written not just to give information but to encourage young people to be active.

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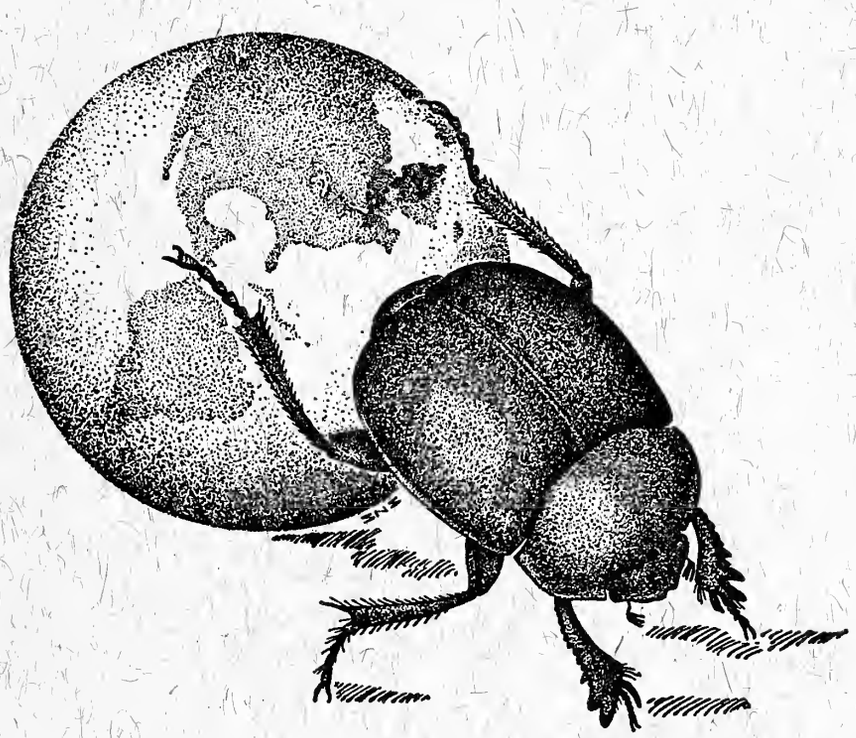

Devoted to Entomology in General

The
New York Entomological Society

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The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P.M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 79th St., & Central Park W., New York 24, N. Y.

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CONTENTS

Undescribed Species of Crane Flies From the Himalaya Mountains (Diptera: Tipulidae), XII[1]

CHARLES P. ALEXANDER
AMHERST, MASSACHUSETTS

Abstract: Six new species of the Eriopterine genera *Ormosia* and *Erioptera* are described, including *Ormosia* (*Oreophila*) **licina** n. sp., from Kashmir and Kumaon, and *Ormosia* (*Parormosia*) **atrotibialis** n. sp., *Ormosia* (*Ormosia*) **subpulchra** n. sp., and *O.* (*O.*) **umbripennis** n. sp., from Sikkim: *Erioptera* (*Ilisia*) **diadexia** n. sp. and *E.* (*I.*) **epicharis** n. sp., from Sikkim.

Part XI of this series of papers was published in the Journal of the New York Entomological Society, **73:** 163–167, 1965. The materials upon which the new species are based were collected by Dr. Fernand Schmid, of Ottawa, to whom I express my deepest appreciation for this outstanding series of Asiatic Tipulidae.

Doctor Schmid collected insect specimens in India and adjoining countries between 1953 and 1961 as a member of the Swiss Zoological Expedition. His insect collections were restricted to certain groups, where they proved to be of paramount importance in making known the exceedingly rich fauna of the region. A summary of the stations visited, as they pertain to the crane flies, is given in a paper by the writer (Philippine Jour. Sci., 90: 163; 1961), covering the period between 1953 and 1960. Between February and October, 1961, still further collections were made by Doctor Schmid in the Kameng Frontier Division of the North East Frontier Agency (NEFA), Assam.

In the crane fly materials several hundred new species were included that have been discussed and presently are being described in a long series of papers that are summarized herewith in order to assist other students of the subject:

Philippine Jour. Sci. (chiefly Tipulinae and Limoniini)
Ann. and Mag. Nat. Hist. (London) (chiefly Tipulinae and Eriopterini)
Proc. Royal Ent. Soc. London (Pediciini)
Trans. Royal Ent. Soc. London (Hexatomini; *Phyllolabis*)
Bull. Brooklyn Ent. Soc. (Tanyderidae, Ptychopteridae, Trichoceridae)
Jour. N. Y. Ent. Soc. (chiefly Eriopterini)
Ent. News (Hexatomini)
Trans. Amer. Ent. Soc. (Eriopterini)

Ormosia (*Oreophila*) **licina** n. sp.

General coloration of mesonotum light brown, sparsely pruinose, pleura yellow; antennae moderately long; wings yellowed, very restrictedly patterned with pale brown, vein *2nd A* sinuous; male hypopygium with the outer dististyle black, coarsely spinulose; lateral margins of gonapophyses produced into two or three acute points.

[1] Contribution from the Entomological Laboratory, University of Massachusetts.

MALE: Length about 4.8–5 mm; wing 5.8–6 mm; antenna about 1.5–1.6 mm.
FEMALE: Length about 5 mm; wing 6 mm.

Rostrum light yellow; palpi pale brown. Antennae of male moderately long, scape obscure yellow, the remainder black; flagellar segments oval to long-oval, shorter than their verticils. Head light gray.

Thorax light brown, sparsely pruinose, pronotum more yellowed, pretergites clear yellow. Pleura and lateral prescutal borders light yellow. Halteres yellow. Legs with coxae and trochanters yellow; remainder of legs yellowish brown, femora more yellowed basally, tarsi brownish black. Wings yellowed, very restrictedly patterned with pale brown, including the stigma, cord, outer end of cell *1st* M_2, and small spots at Sc_2 and origin of *Rs*. Venation: Sc_1 ending nearly opposite the fork of R_{2+3+4}, Sc_2 far retracted, about opposite one-third to two-fifths *Rs*; vein R_2 close to fork of R_{2+3+4}; cell *1st* M_2 elongate, subequal to distal section of M_{1+2}; vein *2nd A* sinuous. One wing of the holotype has cell M_2 open by atrophy of the basal section of M_3.

Abdominal tergites brown, basal sternites paler. Male hypopygium with the dististyles slightly subterminal, broadly united basally; outer style blackened, relatively short and stout, the outer half with numerous strong spinules; inner style pale, relatively short, the outer margin with a strong lobe before midlength. Phallosome with lateral margins of outer apophyses produced into two or three acute points; aedeagus short, black.

HOLOTYPE ♂, Dakwani, Pauri Garhwal, Kumaon, 9,300–11,000 feet, August 5, 1958 (Schmid). Allotopotype, ♀, pinned with type. Paratypes, ♂ ♀, Gangrea, Pauri Garhwal, 7,500–10,000 feet, June 12, 1958; 1 ♂, Tales, Kashmir, August 13, 1954 (Schmid).

Ormosia (*Oreophila*) **licina** is most similar to *O.* (*O.*) *hutchinsonae* Alexander, which differs in the coloration, venation, as the short straight vein *2nd A*, and in the structure of the hypopygium, especially the phallosome and the elongate dististyle.

Ormosia (*Parormosia*) **atrotibialis** n. sp.

Generally similar and closely allied to *Ormosia* (*Parormosia*) *leucoplagia* Alexander, differing in the coloration of the legs in the male.

MALE: Length about 4.5–5 mm; wing 5.2–5.6 mm.
FEMALE: Length about 5 mm; wing 5.8 mm.

Antennae light yellow, in cases with the intermediate flagellar segments bicolored, their bases narrowly dark brown, the outer two-thirds to three-fourths yellow. Mesonotal prescutum obscure yellow with a more or less distinct capillary brownish black median line; scutum brown, scutellum and postnotum darker. Legs black in both sexes, the tips of the femora narrowly yellow, including about the outer tenth of segment, extreme tibial bases more narrowly yellowed. In *leucoplagia* the tibiae and basitarsi of male yellow, of the female black, as in the present fly.

HOLOTYPE ♂, Lachen, Sikkim, 8,900 feet, June 13, 1959 (Schmid). Allotopotype, ♀. Paratopotypes, 4 ♂ ♀; paratypes, 1 ♂, 2 ♀ ♀, Lachung Sikkim, 8,610 feet, July 2, 1959 (Schmid).

Ormosia (*Ormosia*) **subpulchra** n. sp.

Allied to *puchra*; general coloration of thorax gray, prescutum with a broad brown

central stripe, humeral region yellowed; femora yellow with two subequal broad brownish black rings, the outer one nearly apical; wings whitened, with conspicuous pale brown clouds; male hypopygium with both dististyles extended into acute blackened points; gonapophyses appearing as a massive black triangular head, its outer margin with three strong spines.

MALE: Length about 4.5 mm; wing 5.3 mm.

Head broken. Pronotal scutum dark brownish gray, scutellum testaceous yellow. Mesonotal prescutum gray, with a broad brown central stripe that is narrowly darker medially; humeral region, including the pseudosutural foveae, yellow, tuberculate pits very reduced; posterior sclerites of notum dark brown, sparsely pruinose. Pleura dark gray, the yellow setae of the posterior pteropleurite very long. Halteres broken. Legs with coxae dark brown; trochanters obscure yellow; femora yellow, each with two subequal broad brownish black rings that are about equal to the pale base or intervening interspace, the tip narrowly yellow; remainder of legs light brown. Wings with the ground color whitened, with conspicuous pale brown clouds chiefly in the outer three-fourths, stigma darker; whitened marginal spots in cells R_2, R_3, and R_4, less evident in cells R_5 and *2nd* M_2, larger in cells M_3, *Cu* and the anals; cells basad of cord more extensively whitened; veins brown, prearcular field and *Sc*, *R*, and *Cu* more yellowed. Venation: R_2 at fork of R_{2+3+4}; cell *2nd* M_2 square at base; vein *2nd A* strongly sinuous, close to border on outer end.

Abdomen, including hypopygium, brownish black. Male hypopygium with apical end of tergite short and broad, the lobes low. Both dististyles extended into acute blackened points. Gonapophysis appearing as a massive blackened triangular head, the basal stem relatively slender, outer margin with three strong spines, with a further series of about four microscopic denticles on lower margin near the stem.

HOLOTYPE a broken ♂, mounted on microscope slide, Zema, Sikkim, 9,100 feet, June 14, 1959 (Schmid).

Ormosia (*Ormosia*) **subpulchra** is related to *O.* (*O.*) *kashmiri* Alexander and *O.* (*O.*) *pulchra* (Brunetti), all three species differing among themselves chiefly in important characters of the male hypopygium.

Ormosia (*Ormosia*) **umbripennis** n. sp.

General coloration of head and thorax brownish black; palpi, antennae, halteres, and legs black; wings strongly infuscated; Sc_2 beyond midlength of *Rs*, cell *1st* M_2 shorter than vein M_4, vein *2nd A* gently sinuous.

FEMALE: Length about 6 mm; wing 6.5 mm; antenna about 1.6 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments long-oval, with dense white setae, the verticils longer than the segments. Head brownish black.

Thorax uniformly very dark brown to brownish black, the surface of mesonotum subnitidous; prescutum and scutellum with a few long setae. Halteres brownish black, base of stem obscure yellow. Legs black. Wings strongly infuscated, especially the prearcular and costal fields and the stigma; veins brown. Venation: Sc_1 ending opposite the oblique R_2, Sc_2 moderately retracted, about opposite three-fifths the long *Rs*; R_{2+3+4} shorter than basal section of R_5; cell *1st* M_2 shorter than vein M_4; *m-cu* at fork of *M*, perpendicular and slightly sinuous; vein *2nd A* gently wavy.

Abdomen brown, the outer segments more blackened. Ovipositor with cerci horn yellow, long and slender, gently upcurved to the acute tips.

HOLOTYPE ♀, Namnasa, Sikkim, 10,000 feet, July 1, 1959 (Schmid).

The only other generally similar regional species is *Ormosia* (*Ormosia*) *nyctopoda* Alexander, of Pakistan, which similarly has the legs black but with the wings pale and having the venational details distinct.

Erioptera (*Ilisia*) **diadexia** n. sp.

Allied to *asymmetrica*; general coloration of thorax gray, the prescutum with two diffuse brown stripes; antennae black; femora brownish yellow, tips brownish black; wings brownish yellow, conspicuously patterned with brown spots and dots, the latter on all veins excepting *Sc* and *Cu*; male hypopygium with the outer dististyle bilobed, inner style broad, yellow, and the tip very obtuse; gonapophyses with the two arms virtually identical, appearing as straight blackened rods, the tip microscopically toothed.

MALE: Length about 5–6.5 mm; wing 5.8–8 mm.

Rostrum gray, palpi black. Antennae relatively long, black; flagellar segments long-oval to fusiform, basal segments with long verticils, all with further dense pale setulae. Head brownish gray.

Prothorax brownish gray; anterior pretergites obscure yellow. Mesonotal prescutum brownish gray, the interspaces more infuscated to form two diffuse stripes; posterior sclerites of notum brownish gray, central area of scutum narrowly brown. Pleura brownish gray. Halteres with stem yellow, knob weakly infuscated. Legs with coxae brownish gray; trochanters brownish yellow; femoral and tibiae brownish yellow, tips brownish black, the tibiae slightly enlarged and darkened beyond bases; basitarsi light brown, remainder of tarsi black. Wings brownish yellow, conspicuously patterned with brown spots and dots, the former including about five costal areas, the second over Sc_2, the third largest, over tip of Sc_1 and R_2, fourth area at tip of R_{1+2}; smaller marginal spots at ends of all longitudinal veins; narrow brown seams over cord, *m*, arculus, and at near midlength of Cu_1; paler brown spots on all longitudinal veins excepting *Sc* and *Cu*, those basad of cord paler; veins yellow in the ground areas, brown in the patterned markings. Venation: R_{2+3+4} about twice R_{2+3}, R_{1+2} nearly as long as *Rs*; *m-cu* far before fork of *M*; vein *2nd A* straight.

Abdomen brownish black. Male hypopygium with inner apical angle of basistyle produced, with very long setae. Dististyles subterminal, the outer style blackened, bilobed, the outer lobe a slender paddlelike blade, its tip obtuse, outer end with delicate setae, inner arm a shorter blade that is dilated outwardly, apex broadly obtuse to truncate; inner style pale, broadly flattened, apex very obtuse to bluntly triangular, surface with long yellow setae. Gonapophysis with the two arms virtually identical in length and diameter, appearing as straight blackened rods, the tips microscopically toothed.

HOLOTYPE ♂, Chachu, Sikkim, 11,500 feet, June 29, 1959 (Schmid). Paratype, ♂, Darkot, Kashmir, 8,900 feet, August 17, 1954 (Schmid).

The most similar described regional species is *Erioptera* (*Ilisia*) *fausta* Alexander, which is generally similar in coloration of the body and wings, differing most evidently in the hypopygial structure, including the trilobed outer dististyle, slender arcuated inner style, and the unequal arms of the gonapophysis. The paratype from Kashmir is much smaller (the smallest measurements given) but the hypopygium is so similar to that of the type that I regard it as being conspecific.

Erioptera (*Ilisia*) **epicharis** n. sp.

Allied to *asymmetrica*; general coloration of thorax brownish gray, the prescutum faintly patterned with darker; halteres yellow; femora darkened, tips brownish black, preceded by a yellow ring; wings whitish yellow with a conspicuous brown pattern, including large costal darkenings and paler brown areas in the anal field, the discal areas restricted; male hypopygium with the outer dististyle trilobed, the inner oval blade with a blackened spur at base, inner dististyle extended into a point at apex; gonapophysis unequally bifid.

MALE: Length about 6.5 mm; wing 7.5 mm.

FEMALE: Length about 6.5 mm; wing 8 mm.

Rostrum brownish gray; palpi black. Antennae relatively long, brownish black, the bases of proximal flagellar segments narrowly paler; segments elongate, a little shorter than the verticils. Head brownish gray.

Pronotum brownish gray, scutum darker laterally, sides of scutellum yellow. Mesonotum brownish gray, the prescutum with a poorly indicated pale brown stripe, narrowly darkened in front and on the sides behind; pseudosutural foveae and tuberculate pits black, shiny. Pleura gray. Halteres pale yellow. Legs with coxae and trochanters pale brown; femora light brown to brownish black, tips broadly brownish black, preceded by a broad yellow ring; tibiae and tarsi pale brown. Wings very pale whitish yellow, clearer yellow in the costal interspaces; a conspicuous brown pattern that is chiefly marginal in distribution, including six darker costal areas that are more extensive than the interspaces, the larger markings at origin of *Rs* and over tip of Sc_1, the last area at the wing tip; cubital and anal fields with comparable large paler brown markings, most extensive in the anal cells, small brown marginal spots on veins M_2 through M_4 narrow darker brown seams over cord, outer end of cell *1st* M_2, and isolated at near midlength of vein *Cu*, with small dots along vein R_5; veins light yellow in the ground, dark brown in the patterned areas, in cases including series of four or five dashes. Venation: Sc_1 ending shortly beyond R_2; *m* transverse, about one-third to one-half the basal section of M_3; *m-cu* before fork of *M*; vein *2nd A* nearly straight.

Abdomen dark brown, including the hypopygium. Ovipositor with valves light horn yellow. Male hypopygium with posterior border of tergite nearly truncate, at midregion with two small paired darkened lobes, separated by a tiny V-shaped emargination, densely set with microscopic spicules. Apex of basistyle produced beyond insertion of the dististyles. Outer dististyle trilobed, the outer blade longer, pale yellow, with abundant very delicate pale setae, those at apex longer; inner arm including an oval to subcircular darkened blade with a blackened spur at its base; inner style yellow, the lower apical angle produced into a point, surface with pale setae, some of the outer ones very long. Phallosome including bifid gonapophyses, the lateral arm an erect blackened rod, its margin nearly smooth in the holotype, microscopically roughened in the Kumaon paratype; inner arm much smaller, at apex dilated into a triangular head; aedeagus appearing as two short slightly divergent spines.

HOLOTYPE ♂, Yagtang, Sikkim, in *Rhododendron* association, 11,200 feet, May 28, 1959 (Schmid). Allotopotype, ♀. Paratopotype, ♀, with the types, 11,600 feet, June 17, 1959; paratypes, ♂ ♀, Chachu, Sikkim, 11,500 feet, June 29, 1959; Chamiteng, Sikkim, 9,900 feet, August 24, 1959; Gey, Sikkim, in *Rhododendron* association, May 18, 1959; Lachung, 8,610 feet, July 10, 1959; Namnasa, Sikkim, 9,500 feet, July 13, 1959; Talam, Sikkim, in *Rhododendron* association, 11,300 feet, June 16, 1959; Tsomgo, Sikkim, in *Rhododendron* association,

12,500 feet, August 26, 1959; Dakwani, Pauri Garhwal, Kumaon, 9,300–11,000 feet, August 5, 1959; Kanol, Pauri Garhwal, 8,530 feet, August 19, 1958; Kulara, Pauri Garhwal, 12,000 feet, August 4, 1958 (Schmid).

Erioptera (*Ilisia*) **epicharis** is quite distinct from the other known regional species of the subgenus, including *E.* (*I.*) *asymmetrica* Alexander (*indica* Senior-White), *E.* (*I.*) **diadexia** n. sp., and *E.* (*I.*) *fausta* Alexander, especially in the wing pattern and hypopygial structure. One male paratype from Tsomgo is smaller (length about 5 mm; wing 5.2 mm) and has the femora almost uniformly darkened but from the wing pattern and hypopygium evidently pertains to this species.

Received for Publication October 7, 1965

Notes on the Biology of *Stelis* (*Odontostelis*) *bilineolata* (Spinola), a Parasite of *Euglossa cordata* (Linnaeus) (Hymenoptera: Apoidea: Megachilidae)

FREDERICK D. BENNETT[1]

Abstract: The activities of the parasitic bee *Stelis* (*Odontostelis*) *bilineolata* (Spinola) in specially constructed box nests of its host *Euglossa cordata* (Linnaeus) are reported. The female enters the nest, forces the attendant *Euglossa* female to abandon the nest, and remains in the nest for several days. She opens those cells containing eggs or small larvae, seals, removes, and destroys them and after depositing her own egg reseals the cell. Cells with older stages of *Euglossa* are not opened but the larva or pupa contained therein is killed. Feeding behavior of the small and large larvae and construction of the cocoon are described.

During studies on the biology of *Euglossa* spp. in Trinidad some of the observation nests were invaded by the parasitic bee *Stelis* (*Odontostelis*) *bilineolata* (Spinola). It is planned to publish the results of the *Euglossa* studies separately when they are completed but it seems advisable at this time to publish a note on the activities of its parasite as a companion paper to one on the morphology of the immature stages by Rozen (1966).

NESTING HABITS OF *Euglossa cordata*

To explain the behavior of *S. bilineolata* it is necessary to describe briefly the nesting habits of *Euglossa*. Two species of this genus, *E. cordata* and *E. variabilis* (Friese),[2] which are solitary species, have been induced to nest in small wooden boxes (inside dimensions $10 \times 6 \times 4.5$ cm) with a 10-mm circular entrance hole on one side. Once a nest is occupied and cell construction started the wooden top can be replaced by a pane of glass through which activities within the nest can be readily observed.

The bee cements the glass lid to the wood with a brown resinlike plant material which is used to seal all cracks and joints on the inside of the box and also to close the entrance hole. When leaving the nest the female opens a smaller circular hole in the resin just large enough for passage. She never closes the entrance when leaving the nest, even when leaving for the last time, but always seals it in the evening and frequently during the day while working inside. Cells of the same resinlike material are constructed either on the floor of the box or on the side, usually each cell being provisioned and sealed before another is started.

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[1] Entomologist-in-Charge, W. I. Station, Commonwealth Institute of Biological Control, Curepe, Trinidad, West Indies.

[2] Although all observations were in nests of *E. cordata* the parasite has also been reared from nests of *E. variabilis*.

Observations on the behavior of *Stelis*

When a *Stelis* adult was first noted in observation box No. 3[3] on July 12, 1964 neither its identity nor the significance of its presence was immediately appreciated. This nest which had been first occupied by *Euglossa* in April contained nine cells, some with immature stages, others from which adults had emerged, and a tenth cell only partially constructed and partially provisioned. Work on this cell stopped about July 4. It is probable that the bee was attacked by a conopid and, although still capable of flight, her ovaries had ceased to function. She was present in the nest with the intruder and on the bottom of the box there was also a small *Euglossa* larva. The *Stelis* frequently approached and nudged the *Euglossa* female with her mandibles; the latter kept turning away and finally retreated to a corner of the box. During the next 20 minutes the *Stelis* female spent most of the time examining the cell mass.

At 6:45 A.M. the following morning both adults were in the nest, the *Euglossa* in a corner and the *Stelis* on the cell mass. By 7:45 A.M. the *Euglossa* went out and the *Stelis* began to close the entrance from the inside. The larva on the floor was dead and partially covered with wax.

The box was examined from time to time on succeeding days and the presence or absence of the two bees noted. This information is summarized in Table 1. Although the *Stelis* female was frequently on the cell mass she did not open any of the cells during the periods of observation. The walls of two cells from which *Euglossa* adults had emerged a few days earlier were partially broken down by the *Euglossa* while the *Stelis* was either resting on the the side of the box or absent from the nest.

No further activity occurred in this nest when (due to my absence from Trinidad) observations were suspended on October 3. When I next examined the nest on December 6 a *Stelis* adult had emerged from one cell. The other cells when opened later contained dead pupae and mature larvae of *Euglossa*.

When observations on the box nests were continued in December it was evident that a number of other nests had been attacked, i.e., sealed cells present, no attendant *Euglossa* adult but the entrance sealed. This was confirmed later when *Stelis* adults emerged from one or more cells in these boxes.

On December 6, nest 12, which was started on September 30 but still retained its wooden cover, contained a dead *Euglossa* adult (parasitized by a conopid); a *Stelis* adult; three sealed cells with somewhat flattened walls, and a fourth partially completed cell. When examined on December 8 the *Stelis* was absent (an adult, possibly the same one, was present in nest 13) but was in again on December 9 and 10. On December 11 the wooden top was replaced by a sheet of glass and by December 12 the *Stelis* utilizing bits of resin present in the box had sealed the glass in place in a manner similar to *Euglossa*. Although out

[3] The boxes were numbered serially as they were occupied by *Euglossa*.

TABLE 1. Records of the presence of *Euglossa* and *Stelis* in the nest during periods of observation.

Date and time of observation		*Euglossa*	*Stelis*	Entrance hole
July 12	7:30 A.M.	In	In	Closed
July 13	6:45 "	"	"	"
	7:45 "	Out	"	Being closed
	12:10 P.M.	In	Out	Closed
	1:20 "	"	In	"
	5:45 "	"	"	"
July 14	7:20 A.M.	"	"	"
	1:05 P.M.	"	"	"
	4:05 "	"	"	"
July 15	7:30 A.M.	"	"	Open
	5:15 P.M.	"	"	Closed
July 16	7:45 A.M.	"	"	"
	12:15 P.M.	"	Out	"
	5:05 "	"	"	"
July 17	7:30 A.M.	"	"	"
	11:45 "	Out	Out	"
	12:45 P.M.	"	"	"
	4:45 "	"	"	"
July 19	7:45 A.M.	"	"	"
	2:45 P.M.	Out[1]	In	"
	3:20 "	"	Out[2]	"
July 20	10:45 A.M.	In	"	"
	1:30 P.M.	Out	In	"
	4:45 "	"	"	"
July 21	7:50 A.M.	Out[3]	"	"
	1:40 P.M.	Out	Out[4]	"

[1] The *Euglossa* female, readily recognized by markings of enamel paint coding, was in a nearby nest abandoned a few days earlier by another female.

[2] The *Stelis* completing the closing of the entrance from the outside.

[3] Observed in an adjacent nest.

[4] Sealing the nest from the outside.

of the nest at 11:40 A.M. on the 12th (an adult was in nest 6 at this time) she returned on October 13 but was not seen thereafter. A week later the entrance of the nest was corked and on February 4 a *Stelis* adult emerged. The other two cells when opened later contained immature dead *Euglossa* pupae. As far as could be determined the cells had not beeen opened and the death of the occupants was apparently attributable to the actions of *Stelis,* i.e., killed either by mandibular crushing of the cell walls or by stinging.

Although a *Stelis* female was noted in a few other nests no further observations of consequence were made until January 24, when a female was observed in nest 9. First occupied by *Euglossa* in August, activity in this nest was suspended three times by the action of conopids: the original female, a succeeding daughter, and finally a parasitized granddaughter that died in the nest. The progeny of the last female emerged between December 9, 1964 and January 3, 1965. A

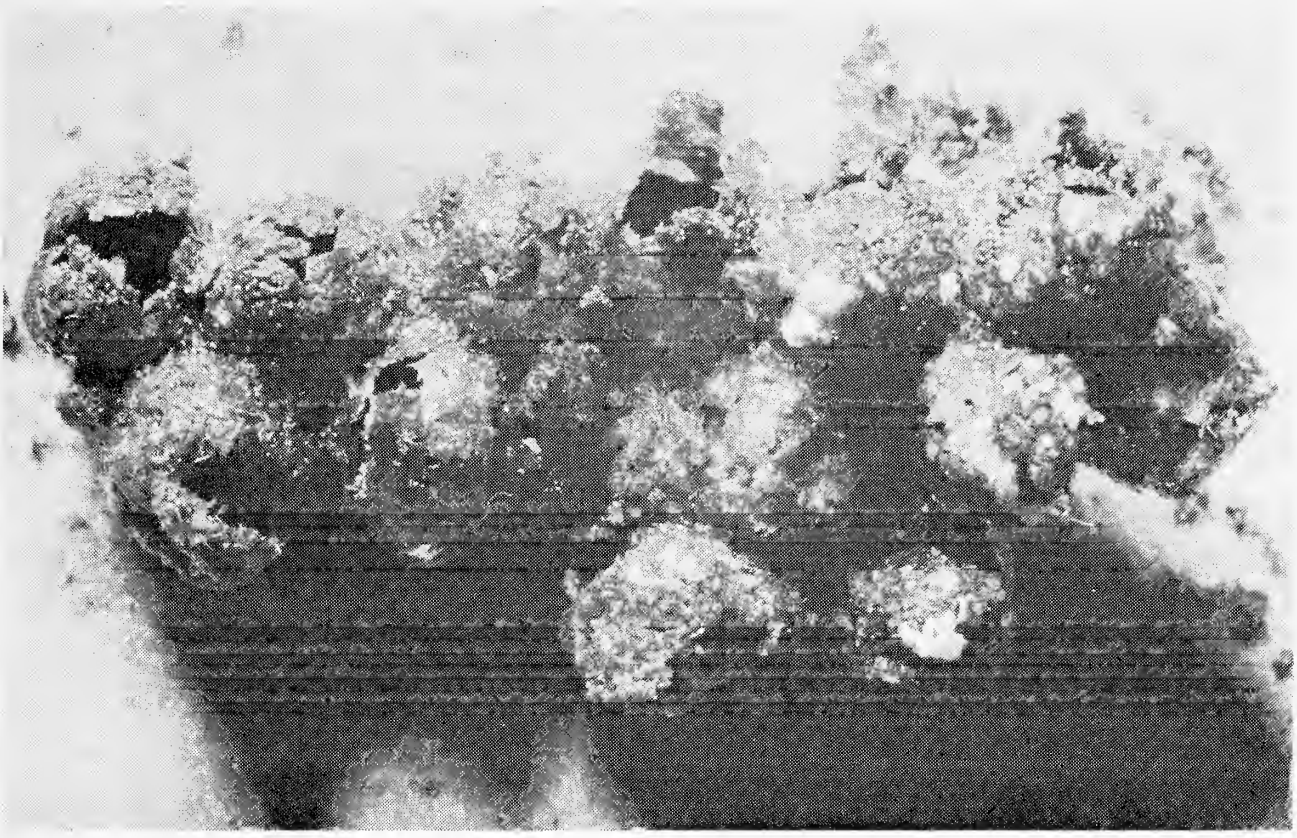

Fig. 1. Nest 9 of *Euglossa cordata* viewed from top. (Cells were opened for observations.) (Photo by J. Rozen.)

female emerging on December 26 remained in the nest. She reconditioned, provisioned, and sealed her first cell on December 31. By January 24 she had provisioned and sealed 12 cells and partially provisioned another when the nest was invaded by *Stelis* on the following day. When examined at 12:35 P.M. the *Euglossa* and a *Stelis* female were in the nest and the entrance closed. During the next 20 minutes the *Stelis* chased and grabbed the *Euglossa* in her mandibles and attempted to sting her on three occasions; each time the *Euglossa* broke free and retreated to a corner of the box. At 12:55 P.M. the *Euglossa* attempted to escape from the nest but before she could open the entrance was chased away by the *Stelis*. The *Stelis* then spent several minutes resealing the entrance. Further pursuit with repeated capture and apparent stinging occurred until finally at 1:09 P.M. the *Euglossa* managed to open the entrance and escape. Less than a minute later the *Stelis* was reclosing the opening. She then explored the walls of the box and approached the cell mass. When observations were resumed at 1:25 P.M., *Stelis* was opening the top of a cell which had been sealed 8 days earlier. By 1:30 P.M. the hole was enlarged enough to permit insertion of her head. She grasped the *Euglossa* larva contained therein (less than one-third grown), tugged it out of the cell, carried it to the front of the box, and dropped it on the floor. After biting and stinging it several times she returned to the cell, inspected it for a few seconds and for several minutes wandered about the box encountering and stinging the larva a number of

TABLE 2. Record of oviposition by *Euglossa* and *Stelis* female in nest 9.

Cell number	Date egg deposited by *Euglossa*	(a) Date egg deposited by *Odontostelis* (b) Contents of cell when opened on February 4
10	December 31	b Dead pupa (E)[1]
11	January 5	b Postdefecating larva (E)
12	" 7	b Prepupa (alive) (E)
13	" 10	b Postdefecating larva (E)
14	" 11	b " " " (E)
15	" 13	b Predefecating larva (E)
16	" 14	b Defecating larva (E)
17	" 17	a January 26
18	" 18	a " 26[2]
19	" 20	a " 27
20	" 22	a " 28[2]
21	" 24	a " 29
22	Provisioned only	a " 28

[1] E = *Euglossa*

[2] Date arrived at by comparative size of larva when examined February 4 and 5.

times. Despite these attacks the larva was still capable of movement. When next examined at 6:20 P.M. the larva was immobile and partially covered with dark wax; the *Stelis* was motionless on the side of the box. The cell from which the larva had been removed was still open at 7:10 A.M. the following morning but was being closed at 12:15 P.M. During the morning she opened another cell (sealed 6 days earlier) and removed and destroyed the tiny larva. This cell was still unsealed in the evening but was closed by 7:15 A.M. the following day (January 27). At midday no change was noted but at 4:15 P.M. a cell sealed on January 24 was opened and the egg removed; by 7:00 P.M. it was resealed. During the night the partially provisioned cell was sealed by *Stelis*, with material obtained from the tops of other cells. Whereas the other cells when resealed by the *Stelis* were nearly identical in appearance to unopened ones, the walls of this cell were shorter but the cell top was similar in shape to the others. All of the newer cells were near one end of the cell mass. During the next few days *Stelis* added wax to their tops, some of it obtained from the older cells and some from the wax seal along the edges of the box. No other cells were open during periodic inspection over the next several days. The female was present in the

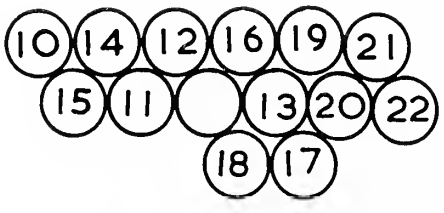

FIG. 2. Diagram of nest 9. Numbers refer to the order in which cells were provisioned by *Euglossa* female. Unnumbered cell was abandoned and capped by an earlier female. Table 2 provides pertinent data on the activities of the *Euglossa* and *Stelis* females.

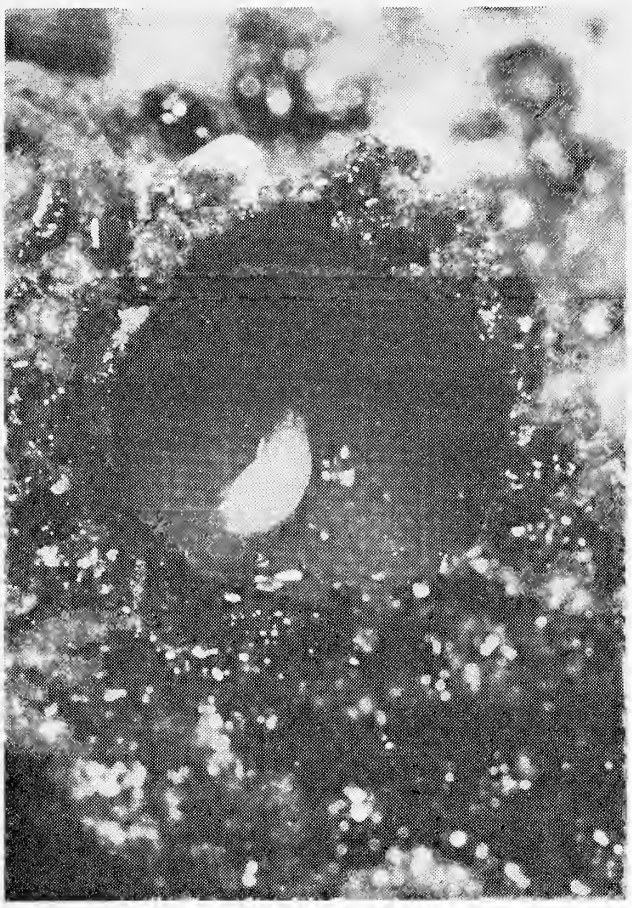

FIG. 3. First-stage larva of *Stelis bilineolata* on provision mass in cell of *Euglossa cordata*. (Photo by J. Rozen.)

FIG. 4. Cocoon of *Stelis bilineolata*. (Photo by J. Rozen.)

box every morning and evening but was out at midday on January 28, 29, and February 1, returning before 1:15 P.M. each day. She was removed from the nest on February 4 when the cells were opened for observation of the feeding habits of the larvae.

Seven cells when opened contained fully fed larvae, prepupae, and pupae of *Euglossa*; all were dead except one prepupa (Table 2 and Figs. 1 and 2). Each of the other six, including the one which had not been completed by *Euglossa*, contained a single developing larva of *Stelis*.

DEVELOPMENT OF THE IMMATURE STAGES OF *Stelis*

The number of observations are inadequate for specific information on the duration of all of the immature stages. The egg which is laid on top of the cell provisions hatches 3 to 4 days after deposition; larval feeding is completed in 9 to 12 days; construction of the cocoon which commences shortly thereafter requires at least 3 days. The duration of the postfeeding larval and pupal stages was not recorded but the period from oviposition to adult emergence is approximately 60 days, i.e., about 7 to 10 days longer than that for *Euglossa*.

The feeding activities of larvae of varying ages were observed. The small

first-stage larva (Fig. 3) appears to be almost sedentary, moving only slightly on the surface of the viscous pollen–nectar mass. The body is only slightly curved dorsoventrally with its ventral surface in contact with the food. Half-grown and larger larvae lie on their backs while feeding, i.e., the dorsal part of the head and succeeding segments in contact with the food and with the posterior of the body towards the top of cell.

Defecation commences at least 48 hours before the provision mass is entirely consumed. The feces are in the form of elongate pellets narrowed at either end. They are from eight to ten times as long as broad with the first pellets smaller and attached lightly to the upper cell wall. Although the pellets are usually flattened by subsequent movements of the larva, the outline of many of the individual pellets can be readily seen in old cells. The feces are deposited in a broad belt on the upper part of the cell wall, some of them adhering to the cell top or dropping to the lower part of the cell. Defecation is completed before construction of the cocoon begins.

The completed cocoon (Fig. 4) is cylindrical with rounded bottom and a top that ends in an extruding nipple. It consists of several layers. First, a number of fine silken strands attached to the cell wall and feces are formed; this is followed by a parchment-like layer which follows the inner contours of the cell except at the top. The nipple protrudes into a depression at the top of the cell, the outer silken threads being more abundant than in the main section of the cell. Although the tip of the nipple normally adheres to the cell top, it is formed even if the top of the cell is removed prior to construction of the cocoon. The outer parchment is followed by a layer of loosely packed silken threads somewhat lighter in color; a further parchment layer which is a lighter golden brown and very smooth on its inner surface completes the cocoon. The inner surface of the top of the cocoon is rounded and quite smooth with no internal indication of the nipple. The silk of the cocoon is pale, almost transparent, as it leaves the salivary opening but later darkens to a golden brown.

The emerging adult chews an irregular, somewhat circular hole through the upper wall of the cocoon and cell.

The cocoon in shape and texture is strikingly similar to that of a small unidentified Trinidadian anthidiine and has a similar nipple-like protrusion. Furthermore, defecation in this species occurs before the cocoon is completed, suggesting that these activities among the parasitic group have not changed markedly from the nonparasitic anthidiines.

DISCUSSION

Although the association of the subgenus *Odontostelis* and *Euglossa* has been known for some time (Friese, 1925), details of the activities of the *Stelis* female in the host nest, particularly the opening of cells and the removal of the *Euglossa* eggs and larvae, have not been reported previously.

The behavior in the latter nest from which the host was driven out and did not return is the more usual because in four other nests which *Stelis* invaded the *Euglossa* adult when driven out never returned. Therefore, the behavior of the bee in the first nest may be considered uncharacteristic; her actions prior to the invasion of *Stelis* suggests parasitism by a conopid. As adults attacked by this parasite usually remain in the nests this would explain her "atypical" behavior in the presence of *Stelis*.

The habit of closing the entrance when entering and leaving the hosts' nest must also be relatively rare among parasitic bees. Also the behavior of the female in the nest, leaving and returning on several successive days, indicates that *Stelis* has retained many of the habits of the nonparasitic species.

Observations indicate that the *Stelis* female without opening a cell can detect whether it is suitable for the development of its young. The dissection of unparasitized cells shows no evidence of having been opened and reclosed when found unsuitable. This is evidence that the *Stelis* female is able to kill the large larvae, pupae, and even unemerged adults either by stinging or by squeezing the cell walls because in none of the nests attacked by *Stelis* did adults of *Euglossa* emerge subsequently. Furthermore, dissection of cells which failed to emerge revealed dead large larvae, prepupae, pupae, or adults of *Euglossa*. Although one live prepupa was found when the cells of nest 9 were examined the *Stelis* had not yet abandoned the nest.

Destruction of mature larvae and pupae in cells unsuitable for the development of her own progeny represents the destruction of potential hosts for successive generations which, on the basis of present observations, appears to be an undesirable trait. However, we do not know the reaction of an emerging *Euglossa* female towards parasitized cells; it is possible that she would sense their presence and either open the cells and destroy their contents or effectively block their emergence by the addition of more wax. If either were likely to occur then the destruction of *Euglossa* pupae and mature larvae would be of definite survival value to her own progeny and to the species.

Acknowledgments

I am indebted to Prof. Pe. J. J. Moure who determined specimens of *Euglossa cordata* and *Stelis* (*Odontostelis*) *bilineolata*. The photographs were taken by Dr. Jerome G. Rozen, Jr., who also reviewed the manuscript and made many useful suggestions for its improvement.

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Received for Publication December 9, 1965.

Further Studies on the Internal Anatomy of the Meloidae (Coleoptera). II. The Digestive and Reproductive Systems of the S. A. Blister Beetle, *Picnoseus nitidipennis* Fairmaire and Germain[1] (Coleoptera: Meloidae)

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Abstract: The digestive and reproductive systems of the South American blister beetle, *Picnoseus nitidipennis,* Fairmaire and Germain has been described, and on the basis of some of the internal anatomical features, this genus has been tentatively placed in the tribe Lyttini.

This paper is a continuation of the study of internal anatomy of blister beetles of the world. In two earlier works (Gupta, 1965, 1966), digestive and reproductive systems of several species of blister beetles have been described and discussed. *P. nitidipennis*, described in this paper, was made available to the author through the courtesy of Mr. L. E. Pena, Santiago, Chile, and was determined by Dr. Antonio Martinez, Buenos Aires, Argentina.

MATERIALS AND METHODS

For details on the techniques, etc., the reader is referred to the earlier work (Gupta, 1965). It must be restated, however, that the descriptions in the present paper in general serve to supplement diagrams and point out important features. In the description of the digestive systems terms "external" and "internal" have been used for convenience of description. The drawing of the stomodaeal intima is slightly diagrammatic and should not be considered bilaterally symmetrical. In the drawings of the reproductive systems, only the organs of one side have been shown. In the drawing of the male reproductive system, the second pair of accessory glands has been stippled to distinguish it from the others, and the extent and the nature of the convolutions of the third pair are not indicated.

DESCRIPTIONS

Digestive System: EXTERNAL (Fig. 1): Esophagus much broadened posteriorly; ventriculus with anterior half lightly wrinkled transversely, remainder rather smooth; lobes of pyloric valve visible externally; six malpighian tubules

[1] Paper of the Journal Series, Agricultural Experiment Station, Rutgers–The State University, New Brunswick, New Jersey.

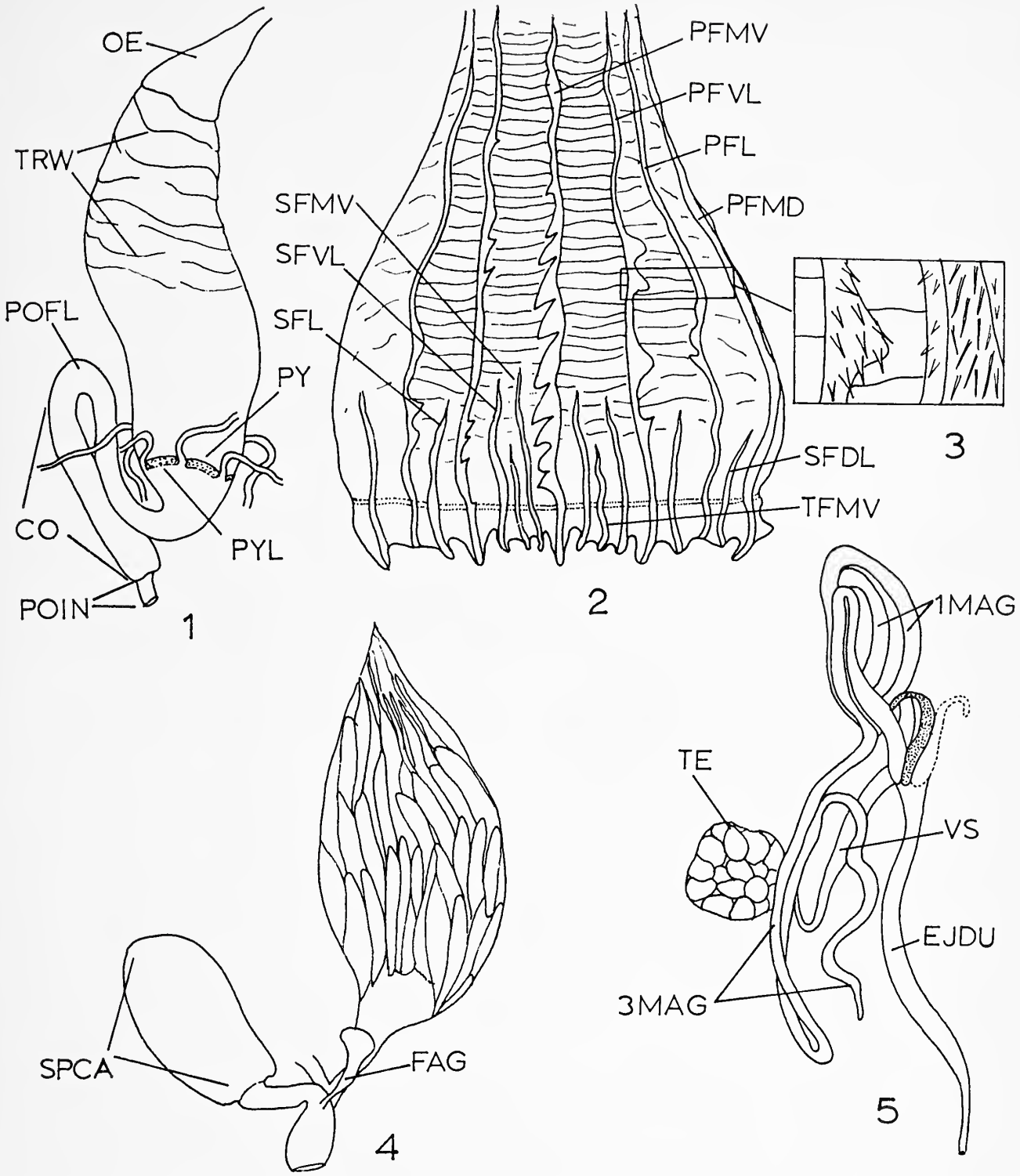

Fig. 1. Lateral view of alimentary canal; 2. Internal view of stomodaeum; 3. Portion of stomodaeal intima magnified; 4. Female reproductive system, dorsal view; 5. Male reproductive system, ventral view.

arising separately, their posterior attachment at inner bend of posterior flexure.

INTERNAL (Figs. 2 and 3): Stomodaeal intima with six primary, eight secondary, and two tertiary folds, median ventral and ventrolateral primary folds with serrate margins, transverse corrugations irregular and indistinct beyond two lateral primary folds and also in region anterior to proventriculus; serrate margins of primary folds with dense, stout spines, remainder of primary folds

and secondary and tertiary folds with long, dense spines, remainder of stomodaeal intima very rarely with minute spines; proventricular region without any distinct pattern. Stomodaeal valve with three well-developed conical primary lobes and three less-developed conical primary and eight secondary lobes, and two poorly developed tertiary lobes.

Reproductive System: FEMALE (Fig. 4): Spermathecal capsule elongate with slight basal swelling, broader and rounded distally, spermathecal duct short, accessory gland vesicular, slightly bent apically and with a short duct. MALE (Fig. 5): Testes small, spherical, vas deferens narrow near testis, vesicula seminalis rather narrow; first pair of accessory glands ovally or spherically coiled, tips of two glands in contact, second pair recurved, recurved portion shorter than basal portion, third pair largest and lightly convoluted; ejaculatory duct slightly broader beyond middle and strongly bowed.

Material Examined: Three specimens (in 10% formaldehyde), Atacama Desert, Chile, IX-22-63 (L. E. Pena).

SYSTEMATIC CONSIDERATIONS

Kaszab (1959) included *Picnoseus* in the tribe Lyttini on the basis of its wing venation. Earlier, Denier (1935) grouped *Picnoseus* with *Lytta* and Borchmann (1907) considered this genus as a subgenus of *Tetraonyx*, and included it in the tribe Lyttini. The writer (Gupta, 1965) characterized the tribe Lyttini by such internal anatomical features as a rather poorly developed stomodaeal valve, absence of V-shaped folds, and the presence of well-developed spermathecal diverticulum. Of these three characters the last one was considered to be an important tribal character. On the basis of this character, and by the presence of such features as a slight basal swelling in the spermathecal capsule and a ventrally recurved second pair of male accessory glands, inclusion of *Picnoseus* in the tribe Lyttini seems to be uncertain although it will be retained in this tribe tentatively. In the earlier work (Gupta, 1965) a basal swelling in the spermathecal capsule and a recurved second pair of male accessory glands were considered to be the tribal features of the Epicautini. However, the absence of V-shaped folds in *Picnoseus* precludes its inclusion in the Epicautini. Borchmann's (1907) consideration of *Picnoseus* as a subgenus of *Tetraonyx* is not supported by the internal anatomical features, inasmuch as *Picnoseus* lacks such tribal characters of Tetraonychini as four V-shaped folds, tubular spermathecal diverticulum, a tubular female accessory gland, and an enlarged vas deferens near testes. It seems to the author that the tribe Lyttini perhaps includes some representatives which have secondarily lost the spermathecal diverticulum (*Cabalia* and *Sybaris*). As more genera belonging to this tribe would be available for study, it would perhaps be necessary to establish two or more subtribes according to the presence or absence of spermathecal diverticulum and other features.

ABBREVIATIONS USED IN FIGURES

CO—colon
EJDU—ejaculatory duct
FAG—female accessory gland
1MAG—first pair of male accessory glands
3MAG—third pair of male accessory glands
OE—esophagus
PFL—lateral primary fold
PFMD—median dorsal primary fold
PFMV—median ventral primary fold
PFVL—ventrolateral primary fold
POFL—posterior flexure
POIN—posterior intestine or rectum
PY—pylorus
PYL—lobes of pyloric valve
SFDL—dorsolateral secondary fold
SFL—lateral secondary fold
SFMV—median ventral secondary fold
SFVL—ventrolateral secondary fold
SPCA—spermathecal capsule
TE—testis
TFMV—median ventral tertiary fold
TRCP—transverse corrugated pattern
TRW—transverse wrinkles
VS—vesicula seminalis

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Taxonomic Descriptions of the Immature Stages of the Parasitic Bee, *Stelis* (*Odontostelis*) *bilineolata* (Spinola) (Hymenoptera: Apoidea: Megachilidae)

JEROME G. ROZEN, JR.[1]

Abstract: This paper describes taxonomically the first and last larval instars and the pupa of this species. It compares the mature larva with that of other known *Stelis*, and although there is considerable intrageneric variation, the larvae of *Stelis* cannot be distinguished as a group from those of other Megachilidae. The pupa of this species agrees in most respects with those of other megachilid bees.

The purpose of this paper is to record details of the anatomy of the first and last larval instars and of the pupa of *Stelis* (*Odontostelis*) *bilineolata* (Spinola) for future taxonomic and evolutionary consideration. Although the mature larvae of a number of species of *Stelis* have been described before, this is believed to be the first account of the mature larva of the Neotropical subgenus *Odontostelis* and to be the first formal description of the pupa and first instar of any *Stelis*.[2] In an accompanying paper Bennett (1966) discusses the biology of this parasitic bee which depredates the nest of the brilliant green apid bee, *Euglossa cordata* (Linnaeus).

Acknowledgment

I would like to thank Dr. Fred D. Bennett, Entomologist-in-Charge, West Indian Station, Commonwealth Institute of Biological Control, Curepe, Trinidad, the West Indies, for the gift of specimens used in this study. Because of his energetic efforts in collecting the immature stages of Trinidadian bees, we are at long last gaining an understanding of the larvae and pupae of many Neotropical apoids.

MATURE LARVA

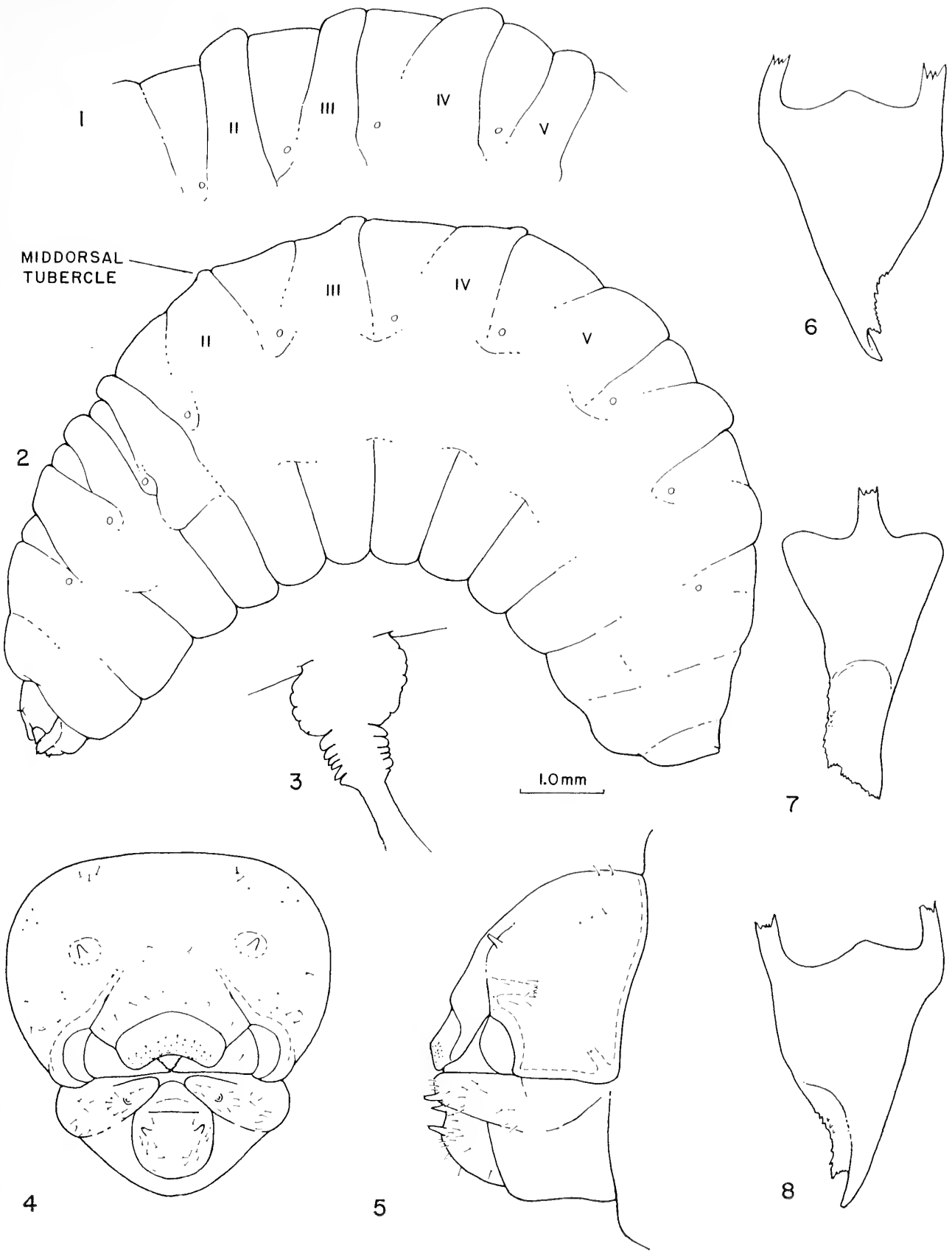
(Figs. 1–8)

LENGTH: 10.0 mm.

HEAD (Figs. 4, 5): Integument with numerous scattered long setae but without spicules except for faint ones on dorsal surface of maxilla; labrum, dorsal mandibular articulation, mandibular apex, hypostomal ridge, cardo, and stipes pigmented; prementum with narrow pigmented sclerite extending from below level of palpus dorsad and laterad of palpus above salivary lips and down other side, thereby circumscribing arc of approximately 270 degrees; antennal papillae and palpi also somewhat pigmented. Tentorium well developed except dorsal arms very short; posterior pits conspicuous and normal in position, i.e., at junctures of posterior thickening and hypostomal ridges; posterior thickening of head capsule and

[1] Chairman and Curator, Dept. Ent., Amer. Mus. Nat. Hist.

[2] The literature search for this project was accomplished with the assistance of the Bibliography of Apoid Biology which is under the direction of Dr. C. D. Michener, University of Kansas, Lawrence.



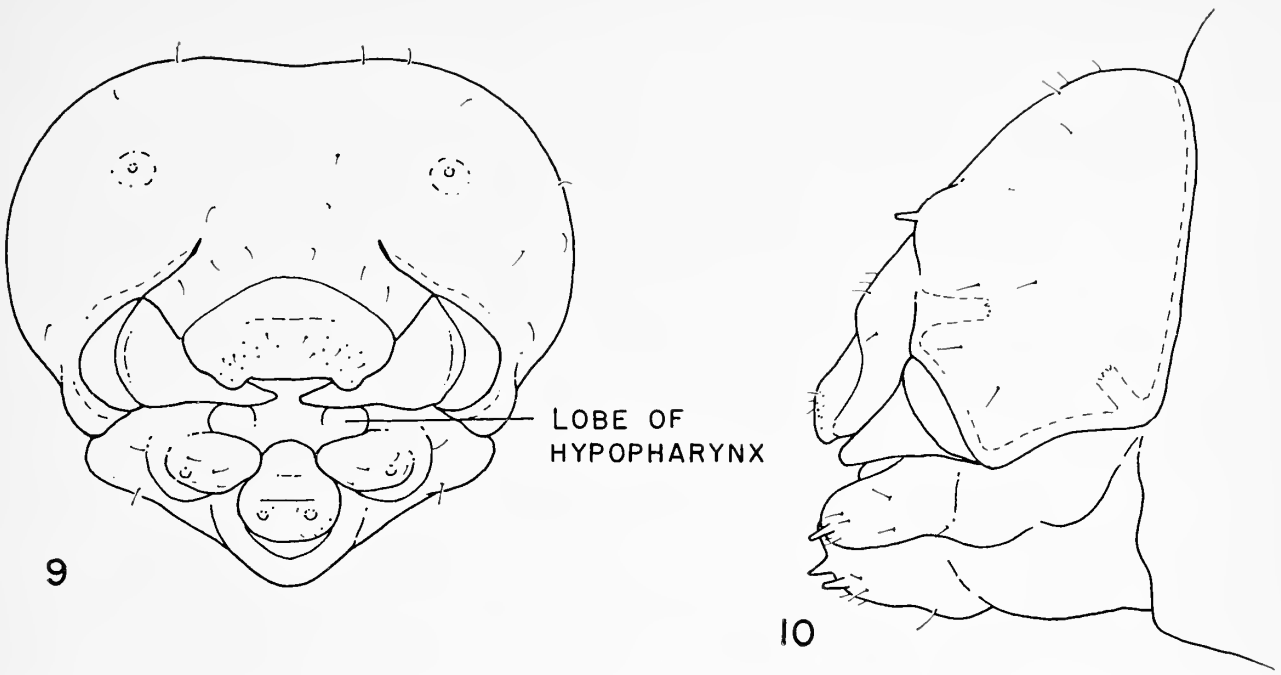
Figs. 1–8. Last larval instar of *Stelis* (*Odontostelis*) *bilineolata* (Spinola). 1. Part of abdominal dorsum, lateral view. 2. Postdefecating larva, lateral view. 3. Spiracle. 4–5. Head, frontal and lateral views. 6–8. Mandible, dorsal, adoral, and ventral views. Scale refers to Figs 1 and 2.

hypostomal ridge well developed; pleurostomal ridge moderately wide but fairly thin; epistomal ridge well developed laterad of anterior tentorial pits and extending dorsomedially short distance mesiad of pits before disappearing; longitudinal thickening of head capsule, cleavage lines, and parietal bands not evident. Antennal papilla elongate, being approximately twice as long as basal diameter; papilla arising from only very low prominence. Labral apex broadly emarginate apically and without tubercles. Mandible (Figs. 6–8) apically bidentate with ventral tooth longer; margin between teeth finely but sharply dentate; mandible with apical concavity limited basally by transverse ridge; dorsal apical inner edge finely but sharply dentate; ventral edge smooth; cusp not dentate. Maxilla with apex produced adorally; galea absent; palpus elongate, being as long as but slightly thinner than antennal papilla; cardo and stipes sclerotic. Labrum projecting, divided into prementum and postmentum, and bearing salivary opening at apex; salivary opening a transverse slit with projecting lips; labial palpi as long as maxillary palpi; hypopharynx with prominent lobe on each side next to maxilla.

BODY: Form (Fig. 2) of postdefecating larva robust and with most segments having distinct intrasegmental lines; low middorsal tubercles present on posterior margin of abdominal segments II to IV; tubercles not evident when these segments telescoped (Fig. 1); ventrolateral tubercles present but not pronounced. Integument of postdefecating form soft; dorsal surface more or less evenly covered with fine light setae (not shown in illustrations); ventral surface with setae sparser. Spiracular atrium (Fig. 3) with short dentate ridges; atrium projecting above body wall and with rim; peritreme present; primary tracheal opening with collar; subatrium moderately short. Tenth abdominal segment short; anus situated dorsally.

MATERIAL STUDIED: Two postdefecating larvae, Curepe, Trinidad, West Indies, February 10, 1965, from cells of *Euglossa cordata* (Linnaeus) (F. D. Bennett).

While preparing the preceding description, I compared in detail the larva of *bilineolata* with the mature larva of *Stelis* (*Microstelis*) *lateralis* Cresson, kindly loaned by Dr. Charles D. Michener. Drawings of the head of *lateralis* (Figs. 9, 10) are presented here to supplement those provided by Michener (1953) with his description of the last instar. The larva of *lateralis* differs from that of *bilineolata* in a number of ways: *S. lateralis* is much smaller, being only 6.0 mm long. Its head is somewhat differently shaped as seen in lateral view, and there is a strong indentation along the median line of the head capsule. The labrum is not so distinctly emarginate apically, and there are two low labral tubercles. The mandibles are remarkably different, as discussed below. The labiomaxillary region is much more strongly produced. Each maxilla is strongly constricted below the base of the mandible whereas in *bilineolata* there is no such modification. The sclerites of the prementum appear to be quite different from those of *bilineolata*; there is no dorsal sclerotic bridge above the salivary opening but the sclerites are joined ventrally behind the palpi and form a wide, faint plate occupying most of the ventral surface of the prementum. The prementum in frontal view is narrower, and the two lobes of the hypopharynx are more pronounced. The middorsal tubercles (Michener, 1953, fig. 114) of the body are more conspicuous and the body setae less numerous. The spiracle (Michener,



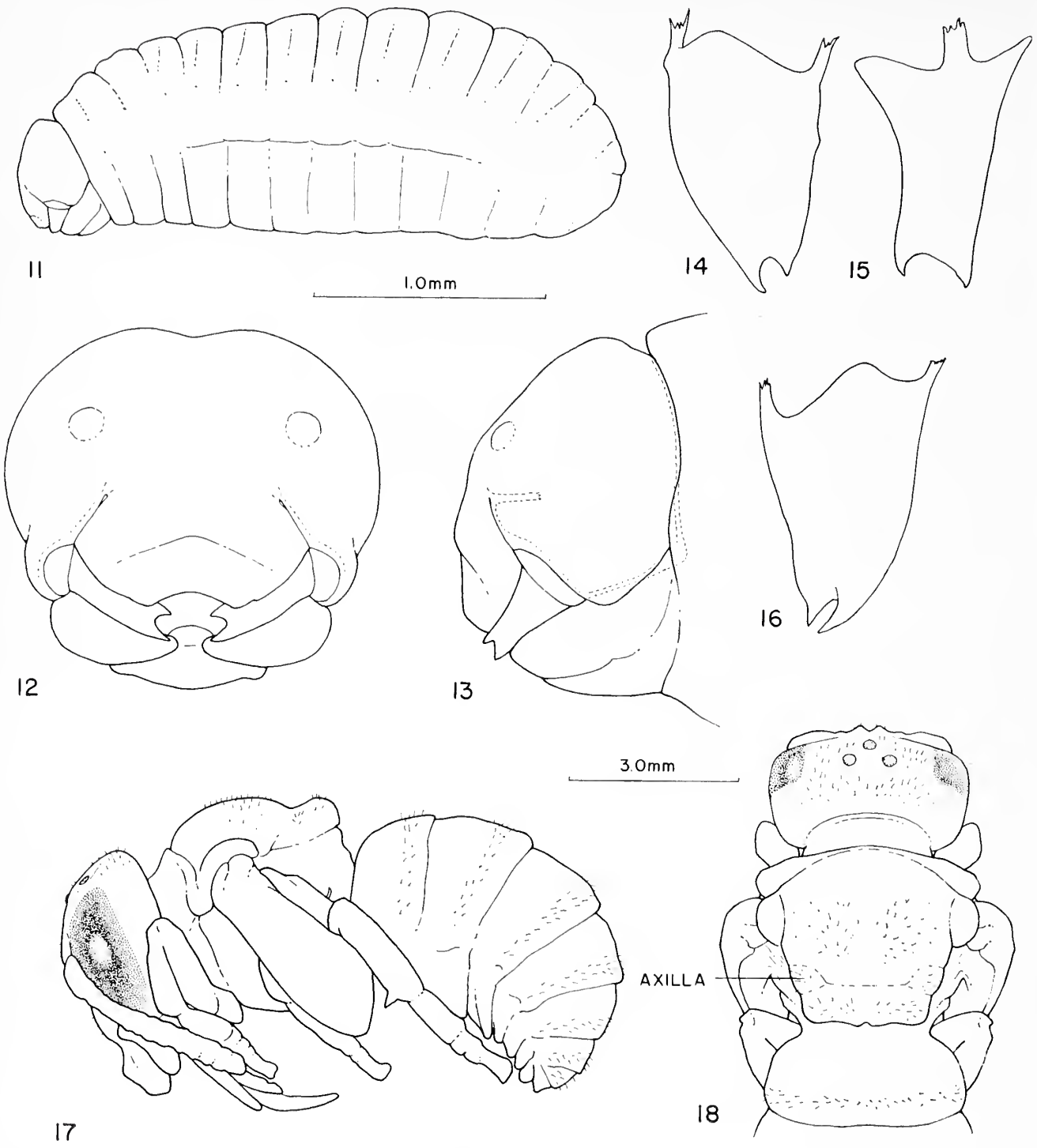
FIGS. 9–10. Head of mature larva of *Stelis* (*Microstelis*) *lateralis* Cresson, frontal and lateral views.

1953, fig. 118) apparently possesses longer atrial spines and a relatively longer subatrium.

Comparisons can also be made, in a general way, with the larvae of a number of other *Stelis* on the basis of the following descriptions in the literature: *Stelis* (*Stelidomorpha*) *nasuta* (Latreille) (Maneval, 1937), (*Stelis*) *minuta* Lepeletier and Serville (Enslin, 1925), (*Stelis*) *ornatula* (Klug) (Micheli, 1935). The resulting conclusions are that the known larvae of *Stelis* possess the megachilid characters presented by Michener (1953), and that no feature or set of features is evident at this time that will enable *Stelis*, as a group, to be distinguished from other Megachilidae.[3]

It seems evident from all studies of *Stelis* larvae that the species differ one from the other to a considerable extent. However, an examination of *bilineolata* reveals that a few apparent dissimilarities may not be so pronounced as previously judged. The extent of expression of the middorsal tubercles seems to depend at least to some degree on whether the body is contracted (Fig. 1) or expanded (Fig 2) at the time of fixation. Also the degree of expression of the intrasegmental lines and of the ventrolateral protuberances depends upon the proper preservation of the larva. Because the larva of *lateralis* studied by Michener (1953) was rather poorly preserved, it is believed that these features

[3] Dr. Robbin W. Thorp has kindly sent me the manuscript of his synopsis of the genus *Heterostelis*, in which he briefly describes the larva of a new species. Its mandible is apically bidentate with the lower tooth longer, but lacks an apical concavity. In other respects, it seems to have the general features of megachilid larvae.



FIGS. 11–18. *Stelis* (*Odontostelis*) *bilineolata* (Spinola). 11. First instar, lateral view. 12–13. Head of first instar, frontal and lateral views. 14–16. Mandible of first instar, dorsal, adoral, and ventral views. 17–18. Pupa, lateral and dorsal views. Scales refer to Fig. 11 and to Figs. 17 and 18.

would be more pronounced in a fresh specimen and therefore would agree more closely with comparable structures of other known *Stelis* larvae.

On the other hand, the dissimilarities of the mandibles in *Stelis* larvae are striking. The mandibles (Figs. 6–8) are apically bidentate, have serrated apical edges, and an apical concavity in *bilineolata*, *nasuta*, and presumably *ornatula*; they (Michener, 1953, figs. 115, 116) are apically simple and without serrations

or an apical inner concavity in *lateralis* and *minuta*.[4] I know of no other case in bees where two such radically different types of mandibles are encountered in the same genus, and this condition, therefore, suggests the possibility of a polyphyletic origin of the genus.

It is tempting to postulate that the bidentate mandible is associated with a life history in which the parasitic larva does not assassinate the host larva; in this case, the *Stelis* larvae would not require specialized modifications of the mandible to eliminate the host larvae. Consequently, the primitive anthidiine type of mandible persists. On the other hand, as specialized apically simple mandibles have evolved several times in those parasitic anthophorids where the cuckoo bee larva destroys the host egg or larva, we might conclude that this sharp-pointed mandible is similarly employed by these *Stelis*.

There is a certain amount of evidence to support this hypothesis. The larvae of *bilineolata* and *nasuta* do not kill their hosts. The adult of *bilineolata* removes the host larva from the cell (Bennett, 1966) and the larvae of *nasuta*, two to 12 of which occupy a single host cell, apparently efficiently consume the food of the much larger host larva so that it starves (Fabre, 1914). Furthermore, the larvae of both *lateralis* (Graenicher, 1905; Michener, 1955) and *minuta* (Enslin, 1925) (though apparently not as first-stage forms) destroy their host larva with the sharp-pointed mandible.

However, this hypothesis seems to break down when *ornatula* is considered. Both Enslin (1925) and Höppner (1904) have seen its larva attack that of the host and yet Micheli (1935) shows it to have a bidentate mandible with a dorsal serrated edge. The hypothesis should not, however, be totally discarded because it is not clear from Micheli's drawings whether *ornatula*'s mandible is like that of *bilineolata* or whether it is perhaps somewhat intermediate between the two extreme types. It should also be pointed out that Enslin (1925) also examined the larva of *ornatula* and stated that the mature larvae of *minuta*, which has a pointed mandible, and of *ornatula* are "quite similar," a statement which reflects doubt on the correct identification of Micheli's specimen.

FIRST INSTAR

(Figs. 11–16)

LENGTH: Approximately 2.5 mm.

HEAD (Figs. 12, 13): Integument without setae, apparently without sensilla, and nonpigmented. Tentorium complete, including thin dorsal arm; posterior thickening of head capsule and hypostomal ridge moderately developed; gena projecting downward so as to cover hypostomal ridge anteriorly; pleurostomal ridge weak but evident; epistomal ridge weak laterad of anterior tentorial pits and absent between them; longitudinal thickening of head capsule, cleavage lines, and parietal bands not evident. Antennal papillae scarcely

[4] This same type of mandible was found on a larva questionably identified as *Stelis punctulatissima* (Kirby) (as *aterrima* (Panzer)) (Hofeneder, 1947). Additional recorded details of the larva are not adequate for comparison with other larvae treated here.

produced. Labral apex emarginate and without tubercles. Mandible (Figs. 14–16) apically bidentate, with scattered minute indistinct denticles along apical edges; apical concavity not defined. Maxilla with apex produced adorally; galea and palpus not evident; cardo and stipes faintly sclerotic. Labium recessed, not divided into prementum and postmentum; salivary opening small and inconspicuous; palpi absent.

BODY: Form (Fig. 11) robust and straight, thickest in posterior half; most segments bearing distinct intrasegmental lines; middorsal tubercles apparently absent; body projecting somewhat on either side below spiracles (in the region of the ventrolateral tubercles of mature larva). Integument without setae but with numerous spicules over most of surface. Spiracles moderately small; atrium apparently without spines or ridges and apparently not projecting above body wall; peritreme distinct; primary tracheal opening with slight collar. Anus dorsal in position.

MATERIAL STUDIED: One larva, Curepe, Trinidad, West Indies, egg deposited February 1–2, larva emerged February 4–5, 1965, in nest of *Euglossa cordata* (Linnaeus) (F. D. Bennett).

Michener (1955) provided some details of the first instar of *Stelis lateralis*. Both species agree in that the straight, robust body protrudes laterally and lacks dorsolateral tubercles. The head is normal in size and the mandibles are not enlarged. Further, there is less difference in the anatomy of the head and mouthparts between the first and last instars of these species than there normally is with parasitic bees.

However, the first-stage forms of the two *Stelis* presumably differ significantly. Whereas the first instar of *bilineolata* has antennal papillae that are much shorter than those of the mature larva, the antennae of the first-stage *lateralis* are longer than those of the last stage. Although setae are not evident on *bilineolata*, setae of *lateralis* are even longer than those of the last larval instar of the same species. As pointed out above, mandibles of the first and last instars of *lateralis* are simple apically and sharp-pointed whereas those of the same stages of *bilineolata* are bidentate.

PUPA

(Figs. 17, 18)

HEAD: Vertex with three small tubercles in position of ocelli; these tubercles about as pronounced as ocelli of adults; vertex and, to lesser extent, frons and clypeus with pigmented setae.

MESOSOMA: Mesoscutum, mesoscutellum, and axillae with pigmented setae. Coxae and trochanters without spines.

METASOMA: Terga I–VI with bands of pigmented setae.

MATERIAL STUDIED: Four males, Curepe, Trinidad, West Indies, February, 1965, from nest of *Euglossa cordata* (Linnaeus) (F. D. Bennett).

Because the basal mandibular tooth of the female *Odontostelis* is much larger than that of the male, female pupae presumably have a correspondingly larger mandibular tubercle than do male pupae.

The pupa of this species lacks the various tubercles commonly encountered in other bee groups. In this respect it agrees with the pupae of *Megachile* described by Michener (1954) and with the pupa of an unidentified *Dianthidium* kindly loaned by Dr. Paul D. Hurd, Jr., from the California Insect Survey. The pupae of all these megachilids share the apparently unique feature of extensive patches of setae on the head, thoracic nota, and metasomal terga. It would seem, therefore, that the pupae of megachilids, like the larvae (Michener, 1953), are very homogeneous.[5]

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[5] Dr. Robbin Thorp's manuscript account of the pupa of a new species of *Heterostelis* is an exception to this statement in that the pupa is "apparently without long setae on vertex, mesoscutum, and metasomal terga." In contrast with *Odontostelis*, *Heterostelis* possesses only a pair of rounded tubercles on the vertex and a spine on the inner apex of each coxa and on the inner base of each trochanter.

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Mature Larvae of the Old World Bee Genus *Panurgus* (Hymenoptera, Apoidea)

JEROME G. ROZEN, JR.[1] AND BARBARA L. ROZEN

Abstract: This paper describes the mature larva of *Panurgus dentipes* Latreille and compares it with the previously published accounts of other species in the genus.

The purpose of this paper is to describe the mature larva of *Panurgus dentipes* Latreille (Andrenidae, Panurginae) and to compare it with the other known larvae of *Panurgus*, so that these data can be referred to in a study of the larvae of North American Panurginae (Rozen, in press). Larvae of *dentipes* were kindly made available by Siavosh Tirgari, Ahwaz Agricultural College, Iran.

Two other species of *Panurgus* have been described and illustrated: *banksianus* (Kirby) (Micheli, 1931) and *calcaratus* (Scopoli) (Micheli, 1936). Although Micheli's written accounts provide little specific information that can be compared with the following description of *dentipes*, his illustrations suggest that the three species probably agree in most major respects. All have an elongate clypeus and reduced body tubercles. The somewhat more pronounced segmental annulations of the species studied by Micheli presumably can be explained by the fact that his specimens were postdefecating forms whereas ours are predefecating. No known North American panurgine (*Nomadopsis*, *Calliopsis*, *Perdita*, *Pseudopanurgus*, and *Panurginus*) possesses an elongate clypeus and only *Panurginus* is known to have reduced dorsal body tubercles. The European *Melitturga clavicornis* (Latreille) (Rozen, 1965) lacks both these features of *Panurgus*.

Mature *P. banksianus* larvae are larger than those of the other two species and Micheli stated there were some differences between the mandibles of *banksianus* and *calcaratus*. At the present time we do not know if larval *calcaratus* and *dentipes* can be distinguished from one another.

Panurgus dentipes Latreille
(Figs. 1–7)

BODY LENGTH 7.5 mm.

HEAD (Figs. 3–4): Integument with scattered sensilla but without setae; antennae, palpi, and labral tubercles scarcely pigmented; vertex moderately produced on each side above antenna; antennae arising from low prominences; clypeal area abnormally elongate compared with that of other known Panurginae (*Perdita*, *Panurginus*, *Pseudopanurgus*, *Melitturga*, *Calliopsis*, and *Nomadopsis*). Tentorium complete; posterior thickening of head capsule moderately well developed; hypostomal ridge well developed; pleurostomal ridge moderately developed; epistomal ridge distinct below anterior tentorial pits, absent mesiad of pits; parietal bands evident. Antenna a low convexity with few (2–3 on specimen examined) sensilla. Labrum bearing two moderately small tubercles. Mandible (Figs. 5–7) moderately

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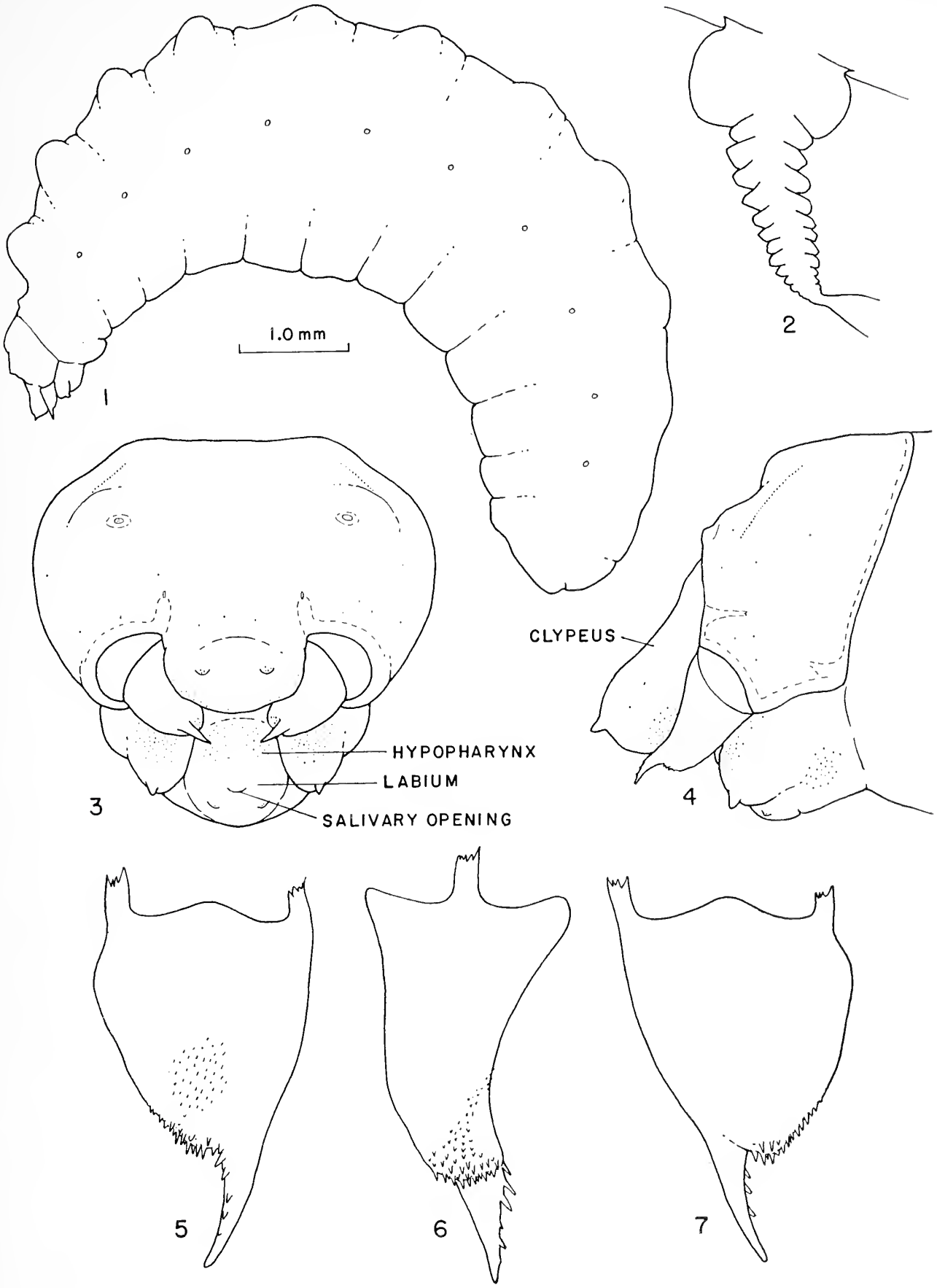

Figs. 1–7. Mature larva of *Panurgus dentipes* Latreille.

Fig. 1. Predefecating larva, lateral view. Fig. 2. Spiracle. Fig. 3. Head, frontal view. Fig. 4. Head, lateral view. Figs. 5–7. Left mandible, dorsal, inner, and ventral views. Scale refers to Fig. 1.

slender, curved as seen in inner view (Fig. 6), narrowing to single point; upper apical margin with conspicuous serrations; lower margin not serrate; cusp strongly produced with numerous teeth, but without large tooth like that of *Melitturga*. Maxilla, as seen in lateral view (Fig. 4), projecting only to apex of labium; palpus fairly slender, directed downward somewhat as in *Panurginus*; integument of maxilla spiculate on dorsal surface but, unlike that of *Panurginus*, palpus not spiculate. Hypopharynx spiculate; hypopharyngeal groove absent, as in most *Perdita*. Labium projecting nearly as far as maxillae as seen in lateral view, but labiomaxillary region recessed in comparison with labroclypeal region; labium indistinctly divided into prementum and postmentum; lateral spiculate areas on labiomaxillary region probably corresponding to maxillary conjunctiva; labial palpus evident, but smaller than maxillary palpus. Salivary opening a gently curved slit.

BODY: Color whitish, spiculate in various areas; tenth abdominal segment spiculate ventrally. Anterior dorsal tubercles (Fig. 1) conical, nonspiculate apically, moderately low and rounded; tubercles becoming less pronounced and perhaps somewhat transverse on posterior body segments; terminal segment not produced dorsally. Spiracles (Fig. 2) moderately small; atrium projecting slightly above body wall; atrial wall smooth; peritreme present; primary tracheal opening with collar; subatrium moderate in length, not elongate as compared with that of *Panurginus*, *Melitturga*, *Perdita*, *Calliopsis*, and *Nomadopsis*.

MATERIAL STUDIED: Five mature predefecating larvae, Lusignan and Usson, department of Vienne, France, mid-September, 1963 (S. Tirgari). Associated adults identified by collector.

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Melanism in Connecticut *Panthea furcilla* (Packard) (Lepidoptera: Noctuidae)

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Abstract: Counts are given of melanic, melanistic, and normal individuals in the total catch of this moth in Connecticut in 1962–1965. Counts of these types are also given in families reared from wild-caught melanic, melanistic, and normal females. Larval melanism occurs, not linked to adult melanism. Adult melanism is dominant and apparently multifactorial. Environmental effects on the polymorphism are discussed.

In a previous article (1964, Jour. N. Y. Ent. Soc. **72**: 142–144) I recorded the counts of my total catch (unbiased by collector selection) of *Panthea furcilla* and other moths at Putnam, Windham County, Connecticut. In the summers of 1962–1965 similar catches were made at the same spot. In 1964 and 1965 six batches of eggs were obtained from wild-caught females, and from these 95 adults were reared which show several degrees of melanism.

Panthea furcilla was chosen for special work because of the large numbers of this species that come to an ultraviolet "black light," the same described in the previous article, from a nearby grove of white pine (*Pinus strobus*), the food plant. It may be noted that this is the true *P. furcilla* Packard, and not the more southern, "hard" pine feeder that some authors have confused with this species.

WILD-CAUGHT SERIES

In the wild-caught series the partially melanic, or "melanistic," individuals form a nearly continuous spectrum of variation from almost totally melanic to very close to the normal, light grey, so that dividing them into a small number of groups is somewhat arbitrary. However, the series is here classified in four groups instead of the three used in sorting the 1961 catch. The category of "melanistic" is divided into: "slightly to strongly melanistic" and "very strongly melanistic." Admittedly, there are many borderline specimens that might as well be sorted one way as another. How much of the variation is genetically based will certainly never be known without a great deal of controlled, experimental work. Probably a number of factors are involved.

The wholly melanic individuals are not all black, the hairs and scales that in the normal form are light grey or white being a very dark, sooty brown against which the normal black markings are discernible. The vestiture of the head and thorax is perhaps as useful as the wing scales for deciding which moths are to be classified as very strongly melanistic, all of these having this vestiture

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extremely dark with only a slight mixture of light hairs and scales. Within the very strongly melanistic group are numerous specimens that have the white scale hairs of the thorax sharply limited to the tips of the tegulae and the area posterad to these, forming sharp, transverse white bars. The wings of such specimens are almost wholly dark except for the white lines that outwardly margin the transverse black markings; these are sharp and clear. Perhaps these sharply and contrastingly marked individuals represent something genetically distinct from the more common, rather smudgy melanistic ones.

Only 13 females were caught at the light, compared with 273 males, although this sex flies strongly enough at times. In 95 reared individuals there were 52 females.

Wild-caught Moths, 1962–1965 inclusive

Wholly melanic	51 = 17.8%
Very strongly melanistic	120 = 42.0%
Slightly to strongly melanistic	56 = 19.6%
Normal	59 = 20.6%
Total	286

For combination with the 1961 catch, which was sorted in only three categories (all melanistics being grouped together), the same is done for the 1962–1965 catch. The 1961 figures are given in parentheses.

Wild-caught Moths, 1961–1965 inclusive

Melanic	51 + (19) = 70	= 18.8%
Melanistic	176 + (47) = 223	= 60.0%
Normal	59 + (20) = 79	= 21.2%
Totals	286 + (86) = 372	

REARINGS

1964, ♀ Pf N-1, a normal, light grey mother. A total of 49 pupae was obtained, of which 16 died during hibernation. The 33 adults obtained were as follows: strongly melanistic, 11; normal, 22. The larvae showed strong dimorphism; 16 were melanic, with the long hair pencils white; 17 were normal, i.e., dull brown to bright orange–brown, with the long hair pencils black. These larvae developed into moths as follows:

16 melanic larvae: strongly melanistic moths, 4; normal moths, 12.

17 normal larvae: strongly melanistic moths, 7; normal moths, 10.

1964, ♀ Pf N-2, a normal, light grey mother. All larvae were normal. A total of 61 pupae was obtained, of which 38 died during hibernation. The 23 adults obtained were as follows: slightly melanistic, 11; normal, 12.

1964, ♀ Pf Ms-1, a strongly melanistic mother. All larvae were normal. A total of 56 pupae was obtained, of which 50 died during hibernation. The 6 adults obtained were as follows: fully melanic, 4; slightly melanistic, 1; normal, 1.

1964, ♀ Pf M-2, a fully melanic mother. All larvae were normal. A total of 40 pupae was obtained, of which 35 died during hibernation. The 5 adults obtained were as follows: fully melanic, 1; slightly melanistic, 3; normal, 1.

1964, ♀ Pf Ms-3, a strongly melanistic mother. All larvae were normal. A total of 83 pupae was obtained, of which 71 died during hibernation. The 12 adults obtained were as follows: fully melanic, 8; strongly melanistic, 3; normal, 1.

1965, ♀ Pf M-1, a fully melanic mother. A total of 22 pupae was obtained, of which 6 died during hibernation. All larvae were normal. The 16 adults obtained were as follows: fully melanic, 5 (all ♂♂); slightly melanistic, 11 (all ♀♀).

Totals of Reared Moths, 1964–1965

Melanic	18 (11 ♂, 7 ♀) = 18.9%
Very strongly melanistic	14 (10 ♂, 4 ♀) = 14.7%
Slightly melanistic	26 (3 ♂, 23 ♀) = 27.4%
Total of melanistics	40 (13 ♂, 27 ♀) = 42.1%
Normal	37 (19 ♂, 18 ♀) = 39.0%
Total	95 (43 ♂, 52 ♀)

DISCUSSION

The total wild-caught series of 1961–1965 shows an approximate proportion of 1 melanic to 3 melanistic to 1 normal. This is indicative of a condition of dominance of melanism with the probability of melanistics being heterozygotes. The wide spectrum of variation in the melanistics suggests that there is more than one gene controlling this. The sharpness and contrast of the markings of some very strong melanistics, compared with the diffuse, smudgy appearance of others equally dark, may be the result of a different gene, perhaps even at a different locus, or may result from some modifying factor expressing itself differently in different environments or under different physiological conditions. Although their numbers are small the melanistics of the reared series buttress the idea of the melanistic condition in general being multifactorial, since 14.7% (n = 95) were strongly melanistic and 27.4% were slightly melanistic; but there were none of the wide range of intermediate melanistics that form the majority of the wild-caught individuals.

It may be noted here that a population sample such as this, no matter how extensive, cannot be regarded as representative of the wild population as a whole. It is probably safe to assume that the differences in coloration ranging from normal, light grey to wholly melanic have different survival values with respect to bird predation, although admittedly this remains to be shown for *P. furcilla*. The population that arrives at the collecting light ranges from very freshly emerged individuals to ones that have evidently been flying for several nights. Many have probably been subjected to the attention of predators, but escaped. Many others probably did not escape, and so never came to the light. The caught series, then, represents a probably biased sample of an original population from which more of the less cryptic individuals may have been

eliminated than of the more cryptic ones. We would expect it to show a higher proportion of cryptic or otherwise protected individuals than the entire, unselected population.

It may also be noted that *P. furcilla* flies in a wide range of local environments, as a result of which there is probably a strong selection for the more or less intermediate, presumably heterozgous, melanistics. Immediately adjacent to my collecting light is a dense and heavily shaded grove of white pine about 30 years old, the trees having very dark bark free from lichens. Here the wholly melanic moths can enjoy the full advantage of their crypsis, while the lighter melanistic and normal ones must be at a strong disadvantage. But within a quarter of a mile are far greater areas of mixed pine–deciduous and mixed deciduous forests, as well as of fields and pastures being invaded by trees and shrubs, many of which are young pines. There are also a number of very old pines, with rough, grey–brown bark, that have lost their lower limbs and have well-lit trunks. The area shows little, if any, sign of industrial pollution; corticolous lichens are still abundant. In this highly mixed environment there are plenty of areas within the flight range of even a heavy female *P. furcilla* where any phenotype shown by the species can be benefited by its crypsis. In the heavily shaded pine groves the melanics would be favored; and in areas predominantly occupied by grey-barked ashes, American elm, and white oak, selection would favor the normal, light grey moths. Such an environment occurs very widely in much of the northeast today where there has not been industrial pollution. Where there has been such pollution, of course, everything is much darker and duller.

Yet, this highly mixed environment is changing. In the relatively stabilized pre-Columbian forest *P. furcilla* must have evolved a relatively stable, balanced polymorphism. Very likely it had a rather dark population; it may be, in fact, that what we call "normal" today was, at least in many areas, a relatively rare thing. In the 17th century man began removing the dense, almost unbroken forest and continued to do so at an ever accelerating rate until by the late 19th century little of the original forest remained and most forest areas had been cut over more than once. Agricultural land was then at its maximum. In this open environment *P. furcilla* must have responded by greatly decreasing its melanism, the light grey form becoming the "normal."

By the beginning of the 20th century, however, a reversal had set in as eastern agriculture, especially in New England, began a rapid decline. Fields and pastures were abandoned to the encroachment of the forest, which was far less cut for fuel. Small, but dense, groves of white pine sprang up everywhere. That on the edge of which the present *P. furcilla* work is being done was open, grassy meadow in 1939. Even local, small lumbering operations declined, as lumber was shipped in from the West; most sawmills were abandoned (many because of the loss of the American chestnut) and old stone

walls, marking former field boundaries, can be found everywhere running through young, but dense, forest. This reforestation is likely to continue. In much of its range, therefore, *P. furcilla* must again be in a transient state, responding, in a reversal of what it did three centuries ago, to the again changing environment.

The above, of course, deals with what for lack of a better term we call "nonindustrial melanism." Certainly this is largely what now occurs at Putnam. In and about the great industrial areas of eastern North America, however, where atmospheric pollution is extremely heavy, *P. furcilla* is undoubtedly "industrially melanic" although we have no proof of this. Selection pressures in polluted areas, however, are far from identical with those in an unpolluted forest area; for not only are the larvae, which must feed on polluted foliage, subject to selection by physiological factors (which may be melanism-linked) that very seasonally as pollution builds up, but also in the environment there is a general darkening of everything that causes selection for dull, smudgy melanistic phenotypes, and against more contrastingly marked ones. Quite different genes or gene combinations may thus be selected for in industrially polluted and nonpolluted areas, even though in both the apparent general effect is one of environmental darkening. In addition, in many areas where little or no industrial pollution exists there may well be something of an inflow of genes from nearby industrially polluted areas.

DISCUSSION OF REARINGS

The rearings were highly disappointing because of an accidental mortality of pupae during the winter of 1964–1965. Consequently, relatively few adults were secured, and the ratios are mathematically unreliable. Furthermore, since nearly all of the adults that were secured were ones that emerged during October, not going into diapause, there is the strong possibility that, representing a physiologically selected group, they may also be melanically selected. The uniformity of the rearing conditions (in screen cages indoors) may also have biased the results by eliminating varying factors that affect wild-reared individuals. Of course, the lack of knowledge of male parents is a great handicap, and the possibility of multiple insemination of wild-caught females by more than one male is something that can never be entirely ignored. Despite such shortcomings, however, the rearings give some valuable information.

The breakdown into phenotypic groups of the reared individuals is interesting when compared with that of the wild-caught ones. The proportions of wholly melanic individuals agree very closely (reared 18 = 18.9%; wild-caught 51 = 18.8%). In the melanistics, however, the figures for the reared and wild-caught groups differ greatly, being: 40 = 42.1% for the reared moths, but 223 = 60% for the wild-caught. Breaking these figures down further: only 14 = 14.7% of the reared moths are very strongly melanistic, compared with

120 = 42% of the wild-caught ones (1962–1965). Furthermore, the reared series contains no intermediately melanistic individuals, having a great hiatus between very strongly and slightly melanistic. This may have resulted from the absence of the proper genetic factors for the intermediate conditions, due to the inadequacy of the sample represented by the parents of the reared group; but it could also result from the rearing conditions or the differential pupal mortality.

The offspring of 1964 Pf N-1 are significant in showing the genetic nature of the larval dimorphism, and in the apparent independence of this from the adult melanism. This is quite in line with findings in many moths in England where larval melanism is scarcely ever linked to adult melanism. Exceptions are *Arctia caja f. fumosa*, in which black larvae always produce black moths; and *Lasiocampa quercus* subsp. *callunae*, in which a high proportion of black larvae produce black moths, indicating linkage (H. B. D. Kettlewell, in litt.).

The numbers of adults secured are too small to have significance, but the fact that of the offspring of 1964 Pf Ms-1 all 5 wholly melanics are males, and all 11 slightly melanistics are females, suggests a possible sex linkage. Also bearing on this is the fact that of the total of 32 reared melanic and strongly melanistic moths (from 5 different mothers) 21 = 66% are males and 11 = 34% are females. A vast preponderance of the slightly melanistic moths (23/26) are females, while the normals run nearly even (19 ♂♂/18 ♀♀) and for the entire reared group the proportions are 43 ♂♂/52 ♀♀. As noted before, the sex ratio of wild-caught moths means nothing here, since very few females come to the collecting light.

One additional feature deserves mention. In some of the reared groups a definite dimorphism of silk color was noted, the silk of some larvae being dark brown while that of others was white. Unfortunately, this was not noticed until too late for full records. However, it occurred only among the offspring of the two very strongly melanistic mothers, 1964 Pf Ms-1 and 1964 Pf Ms-3; all larvae from all other mothers spun brown silk. One larva of 1964 Pf Ms-3 that spun white silk developed into a very strongly melanistic male. At least 10 larvae of 1964 Pf Ms-1 spun white silk; of these 4 developed into wholly melanic moths (1 ♂ and 3 ♀♀) and the others died in pupa; the single slightly melanistic female and the single normal male of this group developed from larvae that spun brown silk. These data merely suggest future observation.

There was no observable correlation between either larval or adult melanism and the rate of larval development or of adult eclosion.

These rearings point beyond this only to the dominance of melanism, and suggest that it is multifactorial. It is hoped, however, that the data here recorded may be of some use as a background, and perhaps a stimulus, for badly needed work on moth melanism in North America.

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An Apparent Association of Mites (Acarina) with the Rock Barnacle, *Balanus*

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Abstract: An apparent association of an oribatoid mite, *Hygroribates marinus* (Banks), with rock barnacles (*Balanus*, spp.) is reported. The mites regularly hide in crevices of the barnacle shell plates. The occurrence of large encrustations of barnacles may favor the spread of these sluggishly moving, ovoviviparous mites.

While collecting Acarina in the littoral region of New York City and vicinity, I have found vast numbers of mites of the suborders Mesostigmata, Trombidiformes, and Sarcoptiformes (Oribatei), evidently restricted to the intertidal zone. All belong to families known to occur in this zone, though most such families consist mainly of terrestrial species. Exceptions to the rule of primarily terrestrial groups with one or a few littoral species are the Halacaridae (Trombidiformes), a truly marine, often pelagic assemblage, and the Ameronothridae (Oribatei), which, as currently defined, consists of two essentially Old World genera each with a small number of described species, which are intertidal or at least strictly littoral. One of the latter family I have found consistently in association with barnacles of the genus *Balanus* (*Balanus balanoides* (Linnaeus), *B. eburneus* Gould, and *B. crenatus* Brugière) in the New York City area. It is closely allied but not certainly identical to the mite described by Banks as *Nothrus marinus* (1896) (= *Hygroribates marinus* (Jacot), 1934). However, owing to the primitive state of knowledge of the ameronothroid genera and species, it can only be provisionally referred to *H. marinus*.

H. marinus was found by Banks on intertidal rock outcrops near Sea Cliff, Long Island, New York. Jacot (1934) rediscovered it in a number of restricted localities along the coast in the vicinity of New York City and near Greenwich, Connecticut, but no farther east. Grandjean (1947) reported what he considered to be this species on the coast of France (two other species are known in Eurasia). It has otherwise seldom been reported. All have found it confined to the surfaces of rough rocks, e.g., schist, coated with small algae, clinging to the surface in small fissures, or occasionally crawling over the rock or among the algae. Little is known of the life history or ecology of this or any others of the family Ameronothridae, except that they are ovoviviparous and that the immature stages are found in the same habitat. It has been pointed out (Jacot, 1934) that owing to the lack of an egg stage, dispersal by water currents is unlikely, as all stages appear to cling tenaciously to the substrate when submerged, and neither swim nor crawl far from convenient crevices.

I have rarely collected *H. marinus* on stones as such or in algae, though other mites, particularly Mesostigmata, and even Oribatei of the family Hermanniidae are common. Instead, they do occur in numbers on the shells of *Balanus*, which encrust rocks in great numbers in the intertidal zone. The mites are invariably found clinging to the shells in the crevices between the mural and other shell plates, and in the vertical grooves of the plates themselves. I occasionally find individuals on the inside of the scutal or tergal plates which cover the living barnacle.

At high tide the barnacles are covered with water to a depth of 2 or 3 feet on some outcrops, and at low tide may be fully exposed for hours. Mites were observed to cling more or less quiescent during the hours of exposure, to become somewhat more active while the incoming tide covered them, and then to become relatively inactive again in the crevices after submergence. I was able to observe them to a depth of several inches. Collecting of barnacles from rocks at depths of up to approximately 2 feet revealed mites, which continued to seek crevices and become quiet after the disturbance jarred some from their hiding places.

Barnacles were kept alive for several days in the laboratory. During this time, mites were inactive by day. Though they were completely submerged during this time, since they do not swim and crawl only sluggishly, they remained alive and on the barnacles even after the latter died. I kept several individuals thus for 6 days. Death of the barnacles and consequent contamination of the water may have contributed to the eventual death of the mites.

No close symbiotic association of *Hygroribates* with *Balanus* is implied. It is suggested the encrustation of rocks with large colonies of barnacles provides a continuous habitat for the mites not furnished by bare, smooth rocks, and that therefore the loose association is advantageous for the spread of the mite. Studies are planned to learn more about the ecology of *H. marinus* and to review the systematics of the Ameronothridae.

Literature Cited

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BYLAWS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

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Organized June 29, 1892

Incorporated June 7, 1893

Reincorporated Feb. 17, 1943

Article I
Members

The Society shall consist of active, sustaining, student, life, and honorary members.

1. Active members shall be persons interested in entomology. They shall be entitled to vote and hold office.

2. Sustaining members shall be active members who elect to become sustaining members by paying annual dues of Twenty-five Dollars ($25).

3. Student members shall be persons interested in entomology who have not reached 21 years of age, or who are currently enrolled as students in a curriculum leading to a bachelor's degree or a higher degree in some field of biology.

4. Life members shall be active members who shall have reached the age of 45 years and who shall have paid the sum of One Hundred Dollars ($100) at any one time in lieu of further annual dues. They shall be entitled to vote and hold office.

5. Honorary members shall be eminent entomologists elected in recognition of their service to science. There shall not be more than twelve (12) honorary members at any one time.

Article II
Election of Members

All candidates for membership must be proposed by an active member of the Society at a regular or annual meeting. They shall be voted upon individually at the following meeting, and the affirmative vote of at least two-thirds of the members present (given by voice, or by ballot if demanded) is required for election.

Article III
Officers and Committees

1. Elective officers of the Society shall consist of a President, a Vice President, a Secretary, an Assistant Secretary, a Treasurer, an Assistant Treasurer, and four Trustees.

2. Elective Committees of the Society shall consist of an Executive Committee, and a Publications Committee. The Executive Committee shall be composed of the President (Chairman) and four Trustees all entitled to vote. The Editor, Vice President, Associate Editor, Secretary, and Treasurer shall also be members of the Executive Committee but not entitled to vote. The Publications Committee shall be composed of three active members who shall elect their own chairman. An Editor or Associate Editor shall be ineligible for membership on the Publications Committee.

3. The President, after consultation with the Publications Committee, and with the advice and consent of the Executive Committee, shall appoint an Editor and Associate Editor for each publication of the Society. The Editor and Associate Editor shall serve for one

year or for such portion thereof as may be designated by the Executive Committee, and shall be eligible for reappointment.

4. Standing Committees of the Society, to be appointed by the President, shall consist of an Auditing Committee composed of three active members; a Program Committee composed of two active members; and a Field Committee composed of two active members and the Director of the Junior Entomological Society who shall be a member ex-officio without vote.

5. Temporary committees may be appointed by the President at his discretion to perform special duties which he shall define. The President also shall appoint a Nominating Committee, consisting of three active members, to nominate a full slate of officers and elective committees at the annual meeting.

Article IV

Election of Officers and Committees

1. Officers and members of elective committees shall be elected at the annual meeting of the Society by a majority vote of the members present or voting by proxy.

2. Trustees shall be elected for a two-year term, two being elected each year. A member who has served for two consecutive terms as trustee shall be ineligible for reelection as trustee for one year after completion of his term of office. If the office of a trustee shall become vacant before the expiration of his term the vacancy may be filled by appointment by the President, but the fraction of the term shall be counted as a full term in determining eligibility for election or reelection.

3. All other officers and members of elective committees shall hold office for one year, or until the next annual election.

4. Any vacancy that may occur among the officers or elective committees, except as elsewhere herein provided, shall be filled by appointment by the Executive Committee. The person appointed to fill the vacancy shall hold office until the next annual meeting.

Article V

Duties of Officers and Committees

1. The President shall preside at all meetings. He shall appoint all committees except the elective committees, and shall make such other appointments as are elsewhere herein provided; he shall be chairman of the Executive Committee and a member ex-officio, without vote, of all other committees.

2. The Vice President shall assume the duties of the President in case of the death, resignation, absence, or disability of the President. In case both the President and Vice President are absent at a meeting, a temporary chairman may be chosen by the members present to preside at the meeting.

3. The Secretary shall keep the minutes of the meetings of the Society for publication in the **Journal**, and shall keep the minutes of the Executive Committee. He shall give notice of the meetings of the Society when not otherwise herein provided for; advise members, in writing, of their election and send their names to the Treasurer; keep all records and files of the Society and generally perform such services as may be delegated to him by the Society. At the expiration of his term of office the Secretary shall deliver to his successor all papers, books, and other records belonging to the Society.

4. The Assistant Secretary shall act in case of the death, resignation, absence, or disability of the Secretary and shall assist the Secretary as need be.

5. The Treasurer shall receive all moneys for the Society and deposit them in the name of the Society in such banking institutions as the Executive Committee may direct; he shall

pay therefrom by draft or check all bills and obligations not exceeding Twenty-five Dollars ($25) and all others when approved by the President or Editor(s). He shall keep an account of all monetary transactions and shall exhibit a statement of them when called for by the President, Editor, Executive Committee, or Auditing Committee, and shall make a full report for the preceding calendar year at the annual meeting. He shall notify members respecting payment of dues within ten days after their election and thereafter when annual dues become payable, and shall send out membership cards on receipt of dues. At the expiration of his term of office, the Treasurer shall deliver to his successor all funds, papers, books, and vouchers belonging to the Society.

6. The Assistant Treasurer shall act in case of the death, resignation, absence, or disability of the Treasurer and shall assist the Treasurer as need be.

7. An Editor shall have general charge, management, and supervision of the publication to which he has been appointed.

8. An Associate Editor shall assist the Editor as need be.

9. The Executive Committee shall meet at the call of the President. It is empowered to call for a report from any of the officers or committees of the Society at its discretion. It shall keep minutes of its proceedings which shall be available to any member of the Society and which may be read to the Society upon request. It shall have general charge of the funds, investments, and property of the Society. It shall decide on the status of members in arrears of dues. With the advice of the Publications Committee it shall determine the subscription price of all publications and discounts allowed in connection with their sale. The Executive Committee shall be the policy-making organ of the Society.

10. The Publications Committee shall make recommendations to the Executive Committee regarding policies relating to publications and shall assist the Editor, or Editors, in carrying out the policies established by the Executive Committee.

11. The Auditing Committee shall examine the accounts and reports of the Treasurer and shall report to the Society thereon at the annual meeting or at some date specified by the President.

12. The Program Committee shall plan and arrange for the programs of the meetings.

13. The Field Committee shall arrange for and manage the excursions and outings of the Society, and shall assist the Director of the Junior Entomological Society.

Article VI

Publication Funds

All funds subscribed or donated for the **Journal** or other publications of the Society shall be used for no other purpose than those specified.

Article VII

Dues

1. Dues for active membership shall be Four Dollars ($4) per annum.
2. Dues for sustaining membership shall be Twenty-five Dollars ($25) per annum.
3. Dues for student membership shall be Two Dollars ($2) per annum.

Payment of Dues

All dues are payable in advance on the first day of January of each year. New members, if elected on or after October 1, shall pay no dues for the year of their election.

Honorary members shall be exempt from the payment of dues.

Article VIII
Members in Arrears

All members in arrears in the payment of dues for one year are subject to the loss of the privilege of voting or holding office. Before the annual meeting the Treasurer shall present a list of the members in arrears in the payment of dues to the Executive Committee, which shall decide upon appropriate action.

Article IX
Subscription to Publications

1. The subscription price of all publications, the price of single numbers to active members, student members and non-members, as well as the price of sets, shall be determined by the Executive Committee on the recommendation of the Publications Committee.
2. Subscriptions shall be payable in advance of the first of January of each year.
3. The **Journal** shall be sent gratis to all Sustaining, Life, and Honorary members.

Article X
Meetings

1. Regular meetings of the Society shall be held at The American Museum of Natural History (or at such other place as the membership shall determine) on the first and third Tuesdays of each month at 8:00 P.M. No regular meetings will be held during the months of June through September or upon a legal holiday or upon the first Tuesday of January.
2. The annual meeting of the Society shall be held at The American Museum of Natural History (or at such other place as the membership shall determine) on the first Tuesday in January of each year at 8:00 P.M., if not a legal holiday, otherwise on the third Tuesday.
3. Special meetings of the Society may be called by the Secretary upon a written request of the President or 10 active members. Such a request shall state the purpose for which the meeting is to be called. The Secretary shall notify the membership of such a meeting, stating its purpose and the time and place at which it is to be held. No other business except that specified in the call shall be transacted.
4. Eleven (11) members shall constitute a quorum for the transaction of business.
5. At any special meeting members in good standing may vote or be represented by proxy.
6. Whenever notice of any meeting is required by the bylaws, it shall be deemed sufficient if given by postal card and addressed to each member of the Society at his last known postal address at least ten (10) days and not more than twenty (20) days before the meeting, or if given as required by the General Corporation Law of the State of New York. If the need for a special meeting, under the provisions of Sec. 3 of this Article, be deemed an emergency by the President or Secretary, the membership may be notified by any practicable means.

Article XI
The Order of Business

The order of business of regular meetings shall be as follows:

1. Reading of minutes.
2. Reports of officers.
3. Reports of committees.
4. Election of members.

5. Proposals for membership.
6. Miscellaneous business
7. New business
8. Reading of papers and scientific discussion.
9. Adjournment.

The order of business of the annual meeting shall be as follows:

1. Reading of minutes.
2. Roll call, verification of proxies.
3. Annual reports of officers.
4. Reports of committees.
5. Election of officers and elective committees.
6. Miscellaneous business.
7. Proposals and elections for membership.
8. Reading of papers and scientific discussion.
9. Adjournment.

The order of business may be changed or suspended at any meeting with consent of two-thirds or more of the members present.

Article XII
Auxiliary Organizations

1. The Society shall sponsor an auxiliary organization to be known as The Junior Entomological Society having its own officers and constitution. It shall be organized solely for educational and scientific purposes and shall conform to the requirements set forth in Article XIII.

2. The Junior Entomological Society shall be under the direction of an active member of the New York Entomological Society, appointed to that capacity by the President and responsible to the Executive Committee. He shall be known as The Director of the Junior Entomological Society. He shall be a member ex-officio, without vote, of the Field Committee.

Article XIII
General Prohibitions

1. The Society shall be organized and operated for scientific and educational purposes. No part of the receipts of the Society shall, under any circumstances, inure to the benefit of any private individual.

2. No substantial part of the activities of the Society shall consist of carrying on propaganda, or otherwise attempting to influence legislation. The Society shall not participate in, or intervene in any political campaign on behalf of any candidate for public office; nor shall it publish or distribute statements on behalf of such candidates.

3. The Society shall not be organized or operated for profit.

4. The Society shall not transact any business with any officer or member of the Society or any substantial contributor to the Society which shall result in gain to that individual (or corporate body) which shall represent more than a proper consideration for services rendered or goods or material sold to the Society.

Article XIV
Distribution on Dissolution

In the event of the dissolution of the Society and after payment of all expenses and

liabilities, all assets remaining will be transferred to an entomological organization to be chosen by the Society which shall have been organized for scientific and educational purposes within the meaning of Section 501 (c) (3) of the Internal Revenue Code of 1954.

Article XV

Amendments

These bylaws may be amended at any regular meeting, or at a special meeting of the Society called for that purpose, by the vote of two-thirds or more of the members present, provided that the proposed amendment or amendments shall have been approved by the Executive Committee, submitted in writing to all members by mail at least thirty days in advance, and presented at a previous meeting of the Society, due notice thereof having been given in conformity with the provisions of Article X.

Date of revision: Dec. 7, 1965

BOOK REVIEWS

The Tarantula. William J. Baerg. University of Kansas Press, Lawrence, 88 pp., photographs and figs. 1958., price $3.00.

The recent reprinting of this pleasantly unpretentious little book justifies a belated review. Originally published by the University of Kansas Press nearly a decade ago, it stands as a reminder to a rather more than modest host of lay readers—and not a few of us who are professional arachnologists—that the scope and depth of Dr. Baerg's long acquaintance with this fascinating group of spiders is still unsurpassed in America. It is not a monograph on the family Avicullariidae, a surprisingly great assemblage of species (some 600 according to a still rather primitive taxonomy), nor would the author make claim to its being an exhaustive treatment of the life history and habits of any one of the modest fraction of the American species known personally to him. In fact, he seems to avoid pedantic terminology, for example, to the extent that it is often difficult to determine just what species he is talking about. Occasionally one senses a superficiality and wishes for further details or more precise documentation. However, this is to quibble out of proportion to the scope and intent of this book, which, like a thin volume of poems, invites light browsing—or careful study.

The casual browser's eye is caught by the striking photograph on the dust jacket of the big golden-banded Mexican *Aphonopelma*, and he is likely soon to be caught up in the author's unabashed enthusiasm for tarantulas. It is to be hoped that more than a few such readers will be left with some appreciation of a grossly misunderstood group of animals.

Richard W. Fredrickson

The Beetles of the Pacific Northwest. Part IV: Macrodactyles, Palpicornes, and Heteromera. Melville H. Hatch, with David V. (sic) Miller, David V. McCorkle, Floyd Werner and Dennis W. Boddy. University of Washington Press, Seattle. Univ. of Washington Publ. in Biol., **16**, viii + 268, 1965.

The fourth volume of Professor Hatch's series on the beetle fauna of the Pacific Northwest (Idaho, Oregon, Washington, and British Columbia) covers a variety of the smaller families, including the polyphagous water beetles, the semi-aquatic beetles, and all of the heteromera, including the large family Tenebrionidae, in all, about 520 species. He has had the help of several collaborators to the extent that about half of the species are covered by others. The work continues to be a set of keys to the families, subfamilies, tribes, genera, and species of the area covered. The keys to the species also contain brief descriptions and notes on the distribution and habitats of the species. The book utilizes typwriter composition and is offset. It may be obtained either paper bound or with a cloth binding.

There are twenty-eight plates of illustrations, most of which are very well done. This should be very helpful to all who use this work. The technique of showing the deflected head detached is especially useful. Unfortunately, many of the new species are not illustrated.

A monumental task such as this cannot be free of errors. It is regrettable that Dr. Hatch has not referred to the more recent literature. His main concern has been to catalog the fauna of the area involved. This may have resulted in the description of species recently described elsewhere (e.g., the omission of reference to the recent monograph of the Heteroceridae, yet the description of two new species and the overlooking of two species recorded from the Pacific Northwest). It is too bad that some of the innovations in the work were not more carefully checked. For instance, his comments on the color forms of

Ditylus are not correct and need to be reviewed, as does the statement about the protibial spurs of *Xanthochroa*. I am sure that Dr. Hatch would have found the specialists on the various families more than willing to check his manuscript before publication.

There remain many groups to be covered before this work is complete. We hope that Dr. Hatch will continue to give it his enthusiastic attention and that he will enlist the help of others to detect the errors noticeable only by the specialists. We look forward to the completion of this badly needed work and hope that it will encourage others to write beetle faunas for other areas.

ROSS H. ARNETT, JR.

Wandering Through Winter. Edwin Way Teale. Photographs by the author. Dodd, Mead, 1965, price $5.95.

The American landscape and its natural history have been written about hundreds of times, by dozens of authors, but seldom with the skill commanded by Edwin Way Teale. For the past twenty years Teale and his wife have been exploring and chronicling the changing character of America through the four seasons. Their record of this experience began with *North With the Spring* (1951) now presents their song of praise to Winter. This book, like each of the three previous volumes of the "American Seasons" series, is really an account of a trip across North America; a winding trek of roughly 20,000 miles from the California coast near San Diego to North of Caribou, Maine, entirely in Winter. The sights, sounds, smells, and friendships of the journey are recorded, and this reader kept wishing he were along.

The book contains a good deal of ornithology, but there are also tales for those particularly interested in botany, or mammals, or insects, or simply in scenery. I particularly enjoyed the sections about riding in a small boat near migrating whales off the California coast, the white squirrels of Olney, Illinois, and the hibernating poorwill, and those about people such as Dr. Edmund C. Jaeger, dean of American desert naturalists, bird watcher Connie Hagar, and "the snowflake man," Wilson Bentley. The photographs are superb, meeting Teale's usual high standard.

Counter strains of enjoyment and regret run through the narrative; enjoyment of the natural beauty of America, and regret at what is being done to it. We are reminded of the fate of the American eagle and the whooping crane, and Teale writes of the ambivalence of trying to escape to a natural, unspoiled world while riding in an automobile which is dependent on conveniently spaced gas stations. Let us hope that there will still be many seasons in which travelers such as the Teales will be able to take a trip like this one and find as much natural beauty to delight them.

DAVID C. MILLER

NOTES—

Help for Ailing Caterpillars?

Anyone who raises Lepidoptera has probably had the experience of losing a large number to disease. This can be frustrating and disappointing if an ambitious program is interrupted by such mischance. This method, which I tried one summer with a few saturnid moths, is reported in the hope that it may be helpful to others.

In June, 1961 I had received about two dozen cecropia eggs and was raising the caterpillars in sleeves on wild cherry trees at my summer cottage in Bucks County, Pennsylvania. In this method, a bag is made of lightweight muslin or netting. The eggs are placed in the bag and the bag is arranged around a terminal branch of a tree with the mouth of the bag tied tightly around the branch. In this way, the hatching larvae have a supply of fresh leaves without the chance of escaping and they are protected from predators. Since I am only at the cottage on weekends, I could care for the larvae only 2 days a week. The larvae were just beginning to hatch in the middle of June when our family departed on a 2-week vacation trip. The larvae were given to a friend, who continued their care in Connecticut while I was away.

When I returned and my friend gave me back the larvae on July 7, I was appalled to find that they had become infected with a disease. During this period, my friend had them all in a large container and had fed them on oak, willow, maple, and wild cherry leaves, all of which they ate interchangeably. Presumably they had picked up the disease from the leaves, or from the fecal contamination of their food. More than half were dead and most of the rest dying. The remaining half dozen I took back to Pennsylvania the following weekend. However, I decided to try an antibiotic treatment before returning them to the sleeves on the wild cherry trees.

Most department stores or pet shops carry an antibiotic, "petmycin," for use with small birds; about a half dozen pellets to a package. The resulting solution disintegrates quickly, so it is necessary to prepare a fresh solution for each treatment. I took one pellet and dissolved it in water according to the directions. I then immersed a few leaves of wild cherry in the solution until their surfaces were entirely covered by the fluid. The leaves were removed from the antibiotic solution, and the excess fluid was shaken off. The larvae were put to feed on these antibiotic-treated leaves, one larvae each in a round, plastic, pint-size food container.

Deciding that I should have a control, I gave untreated leaves to the healthiest, biggest larva, which as yet showed no sign of the disease. The other five larvae received only the leaves which had been immersed in the antibiotic during the 2 days of the weekend. Late Sunday afternoon, before leaving the cottage for 5 days in the city, all larvae were put back in sleeves on the wild cherry trees. Two of these larvae were so far gone that they refused to eat at all, and they died. The other three sick larvae recovered, grew to pupation, and were put away for the winter. The control, the larva fed untreated leaves, also pupated, and it was kept separately for the winter. The following spring the three larvae, which had received the leaves soaked in the antibiotic, emerged as moths, while the "healthy" control larva did not emerge. When I broke open the pupal case, there was nothing inside.

It would be interesting to know of similar or different techniques which others have used to help ailing caterpillars.

Alice L. Hopf

MEMBERSHIP OF NEW YORK ENTOMOLOGICAL SOCIETY

The names are arranged alphabetically. The class of membership, other than regular member, is designated by the letter in parentheses: H—Honorary, L—Life, S—Sustaining, St—Student.

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Recent Publications

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Insect Sex Attractants. Martin Jacobson. Interscience Publishers, New York, $7.75, 154 pp., 1965.

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Chromosomes from Testicular Preparations of Lepidoptera. Lee D. Miller and Susan M. Miller. Science, **152:** 529–630, illus., 1966.

Pteridines of the Fat Body of a Mutant of *Drosophila melanogaster.* C. P. Wright and E. W. Hanly. Science, **152:** 533–535, 1966.

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Myiasis in Man and Animals in the Old World, A Textbook for Physicians, Veterinarians, and Zoologists. F. Zumpt, Butterworths, Washington and London, $26.00, 267 pp., 1965.

Scolytid Beetles Associated with Douglas Fir: Response to Terpenes. J. A. Rudinsky, Science, **152:** 218–219, 1966.

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The Accessory Burrows of Digger Wasps. Howard E. Evans. Science, **152:** 465–471, illus., 1966.

Proceedings of the New York Entomological Society

(Meetings held in Room 129 of the American Museum of Natural History unless otherwise indicated)

Editor's note: The following is the abstract of the talk of the same title which was given at the May 4, 1965 meeting. It was received too late for the **Proceedings** published in **73**(3): 188, the September, 1965 issue of the **Journal.**

The Biology of Parasitic Copepods

In both *Lernaea cyprinacea*, a freshwater species, and *Lernaeenicus polyceraus*, a marine species, the parasitic females are anchored in the host's tissues. These two morphologically similar species are placed in the same order (Caligidae) as *Caligus rapax*. Both sexes of the latter are parasitic, but are capable of moving freely over the surface of their marine hosts. Although *C. rapax* is morphologically distinctly different than either of the other species, life history studies indicate marked similarities with that of *Lernaeenicus polyceraus*.

Both of the marine species have as a part of their cycles a larval stage, the chalimus, attached to the host by a secreted frontal filament. Such a structure is absent in the freshwater form, the larvae adhering to the host only by means of the maxillipeds. This allows movement about the host and transfer to new hosts. Transfer between hosts is facilitated by the low degree of host specificity shown by the larvae of *Lernaea cyprinacea*. In contrast, the larvae of both of the marine species are highly specific. Only a single host species is known to be capable of supporting development of *Lernaeenicus polyceraus*. All three species are capable of completing the life history on a single host, but the involvement of more than one host is probably common. Also, the three species pass through the same free-swimming stages, but the marine forms develop in a third of the time necessary for the freshwater parasite.

Thus, the life histories of parasitic copepods seem to be adaptations to particular habitats. While morphology may indicate relationship between species, life histories may vary considerably.

Robert Shields

Meeting of October 5, 1965

President Jerome Rozen presided; 21 members and 3 guests were present. Dr. Dennis O'Brian of Seton Hall University in New Jersey, proposed for membership at the last meeting, was elected and Mrs. Beatrice Vogel, a student at Yale University working on the systematics of spiders, was proposed for membership. Dr. Rozen complimented the Committee on the Bylaws Revision on its work and announced that copies were ready for mailing to the members for discussion at a forthcoming meeting.

Program. **Summer Activities of Members.** Dr. Rozen opened the program by exhibiting living specimens of euglossinid bees from Trinidad. He discussed a recent article in Life magazine on an African subspecies of the common honey bee which had been introduced into South America and is causing havoc there. Miss Alice Gray announced that the Junior Society went on an overnight trip in June, primarily to do black-light collecting. They have now had their first meeting of the fall, and have 10 active members, 1 candidate, and 4 prospective members. She showed a "railroad worm" or luminous larviform female of a phengoid beetle, and a children's insect book in Japanese. Miss Iona Deur showed some drawings of insects. Mr. Albert Poelzl has been tape recording some insect sounds. Dr. Stanislaus Bleszynski, a Polish lepidopterist specializing in the Crambinae, was introduced by Dr. Alexander Klots. Dr. Bleszynski spent part of the summer in Ontario collecting Lepidoptera and Trichoptera

and found *Cicada bipunctulata*, not previously recorded from North America. He is the author of a section in the *Microlepidoptera Palaeartica* which was exhibited. Dr. Asher Treat invited members to attend the Biology Colloquium of the City College for this fall semester which is on **The Sensory Physiology of Arthropods.** Dr. Edwin W. Teale gave some observations on the wildlife near his home, including 52 species of birds sighted this summer. His latest book, **Wandering Through Winter**, was exhibited. Mr. Bernard Heineman collected moths in light traps for part of the summer. Mrs. Patricia Vaurie did some collecting in Pennsylvania, but reported poor results. Dr. Klots showed some caterpillars of *Dasychira* (Lymantriidae) which are apparently larvae at the wrong part of the season. He mentioned that Mrs. Alice Hopf has published a book on the Monarch butterfly. Dr. John Schmitt told of his current interest in the maritime earwig. Mr. Rutkowski observed local colonies of butterflies. Mr. Arthur Bordes showed material collected in the tropics. Dr. David Miller commented on 2 weeks spent in Jamaica. Dr. Richard Fredrickson told of his hike along the Appalachian Trail from Bear Mountain to central Pennsylvania. Mr. John Stamatov made observations on *Cicindela olivacea* in the Florida Keys. This insect is a recent arrival from Cuba. The Robert Buckbees took a trip to Hawk Mountain, and they have recently reared some *Romalea*, a lycosid spider, and some *Hydrophilus* from Florida.

DAVID C. MILLER, *Secretary*

MEETING OF OCTOBER 19, 1965

President Rozen presided; 25 members and 13 guests were present. Mrs. Beatrice Vogel was elected and Mr. Pat Bartolone was proposed for membership. Dr. Roman Vishniac exhibited an entomological book published in 1557. Dr. John Schmitt noted the passing of Dr. Paul Mueller at Basil, Switzerland, who was the discoverer of the insect killing properties of DDT and the Nobel Laureate in 1948 for medicine and physiology. Mr. Lucien Pohl introduced Dr. Claude Lemaire, a lepidopterist from Paris, France, who is visiting at the Museum.
PROGRAM. **New Findings on Legionary Ant Research.** Dr. Theodore C. Schneirla of the Department of Animal Behavior of the Museum compared the behavior of the *Eciton*, *Neivamyrmex*, *Aenictus* genera, in which the cyclic alternation between statory and nomadic phases is regular, and *Anomma*, *Labidus*, and others in which this alternation is irregular and the stimulus to the change of phase is the condition of the brood. The talk was illustrated with slides.

DAVID C. MILLER, *Secretary*

November 2, 1965, no meeting—Election Day

MEETING OF NOVEMBER 16, 1965

Doctor Rozen convened the meeting; 31 members and 4 guests were present. Mr. Pat Bartolone was unanimously elected to membership. Dr. Elsie Klots presented the proposed revised Bylaws which had been previously mailed to the members. These were discussed section by section and some small changes in wording was made. Voting for the acceptance of the Bylaws will take place at the meeting of December 7. Dr. Rozen spoke of the recent work of the Executive Committee of the Society; in addition to approving the proposed new Bylaws, it has been considering details of a proposed merger with the Brooklyn Entomological Society.
PROGRAM. **Tropical Biology and Passalid Beetles as Ecological Indicators.** Dr. Janus Roze of the Universidad Central de Venezuela in Caracas described many of the ecologically different areas found in Venezuela and indicated the presence of different species of Passalidae in these areas. His talk was illustrated with slides.

DAVID C. MILLER, *Secretary*

MEETING OF DECEMBER 7, 1965

President Rozen called the meeting to order in Room 319. Although 25 members and 33 guests signed the attendance book, there were over 100 people present. Mr. J. N. L. Stibick of the Catholic University of America, Washington, D. C., was proposed for membership. Dr. Elsie Klots of the Bylaws Revision Committee reported on the rewording of Article X, Sections 3 and 6. It was then moved by Dr. Ruckes and generally seconded that these proposed Bylaws be accepted as the Official Bylaws of the Society. The motion was unanimously passed. A vote of thanks was made to this Committee, which consisted of Mr. Bernard Heineman, Dr. Asher Treat, and Dr. Elsie Klots, the chairman. Some guests were introduced: Miss Ragna Tischler, daughter of a Professor of Entomology at Kiel, Germany; Mr. William Howe of Ottawa, Kansas, who showed several paintings of Lepidoptera which he had done; Mr. Hobart Van Deusen of the Department of Mammals at the Museum.

PROGRAM. **20,000 Miles Through Winter.** Dr. Edwin Way Teale, the noted natural history author and long-time member of the Society illustrated his talk with excellent color slides. He took us on a trip through North America from the Southern California coast to New England during the winter season. This was the material-gathering trip for his recently published book **Wandering Through Winter.** The talk was excellently received.

DAVID C. MILLER, *Secretary*

MEETING OF DECEMBER 21, 1965

In the absence of the President, Vice-President Richard Fredrickson presided; 20 members and 6 guests were present. Mr. J. N. L. Stibick was unanimously elected to membership. Dr. Elsie Klots introduced Professor James C. Bradley of Cornell University as a guest. Dr. Fredrickson announced the appointment by President Rozen of the following Committees: Auditing—Mr. John Pallister and Dr. Fredrickson; Nominating—Dr. Asher Treat, Mr. Bernard Heineman, and Dr. David Miller.

PROGRAM. **My Favorite Insect.** This consisted of short discussions of insects by the members. Dr. Fredrickson began by showing a few slides of mites in the hypopal stage, and he commented on the biology of this stage. Dr. Miller discussed the biology of mites of the genus *Sennertia*, which live a hypopodes on carpenter bees and spend the remainder of the life history in the nests of these bees. Mr. Michael Orlove discussed observations on the biology of the carpenter bee, *Xylocopa virginica*. Dr. A. B. Klots commented on the increase in melanism in recent years in the moth, *Panthea furcilla* (Grote) in the eastern United States. Mr. Daniel Schweitzer showed some attractive Riker mounts of insects.

DAVID C. MILLER, *Secretary*

Meeting of January 4, 1966 cancelled because of the New York City transit strike

MEETING OF JANUARY 18, 1966

President Rozen called the Annual Meeting to order in Room 319; 27 members and 25 guests were present. Dr. Lucy Clausen, in her report as Editor of the **Journal**, stated that the first full year with the new printer, the Allen Press, has resulted in a substantial reduction of the publication costs. The printer uses a billing system based on a flat page charge. This makes it possible to readily allocate costs for illustrations and tabular material if charges to authors are necessary. Several authors have paid for the publication of their papers from grant money, and a commercial firm has contributed to the costs of one of the longer papers. The **Journal** for this past year has contained 248 pages, representing 33 papers, book reviews, proceedings, etc. The papers include eight orders of insects and a few general papers. Waiting time for publication is now 3 to 6 months after receipt of the paper. Manuscripts are solicited. Dr.

Asher Treat reported for the Nominating Committee. He explained that the provisions in the new Bylaws concerning trustees required the election this year of four to serve staggered terms. The following slate of officers was nominated and elected:

President—Dr. Richard Fredrickson
Vice-President—Dr. Kumar Krishna
Secretary—Mrs. Lucy Heineman
Assistant Secretary—Mr. Albert Poelzl
Treasurer—Mr. Raymond Brush
Assistant Treasurer—Mrs. Patricia Vaurie
Trustees—One-year term, Dr. Alexander B. Klots
Dr. John B. Schmitt
Two-year term, Dr. Jerome Rozen, Jr.
Mr. Robert Buckbee
Dr. Asher Treat
Dr. Pedro Wygodzinsky

Dr. Richard Fredrickson, the newly elected President, took over the meeting. The outgoing officers were accorded a vote of thanks for their very fine services rendered to the Society.
Dr. George Steyskal of the U. S. Department of Agriculture was introduced as a guest along with several plant quarantine inspectors who were in New York taking courses in inspection procedures.
Miss Margaret Pogany of the Washington Square Press was nominated for membership.
The following memorial resolution for Dr. Herbert Ruckes, prepared by Dr. Asher Treat, was read:

> The death of Herbert Ruckes on December twenty-third, nineteen sixty-five, leaves the New York Entomological Society both saddened at the personal loss of a dear friend, and dismayed at the unfillable vacancy created in our councils by his passing. We recall with pride and gratitude the many distinguished papers that he contributed to our **Journal**, the rich humor and experience with which he enlivened so many of our meetings, and the years of devoted service that he gave us both in the offices that he filled and in his unfailing helpful relations with his fellow members. Few can reckon or remember all that he did for us, but all of us know how much we shall miss his wisdom and companionship. We have been honored and strengthened by his long association with us, and we shall always remember him with thankfulness and with affection.
>
> Be it resolved, therefore, that the Society rise in tribute to the memory of Dr. Ruckes, that this resolution be spread upon the minutes, and that a copy be sent to the surviving members of his family.

The members stood for a moment of silence in his memory.
PROGRAM. **Secular Genetic Changes in Natural Populations of *Drosophila pseudoobscure*** by Dr. Theodosius Dobzhansky of the Rockefeller University. (An abstract follows.)

DAVID C. MILLER, *Secretary*

Secular Genetic Changes in Natural Populations of *Drosophila pseudoobscura*.

Populations of *D. pseudoobscura* were sampled during the summers of 1964 and 1965 in 17 localities in British Columbia, Washington, Oregon, Utah, Colorado, Arizona, New Mexico, and Texas. The variation in the gene arrangement in the third chromosome was studied. The data so obtained are compared with those for California and Nevada populations sampled in 1963, and with older samples taken in 1957 and in 1940 or thereabouts.
With few exceptions, the populations of the Pacific Coast states underwent similar changes

between 1940 and 1963–1965, certain gene arrangements having grown more and others less frequent. No such systematic changes occurred in the populations living further to the east. In some localities the genetic composition of the populations remained unchanged; in other localities considerable changes were observed, but these changes were different in kind in different populations.

The causation of the genetic changes observed remains problematic.

Theodosius Dobzhansky

Necrology

HERBERT RUCKES (1895–1965)

The New York Entomological Society records with regret the death of Dr. Herbert Ruckes on December 23, 1965, at the age of 70.

Born in New York City, Herbert Ruckes attended the city public schools. He received the degrees of Bachelor of Science and Master of Arts from Cornell University in 1917, and that of Doctor of Philosophy from Columbia University in 1929. He served as Instructor in Biology at Grove City College, Pennsylvania from 1917–1919. In 1920 he was appointed to the staff of The City College; upon his retirement in 1954 he was appointed Professor Emeritus.

Professor Ruckes' research was in the widely divergent fields of chelonian osteology and the systematics of the Pentatomidae, a worldwide family of hemipterous insects. A major work on chelonian osteology was awarded the A. Cressy Morrison prize of the New York Academy of Sciences in 1928, and was published by the Academy. He was for many years a Research Associate in the Department of Entomology of the American Museum of Natural History, and was a National Research Foundation Fellow from 1959 through 1961. He worked steadily and faithfully at the museum until his last illness. In his research on the pentatomids, he did fieldwork in Central America and the Rocky Mountains, and visited the major museums of Europe studying the collections and the types of pioneer entomologists.

In our own Society, Doctor Ruckes had served on many committees and in many capacities: Vice-President—1935, President—1936, many times a member of the Executive Committee, at the time of his death he was on the Publications Committee. He was an active member and had served in offices of a number of other scientific societies.

He is survived by his widow, the former Frances Anna Nillo, and a son, Herbert Ruckes, Jr.

By his keen interest and accomplishments in biological research, his broad knowledge, his cheerful disposition, and his ready cooperation, Herbert Ruckes set an inspiring example for his colleagues and associates in the New York Entomological Society.

INVITATION TO MEMBERSHIP

The New York Entomological Society was founded in 1892 and incorporated the following year. It holds a distinguished position among scientific and cultural organizations. The Society's **Journal** is one of the oldest of the leading entomological periodicals in the United States. Members and subscribers are drawn from all parts of the world, and they include distinguished professional naturalists, enthusiastic amateurs, and laymen for whom insects are only one among many interests.

You are cordially invited to apply for membership in the Society or to subscribe to its **Journal** which is published quarterly. Regular meetings are held at 8:00 P.M. on the first and third Tuesdays of each month from October through May at the American Museum of Natural History, the headquarters of the Society. A subject of general interest is discussed at each meeting by an invited speaker. No special training in biology or entomology is necessary for the enjoyment of these talks, most of which are illustrated. Candidates for membership are proposed at a regular meeting and are voted upon at the following meeting.

CLASSES OF MEMBERSHIP AND YEARLY DUES

Active member: Full membership in the Society, entitled to vote and hold office; with **Journal** subscription $9.00

Active member without **Journal** *subscription* 4.00

Sustaining member: Active member who voluntarily elects to pay $25.00 per year in lieu of regular annual dues.

Life member: Active member who has attained age 45 and who pays the sum of $100.00 in lieu of further annual dues.

Student member: Person interested in entomology who is still attending school; with **Journal** subscription 5.00

(Student members are not entitled to vote or to hold office.)

Student member without **Journal** *subscription* 2.00

Subscription to **Journal** *without membership* 8.00

APPLICATION FOR MEMBERSHIP

Date.....

I wish to apply for ..... membership (see classes above).

My entomological interests are: .....

If this is a student membership, please indicate school attending and present level.

Name .....

Address .....

.....

(Zip Code *must be* included)

— Send application to Secretary —

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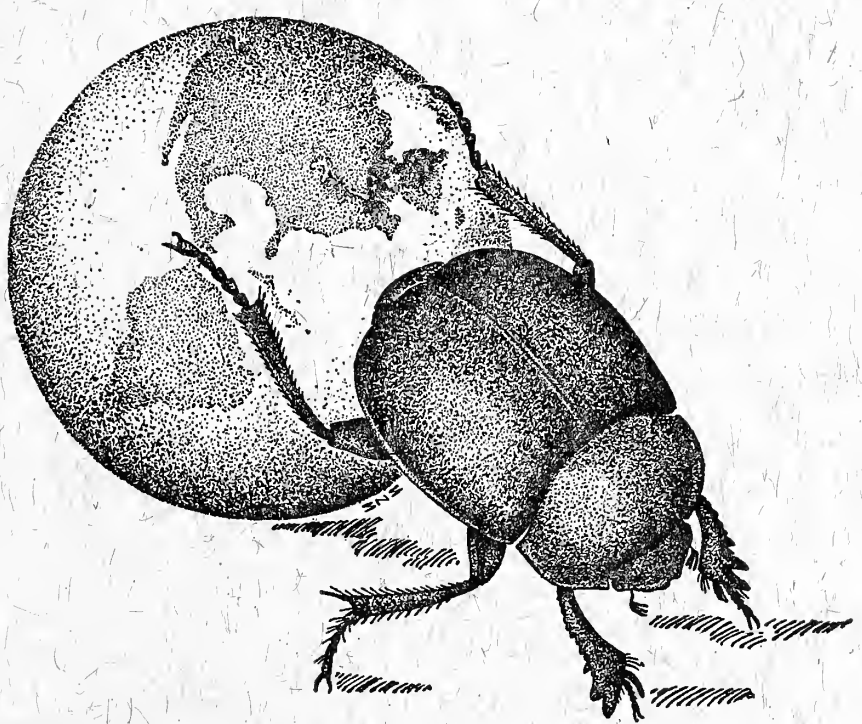
Journal

of the

New York Entomological Society



Devoted to Entomology in General

The
New York Entomological Society

Organized June 29, 1892—Incorporated February 25, 1893
Reincorporated February 17, 1943

The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P.M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 79th St., & Central Park W., New York 24, N. Y.

Annual dues for Active Members, $4.00; including subscription to the Journal, $9.00.

Members of the Society will please remit their annual dues, payable in January, to the Treasurer.

Officers for the Year 1966

President, Dr. Richard Fredrickson
College of the City of New York 10031

Vice President, Dr. Kumar Krishna
American Museum of Natural History, New York 10024

Secretary, Mrs. Lucy Heineman — 115 Central Park West, New York 10023

Assistant Secretary, Mr. Albert Poelzl
230 E. 78th Street, New York 10021

Treasurer, Mr. Raymond Brush
American Museum of Natural History, New York 10024

Assistant Treasurer, Mrs. Patricia Vaurie
American Museum of Natural History, New York 10024

Trustees

1 Year Term

Dr. Alexander B. Klots — Dr. John B. Schmitt

2 Year Term

Dr. Jerome Rozen, Jr. — Mr. Robert Buckbee

Mailed September 15, 1966

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CONTENTS

David Bruce (1833–1903) and Other Entomological Collectors in Colorado*

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Abstract: Brief comments upon the men who collected insects before Bruce: W. S. Wood, Jr., W. J. Howard, Jas. Ridings, A. A. Allen, Lt. MacCauley, and T. L. Mead preface a biographical sketch of David Bruce, well-known as a collector of Colorado insects from 1883 to 1897. The information about Bruce was garnered from letters written by him to Herman Strecker and newspaper articles published at the time of his death in Brockport, New York. He is best known for his cooperation with W. H. Edwards in studies of the life histories of high altitude butterflies.

Thirty-five years ago, when my interest in the butterflies of Colorado was aroused, two names were prominent as early collectors of specimens for the students of these insects. These were Theodore Lutrell Mead and David Bruce. Mead had spent the summer of 1871 in the mountains of central Colorado as a quasi-member of the Wheeler Survey party. Later he prepared the text for the portion of Volume 5 of the reports of that Survey that is devoted to Lepidoptera. In 1934 and again in 1956 I published notes about Mead's work in Colorado, including a fairly detailed itinerary of his travels based upon his collection. In my continuous search for information about the early naturalists who worked in Colorado I failed to discover much that was useful about David Bruce. I did find bits and pieces about other early naturalist-explorers—William S. Wood, Jr. who visited this part of Kansas Territory in 1859 (Brown 1957a); Winslow J. Howard, a jeweler-naturalist who followed the mining camps of the west and lived in Denver City and Central City during the early 1860's (Brown 1957a); James Ridings who was here in the summer of 1865; A. A. Allen in 1871 (Brown 1957b); and Lt. McCauley who performed a reconnaisance of the extreme southwestern portion of the state in 1877 (Brown 1958). There are others about whom I have gathered a few notes, but not enough to say more than that they visited the state.

Wood was a youngster when he was commissioned by the Entomological Society of Philadelphia to explore and collect in the Rocky Mountains, and his insects are so-labeled, "Rocky Mts." It was through examination of his bird-skins and their documentation that I discovered where in the Rocky Mountains he had spent the summer of 1859. He ranged perhaps no more than thirty or thirty-five miles from Denver spending much of his time in the foothills to the west and southwest of the budding city. He collected insects for the Society's

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cabinet and members and bird-skins for the Academy of Natural Sciences of Philadelphia.

Howard had been employed by Tiffany in New York as a jeweler and watchmaker. In 1860 he appeared in Denver. In the **Western Mountaineer** for July 19 of that year appeared this notice: "Watches and Jewelry—We solicit your special attention to the advertisement of W. J. Howard, Esq., which appears in this issue. Mr. Howard was formerly in the leading establishment in his line on the continent—that of Messers Tiffany & Co., New York City—and we are able to assure our readers from personal knowledge that any work entrusted to him will be skillfully and properly done. He has a rare collection of the natural curiosities of the Rocky Mountains, which will be found very entertaining to those interested in natural science. Give Mr. Howard a call, and if you have any interesting specimens of the mineral wealth of the country, take them with you."

Howard's place of business was on the east corner of Larimer and F. Streets in Denver. He probably moved to Central City in late 1861. He gave that city as his address in his application for membership in the Entomological Society of Philadelphia in March of 1862. In Central City he established the firm of Howard and Colony, manufacturing jewelers. Apparently Howard returned to the East in 1865. A note in the **Rocky Mountain News** of February 25, 1866, stated that he was living in Brooklyn and had married. In the fall of that year, according to the **News** for October 15, Howard passed through Denver on the way to Montana. Then I lose him until the 1870's when he was established in Prescott, Arizona. Recently I came across a lead to him in Leadville at a later date, 1879, but as yet have not been able to pin down his activities.

Ridings was a member of the Entomological Society of Philadelphia, an Englishman who by vocation was a house builder and cabinet maker. Apparently he was successful. In Cresson's history of the society this appears: "rapid increase . . . made it necessary to procure more convenient and commodious quarters . . . This need was promptly supplied by James Ridings, who generously erected for the sole use of the society, a two story brick building on the northwest corner of 13th and Rodman Streets. . . ." There is no evidence in the treasurer's accounts that the Society paid anything for the erection of the building or for rent of it.

The journey into Colorado was made by stage up the Platte River. Ridings was passenger in one of the few coaches that passed through unmolested by the Indians in 1864. By the time that he returned to the East the troops had the Indians in control along the Platte. While in Colorado Ridings' activities took him west to Empire City and north to Burlington, as Longmont then was called. One result of Ridings' collecting in Colorado was the first published summary of knowledge of the butterflies of Colorado written by Tryon Reakirt and published in 1865.

The first collector to venture deeply into the mountains was Theodore Mead in 1871. At the expense of his family and of his future father-in-law, W. H. Edwards, Mead joined the Colorado party of the Wheeler Survey. His wanderings carried him west to the Independence Pass area, north through Middle Park and south to Canyon City. The result of his work about doubled our knowledge of the butterflies of Colorado, if not of all of the Rocky Mountain Region. Outside of Colorado, only Constantin Drexler, a taxidermist from the Smithsonian, had previously done any collecting in southwestern Wyoming; and John Pearceall, a member of the Entomological Society of Philadelphia, who had accompained the Mullen Expedition in the Bitterroot Mountain region, had contributed to our knowledge of these insects. The two had spent time in the late 1850's collecting everything that they could lay their hands upon from minerals and fossils to plants and animals.

Lt. Charles McCauley was dispatched in the summer of 1877 to make a survey of the roads in southewestern Colorado. At S. F. Baird's suggestion that "natural history collections made would be of interest" he sampled the area from Tierra Amarilla to the site of Durango travelling via the old Spanish road.

It will be noticed that none of these naturalists spent more than a few months in Colorado. It was not until David Bruce arrived on the scene in 1883 that we find a man who, year after year, searched the state for moths and butterflies. This he did until the turn of the century. It is only in the last few months that I have found any thing about Bruce except that he had collected this or that specimen. In the "Strecker hoard" in Chicago, which I am studying for the Chicago Natural History Museum with National Science Foundation support, I found 103 letters written by Bruce to Herman Strecker. What I retail from now on has been gleaned from those letters and odds and ends that I have picked up elsewhere.

Bruce wrote "newsy" letters to Strecker, although he had never met the man. The correspondence between the two started in 1882 and ended in 1897. David Bruce was born in Perth, Scotland, on June 13th, 1833; this he told Strecker in a letter dated January 30, 1883. In it he stated "my family removed to the City of Norwich, Norfolk, England, when I was less than a year old. I have since been knocking about in different parts of the world for 49 years." He early developed an interest in birds and butterflies and painting. In 1861, he fortuitously met one of the "greats" of English entomology, William C. Hewitson, noted for his beautiful precise illustrations of insects. Hewitson urged Bruce to develope his art and to devote his life to scientific illustration. Bruce did not wholly follow the advice. Later in 1861 Bruce set off for New Zealand. Let me quote him (10iv83) in reply to Strecker's query about the insects of those islands: "I am sorry to say I never captured any insects except fleas and bedbugs. I have no pleasurable recollections connected with my journey there. I went there first simply because my girl and her people went, but after being in the same vessel

with her for three months I came to the conclusion I didn't want her, so went to Australia where I didn't stay long for I was anxious to get back." "My second voyage was just after the death of my first wife. My brother was located in New Zealand. I collected birds only and done a little Agency in fine colors and paperhangings." Later on there appears another tid-bit linking Bruce to New Zealand. "I perhaps mentioned I had a son in New Zealand. My brother there had seven daughters (his second wife went in for twins) he implored me to send him one of my boys, he would send two girls for it in the way of trade. As my eldest son was willing I sent him but as I had some of my own declined the girls. Well, the luck of the family clung to poor Teddy. The vessel was lost and nothing heard of him for 15 months when he was brought back to London, having been picked up by another ship and been around the world. His passage was renewed without additional expense and he went out without any other adventures."

Bruce married Rachel Marshall at Graves End, England, in 1871 and was in Paris at the time of the Seige. When he arrived in this country I do not yet know. I suspect about 1880. He settled in Brockport, New York, and established a business in which his sons joined him. Bruce put to work his painting ability and journeyed around western New York painting frescoes for churches, hotels and mansions. He was a good business man, and did not object to doing just straight interior house painting. He was successful enough in this area to be financially free to take annual trips to Colorado to study and collect. The first of these trips was in 1883. His ticket, first class, from Rochester to Denver on the Rochester & Pittsburg and the Burlington cost $50 for the round trip. He was able to stay only 8 days since he was called back early in July to do the interior of the Brockport Episcopal Church. In that short time he prepared 200 bird skins and caught several hundred butterflies and moths. This short first stay was made at Buffalo Creek in the Platte Canyon where he lived with an English family summering there. They were the W. G. Smith family. En route to Colorado Bruce had stayed a short time in Red Cloud, Nebraska. He had been injured falling from a scaffold about a month before his departure from the East and needed to rest en route. He made a similar stop on his hurried trip home. In late July he was again at Buffalo Creek! This time he stayed through August. In the family were young son and daughter who went with Bruce on his collecting trips. He left collecting gear with the teen-agers when he finally returned to the east.

During the winter Bruce bought a copy of Mead's report on the butterflies he had collected in Colorado in 1871. This provided him with information that he had previously lacked and he began making plans to return to our state. In mid-July, 1884, he wrote from Denver, "I returned to Denver yesterday after a sojourn of a couple of weeks in the hills. The season is very backward this year. The roads in the mountains are impassible from deep snows, yet on the whole

I don't think I have much to grumble about with my success in collecting Lepidoptera. My business venture in Colorado is at present at zero or so near a failure that I can hardly hope much of it, in fact everything here is very dull, the mining prospects are poor and nothing goes down with the monied men but the cattle business . . . I go up to the mines again on Thursday and shall stay probably two or three weeks at a high elevation (10 to 12,000 feet) and shall put in all the time I can collecting."

He returned from the high country on July 28. He had been on the summits of the Hayden Mountains at 12,000 feet. Now he planned to work the lower country at about 8,000 feet, to the west of Denver. On the 19th of August, just before he set out for home, he wrote Strecker, "I had the most cursed luck last week imaginable, for I and a friend borrowed a horse and wagon for a few days to go off on an exploring expedition for about 25 miles. On the second day out we drowned the horse and almost ourselves in crossing a stream. Had to walk 7 miles in wet clothes over the most devilish road in an awful storm of thunder, lightning, wind and hail. Had to pay 80 dollars for the horse." The return address for this letter was "c/o H. Tammen, Rocky Mountain Museum, 454 Larimer Street, Denver, Colo." During this stay Bruce's base was "two miles from Denver, right by the foothills."

On this trip Bruce had met with a rancher operating on the Cache la Poudre who was a kindred soul in loving the out-of-doors and collecting specimens. He quoted part of a letter from this cattleman-nimrod, "My friend is one of the best and most fearless hunters living and would run himself nearly to death to catch a good butterfly or shoot a rare bird for me, but he cannot get hold of the names—he tells me he shot a splendid 'White Pilgrim' the other day. That is as near as he gets to Pelican. But as long as he lets me have them he can call them what he likes."

During the summer of 1884 when in the high country Bruce made his headquarters at or near the Whale Mine in Hall Valley. When writing about plans for the next summer he told Strecker "The proprietor of the silver mine there refers in glowing terms to my visit and hopes to see me again early next summer when he will try "and make things pleasant." I visited Bruce's cabin above the Whale Mine several times in the 1930's and caught there many of the species first described from those barren highlands from Bruce's specimens.

On March 16th, 1885, Bruce wrote to Strecker, "My son in Cheyenne has a contract that will oblige him to visit all of the Forts on the Mexican and Canadian borders during the next two summers. He has invited me to go with him which I have made up my mind to do as I shall get lots of free riding and liesure to entomoligize. . . . We start in middle April." Bruce's wonderful summer was doomed. In a letter of November 10 we read, "This year to me has been an utter blank entomologically and worse than that personally and financially. My son died June 13 of pneumonia. I returned from Cheyenne to find my wife had

fallen down the cellar stairs from stumbling on a kitten and hurt herself severely."

Shortly after this Bruce and Strecker had a set-to, as appears usual with all of Strecker's correspondents. From here on there no longer are gossipy and newsy letters. Bruce collected in Colorado during 1886 and 1887, principally for W. H. Edwards who quoted Bruce extensively in "Butterflies of North America," a sumptuous three-volume work. Bruce had been so successful collecting in the high country of Colorado that his material now is found in the principal museums of the world. For Edwards he collected eggs and larvae and between the two of them we know more about high altitude butterflies of Colorado than of any other high country in the world. In 1888 Bruce did not visit the state but stayed at home busy at his decorating business.

In 1889 and through the 1890's Bruce's letter-drop in Denver was George Eastwood at Taylor's Free Museum on Larimer Street. He wandered all over the western half of the State. Dr. Alexander Shaw of Denver and with interests in the D & RG Railroad saw to it that Bruce had 1,000-mile passes to carry him about in Colorado and Utah. In return Bruce built "pictures" composed of tropical butterflies mounted behind glass for Shaw. In 1892 Bruce was commissioned to gather an exhibit of moths and butterflies of the State to be part of the Colorado State exhibit at the Chicago World Fair. This he did, being given free travel and a good salary for his work. The World Fair committee paid half of these costs and Colorado Agricultural and Mechanical College at Fort Collins the other half.

One letter written March 26, 1891, gives us a verbal picture of Bruce. Strecker had written to him asking for a photograph. Bruce replied "have not had my 'picter' taken in America at all—but soon will—I am old and grey (56) but very active, eyes and teeth as good as ever—5 7½—weigh 200 pounds—fresh ruddy complection yet long grey beard— now you ought to know me when I drop on you as I shall one day." Bruce never did visit Strecker.

During 1892 and 1893 while working at Glenwood Springs Bruce became very much interested in what he believed to be natural hybrids that he was catching. This was a biologically moot point that many naturalists denied occurring. Later, in 1894, his patron W. H. Edwards joined him in this study at Glenwood Springs and the facts were proven conclusively. In connection with these studies Bruce wrote Strecker, who questioned natural hybridism, "I am afraid hybridism is common in Colorado. Whoring is a recognized institution in all mining districts and the insects have taken to it as well as the genus Homo."

Early in 1893 Bruce sold his private collection to the University of Wisconsin at $100 per thousand specimens. This was Bruce's going price to all comers. The size of the Wisconsin purchase made no difference. Material poured from Brockport to Madison until in late 1895 the University called a halt. They had run out of room in the museum! Two families were yet to be shipped, the

smaller Noctuids and all of the Geometrids. I wrote to Dr. Shenefelt at Wisconsin to learn more about this collection and to find out whether or not they had received the rest of it. He had the University archivist, Mr. J. E. Boell, look into the matter. His reply to Dr. Shenefelt was, "We have searched high and low for information on this collection, but the only thing that we could find was that the Regents authorized expenditure of funds for a wire partition up in Science Hall to hold the butterfly collection. We could find nothing in the financial records that indicated a payment to Bruce for this collection. We have no letters between Bruce and Owen." From the forgoing it sems probable that Owen himself was paying for the collection and that it rests, unmarked, among the Owen Collection.

The Owen Collection no longer is at the University of Wisconsin. A recent letter from Mr. William Sieker, of Madison, Wisconsin, reads in part "When I came to school here in 1931, Owens Collection was being shipped to the U. S. National Museum. I was hired (at about 50¢ an hour) to pin the insects more securely into the boxes. I was pretty green then, and was overwhelmed with the size of his collection. It was big—but lacked labels by the thousands, as Owen, I guess, was not too particular about data. This I gathered from what others have said and what short opportunity I had to observe his collection." Owen probably used a collection method that was in vogue during the late 19th Century. This was to put all of the data on a general label at the head of each series and none on the specimens themselves. A variant of this was to label the first specimen of a series with a pin-label containing the locality data and follow this specimen with the rest of the series without labels. Once such a collection is disturbed it is hopeless to try to label the specimens correctly.

Bruce was now in his sixties. He did not take to the field in 1895 nor in 1896. He did return to Colorado in the following year and joined forces with John T. Mason. This proved unsatisfactory to Bruce in many ways. He did not get on well with Mason in the field and the two men had totally different ideas about how to split the monetary rewards for the work. The Mason Collection is in the Denver Museum of Natural History.

I know little of Bruce from this time on until his death on September 24, 1903. Fifty years after that event Mr. A. E. Elwell, well on in his eighties, wrote about Bruce for the **Brockport Republic-Democrat** of November 25, 1954. This article stresses Bruce's ability as a taxidermist and artist. From it I gather that the now almost universally used "habitat group" method for exhibiting specimens in Museums was a creation of Bruce, not Ackley. Bruce's death was a sudden one. The **Brockport Republic** for October 1, 1903, published, "Soon after entering the yard of Mrs. John Sheplar on the Moscow Road in Hamlin, Thursday afternoon, David Bruce fell to the earth and expired before being found. He was seen to enter the yard and a moment later when the family looked

out, Mr. Bruce was discovered on the ground and examination showed that he had died." Bruce is buried in the Lake View Cemetery in Brockport, N. Y.

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Through the courtesy of Mrs. Willis Knapp, Chairman of the Brockport Museum Committee, I received typed copies of the obituary for Bruce and of Mr. Elwell's article cited in the text.

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Vitamin Synthesis by the Symbionts in the Fat Body of the Cockroach, *Periplaneta americana* (L.)

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Abstract: Determinations were made on the vitamin content of the fat bodies of normal and aposymbiotic cockroaches. Of the 10 vitamins studied (ascorbic, folic, nicotinic and pantathenic acids, biotin, cyanocabalamin, inositol, pyridoxine, riboflavin and thiamine), only 3 (ascorbic, folic and pantathenic acids) were present in considerably larger amounts in the normal fat body. Cultured symbionts were able to synthesize them. The lighter cuticular color, sluggishness and reduced reproductive ability of the aposymbiotic insect may be explained by the absence of these vitamins.

Blochmann (1888), working with the cockroach, *Blatta orientalis*, was probably the first to observe intracellular bacteroids in the fat body of an insect. Glaser (1920, 1930) isolated the organisms, successfully cultured them and classified them as bacteria belonging to the genus *Corynebacterium*. Trager (1952), Peklo (1953), Brooks and Richards (1955a, b and 1956) all agreed that the bacteroids are intracellular symbionts.

Wigglesworth (1929) suggested that the role of the symbionts may be the synthesis of vitamins. He thought that the intracellular microorganisms in the fat body of the tsetse fly, *Glossina*, may synthesize vitamins necessary for growth. Evidence to support this view was given by Fraenkel and Blewett (1943a and b), Blewett and Fraenkel (1944), Pant and Fraenkel (1950, 1954) and Keller (1950), when they showed that insects with intracellular microorganisms did not, and those without them did, require most of the B vitamins in their diet. In addition to the B vitamins, there is evidence that the symbionts might be responsible for the synthesis of ascorbic acid. Filosa (1955) and Cordero (1956) demonstrated that homogenates of the cockroach, *Periplaneta americana*, can synthesize ascorbic acid using most of the D-sugars as substrates. Lisa (1958) observed that homogenates of the cockroach, *Leucophaea maderae*, synthesized ascorbic acid from D-mannose, and Pierre (1962), that the symbionts present in the fat body of this insect are responsible for this synthesis. Noland, Lilly and Baumann (1949) reported that the symbionts in the fat body of the cockroach, *Blatella germanica,* are largely responsible for the production of folic acid.

The present investigations, which consist of a comparison of the vitamin content of fat bodies of normal and aposymbiotic insects, were undertaken to determine whether vitamins are synthesized by the symbionts of the cockroach, *P. americana*.

TABLE 1. Methods used for the quantitative determination of vitamins in the fat bodies of normal and aposymbiotic cockroaches.

Vitamin	Methods of assay
Ascorbic acid	Spectrophotometric method of Roe and Kuether (1942, 1943) with modifications of Lowry, Lopez and Bessey (1945) and by Mills and Roe (1947).
Biotin	Microbiological method of Pennington, Snell and Williams (1940), modified by the use of *Lactobacillus arabinosus* as given by Strohecker and Henning (1965). Paper chromatographic method of Radhakrishnamurthy and Sarma (1953).
Cyanocobalamin	Microbiological method using *Lactobacillus leichmanii* ATCC 7830, outlined by Strohecker and Henning (1965).
Folic acid	Microbiological method of Capps, Hobbs and Fox (1948).
Inositol	Microbiological method of Stokes, Larsen, Woodward and Foster (1943). Paper chromatographic method of Hough, Jones and Wadman (1948).
Nicotinic acid	Microbiological method of Snell and Wright (1941). Paper chromatographic method of Kodicek and Reddi (1951).
Pantothenic acid	Microbiological method of Pennington, Snell and Williams (1940).
Pyridoxine	Microbiological method of Stokes, Larsen, Woodward and Foster (1943). Paper chromatographic method of Snyder and Wender (1953).
Riboflavin	Microbiological method of Snell and Strong (1939). Chemical method of Scott, Hill, Norris and Hensen (1946).
Thiamine	Microbiological method of Sarett and Cheldelin (1944). Chemical method of Hennessy and Cerecedo (1939).

MATERIALS AND METHODS

The technique employed for rendering the cockroaches aposymbiotic was that of Brooks and Richards (1955a), except that they used a 0.1% antibiotic diet and the insects became aposymbiotic in the second generation; whereas in the present experiments, a 10% antibiotic diet was fed and they became aposymbiotic 120 days from the beginning of treatment. The diet consisted of 80% Gaines' dog pellets, 5% Brewer's yeast, 5% dextrose and 10% of a mixture of aureomycin and terramycin in a 1:1 ratio. The dog pellets were powdered and then mixed with the other ingredients. This food preparation was changed every 5 days to insure the freshness of the antibiotics. Controls were maintained on a diet of Gaines' dog pellets and water. Sub-groups of insects were cultured on diets which were deficient in the specific vitamin to be tested. Histological sections of the fat body were prepared at the end of 60, 90, 100 and 120 days to determine aposymbiosis.

Cultures of symbionts were obtained from the fat body according to the techniques of Begg and Sang (1950) and of Pant, Nayar and Gupta (1957). These cultures were maintained in lactose broth at 30° C.

TABLE 2. Amount of different vitamins found in the normal and aposymbiotic fat bodies of the cockroach. Values are given as amount/gram of fat body. Each is an average of 10 determinations.

Vitamin	Normal			Aposymbiotic		
	Micro-biological method	Chemical method	Chromato-graphic method	Micro-biological method	Chemical method	Chromato-grraphic method
Ascorbic acid		0.2 mg.			0.03 mg.	
Biotin	48.0 mμg.		42.0 mμg.	45.0 mμg.		39.0 mμg.
Cyanocobalamin	28.0 mμg.			26.0 mμg.		
Folic acid	62.0 μg.			9.6 μg.		
Inositol	126.8 μg.		120.0 μg.	159.0 μg.		131.0 μg.
Niacin	408.0 μg.		305.0 μg.	528.0 μg.		420.0 μg.
Pantothenic acid	74.0 μg.			0.0 μg.		
Pyridoxine	67.6 mg.		61.0 mg.	61.0 mg.		62.0 mg.
Riboflavin	70.0 μg.	70.0 μg.		68.0 μg.	68.0 μg.	
Thiamine	66.0 μg.	71.0 μg.		62.0 μg.	69.0 μg.	

All analytical procedures were carried out on homogenates of fat bodies from normal and aposymbiotic nymphs. Five per cent homogenates were made in 0.2 molar phosphate buffer at a pH of 6.8, except for the determinations of riboflavin, nicotinic acid and thiamine, in which cases the fat bodies were homogenized in sterile distilled water. The various methods used to assay each vitamin are given in Table 1. Details of each are given by Gallagher (1962), and descriptions of the various methods for vitamin assays by Strohecker and Henning (1965).

OBSERVATIONS

Organisms fed an antibiotic diet did not become completely aposymbiotic until 120 days of treatment. One manifestation of aposymbiosis was a change in the color of the cuticle from mahogany to a light tan. This change began approximately 80 days after the insect was placed on antibiotics. They also appeared less active, demonstrated a slower response on exposure to light and less speed in avoiding capture as compared to normal insects. They were also of smaller size and molted less frequently than normal insects.

The results of the vitamin assays are summarized in Table 2. The table shows that in all cases there is a close agreement in the results obtained by different methods for each of the vitamins. Of the 10 vitamins assayed, only 3 were present in smaller amounts in the fat bodies of the aposymbiotic than in those of the normal insect. They are ascorbic, folic and pantothenic acids. It appears that these vitamins are synthesized by the symbionts. Additional experiments, using cultures of isolated symbionts, verified this conclusion.

DISCUSSION

The fading of the cuticular color in the aposymbiotic insect may be associated with the absence of ascorbic acid. In the normal insect, melanin is formed from the oxidation of tyrosine by tyrosinases. Ascorbic and pantothenic acids are activators of tyrosinase (Levine, Dann and Marples, 1943). In vertebrates, defective tyrosine metabolism can be corrected by the administration of either folic or ascorbic acids (Rodney, Swendseed and Swanson, 1947). If the reactions involving ascorbic, folic and pantothenic acids are similar in insects to those in vertebrates, a deficiency of any or all of them could produce a fading of the cuticular color. The present experiments demonstrate that they are all produced by the symbionts cultured from the fat body and are absent from the fat body of the aposymbiotic cockroaches. Henry (1962) reported that another deficiency of the aposymbiotic cockroach, *Blatella germanica*, is the inability to synthesize certain amino acids, including tyrosine, from glucose. Thus in insects without symbionts, the substrate from which melanins are formed is also lacking.

The decrease in reproductive capacity noted in the aposymbiotic insect may be caused by a deficiency of folic acid. Berger (1944) gave the first cytological evidence of the necessity of this vitamin for cell division when he showed that sulfanilamide, a folic acid antagonist, caused metaphase arrest in onion roots. Hindmarsh (1949) found that this inhibition of mitosis could be reversed with p-aminobenzoic acid, a precursor of folic acid. Goldsmith and Grank (1952) induced sterility in the vinegar fly, *Drosophila melanogaster*, by inhibiting mitosis in the germ cells with aminopterin, a folic acid antagonist. Mitlin, Butt and Shortino (1957) prevented oviposition in the house fly, *Musca domestica*, by feeding aminopterin. A microscopic examination of the ovaries showed inhibited ovarian growth and the eggs contained much less yolk than those of normal flies. Gersdorff and Mitlin (1954) showed that the addition of folic acid to the rearing medium reversed the antagonism of aminopterin in house fly larvae.

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Life History Notes on *Lagoa laceyi* (Barnes & McDunnough) (Lepidoptera: Megalopygidae)

ALEXANDER B. KLOTS*

Abstract: Descriptions are given of the egg and larvae. The mature larva is figured. The mature larva is strongly aposematic in coloration.

On 24 July 1959 a number of small larvae were collected in Big Canyon, Guadalupe Mts., Eddy Co., New Mexico, feeding on a scrubby oak, probably *Quercus gambeli.* Big Canyon, just north of the Texas-New Mexico border, runs from extremely arid, creosote bush and mesquite desert up into the timbered interior of the mountain range. The larvae were found at about 5500 ft. elevation in a zone characterized by alligator-barked juniper (*Juniperus deppeana*) and the lower fringes of yellow pine (*Pinus scopulorum*). During the summer's field work they were taken to the Southwest Research Station of the American Museum of Natural History near Portal, Arizona, where they fed freely on *Quercus emoryi*; and eventually to Connecticut, where they fed freely on *Q. ilicifolia* and *coccinea.* By early September they had entered the last instar, and by the end of September had all enclosed themselves in cocoons. Twelve adults (6 ♂♂ and 6 ♀♀) emerged 14–29 April 1960.

After being bred to one of the males, one of the females laid about 180 eggs, nearly all of which hatched. The larvae of this F_1 generation were reared on various species of eastern *Quercus,* at first by the author and then, while he was out of the country, by Miss Alice Gray of the American Museum of Natural History. Considerable material of various larval instars, cocoons and adults has been preserved and is in the American Museum of Natural History and the United States National Museum.

Three ♂♂ and three ♀♀, one of each with the genitalia dissected, were compared with the type material of *Logoa laceyi* (Barnes and McDunnough) in the U. S. National Museum by Dr. Don Davis, and later by the author. Both Dr. Davis and the author consider them identifiable as *laceyi.* However, in the absence of any modern systematic work on the group it would be unwise to say what *laceyi* (type locality Texas) is—a distinct species or a subspecies or form of something else, especially since neither the genitalia nor the color and pattern show clear-cut distinguishing characters, and adequate material is lacking. At present, therefore, it seems best merely to record the characteristics of this material for the benefit of some future student.

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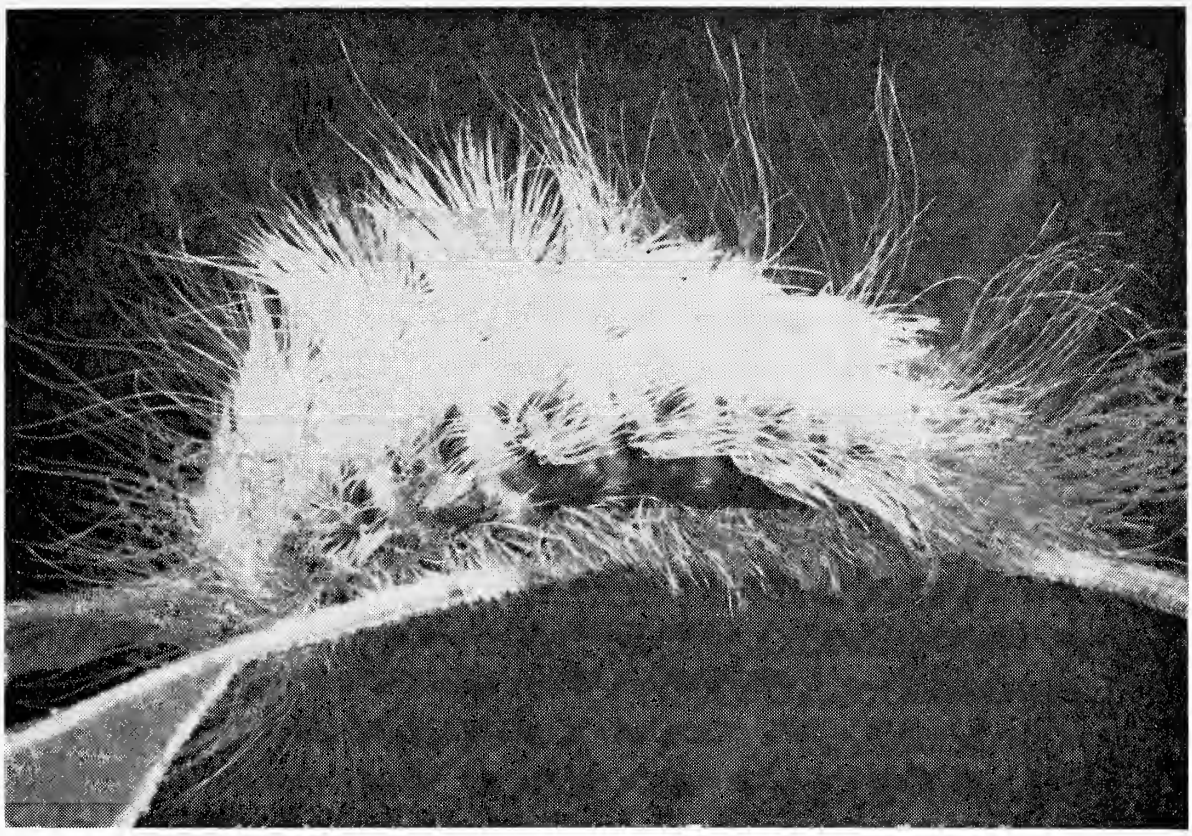

Fig. 1. *Lagoa laceyi* (Barnes & McDunnough) mature larva, lateral aspect (head to left) × 3.

eggs Length 2.2–2.5 mm., width about 1 mm. Bluntly ovoid, somewhat flattened. Laid in rows, with the sides contiguous, and thickly covered with hairs and hair-like scales of the female's vestiture. Hatching period: 7–9 days.

immature larva Vestiture, except in color, as described below for mature larva; almost wholly white, only the urticating setae being brownish and, in penultimate instar, some of the medium length plumose setae being faintly brownish.

mature larva (Fig. 1) Length 20–30 mm. Skin creamy to slightly pinkish white. Prothorax greatly expanded cephalad and ventrad, forming a hood enclosing head; largely naked, with a fringe of hairlike setae around cephaloventral margin. Remainder of body with short, inconspicuous hairs arising from small patches around and above leg and proleg bases, and corresponding regions in legless segments; but prominent vestiture arising in tufts from flat, only slightly projecting verrucae. Vestiture of each verruca as follows: centrally a group of short, stiff, sharply pointed, smooth, brownish urticating setae; in a zone around these many very long, finely plumose, delicate hairlike setae; in a zone around these many shorter, stiffer, finely plumose setae. The urticating setae are more or less brownish. The very long plumose setae are white on the meso- and metathorax and abdominal segments 1–7, but brick red on abdominal segments 8–10. The shorter plumose setae are mostly dark to blackish except that on the mesothorax they tend to be paler brown, or even in part whitish.

On the mesothorax there are four verrucae on each side. The most ventral, and largest, is just posterior and slightly ventral to the prothoracic spiracle. The other three, somewhat smaller and nearly equal to each other, lie farther caudad on the segment, and extend in a line dorsad. On the metathorax and abdominal segments 1–8 there are only 3 verrucae on each side, forming 3 longitudinal series, subdorsal, supraspiracular and subspiracular; of

these the supraspiracular ones are the largest. On the 9th abdominal segment on each side the verrucae of the subdorsal and supraspiracular series are like those of these series anterior to them; but the most ventral one is much smaller and only slightly ventrad and considerably posterad of the one above it. The last segment is largely naked dorsally, with a fringe of long, plumose setae around the caudal margin and a tuft above each proleg.

In the mature larva many of the very long, white setae of the thorax tend to droop cephalad and ventrad; the more dorsal ones of the anterior abdominal segments stand up almost straight dorsad, forming a conspicuous crest. There is a similar, but less conspicuous middorsal crest on the posterior abdominal segments. The shorter plumose setae vary considerably in individuals from a medium brown to almost black; these are most conspicuous laterally, especially those of the subspiracular verrucae. In the immature larvae the long setae show no such arrangement, protruding randomly.

COCOON Length 18–22 mm. Parchment-like, formed of brown silk and other secretions, in which are intermingled most of the soft, red, white and black larval setae but few, if any of the urticating ones. Near the anterior end is a dorso-ventrally diagonal, flat, very hard and stiff partition. Anterior to this the cocoon is very thin and delicate, with an especially abundant mass of the larval setae filling the anterior space. During eclosion the pupa pushes against the hard partition and is led by its slant to the surface of the cocoon away from the solid object to which the cocoon is fastened; this corresponds to the ventral surface of the pupa. The edge of the stiff partition here breaks easily away from the wall of the cocoon, forming a subterminal slit through which the pupa emerges for at least the length of its head and thorax.

SIGNIFICANCE OF THE LARVAL APPEARANCE

It is perfectly possible that the all-white, fluffy appearance of the smaller larvae has a protective function, making them resemble the tangled masses of cottonwood (*Populus*) down that is almost omnipresent in the Southwest at this stage of the larval life, floating thickly in the air and accumulating in masses on nearly everything. The similarity of the larvae to this down was, in fact, noted when they were collected. The mature larvae must be regarded as definitely aposematic, their black, white and red coloration making a distinctive recognition pattern. They are, of course, well protected by their urticating setae.

Another point of interest is the similarity to these and other protected megalopygid larvae of the larvae of some of the metalmark butterflies (Riodinidae), occurring in the same environments, which also have long, drooping white hairlike setae. The metalmark larvae may benefit from their resemblance to cottonwood down, and may also benefit, as Batesian mimics, from their resemblance to the megalopygid larvae. The author, in fact, thought that the very small laceyi larvae were metalmarks when he first saw them.

The author is greatly indebted to Mr. Bruce Harris of the New Mexico Department of Game and Fish for information and aid about collecting places in the Guadalupe Mts.; to Dr. Don Davis of the U. S. National Museum for comparing specimens with the type of *L. laceyi*; and to Miss Alice Gray of the American Museum of Natural History for rearing the F_1 generation when the author was unable to do so.

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A New *Blattisocius* (Acarina: Mesostigmata) from Noctuid Moths

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Abstract: *Blattisocius patagiorum* is distinguishable from previously described species by the slender, edentate form of the movable cheliceral digit in nymphs and females. Males possess an accessory organ lateral to each peritreme. Behavior suggests facultative parasitism upon noctuid moths.

The six previously known species of the ascid genus *Blattisocius* have been recorded (Chant, 1963) from a great variety of habitats, including association with insects in stored grains. Evans (1958) reported *B. dentriticus* (Berlese) from the thorax of a noctuid moth, *Caradrina morpheus* (Hüfn.), taken in Darlington, Yorkshire, England, but he gave no details regarding its relationship to the host. The species here described has been found on several noctuids under circumstances that provided an unusual opportunity for detailed observations on certain aspects of its behavior and reproduction.

Genus *Blattisocius* Keegan, 1944
Blattisocius **patagiorum** n. sp.

This species differs from others of the genus in the slender, wholly edentate form of the movable digits of the chelicerae in nymphs and females. The peritremes of the female are a little longer than those of *B. keegani* Fox, but shorter that those of *B. tarsalis* (Berlese). The length of the fixed cheliceral digits is also intermediate as between these species, being longer than that of *B. tarsalis*, but shorter than that of *B. keegani*.

FEMALE In the six specimens at hand, the length of the dorsal shield varies from 530 to 570 μ, averaging 546. Its variation in width is from 258 to 280, with an average of 267 μ. It is lightly reticulated in all areas, and bears 33 pairs of setae. The average length of seta j6, which is typical of the dorsocentral series, is 48 μ. Setae J4, J5, and Z5 are very finely serrate; the others are simple. Dorsally, the soft integument bears 19 pairs of setae (Fig. 1a).

The tritosternum (Fig. 2a) is about 72 μ long and is undivided in its basal three fourths; the laciniae are finely plumose. The sternal shield is lightly reticulate. The fourth sternal setae are on the membrane. Anteromedial to them are minute metasternal plates bearing pores. The genital shield is about as wide as the sternal shield. Its side margins are concave and its rear margin truncate. The genital setae are on the edges of the shield, the paragenital "pores" in small plates at its sides. There are two pairs of elongate metapodal plates. The ventrianal shield is roughly rectangular and lightly reticulate. It bears three pairs of preanal setae. Five pairs of setae are based upon the soft ventral integument. The peritremes extend to about the middle of coxae III. The peritremal shields are broadly joined to the exopodal plates embracing coxae IV. There are prominent expodal plates flanking coxae II and III, but endopodal plates are lacking. The spermathecae are as shown in Fig. 2b.

The tectum or epistome is smooth and convex anteriorly (Fig. 1b). The movable digits of the chelicerae taper smoothly to their pointed tips, and are without teeth (Fig. 2c). They average 33 μ in length. The fixed digits are about three fifths this length, smooth, and provided with a pilus dentilis. The corniculi (Fig. 2d) are slender and approximated.

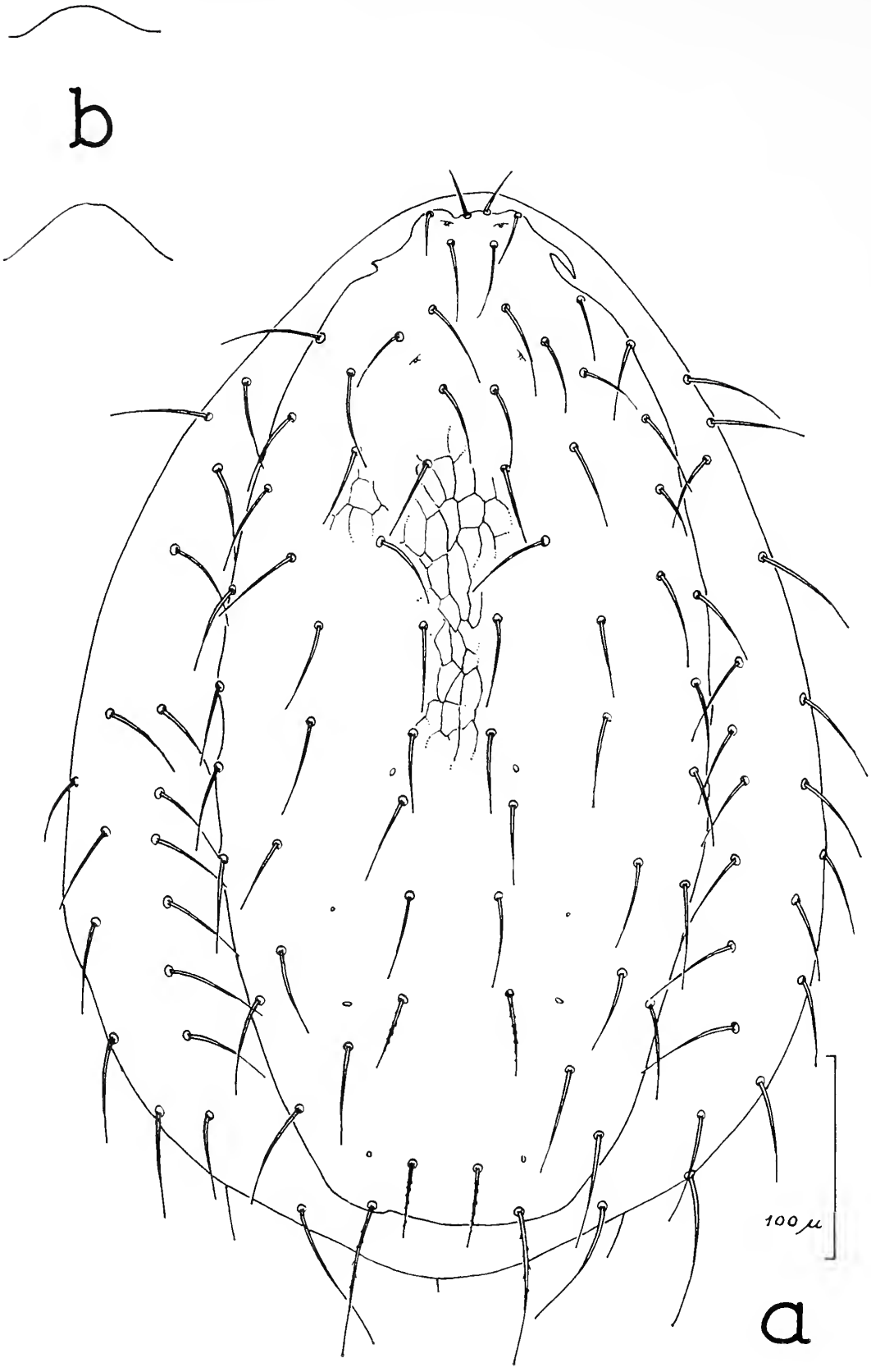

FIG. 1. *Blattisocius* **patagiorum** n. sp.; a, dorsal surface of idiosoma of holotype female; b, epistome (tectum), showing variation in form.

Deutosternal denticles form a narrow series of seven "rows," with a single denticle in each except the sixth, which may have two. The palpi are normal for the genus.

Average leg lengths in microns are: I, 528; II, 422; III, 412; IV, 535. Setation conforms to that given for the genus by Lindquist and Evans (1965). Macrosetae are not present.

The legs turn somewhat brown with age, but do not become so conspicuously tanned as in *B. tarsalis.*

MALE In the five specimens studied the dorsal shield varies in length from 408 to 452 μ, and in width from 227 to 250. Average length and width are 430 and 236 μ. The reticular pattern resembles that of the female. There are 33 or 34 pairs of setae on the shield and 11 or 12 pairs on the soft dorsal integument. Setae J3, J4, J5, and Z5 are very slightly serrate (Fig. 3a).

The tritosternum (Fig. 3b) is about 60 μ long, and is divided for about half its length. The sternogenital shield is elongate, with lateral projections anterior and posterior to coxae II. It bears four pairs of setae and is flanked by the genital pair near its posterior end. The ventrianal shield is broadly triangular and lightly reticulate. In some specimens it bears five, in others six pairs of preanal setae.

The exopodal and peritremal shields are similar to those of the female, but dorsolateral and slightly anterior to each peritreme is a structure which I shall refer to as an accessory organ (Fig. 3c). In the most favorably oriented specimen, this appears to lie beneath or within a cuticular fold or pouch (Fig. 4a). The accessory organ is surrounded by a broadly oval plate with tapering anterior and posterior extensions that run parallel to and may join the peritremal plate toward their extremities. Enclosed by this plate is a cigar-shaped, transparent tube or trough with fine transverse ridges or folds projecting into its interior from its median border (Fig. 4b). It is about equal to the peritreme in length and width. Such a structure was mentioned and figured by Oudemans (1929) and is figured, from Oudemans' Plate 104, by Nesbitt (1951) in his drawing of the male of *B. tarsalis* (as *tineivorus* Oud.). Oudemans compares it to a piece of a peritreme, and says that he has never seen anything like it. Keegan (1944) also figured this part of the organ in his description of *B. tarsalis* (as *triodons*), but mentioned it no further than to say that in the male the "peritremal plate differs from that of the female." In *B.* **patagiorum**, however, the transverse ridges produce a distinctly striated and not punctate appearance as figured in Nesbitt and by Keegan. The accessory organ differs in this respect from the peritreme, which does indeed appear punctate. As one focuses on the deeper, more dorsally situated parts of the organ, the ridges disappear, and the outlines change to a form which curiously resembles that of a canoe or gondola with elevated and projecting prow and stern (Fig. 4c). The "prow" and "stern" projections taper to blunt points, or in some specimens to apparently open ends, with the tapered portion at the anterior end occasionally showing some suggestion of coiling. The accessory organ seems to have no connection to the peritreme other than that of proximity. Its restriction to the male suggests a sexual function, possibly as a sensory organ or as a scent releaser. It occurs in the males of *B. keegani*, as well as in those of *B. tarsalis*, but is not found in *B. dentriticus*. I have not seen males of the other species of *Blattisocius*.

The gnathosoma of the male resembles that of the female except for being relatively shorter and broader, and for having the corniculi more widely separated at their bases. The spermatodactyl is as shown in Fig. 3d, e. Leg lengths average 434, 343, 335, and 437 μ for legs I to IV respectively. Leg setation is like that of the female.

EARLY STAGES The eggs are laid singly and adhere only lightly to the substrate. They are smooth, firm, pearly white, and subcylindrical, measuring about 254 by 188 μ. Empty egg cuticula retain the shape of the egg. Larvae and nymphs are in most respects typical for the genus as described by Lindquist and Evans (1965). The larval cuticle is unstriated. The area corresponding roughly with that of the future peritremal shields is covered with coarse granulations or cuticular bosses (Fig. 5a, b). The movable digits of the larval chelicerae are short and broad based, but as in all subsequent stages, without teeth. There is a pair of trumpet-shaped organs in the ventral integument posterior to the third pair of sternal setae

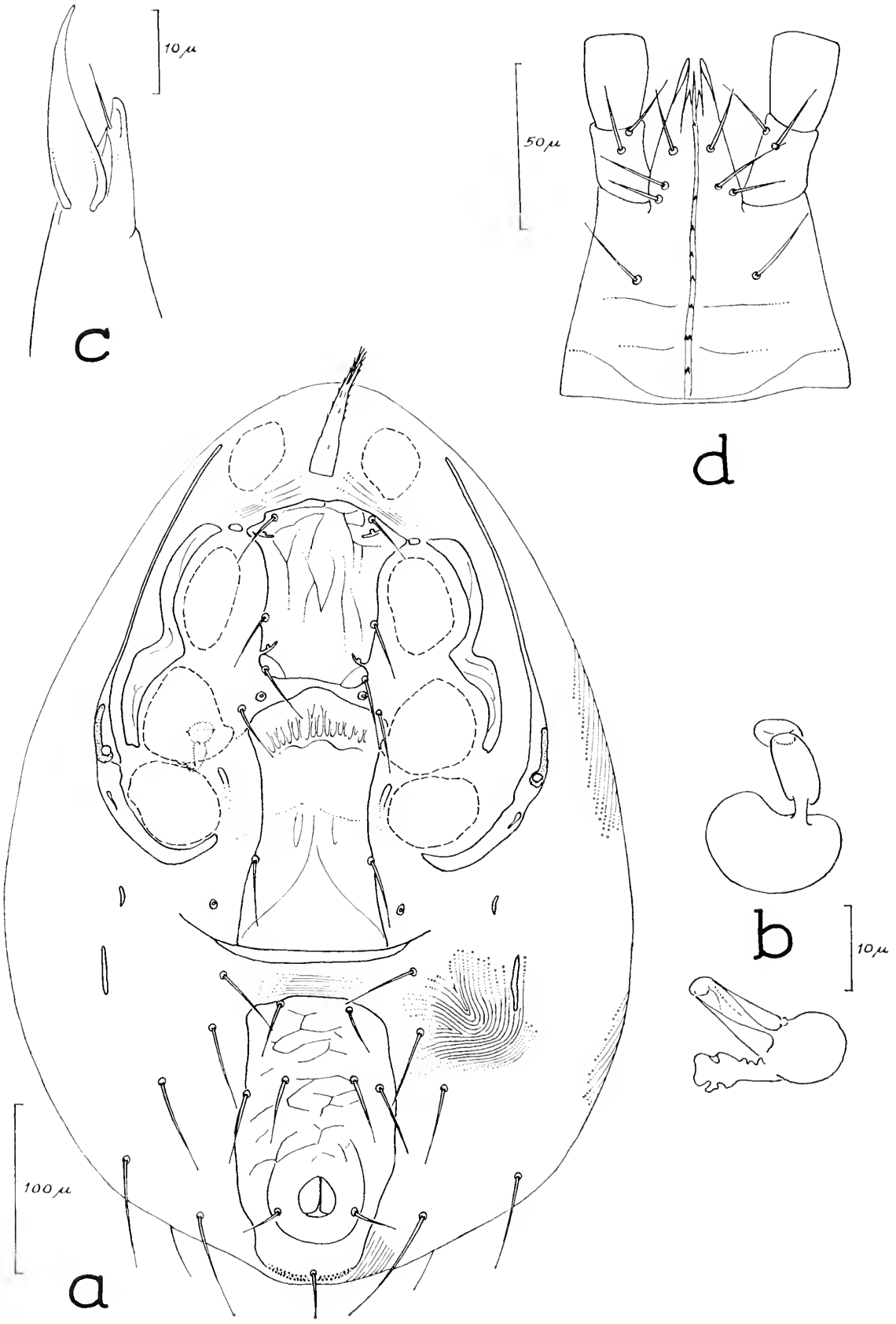

FIG. 2. *Blattisocius* **patagiorum** n. sp.; a, ventral surface of idiosoma of holotype female; b, spermathecae, showing variations in form, that in the lower figure partly collapsed; c, right chelicera of female; d, gnathosoma of female.

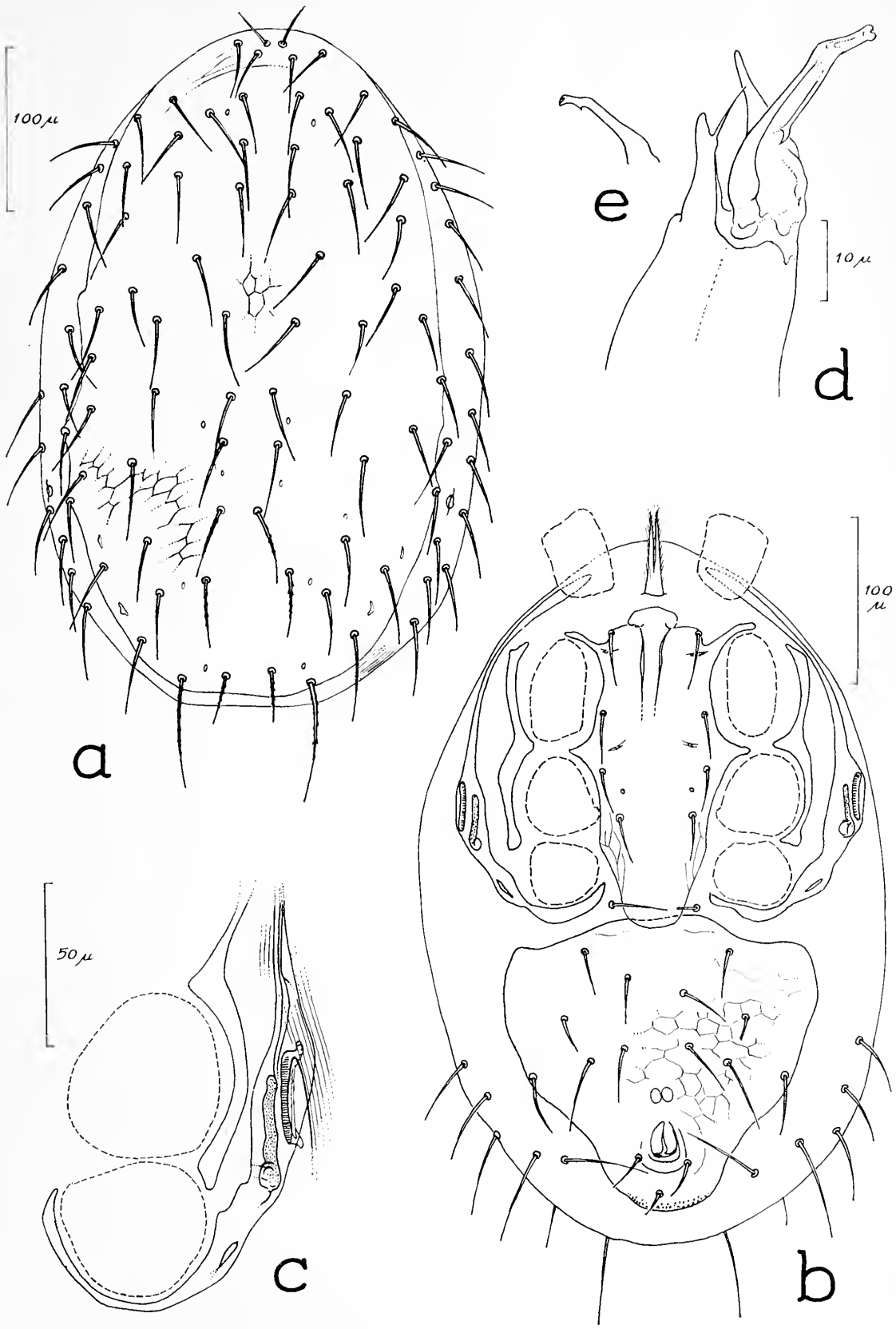

Fig. 3. *Blattisocius* **patagiorum** n. sp.; a, dorsal surface of idiosoma of allotype male; b, ventral surface of idiosoma of male; c, left peritreme and accessory organ of allotype male (compare Fig. 4); d, tip of right chelicera of allotype male; e, spermatodactyl of another male at lower magnification and positioned so as to show ventral projection near tip.

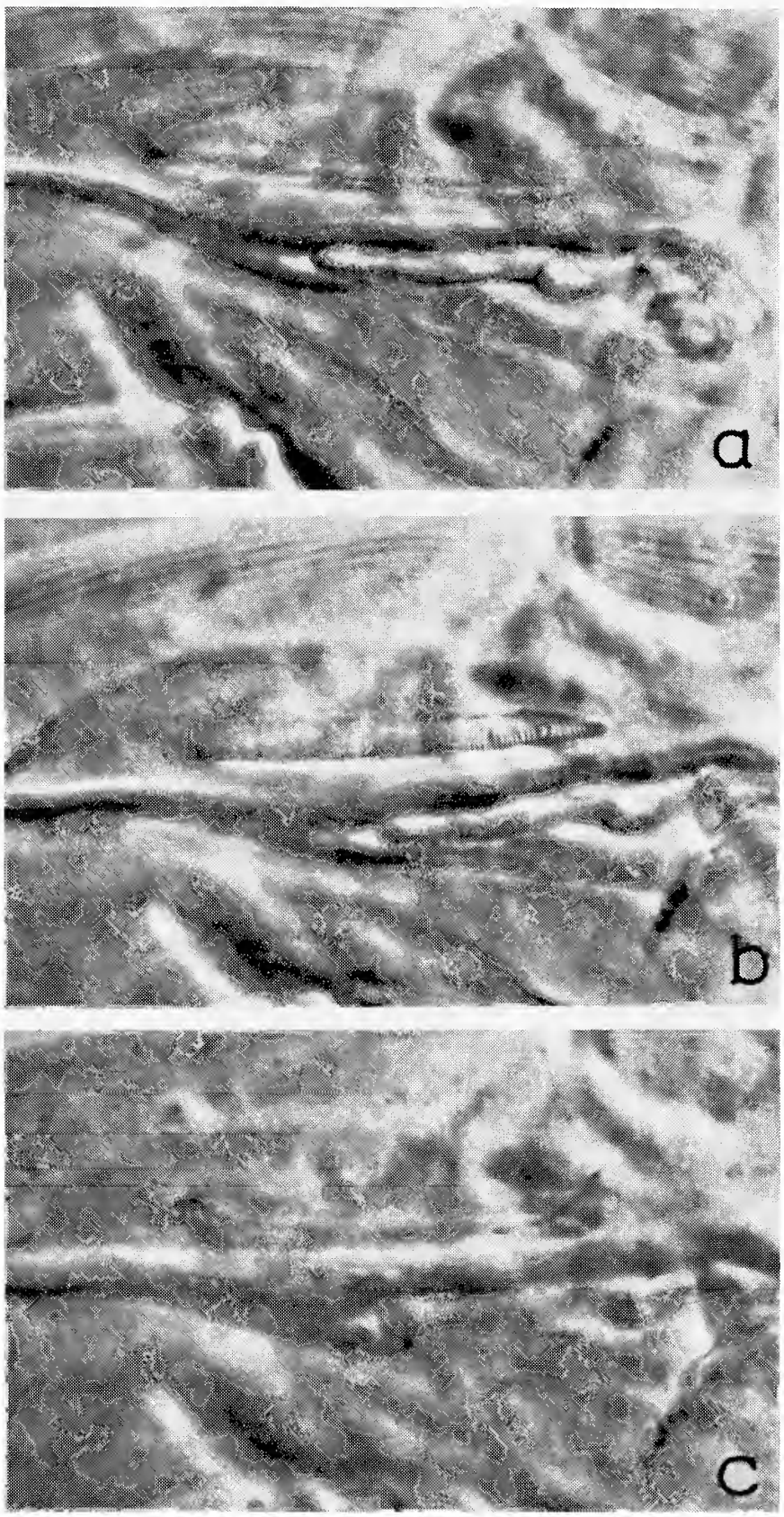

FIG. 4. *Blattisocius* **patagiorum** n. sp.; dark phase contrast photographs of left accessory organ of allotype male at different focal levels; a, ventralmost level: the arc at the lower border of the striated integument in the upper part of the figure appears to be the lateral lip of a fold or pouch covering the deeper portions of the organ; b, intermediate level, showing fusiform portion of organ with transverse ridges or folds; c, deepest level, showing the canoe-shaped portion. The finger-shaped object below the accessory organ in a and b is the left peritreme.

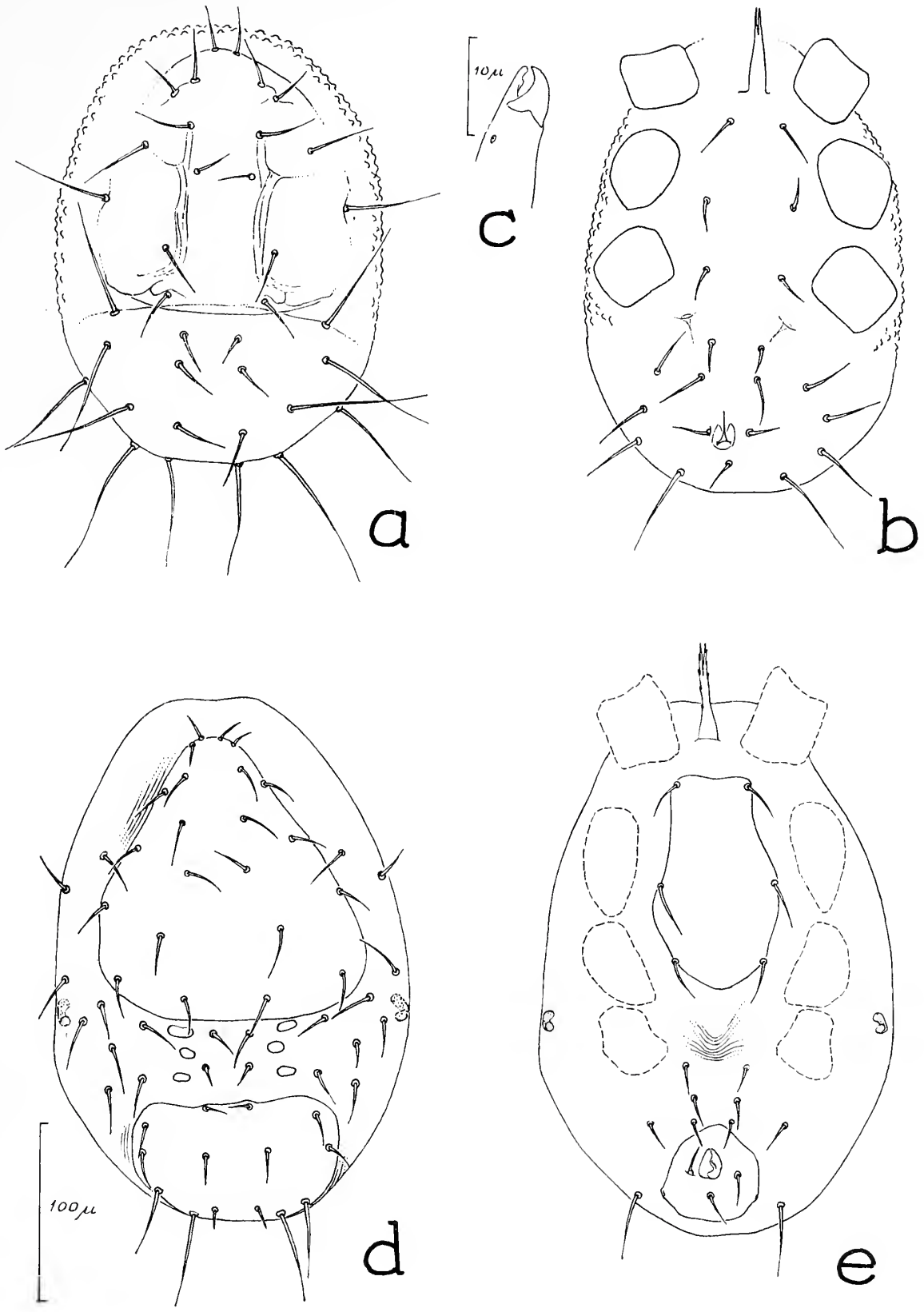

Fig. 5. *Blattisocius* **patagiorum** n. sp.; a, dorsal surface of idiosoma of larva; b, ventral surface of idiosoma of larva; c, tip of right chelicera of larva; d, dorsal surface of idiosoma of protonymph; e, ventral surface of idiosoma of protonymph.

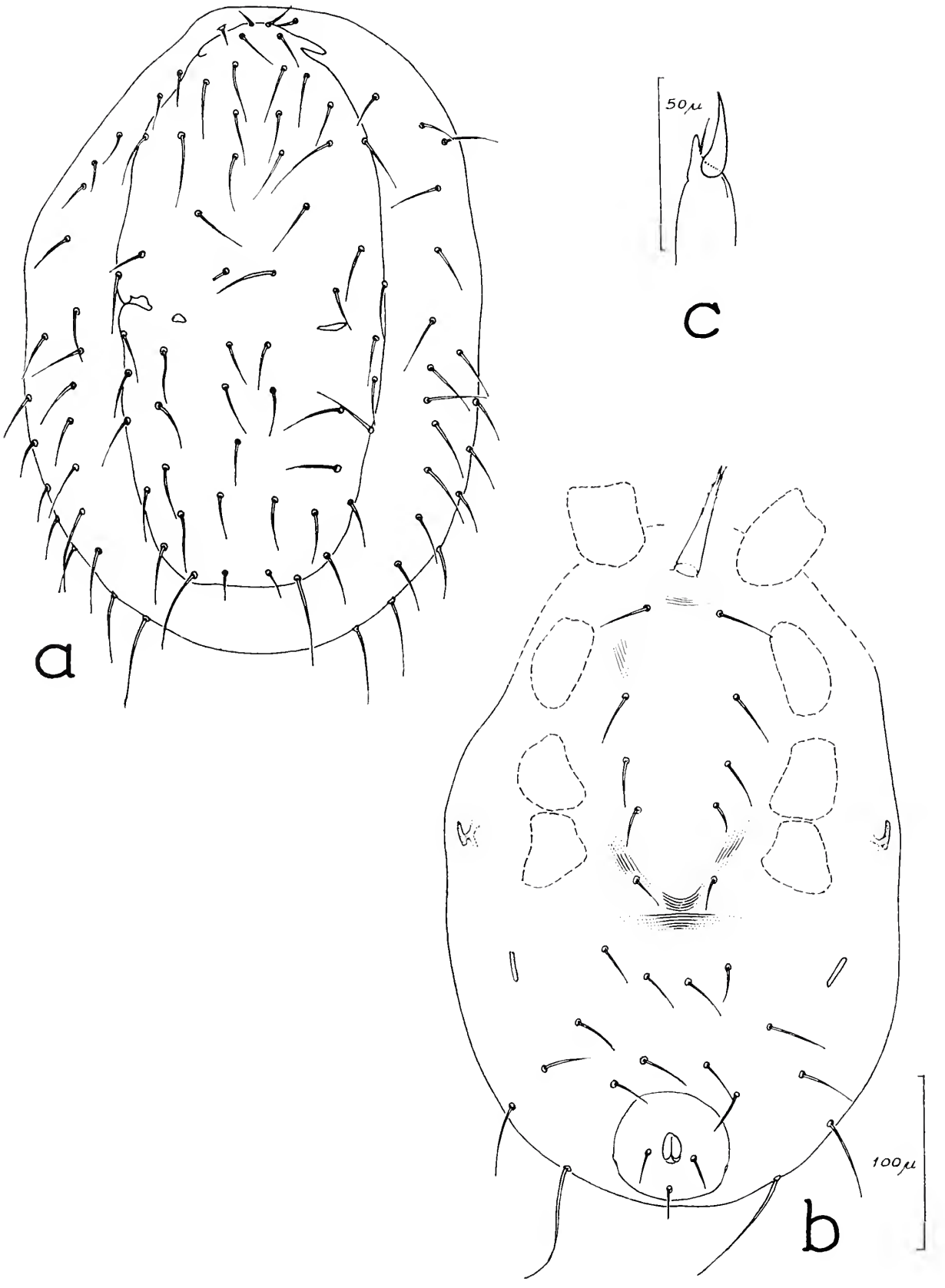

FIG. 6. *Blattisocius* **patagiorum** n. sp.; a, dorsal surface of idiosoma of deutonymph; b, ventral surface of idiosoma of deutonymph; c, right chelicera of deutonymph.

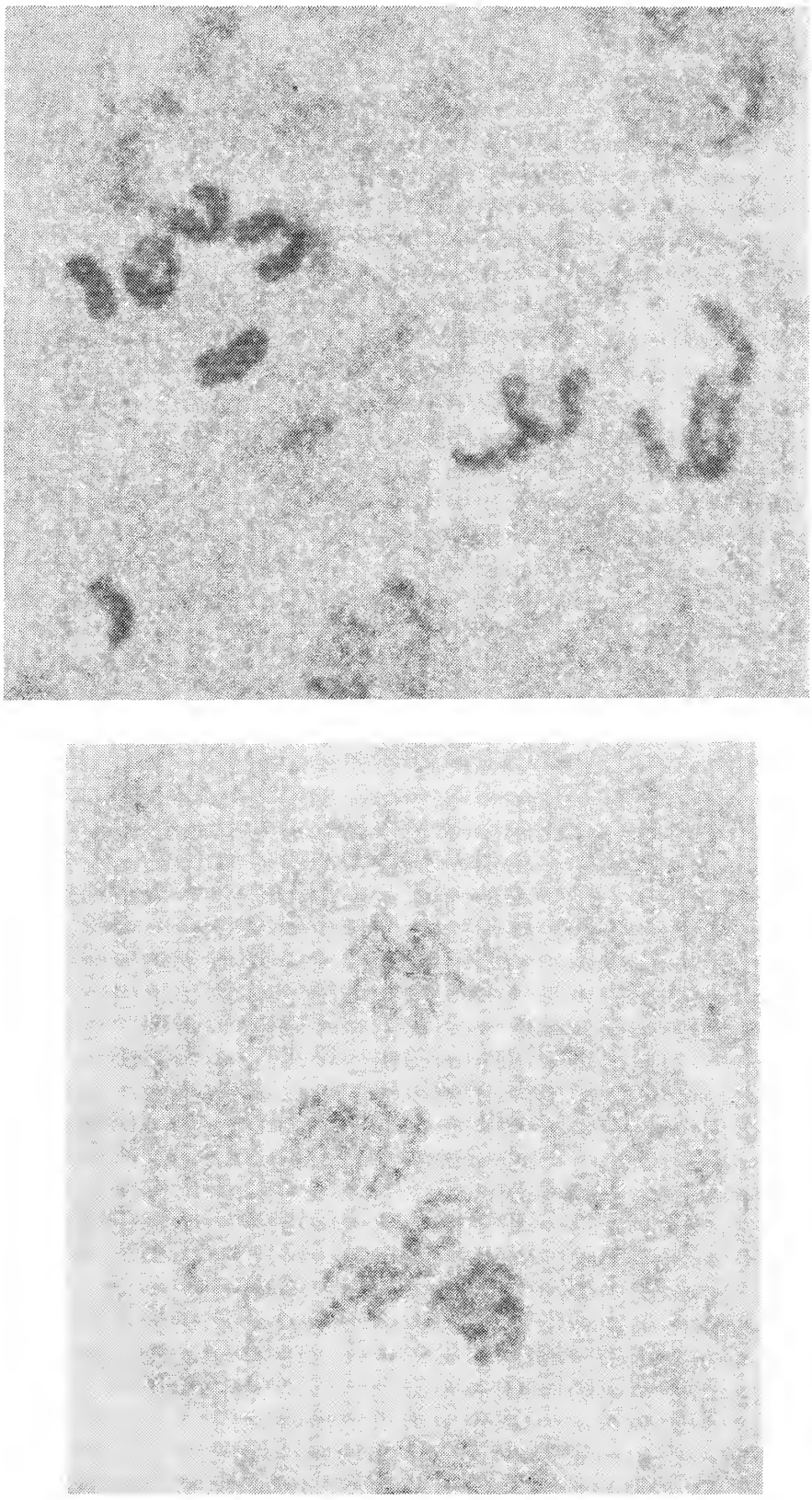

Fig. 7. *Blattisocius* **patagiorum** n. sp.; chromosomes from aceto-orcein squash of an embryo of undetermined age.

(Fig. 5b). The protonymph (Fig. 5d, e) has the two setae typical of the genus on the palpal trochanter. The soft cuticle is striated in the nymphal and adult stages, and does not show the coarse granulations seen in the larvae. In the deutonymph (Fig. 6) the dorsal shields are united, but with some indication of the line of fusion.

TYPE MATERIAL The above description is based upon 6 females, 5 males, 1 deutonymph, 12 protonymphs, 2 larvae, and 6 eggs, all collected or reared from moths taken in Tyringham, Berkshire County, Massachusetts. One male was found on 24 July, 1958, the other specimens during July, August, and September, 1965. Additional specimens have been taken from pinned moths collected in Giles County, Virginia, in 1956 and now in The American Museum of Natural History. These comprise 2 males, 2 deutonymphs, and 1 protonymph. Moths of the following species, all noctuids, have been found infested: 4 females and 1 male of *Spaelotis clandestina* Harris; 1 male and 1 female of *Pseudospaelotis haruspica* (Grote); 1 male of *Amphipyra pyramidoides* Guenée; 1 female of *Septis lignicolora* (Guenée). The number of mites per host varied from one to eight. The holotype is from a female of *Pseudospaelotis haruspica* found among porch sweepings in Tyringham, Massachusetts, on 31 July, 1965. The allotype male is from the same host; it was observed in copula with a female (not the holotype) on 4 August, 1965. Both holotype and allotype are in The American Museum of Natural History. Paratypes well be sent to the United States National Museum, the Canadian National Collection in Ottawa, and the Institute of Acarology at Columbus Ohio.

APPEARANCE AND BEHAVIOR The mites were found on the thorax of their hosts, typically facing forward and head down among the hairs and scales on or just behind the patagia. It was this that suggested the specific name **patagiorum.** As each mite pushes its way down among the hair and scale bases, it creates a temporary, funnel-shaped burrow, at the mouth of which the rear end of the mite can be seen. Adults and deutonymphs are yellow, as is the hemolymph of the host; the earlier stages, at least until feeding begins, are transparently white. The females are somewhat glossy when engorged. The dorsal shield is nearly flat, giving the living mites a rectangular profile in side view. In contrast to more heavily sclerotized ascids, these mites succumb quickly when placed in alcohol or lactic acid.

One of the hosts, a female *Spaelotis clandestina,* survived for more than two months after its capture on the 19th of August, while its mites completed one whole reproductive cycle. This moth was kept at room temperature in a 9 cm plastic petri dish with about six square cm of bibulous paper, moistened occasionally to prevent excessive drying. Although I offered the moth a soaked raisin from time to time, I never saw it drink or take any food. It was active only when disturbed, and was probably uninseminated. Two other host moths oviposited during captivity, and in one instance the eggs proved viable.

The mites, as a rule, moved about but little, spending many hours or days in a single "burrow." At intervals ranging from a few seconds to a minute or more, there was a moment of activity for which I can think of no better term than "bustling." It was impossible to see exactly what the mite was doing at such moments, because its fore parts were always hidden among the hairs of the host. There were leg movements and slight shifts of stance without any resulting change of location. I got the impression that the bustling mite was trying to push more deeply among the hair bases, perhaps seeking closer contact of the mouthparts with the host's surface. At no time, however, did there appear to be any fixed attachment of the mite to the moth.

When removed from its burrow and transferred to a glass observation tube, a mite would wander at random in a way somewhat similar to that of a moth ear mite, *Dicrocheles phalaenodectes* (Treat, 1965), but with slower and more deliberate gait. The forelegs were kept low and were used to palpate the substrate, only occassionally being lifted into the antennal position. A mite experimentally transferred to a fresh host would soon start to burrow among the thoracic hairs, often with jerky, thrusting movements reminiscent of *Dicrocheles*. occasionally a mite would leave its burrow spontaneously and wander about the thorax for a time before making another burrow, usually not far from the first. Both sides of the moth were used freely.

The act of defecation resembled that in the moth ear mite except that the anus being ventral or subventral rather than terminal, the fecal droplets were left on the floor of the burrow rather than upon objects directly rearward. Spherical white or pale yellow fecal pellets sometimes accumulated about the mouth of a burrow. These were dry and powdery after dehydration, not waxy or gummy as are those of the moth ear mite. Eventually these pellets disappeared, perhaps being dislodged by movements of the mite. A burrow that had been occupied for several days had its flooring hairs or scales lightly stuck together, though not matted or tangled. It may be some component of the feces that causes this sticking. Examined microscopically, the feces were seen to comprise a yellow, water soluble component and globular or twined guanine granules averaging about 1.5 μ in diameter.

Although no controlled experiments were performed, the mites showed no obvious sensitivity to light. Bustling continued in bright light from a microscope illuminator as well as in the dimmest window light that would allow the mites to be seen. Heat and moisture sensitivity were not tested. On one occasion, within a period of less than eight hours, a mite that had been transferred to a fresh host in a separate petri dish found its way back to the original host. During this time the two dishes had been stacked in a dark box, with their covers raised at one edge by the thickness of a single sheet of bibulous paper.

A surprising observation was that at times adult mites in their burrows reacted repeatedly and consistently to ultrasounds. This was first noted while I

was testing a host moth with a Galton whistle. The moth showed no reaction, but at each blast of the whistle the mite lurched forward and then made several leg movements. The reaction occurred regularly in tests made at various intervals over a period of several days. It was also tested and confirmed by another observer experienced in insect acoustics, Dr. K. D. Roeder of Tufts University. In one instance the mites continued responding to the sounds for several hours after the death of their host, thus eliminating the possibility that the response of the mites was secondary to some unobserved reaction on the part of the moth. Air turbulence as a possible artefact stimulus was ruled out by substituting an electrically driven Rochelle salt crystal for the Galton whistle. This produced pure ultrasound with no air blast or audible component. In the rated range of 32 to 44 Herz it proved an effective stimulus, while outside that range it evoked no response. It was not possible at the time to monitor this sound source or to check its intensity. No reaction was seen in mites that were already active at the time of stimulation, or in mites that had been placed upon a smooth substrate. In the absence of any known or suspected auditory organ, and with no obvious advantage to the mites in possessing such an organ, it seems reasonable to speculate that the effective stimulus for the observed responses was the acoustic displacement of some of the host's setae in contact with the mite, and that the apparently auditory reactions were in fact mediated by primarily tactile receptors, possibly by the mites' own setae. No such responses have seen, though often sought, in the moth ear mite.

REPRODUCTION Living males are not easily distinguishable from females except under high magnification. Their general behavior is similar except that the males move from place to place a little oftener than the females. Encounters between one mite and another did not ordinarily evoke much observable reaction. Even mites of other species (*Dicrocheles phalaenodectes* and *Lasioseius* sp.), when placed experimentally upon a moth infested with *B.* **patagiorum**, were allowed to enter a burrow and to climb over the occupant without opposition. I witnessed copulation three times: once (15 September) from its beginning, and twice (4 August and 13 September) when already in progress. A few apparent but unsuccessful attempts were also observed, in which a male climbed upon the back of a female but then dismounted and went elsewhere. On 15 September a male that had already been in copula with a mite on another moth was transferred to a second host carrying two mites, both probably virgin females though one might still have been a deutonymph at this time. The male approached a burrow on the left patagium, containing one of the mites, but then turned away to wander over the moth's left tegula and forewing. He soon returned to the same burrow, but again left without entering. At 5:15 PM, five minutes after his transfer to the second host, the male found and entered a burrow on the right patagium, containing the second female. He immediately crept under her, embracing her

opisthosoma with legs III and IV, his mouthparts at the level of her genital region. Except for slight movements the mites remained quietly in this position for at least three and a half hours. It was not possible to see whether or not a spermatophore was transferred. At 10:20 PM the male was seen leaving the dorsal side of the female, after which he wandered over the moth for a few minutes and was then transferred to alcohol. Five days later his mate, then fully engorged, had left the moth and was lost. She had laid no eggs.

The previous mating of the same male with another female on the earlier host had been followed by oviposition within 36 hours. In this case the female had been the only occupant of the moth from its discovery on 19 August until 12 September, when the male was transferred to it from a moth of another species (*Amphipyra pyramidoides*). On the following day the mites were seen in copula, and on 15 September the female laid the first of about 30 eggs. The last egg was laid on 28 September, but the female survived until the death of the host, three weeks later, at which time the mite was mounted for study. Intervals between successive eggs varied from about four to more than twelve hours, the average being probably about eight hours. The temperature varied considerably during the period of oviposition; at the time of four-hour intervals it was about 30° C.

On 18 September I watched, under 42.5X magnification, the laying of the tenth egg, and made the following notes. "At 3:30 PM bustling movements were occurring every three or four seconds, but they became less frequent until by 3:50 the mite was quiet for a minute or more at a time. She was well engorged, with no depression of the ventrianal plate. Her white, nodular malpighian tubules showed intermittent undulations, some beginning proximally (nearest the rectum, which was full of white matter) and some distally, the former being the more frequent. There were also elongations and shortenings of the malpighian tubules, but no translational movements of the nodes. At intervals of a minute or more the ventrianal plate was deeply depressed, most markedly on the left side, where also, a large ovoid white mass could be seen through the dorsal surface. I thought at first that this mass was the tenth egg, but this proved incorrect, for it was still there after the tenth egg had been laid. It may have been the eleventh. Twice there were movements that suggested compressional straining. At 4:10 PM the gnathosomal end of the mite was slowly lifted up as the egg was passed forward. This egg emerged more slowly than a *Dicrocheles* egg but was free within about five seconds after the movement began. The ventrianal plate was deeply depressed at this time, and remained so until about 4:30, when the opisthosoma was regaining its distended form through re-engorgement or otherwise. Immediately after the egg was free, the mite caressed it a few times with her forelegs and palpi, but then moved aside slightly and began a series of jerky, thrusting movements toward the depths of the burrow, which had the effect of shifting the egg rearward along her left side. She then probed deeply into the

burrow and became quiet, possibly feeding, until about 4:30 PM, at which time the usual bustling was resumed."

The eggs adhered only lightly to the host, and if not removed experimentally were lost from the moth within a few hours. Their surface was dry, and they were often electrostatically repelled by the needle when I tried to pick them up. They hatched in from one to three and a half days, probably depending upon the temperature. The last four shrivelled and failed to hatch.

I squashed ten of the eggs in aceto-orcein, but although the chromosomes stained fairly well I could not determine the chromosome number unequivocally. In many of the cells there were two short, straight chromosomes, two straight ones of intermediate length, and two long V- or C-shaped bodies, which, if these last were single units, would give a chromosome total of six, but if double (i.e., actually two chromosomes each), a total of eight. I think six is the more likely number. Some cells, however, appeared to have only three, and some four chromosomes, while others seemed to be polyploid. All of the embryos yielded similar squashes; there was no sign of "commas" or sex chromatin masses as in males of *Dicrocheles* (Treat, 1965).

The larvae were water white. They moved with a rhythmic, swinging gait, with legs I in the antennal position. When placed on a moth, some larvae, after a momentary freeze of ten seconds or more, began to wander superficially over the scale tips. These were soon brushed or flicked off by sudden movements of the moth. Other larvae burrowed among the scales much as do the adults, but farther back on the thoracic disc. These remained on the host and within a few hours transformed into protonymphs, leaving their exuviae on the floor of their burrows. Evidently feeding is not necessary in the larval stage, because protonymphs were produced from larvae kept in glass vials without food.

The protonymphal stage varied in duration from a few hours to two days, and in the longer period at least, involved some feeding. The deutonymphs became yellow and engorged, and in this condition were not easily distinguished from adults. In one instance, transformation to the adult occurred after a deutonymphal stage of four days, the total time from egg to adult in this case being ten days. Molting was not observed directly, but in all instances the cast skins were left on the floor of the burrow.

DISCUSSION

The details given above raise questions with regard to the relationship between these mites and their noctuid hosts. Are the mites to be considered parasites, or are they not? And if not, what then? Certainly the association involves something more than phoresy. The long survival period, the ability of the female to produce many viable eggs, and of the offspring to reach adulthood on the original host, all indicate a source of food either in or on the host itself, although the

failure of the eggs to adhere to the host suggests that in nature the earliest stages, at least, may be passed elsewhere.

For the instars actually associated with moths, whether regularly or only occasionally, commensalism in the strict sense is unlikely, since the moths under observation took no food and were not dusted with pollen. The remaining possibilities are parasitism and phagophily—the use of other symbionts as food. If these mites were phagophiles, they certainly did not feed upon other mites, since none was present except when one or two were placed upon the moths experimentally, and these were ignored by the *Blattisocius*. Conceivably the food was some kind of microörganism. To be sure, the long-surviving host (numbered 85 for identification) occasionally had small patches of white mycelial growth upon its thorax. The hyphae were septate and bore spores of various sizes on short conidiophores. But this bloom was apparently ignored by the mites, and it disappeared when the humidity was reduced. The patagia of some arctiid moths give out a repugnatorial secretion, but no such secretion has been seen or described in the noctuids with which we are concerned.

Some months after moth number 85 had been injected with alcoholic Bouin's solution, I denuded the patagia and examined them microscopically. Along their dorsal margins, in places previously occupied by the mites, were several minute, dark brown discolorations. Under high magnification these appeared to be limited to the goblet-like bases of individual scale sockets. The bustling activities of the mites, the stylet-like shape of their movable chelae, and the appearance of their midgut and rectal contents suggest that the food is hemolymph which exudes from minute punctures in the host's cuticle, possibly through the scale bases. The bustling movements might be concerned with removing plugs of coagula and releasing a fresh supply of the liquid. This notion is, of course, wholly speculative and may prove quite incorrect. According to Lindquist and Evans (1965), "No ascid mites are known to be truly parasitic."

If *B.* **patagiorum** were shown to be a true parasite, the questions would still remain whether its parasitism is facultative or obligate, and whether the choice of hosts is restricted to moths. Other species of the genus have been reported from many different hosts and habitats including lizards, birds' nests, mammals, and various kinds of moths and other insects, particularly those infesting stored grains (Hughes, 1961). I have found *B. dentriticus* on the noctuid *Pseudaletia adultera* (Schaus) from Pelotas, Brazil, and also on a notodontid, *Datana ministra* (Drury) from New Jersey. I have found *B. keegani* on this same species of notodontid, on the noctuids *Polia contigua* (Schiff.) from Kyoto, Japan, and *Zale lunata* (Drury) from Charleston, South Carolina, and on a tineid, *Tineola biselliella* (Hum.) from Pittsburgh, Pennsylvania. I have taken *B. tarsalis* from the noctuids *Crymodes devastator* (Brace) from Salt Lake City, Utah, and *Epizeuxis aemula* (Hbn.) from Tyringham, Massachusetts. In several

instances (e.g., Rivard, 1960) *Blattisocius* species have been shown to be predators on other mites, though capable of living also upon molds.

It is noteworthy that the hosts of *B.* **patagiorum** as recorded on page 152, though representing two more or less divergent noctuid subfamilies, have this in common—that they characteristically rest by day in crevices under the bark of dead trees or in dead wood, often in the joints and crevices of buildings. Such situations favor mite populations of various kinds, and could be expected to yield occasional examples of disjunctive or facultative association between some of the regular occupants and casually intruding moths. I have come across other instances of such association, involving various gamasines, particularly ascids of the genera *Proctolaelaps and Lasioseius*, which I hope to report elsewhere. It is interesting to note that notwithstanding the latitude in the selection of host species suggested by these records, there is considerable restriction in a given species of mites with regard to the part of the host's body that is occupied. *Blattisocius* **patagiorum,** for example, is recorded only from the thorax of the host, and usually from its dorsal surface. My specimens of *Proctolaelaps* and *Lasioseius,* by contrast, regardless of the moth species on which they were discovered, have almost invariably been found between the palpi, under the base of the proboscis. This consistency in site selection might argue some degree of regularity in the association of the mites with moths, but it could also be merely the result of inherent differences in responsiveness to tactile or other stimuli, which, though perhaps adaptive in some other context, might lead to relatively meaningless differences in the sites occupied on casually or accidentally boarded hosts. Many more collection records and behavioral studies will be needed to resolve such problems. In any event, it seems unlikely that the mites in question significantly reduce the life span or population density of their noctuid associates.

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(Meetings held in Room 129 of the American Museum of Natural History unless otherwise indicated)

Meeting of February 1, 1966

President Richard Fredrickson presided; 14 members and 2 guests were present. Miss Margaret Pogany was elected to membership and Mr. Howard Topoff, a graduate student at the City University, was proposed for student membership. Dr. Rozen introduced Dr. Herbert Ruckes, Jr., the son of our recently deseased Dr. Ruckes. He is a specialist in the Anobiidae (Coleoptera). Dr. Asher Treat proposed him for membership.

PROGRAM. **Blackflies of Western South America.** Dr. Pedro Wygodzinsky of the Museum staff discussed the biogeography of blackflies and the attempts by others and himself to find primitive genera in Western South America. Available evidence indicates that the more primitive forms are limited to the Northern Hemisphere. Thus, either the group originated in the Northern Hemisphere and radiated southward, or the primitive forms have died out in South America; this latter explanation does not seem likely. The talk was illustrated with specimens and slides.

DAVID C. MILLER, *Sec. pro tem.*

Meeting of February 15, 1966

Dr. Fredrickson presided; 25 members and 4 guests were present. Mr. John Pallister presented the report of the Auditing Committee for the year 1965 and stated that the Society's financial records are in proper order. Dr. Herbert Ruckes, Jr., and Mr. Howard Topoff were unanimously elected to full and student membership respectively. Mr. Aaron Nadler, a specialist in the Psocoptera who has done a great deal of collecting for the Museum, was proposed for membership. A note from Mrs. Herbert Ruckes, Sr. was read thanking the Society for the memorial resolution and the expression of sympathy which was sent to her on her husband's death. Miss Joan Todd, a grade school Biology teacher, was introduced as a guest.

PROGRAM. **A World Without Butterflies, and One Man's Fight to Delay It.** Dr. Kurt Gohla, Professor of German, Fordham University was the speaker of the evening. (An abstract follows.)

DAVID C. MILLER, *Sec. pro tem.*

A World Without Butterflies, and One Man's Fight to Delay It

On a visit to Germany during the summer of 1965, a collecting trip to Tegernsee, a mountain resort in the foothills of the Bavarian Alps, was made expressly to obtain the Black Apollo butterfly, *Parnassius mnemosyne* L. In spite of fertile mountain meadows, neither this species nor any other Lepidoptera were seen. An effort to explain the diminishing of butterflies and moths in this area is offered in a pamphlet issued by the Society for the Protection of Alpine Flowers and Animals. Three possible causes are under consideration by Doctor Max Dingler, Professor of Zoology at the University of Munich:

Atomic contamination by radioactive dust in the atmosphere which may have a sterilizing effect upon the reproductive organs of insects in general;
Electromagnetic sound waves which may interfere with the fine system of sense organs located in the antennae of the Lepidoptera;

The use of artificial fertilizers which have caused some wild flowering plants, preferred by butterflies, to disappear.

The disappearance of Lepidoptera from their customary mountain meadows and haunts constitutes a loss of ethical and esthetic values and would be an impoverishment of our entire social way of living.

Color slides were shown demonstrating the work of an amateur lepidopterist, Mr. Walther Ender of Lage, Westphalia, who breeds Lepidoptera in great numbers and releases them in order to repopulate the area of the Teutoburg Forest in the northwestern part of West Germany.

KURT GOHLA

Meeting of March 1, 1966

President Fredrickson called the meeting to order; 28 members and 10 guests were present. Mr. Aaron Nadler was elected to membership. Dr. Edwin W. Teale read excerpts from a letter he had received from Mr. Roy Latham, now 85 years old, telling of his experiences with lights to attract moths at Orient Point, Long Island. Almost none came to the lights and those that did were common ones; only very few oher insects, such as Japanese beetles, are collected at lights. Dr. Pedro Wygodzinsky told of weevils from New Guinea that are covered with lichens and mosses in which mites are found.

PROGRAM. **Zoological Collecting in New Guinea.** Mr. Hobart M. Van Deusen, a curator in the Museum's Department of Mammology and in charge of the Archbold Collections, opened his talk by showing the pelts of some of the few mammals that are found in New Guinea: a bat with a wing spread of five feet; an arboreal, giant rat, the largest specimen which is a trifle short of three feet; a spiny anteater, and a tree-climbing kangaroo. All of the animals are nocturnal which makes collecting rather difficult. Since 1933 the Archbold expeditions have returned to New Guinea every 3 or 4 years. The last one in 1964 explored the Huon Peninsula were rift valleys separate mountain peaks into what are virtually islands. Remarkable slides were shown which gave excellent views of the terrain, mountain peaks, plateaus, and caves, as well as the mammals, including one of a kangaroo with young in its pouch.

LUCY M. HEINEMAN, *Sec.*

Meeting of March 15, 1966

Doctor Fredrickson presided; 17 members and 9 guests were present. Mr. John A. Novak was proposed for student membership. Miss Alice Gray exhibited specimens of wingless scorpion flies collected by a former student now at Ithaca. Dr. Asher Treat questioned a statement in a story on *Brachymeria intermedia*, a parasite of the Gypsy Moth (**New York Times,** Sunday, March 13, 1966), that these parasitic wasps do not sting humans. He reported having been stung several times by ichneumon wasps. Dr. Elsie Klots recounted a similar experience. The stings were painful but did not produce swellings or after-effects. He also called attention to an account by H. E. Hinton and M. S. Blum of the University of Bristol, England (**New Scientist,** Oct. 28, 1965, pp. 270–1) summarizing Hinton's experience with the larvae of the chironomid fly, *Polypedilum vanderplanki* (Hint.) which is able to produce apparently normal adults when restored to water after total dehydration and exposure, in the dry state, to temperatures as low as –270 degrees and as high as 104 degrees centigrade. The ability to survive alternate hydration and dehydration in this and in many more primitive organisms has suggested to the authors that life may have originated not in the sea, as is generally supposed, but in rock crevices or similar situations on land.

PROGRAM. **The Importation of Foreign Plant Material.** Mr. Charles A. Andrews of the Plant Quarantine Division of the U.S. Dept. of Agriculture discussed the need for restrictions on imported plants and plant materials, and he traced the history of our present regulations. He stressed the point that the Division has attempted to develop a plant pest protection program which will give us the maximum interference with commerce. The steps used in making inspections and the procedures in processing plants which enter our country from foreign propagators were outlined. Mr. Andrews showed slides depicting the carrying out of the restrictive provisions of the Division in the handling of tulip bulbs in Holland. Some showed the pests in bulbs and nuts, others were microscopic sections to explain how the identification of the pests are made.

LUCY M. HEINEMAN, *Sec.*

Meeting of April 5, 1966

President Fredrickson called the meeting to order; 14 members and 4 guests were present. Mr. John A. Novak was elected to student membership and Mr. Robert Mesibov was proposed for membership. Miss Alice Gray demonstrated a fossil arthropod which showed up well when illuminated with ultra-violet black light.

PROGRAM. **Fossil Roach-like Insects from the Carboniferous.** Mr. Christopher Durden of the Biology Department of Yale University discussed the distribution and the classification of the numerous roach-like fossils which are now available. Wing venation and their manner of folding are important features. Some had wing margins that might have been used for stridulation. Most of the Carboniferous roach fossils are about as large as our present roaches. The talk was illustrated with slides.

ALBERT J. POELZL, *Assistant Secretary*

Meeting of April 19, 1966

President Fredrickson presided; 31 members and 7 guests were present. Mr. Robert Mesibov was elected to student membership, and Miss Alice Gray proposed Mr. Kenneth Friedman and Mr. David F. Kanter for student memberships. Dr. Alexander Klots introduced Dr. and Mrs. Traub of Bethesda, Maryland. Dr. Traub, a former student at C.C.N.Y., a retired Army colonel, is an authority on fleas as typhus carriers. Miss Anne Birdsey called attention to an article on the science page of the Sunday **New York Times** written by Norton T. Novitt, a Denver, Colorado amateur scientist, which proposed that flying saucers may be electrified flying ants. She also showed a paperback copy of "1001 Answers About Insects" by Alexander and Elsie Klots. Dr. Klots announced that the Honorable Miriam Rothschild is now in the United States. Unfortunately, she was not able to stay in New York for tonight's meeting. She is currently engaged in a project concerning repellant insecticides which necessitates her using many specimens of the moth, *Diacrisia virginica*. She would appreciate having egg masses of this moth air-mailed to her at Elsfield Manor, Oxford, England. Miss Alice Hopf is anxious to obtain specimens of the viceroy butterfly in any of its stages.

PROGRAM. **Termites and Evolutionary Processes.** Dr. Alfred E. Emerson, Professor Emeritus of the University of Chicago, a Research Associate in the Dept. of Insects of the Museum for many year, discussed regressive evolution, recapitulation, convergent evolution, and the evolution of behavior as illustrated by termites. He stressed that the unit of natural selection in these insects is the entire colony rather than the indivdual. The king and the queen are the only individuals in the colony capable of reproducing, and the genes controlling structural and adaptive characteristics which are manifested in the sterile castes,

the workers and the soldiers, are transferred through these reproductives; though they, themselves, do not manifest these characteristics. The talk was illustrated with slides.

Lucy M. Heineman, Sec.

Meeting of May 3, 1966

Dr. Fredrickson called the meeting to order; 15 members and 9 guests were present. Several guests were introduced: Mr. Harry Steen; Mrs. Michal Emsley of the New York Zoological Society Research Station, "Simla," in Trinidad; Dr. and Mrs. Leon Cahen who are active members of the Explorers Club. Mr. Kenneth Friedman and Mr. David Kanter were elected to student membership. Mr. Kennith Watson, Mr. H. Steen, and Dr. Philip Spear were proposed for membership. Dr. Fredrickson mentioned that progress is being made on the proposed merger of the N.Y. and the Brooklyn Entomological Society. The lawyers for the two societies are in consultation and an agreement has been drawn up . The members will be kept informed about future developments and will be required to vot on the agreement after it has been approved by the Executive Committee of our Society. The President, also, announced that our member, Dr. Edwin Way Teale, received a Pulitzer Prize for his book, **"Wandering Through Winter,"** the final volume of his history of the four seasons in America. The Secretary was instructed to convey to Dr. Teale the hearty congratulations of the Society on the receipt of this well-deserved honor.

PROGRAM. **Entomology and the National Pest Control Operators.** Dr. Philip Spear, Technical Director for the National Pest Control Association, explained that Pest Control operators are concerned with pests in and around structures, within the contents of the structures, and with the use and the problems of pesticides. Insects occupy a large part of the time and energy of the operators. Thus, entomology in all its phases is an important study in this industry. About 5,000 firms are members of the Association, and approximately 30,000 workers are employed in the field. They deal, usually, with emergency situations, but they do prefer to operate on a preventative basis. His talk was illustrated with many slides which showed the scope of work done in structures, the damages done by various pests, and the pests.

Lucy M. Heineman, Sec.

Meeting of May 17, 1966

President Fredrickson presided; 27 members and 21 guests were present. One of the guests present was Dr. John Vandenburg of the New York University Medical School, Dept. of Preventive Medicine. Mr. Kennith Watson, Mr. Harry Steen, and Dr. Philip Spear were elected to membership. Dr. James Forbes, Associate Editor of the Journal, reported on the 10th Annual Meeting of the Council of Biological Editors which was held May 3–4 in the Center for Continuing Education on the campus of Notre Dame University. Dr. Forbes represented the Society at this meeting. Dr. Klots read a letter from the Edwin W. Teales in which he thanked the Society for its good wishes and described happenings on their trip through England. Dr. Fredrickson reported that on the proposed merger of our Society with the Brooklyn Entomological Society it will probably be necessary to call for a special meeting in order to vote on the final agreement. Notices will inform the membership.

PROGRAM. **National Geographic Society Motion Picture** on the work being done by Dr. L. S. B. Leaky in finding human fossil remains in the Oldvai Gorge in Africa; filmed by Baron Hugo van Lavick. This was accompanied by a recorded, running commentary by Dr. Leaky. It was a fascinating film showing the work camps, the terrain, and how the fossils were found. It supported Dr. Leaky's theory that there were two contemporary

types of man, herbivorous and carnivorous. The film demonstrated differences between the mouthparts and the feeding of these two types of animals. The photography of insects and the feeding of the different forms was superb.

Lucy M. Heineman, Sec.

Recent Publications

Aspects of Insect Biochemistry. 1965. Biochemical Society Symposium (London), T. W. Goodwin, Ed. Academic Press, New York, 119 pp., illus., $6.00. Seven papers: "Active Transport in Insects" by J. E. Treherne; "Formation of the Specific Structural and Enzymic Pattern of the Insect Flight Muscle" by Th. Bücher; "Some Distinctive Features of Insect Metabolism" by F. P. W. Winteringham; "Intermediary Metabolism and the Insect Fat Body" by B. A. Kilby; "The Metabolism of Aromatic Compounds" by P. C. J. Brunet; "Hormones Controlling Growth and Development in Insects" by V. B. Wigglesworth; and "Skeletal Structure in Insects" by K. M. Rudall.

Pesticides in Clinical Practice, Identification, Pharmacology and Therapeutics. 1966. Royal L. Brown. Charles C. Thomas, 504 pp., $15.75.

The Entomology of Radiation Disinfection of Grain. 1966. Edited by P. B. Cornwall. Pergamon Press, Long Island City, New York, 256 pp., $9.50.

Ticks of the Genus Ixodes in Africa. 1966. Don R. Arthur. University of London Press, London: Oxford University Press, New York, 365 pp., $11.20. Reviewed in Science **152:** No. 3723, p. 750.

Polymorphism in Some Nearctic Halictine Bees. 1966. G. Knerer and C. E. Atwood. Science **152:** 1262–1263.

Classification of the Bees of the Australian and South Pacific Regions. 1965. Charles D. Michener. American Museum of Natural History Bulletin, **130:** 1–362, $10.00.

Termites (Isoptera) of Thailand. 1965. Muzaffer Ahmad. American Museum of Natural History Bulletin, **131:** 1–114, $2.00.

Insect Aerodynamics: Vertical Sustaining Force in Near Hovering Flight. 1966. Leon Bennet. Science, **152:** 1263–1266.

A Revision of the Neotropical Genus *Metamasius* (Coleoptera: Curculionidae, Rhynchophorinae): Species Groups I and II. 1966. Patricia Vaurie. American Museum of Natural History Bulletin, **131:** 211–338, $5.00.

Contributions Towards a Revision of *Myrsidea* Waterson I (Mallophaga: Menoponidae). T. Clay. British Museum (Natural History) Bulletin: Entomology, **17:** 327–395, 1£ 10s.

A Revision of the British Aleyrodidae (Hemiptera: Homoptera). L. A. Mound. British Museum (Natural History) Bulletin: Entomology, **17:** 397–428, (14s).

The Interrelationships of Three Gall Makers and Their Natural Enemies, on Hackberry (*Celtis occidentalis* L.). John Conrad Moser. 95 pp., $1.00.

A Handbook for the Identification of Insects of Medical Importance. 1965. John Smart with chapters by Karl Jordon and R. J. Whittick. British Museum (Natural History), London, 4th ed., 340 pp., £3. Reviewed in Science, **152:** 748–749.

INVITATION TO MEMBERSHIP

The New York Entomological Society was founded in 1892 and incorporated the following year. It holds a distinguished position among scientific and cultural organizations. The Society's **Journal** is one of the oldest of the leading entomological periodicals in the United States. Members and subscribers are drawn from all parts of the world, and they include distinguished professional naturalists, enthusiastic amateurs, and laymen for whom insects are only one among many interests.

You are cordially invited to apply for membership in the Society or to subscribe to its **Journal** which is published quarterly. Regular meetings are held at 8:00 P.M. on the first and third Tuesdays of each month from October through May at the American Museum of Natural History, the headquarters of the Society. A subject of general interest is discussed at each meeting by an invited speaker. No special training in biology or entomology is necessary for the enjoyment of these talks, most of which are illustrated. Candidates for membership are proposed at a regular meeting and are voted upon at the following meeting.

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My entomological interests are: .....

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Name .....

Address .....

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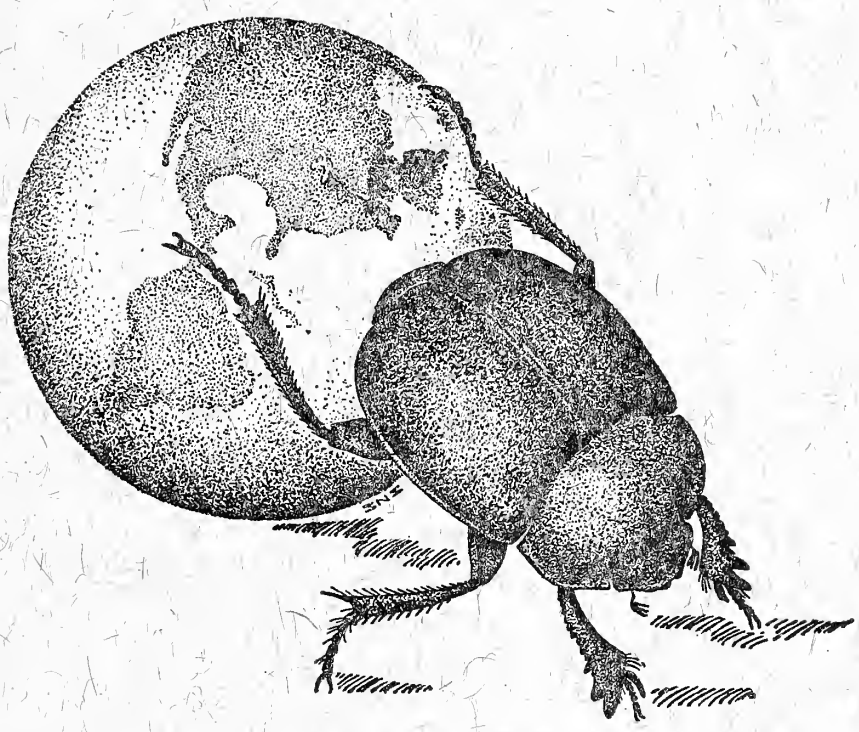
— Send application to Secretary —

Vol. LXXIV DECEMBER 1966 No. 4

Journal

of the

New York Entomological Society



Devoted to Entomology in General

The
New York Entomological Society

Organized June 29, 1892—Incorporated February 25, 1893
Reincorporated February 17, 1943

The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P.M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 79th St., & Central Park W., New York 24, N. Y.

Annual dues for Active Members, $4.00; including subscription to the Journal, $9.00.

Members of the Society will please remit their annual dues, payable in January, to the Treasurer.

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Mailed December 29, 1966

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Journal of the New York Entomological Society

VOLUME LXXIV DECEMBER 29, 1966 No. 4

CONTENTS

The Nerves of the Thoracic Segments of the Larva of *Prodenia litura* (Lepidoptera: Noctuidae)

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Abstract. The nervous system of the thoracic segments of the larva of *Prodenia litura* is described. The dorsal and transverse nerves remain connected to each other at three points through three connectives. But in the prothoracic segment, there is no transverse nerve, so that the dorsal nerve establishes a connection with subconnective nerve by a plexus. Ordinarily no connection is found between the dorsal and ventral nerve but in the prothoracic segment, such a connection is established at one point.

INTRODUCTION

The studies on the nervous system started with the work of Lyonet (1762). Since then many aspects of it have been dealt with. Du Porte (1915) described the nervous system in *Sphida* and Ruckes (1919) studied the innervation of the male genital organs in certain lepidopterans. However, the real work on the nerve pattern started with Maki (1936) who described it in the alderfly, *Chauliodes formosanus*. Nesbitt (1941) studied the nerve patterns in Orthoptera and other related orders. Schmitt (1954, 1959) studied the nervous system of cervicothoracic and the pregenital abdominal segments in some orthopterans. With these studies it was realized that there exists a basic segmental nerve pattern in insects. Whether such a homology can be traced in widely separated orders as Orthoptera and Lepidoptera, is yet to be seen. Libby (1959, 1961), however, investigated the nerve pattern of certain abdominal segments of the larva and adult of the moth, *Hyalophora cecropia* and tried to establish homology with other insect nerve patterns. The short review shows that the thorax has not been tackled so far in detail. To fill up this lacuna and to establish how far there exists a basic homology with the thorax of other insect orders, the authors undertook a very detailed study of the nerves of the thoracic segments of the larva of *Prodenia litura*.

MATERIAL AND TECHNIQUES

The full grown larvae were directly collected from the cabbage fields and kept in the laboratory. For the studies on the distribution of the nerves, 1% methylene blue in normal salt solution was injected into the body cavity of the larva. After a few hours, the insect was etherized and dissected in normal saline (0.65%). Sometimes, instead of injecting the solution into the body cavity, the dye was directly poured over the dissected animal and allowed to stay for 2 to 4 hours to secure better staining of finest motor nerves. Further dissection was done in normal saline. To destain the adjoining tissues, acid water was sometimes used. Normally, all the nerves of a particular segment

could not be traced in one day and hence the dissection used to be kept in normal saline with a few drops of formalin. In such preservation, the blue colour of the nerves disappears but they remain quite distinct because of the milky white appearance which they attain. All the dissections were carried out under the stereoscopic binocular microscope in artificial light. The diagrams are purely diagrammatic.

OBSERVATIONS

The thorax is composed of three segments with their ganglia. The prothoracic ganglion remains connected to the suboesophageal ganglion by a pair of stout but short connectives which lie free throughout their entire length. The connectives between the other ganglia lie united anteriorly for about one fifth of the distance and then diverge gradually, continuing their course separately until they enter the anterior border of the succeeding ganglion. The two separated connectives enclose between them some space within which the diagonal muscles cross each other near their point of insertion. The enclosed space is smaller in the prothoracic segment but larger in the other two segments.

NERVES OF THE PROTHORACIC GANGLION (Fig. 1)

The prothoracic ganglion gives rise to two pairs of lateral nerves and a pair of subconnective nerves. The lateral nerves are designed as the dorsal and the ventral nerves. From the median portion of the ganglion arises a pair of subconnective nerves. *The Dorsal Nerve*: The dorsal nerve (DN) leaves the ganglion and runs obliquely outwards and upwards over the ventral median muscles and ventral internal lateral muscles to reach the subconnective nerve (SN) with which it forms a plexus (px). It then sharply bends downwards, passes over the ventral internal muscles and extends to a considerable distance, giving branches at intervals. The first branch (ID) arises over the ventral internal longitudinal muscle and divides into two branches; the inner branch (a) passes downwards and curves slightly inwards and bifurcates to innervate the tracheae and the tracheoles. The outer branch (b) curves and bifurcates into b′ and b″. Whereas the former innervates the ventral internal lateral longitudinal muscle, the latter meets the longitudinal nerve of the dorsum (LND) which extends from the head up to the intersegmental fold of this segment. The main dorsal nerve proceeds further and after a short distance, besides receiving the sixth branch (6V) of the ventral nerve, itself gives rise to the second branch (2D). This branch divides into a number of branches to innervate the adjoining neck muscles and the tracheae. The third branch (3D) proceeds dorsally and gives rise to a number of branches which again innervate the various muscles and integument of the neck region. The fourth branch (4D) innervates the tergosternal muscle. The main dorsal nerve ulti-

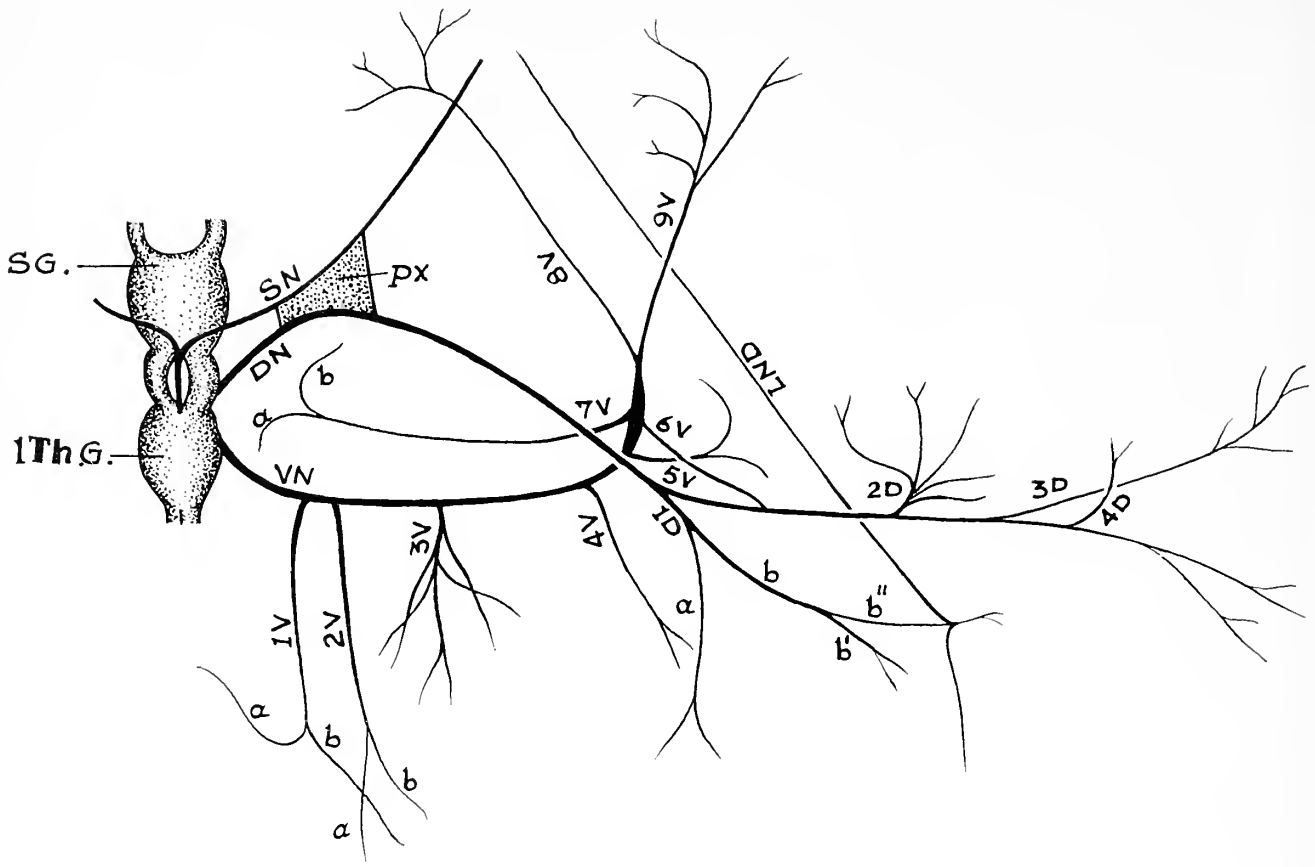

Fig. 1

FIG. 1. Diagram of the nerve pattern of the prothoracic segment of the larva of *Prodenia litura*.

mately terminates into fine branches supplying the dorsal longitudinal muscles. THE VENTRAL NERVE: The ventral nerve (VN) leaves the ganglion at the middle of the lateral margin and passes posteriorly below the ventral median muscle group and over the ventral external oblique muscles. It gives rise to a number of branches. The first branch (1V) runs obliquely downwards and bifurcates into a and b. The former passes deep into the prothoracic leg to innervate its muscles whereas the latter innervates the ventral internal and external oblique muscles. The second branch (2V) gives rise to a fine branch (a) which supplies the muscles of the leg and the other branch (b) innervates the ventral median muscle. The third branch of the ventral nerve (3V) subdivides into a number of fine branches to innervate the tracheae and ventral internal lateral muscles. The main ventral nerve after proceeding ahead for a short distance, curves anteriorly above the ventral internal lateral muscle and flattens. From the proximal part of this arises a small fourth branch (4V) which innervates the tracheae. The fifth branch (5V) innervates the tracheae and the ventral internal lateral muscles. The sixth branch (6V) extends to join the main dorsal nerve. Whereas the seventh branch (7V) proceeds as far as the prothoracic ganglion and innervates the ventral external oblique muscles, the eighth nerve (8V)

extends into the head to supply the tracheae and muscles of that region. The ninth nerve (9V) gives origin to a number of minute nerves which innervate the various ventral longitudinal and oblique muscles and tracheae of the neck and adjoining regions.

THE SUBCONNECTIVE NERVE: There is no median nerve in this ganglion so that the transverse nerves are also absent. From the mid antero-dorsal side of the prothoracic ganglion arises a single nerve which may be taken as the median nerve. It proceeds anteriorly for a very short distance and then bifurcates above the suboesophageal ganglion to give rise to a pair of the so-called subconnective nerves (SN). Each nerve passes laterally to innervate the various muscles of the head but before taking a curve, a plexus (px) is formed between it and the adjoining dorsal nerve.

NERVES OF THE MESOTHORACIC GANGLION (Fig. 2)

THE DORSAL NERVE: This nerve (DN) arises from the outer margin of the interganglionic connective, just a few millimeters above the mesothoracic ganglion. It passes laterally over the external and internal median muscles and after a short distance extends its first branch (1D) which passes over the ventral internal lateral longitudinal muscles and fuses with the transverse nerve. It, however, gives rise to a branch (a) which extends another three small branches to innervate the tracheae, ventral internal lateral muscles and the lateral internal oblique muscle.

The main dorsal nerve proceeds ahead and gives rise to another connective branch (2D) which also fuses with the transverse nerve, just posterior to the spiracle. But before fusion, it gives rise to a branch at the point c′ which proceeds antero-dorsally and divides into a number of minute branches. The branch c1 extends posteriorly to innervate the two pleurosternal oblique muscles, the branch c2 innervates the tergosternal muscle and the branches of the lateral tracheal trunk and the branches c3 and c4 proceed to innervate the dilator and occlusor muscles of the spiracle respectively. In addition to these, the branch 2D gives rise to two small branches (a and b) which innervate the lateral internal oblique and ventral external oblique muscles respectively.

The main dorsal nerve passes dorsally above the lateral longitudinal tracheal trunk and gives rise to a connective (3D) which runs to fuse with the transverse nerve. The connective gives off two minute branches posteriorly and they innervate the dorsal and lateral external oblique muscles and tracheae. The fourth branch (4D) innervates the integument and the dorsal internal lateral muscle. The main nerve, by now, becomes thin and extends ahead into the dorsal region, giving off small branches. The branches 5D, 6D and 7D innervate the dorsal external oblique muscle and dorsal internal lateral muscle group. The main nerve ultimately terminates into a number of very fine branches which innervate the tracheae and the dorsal internal median and

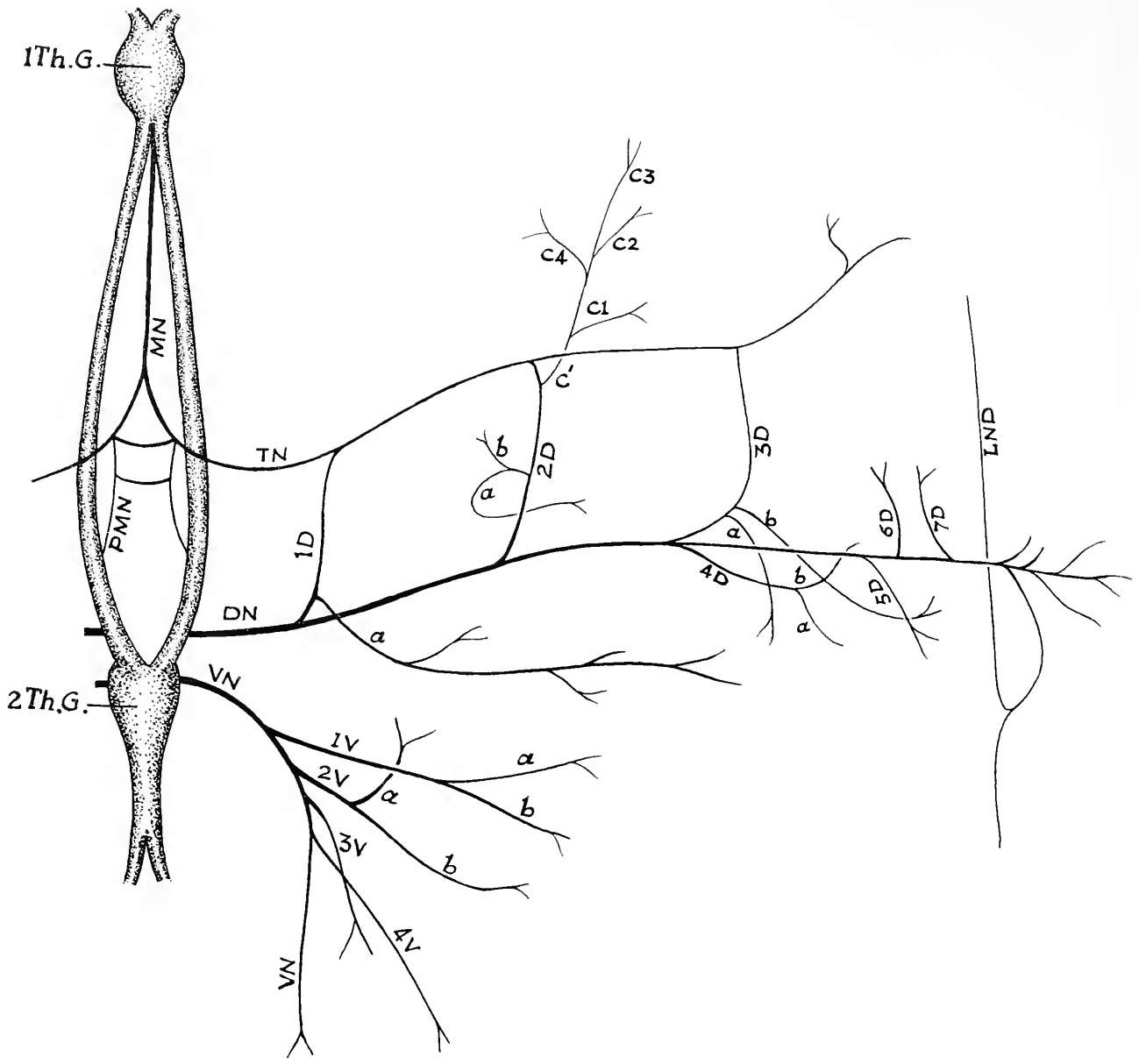

Fig. 2

FIG. 2. Diagram of the mesothoracic nerve pattern of the larva of *P. litura*.

oblique muscles. The longitudinal nerve of the dorsum (LND) is also present in between the intersegmental folds. It has its anterior attachment with the integument at the base of the dorsal internal lateral longitudinal muscles and its posterior attachment with the posterior intersegmental fold, beneath the insertion of the lateral internal oblique muscles. It remains connected to the dorsal nerve by a fine terminal branch of the dorsal nerve.

THE VENTRAL NERVE: The ventral nerve (VN) arises from the ganglion about the middle of its lateral margin and passes obliquely posteriorly over the ventral external oblique muscles. It gives rise to three branches, amongst which, the first branch (1V) extends two branches (a and b) to innervate the ventral external and lateral oblique muscles, tergosternal muscle and tracheae. The second branch (2V) bifurcates so that one branch (a) innervates the meso-

thoracic leg, ventral external oblique muscle and the integument, and the other branch (b) innervates the mesothoracic leg. Very near to the second branch, originates the third branch (3V) which innervates the ventral external and internal oblique muscles and tracheae. The fourth branch (4V) directly runs into the mesothoracic leg to innervate its muscles. The main nerve itself passes posteriorly to innervate the ventral external and internal oblique muscles.

THE TRANSVERSE NERVE: The unpaired median nerve (MN) of the mesothoracic segment arises from the fused intersegmental ganglionic connectives at the point where the connectives separate, that is, a very short distance posterior to the prothoracic ganglion. The median nerve travels about two thirds of the distance in between the interganglionic connectives and then gives off a pair of transverse nerves (TN). The transverse nerve receives three connective branches from the dorsal nerve as already stated. The two lateral connectives lie on the two sides of the lateral longitudinal tracheal trunk. The main transverse nerve which runs over this tracheal trunk, above the dorsal internal lateral muscles, terminates into the aorta to innervate it.

POSTMEDIAN NERVE: A pair of fine nerves which may be designated as the postmedian nerves (PMN) arise from the transverse nerves, very near to the point of bifurcation of the median nerve. They proceed posteriorly and meet the interganglionic connectives at two points, a little above the mesothoracic ganglion. The two nerves communicate with each other by a pair of very short connectives.

NERVES OF THE METATHORACIC GANGLION (Fig. 3)

THE DORSAL NERVE: The dorsal nerve (DN) arises from the outer margin of the interganglionic connective and passes over the ventral external oblique muscles for a short distance and then penetrates to run beneath the ventral internal lateral muscles. The first branch (1D) of the dorsal nerve extends to meet the transverse nerve but in addition gives rise to a branch (a) which subdivides into a number of minute branches to innervate the ventral external and internal oblique muscles and the ventral internal lateral longitudinal muscles. The main dorsal nerve subsequently sends off another connective branch (2D) which proceeds antero-laterally and fuses with the transverse nerve. But just near the fusion point, the branch 2D extends a branch anteriorly which innervates certain sternopleural muscles and tracheae. In addition, the branch 2D gives rise to two small branches (a and b) which innervate the lateral internal oblique and ventral external oblique muscles respectively. The third connective branch (3D) of the dorsal nerve again fuses with the transverse nerve. A side branch (a) from this nerve bifurcates to innervate the sternopleural muscles, tracheae and integument.

The main dorsal nerve then passes towards the mid-dorsal region and extends the fourth branch (4D) which passes anteriorly and then curves sharply

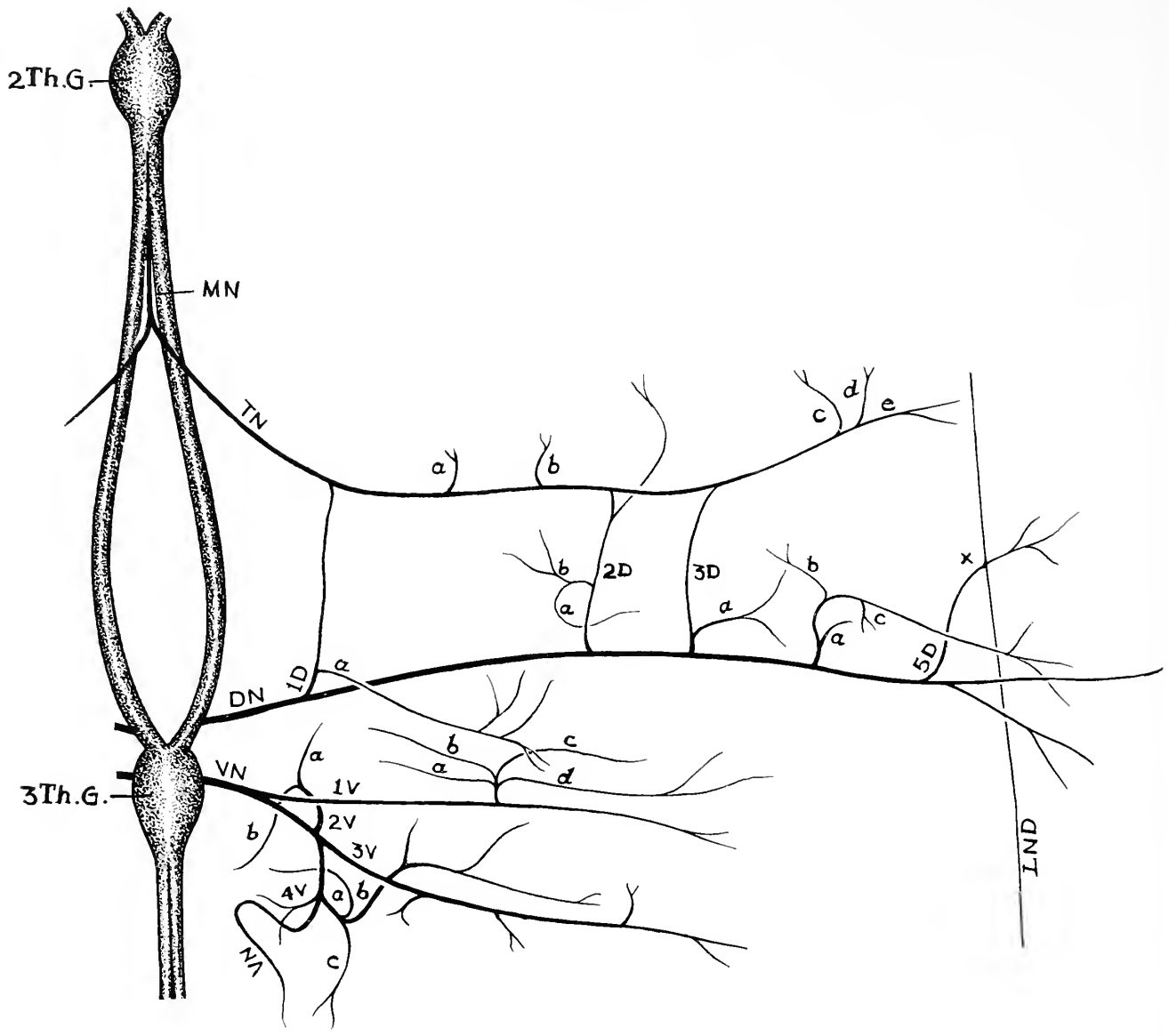

Fig. 3

FIG. 3. Diagram of the metathoracic nerve pattern of the larva of *P. litura*.

postero-dorsally, giving origin to a number of minute branches at intervals. Its first minute branch (a) innervates the paratergal muscle, the second, third and fourth branches (b, c, d) innervate the lateral internal oblique muscles and the dorsal internal lateral longitudinal muscle. The other branches innervate the various median and lateral longitudinal muscles of the dorsal region. The fifth branch (5D) of the dorsal nerve is short and fuses with the longitudinal nerve of the dorsum (LND) at the point x. The main dorsal nerve by now becomes extremely thin and fine and bifurcates into two branches which innervate the integument, dorsal internal median and dorsal external muscles.

THE VENTRAL NERVE: This nerve (VN) leaves the ganglion from the middle of its lateral margin and passes obliquely posteriorly beneath the crossed diagonal muscles and over the ventral external oblique muscles. It is com-

paratively shorter and extends into the metathoracic leg to innervate its muscles. It, however, gives rise to a number of branches during its course. The first branch (1V) runs below the ventral internal lateral muscles and gives rise to a small branch which immediately subdivides into four minute branches. Among these, the first three branches (a, b, c) innervate the integument whereas the other branch (d) passes over the lateral longitudinal tracheal trunk and bifurcates to innervate the sternopleural muscle and the integument of the dorsal region. The main branch (1V) extends further ahead over the lateral longitudinal tracheal trunk and gives rise to several small branches which innervate the lateral external oblique and tergosternal muscles and the integument.

The second branch (2V) of the ventral nerve runs anteriorly and bifurcates. Whereas one branch (a) innervates the metathoracic leg, the other (b) innervates the integument. The third branch (3V) arises near the origin of the second branch and while it proceeds laterally, it gives rise to a number of minute branches which innervate the ventral external and internal oblique muscles, sternopleural and tergopleural muscles and the integument of that region. The fourth branch (4V) penetrates into the leg to innervate it whereas the fifth branch (5V) divides into three branches. The first branch (a) innervates the leg muscles, the second (b) innervates the ventral internal median muscle, the integument and tracheae and the last branch (c) runs posteriorly to innervate the two ventral external oblique muscles.

THE TRANSVERSE NERVE: A pair of transverse nerves (TN) arises by the bifurcation of a median nerve. Each transverse nerve passes over the dorsal and ventral internal longitudinal muscles and receives three connections from the dorsal nerve as already stated. During its course, it gives rise to two very minute branches (a and b) which innervate the tracheae. Before terminating, the transverse nerve divides into three minute branches. The first two branches (c and d) pass inwards to supply certain small muscles, integument and tracheae whereas the third branch (e) passes towards the mid-dorsal region to innervate the aorta.

DISCUSSION

In the *Prodenia* larva, the thorax bears three distinct ganglia. The dorsal nerve arises directly from the prothoracic ganglion but in the meso and metathoracic segments it arises from the interganglionic connectives. Nesbitt (1941) in Orthoptera described an anterior ganglionic connective extending from one ganglion to the other. He has shown that the anterior part of the nerve may adhere to or even become incorporated in the adjoining interganglionic connective. This nerve has been termed as intercalary nerve by Pipa and Cook (1959) and Matsuda (1956) whereas dorsal nerve connective or anterior ganglionic connective by Schmitt (1959). In *Dissosteira, Acheta, Periplaneta* and *Orchelimum,* Schmitt found varying degrees of adherence to or fuse with the

adjoining interganglionic connective so that with the adherence of the anterior ganglionic connective too, the dorsal nerve seems to emerge from the connective. This condition is seen in the metathorax of *Orchelimum*. In *Prodenia* larva also the dorsal nerves in the meso and metathorax arise from the interganglionic connectives, as already stated and as such the case appears to be parallel with that of *Orchelimum*. In *Chauliodes* (Neuroptera) also Maki (1936) found a similar condition and Schmitt thinks that it is possible that the dorsal nerve in this insect is simply adhering to the nerve cord and does not lack an anterior connective but the resemblance with *Orchelimum* suggests that a dorsal nerve connective occurs in *Chauliodes* too. It must, therefore, be taken as fused. In the prothoracic segment of the *Prodenia* larva, however, the dorsal nerve arises directly from the ganglion. It appears that the proximal part of the dorsal nerve in this case has not fused with the interganglionic connective but the anterior ganglionic connective has fused with the interganglionic connective. Among other lepidopterans, Weber (1954) found an anterior connective of the dorsal nerve but Du Porte (1915) did not observe it in *Sphida* and has shown the dorsal nerve to arise from the interganglionic connective similar to the condition seen in *Prodenia* larva.

The median or unpaired nerve in the larva is a short nerve which bifurcates to form two transverse nerves of a segment. Exceptions were noted in the larva of *Papilio* by Hillemann (1933) who figured a continuous median nerve between the second and third thoracic ganglia, and the same was observed by Marquardt (1939) in *Carausius*. The origin of the prothoracic median and transverse nerves is different in the larva so that the latter have been named as the subconnective nerves. Each nerve meets the dorsal nerve through a plexus and hence on this basis it can be conveniently presumed that these nerves are actually the transverse nerves. Peterson (1912) also reported the presence of subconnective nerves in the larva of tomato worm. In *Prodenia* larva, fusion of the transverse nerve from the prothoracic ganglion with mesothoracic dorsal nerve and of the transverse nerve from the mesothoracic ganglion with the metathoracic dorsal nerve has been observed. Such fusions have also been reported in *Chauliodes, Aqulla, Perla, Carausius, Blattella, Periplaneta, Telea, Dissosteira* and *Papilio*. Most writers have designated the transverse nerve by that name but Pipa and Cook (1959) identified it simply as "nerve 8."

Whereas in the prothoracic segment, the subconnective nerve joins the dorsal nerve through a plexus, in the meso and metathoracic segments the connection between the transverse and dorsal nerves is maintained by three connectives. Du Porte (1915) also reported three such connections in *Sphida* larva but Swaine (1920) observed two or three in *Sthenopis* larva. Hillemann (1933) found two connections in the *Papilio* larva. Nothing appears to be known regarding the function of the axons which presumably pass from the transverse or subconnective nerve to the prothoracic dorsal nerve. Wittig (1955) found

that in *Perla* these transverse nerves pass to certain small dorsal longitudinal muscles and have no contact with the dorsal nerves but Schmitt (1959) reported that in *Dissosteira* the transverse nerves join the second cervical nerves and that somewhat distad of the junction, there is a connection from the second cervical nerve to the prothoracic dorsal nerve by means of which presumably axons from the transverse nerve could reach the same destination as in *Carausius* and *Chauliodes* and perhaps *Perla* also. In *Prodenia* larva the case too appears to be similar though the connection between the subconnective and prothoracic dorsal nerves is through a plexus. In the larva the transverse nerve actually terminates in the dorsal vessel and the same innervation was described by Libby (1961) in the abdomen of *Hyalophora*. In the abdomen of Orthoptera, however, Alexandrovicz (1913), Nesbitt (1941) and Schmitt (1959) found the innervation of the dorsal vessel from the dorsal nerves. The question whether there is a real difference in the innervation of the dorsal vessel in Lepidoptera and Orthoptera or the same axons are involved but follow different nerve paths appear problematic. The fact that the transverse nerve directly innervates the dorsal vessel but receives three connective branches from the dorsal nerve suggests that the dorsal vessel is innervated not only by the axons of the transverse nerve exclusively but by those of the dorsal nerve, also. This interpretation reconciles the views of orthopteran and lepidopteran workers.

In the larva of *Prodenia*, there is only one pair of thoracic spiracles lying in the prothorax. Each is innervated by a branch from the second connective joining the transverse and dorsal nerves of the mesothoracic segment. Case (1957) has shown that in the cockroach the axons to the spiracular muscle actually issue from the transverse nerve and the same was demonstrated by Hoyle (1959) in *Schistocerca gregaria*. On the basis of their findings it can be presumed that here also the axons from the transverse nerve travel into the connective branch and then into the spiracular muscle through another minor branch. The spiracular muscle also receives axons from the dorsal nerve, travelling by the same path.

It has already been pointed out that the thoracic spiracle is innervated by a branch from the connective 2D so that it may be considered to be homologous to the A–B connection present in the abdomen in Orthoptera, Plecoptera (Schmitt 1954, 1962, 1963), Lepidoptera (Libby 1959), and Neuroptera (Maki 1936).

The ventral nerve usually innervates the leg muscles, the various ventral oblique muscles and the integument. In the meso and metathorax of *Prodenia* larva there is a pair of ventral nerves in each segment. In other lepidopterous larvae also the same arrangement and number has been observed (Swaine, 1920; Hillemann, 1933; Du Porte, 1915 and Peterson, 1912). In the prothorax of the larva, the ventral nerve not only innervates the leg muscles and oblique muscles but also the muscles lying at the base of the head. In *Dis-*

sostera, Schmitt found a prothoracic nerve to join one of the cervical or ventral nerves. He further considered this prothoracic nerve to be the counter part of the dorsal nerve of the meso and metathorax. In the present case though there is no connection between the prothoracic nerve and the ventral nerve, yet there exists a connection (6V) between the dorsal and the ventral nerves. On the basis of Schmitt's interpretation, it may be concluded that it is through this connective that the axons from the dorsal nerve travel to the muscles at the base of the head.

The concept that in ancestral insect, there was a common ancestral pattern of musculature as well as innervation in each segment of the body, gets support in the present study that the nerve patterns in thorax as well as in abdomen (unpublished) of *Prodenia* larva are practically identical especially with reference to the 2D or A–B connection. This connection has been described in the abdomen of widely separated orders of insects like Orthoptera, Plecoptera (Schmitt 1954, 1962, 1963), Neuroptera (Maki, 1936), and Lepidoptera (Libby, 1959). The presence of this connection in different insect groups suggests the existence of a basic segmental nerve plan.

SUMMARY

The nerves of the thoracic segments of the larva of *Prodenia litura* have been described in detail. The thorax bears three distinct ganglia, each giving rise to three pairs of nerves which are dorsal, ventral and transverse. The dorsal nerve mainly innervates the dorsal muscles whereas the ventral nerve innervates the leg and ventral muscles. The transverse nerve mainly supplies the dorsal vessel. The dorsal nerve of the prothoracic ganglion remains connected by a plexus to the subconnective nerve which has been considered to be a transverse nerve. In the other two segments, the dorsal nerve fuses with the transverse nerve at three points by means of three connectives. In contrast to this, the ventral nerve does not fuse with the transverse nerve. The spiracular muscles are innervated from the connective lying in between the dorsal and transverse nerves. The pattern of the nerves is the same as found in other lepidopterous and orthopterous insects and that supports the concept that a basic segmental nerve pattern exists within the insects.

Acknowledgement

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KEY TO ABBREVIATIONS

DN = Dorsal nerve, LND = Longitudinal nerve of the dorsum, MN = Median nerve, PMN = Post median nerve, px = plexus, SG = Suboesophageal ganglion, SN = Subconnective nerve, TN = Transverse nerve, Th.G = Thoracic ganglion, VN = Ventral nerve.

Undescribed Species of Crane Flies from the Himalaya Mountains (Diptera: Tipulidae), XIII[1]

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Abstract: Six new species of Eriopterine crane flies are described, these being *Neolimnophila* **citribasis** n. sp., from Assam; *N.* **daedalea** n. sp., Sikkim; *Lipsothrix* **decurvata** n. sp., Sikkim; *Styringomyia* **subobscura** n. sp., Assam; *S.* **tarsatra** n. sp., Nepal; and *Toxorhina* (*Ceratocheilus*) **tuberifera** n. sp., Sikkim.

Part XII of this series of papers was published in the **Journal of the New York Entomological Society, 74:** 66–71, 1966. As before, the materials discussed were collected by Dr. Fernand Schmid and Dr. Edward I. Coher, to whom my sincere thanks are extended.

Neolimnophila **citribasis** n. sp.

General coloration of body brown, the praescutum with four darker brown stripes, the intermediate pair narrowly separated; antennae 16-segmented; wings brownish yellow, the basal third, including the veins, clear orange-yellow, narrow brown seams over cord and outer veins; R_2 about twice its length before fork of R_{3+4}.

FEMALE: Length about 7 mm; wing 7.8 mm; antenna about 1.4 mm.

Rostrum dark brown; palpi black. Antennae 16-segmented, black, the scape more pruinose; proximal two flagellar segments barely connate, the separating suture narrow but complete, outer segments progressively more slender, the outer pair shorter; longest verticils subequal to the segments. Head brownish gray; vestiture black, from small dark punctures.

Pronotum dark brown. Mesonotal praescutum yellowish brown with four dark brown stripes, the intermediate pair separated only on posterior two-thirds; pseudosutural foveae and tuberculate pits black; posterior sclerites of notum brownish black. Pleura dark gray, dorsopleural membrane brown. Halteres elongate, clear light yellow. Legs with coxae black, gray pruinose; trochanters obscure yellow; femora brownish black, bases yellowed, broadly on the posterior pair, remainder of legs brownish black; tibial spur of fore leg lacking, present on hind pair (middle legs lacking). Wings brownish yellow, the basal fifth clear orange yellow, including the veins; narrow brown seams over cord, outer end of cell *1st* M_2, origin of *Rs,* and the outer forks, more diffuse and paler on *Cu* and the outer veins; veins light brown, the yellow bases extended outwardly to include all of *Sc* and less evidently on other primary veins. Venation: Sc_1 ending opposite fork of *Rs*; R_2 about twice its length before the fork of R_{3+4}; origin of vein R_4 angulated and short-spurred; cell M_1 subequal to its petiole; *m-cu* just beyond the fork of *M*.

Abdomen black, the genital segment intensely so; valves of ovipositor horn yellow.

HOLOTYPE ♀, Jhum La, Kameng, North East Frontier Agency, Assam, 7,800 feet, May 13, 1961 (Schmid).

In its general appearance *Neolimnophila* **citribasis** is most similar to *N.*

[1] Contribution from the Entomological Laboratory, University of Massachusetts.

daedalea n. sp., of Sikkim, being readily told by the extensive brightening of the wing base and the more restricted darkened pattern of the disk. The lack of a distinct flagellar fusion-segment is especially noteworthy. Both *N.* **daedalea** and *N. fuscinervis* Edwards, of Yunnan, have the basal segment of the flagellum elongate, resulting from four fused segments, with ten free segments beyond.

Neolimnophila **daedalea** n. sp.

General coloration of thorax blackened, the praescutum with four darker stripes, the intermediate pair vaguely separated; wings light yellow, most of the veins heavily seamed with brown, cells *C* and *Sc* conspicuously brownish yellow; a darkened cloud in outer half of cell *R* behind *Rs*.

MALE: Length about 5.5 mm; wing 8 mm; antenna about 1.2 mm.

FEMALE: Length about 6–6.5 mm; wing 8–8.2 mm; antenna about 1.4 mm.

Rostrum and palpi black. Antennae black, scape pruinose; fusion-segment of flagellum involving four segments, with ten free segments beyond. Head brownish gray; anterior vertex broad.

Pronotum blackish gray. Mesonotal praescutum with four blackened stripes, the intermediate pair only vaguely separated, the lateral stripes poorly indicated, lateral margins of segment light gray; posterior sclerites of notum black, very sparsely pruinose. Pleura gray. Halteres light yellow. Legs with coxae black, pruinose; trochanters brown; remainder of legs brownish black, femoral bases very narrowly paler. Wings strongly light yellow, the prearcular field bright yellow; a heavy brown pattern over the cord, outer end of cell 1st M_2 and vein *Cu,* narrower but still conspicuous on veins beyond cord with the exception of M_{1+2}, M_1 and M_{3+4}; no darkenings on *M* or *1st A*; a conspicuous marking in outer half of cell *R* behind *Rs*; cells *C* and *Sc* brownish yellow. Venation: R_2 some distance before fork of R_{3+4}, subequal to R_3; position of *r-m* slightly variable, in cases at or just before the fork of *Rs*.

Abdomen dull black. Valves of ovipositor long and straight, tips of cerci with coarse yellow setae.

HOLOTYPE ♀, Kalep, Sikkim, in *Rhododendron* association, 12,100 feet, June 18, 1959 (Schmid). Allotype, ♂, Yumtang, Sikkim, in *Rhododendron* association, 12,140 feet, June 27, 1959. Paratypes, 3♂♂, with the allotype; 1 ♀, Chachu, Sikkim, 11,500 feet, June 29, 1959 (Schmid).

Other Himalayan species include *Neolimnophila genitalis* (Brunetti), with unpatterned wings, together with *N. bifusca* Alexander and *N.* **citribasis** n. sp., previously described in the present report. In the higher mountains of western China still other species are found, including *N. fuscinervis* Edwards, *N. perreducta* Alexander and *N. picturata* Alexander, all with the details of wing pattern and venation distinct.

Lipsothrix **decurvata** n. sp.

Pronotum and anterior end of praescutum brownish black, the remainder of the praescutal stripes paler, pleura light yellow; femora yellow, tips conspicuously brownish black; wings faintly darkened, prearcular and costal fields more brownish yellow; *Rs* relatively long, nearly twice R_{2+3+4}, vein R_4 very strongly decurved outwardly, its tip at or beyond the wing apex, cell *1st* M_2 short-rectangular.

MALE: Length about 7–7.2 mm; wing 7.5–7.8 mm; antenna about 2.7–2.8 mm.

Rostrum brownish yellow; palpi black. Antennae relatively long, as shown by the measurements; scape and pedicel brownish yellow, flagellum brownish black; segments long-subcylindrical, verticils short and sparse. Head light brown.

Cervical region and pronotum brownish black. Mesonotal praescutum extensively obscure yellow, with a light brown central stripe, anterior half more brownish black, this being a continuation of the pronotal darkening, region of the suture yellowed; scutal lobes and posterior sclerites darkened, including the pleurotergite. Pleura light yellow. Halteres with stem pale, knob darkened. Legs with coxae and trochanters yellow; femora yellow, tips conspicuously brownish black; tibiae obscure yellow, tips more narrowly darkened; tarsi obscure yellow; claws long, with a major subbasal spine and two or three smaller more proximal denticles. Wings faintly darkened, prearcular and costal regions more brownish yellow, stigma still darker; veins brown, more yellowish brown in the brightened fields. Macrotrichia of veins very long. Venation: Sc_1 ending just beyond fork of the long Rs, Sc_2 near its tip; R_2 faint, subequal to or shorter than R_{1+2}; vein R_4 very strongly decurved outwardly, ending at or beyond the wing tip, cell R_3 at margin slightly more extensive than cell R_2; cell *1st* M_2 short-rectangular, less than one-half the veins beyond it; *m-cu* about one-third its length beyond the fork of M, in cases close to the fork.

Abdomen including hypopygium, dark brown. Male hypopygium with the interbase slender; phallosome strongly developed, about as in *malla*.

HOLOTYPE ♂, Chateng, Sikkim, 8,700 feet, June 12, 1959 (Schmidt). Paratopotypes, 4 ♂♂, on two pins.

Lipsothrix **decurvata** is close to *L. malla* Alexander, of Nepal, differing in details of body coloration and in the venation, especially cell *1st* M_2 and the radial field, including the more decurved vein R_4.

Styringomyia **subobscura** n. sp.

Allied to *obscura*; general coloration of body black; legs blackened, middle and hind femora each with a narrow yellow subterminal ring, posterior tarsi whitened; wings slightly suffused, virtually unpatterned; male hypopygium with a long sinuous rodlike spine near base of inner arm of dististyle; apex of phallosome bilobed.

MALE: Length about 6.5 mm; wing 4.6.

FEMALE: Length about 6 mm; wing 4.5.

Rostrum and palpi black. Antennae with proximal five or six segments black, the outer ones brownish yellow; flagellar segments oval. Head brownish black.

Thorax black, sparsely gray pruinose to appear dull; central region of sternum somewhat paler. Halteres with stem dark brown, knob brownish black. Legs with coxae light brown; trochanters brownish yellow; remainder of fore legs uniformly blackened; middle femora restrictedly obscure yellow at base, remainder brownish black with a narrow obscure yellow ring some distance before tip, tibiae brownish black, the extreme base pale, tarsi brownish black, the extreme bases vaguely paler; posterior legs chiefly black, femur with a conspicuous pale yellow subterminal ring, the darkened tip nearly three times as extensive, tibiae brownish black, tarsi whitened, the extreme tips of the individual segments pale brown, terminal segment uniformly darkened. Wings beyond cord with a slight darkened suffusion, basal cells more whitened; a dusky seam along vein *Cu* involving both cells; veins dark brown. Venation: Anterior branch of *Rs* more nearly erect than in *obscura*.

Abdomen black. Male hypopygium generally as in *obscura*, differing in all details, especially of the dististyle and phallosome. Outer rod of dististyle without basal setae; outer arm large, its surface with numerous scattered setae; margin with an unbroken

comb of strong spinoid setae, those at either end of row slightly longer; inner arm of style more slender, with two terminal combs, two strong similar spines near base, and a long sinuous rodlike spine on outer margin near base; origin of dististyle with a blackened rod, its apex dilated into a head. Phallosome on either side with a recurved or pendant lobe, the obtuse apex blackened; in *obscura* this represented by a single powerful terminal spine. HOLOTYPE ♂, Chapai, Kameng, North East Frontier Agency, Assam, 700 feet, February 26, 1961 (Schmid). Allotype ♀, Bhairabkunda, Kameng, 700–1,000 feet, March 5, 1961 (Schmid).

The closest relatives of the present fly are *Styringomyia obscura* Brunetti and *S. schmidiana* Alexander, both with the hypopygial structure quite distinct. The male hypopygium of *obscura* has been described and figured by the writer (**Philippine Jour. Sci. 86:** 447–448, pl. 4, fig. 56; 1957).

STYRINGOMYIA **tarsatra** n. sp.

Size small (wing 4.5 mm or less); general coloration of mesonotum dark gray and black, ventral half of thoracic pleura abruptly yellow; halteres black; femora black, bases and a narrow subterminal ring yellow, all tibiae and tarsi black; wings with a weak brownish tinge, the basal third more whitened; abdomen black; male hypopygium with the modified sternal setae apical in position; outer lobe of basistyle with a single modified seta; intermediate and inner arms of dististyle with rows of blackened pegs; phallosome unusually small and inconspicuous, the blackened apex rounded.

MALE: Length about 6.2–6.5 mm; wing 4–4.5 mm.

FEMALE: Length about 6 mm; wing 4.2 mm.

Rostrum and palpi black. Antennae with scape, pedicel and proximal flagellar segments black, intermediate segments paler, the outer ones again blackened; pedicel enlarged, flagellar segments oval. Head dark brown to brownish black, sparsely pruinose.

Pronotum dark brown, obscure yellow medially. Mesonotum gray, patterned with black including sublateral praescutal stripes and margins to the scutal lobes; scutellum with a central pale yellow spot. Pleura conspicuously blackened above, including the dorsopleural membrane, lower half abruptly yellow, including also the coxae of all legs. Halteres black. Legs with trochanters yellow, femora black, the bases restrictedly paler, with a narrow obscure yellow subterminal ring at about twice its length from the tip; tibiae and tarsi of all legs black. Wings with a weak brownish tinge, the basal third or more whitened; veins brown. Venation: Anterior branch of *Rs* oblique; cell *2nd* M_2 narrowly to more broadly sessile.

Abdomen black, hypopygium brownish black. Male hypopygium with the tergite narrowed outwardly, apical lobe provided with dense retrorse setae; sternite long and narrow, the two modified setae terminal, placed at outer apical angles of sternal lobe, surface microscopically setulose. Basistyle with a single modified seta, subequal in length to its basal tubercle. Dististyle with outer arm bearing a single weak seta at near one-third the length; intermediate and inner arms provided with blackened pegs; inner arm with a slender pale rod on outer margin, the inner edge near base with a group of about 10 to 12 very long setae. Phallosome unusually small and inconspicuous, the outer end rounded and blackened.

HOLOTYPE ♂, Parewavir, Nepal, March 28, 1957 (Coher). Allotype ♀, Amlekhgang, Nepal, 520 meters, July 26, 1957 (Coher). Paratopotypes, 6 ♂♂, with the type, March 15–28, 1957 (Coher).

Other somewhat similar regional species include *Styringomyia obscura* Brunetti, *S. schmidiana* Alexander, and *S.* **subobscura** n. sp., from which the present fly differs in the small size, details of coloration, including the uniformly blackened tarsi of all legs, and in the details of hypopygial structure, including particularly the dististyle and phallosome.

Toxorhina (*Ceratocheilus*) **tuberifera** n. sp.

General coloration of head and thorax gray, the praescutum with three virtually confluent brown stripes; halteres and legs black, the femoral bases restrictedly yellow; wings subhayaline, base more yellowed, anterior branch of *Rs* sinuous, cell R_1 narrowed at margin; abdomen brownish black; male hypopygium with a strong tubercle near proximal end of basistyle; dististyle terminal, the marginal tubercle small; arms of aedeagus very short.

MALE: Length, excluding rostrum, about 5 mm; wing 5 mm; rostrum alone about 3 mm.
FEMALE: Length, excluding rostrum, about 5.5 mm; wing 5 mm; rostrum about 3 mm.

Rostrum black, more than one-half the length of wing. Antennae black. Head black, sparsely pruinose, without a corniculus; anterior vertex relatively narrow, slightly wider than the diameter of the scape.

Cervical region and pronotum blackened. Mesonotal praescutum with three virtually confluent brown stripes, the median extension darker in front, lateral praescutal borders gray; posterior sclerites of notum black, gray pruinose, scutal lobes more infuscated. Pleura black, sparsely pruinose to appear plumbeous. Halteres black throughout. Legs with coxae brownish black, trochanters brownish yellow; remainder of legs black, femoral bases restrictedly yellowed. Wings subhyaline, the base more yellowed; veins brown, those at wing base more brownish yellow. Certain veins beyond cord with sparse trichia, including both sections of R_5 and distal section of M_{1+2}; a single trichium near outer end of vein M_3. Venation: Sc_1 ending just beyond origin of *Rs*, Sc_2 before the origin; anterior branch of *Rs* sinuous but more erect than in *mesorhyncha,* cell R_1 narrowed at margin; *Rs* nearly as long as basal section of R_5; *m-cu* before fork of *M*. In the allotype female both wings have cell M_2 open by the atrophy of *m*.

Abdomen, including hypopygium, brownish black. Male hypopygium with a strong tubercle on mesal face of basistyle near proximal end, provided with several strong black setae. Dististyle single, terminal in position, extended into a long slender beak bearing a low lateral flange, outer margin shortly before midlength with a small tubercle. Interbases appearing as narrow blades. Arms of aedeagus unusually short, less than the distance separating them at bases.

HOLOTYPE ♂, Lathong, Sikkim, 6,560 feet, July 26, 1959 (Schmid). Allotopotype, ♀.

The closest relative is *Toxorhina* (*Ceratocheilus*) *mesorhyncha* Alexander which differs in the venation of the radial field and in the hypopygial structure, especially the dististyle and aedeagus.

RECEIVED FOR PUBLICATION AUGUST 5, 1966

The Larva of *Amblyscirtes samoset* (Scudder) (Lepidoptera: Hesperiidae)

Alexander B. Klots[1]

Abstract: The mature larva is described, figured and compared with that of the largely sympatric *A. vialis* (W. H. Edwards). Some larval characters of the genus *Amblyscirtes* Scudder are discussed.

A female *Amblyscirtes samoset* (Scudder) was observed, by Cyril dos Passos and the writer, ovipositing on *Poa pratensis* L. near West Bridgewater, Vermont, on 9 June 1956. A single egg was found, from which the larva was reared to maturity by Dr. dos Passos. The larva was then photographed, studied and preserved by the writer. It is in the American Museum of Natural History. The larva of this species is relatively unknown, almost the only published data on it being those of Scudder (1889, p. 1589–1592, pl. 77, fig. 29). Scudder, however, merely copied one of Abbot's pictures; and his description and figure are quite inadequate.

DESCRIPTION OF MATURE LARVA

LENGTH AT REST: 22.5 mm. Head rounded and only very slightly emarginate dorsally at epicranial suture (Fig. 3), from anterior aspect as wide as high; and with very little taper dorsad; covered with fine, ridgelike reticulations; very sparsely and finely setose. Face (including the central triangular sclerite, the narrow sclerites bordering this laterally, and the anterior edges of the epicrania[2]) dark brown, forming a triangle that narrows toward vertex, and behind vertex joins the dark posterior region of the head; laterad of this on either side a broad, very pale brown band running dorsad almost to vertex (Figs. 1 & 2); posterad of this on either side a dark brown band, ventrally including the anterior 4 stemmata, running dorsad to vertex; posterad of this on either side a broad, pale band running dorsad almost to vertex; vertex and posterior region of head dark brown. Labrum shallowly emarginate. A strong, projecting, slightly recurved spine (here called the *paraclypeal spine*) arising laterad of each ventro-lateral angle of clypeus, protruding forward and ventrad. Stemmata: Nos. 1–4 forming an anterior curving group; of these, 4 is the largest, 3 is slightly smaller than 4, 1 is slightly smaller than 3, and 2 is slightly smaller than 1. No. 6 is almost directly caudad of 4 and about as far from it as 1 is from 3.

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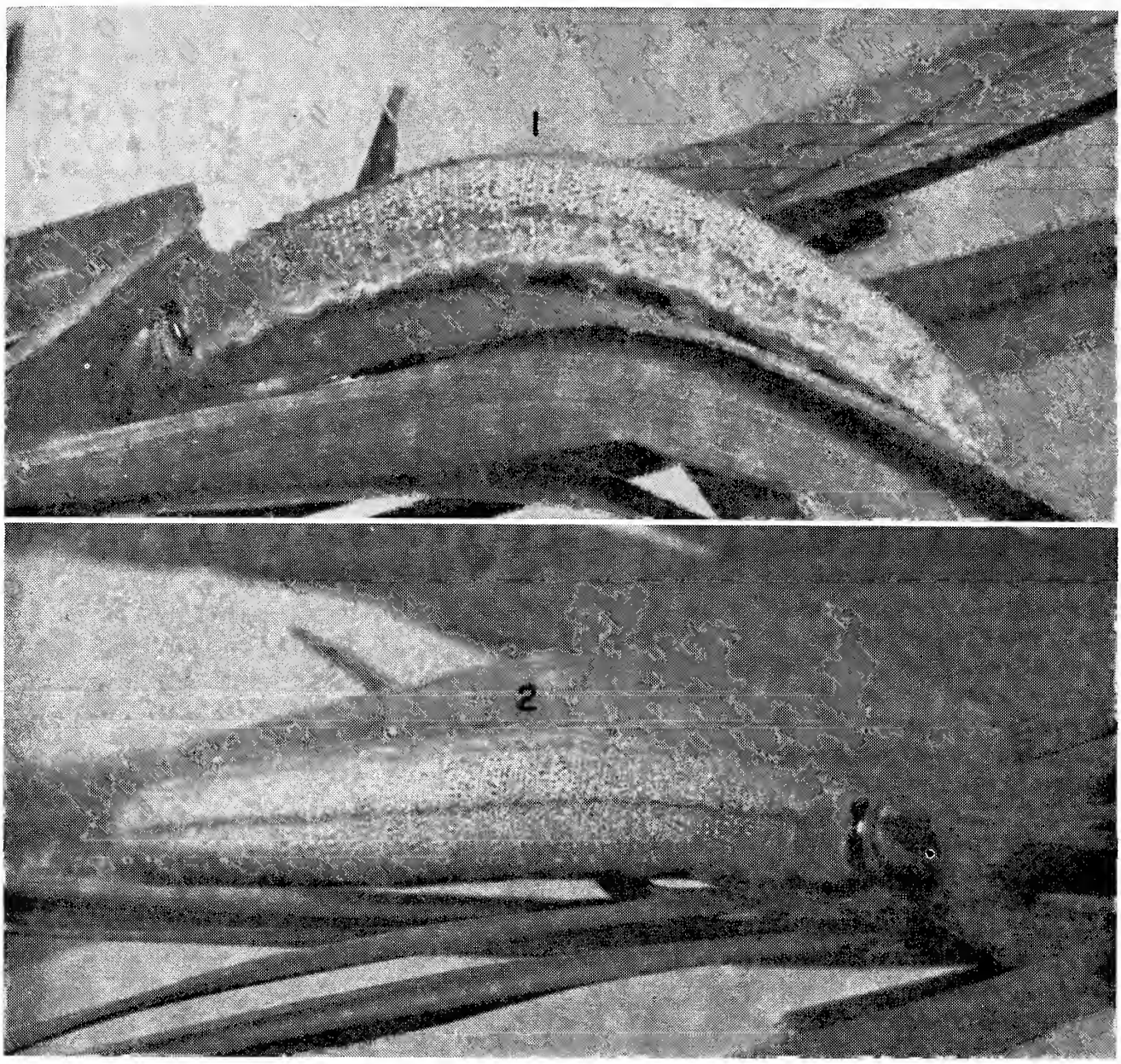
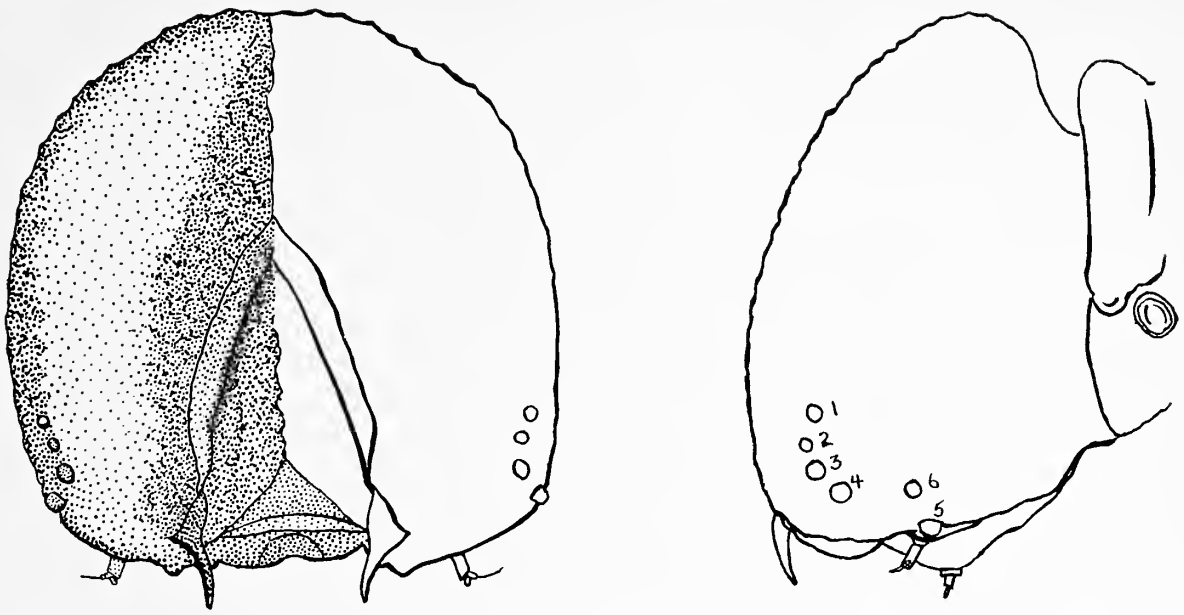
[2] The nomenclature of the anterior surface of the head of lepidopterous larvae is somewhat confused. Most recent systematists call the large, triangular, central sclerite the *frons*, the narrow sclerites along each side of this the *adfrontals*, and the transverse area ventrad of the so-called frons the *clypeus*. However, as shown by Snodgrass (1935, p. 121, fig. 64) the triangular central sclerite is really the clypeus; most of the true frons is invaginated within the so-called epicranial suture dorsad of the true clypeus; and the narrow, lateral sclerites are the ventral remnants of the true frons, separated by the dorsad extension between them of the true clypeus. Scudder (loc. cit., **I**, p. 8) calls the whole complex the "facial triangle, or clypeus."



FIGS. 1 & 2. Mature larva, *Amblyscirtes samoset* (Scudder), from life. FIG. 1: lateral aspect. FIG. 2: dorsal aspect.

No. 5 is ventrad and slightly caudad of 6, just above and slightly caudad of base of antenna and directed ventrad. Prothoracic shield heavily sclerotized, black, shining, its ventral margins somewhat undulate. Prothoracic spiracle very large, broadly and symmetrically oval.

Ground color of body very pale whitish green with darker dull green markings (Figs. 1 & 2). Meso- and metathorax fairly thickly covered with short setae arising from circular, well-sclerotized bases; remainder of body with shorter, much sparser setae, nearly all of which arise from almost unsclerotized bases. A distinct narrow, mid-dorsal, dark line from anterior end of mesothorax to posterior end of abdomen, weakening posteriorly; a more diffuse, dark, lateral, supraspiracular line from thorax to posterior end of abdomen, weakening posteriorly. A pale whitish, subspiracular line along the edge of a distinct, folded, lateral ridge from anterior edge of prothorax to posterior end of abdomen. Mesothorax almost completely dark, metathorax lighter, abdominal segments progressively lighter. On the posterior part (somewhat more than half) of each abdominal segment are 4 or 5 very narrow, somewhat irregular transverse dark lines between which are transverse rows



3 4

FIGS. 3 & 4. Head of mature larva, *Amblyscirtes samoset* (Scudder). FIG. 3: anterior aspect; the shading shows pigmentation, not contour. FIG. 4: lateral aspect, showing also prothoracic shield and spiracle.

of dark dots; and on the anterior part (somewhat less than half) of each segment a number of dark dots, sometimes more or less in transverse rows, sometimes irregularly located.

DISCUSSION

Scudder's description and figures of the larvae of *A. vialis* (loc. cit., p. 1575–1588, Pl. 77, fig. 24 and Pl. 80, figs. 46–50) show it differing from that of *A. samoset* in a number of features. *A. vialis* has the head narrower and more emarginate and tapering dorsally; the frontal triangle is more largely pale; on either side of it is a narrow, vertical dark stripe that does not run dorsad to join the other dark areas; and the body is paler and more thickly setose and lacks the dark middorsal line and most of the other dark markings of *samoset*. Scudder cites the dorsally tapering, emarginate head and the protruding paraclypeal spines as generic characters for *Amblyscirtes*. Heitzman ("1964" [1965] and 1965) has described and figured in detail the larvae of *A. nysa* W. H. Edwards and *A. belli* A. Freeman. Each has a dark middorsal line, a dorsally tapering, emarginate head, and a distinctive dark and light banded head pattern generically like those of *A. vialis* and *samoset*. Paraclypeal spines are figured for the larva of *A. belli* but not mentioned; but are not mentioned or figured for the larva of *A. nysa*. In the latter case they may have been overlooked. The stemmata and prothoracic spiracle are not shown in detail. It seems probable that the paraclypeal spines and the banded head pattern may be regarded as characters for *Amblyscirtes,* but that the dorsally broader and non-emarginate head is peculiar to *A. samoset*. Details of the body pattern

and the surface sculpturing of the head may well prove to be characters of specific value when the larvae of more species are known.

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The Discovery of Additional Journals of Frank E. Watson

In an obituary of Frank Edward Watson, 1877–1947, published in the **Journal of the New York Entomological Society** (1958, **66**: 1–6) the finding of some of his loose-leaf journals covering the years 1904 in part, 1906–1910, 1911 in part, 1912–1913, 1915 and 1923–1925 was reported. During Watson's last years he made his home with William Friedle of Ozone Park, Long Island, New York. With the death of William Friedle a few months ago his step nephew, Mr. Bruce Friedle, discovered a number of additional volumes of Watson's journals that had not been delivered to the undersigned when he purchased Watson's butterfly collection and library from Friedle after the former's death.

These additional journals have been kindly given by Mr. Friedle to the Department of Entomology of the American Museum of Natural History and are as follows: 1896–1905, 1914–1922, 1926–1931, 1934–1947. Thus the American Museum now has all of Watson's diaries in the Department of Entomology with the exception of those covering the years 1932 and 1933. These must be assumed to have been lost.

The Watson journals, as before observed, are extremely interesting and important as showing his activities in the field from day to day and in rearing Lepidoptera. Further details of these matters will be found on page 3 of the aforementioned paper. They also fix definitely his collecting localities which are only indicated on his specimens by code letters.

CYRIL F. DOS PASSOS

Studies on Parasitic Mites of New Jersey[1]

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Abstract: A study of mites of the Trombiculidae, Myobiidae, Pyemotidae, Tetranychidae, and Acarinae collected from mammals in New Jersey included 26 recognized species and 3 probable new species. New records for the state and host and date-locality records are included.

INTRODUCTION

In view of the scarcity of New Jersey ectoparasite records, a survey was undertaken from 1951 to 1953 by the New Jersey Agricultural Experiment Station with cooperation from the New Jersey Department of Agriculture, and the New Jersey Division of Fish and Game. During this survey, about 4,000 mammals of twenty-nine species were collected.

This paper summarizes information on the Trombiculidae, Myobiidae, Pyemotidae, Tetranychidae, and Acarinae which were taken from mammals and are new collection and/or host records for New Jersey.

Most of the small mammals other than rats were collected with Sherman live traps or snap mousetraps. Rats were usually collected from municipal dumps by use of cyanide gas. All mites were mounted in Hoyer's medium.

RESULTS

New records for the state are listed below together with information on hosts and comments on species where warranted. In the records abbreviations are as follows: L indicates larva, N indicates nymph, T indicates tritonymph, F indicates female, and M indicates male. Specimens without letter designations are adults. Numbers appearing after the word "plus" indicate specimens not mounted and not identified by the author, but which were thought at the time of mounting to be identical with those mounted. All mites of the same species found on the same day on the same host species in the same locality are dealt with as one record.

TROMBICULIDAE

Wharton and Fuller (1952) summarize much general information pertaining to the biology and ecology of chiggers. They also present keys to genera, and list all species and all references. Brennan and Jones (1959) present keys including all North American species of chiggers.

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[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station. From a thesis submitted to the Graduate Faculty, Rutgers—The State University in partial fulfillment of the requirements for the M.S. degree.

TABLE 1. Mites and hosts found in the present study.

	Didelphis virginiana	*Blarina brevicauda*	*Clethrionomys gapperi*	*Microtus pennsylvanicus*	*Peromyscus leucopus*	*Pitymys pinetorum*	*Mus musculus*	*Rattus norvegicus*	*Marmota monax*
Leptotrombidium myotis					2	1*			
Miyatrombicula cynos								1*	
Neotrombicula whartoni	20*			11		3*		1*	
Euschongastia peromysci			9	6	41	6		1*	
Euschongastia marmotae									23
Euschongastia blarinae		5							
Euschongastia setosa					1				
Protomyobia claparedei		1		1*					
Blarinobia simplex		88					1*		
Radfordia subuliger					1*				
Radfordia lemnina				2		3*			
Radfordia affinis							7		
Radfordia ensifera		1*		3*		5*	1*	7716	
Myobia musculi							1		
Bryobia praetiosa	4	2*		1*		1*		3*	
Pygmephorus erlangensis		8*						554*	
Pygmephorus sp.		1*						569*	
Pygmephorus sp.						5*			
Pediculaster mesembrinae								1*	
Pseudopygmephorus sellnicki								26*	
Pseudopygmephorus tarsalis								3*	
Neopygmephorus bavaricus		2*				11*		2*	
Neopygmephorus lithobii				1*					
Neopygmephorus sp.		1*		18*		159*			
Acarus siro								73	
Acarus immobilis								5*	
Tyrophagus similis								1*	
Tyrophagus palmarum								2*	
Tyrophagus putrescentiae								38	
Total hosts examined	13	88	2	152	156	146	44	2795	3

* No previous records on this host.

Keys including all species of the *Neotrombicula,* detailed descriptions, and many diagrams, are presented by Brennan and Wharton (1950). Complete records of United States *Neotrombicula* are also presented.

The most important work dealing with the genus *Euschongastia* is that of Farrell (1956) which includes a key to species, complete descriptions and much ecological information.

Leptotrombidium myotis (Ewing)

Seabrook, 22 Sept. 52, ex *Peromyscus leucopus*, 2L; Seabrook, 22 Sept. 52, ex *Pitymys pinetorum,* 1L.

Miyatrombicula cynos (Ewing)

Vernon, 7 Feb. 52, ex *Rattus norvegicus,* 1L.

Neotrombicula whartoni (Ewing)

Eldora, 9 Apr. 53, ex *Pitymys pinetorum,* 1L; Moorestown, 18 Mar. 53, ex *Pitymys pinetorum,* 1L; Riverton, 21 Apr. 53, ex *Pitymys pinetorum,* 1L; Barnegat, 19 Nov. 53; ex *Microtus pennsylvanicus,* 10L; Clayton, 16 Dec. 52, ex *Microtus pennsylvanicus,* 1L; Clinton, 29 Oct. 51, ex *Didelphis virginiana,* 20L; Riverton, 15 Feb. 52, ex *Rattus norvegicus,* 1L.

Euschongastia peromysci (Ewing)

Bamber, 10 Nov. 53, ex *Peromyscus leucopus,* 4L; Monroeville, 13 Feb. 53, ex *Peromyscus leucopus,* 2L; New Brunswick, 4 Feb. 53, ex *Peromyscus leucopus,* 1L; New Brunswick, 9 Mar. 53, ex *Peromyscus leucopus,* 7L; New Brunswick, 10 Mar. 53, ex *Peromyscus leucopus,* 3L; New Brunswick, 23 Mar. 53, ex *Peromyscus leucopus,* 1L; Seabrook, 22 Sept. 52, ex *Peromyscus leucopus,* 23L; Clayton, 16 Dec. 53, ex *Pitymys pinetorum,* 1L; Lakehurst, 12 May 53, ex *Pitymys pinetorum,* 1L; New Brunswick, 4 Feb. 53, ex *Pitymys pinetorum,* 1L; Seabrook, 22 Sept. 52, ex *Pitymys pinetorum,* 3L; Chester, 17 Dec. 52, ex *Microtus pennsylvanicus,* 1L; Clayton, 16 Dec. 52, ex *Microtus pennsylvanicus,* 1L; New Brunswick, 5 Feb. 53, ex *Microtus pennsylvanicus,* 4L; Seabrook, 22 Sept. 52, ex *Clethrionomys gapperi,* 9L; Pedricktown, 10 Mar. 52, ex *Rattus norvegicus,* 1L.

Euschongastia marmotae Farrell

Clinton, 1 Oct. 51, ex *Marmota monax,* 23L.

Euschongastia blarinae (Ewing)

Clinton, 30 Sept. 51, ex *Blarina brevicauda,* 5L.

Euschongastia setosa (Ewing)

Seabrook, 22 Sept. 52, ex *Peromyscus leucopus,* 1L.

MYOBIIDAE

Ewing (1938) described all known North American Myobiidae, and included host, date, and locality records. Jameson (1955) taxonomically and ecologically summarized the genera of the Myobiidae. A key to genera is presented, as well as phylogentic relationships of genera. With respect to *Radfordia,* an excellent key is presented by Howell and Elzinga (1962).

Protomyobia claparedei (Poppe)

High Bridge, 11 Feb. 53, ex *Blarina brevicauda,* 1F; Barnegat, 19 Nov. 53, ex *Microtus pennsylvanicus,* 1F.

Blarinobia simplex (Ewing)

Allentown, 20 Jan. 53, ex *Blarina brevicauda,* 1F plus 60; Clinton, 30 Sept. 53, ex *Blarina brevicauda,* 3F; Eldora, 10 Apr. 53, ex *Blarina brevicauda,* 2F; Port Republic, 16 Apr. 53, ex *Blarina brevicauda,* 1F plus 8; Riverton, 21 Apr. 53, ex *Blarina brevicauda,* 3F plus 4; Robinsville, 15 Jan. 53, ex *Blarina brevicauda,* 1F; Somerset County, 5 Apr. 52, ex *Blarina brevicauda,* 1F, 2FN; Trenton, 21 Apr. 53, ex *Blarina brevicauda,* 1F; Yardville, 30 Nov. 53, ex *Blarina brevicauda,* 1F; Trenton, 22 Jan. 53, ex *Mus musculus,* 1F.

Radfordia subuliger Ewing

New Brunswick, 3 Feb. 53, ex *Peromyscus leucopus,* 1F.

Radfordia lemnina (Koch)

Princeton, 22 Jan. 53, ex *Microtus pennsylvanicus,* 1M; Morris County, 6 Feb. 53, ex *Microtus pennsylvanicus,* 1F; Seabrook, 15 Dec. 52, ex *Pitymys pinetorum,* 1F plus 1; Clayton, 16 Dec. 52, ex *Pitmymys pinetorum,* 1M.

Radfordia affinis (Poppe)

Trenton, 24 Jan. 53, ex *Mus musculus,* 1F plus 5; Trenton, 26 Jan. 53, ex *Mus musculus,* 1F.

Radfordia ensifera (Poppe)

Bridgeton, 19 Dec. 52, ex *Pitymys pinetorum,* 1F; Robbinsville, 14 Jan. 53, ex *Pitymys pinetorum,* 1F; Vincentown, 23 Jan. 53, ex *Pitymys pinetorum,* 2M, 1F; Fortescue, 20 Jan. 53, ex *Blarina brevicauda,* 1M; Princeton, 22 Jan. 53, ex *Microtus pennsylvanicus,* 1M plus 2; Princeton, 22 Jan. 53, ex *Mus musculus,* 1M.

Over 7,000 *Radfordia ensifera* were collected from *Rattus norvegicus.* The localities of these collections are presented in Figure 1.

Radfordia ensifera is common on New Jersey rats; 34% of those examined were found to possess *Radfordia ensifera.* The per cent infestation appeared to be constant throughout the year, although the average number of mites per infested rat was not. An average of 8.1 specimens of *Radfordia ensifera* was found per infested rat. No significant difference was found between the average number of *Radfordia ensifera* per rat in the various sections of New Jersey.

Radfordia ensifera may be found on New Jersey rats throughout the year. The seasonal fluctuations are the same throughout the state. In summer this myobiid is about two and one-half times as abundant as during the rest of the year.

Myobia musculi Schrank

Trenton, 9 Feb. 53, ex *Mus musculus,* 1F.

PYEMOTIDAE

Cross (1962) deals with many pyemotids found throughout the country. Krczal (1959) describes many new European pyemotids.

Pediculaster mesembrinae (Canestrini)

Woodbury, 27 Aug. 52, ex *Rattus norvegicus,* 1F.

Pygmephorus erlangensis Krczal

Dividing Creek, 15 Jan. 53, ex *Blarina brevicauda,* 1F; Franklin Township, 5 Apr. 52, ex *Blarina brevicauda,* 2F; Robbinsville, 15 Jan. 53, ex *Blarina brevicauda,* 1F plus 1; Yardville, 29 Nov. 53, ex *Blarina brevicauda,* 1F plus 2.

The following records are all ex *Rattus norvegicus*:

Atlantic City, 6 Feb. 52, 2F plus 94; Audubon, 1 Feb. 52, 1F; Barrington, 4 Feb. 52, 2F; Bernardsville, 7 Dec. 51, 1F; Bloomingdale, 16 May 52, 1F; Bridgeton, 11 Feb. 52, 1F; Burlington, 28 Feb. 52, 3F plus 12; Cranbury, 7 Apr. 52, 7F plus 26; Elizabeth, 30 Jan. 52, 2F plus 14; Fairview, 9 May 52, 1F plus 8; 11 Aug. 52, 1F plus 18; Flemington, 10 Dec. 51, 3F; Gibbstown, 12 Mar. 52, 2F plus 13; Hackensack, 20 May 51, 1F; Hackettstown, 26 Mar. 52, 4F; Hightstown, 21 Apr. 52, 6F plus 7; Jersey City, 14 Nov. 51, 1F; 25 Feb. 52, 6F plus 9; 28 Feb. 52, 3F plus 12; Lyndhurst, 8 May 52, 1F plus 73; McAfee, 7 Feb. 52, 2F; 13 Feb. 52, 2F; National Park, 2 Apr. 52, 1F; Newark, 28 Feb. 52, 1F; North Arlington, 25 Feb. 52, 2F plus 7; Palmyra, 27 Mar. 52, 2F plus 1; Pedricktown, 10 Mar. 52, 4F plus 16; Pennsauken Township, 26 Feb. 52, 3F plus 12; Pennsgrove, 6 Mar. 52, 2F plus 10; Perth Amboy, 20 May 51, 2F; 16 Mar. 52, 4F plus 2; Phillipsburg, 21 Mar. 52, 2F plus 7; Pine Brook, 9 June 52, 2F; Rahway, 8 Jan. 52, 1F; 30 Jan. 52, 1F; 23 Apr. 52, 2F; Raritan, 6 Dec. 51, 1F plus 19; 15 May 52, 1F; Riverside, 27 Feb. 52, 1F; 28 Mar. 52, 4F plus 2; Riverton, 15 Feb. 52, 3F plus 3; Roebling, 28 Feb. 52, 1F plus 7; Rutherford, 13 June 52, 5F plus 6; Salem, 30 Nov. 51, 2F; 5 Mar. 52, 1F; Seabrook, 7 Feb. 52, 6F plus 5; Secaucus, 26 Feb. 52, 2F; South Camden, 14 Mar. 52, 3F plus 7; South

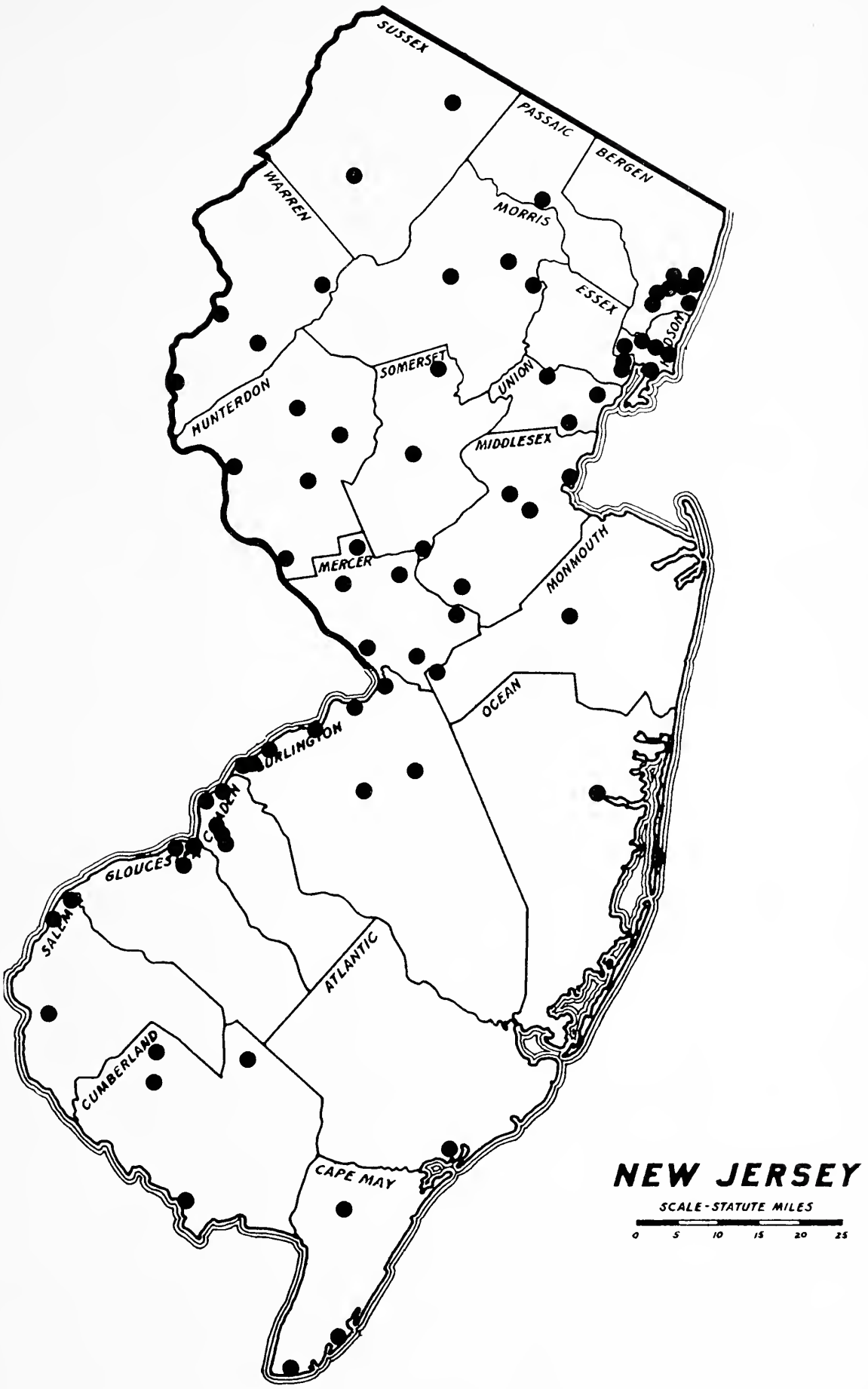

FIG. 1. Distribution of *Radfordia ensifera*.

River, 27 Feb. 52, 4F plus 12; 22 Apr. 52, 1F; Trenton, 20 Feb. 52, 4F plus 7; Union City, 31 Aug. 51, 2F; Westville, 5 Feb. 52, 4F plus 3; Wildwood, 20 Feb. 52, 1F plus 8; Woodbury, 15 Feb. 52, 5F plus 14.

Pygmephorus erlangensis was found throughout the year, being most abundant during winter and early spring.

Pygmephorus sp.

Eldora, 10 Apr. 53, ex *Blarina brevicauda* (dead), 1F.

The following records are all ex *Rattus norvegicus*:

Allentown, 20 Aug. 52, 1F; Belvidere, 13 May 52, 1F plus 12; Cranbury, 7 Apr. 52, 3F plus 7; Fairview, 28 Aug. 51, 2F; Hackensack, 20 May 51, 2F plus 1; North Arlington, 25 Feb. 52, 3F plus 6; Phillipsburg, 21 Mar. 52, 1F; Rahway, 23 Apr. 52, 3F plus 5; Raritan, 15 May 52, 1F plus 3; Riverside, 27 Feb. 52, 2F; Riverton, 15 Feb. 52, 1F; Secaucus, 19 Feb. 52, 2F; 26 Feb. 52, 1F; 7 May 52, 2F plus 483; Somers Point, 13 Feb. 52, 1F; South River, 22 Apr. 52, 1F plus 5; Trenton, 20 Feb. 52, 1F; Union City, 6 May 52, 1F plus 10; Woodbury, 15 Feb. 52, 1F plus 7.

This species is similar to *Pygmephorus* sp. of Cross (1962) as well as to *Pygmephorus spinosus* Kramer. It differs from the former in the following respects: (1) The caudal setae are only about half as long as in the diagram of Cross. (2) The lengths of dorsal setae I and II relative to the length of the hysterosome are similar to those of *Pygmephorus spinosus*. (3) The lateral setae I are but slightly longer than dorsal setae I. (4) The stigmatal setae of the propodosoma are about twice as long as in the diagram of Cross. (5) The distance between the base of a stigmatal setae and the base of the anterior pseudostigmatal seta on the same side is about two-thirds as great as the distance between the base of the anterior pseudostigmatal seta and the base of the posterior pseudostigmatal seta on the same side.

No intermediates between *Pygmephorus erlangensis* and the undescribed *Pygmephorus* sp. were found. This *Pygmephorus* sp. differs from *Pygmephorus erlangensis* in the following respects: (1) Stigmatal setae are only about sixty percent as long as those of *Pygmephorus erlangensis*. (2) External ventral setae II barely reach the bases of the internal presternal setae, whereas in *Pygmephorus erlangensis* they almost reach the bases of the external presternal setae. (3) All three pairs of caudal setae are the same length, whereas in *Pygmephorus erlangensis* the most lateral pair is slightly more than twice as long as the others. (4) The distance between internal caudal setae and external caudal setae I is only one-half as great as the distance between external caudal setae I and external caudal setae II, whereas in *Pygmephorus erlangensis* the two distances are equal.

The specimen taken from *Blarina brevicauda*, the same host with which Cross's specimen was associated, differs slightly from the others and may be another species. In this specimen the relative lengths of lateral setae I and dorsal setae I are as diagrammed by Cross. However, the other differences noted above remain.

Pygmephorus sp.

Fellowship, 22 Jan. 53, ex *Pitymys pinetorum,* 3F (questionable record); Jamesburg, 14 Nov. 52, ex *Pitymys pinetorum*, 1F; New Brunswick, 4 Feb. 53, ex *Pitymys pinetorum,* 1F.

This species is somewhat similar to *Pygmephorus microti* Krczal, known only from Europe on *Microtus arvalis* and *Sorex araneus. Pygmephorus* sp. differs from *Pygmephorus microti* in the following respects: (1) The bases of lateral setae III are slightly anterior to the bases of dorsal setae III. (2) The caudal setae are almost as wide as the dorsal setae. (3) The external caudal setae II are about half as long as the dorsal setae IV. (4) The external caudal setae I are about half as long as the external caudal setae II. (5) The internal caudal setae are about two-thirds as long as the external caudal setae I.

Pseudopygmephorus sellnicki (Krczal)

Dover, 28 May 52, ex *Rattus norvegicus*, 1F; Jersey City, 8 July 52, ex *Rattus norvegicus*, 1F; Kearny, 8 July 52, ex *Rattus norvegicus*, 1F; Lyndhurst, 12 June 51, ex *Rattus norvegicus*, 1F; New Brunswick, 23 Apr. 51, ex *Rattus norvegicus*, 1F; Perth Amboy, 20 May 51, ex *Rattus norvegicus*, 2F; Rahway, 12 June 51, ex *Rattus norvegicus*, 1F; Rahway, 5 July 51, ex *Rattus norvegicus*, 1F; Union City, 7 Aug. 52, ex *Rattus norvegicus*, 1F plus 15; Woodbury, 27 Aug. 52, ex *Rattus norvegicus*, 1F.

Pseudopygmephorus tarsalis (Hirst)

Kearny, 8 July 52, ex *Rattus norvegicus,* 1F; Lyndhurst, 21 June 51, ex *Rattus norvegicus,* 1F; Perth Amboy, 10 Sept. 51, ex *Rattus norvegicus,* 1F.

Neopygmephorus bavaricus (Krczal)

Clayton, 16 Dec. 52, ex *Pitymys pinetorum*, 1F; Haddonfield, 22 Jan. 53, ex *Pitymys pinetorum*, 1F; Jamesburg, 12 Nov. 52, ex *Pitymys pinetorum*, 1F; Jamesburg, 14 Nov. 52, ex *Pitymys pinetorum*, 1F; Riverton, 21 Apr. 53, ex *Pitymys pinetorum*, 1F plus 1; Vincentown, 23 Jan. 53, ex *Pitymys pinetorum*, 2F plus 3; Bridgeton, 22 Apr. 52, ex *Rattus norvegicus*, 1F; South Camden, 14 Mar. 52, ex *Rattus norvegicus*, 1F; Franklin Township, 5 Apr. 52, ex *Blarina brevicauda*, 2F.

Neopygmephorus lithobii (Krczal)

Seabrook, 22 Sept. 52, ex *Peromyscus leucopus*, 1F.

Neopygmephorus sp.

Clayton, 16 Dec. 52, ex *Pitymys pinetorum*, 1F plus 1; Glassboro, 17 Dec. 52, ex *Pitymys pinetorum*, 1F plus 2; Haddonfield, 22 Jan. 53, ex *Pitymys pinetorum,* 2F; Jamesburg, 14 Nov. 52, ex *Pitymys pinetorum*, 2F; Manalapan, 23 Apr. 53, ex *Pitymys pinetorum,* 1F; Penns Neck, 24 Apr. 53, ex *Pitymys pinetorum*, 1F plus 1; Princeton, 9 Feb. 53, ex *Pitymys pinetorum*, 3F plus 1; Seabrook, 15 Dec. 52, ex *Pitymys pinetorum*, 3F plus 7; Seabrook, 18 Dec. 52, ex *Pitymys pinetorum*, 9F plus 85; Vincentown, 23 Jan. 53, ex *Pitymys pinetorum*, 13F plus 27; Dividing Creek, 15 Jan. 53, ex *Microtus pennsylvanicus*, 1F plus 1; Jamesburg, 12 Nov. 53, ex *Microtus pennsylvanicus*, 1F plus 12; Princeton, 20 Feb. 53, ex *Microtus pennsylvanicus*, 1F plus 1; Robbinsville, 16 Jan. 53, ex *Microtus pennsylvanicus,* 1F; Flemington, 21 Jan. 53, ex *Blarina brevicauda,* 1F.

In most respects, the present specimens resemble the *Neopygmephorus* sp. found in a rodent cache and diagrammed by Cross (1962). However, the present species differs from that diagrammed by Cross in that lateral setae IV are longer than dorsal setae IV by about an eighth, and the presternal and posternal setae have relative lengths and positions resembling those of *Neopygmephorus blumentritti* (Krczal).

TETRANYCHIDAE

This family is entirely phytophagous, and its presence on mammals found during the ectoparasite survey is believed accidental.

Bryobia praetiosa Koch

Passaic County, 10 Feb. 53, ex *Blarina brevicauda* (dead), 1F; Somerville, 22 Apr. 53, ex *Blarina brevicauda* (dead), 1F; Clinton, 29 Oct. 51, ex *Didelphis virginiana*, 4F; Flemington, 9 Oct. 51, ex *Rattus norvegicus*, 3F; Camden County, 22 Jan. 53, ex *Microtus pennsylvanicus* (dead), 1F; Vincentown, 23 Jan. 53, ex *Pitymys pinetorum* (dead).

ACARINAE

The Acarinae, a subfamily of Acaridae, are not parasitic but specimens were taken from some mammals.

Acarus siro L.

Belvidere (feed mill), 1 Feb. 52, ex *Rattus norvegicus*, 1F; *Elizabeth* (feed company), 30 Jan. 52, ex *Rattus norvegicus,* 2M, 4F; North Brunswick (farm), 29 Apr. 52, ex *Rattus norvegicus,* 1F; Springfield (farm supply store), 30 Jan. 52, ex *Rattus norvegicus,* 13M, 22F; Vineland (warehouse), 10 Jan. 52, ex *Rattus norvegicus*, 2M, 3F plus 10; Vineland (warehouse), 11 Jan. 52, ex *Rattus norvegicus*, 1M, 3F plus 11.

Acarus siro feeds on dry farinaceous products (Hughes, 1961). All the above records are from places where such products probably occurred.

Acarus immobilis (Griffiths)

Flemington, 4 Jan. 52, ex *Rattus norvegicus*, 1F; Long Branch, 21 Aug. 52, ex *Rattus norvegicus*, 1F; Westville, 5 Feb. 52, ex *Rattus norvegicus*, 1F plus 2.

Tyrophagus similis (Volgin)

Secaucus, 26 Feb. 52, ex *Rattus norvegicus*, 1F.

Tyrophagus palmarum Oudemans

Salem, 29 Nov. 51, ex *Rattus norvegicus*, 1F; Seabrook, 7 Feb. 52, ex *Rattus norvegicus*, 1F.

Tyrophagus putrescentiae (Schrank)

All records below are ex *Rattus norvegicus*:

Atlantic City, 30 Jan. 52, 1FT; Bernardsville, 13 Aug. 52, 2F; Bloomingdale, 6 Sept. 51, 1F, 1M; 5 Sept. 52, 1F; Flemington, 15 Aug. 52, 1F; Hightstown, 19 Aug. 52, 1F, 1M; Jersey City, 19 Dec. 51, 1M, 2F; 6 Aug. 52, 1F; Long Branch, 23 July 52, 3F; Newark, 3 June 52, 1M; Newton, 7 Feb. 52, 1M, 3F; North Arlington, 20 Nov. 51, 1F; Palisades Park, 2 Aug. 51, 1F; 7 Aug. 51, 1F, 1FT, plus 1; 22 Aug. 51, 1M, 1F, plus 1; 30 Aug. 51, 1F; Perth Amboy, 10 Sept. 51, 1F; Phillipsburg, 18 Aug. 52, 1FT; Rahway, 25 July 51, 1F; 4 Sept. 51, 1M, 1FT; 30 Jan. 52, 2F; Woodbury, 27 Aug. 52, 1F.

Table 1 summarizes the present study, listing the species found, the hosts, and the number found on each host.

Acknowledgment

I would like to express my appreciation to Dr. Elton J. Hansens for his advice and guidance throughout the course of this study.

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Structure of Gastric Apex as a Subfamily Character of the Formicinae (Hymenoptera: Formicidae)

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Traditionally, the shape of the "cloacal orifice" in ants has been used as a taxonomic character to separate subfamilies Dolichoderinae and Formicinae. In Formicinae, the orifice is said to be circular, while in Dolichoderinae it is described as "slit-shaped." This nomenclature is as inexact as it is persistent. Despite a clarification by Emery (1922) and re-emphasis of Emery's findings by Buren (1944) and Brown (1954; also in key in Brues *et al,* 1954), most recent keys to the subfamilies preserve the error.

Emery showed that in the Formicinae, the outlet called "cloacal orifice" is in fact the opening of the poison spray duct to the outside, framed in the in-rolled apex of abdominal sternum VII, and that the true anus is situated dorsal to, and separate from, this opening. In order to render discussion easier and more exact, we here introduce the new term *acidopore* for the actual opening of the duct from the poison glands to the outside, as found in Formicinae.

In his paper, Emery showed the acidopore as lying completely within the heavily sclerotized part of the hypopygium (= sternite VII). Our investigation shows that the hypopygium in Formicinae always has thin, flexible, normally concealed extensions of its free lateral edges; we here call these extensions *apicolateral phragmata* (stippled areas in the figures). The phragmata are normally covered by the pygidium (tergum VII) in live specimens of formicine ants examined. We have found that the acidopore, at least in the Camponotini, is partly formed by the phragmata. This is true even of *Camponotus gigas*, the species illustrated by Emery (his figure II). We have redrawn Emery's figure to illustrate the difference in interpretation (Fig. 2).

Usually the hypopygium of formicines projects noticeably from the ventral apex of the gaster, forming a small nozzle-like piece, and the rim of the acidopore is commonly furnished with a funnel-shaped ring or tuft of short, fine setae, situated so as to keep the poison spray directed outward, away from the ant's body. This setal ring is called the *coronula*. Exceptions to this plan occur in tribe Camponotini, which has many species that lack the coronula, and others in which the hypopygium is more or less reduced, or at least not nozzle-like and projecting. In these species, the pygidium (tergite VII) is narrowly rounded at its apex, and may even have a somewhat beak-like free margin; in such cases, the functional acidopore is formed as much by the

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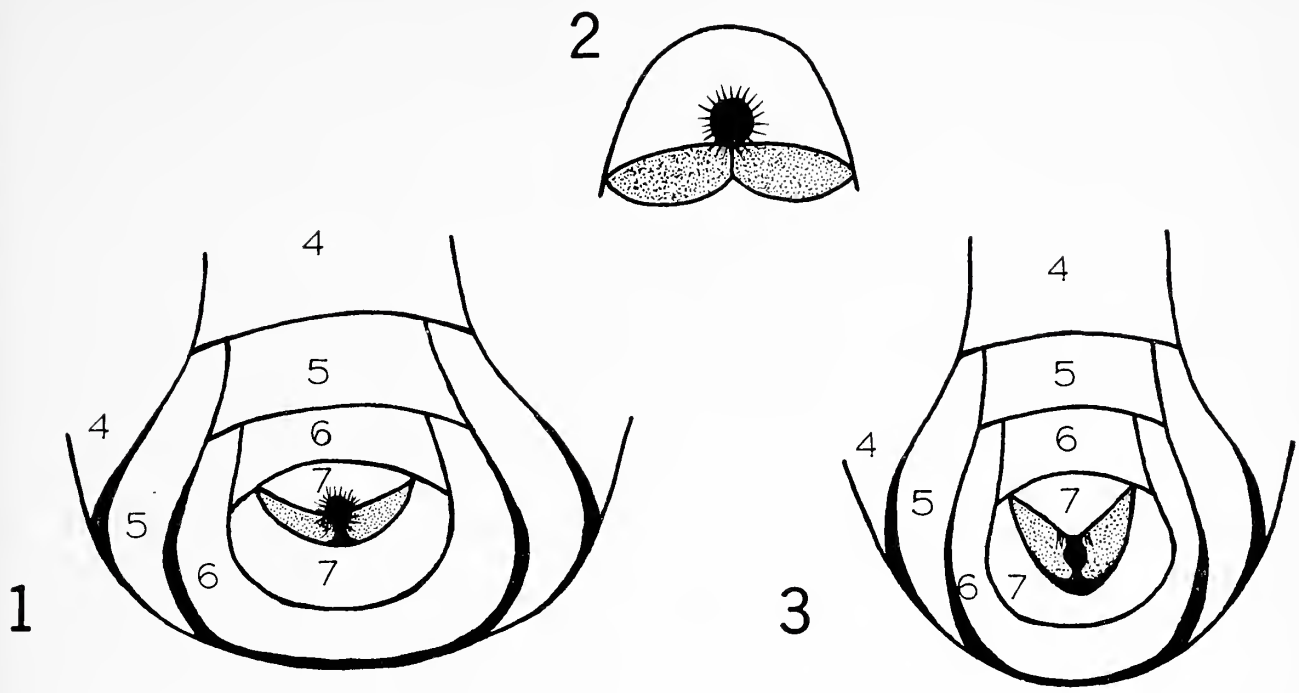

Figures 1–3, ventral views of gastric apex of workers of certain camponotine Formicinae to illustrate form of hypopygium and its phragmata as seen when the vent is open; phragmata stippled. Fig. 1, *Polyrhachis pyrrhus* (s-g. *Campomyrma*). Fig. 2, *Camponotus gigas*, hypopygium only, redrawn in reversed position after Emery, 1922. Fig. 3, *Polyrhachis rastellata* (s-g. *Cyrtomyrma*).

pygidium as by the hypopygium, and the outline of the opening remains more or less circular even when the phragmata are covered by the pygidium.

In the extreme of modification, the acidopore is formed virtually entirely within the phragmata, while the body of the hypopygium forms a subtriangular shield with narrowly rounded apex that fits snugly against the free margin of the pygidium in the resting position. Thus, in species with this arrangement (particularly *Polyrhachis* species of the *schang, porcata, armata* and *rastellata* groups), the gastric apex may appear to have a curved, slit-like orifice when the pygidium and hypopygium are closed together, completely covering the phragmata and contained acidopore. Such specimens can easily be mistaken for Dolichoderinae if other characters are not noted; indeed, misinterpretation of this key character has more than once led to genera being described as new in the wrong subfamily. Of course, if some specimens have the gastric apex open, or are dissected, the phragmata and circular acidopore will be found present in Formicinae, and absent in Dolichoderinae.

We have already mentioned the variable development of the acidopore in the Camponotini. One of us (Hung) has studied this variation in the various groups (erstwhile "subgenera") of genus *Polyrhachis,* and it is summarized as follows:

clypeata group (= s-g. *Campomyrma*). Acidopore formed by body and phragmata of hypopygium; coronula present or absent (worn off?) (Fig. 1).

thrinax group (= s-g. *Myromothrinax*). Acidopore border heavily sclerotized, but without coronula.

schang group (= s-g. *Myramatopa*). Acidopore formed within phragmata; body of hypopygium a narrowly-rounded shield-like platform.

ammon group (= s-g. *Hagiomyrma*), *ornata* group (= smg. *Hedomyrma*), and *guerini* group (= smg. *Chariomyrma*). All have acidopore partly in body of hypopygium and partly in phragmata, but coronula hairs present on body of hypopygium only.

porcata group (= s-g. *Aulacomyrma*), *armata* group (= s-g. *Myrmhopla*), and *rastellata* group (= s-g. *Cyrtomyrma*). As in *schang* group, but with a tuft of hairs on each side of the narrowly-rounded apex of the hypopygial body (Fig. 3).

militaris group (= s-g. *Myrma*), *parabiotica* group (= s-g. *Anoplomyrma*), and *bihamata* group (= s-g. *Polyrhachis*). Acidopore formed in phragmata; tip of body of hypopygium rounded, without hairs.

The situation in the *revoili* group (= *Pseudocyrtomyrma*) remains unknown.

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Xenillidae, A New Family of Oribatid Mites (Acari: Cryptostigmata)**

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Abstract The taxonomic placement of *Xenillus* is reviewed as a basis for the establishment and characterization of the new family, **Xenillidae**. The family is differentiated from Liacaridae primarily by the rugose or pitted integument, relatively broad, rugose lamellae with or without cusps and mucro, types and numbers of notogastral and ventral setae. The distinctive traits of the type genus and species, *X. clypeator*, and *X. latus*, *X. tegeocranus*, *X. splendens*, *X. sculptrus* are summarized and illustrated. Four new species are described and figured, *X.* **gelasinus** from Utah, *X.* **anasillus** from Lebanon, *X.* **phryxothrixus** from North Carolina, and *X.* **ionthadosus** from Georgia, Louisiana, Utah, and North Carolina. **Stenoxenillus atraktus**, n. gen., n. sp., from North Carolina is described and illustrated. Three new species of the new genus **Stonyxenillus** are described, **S. spilotus** from North Carolina, **S. anakolosus** from North Carolina, Tennessee, and Alabama, and **S. akidosus** from Virginia. Another new genus and species, **Leuroxenillus trichionus** from Oregon, is also described. A key to the genera and species is included.

The taxonomic placement of the genus *Xenillus* Rob.-Desv., 1839, has changed over the years. Willmann (1931) included *Xenillus* in the family Carabodidae with many of the genera indicated for that family by Sellnick (1928). Baker and Wharton (1952) followed Willman's arrangement and explained the synonymy of *Xenillus* with *Cepheus* and *Banksia*. Sellnick (1928) placed the synonym *Banksia* in the family Tegeocranidae with several other carabodid genera. His placement of *X. castaneus* and *X. pectinatus* was changed to *Oribella* by Willmann (1931) since the two species were not *Xenillus*. Balogh (1961) erected the superfamily Liacaroidea and included *Xenillus* in the family Liacaridae with the genera *Liacarus* Michael, 1898, and *Adoristes* Hull, 1916. Balogh's other papers (1963, 1965) followed this scheme.

After a review of the literature and a comparative study of several species of mites similar to *Xenillus,* it appears to us that the genus belongs neither in Liacaridae nor Carabodidae, although the mites are definitely liacaroid. We propose a new family for this complex of mites, the bases of which are discussed below in addition to distinctive features of existing species, and descriptions of new genera and species disclosed by this research.

XENILLIDAE, new family

This new family is characterized by an unnotched or slightly notched rostrum; broad, blade-like lamellae, with or without cusps or a mucro; surface of prodorsum and lamellae pitted, tuberculous, or rugose; translamella usually present;

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with two pairs of humeral setae at shoulders of hysterosoma; dorsal and ventral integument pitted, tuberculous or rough (as contrasted to the smooth integument of Liacaridae); sensillus clavate, spindleform, lanceolate, or setiform; usually twelve pairs of notogastral hairs; seven to nine pairs of coxisternal setae; usually six pairs (five pairs may be present) of genital setae; fissure *iad* anterior to ada:3 as in other Liacaroidea; two pairs of anal setae, usually inserted near medial margin of cover; legs heterotridactylous; trochanteral fossae II, III with tubercles.

From the comparisons made we have decided that the genus *Xenillus* should be restricted to those mites of this complex with a clavate sensillus (pseudostigmatic organ). We have concluded that the sensillus is of generic significance in this complex and is a more consistent feature at the generic level than other structures. New genera described below are distinguished by spindleform sensilli. Others yet to be described exhibit setiform sensilli.

As previously designated by Willmann (1931) for the genus the established species *Xenillus clypeator* Rob.-Desv., 1839, represents the new family as type. We have summarized below the main descriptive characters of the type and each of the current species from the literature. The immature stages of *X. clypeator* and *X. tegeocranus* have been described by Costeseque and Taberly (1961). Our study involved preserved adults only.

Xenillus clypeator Rob.-Desv., 1839
(= *Notaspis tegeocranus* Herm.) Willmann (1931), p. 145; Jacot (1929), p. 128
(Fig. 1)

Large, arched mites with wide, converging lamellae; with a small mucro; notogastral setae slightly decurved.

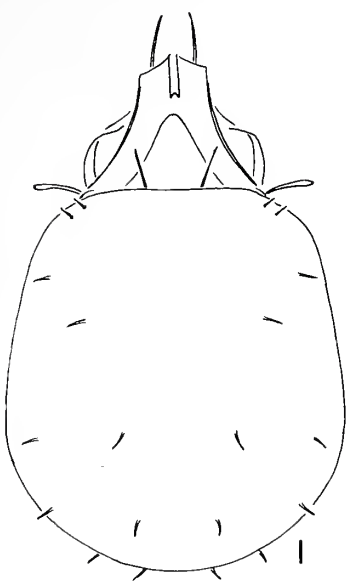
Specimens of the next two species were obtained for study from the Regensburg collections of Jacot through the assistance of Dr. H. W. Levi and the auspices of the Museum of Comparative Zoology at Harvard.

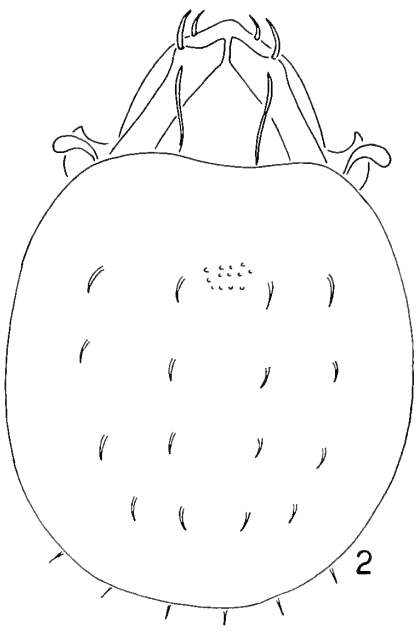
Xenillus latus (Nic., 1855), Michael 1883, p. 295
(Fig. 2)

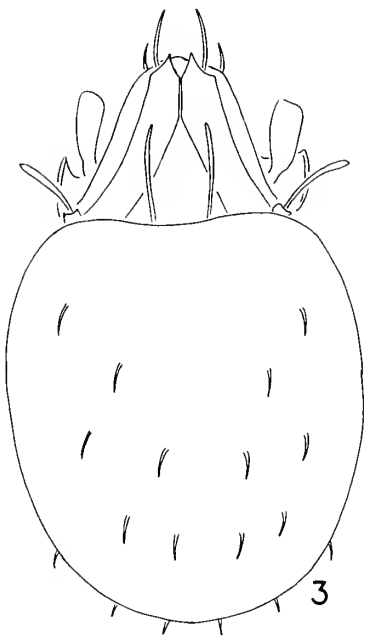
Lamellae wide, horizontal, approaching anteriorly; lamellar hairs long, thick, curved, and rough; interlamellar hairs twice as long as lamellar hairs; clavate sensillus short, pyriform, recurved.

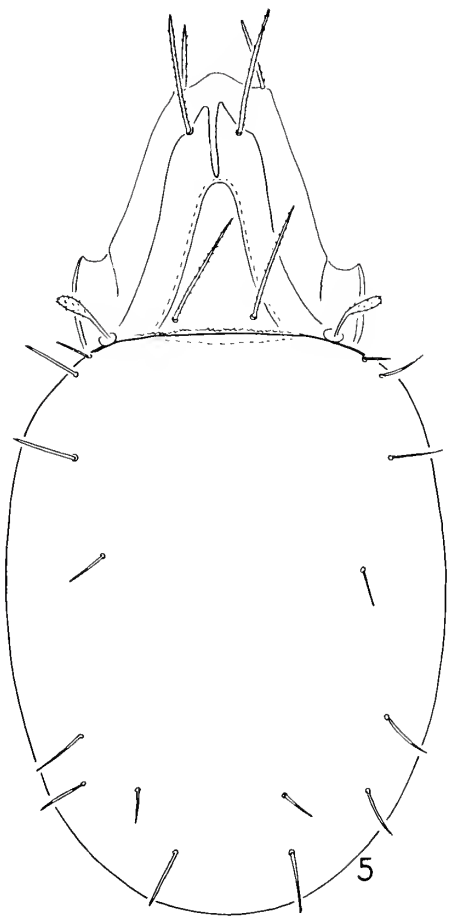
Xenillus tegeocranus (Herm., 1804), Michael 1883, p. 292
(Fig. 3)

Lamellae with sharp, medial dens; lamellar hairs inserted near outer angles of lamellae; interlamellar hairs rod-like; hysterosoma with pitted surface, margins of pits running together (Michael says: "coarsely reticulated on both upper and lower surfaces"); sensillus elongated, clavate.









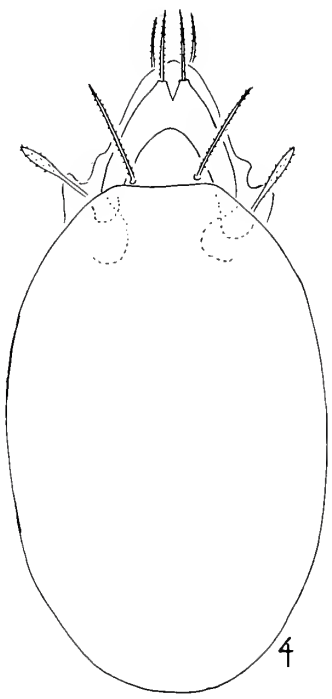


Fig. 1. *Xenillus clypeator* from the dorsal aspect (After Balogh, 1943).
Fig. 2. *Xenillus latus* from the dorsal aspect (After Michael, 1883).
Fig. 3. *Xenillus tegeocranus* from the dorsal aspect (After Michael, 1883).
Fig. 4. *Xenillus splendens* from the dorsal aspect (After Balogh, 1943).
Fig. 5. *Xenillus sculptrus* from the dorsal aspect (After Kuliev, 1963).

Xenillus splendens (Coggi, 1898), Balogh, 1943, p. 132
(Fig. 4)

Lamellae broadly curved, with truncated anterior cusp; with translamella; rostral, lamellar, and interlamellar hairs barbed; lamellar hairs inserted in ends of lamellae; interlamellar hairs as long as lamellae, setose; sensillus clavate, with tiny barbs; notogaster with pitted surface.

Xenillus sculptrus Kuliev, 1963
(Fig. 5)

Lamellae with blunt medial dens; rostral, lamellar, interlamellar hairs barbed; translamella narrow, a deep cleft between cusps of lamellae; sensillus clavate, barbed, slightly recurved; anterior humeral bristle much shorter than posterior.

Xenillus **gelasinus**, n. sp.
(Figs. 6, 7, 8)

DIAGNOSIS: Lamellae convergent and with two sharp dentes, lateral dens longer than medial; surface of notogaster with elongated pits; differing from other species of the genus in the lamellae and the sculpturing of the notogaster.

The specific name indicates the dimpled nature of the integument of the prodorsum, lamellae, and notogaster.

DESCRIPTION: Color dark rust-brown; prodorsum broadly triangular, rostrum rounded; rostral hairs barbed, longer than sensilli, inserted in notch at anterolateral margin of rostrum about one of their lengths apart; lamellae as wide as pedotecta I as seen from dorsal aspect, not reaching end of rostrum, of equal width throughout, surface dimpled with elongated pits, anterior end cusped, notched, with short, sharp lateral dens, smaller medial dens; lamellar hairs stout, but broken off in type specimen; translamella with a short, rounded mucro; interlamellar hairs simple, erect, nearly as long as lamellae, inserted in front of dorsosejugal suture near medial margin of lamellae; pseudostigmata mostly beneath anterior margin of hysterosoma, cup-shaped; sensillus clavate, slightly curved, with tiny barbs; pedotecta I blunt, rounded (Fig. 6).

Hysterosoma nearly round, anterior margin of dorsosejugal suture nearly straight; suture with a roughened edge; two pairs of simple setae at shoulders, ten other pairs of notogastral setae visible; fissure *im* lateral; dorsal surface dimpled with large, elongated pits, and fine granulations (Fig. 6).

Camerostome oval; mental, genal, rutellar, and ventral setae as seen in Fig. 7; genital aperture between levels of coxae III, IV, trapezoidal, about two and one-half times its length anterior to anal aperture; each genital cover with six setae, g:1, g:2, g:3, g:4 close together in anterior half of cover near medial edge, g:5, g:6 diagonally placed in posterior half of cover, g:5 more lateral than g:6; aggenital setae about twice their lengths directly posterior to genital aperture; ventral plate anterior of genital opening less sclerotized than posteriorly, dimpled with large pits between genital and anal openings (Fig. 7); anal opening squarish but with rounded corners, close to posterior margin; each anal cover with two simple setae; fissure *iad* anterolaterad of anal opening; two pairs of adanal setae visible in type specimen, ada:3 near anterolateral corner of anal opening, ada:2 laterad, between levels of a:1 and a:2; ada:1 not visible (probably due to overlapped margin of hysterosoma).

LEGS: Heterotridactylous, median claw longer, but not moderately heavier than lateral claws; setal complex of tarsus and tibia I as seen in Fig. 8.

LENGTH: 1,008 μ, hysterosoma 750 μ, prodorsum 258 μ; width: 714 μ.

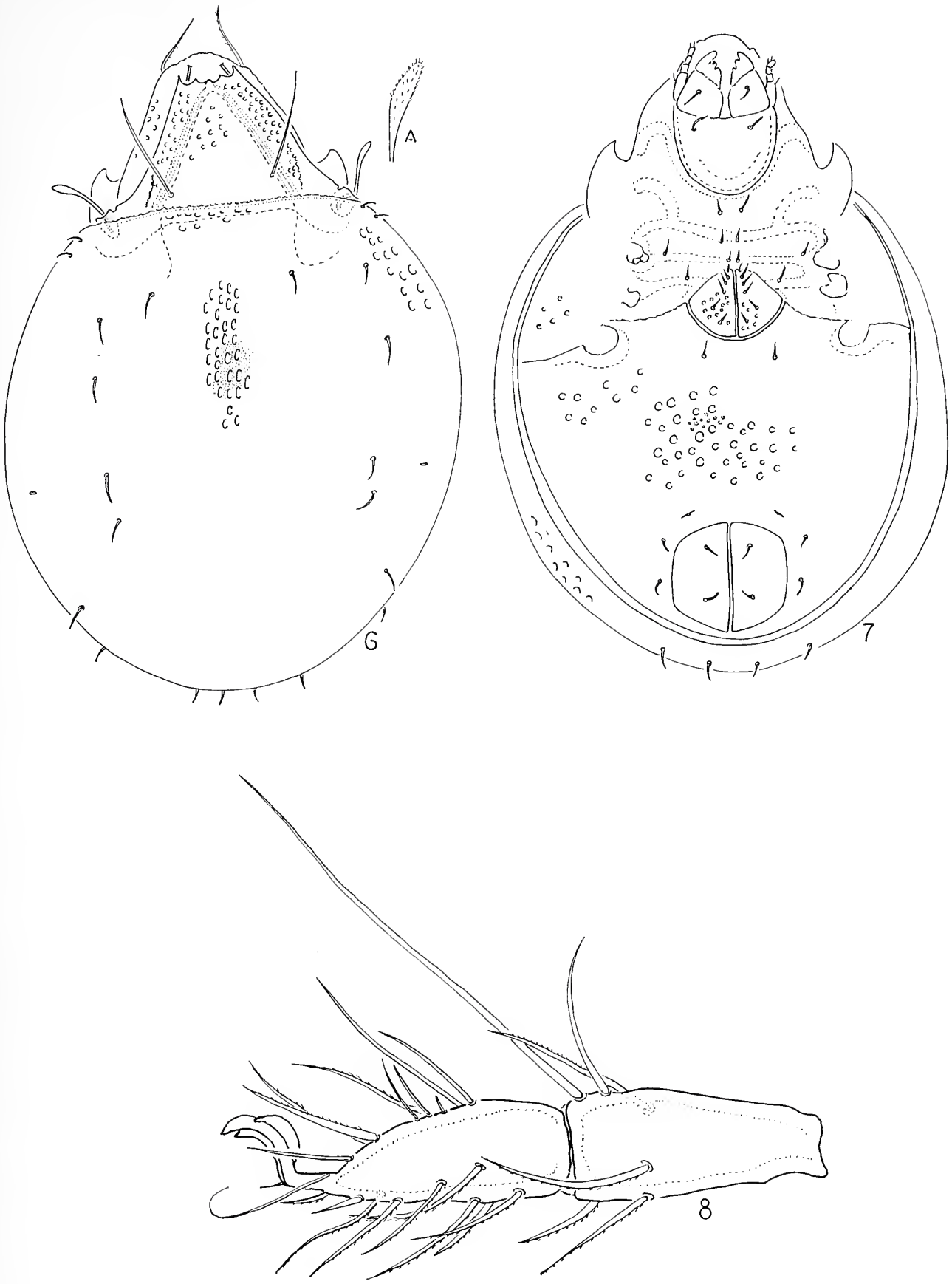


Fig. 6. *Xenillus* **gelasinus**, n. sp., from the dorsal aspect; A, free-hand sketch of sensillus.

Fig. 7. *Xenillus* **gelasinus**, n. sp., from the ventral aspect.

Fig. 8. Tibia and tarsus I of *X.* **gelasinus**, n. sp., from the lateral aspect.

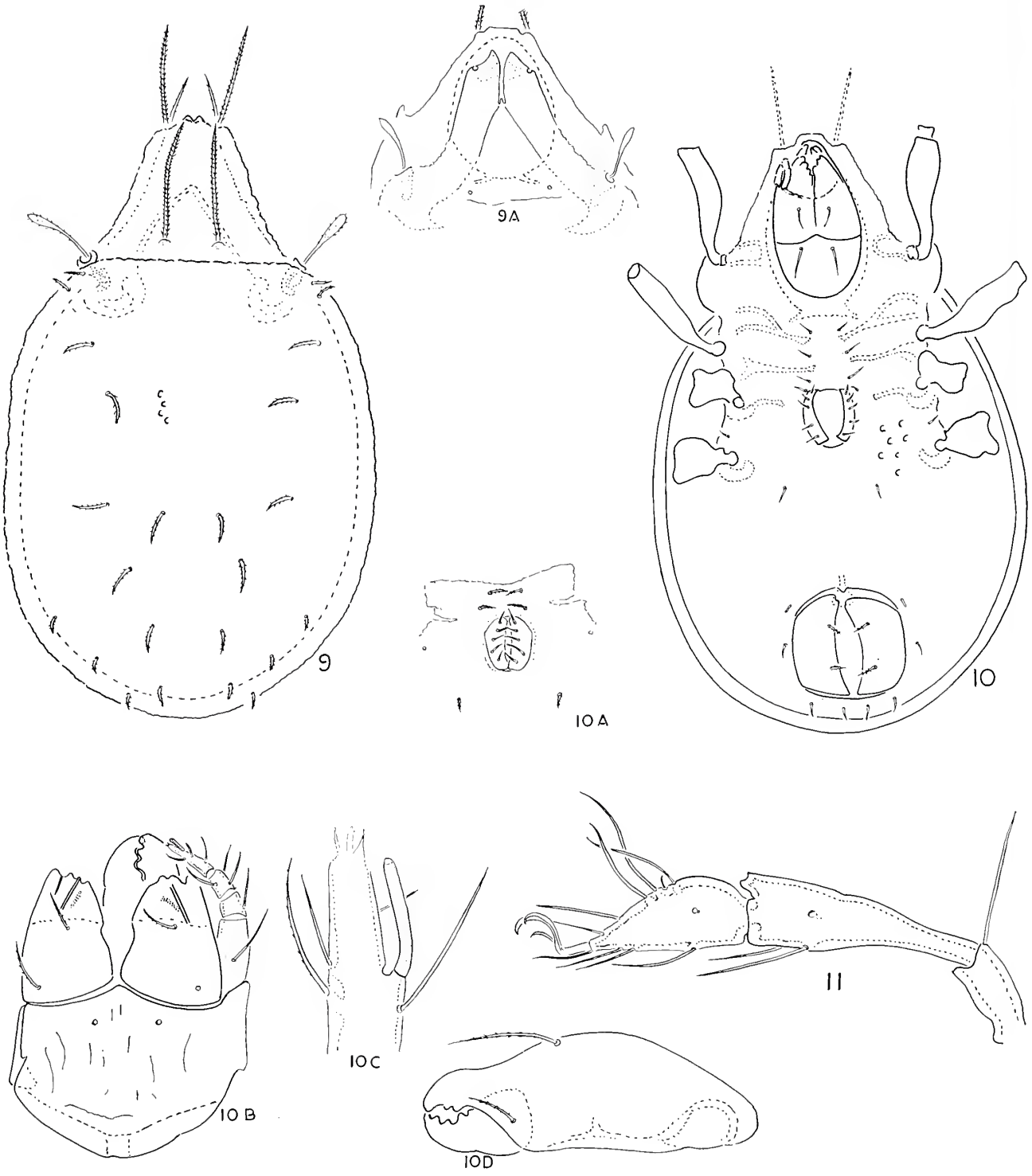


FIG. 9. *Xenillus* **anasillus**, n. sp., from the dorsal aspect, cerotegument in place on prodorsum; 9A, dissected specimen from The Cedars, cerotegument removed, prodorsum.

FIG. 10. *Xenillus* **anasillus**, n. sp., from the ventral aspect; 10A, dissected specimen from The Cedars, genital area; 10B, same, infracapitulum; 10C, same, palp tarsus; 10D, same, chelicera.

FIG. 11. Tibia and tarsus I of *X.* **anasillus,** n. sp., from the lateral aspect, some setae missing.

The type, a single specimen, was collected at Soapstone, Wasatch Co., Utah, 4 September 1955, by H. and M. Higgins.

?*Xenillus* **anasillus**, n. sp.
(Figs. 9, 10, 11)

The specimens of this species from Lebanon are newly emerged adults with a cerotegument or nymphal skin attached. The characters appear to be definitive, however, so the species is described below with a slight reservation concerning the maturity of the specimens.

DIAGNOSIS: Differs from other known species of *Xenillus* in the setose hairs on the prodorsum and notogaster. This is indicated in the specific name, **anasillos**, implying bristled hairs.

DESCRIPTION: Color yellow; prodorsum broadly triangular with a squarish, truncated rostrum; rostral hairs setose, about half as long as lamellar hairs, inserted on either side of truncated rostral tip in broad notches; lamellae wide, flat blades with wide, medially pointed cusps (Fig. 9); lamellar hairs setose, about as long as interlamellar hairs, inserted in lateral corners of lamellar cusps; a small mucro on translamella at base of lamellar cusps; pseudostigmata cornuate, at bases of lamellae; sensillus clavate, slightly setose (Figs. 9, 9A).

Hysterosoma with wrinkled margins, integument pitted; dorsosejugal suture nearly straight; twelve pairs of setose, slightly curved notogastral setae; two pairs of humeral setae at shoulders, others as in Fig. 9.

Camerostome, mentum, mental hairs, gena, genal hairs, rutella, chelicerae, and palps as seen in Figs. 10, 10B, 10C, 10D; palps with a bent, finger-like solenidion near tip of tarsus (Figs. 10B, 10C); rutella with roughened molar surface on dorsal face; ventral plate pitted, ventral setae and apodemata as in Fig. 10; apodemata III interrupted, medial and remote from genital opening; genital aperture closer to level of insertion of legs III than to IV, about two and one-half times its length anterior to anal opening; each genital cover with five setose setae (Figs. 10, 10A); aggenital setae setose, short, posterolaterad of genital opening; anal opening squarish, about three times larger than genital, each anal cover with two slightly barbed setae inserted nearer medial margin than lateral; fissure *iad* near antero-lateral corner of opening; three pairs of adanal setae, ada:3 lateral to anal opening between levels of a:1 and a:2; ada:2, ada:1 posterior to anal opening.

LEGS: Heterotridactylous; tibia and tarsus I as seen in Fig. 11.

LENGTH: Prodorsum 174 μ, hysterosoma 552 μ; width: 456 μ.

The type is one of four specimens taken from Syni Latakia, Lebanon, 2 August 1953 by K. A. Christiansen; one specimen was collected at The Cedars, Lebanon, 2 May 1953, by K. A. Christiansen; two specimens were collected at Chamlane, Lebanon (277b) in 1953, and one nymph was collected at Ain Zahlte, Lebanon, 28 November 1953, by K. A. Christiansen.

DISCUSSION: One of the most striking features of this species is the barbed, setose hairs of the prodorsum and notogaster. This is characteristic of most of the ventral setae as well. Another apparently diagnostic feature is the finger-like solenidion of the palp tarsus, although a similar arrangement has been observed in other Liacaroidea.

Most of the traits of this species place it in the genus *Xenillus* without question, but one disjunct characteristic is the number of genital hairs. We have indicated this slight disparity, which may be due to the relative maturity of the specimens, by the question mark preceding the name.

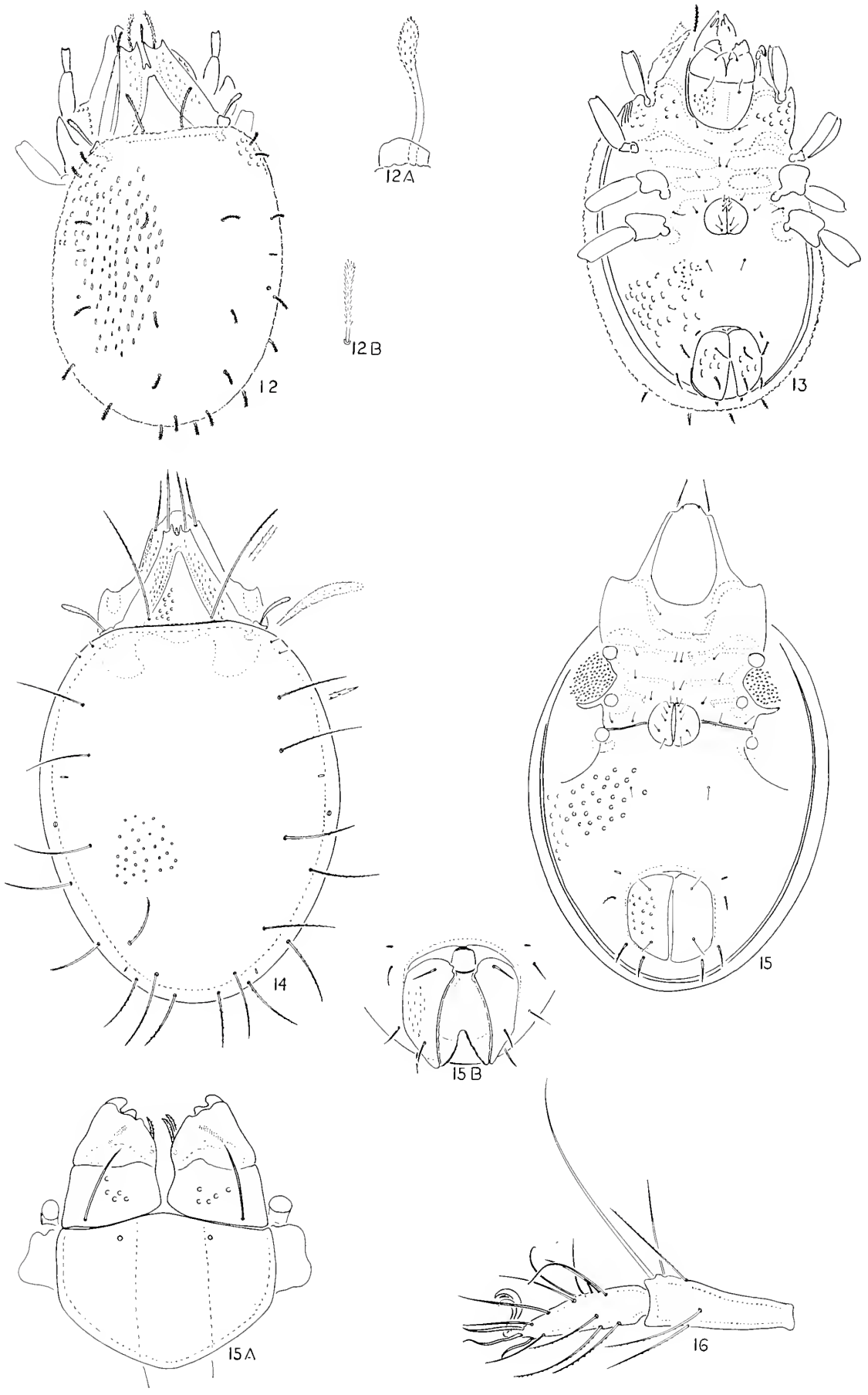


FIG. 12. *Xenillus* **phryxothrixus**, n. sp., from the dorsal aspect; A, sensillus, enlarged free-hand sketch; B, notogastral hair, enlarged free-hand sketch.

FIG. 13. *Xenillus* **phryxothrixus**, n. sp., from the ventral aspect.

FIG. 14. *Xenillus* **ionthadosus**, n. sp., from the dorsal aspect.

Xenillus **phryxothrixus,** n. sp.
(Figs. 12, 13)

DIAGNOSIS: The most distinctive feature of this new species is the bristling, barbed hairs of the prodorsum and notogaster, as implied in the trivial name. The lamellae are similar to *X. clypeator*, but have pointed, subequal dentes and a more prominent mucro. The elongated pits of notogaster are similar to *X.* **gelasinus,** n. sp., but again, the lamellae are much different. The new species differs from *X.* **anasillus,** n. sp. in the lamellar cusps and shorter length of prodorsal hairs, although in both species the hairs are barbed.

DESCRIPTION: Color yellow-brown; prodorsum broadly triangular, surface pitted; rostral hairs with fine bristles, shorter than lamellar hairs inserted in short prominences at distal ends of tutorium; lamellae broad, pitted, covering most of lateral and anterior surface of prodorsum, with cusps about as long as rostral hairs, each cusp with an excavated anterior margin forming two sharp, subequal dentes; lamellar hairs beset with fine bristles, about a fourth longer than rostral hairs, inserted in distal excavation of lamellar cusps; translamella consisting of a short bar and bluntly pointed mucro; interlamellar hairs with fine bristles, longer than rostral or lamellar hairs, inserted near dorsosejugal suture mediad of lamellae; pseudostigmata cornuate, protruding slightly from beneath anterior margin of hysterosoma; sensillus clavate, with fine spines on surface; pedotecta I robust, anterolaterad of pseudostigmata.

Hysterosoma broadly oval in outline, with somewhat roughened, straight dorsosejugal suture, surface with elongated pits, pits slightly longer than width of notogastral setal insertions; notogastral hairs somewhat robust, beset with fine bristles, claviform; fissure *im* and glandular opening as seen in Fig. 12.

Infracapitulum with pitted mentum; setae, ventral plate, apodemes as seen in Fig. 13; surface of venter with elongated pits similar to those of notogaster, pits extended in different directions, with fine stippling between pits; genital opening trapezoidal, each genital cover with five setae; g:4, g:5 closer to posterior margin; aggenital setae simple, closer to genital opening than to anal; anal opening more than twice as large as genital, each anal cover with elongated pits and two finely barbed anal setae; fissure *iad* at anterolateral corner of anal opening; adanal setae finely barbed, ada:3, ada:2 laterad of anal opening, ada:1 posterior.

LEGS: Heterotridactylous.

LENGTH: 528 μ, hysterosoma 372 μ; width 312 μ.

The type was collected at Durham, N. C., 10 March 1963, by Louis J. Metz (RT-S-1, 231-D) and will be deposited in the U. S. National Museum. Six additional specimens were collected by Dr. Metz from the same locality, but on different dates, two specimens on 11 May 1963, three specimens on 8 November 1962, and one specimen on 14 November 1963. Another specimen of this species was collected from floor debris at Dismal Gardens, Franklin Co., Alabama, 4 September 1961 by J. Wagner and W. Suter.

DISCUSSION: Like *X.* **anasillus**, n. sp., from Lebanon, *X.* **phryxothrixus**, n. sp., has barbed, bristling hairs, but differs markedly in the cuspal features of the lamellae, the insertions of the lamellar hairs, and the pitted integument. In the

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FIG. 15. *Xenillus* **ionthadosus**, n. sp., from the ventral aspect; A, ventral view of infracapitulum without palp; B, anal aperture of paratype showing preanal piece and anal membranes.

FIG. 16. Tibia and tarsus I of *X.* **ionthadosus,** n. sp., from the lateral aspect.

specimens available only five genital setae were observed on each genital cover, which is common to both of these species. Dissections of additional specimens may demonstrate more setae, especially if the specimens observed of *X.* **anasillus** prove to be subadult.

Xenillus **ionthadosus**, n. sp.
(Figs. 14, 15)

DIAGNOSIS: This new species differs from other species of the genus in the distinctively long, finely barbed notogastral setae as implied in the trivial name. The lamellae are similar to *X.* **gelasinus**, n. sp., but have longer medial dentes and a more pointed mucro; the interlamellar hairs of the new species are longer than the prodorsum, another distinguishing characteristic.

DESCRIPTION: Color reddish-brown; prodorsum pitted, broadly triangular in outline, with blunt, truncated rostrum; rostral hairs slightly shorter than lamellar hairs, finely barbed, inserted in angled prominences at anterolateral margins of prodorsum, behind rostrum; lamellae about as wide as width of rostral tip, pitted, with two dentes at ends of cusps, medial dens longer than lateral, a pointed mucro between cusps; lamellar hairs slightly longer than rostral hairs, finely barbed, inserted in distal ends of lamellae between cusps; translamella present; interlamellar hairs finely barbed, about three times as long as rostral hairs, curved outward, inserted near base of lamellae at margin of dorsosejugal suture; pseudostigmata partly extended beyond margin of hysterosoma; sensillus clavate, finely barbed; pedotecta I as in Fig. 14.

Notogaster oval in outline, with nearly straight, roughened dorsosejugal suture; eleven pairs of notogastral setae; two pairs of simple, short, humeral setae; remaining dorsal setae longer than lamellar pairs, finely barbed, slightly curved; surface of notogaster pitted; fissure *im* and glandular opening as in Fig. 14.

Camerostome oval; infracapitulum with rounded pits on ventral surface (Fig. 15A); each rutellum with a rutellar brush and spinose area on dorsal surface, two setose hairs on dorsomedial margin; surface of ventral plate pitted, pits rounded, larger than on notogaster; ventral setae, apodemes as in Fig. 15; trochanteral fossae of legs II, III with small tubercles; genital opening nearly round, surface of each genital cover finely stippled; six pairs of genital setae; a prominent transverse suture dividing ventral plate between genital opening and legs IV; aggenital setae simple, inserted slightly closer to genital opening than to anal; fissure *iad* remote from anterolateral corner of squarish anal opening; surface of each anal cover with rounded pits, smaller than pits of venter, anal setae simple; adanal setae finely barbed, ada:3 behind level of a:1 laterad of anal opening, ada:2 posterolaterad of corner of opening, ada:1 behind anal opening, closer to corner than to medial edge of cover.

LEGS: Heterotridactylous; tibia and tarsus I as in Fig. 16.

LENGTH: 936 μ, prodorsum 222 μ, hysterosoma 714 μ; width: 564 μ.

The type and 48 specimens were taken from debris at log, Cloudland State Park, Trenton, Dade Co., Georgia, 3 September 1961, by J. Wagner and W. Suter. One specimen was collected at Soapstone, Wasatch Co., Utah, 4 September 1955, by H. and M. Higgins. One specimen was obtained at Whitesides Cove, Highlands, North Carolina, 28 July 1957 by S. and D. Mulaik. Three specimens were collected from leaf litter at E. Baton Rouge Parish, Louisiana, 6 October 1962, by C. L. Rockett. The type and some paratypes will be deposited in the U. S. National Museum.

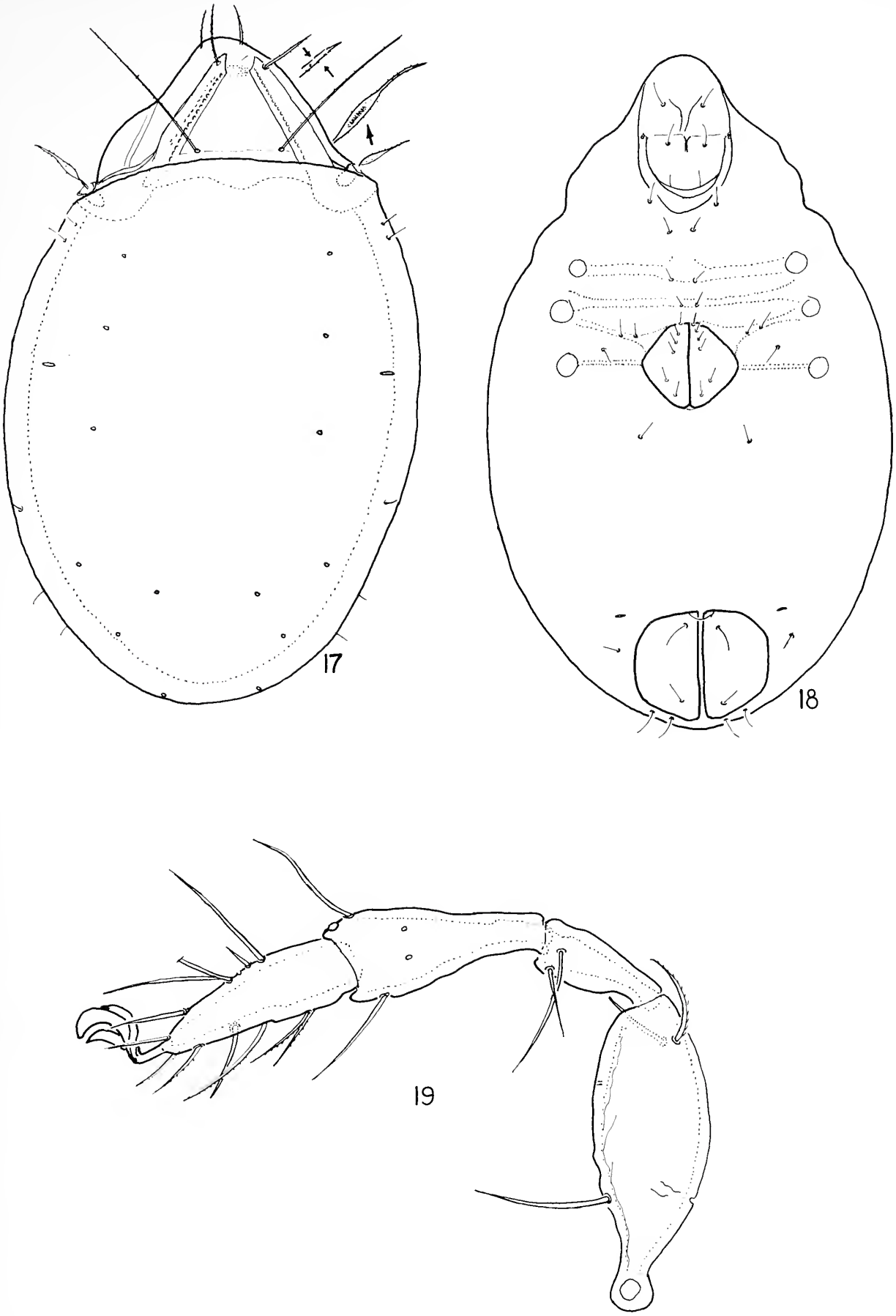


Fig. 17. **Stenoxenillus atraktus**, n. gen., n. sp., from the dorsal aspect.

Fig. 18. **Stenoxenillus atraktus**, n. gen., n. sp., from the ventral aspect.

Fig. 19. Leg I of **Stenoxenillus atraktus**, n. gen., n. sp., from the lateral aspect, some setae missing.

DISCUSSION: The long notogastral hairs comprise the most distinctive feature of this species and differentiate it from all other species in the genus. The transverse suture extending from the genital opening and dividing the ventral plate may also be distinctive, but similar sclerotization occurs in at least one other example of the family, **Stonyxenillus akidosus**, n. gen., n. sp. Further comparisons of this feature will have to be made.

New Genera and Species

The following new genera and species are characterized by a spindleform sensillus that is barbed or smooth, and are differentiated principally by this type of organ from *Xenillus* with its claviform sensillus. One species in the literature, *Xenillus alpestris* Willmann, 1929, also has a spindleform sensillus, but the lamellae are extremely narrow, and only one humeral bristle is present. We conclude that *X. alpestris* is not a *Xenillus*, nor does it fit within any of the new genera, although it appears to be in the Liacaroidea. Since its placement is uncertain, we have omitted it temporarily from consideration within this complex.

Stenoxenillus atraktus, n. gen., n. sp.
(Figs. 17, 18, 19)

DIAGNOSIS: Lamellae narrow and straight with a small lateral dens at distal end, medial margin rough, with small cornicles along medial edge; sensillus elliptical and spindle-shaped; surface of notogaster with elongate pits. The generic name applies to the narrow and straight lamellae without a translamella, contrasting with *Xenillus*; the trivial name implies a spindle-like sensillus.

DESCRIPTION: Color dark brown; rostrum triangular, rounded anteriorly; rostral hairs missing in type specimen (in another specimen these hairs are finely barbed, shorter than lamellar hairs); surface of prodorsum finely pitted; lamellae long, narrow blades, a lateral dens at end of cusp, medial margin of lamellae roughened with small cornicles, other surface finely pitted; lamellar hairs about half as long as lamellae, extended upward, finely barbed, inserted posterior to cusp; interlamellar hairs absent in type (in another specimen more than twice as long as lamellar hairs, finely barbed), insertions anterior to dorsosejugal suture; pseudostigmata at posterolateral corners of prodorsum; sensillus spindle-shaped, a narrow pedicel, swollen mid-part and spine-like distal tip, finely barbed.

Surface of notogaster with very tiny pits; twelve pairs of simple notogastral setae (Fig. 17); fissure *im* lateral.

Camerostome oval; infracapitulum, ventral setae, and apodemata as seen in Fig. 18; genital aperture trapezoidal, about twice its length anterior to anal opening; each genital cover with six setae, g:1, g:2, g:3, g:4 in a slightly diagonal line, closer together than g:5, g:6; g:5 more laterally placed than any of the genital setae; aggenital setae about twice their length from genital aperture; anal opening nearly twice as large as genital opening, nearly square, adjacent to posterior margin of ventral plate; each anal cover with two simple setae; fissure *iad* at anterolateral corner of anal opening, remote from margin of opening by about twice its length; three pairs of anal setae, ada:3 at level of middle of cover, ada:2, ada:1 posterior to anal opening; other features of venter as seen in Fig. 18.

LEGS: Heterotridactylous; part of leg I as seen in Fig. 19.

LENGTH: 1,050 μ; width: 636 μ.

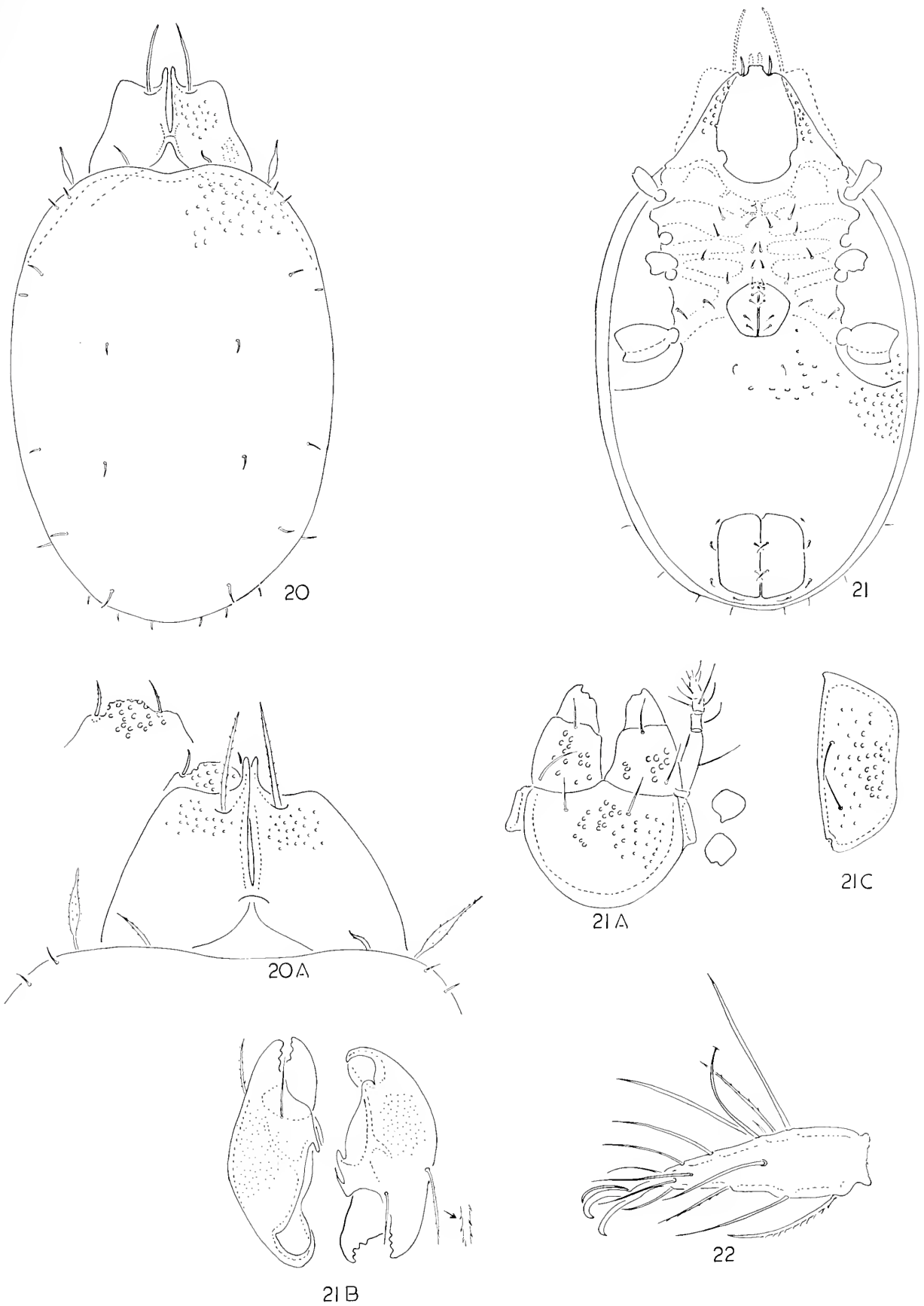


FIG. 20. **Stonyxenillus spilotus**, n. gen., n. sp., from the dorsal aspect; A, enlarged sketch of prodorsum, lamellae, and rostrum.

FIG. 21. **Stonyxenillus spilotus**, n. gen., n. sp., from the ventral aspect; A, infracapitulum from ventral view; B, chelicerae; C, anal plate from ventral view.

FIG. 22. Tarsus I of **Stonyxenillus spilotus**, n. gen., n. sp., from the lateral aspect.

A single specimen of this species was collected at Duke Forest, Durham, N. C., August 1952 by S. Mulaik. This type specimen will be deposited in the U. S. National Museum. Another specimen was taken from a floor debris pocket, Dismal Gardens, Franklin Co., Alabama, 4 September 1961 by W. Suter and J. Wagner.

DISCUSSION: This new species, **Stenoxenillus atraktus**, differs from other species and some genera in the family by the narrow, straight lamellae and the absence of a translamella or a mucro. It is further differentiated by the corniculated medial margin and finely pitted surface of the lamellae. Since the type and only one other specimen were found, it is not possible to discuss variations of form, but we consider this species is distinct from any others of the family that we have observed so far.

Stonyxenillus, n. gen.

DIAGNOSIS: The genus is characterized by a barbed, spindleform sensillus and broad lamellae that may cover the prodorsum and have one or two dentes. The name is from the Greek, *stonyx*, indicating a sharp point for both the sensillus and the cuspal dentes of the lamellae, but the name is tied to *Xenillus* to indicate familial and generic relationships.

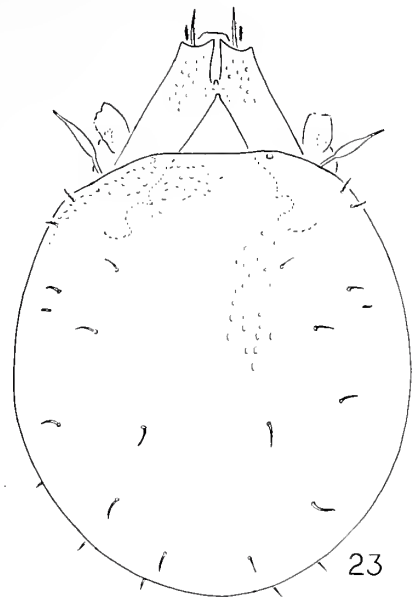
Stonyxenillus **spilotus**, n. sp.
(Figs. 20–22)

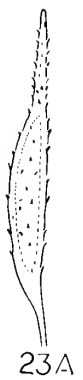
DIAGNOSIS: Differs from other species in the genus by the broad lamellae covering nearly all of the prodorsum, the long, pointed medial lamellar dentes, and the long lamellar hairs.

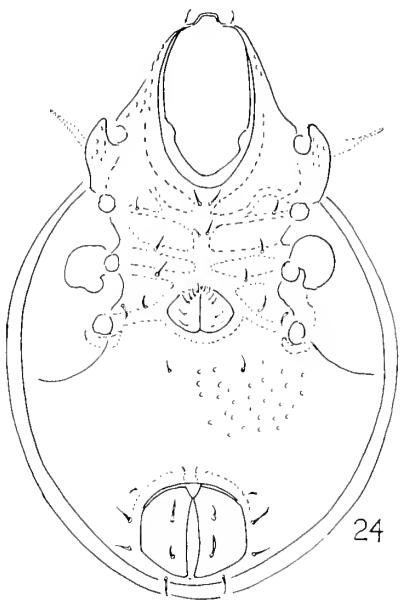
DESCRIPTION: Color dark brown; rostrum truncated anteriorly, with lateral notches for insertions of rostral hairs, pitted surface (Figs. 20, 20A); rostral hairs about as long as dens of lamella, slightly barbed, decurved, inserted in notches posterior to truncated rostral tip; lamellae broader than prodorsum, pitted dorsally, with prominent anterior medial dens, deeply cleft to level of short translamella; lamellar hairs nearly straight, as long as width of lamella at level of translamella, with small barbs, inserted posterior to anterior margin of lamella in a broad cleft, closer to medial margin than to lateral (Figs. 20, 20A); translamella short, heavily sclerotized, located at base of cleft between lamellae, closer to dorsosejugal suture than to anterior tips of lamellae; interlamellar hairs about same length as rostral hairs, decurved, inserted beneath anterior margin of hysterosoma, approximately in middle of width of lamella; pseudostigmata under anterolateral margins of hysterosoma; sensillus spindleform, with tiny barbs on surface (Figs. 20, 20A).

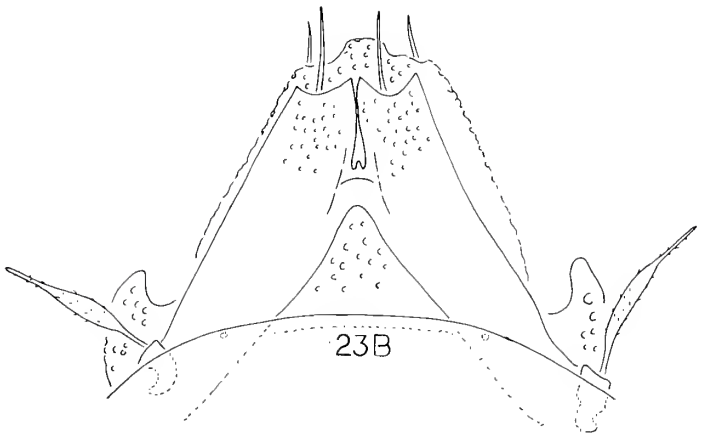
Notogaster oval in outline except for slightly invaginated anterior margin, surface pitted; twelve pairs of notogastral setae, the two pairs of simple humeral bristles in clear margin adjacent to pseudostigmata and sensillus (Figs. 18, 20).

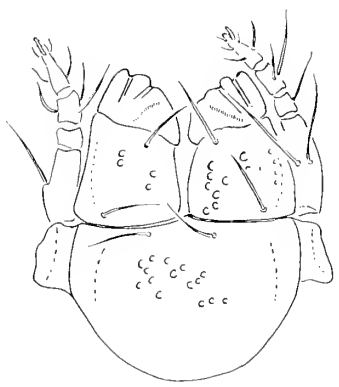
Camerostome truncate posteriorly, heavily pitted laterad of opening; infracapitulum, chelicerae, mentum, rutella as seen in Figs. 21A, B; ventral surface of mentum pitted, with two squarish, articulating condyles; ventral setae, apodemata as seen in Fig. 21; genital opening between levels of legs III and IV, trapezoidal in outline; each genital cover with six simple, short setae, g:1, g:2, g:3, g:4 close together in straight line near medial margin of cover, g:5, g:6 nearer posterolateral margin of cover; aggenital setae about three times their lengths posterior to genital opening; anal aperture nearly square, in posterior end of

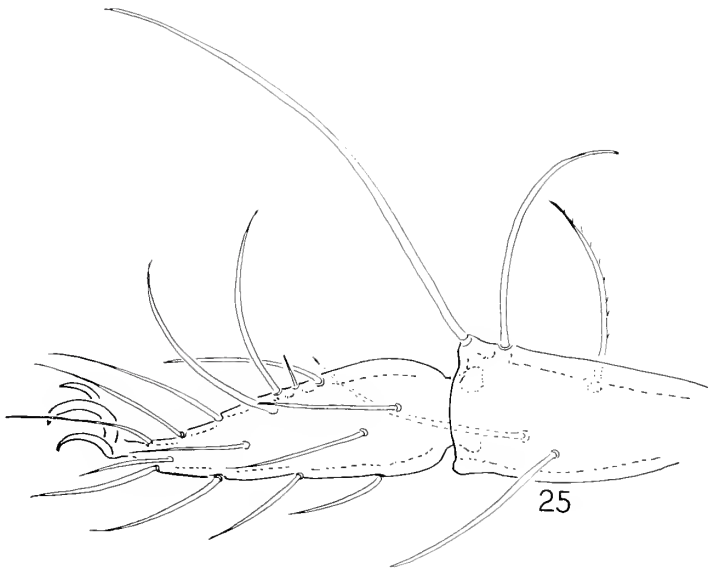












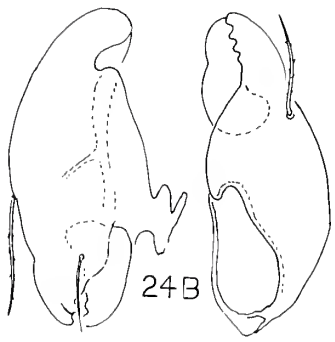


FIG. 23. **Stonyxenillus anakolosus**, n. gen., n. sp., from the dorsal aspect; A, enlarged free-hand sketch of sensillus; B, enlarged sketch of prodorsum and lamellae.

FIG. 24. **Stonyxenillus anakolosus**, n. gen., n. sp., from the ventral aspect; A, infracapitulum; B, chelicerae.

FIG. 25. Tibia and tarsus I of **Stonyxenillus anakolosus,** n. gen., n. sp., from the lateral aspect.

ventral plate; each cover with two simple setae near medial margin of cover and nearer center of length of cover than ends (Figs. 21, 21C); fissure *iad* near anterolateral corner of anal opening; adanal setae as seen in Fig. 21, ada:1 posterior to cover, ada:2 at posterolateral corner of opening, ada:3 lateral to anal opening at level of a:1.

LEGS: Heterotridactylous (Fig. 22).

LENGTH: Hysterosoma 454 μ; prodorsum 138 μ; width: 318 μ.

The specific name from the Greek, **spilotos**, implies a spotted appearance based on the pitted integument of the lamellae and notogaster.

Four specimens of this species were collected seven miles from Highlands Biological Station, Whiteside Cove, Jackson Co., North Carolina, elevation 3,300′, 5 July 1961, by S. and D. Mulaik. The type will be deposited in the U. S. National Museum.

Stonyxenillus **anakolosus**, n. sp.
(Figs. 23–25)

DIAGNOSIS: The broad lamellae of this species are similar to those of *S.* **spilotus**, n. sp., but have two short, subequal dentes and a small mucro on the translamella; the lamellar hairs are inserted in the tips of the lamellae between the dentes; the new species is also smaller and more rotund than *S.* **spilotus,** n. sp.

DESCRIPTION: With characters of the genus; color dark brown; prodorsum nearly covered by lamellae, rostrum truncate anteriorly, with pitted surface, lateral notches for insertions of rostral hairs; rostral hairs simple, about as long as width of lamellar cusp, inserted in flat notches lateral to anterior tip of rostrum; lamellae of about equal width throughout length, with pitted surface and prominent, wide cusps, cusps slightly excavated anteriorly producing two short dentes, a deep cleft between cusps; lamellar hairs fairly straight, slightly longer than rostral hairs, inserted in anterior margins of lamellar cusps; translamellar present, with a short, blunt mucro in cleft between lamellar cusps; insertions of interlamellar hairs beneath margin of dorsosejugal suture; surface of prodorsum with larger pits than on lamellae; pseudostigmata under humeral margins of hysterosoma; sensillus spindleform, with fine barbs on surface (Fig. 23A).

Hysterosoma nearly round in outline, with slightly excavated anterior margin, surface pitted with small pits (Fig. 23); twelve pairs of slightly barbed notogastral setae, two pairs humeral in position (in the type specimen three humeral setae are present on the left side, two on the right); fissure *im* inserted near lateral margin nearly midway the length of the dorsum.

Camerostome elongated and oval, with sclerotized, pitted margins; infracapitulum, chelicerae, mentum, rutella as seen in Figs. 24A, B; rutella with diagonal roughened surface, the *rutellar brush*, posterior to distal toothed margin on dorsal surface; ventral setae, apodemata as seen in Fig. 24; genital aperture a third as large as anal, located between levels of legs III, IV, trapezoidal in outline, with a perigenital ring formed of the confluence of apodemata III, IV; each genital cover with six setae, g:1, g:2, g:3, g:4 inserted close together in a diagonal line, g:5, g:6 in middle of width of cover nearer posterior margin (Fig. 24); aggenital setae simple, about three times their lengths posterior to genital opening; anal opening nearly square; each anal cover with two setae inserted nearer medial margin of cover than lateral; fissure *iad* near anterolateral corner of anal opening; adanal seta ada:1 posterior to anal aperture, ada:2, ada:3 laterad of anal opening, nearly at levels of a:2 and a:1 respectively.

LEGS: Heterotridactylous; tibia and tarsus I as seen in Fig. 25.

LENGTH: Prodorsum 126 μ, hysterosoma 354 μ; width: 294 μ.

A single specimen of this species, the type, was collected four miles north of Cherokee, N. C., 28 May 1957, by W. Mason; one specimen from Newfound Gap, Great Smoky National Park, N. C., 10 July 1957, by S. and D. Mulaik; one specimen from Murphy, N. C., 19 July 1957, by S. and D. Mulaik; eight specimens from between boulders, Smoky Mountain Nat. Park, Sevier Co., Tenn., 25 July 1956, by H. Dybas (CNHM 56-28); one specimen from debris, Dismal Gardens, Franklin Co., Alabama, 4 September 1961, by J. Wagner and W. Suter. The specimens from Tennessee were found in company with *Liacarus spiniger* Jacot, 1937, and a new species of *Liacarus* to be described. The type specimen will be deposited in the U. S. National Museum.

DISCUSSION: This species is of smaller size than others previously described. It differs from **S. spilotos**, n. sp., in the two sharp dentes at the ends of the lamellar cusps, in the variations of the sizes of pits on the lamellae, prodorsum, and notogaster, and in the minute details of the barbed sensillus.

The trivial name is taken from the Greek, **anakolosos**, which implies docked or shortened, and has particular reference to the smaller, stocky form that typifies this mite.

Stonyxenillus **akidosus**, n. sp.
(Figs. 26, 27)

DIAGNOSIS: This new species differs from S. **spilotus** and S. **anakolosus,** n. spp., in the narrower lamellae and the barbed notogastral hairs, the latter indicated in the trivial name. The generic character of the barbed, spindleform sensillus is characteristic of all three species. The humeral bristles of *S.* **akidosus,** n. sp., are longer, more robust, and finely barbed rather than simple and short as in other species in the family.

DESCRIPTION: Color yellowish-brown; rostrum truncated, slightly notched; rostral hairs straight, finely barbed, about same length as lamellar hairs, inserted in distal tips of tutorium; lamellae flattened, a fourth as wide as prodorsum, with pitted surface, cusps short, with two subequal dentes; lamellar hairs straight, about same length as rostral hairs, finely barbed, inserted in distal tips of lamellar cusps between dentes; translamella short, with a pointed mucro about same length as medial cuspal dens; interlamellar hairs slightly longer than lamellar hairs, finely barbed, inserted near dorsosejugal suture at medial edge of lamellae; pseudostigmata posterior to pedotecta I; sensillus spindleform, finely barbed (Fig. 26); pedotecta I about a third as long as prodorsum, rectangular.

Surface of hysterosoma with fine pits (Fig. 26); dorsosejugal suture nearly straight, hysterosoma nearly round in outline; eleven pairs of finely barbed notogastral setae; humeral bristles more robust than in other species, barbed; fissure *im*, other details of dorsum as in Fig. 26.

Infracapitulum, chelicerae, ventral plate, ventral setae, and apodemata as seen in Fig. 27; trochanteral fossae II, III with small tubercles; genital opening trapezoidal, each cover with six genital setae, g:1 in anterior margin of cover near medial corner, g:2–5 inserted in diagonal line posterolaterally, g:6 near medioposterior corner of cover; aggenital setae inserted nearly equidistant between genital and anal openings, but slightly closer to genital; squarish anal aperture about twice as large as genital, each anal cover with two setae; fissure *iad* posterolaterad of anal opening, at level of a:1; adanal setae finely barbed, ada:3 inserted laterad of anal opening at level of middle of cover, ada:2 near posterolateral corner of cover; ada:1 posterior to each anal cover.

LEGS: Heterotridactylous, femora II, III, IV keeled.
LENGTH: 618 μ, prodorsum 132 μ, hysterosoma 486 μ; width: 396 μ.

The type and five paratypes were collected from mixed forest floor northeast of Fentress, Norfolk Co., Virginia, 5 June 1965, by W. Suter. The type will be deposited in the U. S. National Museum.

DISCUSSION: Compared to other species of **Stonyxenillus**, **S. akidosus**, n. sp., has the longest notogastral hairs of any, and the humeral bristles are the longest of any in the family. Conversely, the lamellae in this species are narrower and less extensive than in the other species of the genus.

Leuroxenillus trichionus, n. gen., n. sp.
(Figs. 28, 29, 30)

DIAGNOSIS: The distinctive generic features of this mite are the smooth, spindleform, narrowly lanceolate sensillus, which contrasts to other currently known genera, and the smooth rostral, lamellar, and interlamellar hairs. The species is distinguished by these features as well as the elongated lamellar cusps with a prominent mucro. No other genera or species currently have these characteristics in this combination. The generic name refers to the smooth sensillus, the trivial name to the relatively short notogastral hairs.

DESCRIPTION: Color yellowish-brown; surface of prodorsum with fine pits; rostrum slightly notched, rostral hairs smooth, straight, shorter than lamellar hairs, inserted in distal tips of tutorium; lamellae narrowed, tuberculous, with elongated cusps about a third the length of prodorsum, cusps with small, subequal dentes; lamellar hairs longer than rostral hairs, straight, smooth, inserted in distal tips of lamellar cusps; lamellae joined medially in a broad translamella with a narrowed median mucro about half as long as length of lamellar cusps; interlamellar hairs setiform, smooth, curved, slightly longer than lamellar hairs, inserted near medial edges of lamellae close to dorsosejugal suture; pseudostigmata projected slightly beyond margin of hysterosoma, cornuate beneath surface; sensillus spindleform, narrowly lanceolate, smooth, slightly longer than lamellar hairs; pedotecta I as seen in Fig. 28.

Hysterosoma ovoid, dorsosejugal suture slightly arched anteriorly; eleven pairs of notogastral setae visible; two pairs of humeral setae shorter than other dorsal hairs, remaining pairs simple, curved, about as long as rostral hairs (Fig. 27).

Infracapitulum, ventral plate, ventral setae, and apodemes as seen in Fig. 29; trochanteral fossae II, III with small tubercles; genital opening rounded, between legs III, IV, each genital cover with six setae, g:1 inserted in anterior edge of cover near medial corner, g:2–4 inserted in diagonal line posterolaterad, g:5 inserted laterally on cover, g:6 inserted more medially; aggenital setae inserted closer to genital opening than to anal; fissure *iad* near anterolateral corner of anal opening; anal aperture about three times larger than genital aperture, each anal cover with pair of long setae; three pairs of simple adanal setae, ada:3, ada:2 laterad of opening, ada:1 posterior to opening.

→

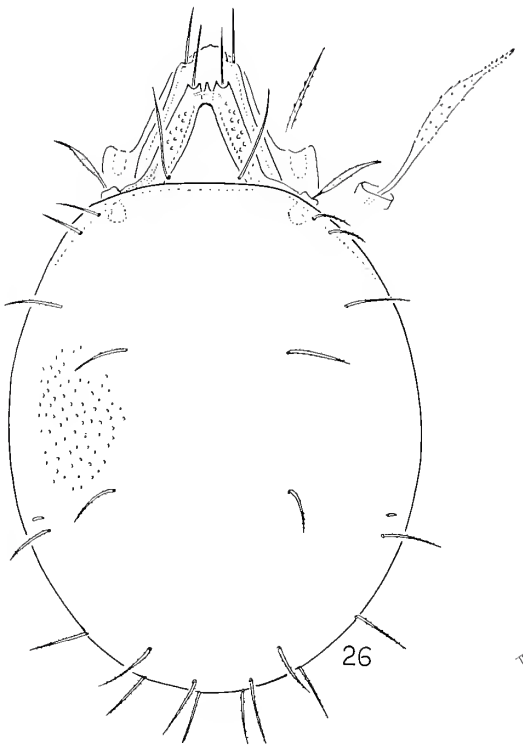
FIG. 26. **Stonyxenillus akidosus**, n. gen., n. sp., from the dorsal aspect.

FIG. 27. **Stonyxenillus akidosus**, n. gen., n. sp., from the ventral aspect.

FIG. 28. **Leuroxenillus trichionus**, n. gen., n. sp., from the dorsal aspect; A, enlarged sketch of prodorsum, rostrum, and lamellae.

FIG. 29. **Leuroxenillus trichionus**, n. gen., n. sp., from the ventral aspect.

FIG. 30. Tibia and tarsus I of **Leuroxenillus trichionus**, n. gen., n. sp., from the lateral aspect.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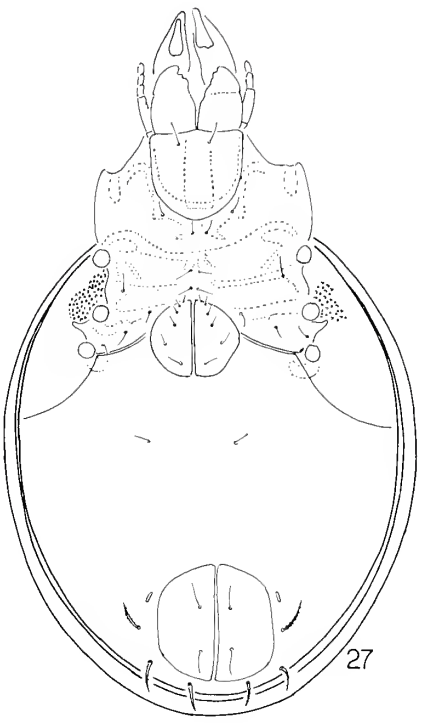
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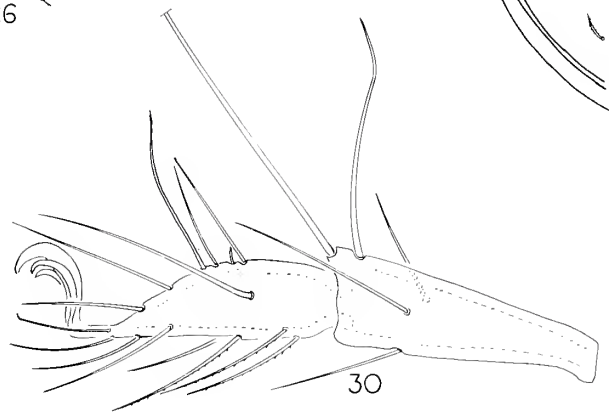
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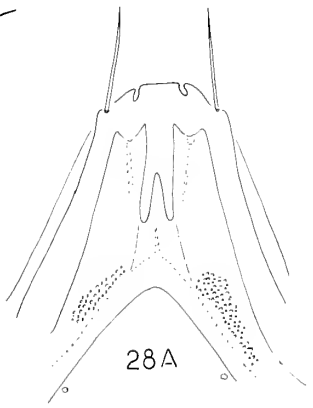
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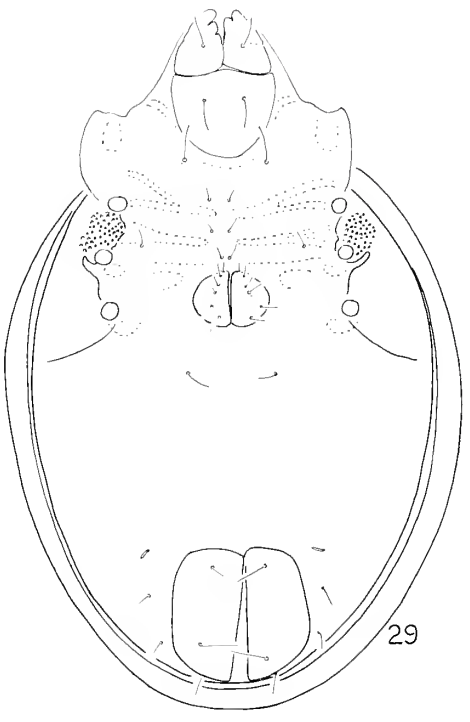
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LEGS: Heterotridactylous; tibia and tarsus I as seen in Fig. 30.
LENGTH: 1,060 μ, prodorsum 240 μ, hysterosoma 820 μ; width: 708 μ.

The type and four paratypes were collected from moss, four miles south of Waldport, Lincoln Co., Oregon, 2 February 1960, by G. W. Krantz and Mr. Lattin. The type will be deposited in the U. S. National Museum.

The drawing of the dorsum of this new species is a composite of several of the specimens.

DISCUSSION: The new family, **Xenillidae**, has a number of distinctive characteristics that have been mentioned previously. Other characteristics common to many liacaroids and not exclusive to genera and species of this new family are also important to note. The rutellar brush and spinose area posterior to it (Fig. 15A) on the dorsal surface of the rutellum are found in most of the Xenillidae examined, as well as in a number of species of liacarids that are under study. These rutellar features may be more extensively exhibited in other families also, as the Galumnidae have at least the rutellar brush. We infer that the brush and spinose area are common to the Liacaroidea. We also infer that many of the Liacaroidea exhibit tubercles on the ventral surface of the trochanteral fossae of legs II, III anterior to pedotecta II and behind pedotecta I. These tubercles are prominent in xenillids, but have also been found in some Liacaridae, though they may be less conspicuous. Research in progress should help to elucidate these characteristics at the familial and superfamilial levels.

Xenillidae, new family

Liacaroid mites with pitted or rugose integument and lamellae, claviform or spindleform sensilli, two humeral notogastral bristles, five or six pairs of genital setae, tuberculous trochanteral fossae II, III.

Key to the Genera and Species of **Xenillidae**

1. Sensillus clavate, barbed ..... Genus *Xenillus* 6
   Sensillus spindleform, barbed or smooth 2
2. Spindleform sensillus narrowly lanceolate, smooth; rostral, lamellar, interlamellar hairs smooth; lamellar cusps narrower than lamellae; mucro half as long as lamellar cusp ..... **Leuroxenillus trichionus**, n. gen., n. sp. (Fig. 28)
   Spindleform sensillus swollen, barbed; rostral, lamellar, interlamellar hairs usually barbed; lamellar cusps usually as broad as lamellae 3
3. Lamellae narrow, without translamella or mucro ..... **Stenoxenillus atraktus**, n. gen., n. sp. (Fig. 17)
   Lamellae relatively broad, with translamella ..... **Stonyxenillus**, n. gen. 4
4. Lamellae with single, long, medial dens at end of cusp; without a mucro ..... **S. spilotus**, n. sp. (Fig. 14)
   Lamellae with two subequal dentes at ends of cusps; with a mucro 5
5. Lamellar hairs about as long as width of cusp, mucro much shorter than length of cusps ..... **S. anakolosus**, n. sp. (Fig. 23)
   Lamellar hairs three times longer than width of lamellar cusp, mucro subequal in length to lamellar cusps and dentes ..... **S. akidosus**, n. sp. (Fig. 26)
6. Translamella absent 7
   Translamella present 8

7. Sensillus pyriform; lamellae without cuspal dentes; lamellar hairs inserted laterally ..... *X. latus* (Fig. 2)
   Sensillus elongate-claviform; lamellae with sharp median cuspal dens; lamellar hairs inserted in distal end of cusp ..... *X. tegeocranus* (Fig. 3)
8. Translamella without a mucro 9
   Translamella with a mucro 10
9. Lamellar hairs inserted in distal tips of conical cusps; interlamellar hairs barbed, about as long as lamellae ..... *X. splendens* (Fig. 4)
   Lamellar hairs inserted posterolaterad of median dens; interlamellar hairs shorter than lamellae ..... *X. sculptrus* (Fig. 5)
10. Lamellae with one median cuspal dens 11
    Lamellae with two subequal cuspal dentes 12
11. Lamellar hairs inserted in center of distal tip of lamellar cusp ..... *X. clypeator* (Fig. 1)
    Lamellar hairs inserted laterally in lamellar cusp behind distal tip ..... *X.* **anasillus**, n. sp. (Fig. 9)
12. Mucro, cuspal dentes subequal in length; notogastral hairs simple ..... *X.* **gelasinus**, n. sp. (Fig. 6)
    Mucro much shorter than cusps; notogastral hairs erect, bristling, barbed ..... *X.* **phyrxothrixus**, n. sp. (Fig. 12)

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Received for Publication October 2, 1966.

Pieris narina oleracera (Harris) in New Jersey (Lepidoptera: Pieridae)

CYRIL F. DOS PASSOS[1]

Abstract: The occurrence in New Jersey of *Pieris narina oleracera* recorded by earlier entomologists but ignored by later authors as misdeterminations has been verified by the capture of a male specimen near Springdale, Sussex County, New Jersey on July 8, 1966.

Pontia oleracera was described by Harris in 1829. The specimens before Harris when writing his original description were taken in New Hampshire and Massachusetts. Possibly there is no type in existence. The type locality does not appear to have been further restricted. For the purposes of this paper it is not necessary to solve these problems. This insect which is double brooded is common throughout the Northeastern United States, Eastern Canada, and extends at least as far south as New Jersey. Originally described as a species it is now considered the spring brood of *Pieris narina* occurring in the northeastern part of the United States and Canada (dos Passos 1965, p. 136).

In Smith's List of the Insects of New Jersey (1909, p. 417) published in the Report of the New Jersey Museum two records are given for the capture of *oleracera*, the first on May 5 by John A. Grossbeck at Paterson and the second without date by John P. R. Carney at Camden. Smith states that this butterfly ". . . occurs occasionally throughout the State but more frequently in the northern portion. It is our native cabbage butterfly, which has been almost exterminated and driven out by the imported species. Only occasionally examples are now found by collectors; in some years none at all."

In Comstock's Butterflies of New Jersey (1940, p. 69) *oleracera* is not listed as occurring in that State but is referred to under *Pieris virginiensis* when he says, "Records of *oleracera* (Smith's 'List') probably refer to this species." However, *oleracera* and *virginiensis* are, in my opinion, distinct species although the later was listed by me (1965, p. 136) as a subspecies of *narina*. Reference to one does not necessarily apply to the other.

Klots (1951, p. 201) ignores the references to the occurrence of *oleracera* in New Jersey with the statement it is "Not recorded s.[outh] of the Catskill Mountains in New York."

In the forenoon of July 8, a hot, clear day while collecting near Springdale, Sussex County, New Jersey, Mrs. dos Passos captured a male *oleracera*, which was not seen by me until the following afternoon when our captures were being papered and spread. This specimen was not badly worn and was taken in a grassy meadow in an open cut below a power line. Doubtless it was a

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stray from the nearby woods. This capture on July 8 was a late emergence for *oleracera*, but it must be remembered that 1966 was a very late season, about 2 to 3 weeks late according to the writer's observations and those of other collectors in New Jersey.

Thus the capture of *oleracera* on July 8, 1966 after a lapse of 60 years not only establishes the occurrence of the species in New Jersey during the intervening years but points out the danger of ignoring old records. Certainly *oleracera* was just as well known to Professor John B. Smith, State Entomologists in 1909 and his colleagues as it is to today's entomologists.

The specimen of *Pieris narina oleracera* captured by Mrs. dos Passos has been given to the American Museum of Natural History.

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Received for Publication September 2, 1966

Two New North American Spiders (Araneae: Linyphiidae)[1]

WILTON IVIE

Abstract: Two species of Linyphiidae are described and figured: *Taranucnus* **durdenae**, n. sp., and *Troglohyphantes* **kokoko**, n. sp. Both are from eastern North America and are first records of their respective genera for this continent.

Two new species of linyphiid spiders from eastern North America are described here. Both represent genera which are not listed for this continent, but are known in Europe. The types are deposited in the American Museum of Natural History.

Family Linyphiidae
Sub-family Linyphiinae
Genus *TANANUCNUS* Simon, 1884
Taranucnus **durdenae**, new species
Figs. 1–5

DIAGNOSIS: Resembling *T. setosus* (Cambridge) in arrangement of eyes, long legs, spination of legs, and general color and shape of body, but with distinctive palpus and epigynum. COLOR: Carapace light yellowish brown, faintly shaded with dusky gray; eyes ringed with black. Chelicerae, legs, palpi, endites, and spinnerets brownish yellow, shaded unevenly with gray but without distinct markings; tarsus of male palpus dusky brown. Sternum and labium dark dusky brown. Abdomen dark gray on sides and venter; pale gray on dorsum with a pattern of dark gray as shown in Fig. 5.

MEASUREMENTS: MALE: Length 2.25 mm; carapace, 1.3 mm long, 1.0 mm wide; tibia-patella I, 3.1 mm, IV, 2.7 mm. FEMALE: Length 2.25 mm; carapace, 1.1 mm long, 0.8 mm wide; tibia-patella I, 2.65 mm, IV, 2.2 mm.

STRUCTURE: MALE: Carapace low and broadly rounded on thoracic part, more elevated and narrower on cephalic part, with clypeus rounded across front. Height of clypeus, 2.7 diameters of anterior lateral eye. Anterior median eyes much smaller than other eyes, 0.4 diameter apart, 0.7 diameter from anterior lateral eyes. Posterior eye row slightly recurved; posterior median eyes 0.65 diameter apart, 0.4 diameter from posterior lateral eyes. Chelicerae vertical, moderately long and slender, length of exposed portion greater than width of both of them; fang simple; anterior margin of fang groove with three widely separated teeth, center one largest. Legs long, femur I being about twice as long as carapace; order of length I, IV, II, III. Femora I, II, and III each with spine above on basal half; femur I with additional spine on prolateral face near middle; all femora with many long setae on under side, more prominent distally, and one long conspicuous ventral seta at base. Patellae with long spine at distal end above, very small one at base. Tibiae with two spines above; tibia I with additional spine on each side distally and one on ventral side near middle; tibia II with one spine on retrolateral side distally. Metatarsi with small spine above near base. Palpus moderately large; patella and tibia short and simple, patella bearing a large spine more than twice length of segment. Base of cymbium complexly modified, including secondary 'paracymbium' above. Embolus very long, slender, and compoundly looped; supported for much of its length by large conductor (Figs. 3 and 4).

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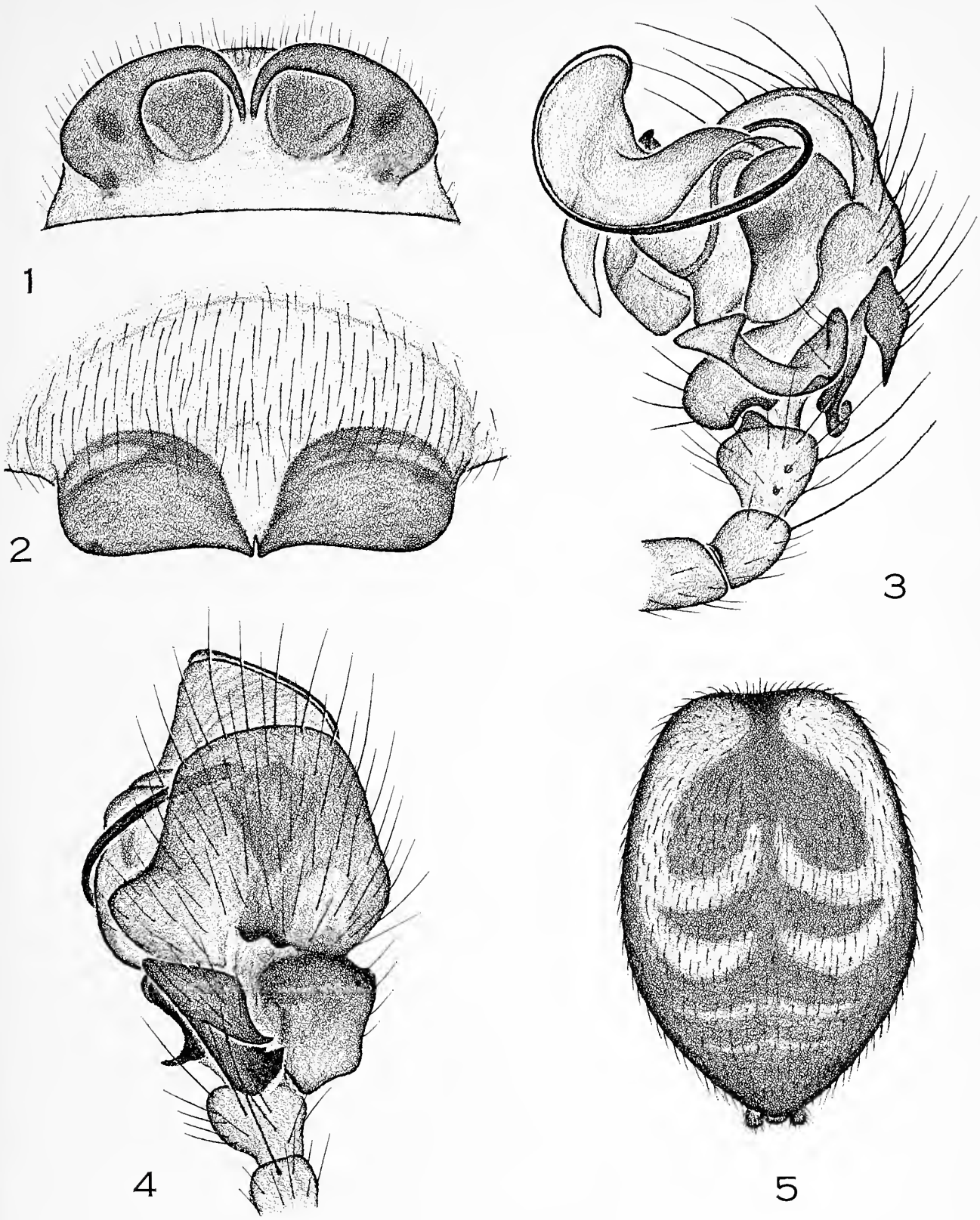
[1] Research Fellow, Department of Entomology, American Museum of Natural History, New York.

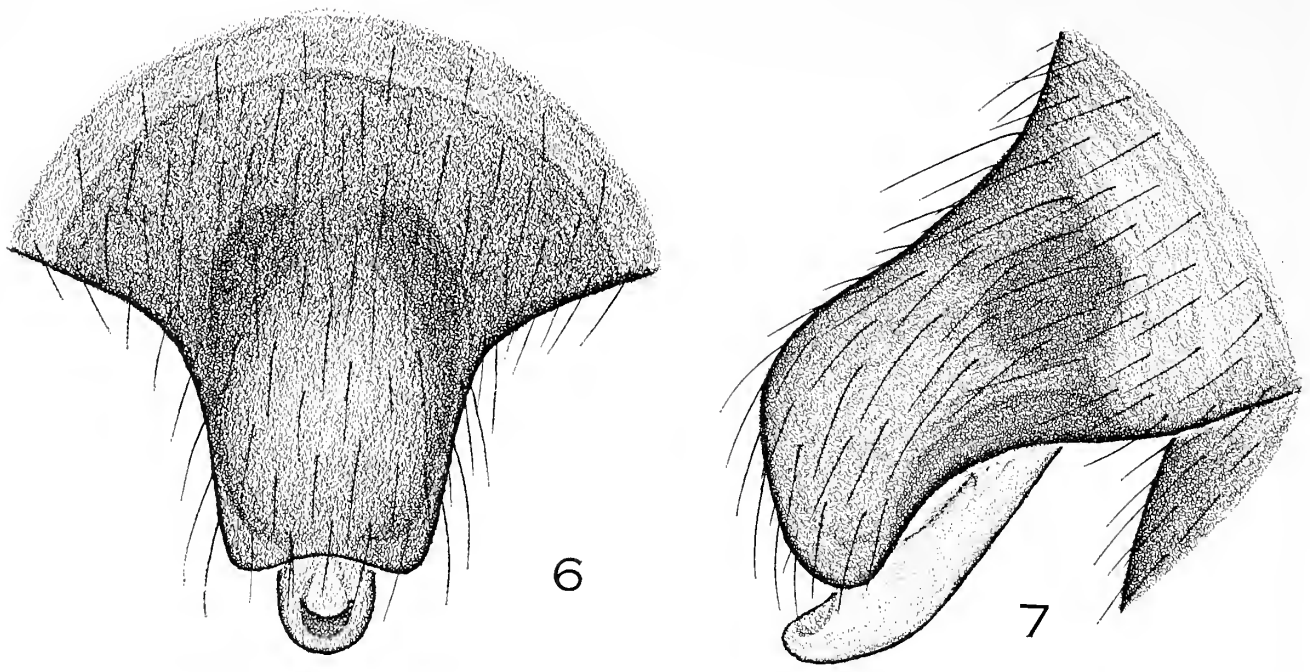
[2] This work was done as a phase of a project supported by a grant from the National Science Foundation (GB-3880).



Figs. 1–5. *Taranucnus* **durdenae**, new species. 1. Epigynum, posterior view. 2. Epigynum, ventral view. 3. Left palpus, ectal view. 4. Left palpus, dorsal view. 5. Abdomen, dorsum.

FEMALE ALLOTYPE: Somewhat teneral and smaller than male in most structural details. Epigynum large, bilobed, transverse swelling, with pair of large openings on posterior aspect (Figs. 1 and 2).

TYPE DATA: Male holotype and female allotype from Pennsylvania: three miles south of Rector; July 4, 1965 (C. and B. Durden).



FIGS. 6–7. *Troglohyphantes* **kokoko**, new species. 6. Epigynum, ventral view. 7. Epigynum, lateral view.

This species is named for Beatrice Vogel Durden, who helped obtain the type specimens.

Genus *TROGLOHYPHANTES* Joseph, 1882
Troglohyphantes **kokoko**, new species
Figs. 6 and 7

DIAGNOSIS: Resembles *T. furcifer* (Simon) in most features; distinguishable by the form of the epigynum.

COLOR: Carapace, chelicerae, and appendages yellowish brown, with shading on side margins of carapace and on tibiae of legs and palpi. Sternum and labium dusky. Abdomen medium gray, with pattern of light gray cross-bands above. Spinnerets pale yellowish.

MEASUREMENTS: FEMALE: Length 2.8 mm; carapace, 1.3 mm long, 1.1 mm wide; tibia-patella I, 2.8 mm, IV, 2.25 mm.

STRUCTURE: Carapace broad and low behind, narrowed and rounded in front. Height of clypeus two diameters of anterior lateral eye. Eye area about 0.75 width of head at posterior eye row. Three rows of setae on head, converging at middle of carapace. Anterior eye row straight; small anterior median eyes about half radius apart, diameter from anterior lateral eyes. Posterior eye row very slightly recurved; posterior median eyes 0.7 diameter apart, 0.5 diameter from posterior lateral eyes. Median ocular quadrangle slightly wider than long, wider behind than in front. Chelicerae vertical; length of exposed portion greater than combined width of both; fang groove with three large teeth on front margin, three denticles on hind margin. Sternum broadly chordate, a little wider than long; hind coxae separated by one of their diameters. Legs long, very slender distally. Femora I, II, and III with spine above on basal half, femur I with additional spine on prolateral face. One spine on each patella above at distal end. All tibiae with two spines above; in addition, tibia I with one spine on prolateral face distally, two spines on retrolateral face distally, and three spines on ventral side; tibia II with one spine on prolateral face distally, and one long spine on ventral side near middle. One dorsal spine on each metatarsus, near base. Epigynum projecting posteriorly and ventrally (Figs. 6 and 7).

TYPE DATA: Female holotype and female paratype from Ontario: Ko-ko-ko Bay, Lake Temagami; August 15–25, 1946 (W. J. Gertsch, W. Ivie, and T. Kurata).

OTHER LOCALITY: New York: Beaver River Flow; August 8, 1931 (Crosby and Davis), one female. (American Museum Collection.)

The name is derived from the type locality and is a noun in apposition.

Received for Publication July 5, 1966

BOOK REVIEWS

The Callaphidini of Canada. W. R. Richards. Mem. Ent. Soc. Canada No. 44, 1965, 149 pp., 189 figs., 40 maps.

This remarkable piece of work on the Canadian fauna of the Callaphidini (Homoptera: Aphidoidea) comprises forty species in sixteen genera. An interesting theory on apparent structural intersexuality of the viviparous forms and apparent sex reversal in other morphs is presented, and progressive neoteny is assumed to be the basic trend in the phylogeny of all groups. Several new criteria are introduced as distinguishing characters, e.g. anterior and posterior discals on head and prothorax and the separation of the cornicle from the lateral sclerite. The keys are provided with mostly only one differential in the couplets. They would be easier to use if they included several features for both adult and immature forms. Illustrations are of good quality, but it would have been better to show also part of the ventral side of the specimens so that the coxae and the rostrum would be seen. Also, the antennae, with distribution of setae and rhinaria, are not represented. The drawings of first instar larvae are lacking detail since antennae, cornicles and setation of the anal segment are not shown. The setal pattern of the first instar of *Patchia* and *Lachnochaitophorus* are evidently incorrect because important hairs have been omitted. Distribution maps reveal that little collecting has been done so far in the vast area of Canada. Perhaps distribution of the species on the whole North American continent would have been more instructive, since very few species are strictly Canadian.

The paper excels in clearness of presentation, however certain aspects have been treated superficially. Some of the newly described species may not be valid because of insignificance of characters to distinguish them from related species. *Tuberculatus* Mordvilko seems not congeneric with *Pacificallis* n. subg. *Tuberculatus* (*Pacificallis*) *columbiae* n. sp. appears to be identical with *Tuberculoides californicus* (Baker). *Monellia caryella* (Fitch) should, according to embryonic chaetotaxy, be placed in *Monelliopsis* n. g. *Monellia microsetosa* Richards seems to intergrade with *M. costalis* (Fitch). *Monelliopsis pleurialis* n. sp. is evidently *Monellia nigropunctata* Granovsky. It was not mentioned that both *Monellia* and *Melanocallis* hold their wings horizontally on the abdomen. Therefore, *Tinocallis ulmifolii* (Monell) should not be placed in *Melanocallis*.

The phylogeny of the Callaphidini has been traced and conclusions on relationships were drawn mainly from studies of the setal patterns. Apparently too much emphasis was laid on this aspect, while others, such as the development of the fore legs into a leaping mechanism, the specialization of the rhinaria and certain differentiations in the ovipara have not been evaluated. It cannot always be agreed as to what has been considered advanced or primitive. The semicircular shape of the cauda may be primitive and not neotenic. The author's view that preservation of a "protopattern" in setation (the term is misleading, since practically all first instar larvae examined are caenogenetical) indicates advanced neoteny is basically sound. The trend in phylogeny of certain groups is well described as a struggle for dominance between the adult pattern and the protopattern. The proposed grouping of the diagram on p. 178 does, however, not satisfy, because closely related genera like *Myzocallis* and *Tuberculoides* are separated, while others without apparent relationship are brought together (e.g. *Pterocallis* and *Protopterocallis, Takecallis* and *Ctenocallis*). It appears sufficiently established from the author's findings that Appendisetines, Therioaphides and Tinocallidines are the most highly evolved groups of the tribe. *Tuberculoides* should not be placed with the Appendisetines, since the lateral abdominal setae of the sixth segment are well separated from the cornicle.

Examples of parallelism and convergence in the tribe are discussed and its origin and dispersal elucidated. It is hypothesized that the modern genera became established by the end of the Cretaceous period, and that they reached their present distribution at that time. A nearctic origin for this group of aphids is suggested.

F. W. Quednau (Quebec).

A History of Entomology. O. E. Essig. A facsimile of the original 1931 edition, The Macmillan Company, by Hafner Publishing Co., New York and London, $16.50.

It is gratifying to see that the enterprising Hafner Publishing Company has brought out a facsimile edition of Essig's great *History of Entomology*. There is no other single volume that presents as much information about economic entomology and its development in California, the first western state to realize the importance of pest control. After an 80-page introduction to entomology in that state from the time of the Indian tribes to 1930, 450 pages are devoted to the details of what has been done to make the fields and orchards of California more productive and the cities and towns safer and more comfortable for humans. No student of economic entomology, or of insects that have economic importance anywhere, can safely overlook this most authoritative and fully documented story of the ceaseless battle between man and pests. Although the introduction of modern organic pesticides makes this 35-year-old book dated so far as control measures are concerned, it is a volume that modern control agencies must study carefully in light of the destructive side-effects of many of the new pesticides. It is quite possible that future legislation to safeguard humans and the environment will force control agencies to turn back to earlier methods of combat. The long chapter upon biological control, 125 pages, is an acute summary of what has been done, and can supply direction to what can be done with this "natural" method.

For me the most valuable part of the entire volume is Chapter IX, a small book in itself, over 250 pages of biographical data about the men whose force has been felt in Californian entomology. There are several hundred sketches, each supported with a bibliography. They treat of taxonomists and field collectors, economic entomologists, exploring entomologists, professionals and amateurs. It is a treasurehouse of information about the great founders of entomology from Linnaeus onward, those who established the study of insects in North America and those who have fostered it in the West. Not all that Essig wrote is true today, but his errors are few and rarely serious. The discovery in archives and libraries during the past three decades of the personal papers and correspondence of many 19th Century, and earlier, American entomologists has brought to light information that was not available to Essig.

Chapter X is equally important to the entomological historian. It is a chronological table "Showing the development and progress of Entomology in relation to History and other Sciences." There are 142 pages of this table, written in three columns, "Births," "Events" and "Deaths." The first entries are the birth of Columbus and Gutenberg's invention of printing with movable type. One lead to the discovery of America, the other to the rapid dissemination of knowledge. The earliest entomological event noted is the printing of Conrad von Megenberg's *Buch der Natur* in 1475. The last year contained in the calendar is 1929 with 19 entomologically important events and the deaths of H. G. Dyar, F. H. Chittenden, W. T. Clarke and C. R. Orcutt reported. A continuation of this calendar by someone well versed in the total field of entomology is a task that should be done.

F. Martin Brown

Plant Galls and Gall Makers. Ephraim Porter Felt. Hafner Publishing Company, 364 pp., photographs and figs. 1965, price $10.75.

This book is a facsimile of the edition published in 1940 which is a modified version of Dr. Felt's "Key to American Insect Galls" which appeared in the New York State Bulletin #200 in 1917. The primary intention of this book is to facilitate the identification of many plant galls common to North America. However, information is presented on the biology, distribution, and plants that are favored by gall producers as well as the collection and study of plant galls.

The major portion of this book is devoted to a key of the various plant galls. The key is first arranged according to the families of plants, after which the galls are grouped in a manner to identify them within the different plant families. A brief summation of galls is presented in the introduction to the more important plant families.

Excellent illustrations are included in the text and serve as an aid in the identification of plant galls. However, some photographs presented in the plates did not lend themselves to a clear reproduction.

Dr. Felt's book is a very substantial contribution with regard to the identification of plant galls and will undoubtedly serve as a useful reference to entomologists, ecologists, and students of nature.

LOUIS M. VASVARY

INDEX TO SCIENTIFIC NAMES OF ANIMALS AND PLANTS

VOLUME LXXIV

Generic names begin with capital letters. New genera, subgenera, species, and varieties are printed in italics. This index does not include the 150 species of "Spiders from Powdermill Nature Reserve," pp. 55–58.

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The New York Entomological Society was founded in 1892 and incorporated the following year. It holds a distinguished position among scientific and cultural organizations. The Society's **Journal** is one of the oldest of the leading entomological periodicals in the United States. Members and subscribers are drawn from all parts of the world, and they include distinguished professional naturalists, enthusiastic amateurs, and laymen for whom insects are only one among many interests.

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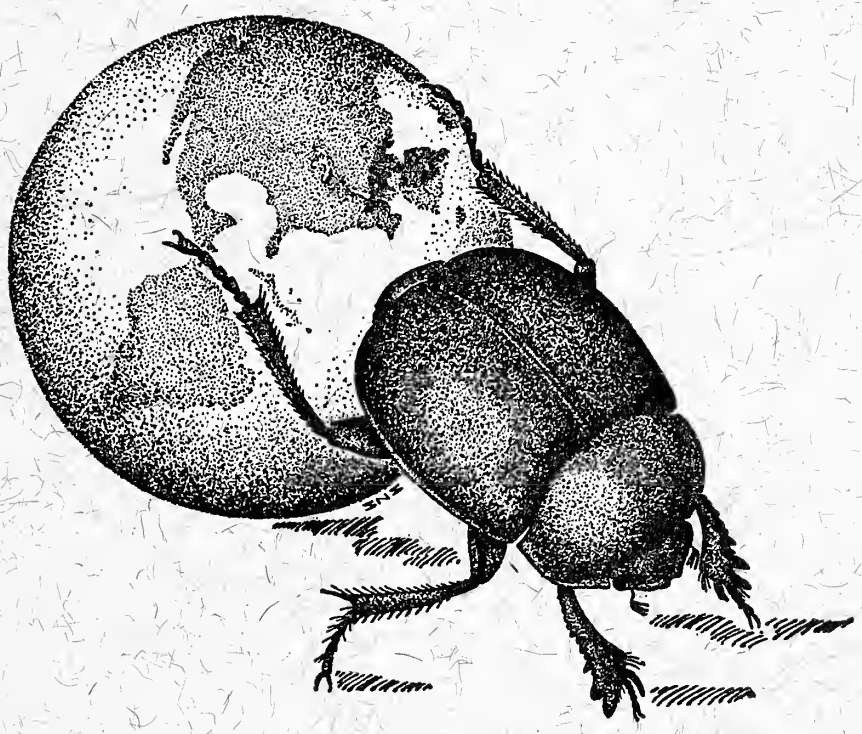

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Genera Tortricoidarum
Check list of genera and subgenera belonging to the families Tortricidae (Ceracidae, Chlidanotidae, Schoenotenidae and Olethreutidae included) and Phaloniidae[1]

By the late Nicholas S. Obraztsov[2]

Abstract: An alphabetical listing of the generic and subgeneric names in the families Tortricidae and Phaloniidae is presented; it is complete up to approximately the end of 1964.

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[1] The present paper was completed by the author approximately until the end of 1964. It is being published unchanged. The manuscript was prepared for publication by Dr. A. Diakonoff, Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands.

[2] Formerly Research Fellow, Department of Entomology, the American Museum of Natural History. The work for the present paper was done under the auspices of the National Science Foundation, GB-1805

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Palpocrinia Kennel, 1919
Pamene Rebel, 1901
Pammene Hübner, 1825
Pamplusia Guenée, 1845
Panaphelix Walsingham, 1907
Pandemia Stephens, 1834
Pandemis Hübner, 1825
Pandurista Meyrick, 1918
Panegyra Diakonoff, 1960
Panoplia Hübner, 1825
Parabactra Meyrick, 1910
Paracelypha Obraztsov, 1960
Parachanda Meyrick, 1927
Parachorista Diakonoff, 1952
Paraclepsis Obraztsov, 1954
Paracochylis Razowski, 1960
Paradichelia Diakonoff, 1952
Paragrapha Sodoffsky, 1837
Parahysterosia Razowski, 1960
Paralipoptycha Obraztsov, 1958
Paralobesia Obraztsov, 1953
Paramesia Stephens, 1829
Parameslodes Diakonoff, 1960
Paranepsia Turner, 1916
Parapammene Obraztsov, 1960
Parapandemis Obraztsov, 1954
Paraphyas Turner, 1927
Paraptila Meyrick, 1912
Pararrhaptica Walsingham, 1907
Paraselena Meyrick, 1910
Parastenodes Razowski, 1960
Parastranga Meyrick, 1910
Parasyndemis Obraztsov, 1954
Paratorna Meyrick, 1907
Paraxanthoides Razowski, 1960
Pardia Guenée, 1845
Parienia Berg, 1899
Pelatea Guenée, 1845
Pelochrista Lederer, 1859
Pendina Treitschke, 1829
Pentacitrotus Butler, 1881
Penthina Treitschke, 1830
Paraglyphis Common, 1963
Peribrosca Gistel, 1848
Peridaedala Meyrick, 1925
Periphoeba Bradley, 1957

Peronea Curtis, 1824
(preocc. by Rafinesque, 1815)
Petalea Walker, 1866
Peteliacma Meyrick, 1912
Petrova Heinrich, 1923
Phaecadophora Walsingham, 1900
Phaecasiophora Grote, 1873
Phaenacropista Diakonoff, 1941
Phalarocarpa Meyrick, 1937
Phalonia Hübner, 1825
Phalonidia Le Marchand, 1933
Phanerophlebia Diakonoff, 1957
Phaneta Stephens, 1852
Pharmacis Hübner, 1823
(preocc. by Hübner, 1820, and Hübner, 1823)
Phalonia Stephens, 1834
Phiaris Hübner, 1825
Philalcea Stephens, 1835
Philedone Hübner, 1825
Philedonides Obraztsov, 1954
Philocryptica Meyrick, 1923
Phlaeodes Guenée, 1845
Phloephila Duponchel, 1834
Phloiophila Duponchel, 1834
Phoxopteris Treitschke, 1829
Phoxopteryx Sodoffsky, 1837
Phricanthes Meyrick, 1881
Phthenolophus Busck, 1910
Phtheochroa Stephens, 1829
Phtheochroides Obraztsov, 1943
Phthinolophus Dyar, 1903
Phthoroblastis Lederer, 1859
Phylacophora Filipjev, 1931
Phylacteritis Meyrick, 1922
Picroxena Meyrick, 1921
Piercea Filipjev, 1930
Piliscophora Diakonoff, 1939
Pilophorica Diakonoff, 1960
Piniphila Falkovich, 1962
Planostocha Meyrick, 1912
Platynota Clemens, 1860
Platypeplum Walsingham, 1899
Platypeplus Walsingham, 1887
Platysemaphora Diakonoff, 1960
Poecilochroma Stephens, 1829
Poedisca Guenée, 1845
Pogonozada Hampson, 1905
Polemographtis Meyrick, 1910
Polychrosis Ragonot, 1894
Polydrachma Meyrick, 1928
Polylopha Lower, 1901
Polyortha Dognin, 1905
Pontoturania Obraztsov, 1943
Pristerognatha Obraztsov, 1960
Proactenis Diakonoff, 1941
Procalyptis Meyrick, 1910
Prochlidonia Razowski, 1960
Procoronis Meyrick, 1960
Procrica Diakonoff, 1960
Proeulia Clarke, 1962
Prohysterophora Razowski, 1961
Propedesis Walsingham, 1900
Propira Durrant, 1914
Propiromorpha Obraztsov, (1954) 1955
Proschistis Meyrick, 1907
Proselena Meyrick, 1881
Protarchella Diakonoff, 1956
Proteopteryx Walsingham, 1879
Proteoteras Riley, 1881
Prothelymna Meyrick, 1882
Protithona Meyrick, 1882
Protobactra Diakonoff, 1964
Protopterna Meyrick, 1908
Protypanthes Meyrick, 1933
Psegmatica Meyrick, 1930
Pseudamelia Obraztsov, 1954
Pseudargyrotoza Obraztsov, 1954
Pseudatteria Walsingham, 1913
Pseudeboda Razowski, 1964
Pseudeucosma Obraztsov, 1946
Pseudeulia Obraztsov, 1954
Pseudexentera Heinrich, 1940
Pseudoclita Bradley, 1957
Pseudococcyx Agenjo, 1955
(invalid)
Pseudococcyx Swatschek, 1958
Pseudogalleria Ragonot, 1885
Pseudohedya Falkovich, 1962
Pseudohermenias Obraztsov, 1960
Pseudophiaris Obraztsov, 1961
Pseudotomia Stephens, 1829
Pseudotomoides Obraztsov, 1959
Pteridoporthis Meyrick, 1937
Pternidora Meyrick, 1911
Pternozyga Meyrick, 1908
Ptychamorbia Walsingham, 1891
Ptycholoma Stephens, 1829
Ptycholomoides Obraztsov, 1954
Pygolopha Lederer, 1859

Pyrgotis Meyrick, 1881
Pyrodes Guenée, 1845
Pyrsarcha Meyrick, 1932

Raumatia Philpott, 1928
Retinia Guenée, 1845
Rhabdotenes Diakonoff, 1960
Rhacodia Hübner, 1825
Rhapsodica Meyrick, 1927
Rhocodita Hübner, 1826
Rhomboceros Meyrick, 1910
Rhopalotenes Diakonoff, 1960
Rhopalovalva Kuznetsov, 1964
Rhopobota Lederer, 1859
Rhyaciona Ragonot, 1894
Rhyacionia Hübner, 1825
Rhythmologa Meyrick, 1926
Ricula Heinrich, 1926
Riculoides Pastrana, 1952
Roxana Stephens, 1834
Rudisociaria Falkovich, 1962

Saetotenes Diakonoff, 1960
Saliciphaga Falkovich, 1962
Salsolicola Kuznetsov, 1960
Saphenista Walsingham, 1914
Satronia Heinrich, 1926
Schoenotenes Meyrick, 1908
Sciaphila Treitschke, 1829
Scinifer Frölich, 1826
Sclerodisca Razowski, 1964
Scolioplecta Meyrick, 1881
Scyphoceros Turner, 1925
Scytalognatha Diakonoff, 1956
Selania Stephens, 1834
Selenodes Guenée, 1845
Semasia Stephens, 1829
Semnostola Diakonoff, 1959
Sereda Heinrich, 1923
Sericoris Treitschke, 1830
Serruligera Diakonoff, 1960
Siclobola Diakonoff, 1947
Siderea Stainton, 1859
Sideria Guenée, 1845
Sillybiphora Kuznetsov, 1964
Sinusia Caradja, 1916
Sisona Snellen, 1901
Smicrotes Clemens, 1860
Sociosa Diakonoff, 1959
Sociosa Diakonoff, 1963
(preocc. by Diakonoff, 1959)
Sociphora Busck, 1920
Sonia Heinrich, 1923
Sorolopha Lower, 1901
Sparganothis Hübner, 1825
Spargonothis Hübner, 1826
Sparganothris Stephens, 1834
Sparganythis Matsumura, 1931
Spatalistis Meyrick, 1907
Sperchia Walker, 1869
Sphaeroeca Meyrick, 1895
(preocc. by Lauterborn, 1894)
Sphaleroptera Guenée, 1845
Spheterista Meyrick, 1912
Spilonota Stephens, 1829
Spinobactra Diakonoff, 1963
Sporocelis Meyrick, 1907
Statherotis Meyrick, 1909
Steganoptera Herrich-Schäffer, 1851
Steganoptycha Stephens, 1829
Stenodes Guenée, 1845
Stenotenes Diakonoff, 1954
Steriphotis Meyrick, 1911
Stictea Guenée, 1845
Stigmonota Guenée, 1845
Strepsiceros Meyrick, 1881
(preocc. by Smith, 1908)
Strepsicrates Meyrick, 1888
Strobila Sodoffsky, 1837
Strophedra Herrich-Schäffer, 1853
Strophosoma Herrich-Schäffer, 1853
(preocc. by Billberg, 1820)
Subargyrotaenia Obraztsov, 1961
Subeana Obraztsov, 1962
Subepiblema Agenjo, 1955
(invalid)
Substenodes Razowski, 1960
Suleima Heinrich, 1923
Sycacantha Diakonoff, 1959
Syllomatia Common, 1963
Symphygas Common, 1963
Syndemis Hübner, 1825
Syndemis Herrich-Schäffer, 1851
(preocc. by Hübner, 1825)
Syngamoneura Mabille, 1900
Synnoma Walsingham, 1879
Synochoneura Obraztsov, 1955
Syntozyga Lower, 1901
Syricoris Treitschke, 1829

Taeniarchis Meyrick, 1931
Talponia Heinrich, 1926
Taniva Heinrich, 1926
Tanychaeta Common, 1963
Tapinodoxa Meyrick, 1931
Teleia Hübner, 1825
Temnolopha Lower, 1901
Templemania Busck, 1940
Tenuisaccula Diakonoff, 1960
Teras Treitschke, 1829
Teratodes Guenée, 1845
(preocc. by Brullé, 1835, and Koch, 1838)
Terthreutis Meyrick, 1918
Thiodia Hübner, 1825
Thiodiodes Obraztsov, 1964
Thirates Treitschke, 1829
Thrincophora Meyrick, 1881
Thylacandra Diakonoff, 1963
Thyralia Walsingham, 1914
Thyraylia Walsingham, 1897
Tia Heinrich, 1926
Tmetocera Lederer, 1859
Topadesa Moore, 1888
Tortricodes Guenée, 1845
Tortricomorpha Amsel, 1955
(preocc. by Felder and Rogenhofer, 1861)
Tortrix Linné, 1757
Trachybathra Meyrick, 1907
Trachybyrsis Meyrick, 1927
Trachyptila Turner, 1916
Trachysmia Guenée, 1845
Trachyschistis Meyrick, 1921
Tremophora Diakonoff, 1953
Trincophora Meyrick,
Tritopterna Meyrick, 1921
Trophocosta Razowski, 1964
Trycheris Guenée, 1845
Trychnophylla Turner, 1926
Trymalitis Meyrick, 1905
Tsinilla Heinrich, 1931
Tubula Diakonoff, 1960
Tymbarcha Meyrick, 1908

Ulodemis Meyrick, 1907

Vellonifer Razowski, 1964
Vialonga Diakonoff, 1960
Viettea Diakonoff, 1960

Xanthosetia Stephens, 1829
Xeneda Diakonoff, 1960
Xenophylla Diakonoff, 1960
Xenotemna Powell, 1964
Xenotenes Diakonoff, 1954
Xenothictis Meyrick, 1910

Zacorisca Meyrick, 1910
Zeiraphera Treitschke, 1829
Zelotherses Lederer, 1859
Zomaria Heinrich, 1926

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Some Biometrics in *Pieris* and *Colias* (Lepidoptera: Pieridae) in Quebec and Nova Scotia

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Abstract: The radii of fore wings and the weights of whole air-dried specimens of adult instars of wild and reared specimens of *Pieris rapae, Colias philodice*, and *C. eurytheme* have been compared. Correlations (*r*) of high orders of significance between these two variables have been determined and shown graphically. The radii and weights of the females of the two species of *Colias*, both wild and reared, exceeded those of the males by less than 10%.

In 1953 (Lepid. News, **7:** 47–8) the author published a short note pointing out the existence of correlations between fore wing radii and total dry weights of specimens of *Pieris rapae* L. reared from eggs in 1951 at Baie d'Urfé in the Province of Quebec, Canada. The mean values for radii and weights of 28 butterflies that developed from eggs collected at random on leaves of *Brassica oleracea,* and of 34 from eggs laid by one female, caught wild, were almost identical. The ranges and means of the values quoted are shown by the graph in Fig. 1. The radii of the fore wings of the 'random' set ranged from 36 to 52 mm., with the mean at 46 mm.; those of 'single brood' from 44 to 50 mm., also with the mean at 46 mm. The weights of the same specimens ranged from 8.4 to 27.5 mg., and fron 15.0 to 26.3 mg., the mean values being 19.8 and 20.5 mg. respectively. The ranges of variation are thus shown to be more extensive in the random group than in the specimens from the one female. The correlations between radii and weights were found to be highly significant (1953).

In 1960 49 males and 50 females of *Colias philodice* Gdt. were caught between 27 August and 23 September at Brighton (Digby County), Nova Scotia. The radii of the fore wings of fresh specimens were measured to the nearest 0.5 mm., and, when air-dry, the specimens were weighed to the nearest 0.1 mg. The standard deviations of the means in the two sexes were very small; in the males that of the radii was about 0.7 per cent, and of the weights 2.0 per cent; in the females, radii about 0.7 per cent, and weights 1.9 per cent. The correlations of these two characters, in each sex, are shown in the scatter diagram in Fig. 2.

In order to simplify the presentation of the results of these analyses in the diagram, each + (for male) and ● (for female) represents the average of five (in one set, four) measurements and weights of specimens taken in the field in sequence of dates. The summated averages agreed almost exactly with the summations of the separate values.

The correlation values (*r*) being positive and of a high order of significance

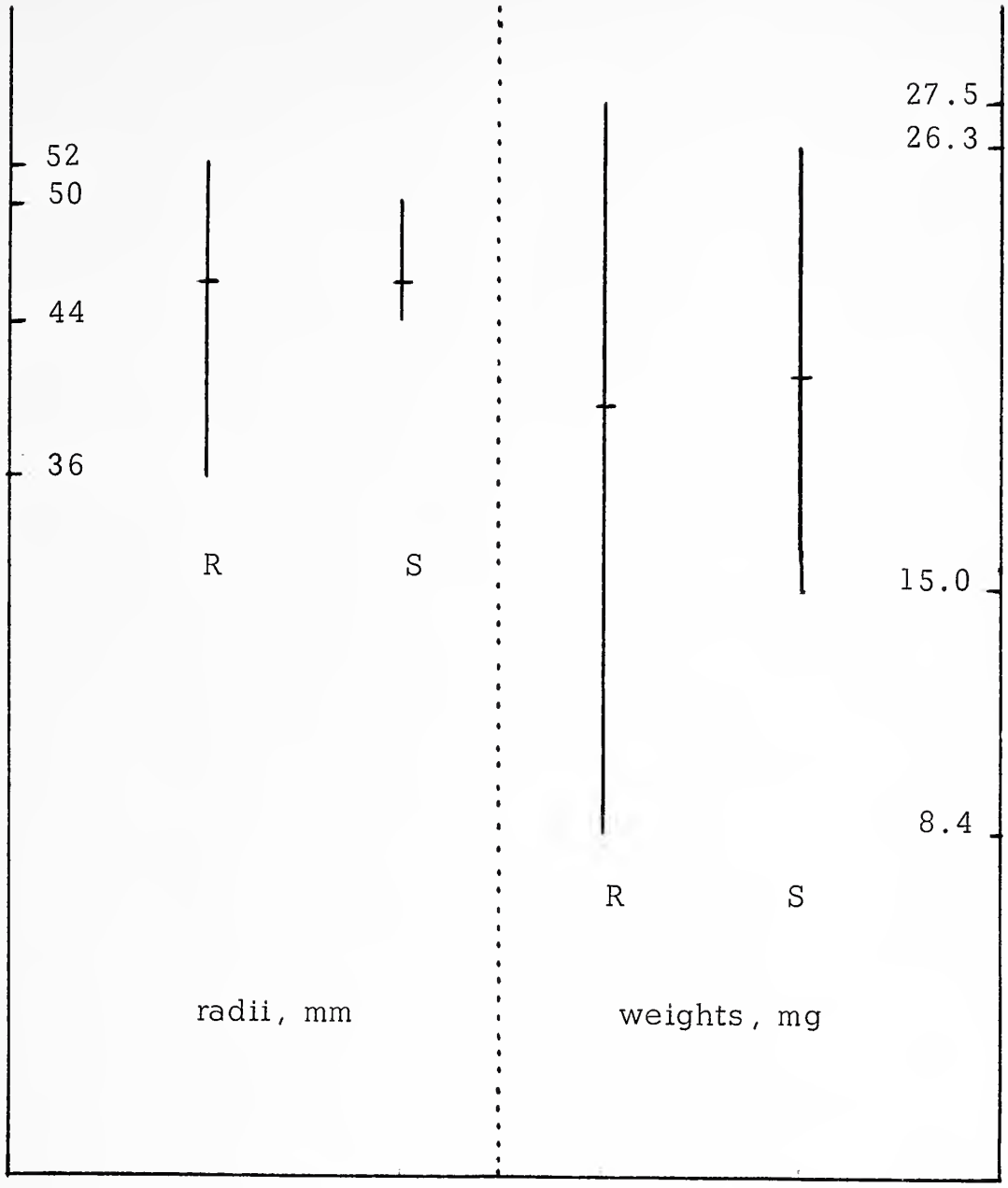

Fig. 1. Ranges of radii of fore wings and of weights of *P. rapae*, 1951. R, from random eggs; S, from eggs laid by one random female. Means are shown by short cross-bars.

suggest that lengths (and possibly areas) of the wings vary directly with the total weights of the insects. These characters have also been compared in specimens reared from larvae derived from eggs laid by white form females, one of *philodice* and one of *C. eurytheme* Bdv.

In 1960 a brood of larvae was reared from eggs laid by a white form female of *philodice* caught in September. The butterfly was kept under glass in a large earthenware flower pot, lighted and warmed by a 50 watt electric lamp. Flower heads of *Gaillardia* dipped in a weak solution of sucrose provided food. About 100 eggs were laid on the flower petals and on leaflets of *Vicia cracca* (common vetch); all the plant stems were resting in water in a narrow-necked bottle. The young larvae were transferred to fresh twigs of vetch as necessary,

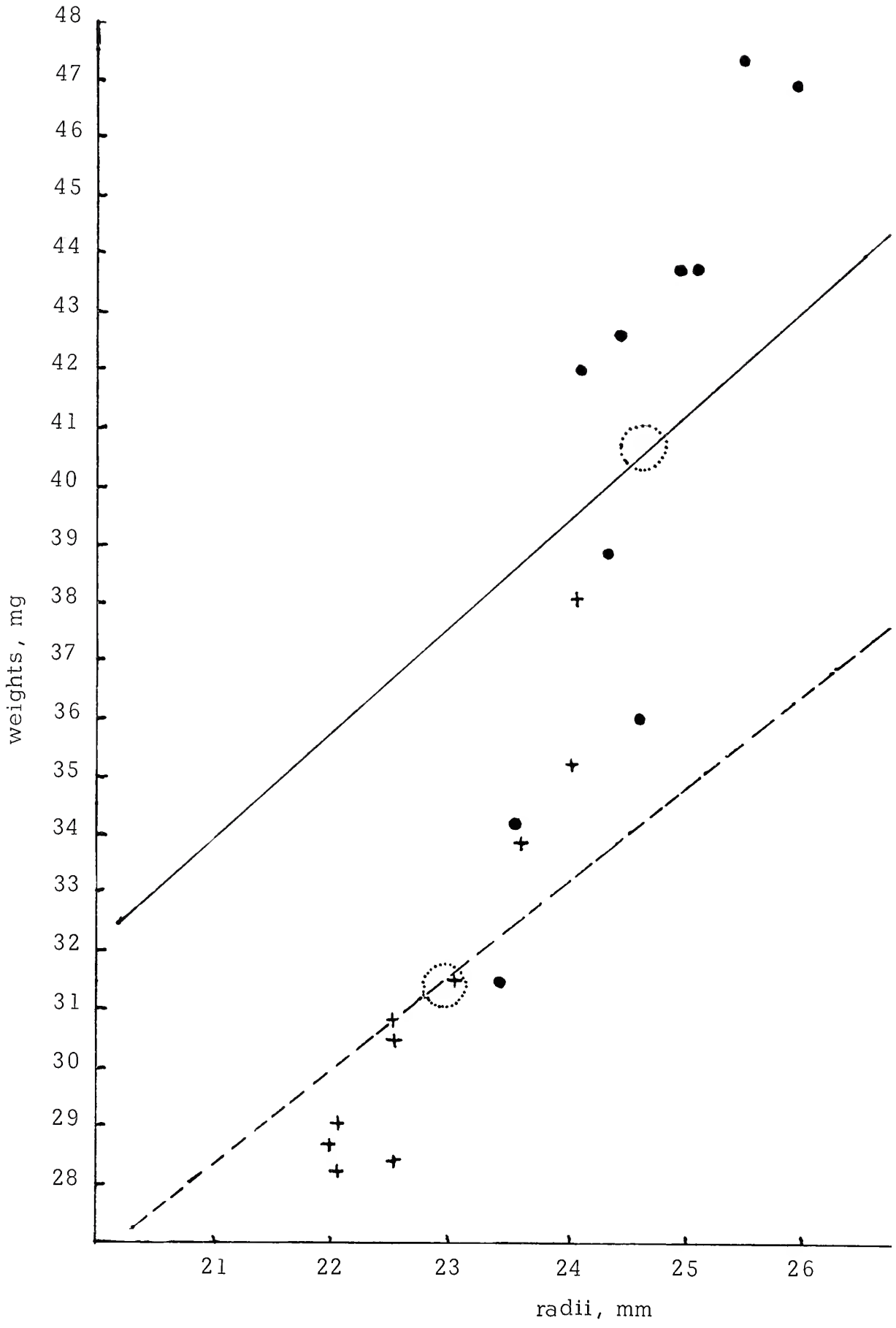

FIG. 2. Correlations between radii of fore wings and weights of *C. philodice* caught wild. + and broken line, males ($r = +0.9645$); ● and solid line, females ($r = +0.9869$). (The means of radii and weights are indicated by the dotted circles around the coordinate positions on the regression lines in Figs. 2, 3, and 4.)

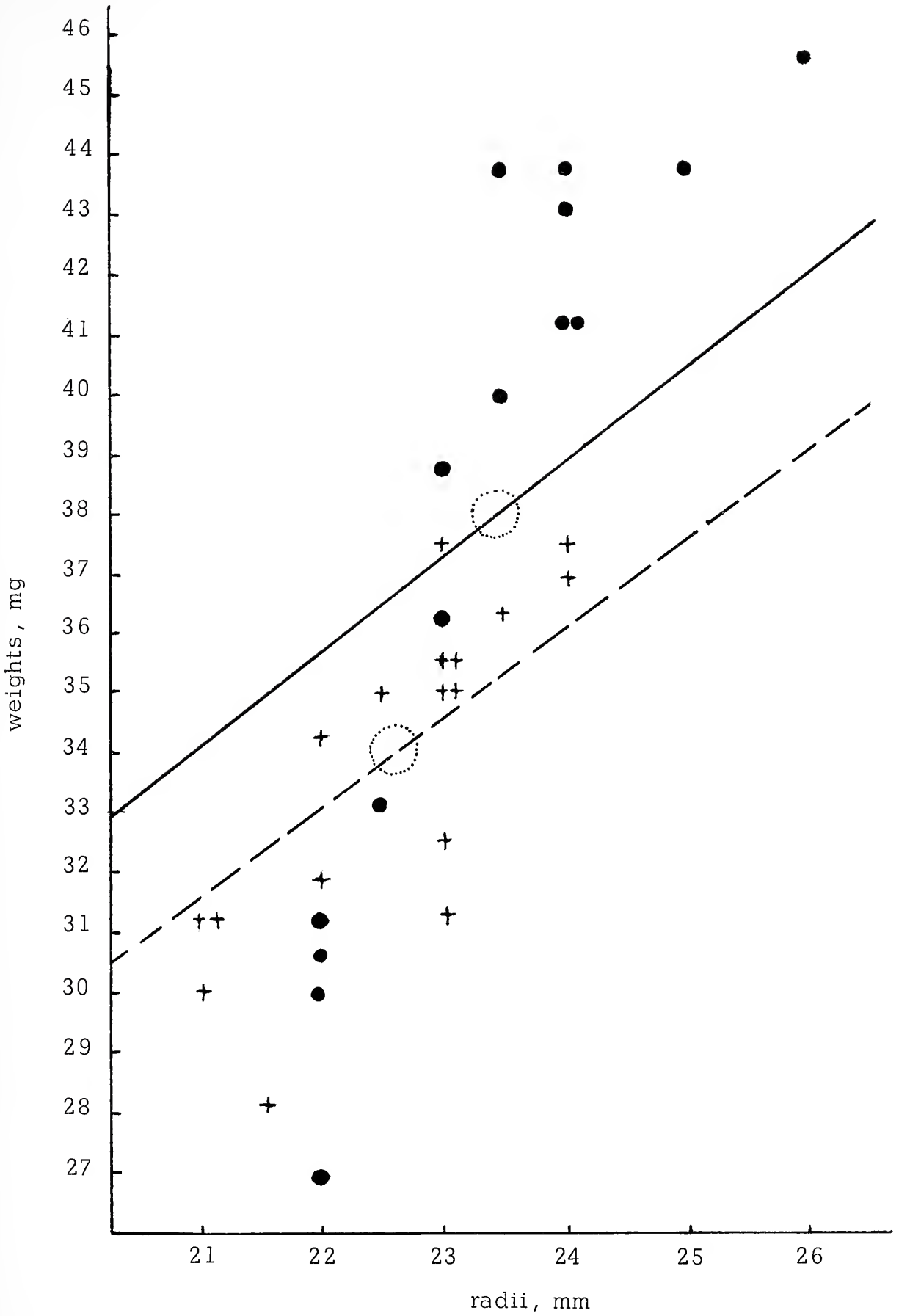

Fig. 3. Correlations between radii of fore wings and weights of *C. philodice* reared from eggs laid by a white form female. Males, $r = +0.9721$; females, $r = +0.9898$.

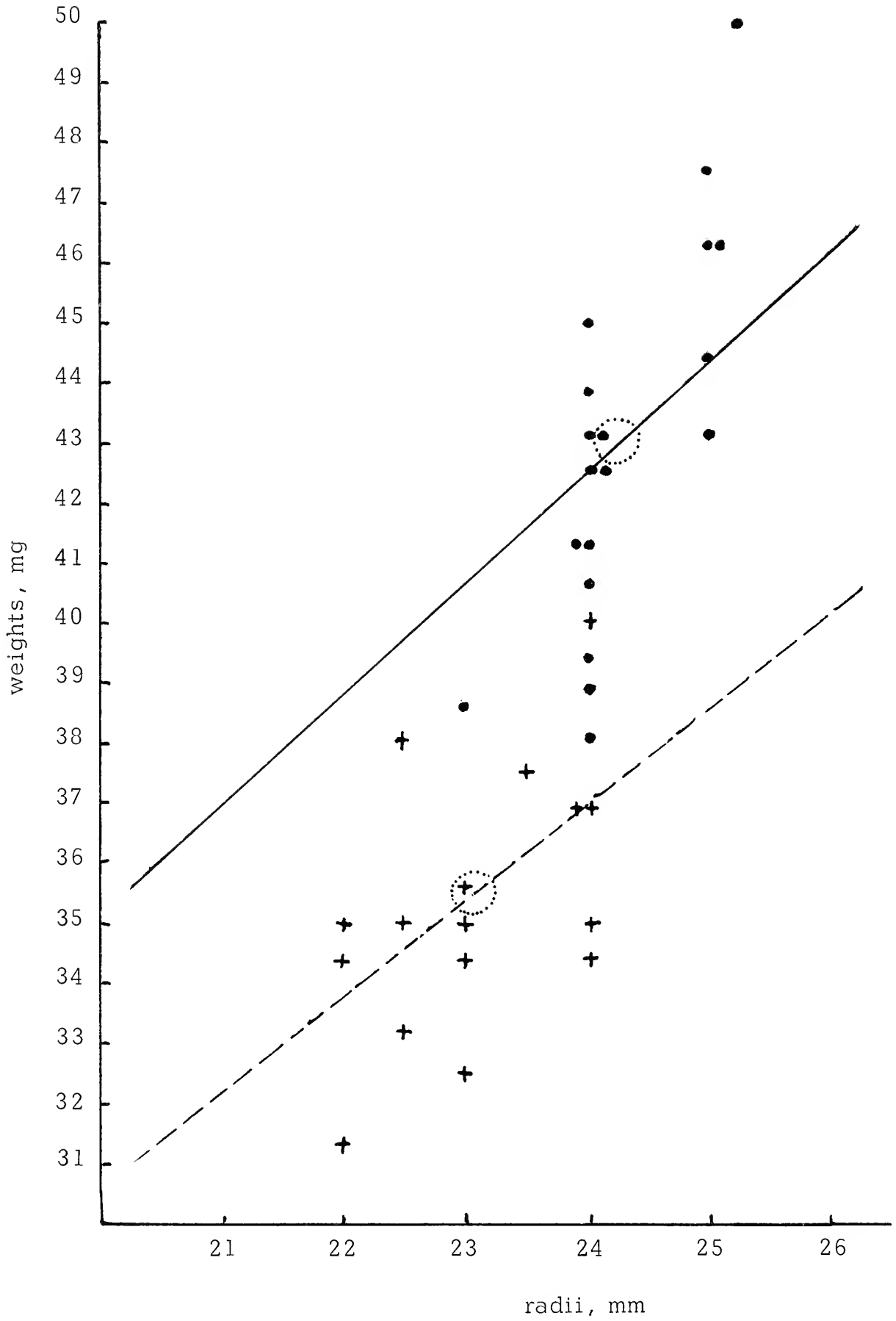

FIG. 4. Correlations between radii of fore wings and weights of *C. eurytheme* reared from a white form female. Males, $r = +0.9845$; females, $r = +0.9845$.

after each new leaflet had been examined for 'alien' eggs. 32 larvae reached the imago stage; 17 were males and 15 females (8 yellow and 7 white).

Standard deviations of the means of both radii and weights in both sexes were low; for the radii about 1.0 to 1.25 per cent, for weights 2.7 and 4.1 per cent, of males and females respectively. The correlations between radii and weights were high, as shown in Fig. 3.

In 1961 a white form female of *C. eurytheme,* caught wild, yielded 16 males and 19 orange form females from larvae grown indoors on vetch. The standard deviations of the characters under study, radii and weights, were less than 1.0 per cent for radii and below 2.5 per cent for weights. The correlations of these characters were highly significant in both sexes (see Fig. 4).

In the three groups of *Colias* studied the females exceeded the males in mean length of radii and in mean weights, but only by less than ten per cent; more so in length of radius than in weight, as shown in the table below.

Excess values of females over those of males, in percentages

	Radii	Weights
C. philodice, wild	9.3	7.7
C. philodice, reared	9.8	8.9
C. eurytheme, reared	9.4	8.2

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A Note on the Flight of *Acrolophus morus* (Grote) (Lepidoptera: Acrolophidae)

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Abstract: It is possible that in Connecticut and New York *Acrolophus morus* (Grote) is consistently a diurnal flyer. This may be a matter of temperature adaptation of this, the northernmost species of an essentially southern and tropical group, and an autumn flyer.

Twice only I have taken *Acrolophus morus* (Grote) in the Northeast. On both occasions the individuals were netted while flying actively and normally (not flushed from shelter) during the day. On 11 October 1953, a male was taken about 2 P.M. near Canopus Lake, Putnam County, New York, flying swiftly in a grassy area at the edge of a marsh. On 29 September 1966, three specimens were seen at about 2:30 P.M. over my lawn in Putnam, Windham County, Connecticut. The soil beneath the lawn is a very dry sand-gravel. One specimen, probably a female, was relatively sluggish—perhaps it had just eclosed. The other two, both males, were flying very fast and erratically about and over it in curves. So fast and darting, in fact, was their flight that at first I thought that they were small, dark skippers far out of season. Unfortunately the female disappeared while the males were being netted. In the recent revision of *Acrolophus* by F. M. Hasbrouck (1964, Proc. U. S. Nat. Mus., **114**:632) a specimen of *morus* from Ithaca, New York is recorded as taken in the daytime. It is suggested that diurnal flight is a characteristic of this species, and that there may well be an adaptive correlation between this and the fact that it flies in the autumn and is the northernmost species of its family, at least in the East.

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The Incidence and Burden of *Hymenolepis diminuta* Cysticercoids as a Function of the Age of the Intermediate Host, *Tribolium confusum*

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Abstract: The incidence and size of the larval tapeworm burden in young, middle-aged, and old confused flour beetles was studied. The influences of sex and length of starvation period were also observed.

Virgin beetles from young parents were permitted to feed for 24 hours on whole gravid proglottids and then returned to the medium for at least fourteen days prior to being preserved, dissected, and examined for cysticercoids. A quantitative approach to feeding eggs to the beetles was unsuccessful.

Old females generally had a significantly smaller burden and incidence of cysticercoids when compared with young or middle-aged females, whereas middle-aged males generally had a significantly higher incidence only when compared with young or old males.

Apparently an age resistance to the establishment of *H. diminuta* in *T. confusum* occurs in the females only.

INTRODUCTION

Since 1892, when Grassi and Rovelli first described the development of *Hymenolepis diminuta* in the insect intermediate host, there have been various investigations on hymenolepidids in insects. While there have been reports of vertebrate host age effects on adult hymenolepidid incidence and burden (Shorb, 1933; Hunninen, 1935), we have found no reports in the literature with regard to the age of the intermediate host on the larval stage of the parasite. Therefore, this study was undertaken with the intent of observing the incidence and size of the cysticercoid burdens in beetles of specific ages. Since host sex and length of starvation prior to exposure to the tapeworm's eggs may also influence the burden, these factors were also considered. The tapeworm *H. diminuta* and the beetle *Tribolium confusum* were selected since the former requires, as part of its life cycle, an arthropod intermediate host and the latter has been shown to serve well in this capacity.

MATERIALS AND METHODS

All stock cultures and experimental groups were raised under constant light at a temperature of 25°C. and a relative humidity of 71% in a medium consisting of 95% bleached Gold Medal Wondra® flour and 5% National Active Dry® yeast. The use of yeast-fortified flour had been proposed by Lund and Bushnell (1939). All stock and experimental beetles were put into fresh containers and medium every two weeks. Eggs randomly selected from a stock

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culture were used to establish a population of beetles of known ages. Eight to eighteen days following oviposition of these beetles, eggs were collected and individually placed in 12 × 35 mm patent lip vials containing approximately 5 mm of medium. In this manner, selection of the first eggs laid by the beetles of known ages was avoided, since this selection may have detrimental effects on the offspring as shown in *Drosophila* (O'Brian, Yablonsky, and Gillooly, 1964).

The adult beetles that developed from these eggs were maintained as virgins in individual vials throughout the experiment. Three different age groups of adults were used: those that were young (four to five weeks), middle-aged (23 to 24 weeks), and old. Adult beetles were considered to be old at 47 to 51 weeks on the basis of parental age studies by Raychaudhuri and Butz (1965) and personal communication with Raychaudhuri (1964).

Each age group was further subdivided into those starved five to six days (Series I) and those starved seven to eight days (Series II). Following the starvation period, all beetles were allowed to ingest an undetermined number of eggs for a 24 hour interval by feeding on three or four freshly obtained whole gravid segments of *H. diminuta*. The male Sprague-Dawley rats from which the tapeworms were removed had been inoculated orally at five weeks of age with three to five cysticercoids dissected from infected meal beetles, *Tenebrio molitor* (Carolina Biological Supply Co.). The infections in the rats were five to fifteen weeks post-inoculation. Only those *Tribolium* which were observed to have fed on proglottids were used in the accumulation and analysis of the data. After exposure to the proglottids, the beetles were returned to vials containing fresh medium for a period of at least fourteen days prior to being preserved in 10% formalin. The preserved beetles were dissected and examined for cysticercoids.

The sex of the beetle was determined in the pupal stage by the method described by Park (1934), in the adult stage by the method described by Hinton (1942), and at the time of dissection.

RESULTS

Table 1 summarizes the incidence and size of the cysticercoid burdens in beetles which fed on gravid proglottids. The significance of the differences ($P < 0.05$) between any two average numbers of cysticercoids was determined by the "*t*" test (Youden, 1951, p. 25) and the trend between any two incidences of cysticercoids by the "Chi square" test (Hoel, 1960, pp. 157–163).

Since there was no difference in the incidence of cysticercoids between the populations starved five to six or seven to eight days, the data was pooled for analysis. Old females had a lower incidence when compared to young and middle-aged females, whereas in the male population the incidence was higher in the middle-aged group when compared to young and old beetles. With re-

Table 1. The burden and incidence of *Hymenolepis diminuta* cysticercoids in beetles of known ages. Mean values are given with the standard errors.

		No. of days starved					
		Series I, 5 to 6 days			Series II, 7 to 8 days		
Age	Sex	No. infected / No. that fed on proglottids	Percent infected	Average ± S.E.	No. infected / No. that fed on proglottids	Percent infected	Average ± S.E.
Young: 4 to 5 weeks	Females	26/33	78.8	7.0 ± 1.62	34/41	82.9	10.6 ± 1.72
	Males	28/39	71.8	6.5 ± 1.41	15/30	50.0	4.0 ± 1.14
Middle-aged: 23 to 24 weeks	Females	33/42	78.6	5.3 ± 0.81	35/42	83.3	7.0 ± 0.99
	Males	24/30	80.0	7.7 ± 1.36	29/33	87.9	7.5 ± 1.39
Old: 47 to 51 weeks	Females	11/28	39.3	0.8 ± 0.28	21/38	55.3	5.9 ± 1.83
	Males	34/64	53.2	5.0 ± 1.17	32/55	58.3	5.4 ± 1.57

spect to differences between the sexes, only old females had a lower incidence than middle-aged males. All these differences were found to be significant employing the difference in proportions using a binomial distribution (Dixon and Massey, 1957, pp. 232–233).

In Series I (five to six days starvation) the burden in old female beetles was significantly smaller than that of young and middle-aged females, and males of all ages. In Series II (seven to eight days starvation) the burden in old females was significantly smaller when compared to young female beetles only. Also, in this series, young males had a significantly lower burden when compared to young females and middle-aged males.

When comparing both series, only old females starved seven to eight days had a significantly greater burden than old females starved five to six days.

DISCUSSION

The lack of reports on the relationships of age and sex of intermediate hosts to their cysticercoid burdens makes this paper unique. It should be noted, preliminary results of this investigation have been reported in the form of an abstract (Kelly et al., 1966).

Age resistance to the establishment of *Hymenolepis nana* has been studied by Shorb (1933) in rats and mice and by Hunninen (1935) in mice only, and both found that older animals had a greater resistance to the tapeworm than younger animals.

In our study, middle-aged male *Tribolium* generally had a significantly higher incidence of cysticercoids than young or old males, whereas old females

generally had a significantly lower incidence and burden than middle-aged or young females. It seems, therefore, that an age resistance to the establishment of *H. diminuta* cysticercoids occurred in female *Tribolium*. Moreover, starvation affected the burden only in old females. This may indicate an increased susceptibility in old females to the tapeworm eggs as marginal food reserves are depleted.

Some work on the effects of age of the insect vector has been carried out with respect to protozoan parasites. Terzian et al. (1956) found that older *Aedes aegypti* mosquitoes were more resistant to *Plasmodium gallinaceum* than younger mosquitoes. However, physiological factors also played a role since particular diets resulted in aged mosquitoes being as susceptible to the parasites as young mosquitoes.

In the literature, one finds contradictions regarding the role of the sex of the intermediate host in its susceptibility to the parasites it transmits. Duke (1930, 1933) considered his work on tsetse flies showed females to be more susceptible than males to trypanosomes. However, according to Burtt (1946), Duke's (l.c.) data showed no significant differences.

With respect to helminths, it is of interest to note that a number of papers have been published on the relationships of nematode parasites to changes in sexual characteristics of insect hosts with some investigators reporting changes occurring more frequently in one sex than the other. In his extensive review of this subject, Wülker (1964, p. 589) notes, "It can be said, generally that, with regard to the gonads, the females are more changed, and with regard to the external sex characters, the males are more changed. However, exact investigations on the possible reasons for this difference and the opposite behavior of internal and external characters do not exist as yet."

In the investigation reported here, the beetles fed only on whole gravid segments, and therefore, the number of eggs ingested per beetle cannot be correlated with the cysticercoid burden. However, it should be pointed out that quantitative feedings were tried during the course of this experiment but were unsuccessful. Moreover, no reports have been observed in the literature where quantitative feedings of *H. diminuta* eggs to beetles have been employed. At the present time in this laboratory, successful feeding attempts have been obtained and will be reported at a later date (Levine, et al.)

It appears from our work and that of others that there is a need for more detailed studies on host-parasite relationships as presented and discussed in this report.

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Undescribed Species of Crane Flies from the Himalaya Mountains (Diptera: Tipulidae), XIV[1]

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Abstract: Six new species of Eriopterine crane flies are described, these being *Trentepohlia* (*Mongoma*) **amphinipha** n. sp., from Sikkim; *T.* (*M.*) **patens** n. sp., Assam; *T.* (*Trentepohlia*) **infernalis** n. sp., Sikkim; *Gymnastes* (*Gymnastes*) **anticaniger** n. sp., Sikkim; *G.* (*G.*) *cyaneus* **nilgiricus** n. subsp., South India; *G.* (*G.*) **latifuscus** n. sp., Assam; and *G.* (*G.*) **tridens** n. sp., Thailand.

Part XIII of this series of papers was published in the Journal of the New York Entomological Society, **74:** 180–184, 1966. The species treated herewith are from Assam and Sikkim where they were collected by Dr. Fernand Schmid and from Northern Thailand, taken by the late Dr. Deed C. Thurman. A subspecies from South India is included in order to complete the data, the materials having been captured by Mr. P. Susai Nathan and by the late Stanley W. Kemp. I express my sincere thanks and appreciation to all of the above for the privilege of retaining the types of the novelties in my personal collection of these flies.

Trentepohlia (*Mongoma*) **amphinipha** n. sp.

Allied to *tenera*; mesonotal praescutum and scutal lobes dark brown, paler laterally; femora brownish black, tips broadly snowy white, including about the outer tenth, tibial bases more narrowly whitened, tarsi and the broad tips of tibiae white; a series of small erect black setae at bases of all femora in both sexes; wings whitish subhyaline, without distinct pattern; squama with a powerful black bristle.

MALE: Length about 7.5–8 mm; wing 7–7.3 mm.

FEMALE: Length about 9 mm; wing 7 mm.

Rostrum and labial palpi yellow, maxillary palpi brownish black. Antennae black, relatively long; flagellar segments long-subcylindrical, exceeding their verticils. Head dark brown, paler behind.

Pronotum brownish yellow, with long erect setae. Mesonotal praescutum dark brown, humeri and lateral borders more yellowed; scutal lobes darkened, scutellum and mediotergite paler brown, yellowed laterally; mesonotal vestiture weak. Pleura brown, posterior sclerites more yellowed. Halteres dark brown. Legs with coxae and trochanters yellow; femora brownish black, bases narrowly yellowed, tips broadly snowy white, including about the outer tenth; tibiae brownish black, bases narrowly white, tips more broadly of this color, including the outer fourth; tarsi white, terminal segment slightly darker; all femora in both sexes with a few small erect blackened setae near base. Wings whitish subhyaline, without distinct pattern, stigma barely indicated; veins brown. Margin of wing at base with three or four long black setae, the squama with a single more powerful erect black bristle. Venation: *Rs* longer than basal section of R_5; R_2 exceeding R_{3+4}; *m-cu* at or before fork of *M*; apical fusion of Cu_1 and *1st A* nearly as long as *m-cu*.

Abdominal tergites dark brown, including the hypopygium; sternites obscure yellow.

HOLOTYPE: ♂, Lingtham, Sikkim, 4,600 feet, September 2, 1959 (Schmid). Allotopotype, ♀, with type. Paratopotypes, 7 ♂♀, on three pins.

[1] Contribution from the Entomological Laboratory, University of Massachusetts.

The only other regional member of the subgenus with unpatterned wings that has the genua of the legs snowy white is *Trentepohlia* (*Mongoma*) *subtenera* Alexander, of Assam, which differs especially in the coloration and trichiation of the legs. In this species the modified erect setae on the paler brown femora are restricted to the posterior legs and are more abundant, about ten in number.

Trentepohlia (*Mongoma*) **patens** n. sp.

General coloration of thorax yellow, the praescutum and scutal lobes patterned with light brown; antennae of male relatively long, exceeding one-half the wings; femora yellow, tips narrowly light brown; wings whitened, veins light brown; cell *Cu* open at wing margin, cell *2nd* A broad.

MALE: Length about 6.5 mm; wing 5.2 mm; antenna about 3.1 mm.

Rostrum yellow; palpi pale brown. Antennae of male elongate, exceeding one-half the wings; scape and pedicel light yellow, flagellum brown; verticils and whitened vestiture of the flagellum short. Front and anterior vertex silvery white, posterior vertex light brown, the orbits narrowly light gray.

Cervical region and pronotum light yellow. Mesonotal praescutum yellow on sides, central region of disk light brown, becoming obsolete before the suture; posterior sclerites of notum yellow, scutal lobes light brown, base of scutellum less evidently of this color. Pleura clear light yellow. Halteres pale brown, base of stem narrowly light yellow. Legs with coxae and trochanters light yellow; femora yellow, clearer basally, tip narrowly light brown; tibiae and tarsi pale brown. Wings whitened, base and costal field more yellowed, stigmal darkening very small to scarcely indicated; veins light brown, more yellowed in the brightened fields. Venation: R_2 just before fork of R_{2+3+4}; *m-cu* at fork of *M*; cell *Cu* open at wing margin; cell *2nd A* broad.

Abdominal tergites brown, sternites more yellowed, outer segments brown, including the hypopygium.

HOLOTYPE: ♂, Pynter, United Khasi and Jaintia Hills, Assam, 1,700 feet, January 20, 1960 (Schmid).

The most similar species are *Trentepohlia* (*Mongoma*) *flava* (Brunetti) and *T.* (*M.*) *horiana* Alexander, which similarly have cell *Cu* of the wings open at margin, differing in the coloration of the body and wings, including the darkened veins. Attention is called to the elongate antennae and the unusually broad cell *2nd A* of the present fly.

Trentepohlia (*Trentepohlia*) **infernalis** n. sp.

Allied to *ornatipennis*; mesonotal praescutum and scutal lobes almost uniformly light yellow, scutellum, postnotum and pleura dark brown; halteres blackened; legs yellow; wings relatively short and broad, anterior half and cells beyond cord chiefly brown, interrupted by three small yellow areas along border from stigma to cell R_4, posterior wing cells more grayish with whitened markings.

MALE: Length about 5 mm; wing 4.8 mm.

FEMALE: Length about 5.2 mm; wing 5 mm.

Rostrum and labial palpi brownish yellow, maxillary palpi brown. Antennae brownish yellow. Anterior vertex gray, posterior vertex and genae obscure yellow, occiput darkened.

Cervical region and pronotum brown. Mesonotal praescutum and scutal lobes almost uniformly light yellow, scutellum and postnotum dark brown. Pleura dark brown. Halteres blackened, base of stem narrowly yellow. Legs with coxae and trochanters yellow; remain-

der of legs light yellow, terminal tarsal segment slightly infuscated. Wings relatively short and broad, as compared with related species; anterior half and the cells beyond cord chiefly brown, posterior cells grayish; a very restricted pale pattern that includes three small yellow spots along border, one at end of Sc_1, the second in cell R_3, third at wing tip, chiefly in cell R_4; more whitened marks in outer end of cell *R* and bases of R_5 and M_2; cells *M*, *Cu* and Anals pale with brown washes in outer ends; veins brown, yellowed in the costal ground areas. Venation: *Rs* a little longer than R_{2+3+4}, R_{3+4} shorter; petiole of cell R_5 subequal to or shorter than basal section of M_{1+2}; apical fusion of veins Cu_1 and *1st A* short; vein *2nd A* highly arched before midlength.

Abdominal tergites dark brown, sternites brownish yellow, outer segments, especially the genitalia, black.

HOLOTYPE: ♂, Lingtham, Sikkim, 6,500 feet, August 10, 1959 (Schmid). Allotype, ♀, Nanga, Sikkim, 5,000 feet, August 4, 1959 (Schmid).

Other related Indian species include *Trentepohlia* (*Trentepohlia*) *bellipennis* Alexander, *T.* (*T.*) *camillerii* Alexander, and *T.* (*T.*) *ornatipennis* Brunetti, all readily told by the wing pattern, distinguished from the present fly by having more pale color in the cells of the anterior half of the wing.

Gymnastes (*Gymnastes*) **anticaniger** n. sp.

General coloration polished black, the thoracic pleura with yellow areas on dorsopleural and metapleural regions; anterior and middle femora uniformly black; wings whitened, base more yellowed, disk with three unusually pale brown bands, the basal area broadly involving cells *M*, *Cu* and *1st A*; vein R_3 simple, slightly oblique; abdomen black, the extreme posterior borders of sternites light yellow.

MALE: Length about 4 mm; wing 4 mm.

FEMALE: Length about 5.5–6 mm; wing 4.5–5.5 mm.

Rostrum, palpi and antennae black; flagellar segments oval, the outer ones shorter, terminal segment long. Head polished black.

Thorax polished black, with scarcely indicated more bluish tints on the praescutum; dorsopleural and metapleural membranes yellowed. Halteres black, knob vaguely tinted with yellow. Legs with coxae and trochanters black; fore femora uniformly black, tibiae brown, tips passing into black, tarsi black; middle femora black, bases vaguely paler, tibiae brown, tips and the tarsi black; posterior femora brownish yellow, the enlarged tips brownish black, tibiae yellow, outer fourth black, tarsi black, the proximal third to half of basitarsi yellow; legs with abundant dark flattened scales, setae inconspicuous on femora, more evident on posterior tibiae and tarsi. Wings whitened, base more yellowed; disk with three unusually pale brown bands, including the apex and a broad area at cord that are almost contiguous in the medial field; third darkened area includes about the basal halves of cells *M*, *Cu* and *1st A*, with an incursion into cell *R*; stigmal area indicated, partly obliterated by the anterior half of vein R_3; veins brown, yellow in the prearcular field. Venation: Vein R_3 simple, slightly oblique, without a spur of R_2; *m-cu* shortly beyond fork of *M*.

Abdomen black, extreme posterior borders of the sternites light yellow. Male hypopygium having the apical margin of basistyle with a blackened flange. Inner dististyle massive, unequally bidentate, the inner point longer.

HOLOTYPE: ♂, Zomphuk, Sikkim, 6,500–8,000 feet, April 11, 1959 (Schmid). Allotopotype, ♀. Paratopotypes, 2 ♀♀, with the type.

Gymnastes (*Gymnastes*) **anticaniger** is related to species such as *G.* (*G.*)

cyaneus (Edwards) and a few others, differing evidently in the blackened fore and middle femora and the unusually pale wing pattern.

Gymnastes (*Gymnastes*) *cyaneus* **nilgiricus** n. subsp.

Very close and generally similar to typical *cyaneus* (Edwards) (*violaceus* Brunetti), differing in slight details of hypopygial structure. Male hypopygium with the arm of the inner dististyle a dark flattened blade that is produced into a powerful spine. In *cyaneus* this arm is slender, narrowed outwardly, near apex with a small conical tooth. Posterior border of the sternite produced into a small cylindrical point. Typical *cyaneus* still is known to me only from various stations in Ceylon. The degree of difference between the two is such that they probably will be considered as representing distinct species.

HOLOTYPE: ♂, mounted on slide, Cherangode, Nilgiri Hills, South India, 3,500 feet, October, 1950 (P. Susai Nathan). Paratopotypes, 2 ♂♂, 1 ♀, May 24, 1950 (Susai Nathan). Paratypes, ♂, on slide, Cinchona, Anamalai Hills, 3,500 feet, May, 1959; 2 ♂♂, 1 ♀, pinned, May 24, 1950 (Susai Nathan); 1 ♂, on slide, Kukkali, Palni Hills, about 6,500 feet, August 29–30, 1922 (S. W. Kemp); identified by Edwards as being *cyaneus*, received from him by exchange.

Gymnastes (*Gymnastes*) **latifuscus** n. sp.

Allied to *cyaneus*; general coloration polished black; wings whitened, with three broad dark brown bands, including the apex and an area at cord, third marking a broad V-shaped darkening in basal cells, the outer part crossing cells *R* and *M* to the origin of *Rs*; male hypopygium with outer arm of inner dististyle bidentate.

MALE: Length about 4 mm; wing 3.7 mm.

FEMALE: Length about 4.3–4.5 mm; wing 4.3–4.7 mm.

Rostrum and palpi black. Antennae with scape brown, pedicel brownish yellow, flagellum black; flagellar segments long-oval, exceeding the verticils, with a further short dense white pubescence. Head behind polished black, the broad anterior vertex vaguely gray.

Thorax polished black, dorsopleural region pale yellow. Halteres black, apex of knob pale yellow. Legs with coxae black; trochanters obscure yellow; femora yellow basally, the color obscured by darkened scales, with a broad black subterminal ring that is preceded by a narrow clear yellow annulus, the extreme tip again yellow; fore and middle tibiae and tarsi almost uniformly brownish black, posterior tibiae obscure yellow, tip broadly black, preceded by a somewhat clearer yellow ring; tarsi black, the proximal two-thirds of basitarsi pale yellow. All femora in male dilated at apex, the posterior pair more strongly so, tibiae with outer fourth slightly enlarged. Wings with the restricted ground white, disk with three broad dark brown bands, including the apex, a broader band at cord and a conspicuous V-shaped area basad of cord sending a broad arm across cells *R* and *M* to the origin of *Rs*; ground areas narrow, particularly the one beyond the cord which is parallel-sided and only about one-third as wide as the dark band at cord; prearcular field and cell *2nd A* except the extreme tip whitened; veins brown. Venation: R_3 simple, longer than R_{2+3+4}, subequal to R_{1+2}; *m-cu* about its own length beyond the fork of *M*.

Abdomen black, in female, the cerci orange. Male hypopygium with outer arm of inner dististyle conspicuously bidentate.

HOLOTYPE: ♂, Langkhe, Manipur, Assam, 5,000 feet, July 20, 1960 (Schmid). Allotype, ♀, Chattrik, Manipur, 1,500 feet, July 21, 1960 (Schmid). Paratopotypes, 2 ♀♀, pinned with type.

The most similar species is *Gymnastes* (*Gymnastes*) *cyaneus* (Edwards)

which has the darkened wing pattern more restricted, the coloration of the legs slightly different, and the dististyle of the male hypopygium simply bilobed, the outer arm not bidentate as in the present fly.

Gymnastes (*Gymnastes*) **tridens** n. sp.

Allied to *ornatipennis* and *cyaneus*; general coloration of head polished dark blue, mesonotum more greenish black; pleura polished black, variegated by yellow; wings whitened, with three major dark brown areas, including the broad apex and a more extensive band at cord; third darkened area V-shaped, subbasal in position, chiefly in cells *Cu* and *1st A*, sending a spur across centers of cells *R* and *M* to base of *Rs*; vein R_3 oblique, as in *ornatipennis*; male hypopygium with inner branch of inner dististyle conspicuously tridentate.

MALE: Length about 5–5.3 mm; wing 4.2–4.6 mm; antenna about 1.4–1.5 mm.

Rostrum and palpi black. Antennae with scape and pedicel brown, flagellum brownish black; flagellar segments decreasing in size outwardly, verticils very small. Head large, above polished dark blue.

Pronotum brownish black, lateral angles of scutellum and adjoining pretergites dull yellow. Mesonotal praescutum and scutum polished greenish black, posterior sclerites more blackened; a yellowed area on posterior dorsal part of pleurotergite. Pleura polished black, with a yellowed area on posterior sternopleurite above the meron; dorsopleural region and membrane above the coxae clear light yellow. Halteres brownish black, knob chiefly light yellow to whitish yellow. Legs with coxae black; trochanters yellowed; femora dilated on outer third, more accentuated on posterior pair, obscure yellow, the enlarged part brownish black, on posterior legs the tip narrowly yellowed and with more darkened rings at and before midlength, these produced by darkened scales; tibiae brownish yellow, tips darkened, on posterior legs more yellowed, the slightly dilated outer fourth black; tarsi brownish black, with almost the proximal half of the posterior pair clear yellow; legs with abundant flattened scales and blackened setae, the latter longer and more numerous near ends of segments. Wings whitened, conspicuously patterned with dark brown, including the broad tip and a complete band at cord; a proximal area near bases of cells *Cu* and *1st A* sends a spur cephalad across the central parts of cells *R* and *M* to the origin of *Rs*; veins obscure yellow, darker in the patterned areas. Venation: Sc_1 ending opposite origin of *Rs*; R_3 present, oblique, approaching to almost confluent with R_{1+2} at tip; R_2 faintly preserved in some specimens, atrophied in others, including the holotype, on posterior portion fused with base of R_3; cell *1st* M_2 long and narrow, exceeding M_4; *m-cu* more than its own length beyond the fork of *M*.

Abdomen, including hypopygium, dull brownish black. Male hypopygium with the dististyle complex, especially the inner branch which is heavily blackened, conspicuously tridentate, including a strong gently curved axial spine, a more basal slightly smaller recurved spine, and a still smaller marginal point between the two.

HOLOTYPE: ♂, Doi Sutep, Thailand, February 7, 1953 (Deed C. Thurman). Paratopotypes, 2 ♂♂, pinned with type.

Gymnastes (*Gymnastes*) **tridens** is quite distinct from the two most nearly related species, *G.* (*G.*) *cyaneus* (Edwards) and *G.* (*G.*) *ornatipennis* (de Meijere), having the venation more as in latter species but the wing pattern generally as in *cyaneus*, with the darkened V-shaped basal area as described. The conformation of the inner dististyle of the hypopygium distinguishes it from all other species.

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BOOK REVIEWS

The New Field Book of Freshwater Life. Elsie B. Klots. G. P. Putnam's Sons, New York, 1966; 398 pp., 4½″ × 7½″, illus.; $4.95.

This book should succeed worthily to the place in our affections long occupied by its predecessor, *The Field Book of Ponds and Streams* by Ann Haven Morgan (Putnam, 1930). Shorter by 50 pages, but a half inch longer and wider in page size, it contains more than twice as many illustrations (over 700) and information regarding many more kinds of plants and animals.

The general scheme of the book resembles the earlier work. There is an introductory chapter briefly describing various kinds of freshwater environment and certain of the limiting factors affecting their plant and animal inhabitants. A second chapter lists, defines, and classifies a number of ecological and other technical terms. The remaining 14 chapters deal successively with the various major groups, first the microörganisms including the Protista, then the bryophytes and higher plants, and finally (Chapters 6 to 16) the animals. The glossary has been omitted, but there is an adequate bibliography and an excellent index. An appendix includes brief suggestions about collecting equipment and about the care and preservation of specimens, and the text discussion of each group of organisms gives valuable hints and directions for the collector. The geographical coverage is for America north of Mexico.

The most noteworthy change is the inclusion of outline groupings intended for the ready determination of the commoner freshwater organisms to taxonomic orders and families, and, for some, to genera. These groupings are in some ways like binary keys, but without the strictly formal and artificial use of couplets. Most of the groupings seem simple and practical, and even the one for the orders of aquatic insects (pp. 176–179) is probably as little confusing as such a scheme can be. Only the use of the book in the field, by the amateur for whom it is mainly intended, will tell whether the grouping plan will do what its author expects of it. Conventional dichotomous keys to the genera of stonefly, mayfly, and odonate nymphs are given in the appendix.

The eight color plates, including photographs of various types of freshwater environment and both photographs and color drawings of characteristic occupants, appear as a group following Chapter Two. The drawings throughout are of the excellence for which the artist, SuZan Noguchi Swain, is well known. In a few instances the text references are not readily correlated with the figure labels, as on pages 237–239, where the text refers to families while the figure labels give only genera. Th type face is slightly larger than that used in Dr. Morgan's book, but there are six more lines to the page of text. The legibility is good, and one hopes that the paper will better resist the yellowing with age that affects the earlier volume.

No book as rich in detail as this one could be wholly free of errors, but the ones I have noticed are mostly trivial and of little consequence for most readers. Probably no one will be seriously misled by the term "pH concentration," by the references (p. 174) to "psychodid caterpillars," or by the substitution of "ventral" for "vertebrals" in the diagram of the turtle shells (Fig. 86), and I have often wondered why the type genus of the water mite family Hydryphantidae is spelled as it is instead of more plausibly "*Hydrophantes*" (and "Hydrophantidae") as on pages 167 and 166.

Mrs. Klots writes with warmth and clarity as well as with scrupulous competence. For little more than a penny a page, she and Mrs. Swain have given us a treasure. Their book well deserves the wide circulation and abundant praise that it is certain to receive.

A. E. Treat

Monograph of Cimicidae. Robert L. Usinger (with sections by Jacques Carayon, Norman T. Davis, Norihiro Ueshima and Harlley E. McKean). The Thomas Say Foundation, Entomological Society of America, **7**, xi + 585 pp., illus., 1966.

This extremely useful work represents a truly collective effort. The general and taxonomic sections written by Usinger, and which occupy the largest part of the work, are complemented by chapters by other authors. The most noteworthy contributions are those on "Traumatic insemination and the paragenital system" by J. Carayon, and "Cytology and cytogenetics" by N. Ueshima. The structure of the spermalege (composed mainly of what was known formerly as the "organ of Ribaga" and "organ of Berlese") and cytological data have been taken into account by Usinger for the construction of his system of the cimicids.

The family is now divided into six subfamilies arranged in 22 genera and 74 species. The Primiciminae, the most primitive subfamily is represented by two genera, both bat parasites: *Primicimex* in Texas and Guatemala, and the recently discovered Chilean *Bucimex*. The latter is somewhat transitional to the next subfamily. The Cimicinae which contains two parasites of man, *Cimex lectularius* and *Cimex hemipterus*, has holarctic, eastern Asian, and South American genera; they occur on bats and birds. There are five precinctive North American species of *Cimex*. The subfamily Cacodminae, with six genera, is restricted to the Old World tropics. The African *Leptocimex boueti* will attack man, but this species, like all others in the subfamily, is normally parasitic on bats. Afrocimicinae is a monotypical African subfamily. *Afroximex* occurs on bats in caves; the males are unique in having functional paragenital openings, viz. a distinctly developed spermalege, with frequent signs of copulation. The monotypical Latrocimicinae is found on fishing bats on Trinidad and in Brazil. The Haematosiphoninae is distributed over the Western hemisphere. Five of the seven genera are monotypic, and all are parasites of birds. *Ornithocoris pallidus* is found in Brazil and in the southeastern United States; the other North American genera are *Cimexopsis, Synxenoderus* and *Hesperocimex*.

The careful descriptions or redescriptions of all subfamilies, genera and species are accompanied by excellent line drawings, mostly by the late Gordon Floyd Ferris, and by Celeste Green. Keys are given not only for adults, but also for fifth and first instar nymphs, and even for the eggs of some species. Abundant data on morphology, biology, host relationship, and even linguistics, are complemented by an extensive bibliography.

This is not only a synopsis of an important group of parasites, but also a readable and at times fascinating book.

Pedro Wygodzinsky

A Case of Teratology in *Monopsyllus vison* (Baker)

Allen H. Benton[1]

Abstract: A female *Monopsyllus vison*, collected in Essex County, New York, had parts of three spermathecae, the three bulgae being fused at their bases. In addition, sternites VII and VIII were quite unlike the normal form.

Teratology in fleas has been the subject of numerous papers, especially those of Smit (1949a, 1949b, 1952, 1953) and Holland (1943, 1959). In male fleas, abnormalities usually take the form of partial or complete castration, and/or bizarre malformations of the sclerites. In females, abnormalities of the spermatheca are most frequently described, particularly the presence of two spermathecae in those species which normally possess only one. This phenomenon has been reported for at least eight species. In addition to the above cited papers, such specimens have been noted by Ewing and Fox (1943); Stark (1953); Sharma and Joshi (1961); Holland (1949); and Mead-Briggs (1964).

In a large collection of fleas from Whiteface Mountain, Essex County, New York, one female *Monopsyllus vison* presents a most unusual appearance. This specimen was taken from a red squirrel, *Tamiasciurus hudsonicus*, on August 27, 1962, by Charles Sloger.

The appearance of the terminalia is shown in Figure 1, contrasted with the appearance of a normal female of this species from the same locality shown in Figure 2. The spermatheca appears to be tripled, with the three bulgae connected at their bases. The small object lying dorsad to the spermathecae appears to be the third hilla, which may have become detached during clearing. It could conceivably be a section of the bursa copulatrix, but this structure is not usually evident in this species. Sternites VII and VIII are also totally unlike those of normal specimens of this species.

Records of specimens with two more or less complete spermathecae fused together are given by Holland (1943), Smit (1949a), and Mead-Briggs (1964). I have seen no records of a specimen with three fused spermathecae.

The research project during which this specimen was collected was supported by the Research Foundation of State University of New York and by the Atmospheric Sciences Research Center of State University of New York. I am grateful to Dr. G. P. Holland, Canada Department of Agriculture, Ottawa, who kindly read the manuscript, and Mrs. Sandra Vandenberg, Instructional Resources Center, State University College at Fredonia, who prepared the illustrations.

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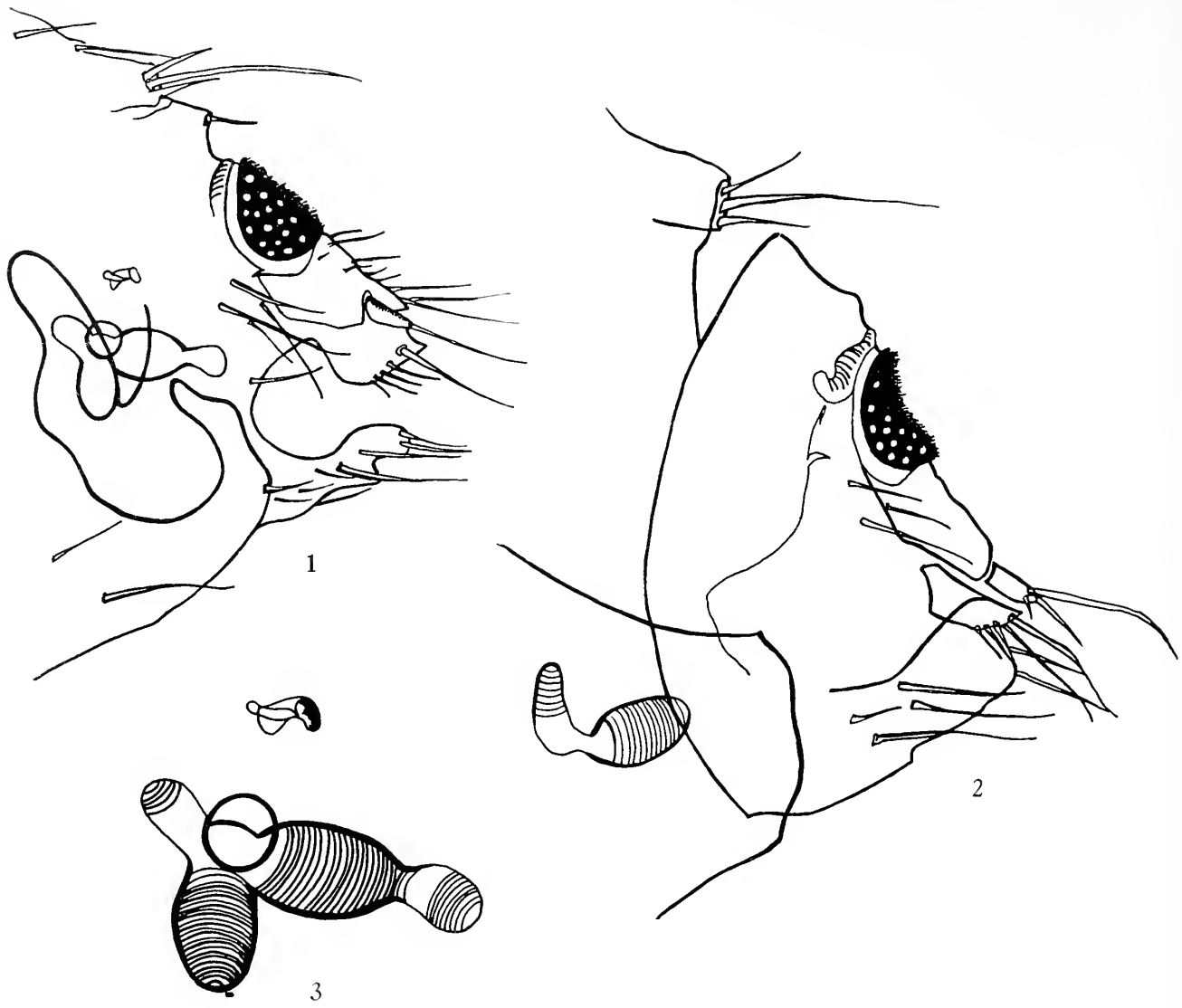

FIG. 1. Terminalia of female *Monopsyllus vison* (Baker) collected at Whiteface Mountain, Essex County, N. Y., August 27, 1962.

FIG. 2. Terminalia of normal female *Monopsyllus vison* (Baker) collected at Whiteface Mountain, Essex County, N. Y., August 30, 1962.

FIG. 3. Fused spermathecae of female shown in Fig. 1. Detached segment at top appears to be a disconnected hilla.

The specimen is in the collection of the Department of Biology, State University College at Fredonia.

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Some Apocryphal Species of the Tortricinae (Lepidoptera: Tortricidae)[1]

By the late Nicholas S. Obztarsov[2]

Abstract: Eleven species are transferred from the subfamily Tortricinae to other groups.

The following species have been erroneously assigned to the subfamily Tortricinae but prove to belong to the groups indicated below.

Subfamily Sparganothidinae

"Epagoge" schausiana Walsingham, 1913, Biologia Centrali-Americana, Lepidoptera Heterocera, **4**: 211.

"Epagoge" spadicea Walsingham, 1913, *op. cit.*, **4**: 212.

"Epagoge" vinolenta Walsingham, 1913, *op. cit.*, **4**: 212.

"Ctenopseustis" flavicirrata Walsingham, 1914, *op. cit.*, **4**: 253, pl. 7, fig. 27.

"Capua" lentiginosana Walsingham, 1879, Illustrations of typical specimens of Lepidoptera Heterocera, **4**: 22, pl. 65, fig. 5.

Subfamily Olethreutinae

"Sciaphila" indivisana Walker, 1864, List of the specimens of lepidopterous Insects, pt. 30, p. 985. This is a new synonym of *Zeiraphera diniana* (Guenée).

Family Phaloniidae

"Tortrix" baboquavariana Kearfott, 1907, Canadian Ent., **39**: 82.

"Tortrix" triplagata Walsingham, 1914, Biologia Centrali-Americana, Lepidoptera Heterocera, **4**: 282, pl. 8, fig. 22.

Cochylis fernaldana Walsingham, 1879, Illustrations of typical specimens of Lepidoptera Heterocera, **4**: 27, pl. 66, fig. 7. Placed erroneously by Meyrick (1912, p. 45) among *Cnephasia* species but does not belong to the Tortricidae.

"Tortrix" desmatana Walsingham, 1914, Biologia Centrali-Americana, Lepidoptera Heterocera, **4**: 288, pl. 8, fig. 28.

Unascertained systematic position

"Tortrix" biocellata Walsingham, 1914, *op. cit.*, **4**: 278, pl. 8, fig. 18.

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[1] This manuscript was prepared for publication by Dr. A. Diakonoff, Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands.

[2] Formerly Research Fellow, Department of Entomology, the American Museum of Natural History. The work for the present paper was done under the auspices of the National Science Foundation, Grant GB-1805.

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The Male Genitalia and Terminal Gastral Segments of Two Species of the Primitive Ant Genus *Myrmecia* (Hymenoptera: Formicidae)[1]

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Abstract: This is the first study of the complete male terminalia for members of the subfamily Myrmeciinae. Described and figured are the genitalic valves, terga IX and X, sterna VIII and IX for *M. tarsata* F. Smith and *M. vindex* F. Smith. The terminalia of these species conform to the usual formicid plan, but there are significant differences in each of the valves and in the terminal segments of these two species. The outer valves have a dorsal, median projection, which is not present in males of other subfamilies previously described. This projection is different for the two species. A sclerotized sliver, which is present on the anteroventral region of the median surface of the inner valves, varies in shape for each species. It has not been reported previously.

This is the first study of the complete male terminalia for members of the formicid subfamily Myrmeciinae; the genitalic valves, the ninth and tenth terga, the eighth sternum, and the ninth sternum are described and figured for *Myrmecia tarsata* F. Smith and *M. vindex* F. Smith. The only other known description of any of these segments is a diagram of the male genitalia of *M. pyriformis* by Emery (1911); however, at the time of his study this genus was included in the subfamily Ponerinae.

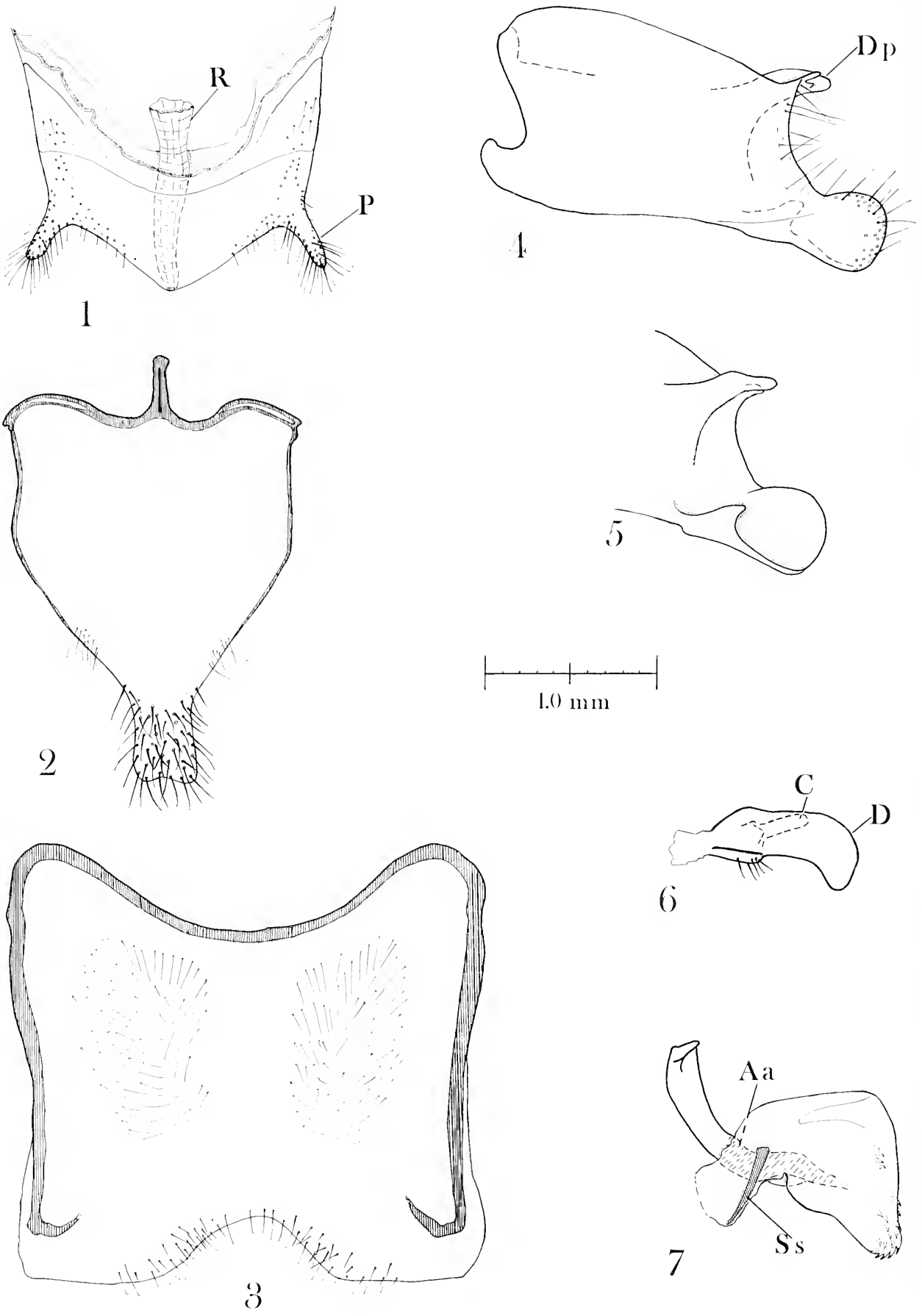
It has been suggested that a comprehensive study of the terminalia of the available males in this genus might aid in properly separating its species (Brown, 1953; Douglas and Brown, 1959). A beginning is made with this study, and the observations reported for *tarsata* and *vindex* could be the base line for such a survey. Descriptions and comparisons of the genitalic and terminal gastral segments of male ants are continually revealing differences in these structures, which will aid in the difficult taxonomy of these insects (Bernard, 1956; Borgmeier, 1950 and 1955; Krafchick, 1959; Forbes and Brassel, 1962).

The *M. tarsata* and *vindex* males were alcohol-preserved specimens furnished by Dr. Caryl P. Haskins of the Carnegie Institution of Washington, D.C. from nests maintained by him. The terminalia were removed from the specimens and dehydrated through 95 percent alcohol. The various segments and the genitalic valves were separated and mounted in diaphane. The drawings were made with the aid of a Bausch and Lomb trisimplex projection apparatus.

OBSERVATIONS

The genitalia of these two species of *Myrmecia* are composed of three pairs of valves, the outer, the middle, and the inner, which are surrounded anteriorly

[1] This study was supported, in part, by a Fordham University Faculty Fellowship granted to the author.



FIGS. 1–7. Terminal segments and male genitalic valves of *Myrmecia tarsata*. All illustrations drawn to the same scale. FIG. 1. Terga IX and X. FIG. 2. Sternum IX. FIG. 3. Sternum VIII. FIG. 4. Lateral view of outer valve. FIG. 5. Median view of posterior end

by the basal ring. This is the typical formicid arrangement. The genitalia are retracted into a genital cavity at the posterior end of the gaster. The roof of this cavity is the anal segment which bears the pygostyles, and it consists of the ninth and tenth terga. The eighth tergum, the last external, dorsal segment, completely covers this anal segment; only the pygostyles project beneath it. The floor of the cavity is the subgenital plate, the ninth sternum. The posterior end of the ninth sternum may extend beyond the posterior margin of the last external, ventral segment, the seventh sternum. The eighth sternum lies between the seventh and the ninth sterna; it covers the anterior end of the subgenital plate and, in turn, is completely covered by the seventh sternum.

In previous reports on male ant genitalia (Forbes, 1952; Forbes and Brassel, 1962; Forbes and Hagopian, 1965) the terminology used was that of Snodgrass in his 1941 paper. In his study and in the observations previously made on male ant genitalia, the outer genitalic valve is separated into the basal portion, the lamina parameralis, and the terminal portion, the paramere. Since in *Mymecia tarsata* and *M. vindex* the outer valves are not divided either completely or incompletely into the two regions, the single designation, paramere, is applied to this valve; this follows the 1957 revision of Snodgrass.

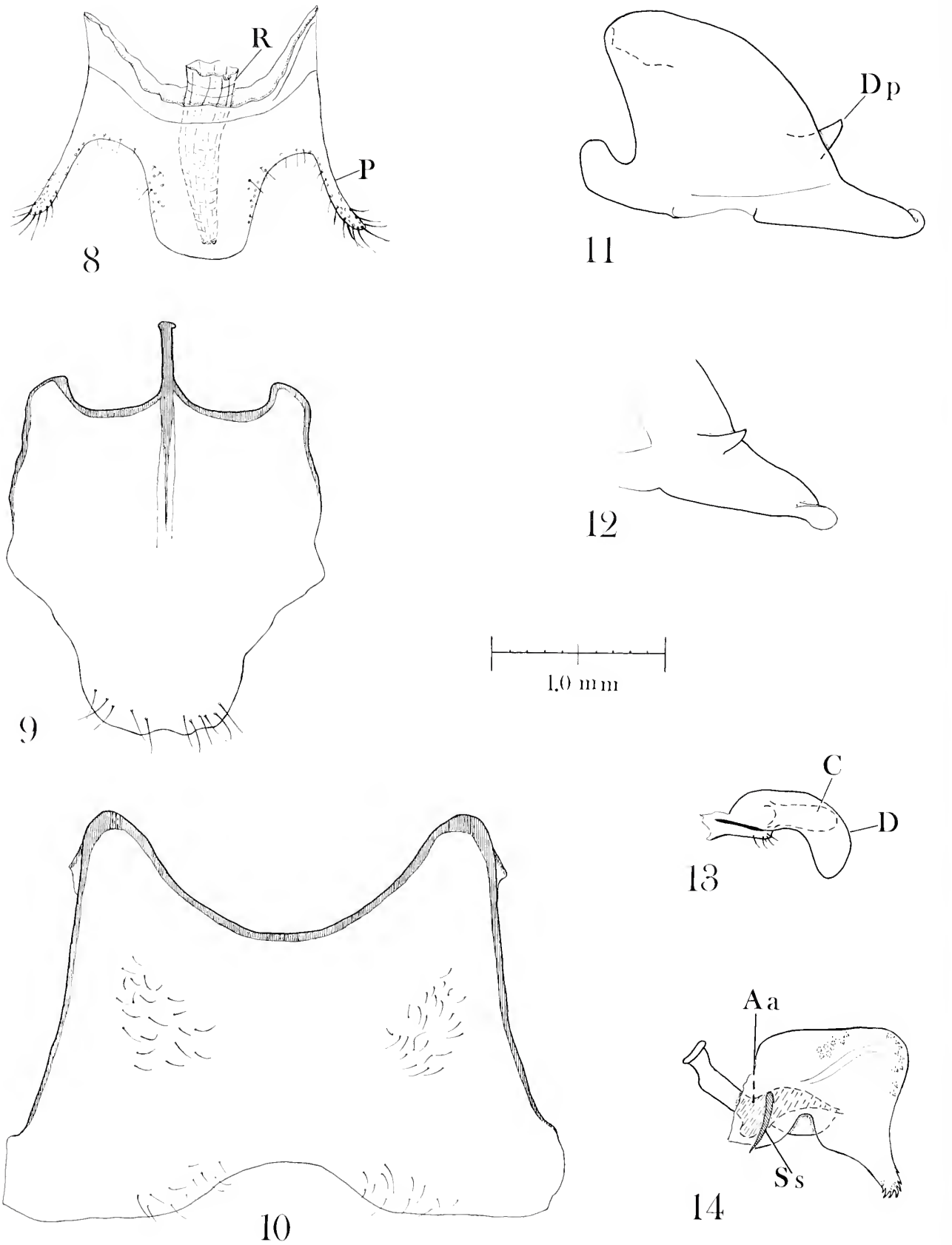
As the terminalia of these specimens were dissected from their surrounding segments and as the genitalic valves were separated from each other, it was noted that the intersegmental and connecting membranes were tough and resisted separation. Also, it was noted that the body wall muscle fibers which attach to these segments were large and strong. The tough membranes and strong body wall muscles suggest primitive characteristics as does the tough, hard integument of these ants.

Myrmecia tarsata

Ninth and Tenth Terga (Fig. 1). This dorsal, terminal segment bears the pygostyles, which are of moderate length. Its posterior margin is indented mediad of the pygostyles. The segment is weakly sclerotized throughout. The pygostyles are slightly more sclerotized than the rest of the segment. The boundaries of the lateral sclerites of the ninth tergum and of the anterior margin of the tenth tergum are indistinctly marked. There are sensory hairs on the pygostyles, and sensory pits are distributed along the lateral regions of the segment; some of these pits have small hairs.

←

of outer valve. Fig. 6. Median view of middle valve. Fig. 7. Median view of inner valve. Abbreviations: Aa, aedeagal apodeme; C, cuspis volsellaris; D, digitus volsellaris; Dp, dorsal median projection of outer valve; P, pygostyle; R, rectum; Ss, sclerotized sliver.



FIGS. 8–14. Terminal segments and male genitalic valves of *Myrmecia vindex*. All illustrations drawn to the same scale. FIG. 8. Terga IX and X. FIG. 9. Sternum IX. FIG. 10. Sternum VIII. FIG. 11. Lateral view of outer valve. FIG. 12. Median view of posterior end of outer valve. FIG. 13. Median view of middle valve. FIG. 14. Median view of inner valve.

Eighth Sternum (Fig. 3). This segment is roughly square in shape; it is a little wider than long, and its anterior and posterior margins are slightly indented. It is moderately sclerotized throughout with a more strongly sclerotized border along its anterior and lateral margins. The posterior margin is the least sclerotized, and the mid-lateral areas show a slightly darker pigmentation. There are patches of fine hairs on either side of the mid-line and along the posterior margin.

Ninth Sternum (Fig. 2). This triangular or shield-shaped subgenital plate has a bluntly pointed apex that is deflected ventrally. The segment is moderately sclerotized with more strongly sclerotized anterior and anterolateral margins; the slender, cranial apodeme is strongly sclerotized. Short hairs may be present on the posterior third, and larger sensory hairs are around the apex.

Basal Ring or Lamina Annularis. This is a broad, prominent, ring-shaped segment, which is moderately sclerotized throughout. Its dorsal, anterior margin is broadly indented, while its posterior margin is slightly indented at the mid-region. On the ventral surface, the mid-posterior indentation is deeper than the mid-anterior indentation.

Outer Valves or Parameres (Figs. 4 and 5). These valves are large and laterally convex. They almost encompass the middle and the inner valves. The ventral, posterior end of each valve is spoon-shaped with its lateral wall higher than the median wall. On the median wall there is a tooth-like projection. Also, on this valve there is a dorsal, median projection, which is blunt in shape and dorsoventrally flattened. The outer valve is moderately sclerotized. However, its posterior region including the dorsal, median projection is more strongly sclerotized than the rest of the valve. There are numerous, sensory pits on the posterior region, and long sensory hairs are attached to some of these pits.

Middle Valves or Volsellares (Fig. 6). These are the smallest and the most strongly sclerotized valves of the three pairs. In arrangement and shape, they are generally similar to reported descriptions for many ants. The anterior or basal portion of each middle valve, the lamina volsellaris, is attached to the ventral, median region of the outer valve, the paramere. A few sensory hairs are found at the ventral, posterior end of the lamina volsellaris. The lateral lobe, the cuspis volsellaris, is finger-shaped and short, but the median lobe, the digitus volsellaris, is broad, flat, and distally hooked. Numerous, small sensory pegs, the sensilla basiconica, are distributed over the dorsolateral area of the digitus and on the apposing surface of the tip of the cuspis.

Inner Valves or Laminae Aedeagales (Fig. 7). These are laterally compressed, moderately sclerotized valves, which are united dorsally by a less sclerotized membrane, the spatha. The ventral, posterior end of each valve projects downward and is toothed; sharp, tooth-like spines are situated on its

lateral face, and a few spines are located on the lateral, mid-posterior region. The anterodorsal extension of the aedeagal apodeme is a fairly thick rod. The median surface of the valve is quite smooth except for a low ridge along its dorsal, posterior region, and a flat, wedge-shaped, sclerotized sliver on the anterior region. The inner surface of the free, ventral margin is notched behind the sclerotized sliver.

Myrmecia vindex

Ninth and Tenth Terga (Fig. 8). This dorsal, terminal segment has long, slender pygostyles. Its posterior margin is deeply indented mediad of the pygostyles. The pygostyles are somewhat more sclerotized than the rest of the segment, which is weakly sclerotized. The boundaries of the lateral sclerites of the ninth tergum and the anterior margin of the tenth tergum are indistinct. Sensory hairs are located on the ends of the pygostyles and along the margins of the indentations.

Eighth Sternum (Fig. 10). This segment is trapezoid-shaped; it is wider at its posterior margin than at its anterior margin. The anterior margin is broadly indented, while the posterior margin has a small indentation in the mid-region. The segment is moderately sclerotized. However, the posterior margin is weakly sclerotized, and the anterior and lateral margins are more strongly sclerotized than the remainder of the segment. Some short hairs are located on the lateral regions and along the posterior margin on either side of the indentation.

Ninth Sternum (Fig. 9). The subgenital plate is shield-shaped with a rounded, posterior margin on which are a few moderately long sensory hairs. The long, slender cranial apodeme is flanked by less extended, lateral apodemes. The segment is moderately sclerotized; the anterior and the anterolateral margins are more strongly sclerotized. The posterior region is darker in color than the central region.

Basal Ring or Lamina Annularis. In general shape, arrangement, and sclerotization this segment in *vindex* conforms to the descriptions for *tarsata*. While in *tarsata* the basal ring is uniform in width from front to back, in *vindex* the anterior diameter is a little smaller than the posterior diameter so that this segment tapers anteriorly.

Outer Valves or Parameres (Figs. 11 and 12). These are large, laterally convex valves, which almost enclose the middle and the inner valves. The dorsal surface of each valve curves ventrally and continues to the posterior end, which is a blunt hook that is turned medially. There are slight variations in the length and downward tilt of this posterior hook. The dorsal, median projection of this valve arises just below the middle of the valve, and it is short and sharply pointed. Some slight variations have been noted in the position and in the tilt

of this dorsal projection. The outer valves are moderately sclerotized, and the posterior end is slightly more sclerotized. There are only a few, long sensory hairs on the posterior margin of this valve.

Middle Valves or Volsellares (Fig. 13). These valves are the smallest and the most strongly sclerotized in this species. The lamina volsellaris of each middle valve is attached to the ventral, median region of the outer valve. A few, small sensory hairs are located on the ventral, posterior end of the lamina volsellaris. The digitus volsellaris is board and sharply hooked. The cuspis volsellaris is a relatively broad, finger-shaped lobe. Almost the entire lateral surface of the digitus is covered with sensilla basiconica, while the cuspis has these sensilla only on the distal end of its median surface.

Inner Valves or Laminae Aedeagales (Fig. 14). These laterally compressed and moderately sclerotized valves are united dorsally by the less sclerotized spatha. The ventral, posterior end of each valve is narrow and serrated and projects downward. A few, sharply pointed spines are found on its lateral surface. Scattered spines are also found on the lateral surface of the valve in the posterior region, and a small cluster of spines projects from the middle, dorsal area. The anterior extension of the aedeagal apodeme is a rod of moderate size. The median surface of the valve is quite smooth except for a low ridge along the dorsal, posterior region. The sclerotized sliver on the median, anteroventral region is small and slightly bent. The inner face of the free, ventral margin is indented behind the sclerotized sliver.

DISCUSSION

The terminalia of *Myrmecia tarsata* and *vindex* conform to the usual formicid plan, but significant differences are described and figured for each of the genitalic valves and for the terminal, gastral segments in these two species.

The outer valves of members of this genus have a dorsal, median projection, which has not been reported for other ants. Emery's diagram (1911) of the undissected genitalia of *Myrmecia pyriformis* shows this to be a sharp, finger-like projection. The descriptions of the *Myrmecia* male in Emery's study and also in the revisionary study of the subfamily Myrmeciinae by Clark (1951) state that a median, dorsal, styliform appendage is present on the outer valve. A dorsal projection is present on the outer valves of *tarsata* and *vindex*, but it is not styliform; the shape varies with the species.

Emery's diagram of the ventral view of the outer valve shows a separation between the posterior and the anterior or basal portion of this valve. In this paper the entire outer valve is called the paramere since no such separation is seen in the outer valves of either *tarsata* or *vindex*.

The sclerotized sliver situated on the anterior region of the median surface of the inner valve has not been previously reported in studies of male ant genitalia. Its shape is different in both *tarsata* and *vindex*.

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The Adaptive Feeding Habit of a Pine Caterpillar

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Abstract: The characteristic feeding habit and position of mature larvae of *Panthea furcilla* (Packard) (Lepidoptera, Noctuidae) on *Pinus strobus* is described and illustrated.

The larvae of *Panthea furcilla* (Packard) (Lepidoptera, Noctuidae) in Connecticut appear to feed chiefly on the white pine (*Pinus strobus*) although it is possible that they feed on other available pines or on larch (*Larix*). The needles of white pine are, however, very long and extremely thin and flexible. If a last instar larva were to crawl out on a single needle its weight would make the needle droop so that the larva would dangle very insecurely. Each needle is, moreover, too long for a larva holding on to a twig with its anal prolegs to be able to reach the tip, the most efficient point at which to begin feeding.

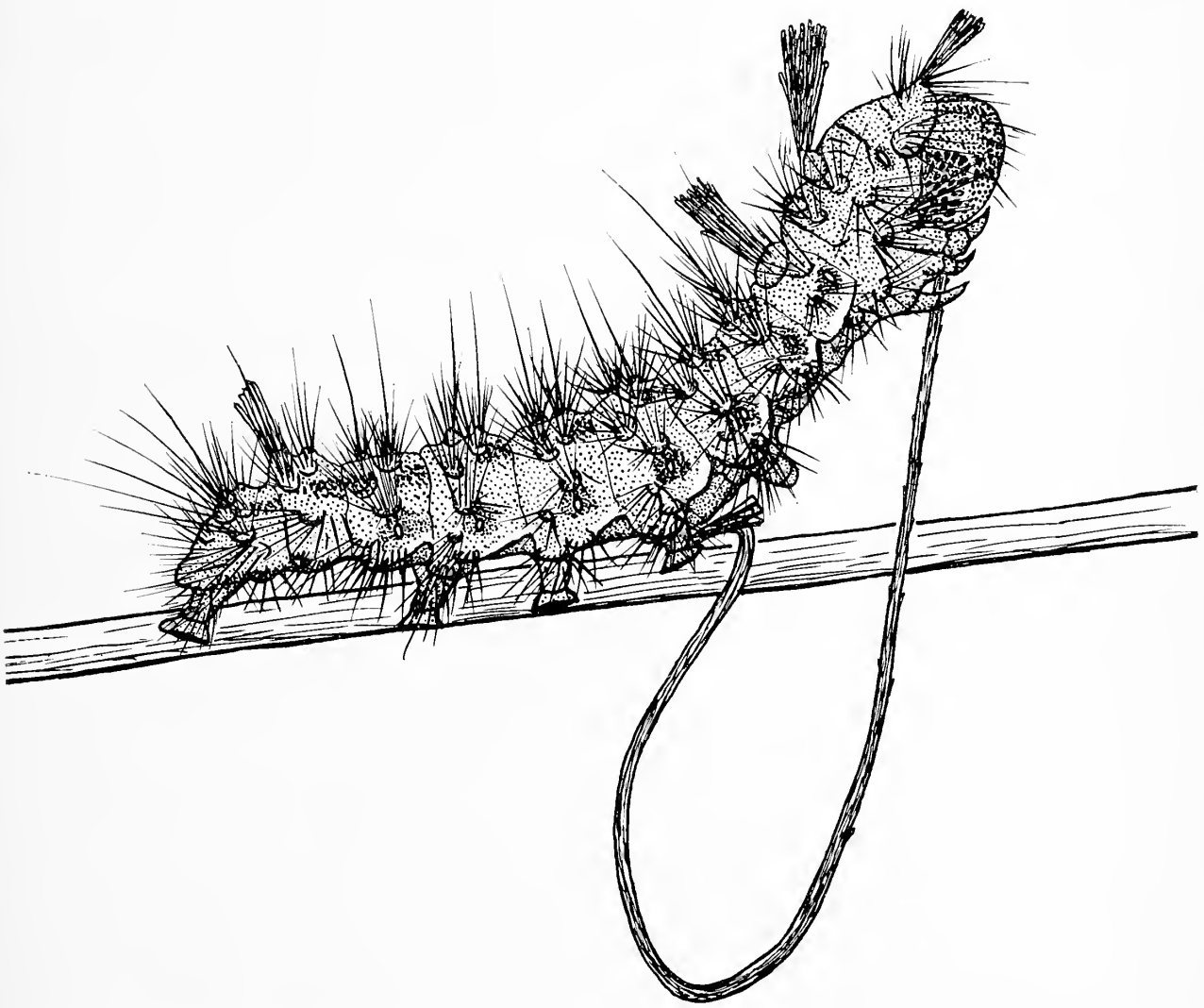

Fig. 1. Larva, *Panthea furcilla* (Packard) in last instar, in typical feeding position on *Pinus strobus*. From a photograph of a specimen from Putnam, Windham Co., Conn.

These factors create a situation in which a normally feeding larva would be faced with the alternatives of physical insecurity or inefficient feeding.

The older, heavier larvae of *furcilla* feed as follows. First, the posterior prolegs take and keep a secure hold on a twig or the firm base of a bundle of needles. Next, the thoracic legs grasp a single needle and "walk" along it, passing it to the rear. As a result the needle, forced backward and down, is bent into a long bow beneath the larva (Fig. 1). When the entire needle is thus bent down the larva begins eating the tip. A slight relaxation of the thoracic legs permits the spring of the needle to force it forward as its tip is eaten away. The larva continues eating until the whole needle has been consumed, backing up a little along the twig to finish the most basal part. Thus, all of the needle is eaten cleanly without the larva having to relinquish its secure posterior hold.

The young larvae of *furcilla* and the small larvae of other pine feeding species (e.g., *Semiothisa*, Geometridae) do not have this problem, since a single needle is rigid enough to support their weight. It would be interesting to know how the heavy larvae of such a species as the pine sphinx, *Lapara*, manage on white pine. It would, furthermore, be very worthwhile to know what is done by other species of *Panthea* that feed on pines with shorter, stiff needles, such as *Pinus resinosa*, *banksiana* and *rigida*; for it would be of considerable phyletic interest if it could be shown that the adaptive feeding habit here described is limited to the white pine feeding *P. furcilla*.

RECEIVED FOR PUBLICATION FEBRUARY 20, 1967

Distribution of Nitrogen During the Embryonic Development of the Mealworm, *Tenebrio molitor* Linnaeus[1]

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Abstract: During embryogenesis of the mealworm, total nitrogen remains constant at 1.27 mg./100 eggs. Approximately 24% of the total was converted from water soluble to water insoluble material. The utilization of albumin accounted for almost 50% of this material. An increase in globulin accounted for 25% of the change in water insoluble protein, while synthesis of scleroprotein accounted for 30%. The remaining materials were not defined by the procedures employed.

The period of embryogenesis involves extensive changes in nitrogenous compounds. Protein metabolism is important because it is involved in the formation of structural elements and enzyme systems. Nitrogenous compounds may also be used for energy metabolism (Needham 1931, 1942).

Farkas (1903) working on the silkworm, *Bombyx mori*; Horowitz (1939), on the gephyrean worm, *Urechis caupo*; Trowbridge and Bodine (1940), on the grasshopper, *Melanoplus differentialis*; and Rothstein (1952), on the Japanese beetle, *Popillia japonica*, found no measureable change in total nitrogen content during embryogenesis. This consistency indicates that proteins of the insect embryo are constructed from nitrogenous substances present in the egg at the beginning of development. During the embryonic period, proteins may be formed by synthesis from low molecular weight precursors or by the transformation of egg protein. This transformation may be direct or involve the catabolism of egg proteins.

Several investigators have fractionated the nitrogenous compounds at various stages of development to study transformations occurring during the developmental period. These studies have yielded a small number of chemically ill-defined fractions. Pigorini (1925) worked on changes in the distribution of nitrogen at several stages of embryogenesis in the silkworm, *B. mori*. His results showed that the albumin and mucoprotein fractions decreased sharply during the last seven days of embryogenesis. These changes were complementary to an increase in the globulin fraction occurring during the same period. Horowitz (1939) described the changes in protein, peptide, non-protein, and amino nitrogen during the development of the egg of *U. caupo*. He reported a 6.4% increase in protein nitrogen due to shifts of material from the amino and peptide fractions.

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[1] Dissertation submitted by the senior author in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Biology at Fordham University.

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He explained this very slight increase by assuming that there is a continuous breakdown of yolk proteins followed by resynthesis into the proteins of the embryo. Ludwig and Rothstein (1952) noted that these changes might have been greater if trichloroacetic acid (TCA) had not been used as a killing agent prior to extraction. They studied the distribution of nitrogen during the embryonic development of the Japanese beetle, *P. japonica*. Approximately 80% of the total nitrogen of the newly laid egg was contained in the water soluble compounds precipitated by tungstic acid. Most of this material was incorporated into insoluble protein as development progressed. In their procedure, the egg was extracted with an alcohol-ether solution followed by boiling water previous to the separation of the tungstic acid precipitate. DelVecchio (1955) demonstrated that this treatment can cause a shift of material into the insoluble fraction. This apparently did not occur in the Japanese beetle egg.

Differences in various procedures do not allow for a clear comparison of results. For this reason the following study of the nitrogenous composition of the mealworm, *Tenebrio molitor*, was initiated. It includes frationations of the egg on each day of development by three different procedures and allows for a more meaningful interpretation of earlier work.

MATERIALS AND METHODS

Newly emerged adults were collected from stock cultures maintained at 25°C. on chick growing mash. The beetles were placed in bowls containing white flour and maintained at 25°C. A bottle of water plugged with moist cotton was placed in each culture. Eggs were collected by sifting the flour at 24-hour intervals from cultures of approximately 1 to 4 weeks of age. They were transferred to a humidifier containing a saturated solution of NaCl (relative humidity 76%) and incubated at 25°C. At the desired stage of development, 100 eggs were removed, placed in a 15 ml. calibrated centrifuge tube, crushed with a glass rod, and immediately vacuum desiccated. They were stored under vacuum desiccation and tested within the following 24-hour period. All measurements were made on samples of 100 individuals at the following stages of development; newly laid, one, two, three, four, five, six, seven day eggs, and newly emerged larvae plus chorions (day 8).

Three fractionation procedures were employed. In all cases, the samples were removed from the vacuum desiccator and powdered with a glass rod previous to subsequent fractionation. The nitrogen content of each fraction was determined by the semimacro-Kjeldahl procedure described by Niederl and Niederl (1938) as modified by Wagner (1940). All fractionation procedures were performed at room temperature.

Using the method of Ludwig and Rothstein (1952), the nitrogenous compounds were divided into four fractions: lipid nitrogen (Fraction A); water

soluble nitrogen not precipitated by TCA (Fraction B); water soluble nitrogen precipitated by TCA (Fraction C); and insoluble nitrogen (Fraction D).

The material was also fractionated by the method of DelVecchio (1955). This procedure is similar to the above, however, the order of fractionation is changed with the removal of water soluble materials preceding the lipid extraction. Furthermore, water at 25°C. was employed in place of boiling water for the aqueous extraction. Four fractions corresponding to the fractions of Ludwig and Rothstein were obtained by this procedure.

A seven fraction technique was developed as an extension of the method of DelVecchio. The water soluble material precipitated by TCA (DelVecchio Fraction C) was separated into two fractions on the basis of heat coagulation. The water insoluble material (DelVecchio Fractions A and D) was divided into four fractions. In this procedure, 8 ml. of distilled water were added to a 15 ml. centrifuge tube containing the powdered sample and the material was suspended by stirring with a glass rod. The suspension was allowed to stand, with frequent stirring, for ten minutes, centrifuged, and the supernate decanted into another 15 ml. centrifuge tube. This extraction was repeated and the supernate decanted into a third 15 ml. centrifuge tube. The two tubes containing the water extract were placed in a boiling water-bath for 30 minutes, centrifuged, and the supernates transferred into two 15 ml. centrifuge tubes. The precipitates were transferred quantitatively to a digestion flask and the nitrogen content determined as Fraction A (water soluble nitrogen precipitated by boiling). Five ml. of 30% TCA were added to each tube containing the supernates obtained after heat coagulation of the water extracts. The contents of the tubes were stirred and allowed to stand for 30 minutes, centrifuged, and the supernates decanted into a 100 ml. digestion flask. The residues were washed with several ml. of 30% TCA, centrifuged, and the supernates added to that already present in the digestion flask. The nitrogen content was then determined as Fraction B (water soluble nitrogen not precipitated by boiling or by TCA). The TCA precipitates were transferred quantitatively to a digestion flask and the nitrogen content determined as Fraction C (water soluble nitrogen precipitated by TCA).

Ten ml. of a 10% NaCl solution were added to the residue remaining after the water extraction. The suspension was allowed to stand, with frequent stirring, for 10 minutes, centrifuged, and the supernate decanted into a 100 ml. digestion flask. This extraction was repeated and the supernate added to that already present in the flask. The nitrogen content of this fraction was determined as Fraction D (water insoluble nitrogen extracted with 10% NaCl). Ten ml. of a 0.1N NaOH solution were then added to the residue remaining after the salt extraction. The suspension was allowed to stand, with frequent stirring, for 10 minutes, centrifuged, and the supernate decanted into a 100 ml. digestion flask. The residue was resuspended in 10 ml. of 0.1N HCl and allowed to stand

TABLE 1. Distribution of nitrogen during the embryogenesis of mealworm (technique of Ludwig and Rothstein). Figures, expressed as per cent total nitrogen, are given with standard errors.

Age	No. of trials	Fraction A	Fraction B	Fraction C	Fraction D
Newly laid eggs	10	8.6 ± 0.146	7.0 ± 0.122	7.4 ± 0.203	77.0 ± 0.142
1 day	8	8.4 ± 0.141	6.7 ± 0.208	7.0 ± 0.106	77.9 ± 0.356
2 day	8	7.8 ± 0.303	6.7 ± 0.208	6.8 ± 0.124	78.7 ± 0.153
3 day	8	7.0 ± 0.191	6.4 ± 0.207	6.6 ± 0.166	80.0 ± 0.241
4 day	8	7.0 ± 0.148	6.8 ± 0.106	5.7 ± 0.140	80.5 ± 0.291
5 day	8	7.1 ± 0.153	6.5 ± 0.202	5.7 ± 0.166	80.7 ± 0.280
6 day	8	6.7 ± 0.131	6.7 ± 0.138	5.8 ± 0.146	80.8 ± 0.134
7 day	8	6.7 ± 0.161	6.3 ± 0.115	6.0 ± 0.113	81.0 ± 0.197
Newly hatched larvae + chorions (Day 8)	8	6.8 ± 0.181	5.7 ± 0.122	5.7 ± 0.130	81.8 ± 0.238

for 10 minutes, centrifuged, and the supernate added to that already present in the digestion flask. The nitrogen content of this fraction was determined as Fraction E (water insoluble nitrogen extracted with 0.1N NaOH or 0.1N HCl). A solution consisting of 1 ml. distilled water, 4.5 ml. absolute ethanol, and 4.5 ml. absolute ethyl ether was mixed with the residue remaining after the base-acid extraction and allowed to stand, with frequent stirring, for 30 minutes, centrifuged, and the supernate decanted into a 100 ml. digestion flask. The residue was suspended in another 10 ml. of alcohol-ether solution, centrifuged, and the supernate added to that already present in the digestion flask. The ether and most of the alcohol were evaporated, 25 ml. of distilled water added, and the nitrogen content determined as Fraction F (water insoluble nitrogen extracted with lipid solvents). The residue remaining after removal of the alcohol-ether extraction was transferred quantitatively to a digestion flask and its nitrogen content determined as Fraction G (insoluble nitrogen).

OBSERVATIONS

The nitrogen content per 100 eggs remained constant at 1.27 mg. during the seven days of development. There was a decrease to 1.10 mg. at hatching, associated with the loss of chorion.

The nitrogen content for the fractions obtained by the technique of Ludwig and Rothstein are given in Table 1. Each fraction is expressed as per cent total nitrogen. Fraction A (lipid nitrogen) decreased from 8.6 to 6.8% through the embryonic period with significant (95% level of confidence) decreases on the third and sixth day. Fraction B (water soluble nitrogen precipitated by TCA) remained relatively constant at approximately 6.8% during the first 6 days with significant decreases to 6.3 during the seventh and to 5.7% on the eighth

Table 2. Distribution of nitrogen during the embryogenesis of the mealworm (technique of DelVecchio). Figures, expressed as per cent total nitrogen, are given with standard errors.

Age	No. of trials	Fraction A	Fraction B	Fraction C	Fraction D
Newly laid eggs	5	3.4 ± 0.109	15.2 ± 0.208	65.1 ± 0.175	16.3 ± 0.183
1 day	3	3.4 ± 0.100	15.8 ± 0.329	60.9 ± 0.674	19.9 ± 0.177
2 day	4	3.5 ± 0.244	16.9 ± 0.274	56.2 ± 0.497	23.4 ± 0.270
3 day	5	3.5 ± 0.479	16.9 ± 0.625	49.2 ± 0.494	30.4 ± 0.455
4 day	3	3.2 ± 0.279	17.0 ± 0.229	48.1 ± 0.218	31.7 ± 0.278
5 day	4	3.4 ± 0.189	16.5 ± 0.075	44.0 ± 0.047	36.1 ± 0.084
6 day	3	3.2 ± 0.178	16.2 ± 0.328	43.0 ± 0.336	37.6 ± 0.123
7 day	3	3.4 ± 0.250	16.2 ± 0.556	40.5 ± 0.379	39.9 ± 0.500
Newly hatched larvae + chorions (Day 8)	3	3.5 ± 0.358	16.9 ± 0.201	39.6 + 1.151	40.0 ± 1.404

day. Fraction C (water soluble nitrogen precipitated by TCA) decreased from 7.4 to 5.7% with a significant decrease on the fourth day. Fraction D (insoluble nitrogen) showed significant changes during the first three days of development, increasing from 77.0 to 80.0%. This fraction was relatively constant from the fourth to the seventh day, and on the eighth day, it increased significantly from 81.0 to 81.8%. This is the only fraction to show a net increase over the entire embryonic period. The 4.8% increase is primarily due to shifts of material from fractions A and C. The major changes occurred during the first three days of development.

The nitrogen content, expressed as per cent total nitrogen, for the fractions determined by the procedure of DelVecchio are given in Table 2. Fraction A (lipid nitrogen), which makes up approximately 3.4%, and Fraction B (water soluble nitrogen not precipitated by TCA), which makes up approximately 16% of the total, show no significant changes during development. Fraction C (water soluble nitrogen precipitated by TCA) decreased from 65.1 to 39.6% with significant decreases on all but the fourth and eighth days. Fraction D (insoluble nitrogen) increased from 16.3 to 40.0% with significant increases on all but the fourth and eighth days. The increases in Fraction D are due entirely to shifts of material from Fraction C.

The results obtained with the seven fraction technique, expressed as per cent total nitrogen, are given in Table 3. Fraction A (water soluble nitrogen precipitated by boiling) decreased during the entire period of development. Significant decreases were found on the first, third, fourth, sixth and seventh days. Fraction B (water soluble nitrogen not precipitated by boiling or by TCA) increased slightly, but significantly during the first two days, and was relatively constant for the remainder of the developmental period. Fraction C (water soluble nitrogen precipitated by TCA) showed significant decreases on the second, third,

TABLE 3. Distribution of nitrogen during the embryogenesis of the mealworm (seven fraction technique). Figures, expressed as per cent total nitrogen, are given with standard errors.

Age	No. of trials	Fraction A	Fraction B	Fraction C	Total water soluble nitrogen
Newly laid eggs	8	12.7 ± 0.167	14.6 ± 0.209	52.7 ± 0.472	80.0
1 day	8	8.6 ± 0.379	15.5 ± 0.121	52.8 ± 0.718	76.9
2 day	8	7.9 ± 0.056	16.0 ± 0.151	47.7 ± 0.321	71.6
3 day	8	6.0 ± 0.140	16.0 ± 0.176	41.9 ± 0.147	63.9
4 day	8	5.1 ± 0.202	15.6 ± 0.174	41.5 ± 0.234	62.2
5 day	8	4.6 ± 0.310	15.6 ± 0.286	40.4 ± 0.544	60.6
6 day	8	3.1 ± 0.147	15.7 ± 0.131	39.9 ± 0.382	58.7
7 day	8	2.2 ± 0.096	15.7 ± 0.236	38.5 ± 0.229	56.4
Newly hatched larvae + chorions (Day 8)	8	2.1 ± 0.088	15.9 ± 0.063	37.8 ± 0.156	55.8

Age	Fraction D	Fraction E	Fraction F	Fraction G	Total water insoluble nitrogen
Newly laid eggs	7.5 ± 0.118	7.7 ± 0.258	1.9 ± 0.113	2.9 ± 0.148	20.0
1 day	8.1 ± 0.220	9.9 ± 0.172	1.8 ± 0.101	3.3 ± 0.147	23.1
2 day	9.0 ± 0.110	13.1 ± 0.248	1.8 ± 0.058	4.5 ± 0.157	28.4
3 day	10.3 ± 0.189	16.5 ± 0.099	2.2 ± 0.070	7.1 ± 0.111	36.1
4 day	10.0 ± 0.110	17.5 ± 0.246	1.9 ± 0.048	8.4 ± 0.056	37.8
5 day	11.0 ± 0.383	18.1 ± 0.240	1.8 ± 0.181	8.5 ± 0.216	39.4
6 day	12.7 ± 0.318	18.3 ± 0.457	1.8 ± 0.112	8.5 ± 0.481	41.3
7 day	13.6 ± 0.190	18.8 ± 0.190	1.7 ± 0.031	9.5 ± 0.101	43.6
Newly hatched larvae + chorions (Day 8)	14.1 ± 1.240	18.4 ± 0.118	1.9 ± 0.045	9.8 ± 0.120	44.2

seventh and eighth days. The largest decrease occurred during the second and third days. The sum of the water soluble fractions (A, B and C) decreased from 80.0 for newly laid eggs to 55.8% on day 8. During the same period, Fraction D (water insoluble nitrogen extracted with 10% NaCl) increased from 7.5 to 14.1% with significant increases on all but the fourth day. Fraction E (water insoluble nitrogen extracted with 0.1N NaOH and 0.1N HCl) increased significantly during each of the first four days and remained relatively constant during the last four days. The major increase in this fraction occurred during the first three days when it increased from 7.7 to 16.5%. Fraction F (water insoluble nitrogen extracted with lipid solvents) remained constant at a level of approximately 1.9% throughout the embryonic period. Fraction G (insoluble nitrogen) increased from 2.9 to 9.8% with significant increases on all but the fifth day, while the total water insoluble nitrogen (sum of D, E, F and G) increased from 20.0 to 44.2%. The major shifts are from fractions A and C into fractions D, E, and G. They occur primarily during the first three days.

DISCUSSION

The consistency of the total nitrogen values reported in this paper is in agreement with work done on other insects (Farkas 1903, on *B. mori*; Trowbridge and Bodine 1940, on *M. differentialis*; Rothstein 1952, on *P. japonica*).

A comparison of the results obtained in the present work on the egg of *T. molitor* using the technique of Ludwig and Rothstein with the results of these authors on the egg of *P. japonica* indicates essential differences in nitrogenous composition. Ludwig and Rothstein observed large shifts in nitrogen during development. Water soluble nitrogen precipitated by protein precipitating agents (Fraction C) was found to decrease from 81.4% of the total in newly laid eggs to 10.0% just before hatching. The insoluble nitrogen (Fraction D) increased from 12.9 to 71.8% during the same period. Fraction C may contain certain mucoids and intermediate products of protein hydrolysis, the latter are best described as relatively low molecular weight polypeptides. In the present study, only slight changes are shown in these fractions indicating, that in the mealworm, the nitrogenous substances in the egg are of a more complex nature. With the method of Ludwig and Rothstein this material is denatured during the fractionation procedure, thereby obscuring changes in protein composition that might otherwise be noted.

Employing the technique of DelVecchio (1955), water soluble proteins of a more complex nature, such as albumins, are included in the water soluble extract, and since these substances are precipitated by TCA, they are included in fraction C. The differences in the sizes of fraction C obtained by the two procedures clearly indicates that a large portion of the stored nitrogen in the egg of the mealworm is in the form of relatively complex water soluble protein. Pigorini (1925), in his work on the silkworm, *B. mori*, found that albumins comprised approximately 40% of the nitrogenous reserve of the egg. Needham's (1931) review of embryonic nutrition indicates that albumins serve as one of the primary nitrogenous reserves throughout the animal kindom. It appears that the apparent absence of large quantities of albumin, and other heat or alcohol-ether denatured proteins, in the egg of the Japanese beetle represents a rather atypical case.

The seven fraction technique introduced in this paper gives a more comprehensive view of nitrogeneous composition and metabolism. Fraction A (water soluble nitrogen coagulation by boiling), consisting entirely of albumins, is included in fraction D by the technique of Ludwig and Rothstein, and in fraction C, by that of DelVecchio. Fraction B (water soluble nitrogen not precipitated by boiling or by TCA), corresponding to fraction B in both the technique of Ludwig and Rothstein and that of DelVecchio, may contain amino, and other non-protein nitrogenous compounds such as urea and ammonium salts. Fraction C (water soluble nitrogen precipitated by TCA) may contain mucoids and

intermediate products of protein catabolism. This fraction, along with fraction A, is equivalent to fraction C by the technique of DelVecchio. The intermediate products of protein catabolism are probably equivalent to fraction C in the technique of Ludwig and Rothstein, while more complex materials are probably denatured, and are therefore included in fraction D by their procedure. Water insoluble nitrogen extracted with 10% NaCl, fraction D by the seven fraction technique, is primarily composed of globulins; however, some lipoproteins may also be included. The globulins are contained in fraction D, by the technique of Ludwig and Rothstein and that of DelVecchio, while the lipoprotein would be included in fraction A by both procedures. Fraction E (water insoluble nitrogen extracted with 0.1N NaOH or 0.1N HCl), which may contain nucleoproteins, and fraction G (insoluble nitrogen), containing scleroproteins, are included in fraction D by the technique of Ludwig and Rothstein and that of DelVecchio. Fraction F (water insoluble nitrogen extracted with lipid solvents) may contain proteolipids. This material, along with the lipoprotein extracted in fraction D by this procedure, is included in fraction A by the techniques of Ludwig and Rothstein and of DelVecchio.

In the present study, it was found that approximately 24% of the total nitrogen of the mealworm egg is converted from water soluble to water insoluble material during embryogenesis. By employing the seven fraction technique it was possible to show that the utilization of egg albumin accounted for almost 50% of this material, with the remainder supplied from fraction B. An increase in globulin content accounts for approximately 25% of the increase in water insoluble protein. The increase in fraction E which accounts for 45% of the change in water insoluble nitrogen, may be due to synthesis of new nucleoproteins; however, the exact composition of this fraction is not known. The synthesis of scleroprotein accounts for 30% of the increase in water insoluble protein. These changes are similar to those reported by Pigorini (1925) for the silkworm, *B. mori*. It appears, therefore, that these two organisms have the same general pattern of protein metabolism during embryogenesis.

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A New Genus and Species of Spirostreptoid Millipeds from the Pacaraima Mountains, British Guiana[1]

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Abstract: A new genus, **Gonepityche** and new species **pacaraimae** of spirostrepsid millipeds from the Pacaraima mountains of British Guiana is described.

During the autumn of 1932, Mr. L. D. F. Vesey-Fitzgerald collected diverse zoological materials during the course of his travels through British Guiana and northern Brasil. Included were various Diplopoda which were recently made available for study by Dr. G. Owen Evans of the British Museum (Natural History). Some of the specimens, originating in the little-known Pacaraima Mountains, have been treated separately in a recent paper (Hoffman, 1966); the present report is concerned with a somewhat disjunct spirostreptoid—apparently representing a previously undefined generic group—likewise from the Pacaraima region.

Insofar as the supply of available generic names is concerned, the South American spirostreptids are afflicted with an embarrassment of riches, some genera such as *Nanostreptus* and *Urostreptus* having already accumulated as many as five or six junior synonymy! And so long as the systematics of this group remains in a backward condition (owing chiefly to a scarcity of workers on the Diplopoda), the proposal of new generic names for single species is a somewhat hazardous undertaking. Yet we venture to add yet another monotypic genus to the roster because of the difficulties encountered in trying to place its type species in any existing generic category.

Family Spirostreptidae

Gonepityche, new genus

Type species: **G. pacaraimae**, n. sp., from British Guiana.

Diagnosis: A genus of moderately small, slender, spirostreptoids with the following characteristics at least in the male sex: Antennae short and massive, articles 3–6 broader than long, 5th and 6th with circular sensory pits on the outer distal ends.

Collum not lobed or produced ventrad, but the lateralmost ends strongly reflexed ventromesad below the uppermost oblique ridge; body segments smooth dorsally; the two subsegments similar in diameter, separated by a narrow but distinct stricture, the latter crossed by a large number of small but sharply defined costulations which on the lower sides continue posteriorly to caudal edge of metazonites as fine sharp ridges. Ozopores in normal sequence and location, opening in the metazonite. Preanal segment rugulose dorsally, medially produced into a short, blunt epiproct that covers only the basal half of paraprocts;

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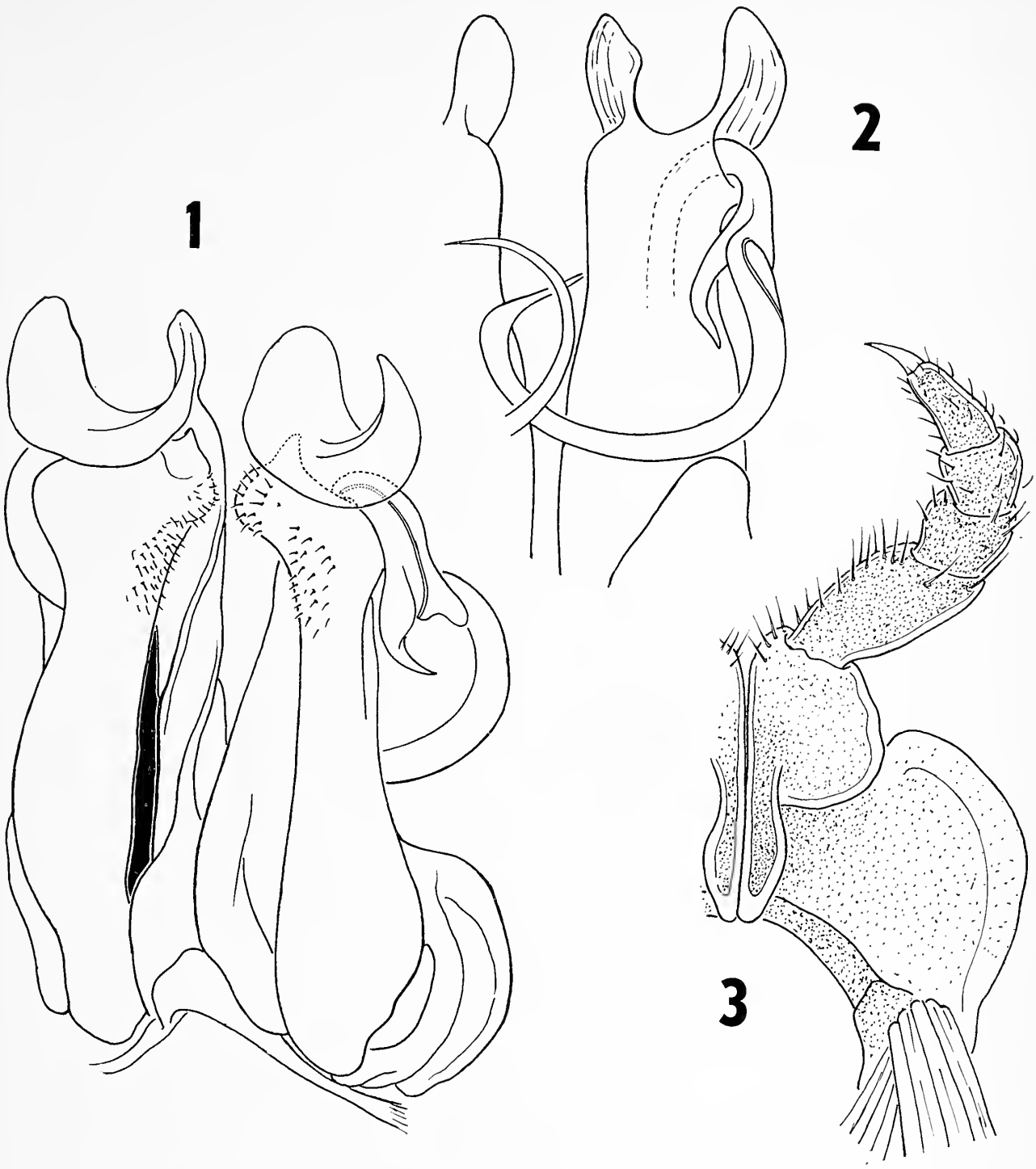

Gonepityche pacaraimae, n. sp.

Fig. 1. Gonopods, seen from the front and slightly to one side to show the gonocoel (dark area). Fig. 2. Right gonopod, aboral aspect. Fig. 3. Left side of first legpair of male, oral aspect.

latter smooth and polished, the median elevated rims set off by prominent submarginal grooves; hypoproct transversely elongated, not fused to preceding segment. Legs short, not extending beyond sides of body; 4th and 5th podomeres with ventral pads only on the anteriormost legs. Coxae unmodified. First pair of legs of the usual form, but coxae lacking the usual enlarged setae on the oral side, and prefemoral processes longer than normal for the family and closely appressed to each other.

Gonopods elongate, slender, the telocoxite distally modified into a broad, thin, semicircular lamella which is medially depressed ventrad over the end of the paragonocoel and thus closing the distal end of the gonocoel like a lid or operculum; telopodite with a short, bisinuate spiniform process located well beyond gonocoel opening, distad of this process the telopodite is abruptly twisted about 180°, beyond which it tapers evenly and without modification to the slender, attenuated apex.

Gonepityche pacaraimae, new species

Figs. 1–3

Type specimen: Male holotype (Brit. Mus. [Nat. Hist.] 1966.**7**:8.1.) from the Pacaraima Mountains, British Guiana; Nov. 12, 1932, L. D. F. Vesey-Fitzgerald, leg. (orig. no. 1147).
Diagnosis: With the characters of the genus.
HOLOTYPE: Adult male, length about 70 mm (broken in several pieces); maximum body diameter, 3.9 mm, body thus about 19 times as long as broad and fairly typical in proportion for the Spirostreptidae.

Coloration altered by long preservation, but apparently in life prozonites yellowish-white, metazonites dark purplish-brown, becoming lighter ventrally. Antennae, legs, and sterna yellowish; front of head light yellowish-brown, darker above, with a dark transverse interocellarial bar.

Head of normal structure and appearance except lower half somewhat broader than usual, essentially as wide as upper; surface evenly convex and smooth. Epicranial suture distinct but short; no trace of interocellarial suture. Labrum, clypeus, and genae continuous, latter not margined laterally. Ocellaria rather small, elongate reniform-triangular, separated by a distance about 2.5 times their length, composed of six rows as follows: 8, 8, 7, 3, 2, 1 = 29. Sides of head produced into an acutely angled ridge running caudad from elevated posterior rim of antennal sockets. Clypeal setae 3-3, labral setae 9-9. Interantennal isthmus broad (1.4 mm), almost half of the antennal length. Antennae short, massive, not extending caudally beyond posterior edge of collum, length about 3.0 mm. 1st article large, hemispherical, globose, articles 2-5 broader than long, abruptly clavate, distally twice as broad as at base, slightly compressed; 6th article narrower than others, slightly longer than wide, oval in cross-section; 7th article in the form of a short disk, with four sensory cones. 5th and 6th articles each with a prominent, circular sensory pit on the outer distal end.

Collum narrowed toward ends, latter set off by an oblique ridge beginning at level of ocellaria; ends of collum below this ridge with about four much smaller grooves, and rather abruptly turned inward at a distinct angle. Surface of collum smooth and polished. Second segment with a distinct ventrolateral ridge similar to that of collum.

Body segments generally similar to each other, basically parallel-sided but metazonites slightly greater in diameter than prozonites, the two subsegments separated by a very prominent deep sulcus extending entirely around the pleuroterga, on the lower sides the metazonites are ornamented with numerous transverse fine ridges extending from caudal edge forward to the sulcus; higher on the body the ridges disappear, leaving only the very anteriormost ends as a series of small but quite prominent light-colored "bridges" crossing the sulcus throughout its course. Surface of both subsegments similar, the texture essentially smooth and polished, but with a profusion of microscopic, elongate oval punctations.

Ozopores beginning at the 6th segment; pores moderately distinct, opening well behind the sulcus in the metazonite.

Posterior end of body normal in appearance, last segment middorsally pitted and wrinkled more prominently than elsewhere on the body and produced into a short, bluntly triangular epiproct covering only the bases of the paraprocts. Latter large, smooth, and convex, with

a broad, deep depression setting off the prominently elevated mesial margins. Hypoproct very broadly triangular in outline, not fused to the preceding segment.

Sterna completely smooth, without trace of transverse striation. Legs very short, completely invisible from above body when extended laterally; podomeres virtually hairless except for scattered macrosetae on the ventral sides of the distalmost, and several dorsally located near the tarsal claws. Legs normal in structure, without modification except for rather weakly developed eversible pads on the ventral sides of the 4th and 5th joints of legs of the anterior half of the body. Tarsal claws about 2/3ds as long as tarsus on anterior legs, but becoming much shorter posteriorly on the body.

Lower ends of 7th segment produced into small, rounded, posteriorly directed lobes formed chiefly from the prozonite.

Gonopods composed on the normal elements (Figs. 1–2). Coxites without basal processes on the median side, connected by a small but distinct subtriangular sternum, its lateral ends prolonged beyond base of paracoxites. Gonocoel partly open as seen in an oblique anterior-median aspect; paragonocoel long, slender, distally enlarged and lobed both medially and laterally, its terminal fourth set with numerous fine short setae. Telocoxite longer than paragonocoel, slightly twisted caudolaterally, distally expanded into a large, semicircular lamella, this structure medially depressed over end of paragonocoel which it covers like a lid or operculum. Telopodite slender, simple in structure, with a short, curved femoral spine originating some distance beyond origin of the exospermite region, beyond the femoral spine there is a slight constriction and torsion, distad of which the telopodite terminates as a long, attenuated, simple falcate blade curving behind the gonopod and partly around it on the medial side. No trace of posterior gonopods evident.

First legs of the form shown in Figure 3; a narrow transverse sternum is evident, with the usual enlarged coxae, the latter glabrous; prefemora with unusually long, contiguous ventrally directed processes that fit into a deep concavity of the gnathochilarial mentum.

Discussion: Insofar as we are willing to guess at this time, the affinities (or at least similarities) of this new form appear to lie with the several species of *Brasilostreptus*. The community of shared traits includes small body size, general pattern of the gonotelopodite, and superficial similarity of the 1st leg pair of the males. *Brasilostreptus* has heretofore been monotypic with *B. gracilis* Verhoeff, but the study of recently-acquired material suggests that some further Brasilian species are referable thereto, and a revision of the genus is now in progress. **G. pacaraimae** differs at least in the ornamentation of the transverse suture, in the formation of the gonopod telocoxite, and in the closely appressed prefemoral processes of the first pair of legs, from the species now provisionally referred to *Brasilostreptus*.

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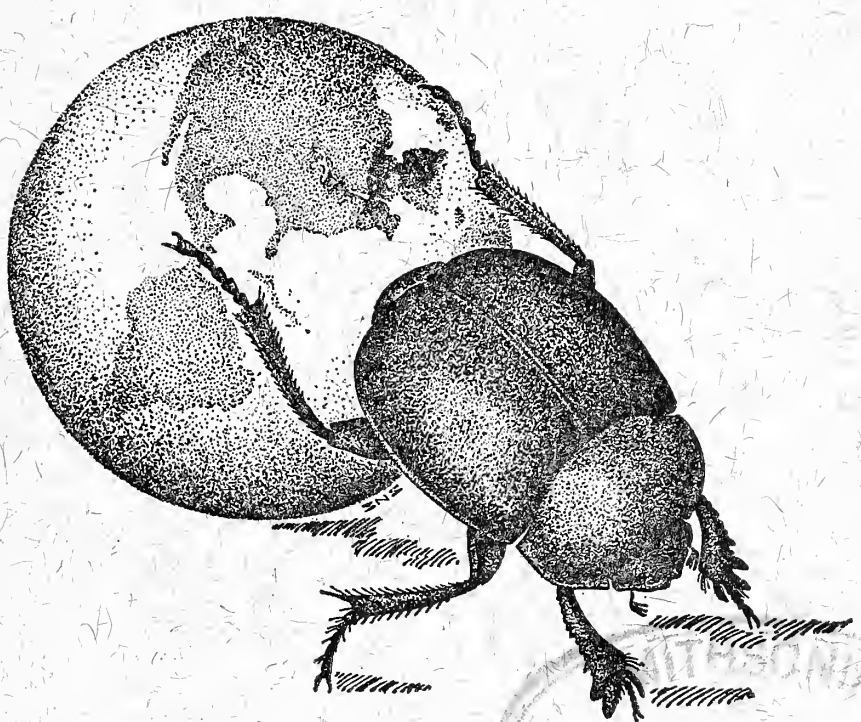

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CONTENTS

Larval Dimorphism and Other Characters of *Heterocampa pulverea* (Grote & Robinson) (Lepidoptera: Notodontidae)

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Abstract: A group of sibling larvae of *Heterocampa pulverea* (Grote & Robinson) from Connecticut showed a very distinct dimorphism of color and pattern with no appreciable intergradation. Of 66 larvae reared to maturity 30 were green, 36 were brown. The dimorphism was apparently not linked with rate of development, sex or any discernible adult characteristic. The larvae of both morphs were highly, but differently, cryptic. Possible adaptive advantages of the morphs are discussed. Dorsal thoracic tubercles in the last larval instar, characteristic of this nominal species, are visible as vestiges in the pupa.

On August 1966 a batch of eggs was obtained from a ♀ *Heterocampa pulverea* at Putnam, Windham Co., Connecticut. The larvae from these were reared on *Quercus coccinea*. Ten were given to another Lepidopterist, but 56 were reared to maturity by the writer, emerging 8–26 October 1966, indoors. It was not until the larvae were in the 4th (penultimate) instar that it was realized that a distinct color and pattern dimorphism existed, approximately half being green and half brown. The two groups were then segregated and reared separately. Records of both types in the last two instars were made by color photography.

Table 1 shows the record of the adults that emerged, grouped by larval morph, sex and the dates of emergence. The adults differ from each other in only very minor details, well within the limits of variation of any series from the region. These data show that the morphs, which must be genetically controlled, are not linked with either sex or rate of development.

The larva of this species was first described by French (1880, p. 83) from an Illinois specimen. Packard (1895, p. 249–250 & 282, Pl. 33, fig. 8–8a) reprinted French's description, described a preserved specimen from Massachusetts, and gave 2 small outline drawings copied from figures of Doubleday of a supposed synonym. Packard also refers to an unpublished colored sketch of the larva by Abbot. The French and Packard descriptions are of green larvae with a pattern not unlike the green morph described and figured here, but differing greatly in some respects. Apparently the white dorsal areas characteristic of both the green and the brown morphs of the present paper, and the lateral white areas of the green one, were not present in the French and Packard specimens, since French refers to these areas as "orange" or "purple," and Packard either does not state what their colors were or else refers to them as "reddish." Neither author mentions a brown larva. The Doubleday figures are too small and simple to be of much value.

It is very likely that the larvae of *pulverea* show a considerable amount of variation, predictably much more than would be expected in a sibling group

TABLE 1. Sibling *H. pulverea* grouped by larval morph, sex and date of adult emergence.

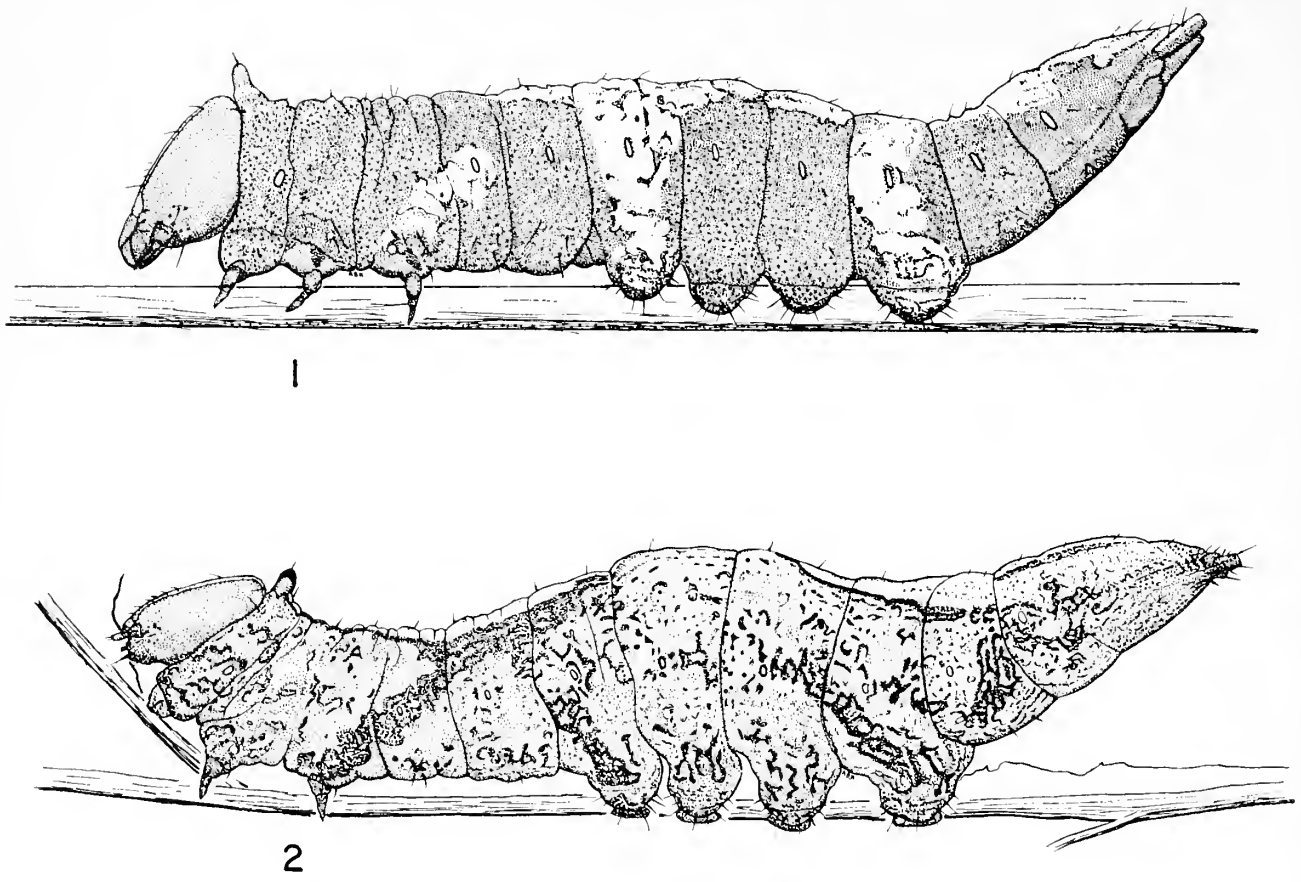
		Green		Brown	
		♂	♀	♂	♀
October	8	2	–	–	–
	9	–	–	–	1
	10	–	3	2	3
	11	2	1	–	–
	12	3	–	1	4
	13	–	–	–	3
	15	2	3	2	3
	16	–	2	–	4
	17	1	1	1	–
	18	–	1	1	1
	19	1	–	4	–
	22	1	–	–	–
	23	–	2	–	–
	26	–	–	–	1
Totals		12	13	11	20

such as that described here. The extent of this in local populations, the amount it is subject to regional variation, and the genetic factors responsible, will all have to be worked out by many rearings of sibling groups and by genetic crosses. At present *H. pulverea* (type locality, Pennsylvania) is considered a northern subspecies of *H. umbrata* Walker (type locality St. John's Bluff, East Florida). It is more than likely that the relationship is a clinal one.

DESCRIPTIONS OF MATURE LARVAE

Green Morph (Fig. 1). Body bright green speckled with small, dark, purplish fuscous dots which remain separate from each other, not coalescing to form lines or scrawls. A distinct white spot around the base of each primary seta. A white patch on either side of metathorax and 1st abdominal segment, running dorso-caudad diagonally from leg base, sometimes barely reaching spiracle, sometimes enclosing it and extending about one or two spiracle's lengths above it. On abdominal segment 3 a broad, white patch running dorsad from the proleg base to join the white dorsal markings, occupying nearly all of the lateral area of the segment. On abdominal segment 6 a similar white patch running dorsad from the proleg base; this may join the white dorsal area or may fail to do so, extending no more than about two spiracle's lengths dorsad of the spiracle. All three of these lateral white patches are very irregularly crenately edged, and contain curved, red-brown dashes and scrawls which differ greatly in extent in different individuals. Rarely there is a small, double patch above each metathoracic leg, and another on the posterior part of abdominal segment 7, largely ventrad of the line of the spiracle.

Dorsally the markings are complex and differ greatly from one individual to another. The fundamental marking is a white dorsal stripe along the entire



FIGS. 1–2. Mature larvae, *Heterocampa pulverea*, lateral and slightly ventral aspect, drawn from projections of 35 mm. photographs. The setae of both larvae are incompletely shown. Fig. 1, green morph. Fig. 2, brown morph.

length of the body, which is more or less margined and marked internally by dark red-brown scrawls, and differs greatly in width on different segments. Prothorax: stripe unmarked, anteriorly as wide as space between prothoracic tubercles, tapering posteriorly to half as wide, black-edged. Mesothorax and metathorax: stripe narrow anteriorly, widening greatly posteriorly, usually considerably marked internally, and sometimes nearly obliterated, by dark scrawls. Abdomen, segment 1: stripe widening greatly posteriorly to slightly more than half the width of the segment; rarely with any included dark markings, but often pale green mid-dorsally, the green area narrow anteriorly but widening greatly posteriorly so as to leave only narrow, white, tapering edges laterally which in extreme individuals may not reach the posterior edge of the segment. Segment 2: white stripe becoming very broad posteriorly, containing more or less green mid-dorsally. Segment 3: white stripe very broad, laterally confluent with lateral white stripe, from dorsal view occupying all or nearly all of the segment; subdorsally a few small, dark, paired dots and scrawls, especially posteriorly. Segments 4 & 5: white stripe very broad anteriorly, narrowing greatly in segment 4 and still more in segment 5; within it a broad, dark scrawled, X-shaped saddle, centering about anterior edge of segment 5, that may obliterate much of the white. Segments 6 & 7: rarely almost solid green

mid-dorsally with only indications of the white stripe laterally; sometimes with only central portions green, and white stripe on either side of this broad and confluent with lateral white stripe on segment 6. Segments 8, 9 & 10: mid-dorsal area green, white stripe on either side of this broadest at anterior edge of segment 8, narrowing to segment 9, broader at anterior edge of segment 9, narrowing posteriorly; sometimes the green areas of the sides and the mid-dorsal green are confluent along the anterior edge of segment 9, breaking the white stripe.

Brown Morph (Fig. 2). Head, prothoracic tubercles, legs and seta bases as in green morph. Body brown with only a faint greenish cast in recently enclosed individuals. Laterally with no white bands or areas other than a few small areas enclosed by dark scrawls. All brown areas with many irregular, dark brown curved lines and scrawls and smaller, orange-brown dots and curved lines. Dark scrawled markings heavier and coalescing to form a diagonal line running dorso-caudad from base of 3d leg across metathorax and abdominal segment 1 to join dark-scrawled border of dorsal markings. A similar, but less complete, line of markings running dorso-cephalad from base of proleg on abdominal segment 3. A similar, also less complete, diagonal line of dark markings running dorso-cephalad from base of proleg on abdominal segment 6 to spiracle on abdominal segment 5, and more or less continued cephalad across abdominal segment 4. Abdominal segment 7 with dark-scrawled patch caudad and mostly ventrad of spiracle, dorsally more or less joining lateral dark edging of dorsal markings.

Dorsally, fundamental pattern like that of green morph, but with some different distribution of white. Prothorax: as in green morph. Mesothorax & metathorax: also much as in green morph, but with less white, the dorsal areas largely filled in with brown scrawled marks as in the most heavily marked green individuals. A large, irregularly edged, diamond-shaped white area from posterior part of metathorax back to about middle of abdominal segment 4, widest in posterior part of abdominal segment 2; within this for most of its length is a pair of narrow, irregular, closely subdorsal, dark lines. An almost solidly brown saddle (in the same position as the dark-scrawled, X-shaped saddle of the green morph), continuous with brown sides, on posterior half of 4th and anterior half of 5th abdominal segments. A large, posterior white patch, beginning narrowly at about middle of 5th abdominal segment and extending to posterior end; on 8–10th abdominal segments this is more or less filled in dorsally with brown scrawls and lines; within it, as in the anterior white patch, is a pair of irregular, thin, dark, closely subdorsal lines for most of its length.

Despite the considerable amount of individual variation, the two morphs in this group of siblings were very distinct, with no intermediate individuals. The nearest to anything of the sort was in a few larvae of the brown morph that had a greenish tone during the early last instar; and one individual of the

green morph that had the green areas much paler than usual and slightly brownish tinged, but had the green morph pattern.

4TH INSTAR LARVAE

The larvae of this instar are easily recognizable by the ends of the prothoracic tubercles, which have two distinct small, setiferous tubercles at the tips, instead of being terminally smooth as in the 5th instar. On the face these larvae have two thin fuscous lines on either side of the median light area instead of the single line of the 5th instar. The white lateral patches, and to a lesser degree the white dorsal patches, of the green larvae tend to be more obscured by dark scrawls. The brown larvae frequently had considerable of a greenish tinge, although their patterns were definitely of the brown morph.

PRE-PUPAL LARVAE

As the larvae stopped eating and entered the ground for pupation, drastic color changes ensued. All fine details of the pattern disappeared. The brown larvae turned a brilliant pink overall, the dark markings of the saddle on abdominal segments 4 & 5 showing slightly darker. The green larvae, on the other hand, changed to a darker green with the white areas of both the sides and the dorsum very bright pink, making them very conspicuous looking objects. All larvae then became pale and almost colorless just before eclosion to the pupa. The pink larvae that had been brown did this at a uniform rate overall. In the green larvae, however, the pink areas were the first to become colorless, so that for a short time these larvae were green with pale, colorless areas. Doubtless these color changes have some physiological significance, but they can hardly have any protective value (as is the case in some other pre-pupal color changes) since they normally take place underground.

DISCUSSION

The patterns of both of the larval morphs are decidedly, but differently, procryptic, the brown larvae resembling crumpled, dead leaves with shadow or edge patterns, and the green larvae resembling green leaf areas with pieces missing. The larvae of both types are highly disruptive from the dorsal aspect, and the green larvae are disruptive from lateral aspect as well. The white lateral patches are so shaded as to appear almost protuberant and three dimensional. A predator that had learned to recognize the appearance of one of the morphs would be very unlikely, because of this, to react to the appearance of the other one and might very well, in fact, be more likely to ignore the other one if the two were close together. The dimorphism must function in this way as a protective device per se, most valuable when the two morphs are completely different from each other, and still more valuable when each morph is highly cryptic.

The proportions of the morphs in this sibling group and their distinctness from each other strongly suggest a single controlling genetic factor. The evidence of French's and Packard's larval descriptions shows that there is much more larval variation than this sibling group showed, and suggests that the morphs may not always be as distinct from each other. For the time being we suggest that the morphs have evolved, and are maintained, by visual predator selection, but that this may well be strongly affected by all sorts of pleiotropic effects of which nothing is known. Much further work is certainly called for to determine the genetic status, possible pleiotropy and extent within both *H. pulverea* and *H. umbrata* of larval dimorphism.

The pupae all showed vestiges of the prothoracic tubercles. Since these tubercles appear to be present in the 5th instar of only the larvae of *H. pulverea* and *H. umbrata*, their presence in the pupa can be used for identification, at least of *H. pulverea*.

Identification of the material as *H. pulverea* was by comparison with the ♀ type in the American Museum of Natural History. The material here reported upon has been placed in the collection of this museum.

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Observations on the Behavior of the Bee *Anthidium manicatum* (L.)

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Abstract: Collection records of the Palaearctic bee *Anthidium manicatum* (L.), reported by Jaycox in 1967 as being adventive in the United States, are brought up to date. New flower host records are included. European literature on the aggressive behavior of the male is briefly summarized. Observations on the behavior of *A. manicatum* in 1965 and 1966 show the male to be territorial and aggressive. The female works without hindrance while other species of bees are struck and driven from the territory being patrolled by the male. No bees showed any inclination to defend themselves against the attacking male of *A. manicatum*. It is believed that *A. manicatum* is a rather unique subject for further study, including distribution, behavior, nest building, flower preferences and genetics.

Jaycox (1967) reports the presence in the United States of the Old World bee *Anithidium manicatum* (L.) (Megachilidae) based on specimens collected by Dr. Roger A. Morse and the writer in 1963, 1964, and 1965. *A. manicatum* is found throughout Europe, part of Asia, and North Africa. It is the only species of *Anthidium* found in England. As mentioned by Jaycox, *A. manicatum* has recently been found in the Canary Islands and in South America.

The specimens seen in 1963 were reared by Dr. Morse from a five inch deep, one quarter inch diameter trap nest in a white pine block, placed in the field early in 1963 near Ithaca, N.Y. The wooden block containing the nest was removed from the field on 27 June 1963; on 20 August 1963, adults, 2 ♂♂ and 8 ♀♀, emerged from the nest. All specimens collected by the writer in 1964 and 1965 were taken, as reported by Jaycox, from the flowers of *Caryopteris* × *clandonensis* at Ludlowville, N.Y.

In 1966, *A. manicatum* was again found at Ludlowville, N.Y. visiting the flowers of *Caryopteris*. Specimens were observed between August 28 and October 3 with peak abundance during the second week of September. It was noted in 1964 and 1965 and again in 1966 that *A. manicatum* visited only the flowers of *Caryopteris* although *Chrysanthemum* and *Potentilla* were interplanted with the *Caryopteris* and were in bloom during the flight period of the bee. Two species of *Mentha* in bloom nearby were attractive to other species of wild bees but were not seen to be visited by *A. manicatum*.

Also in 1966, a total of 13 ♀♀ and 15 ♂♂ were taken on the Cornell Campus at Ithaca on various dates between August 23 and September 2 by Jan Nowakowski, Paul Minacci and George Strang from a bed solidly planted to blue flowering salvia (*Salvia farinacea*). Dr. Nowakowski informs me that none were taken from adjoining beds planted to white salvia (*S. farinacea*) and red salvia (*S. splendens*). Also on the Cornell Campus, Dr. Nowakowski took 3 ♀♀ and 1 ♂ from *Lythrum salicaria* on August 16 and a single ♀ from

Solidago on September 12. Dr. Nowakowski noted aggressive actions against other bees by the males of *A. manicatum* he collected from salvia.

It is of interest, although possibly of little significance, that during a three year period all but one specimen of *A. manicatum* were collected on blue or purple flowers and all but five specimens from the rather closely related families Labiatae (*Salvia*) and Verbenaceae (*Caryopteris*). Friese (1898) says *A. manicatum* prefers Labiatae in Europe but there is no general agreement by other workers on this. It also raises the question of why plants of *Mentha* (Labiatae) in full bloom were ignored at Ludlowville.

Unfortunately no notes were made on the structure of the nest from which specimens were reared by Dr. Morse in 1963. None have been found in trap nests in subsequent years. Very likely the nest is made from soft flocculent material scraped from plants as reported in Europe. Fabre refers to nests of the group to which *A. manicatum* belongs as "—quite the most elegant specimen of entomological nest building" and Friese calls them "wunderbaren Nestbau." In 1965 the writer observed a female stripping the pubescence from the flower stem of a potted geranium (*Pelargonium*), probably with the intent of using it as nesting material.

No collections of adults have been made in New York before August. However, the specimens reared in August 1963 by Dr. Morse came from a trap nest placed in the field early in 1963 and completed by June 27. This may indicate that *A. manicatum* has two broods.

Green (1921) in England seems to have been the first to note the aggressive habits of *A. manicatum* males when he reported it attacking *Bombus*.

Ward (1928), also in England, published detailed observations on attacks by males of *A. manicatum* on bumble bees (*Bombus*) and hive bees (*Apis*). He indicates that definite territories were marked out when he states, "—males patrolling patches of Red Dead Nettle at two spots and having the effect of keeping other insects away; but a few yards away Bumble Bees feeding fairly regularly at the Dead Nettle with little or no molestation." He noted that aggression declined when the sun was obscured by clouds. Ward also found that some individuals of bumble bees and honey bees had their wings damaged so they could not fly when struck by *A. manicatum*.

In spite of Ward's detailed notes, Perkins (1928) regarded the attacks on other bees as "an accidental occurrence."

Sitowski (1947) in Poland reports that the male of *A. manicatum*, "—hovers in an area, or patrols where the female is working and kills or drives out all competing intruders with ferocious attacks." He states that not only is the competing bee knocked to the ground but that the male *A. manicatum* may continue its attack on the ground using its mandibles, and abdominal spines on the last two abdominal segments, to disable or kill honey bees and bumble bees.

The observations of Haas (1960) in Germany are similar to those of Ward. He regards the territory established by the male as part of a behavior pattern which involves swarming. The territory itself he believes to be sort of an exclusive swarming area in which the male as Haas puts it, "swarms alone."

The writer first observed the male of *A. manicatum* attacking other bees on 14 September 1965. An abstract of notes taken on that day follows:

14 SEPTEMBER 1965 In addition to honey bees, bumble bees and a few other native bees, two female *Anthidium manicatum* were present most of the day on *Caryopteris* flowers. The females were distinguished by their very fast flight and by being easily disturbed and alarmed; when disturbed by anything other than another bee they would leave the area and not return for some time. The females were far from aggressive. If one started to land on a flower and found it occupied by another bee, it would go to another flower. A bumble bee once pushed a female from a flower; the female flew to a leaf where it remained motionless for almost three minutes, then preened its legs and antennae for half a minute and then flew to another *Caryopteris* flower on a different plant.

The male *A. manicatum* moved very rapidly. It would work a flower for a second or two but it spent most of its time patrolling the largest *Caryopteris* plant. It was very aggressive and would strike honey and bumble bees which were working flowers, knocking them from the flowers. The male frequently would strike two or three bees in as many seconds. On one occasion the writer frightened the male and it flew away for several minutes. In its absence, two bumble bees and three honey bees moved to the *Caryopteris* plant which had been patrolled by the male *A. manicatum*. On its return, the male immediately struck all five bees almost faster than the eye could record, the whole episode being over in five seconds or less with all five bees in flight.

Observations were made on two successive days in 1966. The area under observation involved one large (56 in. high, covering an area of 18 sq. ft.) *Caryopteris* and a group of smaller (42 in. high, covering an area of 14 sq. ft.) *Caryopteris* plants separated by a pink flowering *Chrysanthemum* plant 23 in. high, covering an area of 3.5 sq. ft. The notes made on these two days follow:

10 SEPTEMBER 1966 One male and one female appeared at approximately 9 A.M. During the day only one female was observed at any one time and apparently only one specimen was involved. The first male to appear was very dark and is referred to as No. 1. A second male with more extensive yellow markings appeared shortly on the smaller *Caryopteris* and is referred to as No. 2. Male No. 1 spent most of its time patrolling the large plant. Occasionally male No. 2 would extend his patrol of the smaller plant into the patrol area of male No. 1. Male No. 1 would immediately drive No. 2 away. On one occasion when No. 1 had pursued No. 2 to the outer side of the smaller plant, No. 2 turned and faced No. 1. Both males hovered about two inches apart, gradually descending toward the ground; at about four inches from the ground hovering continued at essentially one place for about half a minute; then No. 1 struck No. 2 head on knocking it to the ground beneath the plant where it remained with wings partly outstretched and with the apical third of the abdomen vibrating. Male No. 2 remained on the ground about three minutes and then it flew away. It was not seen again.

Following this episode, male No. 1 rarely left the large *Caryopteris* all day. Occasionally it would make a quick patrol of the group of small plants formerly patrolled by No. 2. It had a regular route around and through the large plant and conducted its patrol by hovering a second or two and then flying four to six inches. All bees except female *A.*

manicatum were driven away. Usually it would strike the center of the thorax, possibly because this was the usual aspect exposed; it was seen once to strike a bumble bee head on and once struck a bumble bee from below. Rarely a very small bee would manage to visit a flower and be overlooked by the male but usually it would be struck as soon as it tried to move to another flower. All bees, including the largest bumble bees, appeared to be panic stricken when struck by the male *A. manicatum*; none made any attempt to fight back and only one, a large *Xylocopa*, was noted to require two strikes. Bumble bees slowly flying by the plant were sometimes struck and immediately put on an amazing burst of speed.

The male rarely bothered the female. Several times it landed on the dorsum of the female giving the impression it was trying to mate. It could not be determined if mating took place but the contact would sometimes last for eight to ten seconds. During contact the female would keep working the flower but once the pair fell from the plant, separating before they reached the ground.

A bumble bee was killed with cyanide and immediately pinned to a flower in a natural position. The male *A. manicatum* did not strike it but circled it twice about one half inch away; from then on it was ignored by the male on his patrol except at rare intervals when it would fly very close to the pinned bee. When the bumble bee was moved to another flower, it continued to be ignored.

A bumble bee was quieted with DDVP and tied to a blossom while still moving its wings. It was struck by the male as it was being tied but was ignored from that time on except for a rare quick investigation. At the same time the male was striking all intruding bees.

It was noted that during the heat of the day the male was extremely aggressive and spent very little time on flowers and none resting. After 5 P.M. it made many stops probing flowers although each stop was only of a few seconds duration. It also would rest for five to eight seconds on foliage. At this time of day it was not quick to strike intruders but it did strike them eventually. This may have been due to lower temperature, wearyness, or the need to secure some nectar to sustain itself.

11 September 1966. The activities of male No. 1 were about the same as noted on the previous day. It now took over the smaller plants patrolled by No. 2 the day before but about 75 percent of its time was still devoted to the large bush. Two females were present most of the time. A second male appeared but was driven off and did not return.

When the male would land on the dorsum of the female, its behavior was quite different than when striking an intruding bee. As it approached the female it would stretch out its legs as for grasping and the female would be seized by them. When striking another bee, the legs were kept tightly under the body and the approach was much faster.

Live bumble bees were attached by a long thread to the end of a stick. To the observer they looked and behaved quite naturally but only occasionally would there be a glancing strike by the male *Anthidium* whether the bumble bees were on a flower or flying. However, if a tethered live bumble bee was dangled two to four inches directly in front of the hovering male, the male could be led for a foot or two but it would not strike. One live bumble bee tied to a flower was closely investigated several times but not struck; most of the time it was ignored.

The male would investigate anything that moved including dangling portions of old flowers but did not strike such objects. It showed only slight aggression against flies and butterflies and these did not show the fear of the male exhibited by the other bee species. The strike against flies and butterflies was usually glancing rather than direct and these insects would usually return to the same or a neighboring flower immediately.

By 6 P.M. the male was spending most of its time visiting flowers. As it approached the flower it would drop its hind legs as does the female.

Observations after September 11 were mostly a repetition of previous observations. The *Caryopteris* bloom was almost gone by the end of September. The last *A. manicatum* noted was seen for a few moments on October 3 about 3 P.M. It was a male and appeared to be the same specimen observed on September 10 and 11.

Observations made in 1965 and 1966 seem to indicate that the male of *A. manicatum* is aggressively territorial. Possibly the easily disturbed timid female needs protection when there is competition for pollen and nectar. Other bees seem to fear the male of *A. manicatum* and never were observed to attempt to defend themselves. Flies and butterflies, although occasionally knocked from flowers, showed no such fear and usually returned to the same or a nearby flower. The male was noted to be most aggressive in bright sunshine during the heat of the day; it is less quick to respond to invasions of its territory as the temperature drops later in the day. Although the male investigates all movement within its territory it does not strike dangling leaves or flowers or bees which are dead or whose movements are inhibited in any way.

It is suggested that further studies of *Anthidium manicatum* in New York are likely to be rewarding. Currently it is not known outside of a limited range in the towns of Ithaca and Lansing in Tompkins County and its pattern of distribution as it spreads will be of interest. No native *Anthidium* is known from New York and one wonders if *A. manicatum* will fit in some unoccupied ecological niche or whether one or more of our native bees may be displaced by this aggressive species. The present population of the species is probably the result of the introduction of a limited number of individuals, possibly of a single nest, so a study of the genetics of the population might be in order. It is of interest in this connection that the color pattern of the males collected in New York run the complete gamut of patterns described from Europe—from mostly yellow with a few black markings to almost completely black. This variation in color pattern is very convenient for the observation of specific individuals.

The writer wishes to thank Dr. Roger A. Morse for providing information on the specimens he reared from a trap nest. Acknowledgement is also due Dr. Jan Nowakowski for information on the specimens collected by him and by Mr. George Strang and Mr. Paul Minacci and additionally for translating the paper by Sitowski. The writer also wishes to thank Dr. Morse and Dr. Elbert Jaycox for reading the manuscript.

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A New Species of *Nepytia* from the Southern Rocky Mountains (Lepidoptera: Geometridae)

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Abstract: *Nepytia* **janetae**, new species, is described from material collected in New Mexico and eastern Arizona. The genitalia of both sexes are illustrated.

Recent collecting trips to the higher mountains of New Mexico by the author and his family produced a nice series of a heretofore undescribed species of the genus *Nepytia* Hulst. One additional specimen was found in the collection of the American Museum of Natural History, being from the White Mountains of Arizona, *ex* collection of G. H. and J. L. Sperry. These moths are now being described in order to make this name available.

The material was collected under the auspices of National Science Foundation Grant numbers G-9037, G-25134, and GB-3856. This assistance is gratefully acknowledged.

Nepytia **janetae**, new species
Figures 1, 2

This species is allied to *regulata* Barnes and McDunnough, and may be distinguished from it by its smaller size, paler color, and by the large discal spot filled with ground color on each forewing.

MALE: Head with vertex and front creamy white, with variable number of yellow scales; palpi slender, grayish brown; antennae with very long pectinations, up to 1.6 mm in length. Thorax pale gray above, with elongate hair-like scales, and with grayish black scaling anteriorly; beneath white. Abdomen pale gray, with a few scattered pale brown scales above.

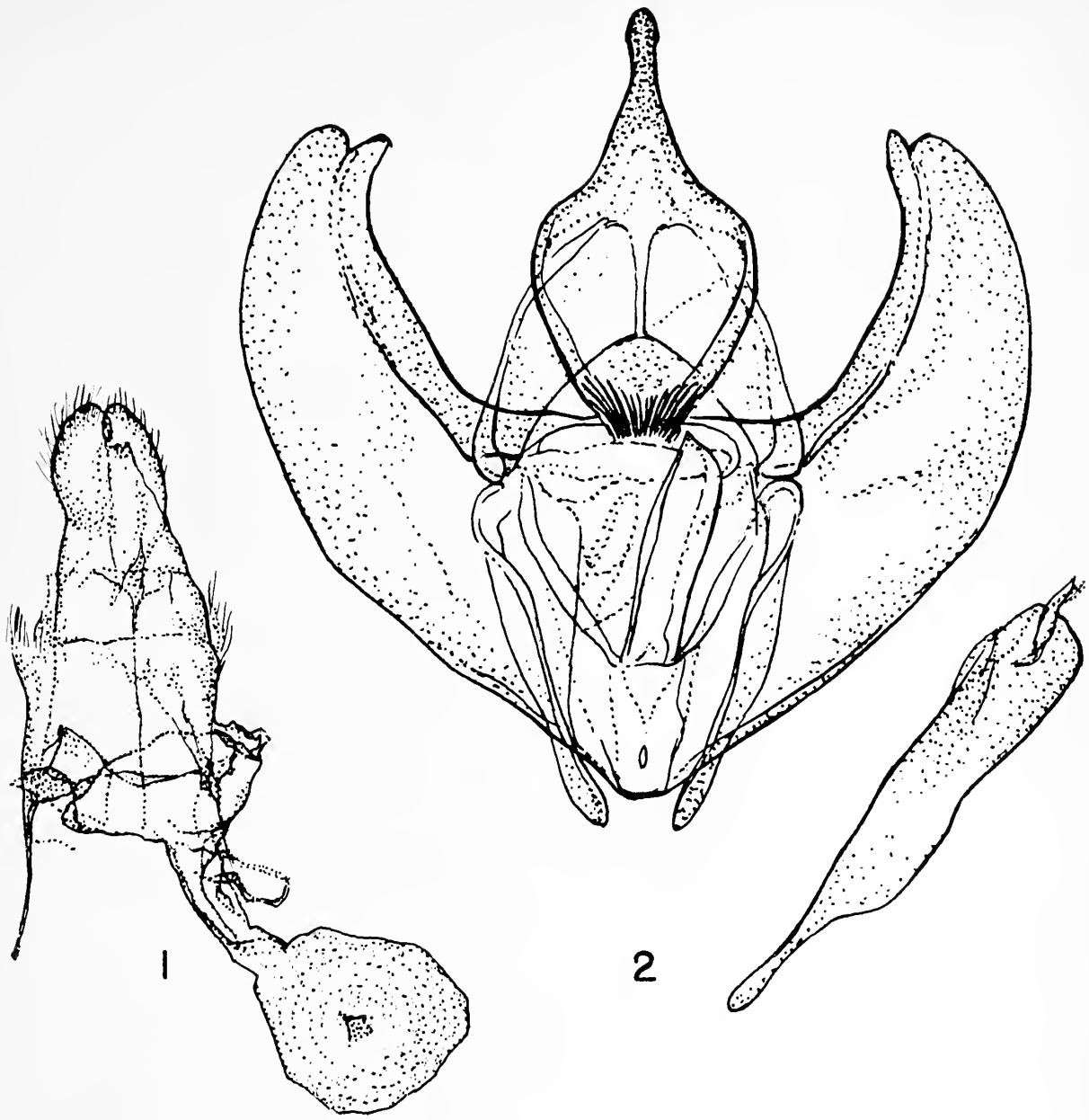
UPPER SURFACE OF WINGS: All wings rather thinly scaled; forewings with ground color pale gray, with scattered black and yellowish scales, the latter concentrated along upper portion of t. p. line and inner margin; t. a. and t. p. lines broad, black or grayish black, and tending to be somewhat diffuse; t. a. line arising on costa one-third of distance from base, outwardly dentate on veins and in cell, inwardly oblique from anal angle to inner margin; discal spot large, occupying most of width of cell, roughly triangular, filled with yellowish ground color; t. p. line strongly inwardly dentate on veins, connected with discal spot anteriorly along vein R_5, and with broadening of t. p. line at junction of base of discal spot, in some specimens with small spot of ground color at origin of vein M_3; subterminal area with nebulous yellowish band distal of t. p. line in upper portion of wing, and with weakly defined s. t. line, shaded distally by ground color; fringe concolorous with wing, with blackish gray spots at ends of veins. Hind wings white, with scattered brownish black scales; extradiscal line weakly indicated, extending straight across wing; discal dot weakly represented in some specimens; fringe like that of forewings.

UNDER SURFACE OF WINGS: Forewings pale grayish white, with maculation of upper surface weakly indicated; hind wings white, with faint extradiscal line.

LENGTH OF FOREWING: 15 to 18 mm; holotype, 17.5 mm.

FEMALE: Similar to male, but with maculation tending to be slightly heavier.

LENGTH OF FOREWING: 15 to 18 mm; allotype, 17 mm.



FIGS. 1 AND 2. Genitalia of *Nepytia* **janetae**, new species. FIG. 1. Female, allotype. FIG. 2. Male, paratype from type locality.

MALE GENITALIA: Gnathos with sides very slender, median spinose enlargement triangular in outline; valves with apex of costa protruding from end of valve, and with outer margin of valvula rounded; furca angled to right side, short, not attaining posterior margin of transtilla, broad, with inner margin straight and outer margin rounded; aedeagus with ventrolateral, sclerotized, posteriorly and asymmetrically bidentate area, and with slender, elongate, posterior, sclerotized process.

FEMALE GENITALIA: Sterigma very broad, posterior margin evenly rounded, and with V-shaped anterior process ventrad of posterior one-half of short ductus bursae; corpus bursae with narrow posterior neck and anteriorly rather short and globular, with stellate signum.

TYPES: Holotype, male, Bursum Camp, 18 miles east of Alma, Catron County, New Mexico, elevation 9000 feet, July 9, 1961 (F., P., and J. Rindge); genitalia mounted on slide no. F.H.R. 10,650. Allotype, female,

same data, July 15, 1961; genitalia mounted on slide no. F.H.R. 13,774. Paratypes: same data as types, various dates between July 7–16, 1961, 26 males and 21 females; Pine Camp, 2 miles northeast of Cloudcroft, Otero County, New Mexico, elevation 8000 feet, July 3–5, 1964 (F., P., and M. Rindge), five males; Bear Trap Camp, 28 miles southwest of Magdalena, Socorro County, New Mexico, elevation 8500 feet, July 1–11, 1965 (F., P., and M. Rindge), seven males and five females; Alpine, Apache County, Arizona, June 18, 1936 (G. H. and J. L. Sperry), one male.

All the type material is in the collection of the American Museum of Natural History.

REMARKS: This species flies with its close ally, *regulata*, at all of the known localities for **janetae**. The new species can be separated from *regulata* by its yellowish vertex, the much longer antennal pectinations in the male, by the paler wing color, and by the very large discal spot of each forewing being filled in with yellowish ground color.

The genitalia of the new species are similar to those of *regulata*. The males of **janetae** can be recognized by the distinctive gnathos, the apex of the costa extending above the surface of the valve, and by the straighter and broader furca. The females structures are characterized by the broader, semicircular sterigma, and by the narrower posterior portion of the corpus bursae.

This species is named for Janet, my oldest daughter, who helped collect the topotypical series.

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Further Records of New Jersey Aphids (Homoptera: Aphididae)

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Abstract: Listed are 93 aphids arranged alphabetically by genera and by species under each genus. Detailed records of the localities, dates, food plants and collectors are given for each species and a list of 101 food plants on which the aphids have been collected is included. Of the aphids 20 species and of the food plants 26 have not previously been recorded from New Jersey. At present 227 aphids on 267 plants are known to occur in New Jersey.

This is a third paper on the distribution and food plants of New Jersey aphids. The previous paper entitled "Additional records of New Jersey aphids" was published in the Jour. N. Y. Ent. Soc. **72:** 79–101, 1964. It increased the number of aphids known to occur in New Jersey to a total of 207 on 241 food plants.

The present paper, based largely on collections made during the past three years, 1963–1965, records 93 aphids on 101 plants of which 20 aphids and 26 plants were not in the previous papers. At present 227 aphids on 267 plants are known to occur in New Jersey.

During visits to Haddonfield I have continued to operate a yellow water-pan or Moericke Trap (in text as MT) in the back yard garden at 217 Rhoads Ave. Starting with 1963 I used the inverted top of an old ash can about 22 inches in diameter placed on a standard which raised it about two and one-half feet above the ground. This pan was exposed continuously in 1963 from 23 July to 30 November during which period about 2500 winged aphids were taken from it. Nearly 25% of this total was collected during November and a little over 40% during October, both of which months were unusually mild. Because of the difficulty of identifying so many free-flying aphids only a few of the records of these are here included. It is hoped at some later time more complete records from the yellow water-pan can be published.

LIST OF APHIDS*

Acyrthosiphon dirhodum (Wlk.)—see *Metopolophium.*

**Acyrthosiphon pelargonii* (Kaltenbach), Geranium Aphid. Maywood (Hoffman, Florist), 5 Aug. 1965, a general heavy infestation of all plants of Salmon Irene geraniums (*Pelargonium* sp.) on stock in a greenhouse which is open in the summer (Conlon coll.)

Acyrthosiphon pisum (Harris), Pea Aphid. In November, 1961, L. W.

* Names preceded by an asterisk (*) are in addition to those in the previous two papers.

Coles of the Japanese Beetle Laboratory, USDA, Moorestown, wrote me about the status of parasites of this aphid in New Jersey. This was omitted from "Additional Records." He says: "The parasites of the pea aphid in New Jersey that we are familiar with are *Aphidius pisivorus* C. F. Smith and *Praon simulans* Provancher. We have observed them in all areas of New Jersey every season for the past six years. *A. pisivorus* is very common and very effective we feel. *Praon* can be found commonly but not nearly so as *A. pisivorus*."

Also omitted from "Additional Records" were any notes on the pea aphid although it is given in the Plant List under alfalfa and red clover. The data is as follows: "The pea aphid caused less damage than usual [to alfalfa]. In some areas of southern counties populations reached 200–300 per sweep during May but, in general, populations were much lighter." (Summary of Insect Conditions—1957 in New Jersey in CEIR **8**(1): 6, Jan. 3, 1958.) "Was far less damaging than usual." (Summary of Insect Conditions—1958 in New Jersey in CEIR **9**(7): 189–190, 1958.) New Brunswick, 16, 20 May and Beemerville, 6 May 1960 on alfalfa (Wave coll.), Middlebush, 8 June 1960 on red clover (Wave coll.).

Acyrthosiphon porosum (Sanderson), Yellow Rose Aphid. McGuire Air Force Base, 3 alatae, 2 "pupae," 2 mature and 3 immature apterae, collected from the buds of cultivated rose in mid-May 1965 (Quinden coll.). Second record for New Jersey.

**Acyrthosiphon sibericum* (Mordvilko). Haddonfield, 2 Sept. 1965 on *Urtica* sp. (MDL and DLW coll.—ATO det.).

Although this aphid is recorded as fairly common in the Rocky Mountain Region it is known elsewhere in the USA only by one collection in N. Y. and 2 in Pa.

Acyrthosiphon solani (Kaltenbach) (placed by some in *Aulacorthum*), Foxglove Aphid. New Brunswick, 23 June 1960, 1 mature aptera on *Taraxacum officinale* (Wave coll.). Omitted from the previous paper.

Anoecia corni Fabricius. Haddonfield, 16–30 Sept., 9 alatae; 1–15 Oct., 2 alatae; 16–31, 4 alatae;—1963 and 1–5 Nov. 1965, 2 alatae—all in MT (MDL coll.).

Anuraphis viburnicola (Gillette)—see *Ceruraphis viburnicola* (Gillette).

Aphis coreopsidis Thomas. Whitesbog, 13 July 1961 on *Nyssa sylvatica* (Marucci coll.).

Aphis crataegifoliae Fitch—see *Brachycaudus crataegifoliae* Fitch.

Aphis fabae Scopoli, Bean Aphid. Moorestown, 12 April 1963 on *Euonymus europaeus* (EAR coll.); 21 May 1963 on rhubarb plants in a garden heavily infested, with leaves curled and crinkled (HWA coll.); 5 Sept. 1963 on cult. nasturtiums (EAR coll.). Bordentown, 24 May 1963, abundant on *Philadelphus* sp. (Webber coll.). Ridgewood, 10, 18 June 1963 a few on *Arctium*

minus (MDL coll.). Columbus, 1 Oct. 1963, 20 alatae from *Arctium* sp. (LW Coles coll.). Haddonfield, 27 Aug. 1963, scarce on nasturtiums (MDL coll.).

Dr. Allen's heavily infested rhubarb made me realize that I had seldom seen records of this aphid on rhubarb. A search reveals it appears there are not many in the United States. The files of Survey and Detection Operations, Plant Pest Control Div., USDA have only the following: USDA Yearbook for 1908, p. 570 "caused serious injury to rhubarb in New Jersey"; Manhattan, Kans., 1 July 1948 taken on rhubarb (R. C. Smith coll.—LMR det.); "Serious damage caused to rhubarb on Mar. 20, 1948 in Arcadia." (Calif. Truck Crop Emergency Survey); Palmer in Aphids of the Rocky Mt. Region states that it occurs on rhubarb. For New York there are only two records: Lockport, 1959 and Orient, L.Id, 1962. Amherst, Mass., 6 June 1960 on rhubarb.

Aphis gossypii Glover, Cotton or Melon Aphid. Whitesbog (Pemberton), 13 July 1961, 3 alatae, 3 apterae on *Leucothoe racemosa* and 9 apterae on *Rhododendron* (*Azalea*) *viscosa* (Marucci coll.—JOP det. with query).

In litt. from Marucci—"*Aphis gossypii* apparently can live on ericaceous plants. On 1 Sept. 1947 we found it colonizing blueberries in our screen-house at Pemberton. The aphids were being attended by ants. We used these aphids to try to transmit blueberry stunt disease and they lived quite well on blueberries. USNM made the determination." Moorestown, 15 May 1963, abundant on shoots of rose-of-sharon (MDL coll. in EAR's garden); 13 June 1963, several mature apterae and some younger ones on *Sophora japonica* (EAR coll. in his garden); 21 May 1965, 9 alatae on *Aguilegia longissima* (HWA coll.)—these may be "drifts" since this aphid has been recorded from *Aguilegia* only by Hall in Egypt; 21 May 1965, 8 alatae on tips of several shoots of *Forsythia* sp. (HWA coll.)—these may be "drifts" since this aphid has been recorded from *Forsythia* only in Japan; 9 alatae on buds of peony (HWA coll.)—probably "drifts" since aphids were stuck to the buds and presumably no aphid has been recorded from peony. Haddonfield, 15 May 1963 a very few apterae on *Campsis radicans* (MDS); 19–26 Sept. 1964, an occasional leaf on two rose-of-sharon shrubs with a single alate, one of these near several very small pale young (MDL); mid-May 1965, a very small immature on a tender tip of rose-of-sharon (MDL & DLW coll.). Trenton, 2 Sept. 1964, the "small form" heavy on leaves of *Catalpa* sp. (Stinson coll.). Princeton, 17 Aug. 1964, heavy infestation on small twigs of several 4–5 foot trees of *Sophora japonica* (Stinson coll.).

*?*Aphis incognita* Hottes & Frison. Pemberton, 1948, an alate on sticky board trap in blueberry field (Marucci coll.—LMR det. as "near *incognita*"). This species has been recorded from Utah, Colorado, and Illinois from *Symphoricarpos*.

Aphis oestlundi Gillette. Mt. Laurel, 25 May 1963 on *Oenothera* sp. (HWA

coll.). Indian Mills, 26 May 1963 on *Oenothera* sp. (HWA coll.). Moorestown, 17 Oct. 1963 on *O. biennis* (T. L. Ladd coll.).

Aphis pomi DeGeer, Apple Aphid. Bordentown, 27 May 1963 on crabapple (Weber coll.). Somerville, 19 June 1963 on flowering crab (Stinson coll.). Bridgeton, 7 Aug. 1964 on Jap flowering quince (W. Junghans coll.). Moorestown, 21 May 1965 on Jap flowering crab, heavily infested (HWA coll.).

Aphis pseudohederae Theobald, Ivy Aphid. Haddonfield, 1963—none could be found during the season on the English ivy at 217 Rhoads Ave., until about Sept. 1 when three or four occurred on as many tender tips; on 31 Oct. 4 small colonies (1 or 2 alatae in each) on vines in another similar situation; 2 Dec. a few were found including several alatae from which several atypical *Lysephlebius testaceipes* (Cresson), det. Muesebeck, were reared; on 25 Sept. 1964 a few, including 3 or 4 alatae, on the tender tips of the English ivy on the house at 217 Rhoads Ave. (MDL); 6 Nov. 1965 a very small colony on the same vines attended by the ant, det. D. R. Smith, as *Prenolepis imparis* (Say). Ridgewood, 28 Oct. 1965, a fair sized colony on a tender shoot of an English ivy vine on a tree trunk, attended by the ant, det. by D. R. Smith as *Prenolepis imparis* (Say), (MDL).

Aphis rumicis Linnaeus, Dock Aphid. Rancocus, 13 May 1963, a heavy infestation on *Rumex crispus* (B Puttler coll.). Moorestown, 17 May 1963 on *R. crispus* (EAR coll.). Deerfield, 20 May 1963 on *R. crispus* (Buck coll.). Mt. Laurel, 25 May 1963 on *R. crispus* (HWA coll.).

Aphis spiraecola Patch, Spiraea Aphid. Whitesbog (Pemberton), 13 July 1961, alatae (possibly "drifts") on *Aronia atropurpurea* (Marucci coll.—JOP det.) and 5 apterae on *Lyonia* (*Pieris*) *mariana* (Marucci coll.—JOP det.). Haddonfield, 1963—several plantings of *Spiraea* sp. in a garden only slightly infested throughout the season. Shiloh (Perkins-deWilde Nursery), 15 May 1963, many on *Pyracantha coccinea* var. *lalandi* (Pope coll.). Moorestown, 21 May 1965, terminal growth of *Spiraea prunifolia* and of *Pyracantha* sp. moderately infested (HWA coll.).

Aulacorthum solani (Kalt.)—see *Acyrthosiphon solani* (Kalt.).

Brachycaudus crataegifoliae (Fitch), formerly *Aphis*. Old Bridge (Helka Bros.), 12 Aug. 1964, heavy on leaves of *Crataegus* sp. (Driver coll.).

Brevicoryne brassicae (Linnaeus), Cabbage Aphid. "Observed generally throughout the State on cabbage, broccoli, and other cole crops (Ins.-Dis. Newsltr. in CEIR **14**(33): 941, 14 Aug. 1964).

Calaphis betulaecolens (Fitch) group. Cherry Hill and Haddonfield, 1963 on *Betula lenta* (MDL coll.—Richards det.).

Calaphis betulella Walsh. Haddonfield, 1961, 1 alate in MT (Gladys Testerman coll.); 1–15 Aug. 1963, 3 alatae in MT; 16–22 May 1965, 6 alatae in MT; 24 Aug.–2 Sept. 1965, 1 alate in MT (all MDL).

Calaphis castaneae (Fitch). Medford Lakes, 6 June 1965, 1 alate and

several small apterae, the latter whitish with antennae black, on chestnut (HWA coll.).

Capitophorus elaeagni (Del Guercio), Oleaster Thistle Aphid. Haddonfield, all 1961, alatae in MT—May 15–25, 3; 1–15 June, 3 and Oct. 4 (Gladys Testerman coll.); 26–30 May 1961, 3 (MDL coll.); 1963—1–15 Oct., 4, 16–31, 3, Nov. 1–15, 32, 16–30, 21, all males (MDL coll.); 1–15 Nov. 1965, 3 alatae in MT (MDL coll.). Riverton, 14 Oct. 1963 on *Elaeagnus umbellata* (EAR coll.).

Capitophorus glandulosus (Kaltenbach). Haddonfield, 1963—The small patches of mugwort reported on during the past several seasons were abundantly infested on 26 June but were only very slightly infested during July and early August and none could be found from then on. Nov. 15 one ovipara containing a single egg was blown into the MT and on Nov. 17 several eggs were found on the underside of several lower leaves. None could be found during 1964 nor in 1965 although during this latter year almost all of the mugwort had been pulled out of the garden.

Capitophorus hippophaes (Walker), Polygonum Aphid. Wycoff, 14 Oct. 1960, very abundant on a small patch of *Polygonum caespitosum* var. *longisetum* (det. E. C. Leonard, USNM), (MDL & DDL coll.). Moorestown, 1 Aug. 1962, 1 alate in MT (EAR coll.). Haddonfield, 14 Sept. 1963, scarce on *Polygonum caespitosum* (det. Shetler), (MDL coll.); by daily collecting in MT throughout Oct. and Nov. 1963 at least 100 alatae were obtained, all males (MDL coll.); 29 Aug. and 2 Sept. 1965, scarce on a large patch of *P. pennsylvanicum* (det. Shetler), (MDL & DLW coll.).

Capitophorus ribis (L.)—see *Cryptomyzus ribis* (L.).

Cepegillettea myricae Patch. Medford Lakes, 27 Oct. 1963, several plants of *Comptonia* (*Myrica*) *peregrina* var. *asplenifolia* growing in a woods lightly infested (G. G. Rohwer coll.).

Chaitophorus sp. Haddonfield, 16–31 Nov. 1963, 1 alate in MT (MDL coll. —ANT det.).

Chaitophorus populicola Thomas, Cloudy-winged Cottonwood Leaf Aphid. Haddonfield, 1–15 June 1961, 1 alate in MT (Gladys Testerman coll.). Pittsgrove, 11 Sept. 1963, heavily infested, scattered small aspens, *Populus grandidentata* (C. W. Holsworth, Senior Forester, Parvin State Park coll.). Medford Lakes, 3 June 1965, 1 "stray" alate on laurel (Quinden coll.).

Chaitophorus viminicola Hille Ris Lambers. Indian Mills, 20 May 1963 on *Salix* sp. (HWA coll.—MacGillivray det.). Recorded elsewhere only from Iowa, Illinois, and Pennsylvania.

**Chromaphis jugandicola* (Kaltenbach), Walnut Aphid. Moorestown, 28 Aug. 1965, fairly common on a large English walnut (MDL & EAR coll.).

Cryptomyzus ribis (Linnaeus), (formerly in *Capitophorus*). Currant aphid. Moorestown, 26 May 1963 on currant (HWA coll.).

Dactynotus spp. The following collections were examined by Dr. Olive

who was unable to determine them specifically; Ridgewood, July 1963 on *Rudbeckia hirta* (DDL coll.). Haddonfield, 1, 16 Oct. 1963 on *Aster simplex* (Shetler det.), (MDL coll.); 1–15 Sept. 1963 in MT (MDL coll.); a number of alatae from mid-Sept. to mid-Oct. 1963 in MT (MDL coll.). Moorestown, 26 Aug. 1963 on *Rudbeckia* sp. and many specimens on *Rudbeckia* sp., 30 June 1965 on *Solidago* sp. (HWA coll.).

Dactynotus (*Dactynotus*) *ambrosiae* (Thomas), Brown Ambrosia Aphid. Haddonfield, 20 Sept. 1963 and Ridgewood, 24 Oct. 1963 on *Ambrosia trifida* (MDL coll.—ATO det.).

Dactynotus (*Lambersius*) *anomalae* (Hottes & Frison). The small patch of hardy purple asters in the garden at 217 Rhoads Ave., Haddonfield was moderately infested several times during the 1963 season but most of the colonies dried up. Predators were often present but no parasites were observed. The last collection was made 18–22 Oct. and soon after the plants were mostly dead. No aphids were observed on these plants in 1964 and fairly early in 1965 all the plants were dug out.

Dactynotus (*Dactynotus*) *chrysanthemi* (Oestlund). Medford, 11 Sept. 1963 on *Bidens coronata* var. *trichosperma* (EAR coll.).

**Dactynotus* (*Uromelan*) *eupatorifoliae* Tissot. Haddonfield, 27, 30 Sept. 1963, fairly common on a small patch of *Eupatorium rugosum* (Shetler det.), (MDL coll.—ATO det.).

**Dactynotus* (*Lambersius*) *gravicornis* (Patch). Haddonfield, 27, 30 Sept. 1963 on *Solidago rugosa* (MDL coll.—ATO det.).

**Dactynotus* (*Dactynotus*) *leonardi* Olive. Ridgewood, July 1963 on *Rudbeckia hirta* (paratypes) and Aug. 1964 on *R. hirta* (DDL coll.—ATO det.).

Dactynotus (*Dactynotus*) *sonchellus* (Monell). Indian Mills, 26 May 1963 on *Lactuca* sp. (HWA coll.—ATO det.).

**Dactynotus* (*Uromelan*) *taraxaci* (Kaltenbach), Dark Dandelion Aphid. Cherry Hill, 5 Nov. 1963, a number of dandelion plants, on leaves and some of the stems, heavily infested with apterae in a back yard lawn and on Nov. 11 many more found, including two alates (DLW coll.—ATO det.).

Dactynotus (*Lambersius*) *tissoti* (Boudreaux). Haddonfield, 27, 30 Sept. and 15 Oct. 1963 on *Solidago rugosa* (Shetler det.), (MDL coll.—ATO det.).

Dactynotus (*Uromelan*) *tuataiae* Olive—Correction to records in "Additional Records"—the data for this species should read as follows: Medford Lakes, 2 Aug. 1962 (G. G. Rohwer coll.) and Moorestown 1 Aug. 1962 (HWA coll.), both on *Ambrosia artemisiifolia*.

Drepanaphis sp. Haddonfield, 16–31 Oct. 1963, 26 males in MT (MDL coll. —CFS det. who writes "I cannot identify these at the present time.").

Drepanaphis acerifolii Thomas, Painted Maple Aphid. Haddonfield, 15 Sept. 1963 on *Acer rubrum* var. *trilobum* (MDL coll.—CFS det.); 25 Sept. 1963 a large *trilobum* maple very heavily infested (MDL coll.—CFS det.); 4

Oct. many males, oviparae, nymphs and 16 Oct. 1963 males and oviparae on *trilobum* maple; in MT, 1963—Aug., 1 alate, 1–15 Sept., 1 alate, 15–30 Sept., 5 alatae, 16–31 Oct., 26 alatae. Cherry Hill, 30 Sept. 1963 apterae on a *trilobum* maple (MDL & DLW coll.—CFS coll.).

**Drepanaphis carolinensis* Smith. Haddonfield, 15 Sept. 1963, 1 alate on *trilobum* maple (MDL coll.—CFS det.); 16–30 Sept. 1963, 4 alatae in MT (MDS coll.—CFS det.).

Drepanaphis parvus Smith. Haddonfield, 16–31 Oct., 1963, 2 alatae in MT (MDL coll.—CFS det.). Second record for New Jersey.

**Drepanaphis simpsoni* Smith. Haddonfield, 16–31 Oct., 2 alatae in MT (MDL coll.—CFS det.).

Eriosoma crataegi Oestlund. Princeton Nurseries, Allentown Farm, 3 Aug. 1964 on *Crataegus mollis* (Stinson coll.). Dunellen, 18 Aug. 1964, heavy infestation on *Crataegus* sp. (Stinson coll.).

**Euceraphis lineata* Baker. Ridgewood, 29 Oct. 1962 at Duck Pond, oviparae on *Betula alba* (MDL & DDL coll.—Richards det.).

**Eulachnus rileyi* (Williams). Haddonfield, 1963 in MT—1–15 Oct., 1 alate, 2 Oct., 15 alatae, 3–15 Oct., 1 alate (MDL coll.—ANT det.).

**Georgiaphis ulmi* (Wilson). Bound Brook, 31 May 1963 on leaves and bark of *Ulmus* sp. (Weber coll.—CFS det.).

Hamamelistes spinosus Shimer, Spiny Bud-gall of Witchhazel. Toms River, H. B. Scammell & Son, 10 June 1964 in corrugated leaves of white birch (Pope coll.).

Lachnus salignus (Gmelin), Giant willow Aphid. Freehold, 5 Aug. 1963 on *Salix* sp. (Pope coll.).

**Macrosiphoniella millefolii* (deGeer). Indian Mills, 26 May 1963, several on *Achillea millefolium* (HWA coll.).

Macrosiphoniella sanborni (Gillette), Chrysanthemum Aphid. Haddonfield, 1963—a small patch of chrysanthemums in a garden was uninfested until about mid-Oct. when some colonies began to appear. Moorestown, 21 May 1965, "hardy" mums lightly infested (HWA coll.).

Macrosiphum spp. Haddonfield, 21 Oct. 1963 on *Mentha spicata* (MDL coll.—ATO det.); alatae in MT—1–15, 16–30 Sept. and 1–15 Oct. 1963 (MDL coll.—ATO det.); a number of specimens were collected.

Macrosiphum dirhodum (Wlk.)—see *Metopolophium dirhodum* (Wlk.).

Macrosiphum euphorbiae (Thomas), Potato Aphid. Cherry Hill, 6 May 1962, 1 alate, several young on *Euonymus europaeus* (DLW coll.). Moorestown, 2 Aug. 1962 on tomato in a garden (HWA coll.); 21 May 1965, a single mature aptera among many *Aphis fabae* on rhubarb (HWA coll.). Medford Lakes, 28 May 1963, heavy infestation on cult. roses (G. G. Rohwer coll.). Medford, 31 May 1963 and 17 June 1964, light on tomato (Quinden coll.). Mt. Laurel, 25 May and Indian Mills, 26 May 1963 on *Apocynum cannabinum*

(HWA coll.). Linwood, 29 April 1963 light on *Tulipa* sp. and Shiloh, 15 May 1963, heavy on cult. roses (Buck coll.). Haddonfield, 16–31 Aug., 1 alate and 1–15 Nov., 6 alatae 1963 in MT (MDL coll.—ATO det.); 9–22 May 1965, many alatae in MT (MDL coll.—JOP det.). McGuire Air Force Base, mid-May 1965, several apterae on cult. rose (Quinden coll.).

POTATO APHID (*Macrosiphum euphorbiae*)—NEW JERSEY—Survey at 25 sites in Cumberland, Salem, Gloucester, Burlington, Mercer, Monmouth, and Middlesex counties revealed smaller number of eggs than in 1964; however, percentage of viable eggs higher. Counts higher in Mercer, Monmouth, and Cumberland counties. Table below gives total number of eggs found and percentage which were viable at time of survey, for last 9 years. (Ins.-Dis. Newsltr.). (CEIR 15(19): 447, 1965).

Comparison of Total Number of Eggs and Percentage of Viable Eggs

Year	*1957*	*1958*	*1959*	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*
Total No. Eggs	427	226	1522	178	713	411	745	1192	774
Percent Viable	65.6	53.1	54.7	74.7	25.2	74.2	78.3	45.6	73.6

Note: It should be pointed out that the egg surveys are made on plants of the swamp rose (*Rosa palustris*).

Macrosiphum liriodendri Monell, Tuliptree Aphid. The following collections were inadvertently omitted from "Additional Records": Montclair, 27 May 1954 (Bartlett Tree Research Laboratories). New Brunswick, 10, 26 June 1962 (Wave coll.—CFS det.). Moorestown, 19 July 1962 (HWA coll.) and 29 July 1962 (det. W. Jones coll.). Oldwick, 8 Aug. 1960 (Wave coll.). Westmont, 28 June 1962 (J. J. Earley of PPCD, USDA coll.).

The following collections were made 1963–1965, all on tuliptree unless otherwise specified: Waterford, 26 May 1963, immatures on *Magnolia virginiana* (HWA coll.—ATO det.). Summit, 22 June 1963, common on a very large tree (MDL coll.). Moorestown, scarce, 31 July 1963 (EAR coll.) and 21 May 1965 (HWA coll.). Haddonfield, 24, 31 July, 19 Aug., 13 Sept., and 27 Aug. 1965, a small street shade tree lightly infested when examined on each of these dates (MDL & DLW coll.), Medford Lakes, 6 June 1965, about 35 apterae of various sizes on *Magnolia virginiana* (HWA coll.).

Macrosiphum rosae (Linnaeus), Rose Aphid. Haddonfield, no aphids could be found on roses at 217 Rhoads Ave., except a few in mid-May, until late Sept. 1963 when the tender shoots on one large bush became heavily infested; several alatae in MT, 16–30 Sept. 1963 (MDL coll.—ATO det.); during May, Aug., and in late Dec. 1965 no aphids could be found. Moorestown, 27 Dec. 1965 EAR collected 3 mature apterae and several young on a rose cutting which had been taken indoors—the weather had been unseasonably mild.

**Masonaphis* sp. Cooper Creek, Haddonfield, 2 Sept. 1965 alatae on *Boehmeria cylindrica* (MDL & DLW coll.—MacGillivray det. who states "I cannot place these in any species known to me.").

Masonaphis (*Ericobium*) *azaleae* (Mason). Philip E. Marucci, Cranberry and Blueberry Research Laboratory, N. J. Ag. Exp. Sta., New Lisbon wrote me on 8 Oct. 1965 that Leon Coles' statement in my "Additional Records" in regard to light parasitism by *Aphelinus* sp. needs correction. Marucci says "*Aphelinus* is a very effective parasite of *M. azaleae* in the field. Last year the ratio of mummified aphids to live aphids was 50 to 1 and this year it is about 71 to 1." Ben Puttler writes me, 11 Jan. 1966 that it was he who originally identified this parasite as undoubtedly *Aphelinus semiflavus* How. but that no specimens were preserved. A hyperparasite reared from this aphid from Lebanon State Forest by Marucci was determined by Paul M. Marsh, USNM, as *Logocerus niger* (How.). It has been recorded as parasitizing a species of *Aphidius*.

Melanocallis caryaefoliae (Davis), Black Pecan Aphid. (Richards, Mem. Ent. Soc. Can. 44: 102, 1965 places this in *Tinocallis*). Moorestown, 1 Aug. 1962, 2 alatae in MT (EAR coll.).

**Metopolophium dirhodum* (Walker), Rose Grass Aphid. (Has also been placed in *Acyrthosiphon* and *Macrosiphum*). Ridgewood, 28 Oct. (MDL coll.) and Summit (MDL & DDL coll.), 29 Oct. 1965, rose bushes in the garden had a number of leaves, each bearing on the underside a single (occasionally two) alate, each with a number of newly born young nearby. This is the first time these fall migrants have been noticed on roses in New Jersey (MacGillivray det.).

Monellia caryae (Monell), American Walnut Aphid. (Richards, Mem. Ent. Soc. Can. 44: 99, 1965, places this in *Monelliopsis*). Ft. Lee, 2 July 1909 on *Juglans nigra* (Gillette in Jour. Econ. Ent. 3(4): 367, 1910). Moorestown, 19 July, 1 Aug. 1962, 10 alatae in MT (EAR coll.—Bissell det.). Haddonfield, 29 Aug. 1965, fairly common on several large black walnut trees (MDL & DLW coll.—Bissell det.).

Monellia caryaella Fitch. Moorestown, 23 May 1962, very scarce on large *Juglans nigra* (MDL & EAR coll.—Richards det.).

Monellia costalis (Fitch), Black-margined Aphid. Haddonfield, 30 May 1947 on *Carya* sp. (MDL coll.—Bissell det.); 1–15 Sept. 1963, 1 alate in MT (MDL coll.—Richards det.).

Monellia nigropunctata Granovsky. Haddonfield, 30 May 1947 on *Carya* sp. (MDL coll.—Bissell det.).

Myzocallis alhambra Davidson, Western Dusky-winged Oak Aphid. (Richards, Mem. Ent. Soc. Can. 44: 57, 1965 considers this as merely a melanistic form of *M. punctata* (Monell). (This species was in the Plant List but not in the Aphid List of "Additional Records"). Haddonfield, 30 May 1947, "drift" alatae on chestnut (MDL coll.); 23–31 July, 1 alate, 16–31 Aug., 6 alatae and 1–5 Sept., 6 alatae—all 1963 in MT (MDL coll.). New Brunswick, 15 July 1960, a "drift" alate on *Ulmus americana* (Wave coll.). Moorestown, 1 Aug. 1962, 1 alate in MT (EAR coll.) and 26 Aug. 1965, 1 alate in MT

(EAR coll.). Ridgewood, 18–22 June 1963, 1 alate in MT (MDL coll.). Summit, 22 June 1963 on *Quercus rubra* (MDL & DDL coll.).

Myzocallis bella (Walsh), Haddonfield, Aug. 1963, 3 alatae in MT (MDL coll.—ANT det.).

**Myzocallis exultans* Boudreaux & Tissot. Haddonfield, 15–17 Sept. 1963, 1 alate mixed in with several *M. frisoni* B & T on a small pin oak street tree (MDL coll.—ANT det.); Aug. 1963, 3 alatae in MT (MDL coll.—ANT det.). Medford Lakes, 3 June 1964, 1 "stray" alate on laurel (Quinden coll.).

**Myzocallis frisoni* Boudreaux & Tissot. Haddonfield, 15, 27 Sept. 1963, alatae, nymphs, 3 oviparae from several small moderately infested pin oaks (MDL coll.—ANT det.); 16–31 Aug., 4 alatae and 1–15 Sept. 1963, 4 alatae and 2 alatae, 24 Aug.–2 Sept. 1965 in MT (MDL coll.—ANT det.); 25–28 Aug. 1965 several large colonies on a pin oak (MDL coll.).

Myzocallis melanocera Boudreaux & Tissot. Haddonfield, Aug. 1963, 2 alatae in MT (MDL coll.—ANT det.).

Myzocallis multisetis Boudreaux & Tissot. Haddonfield, 1–15 1963, 2 alatae in MT (MDL coll.—ANT det.).

Myzocallis punctata (Monell), Clear-winged Oak Aphid. Haddonfield, 16–30 Sept. 1963, 1 alate in MT (MDL coll.).

Myzocallis tiliae (Linnaeus), Linden Aphid. Haddonfield, 16–31 Aug., 1 alate, 1–15 Sept., 2 alatae, and 1–15 Nov., 1 alate 1963 all in MT (MDL coll.). Moorestown, 28 Aug. 1965 scarce in a *Tilia europaea* (MDL & EAR coll.).

Myzocallis ulmifolii (Monell), Elm Leaf Aphid, (Richards, Mem. Ent. Soc. Can. 44: 104, 1965 places this in *Tinocallis*). Princeton, 22 Sept. 1965 common on *Ulmus* sp. (Weber coll.).

Myzocallis walshii (Monell). Cherry Hill, 30 Sept. 1963, a few leaves of a large *Quercus velutina* lightly infested, alatae and nymphs present (MDL & DLW coll.—ANT det.). Haddonfield, Aug. 1963, 2 alatae and 16–31 Oct. 1963, 2 alatae in MT (MDL coll.—ANT det.).

Myzus cerasi (Fabricius), Black Cherry Aphid. Helmetta, 5 Aug. 1964, light on leaves of Kwanzan cherry, *Prunus* sp. (Driver coll.). Moorestown, 21 May 1965, a cult, sour cherry, *Prunus cerasus*, lightly infested (HWA coll.).

**Myzus dianthi* Schrank, Carnation Aphid. In my "Additional Records" *Myzus polaris* Hille Ris Lambers is recorded from Weston, 5 April 1946 on carnation (F. S. Smith coll., 1 slide in USNM). It has since been found that this is the carnation aphid.

This aphid and/or *Myzus persicae* presumably occurs on carnations in New Jersey but no collections (other than the above) have been made to substantiate the presence of either. However, on 31 Dec. 1965 I visited a florist in Barrington who had a large glass house of carnations. Unfortunately time did not permit me to examine any of the plants but I was told by the production

foreman that small infestations of a small greenish aphid occasionally appeared but were readily held in check by timely applications of an insecticide.

Myzus persicae (Sulzer), Green Peach Aphid. Moorestown, 19 Sept. 1962, many on *Cleome spinosa* (MDL & EAR coll.); omitted from "Additional Records." Linwood, 4 June 1963, a heavy infestation on *Anthurium* sp. (Sohl coll.). Mrs. Sohl writes that "the tips and flower stems of the new growth of many plants growing in a greenhouse were heavily infested and that the leaves and flowers were affected by slight crinkling and/or gnarling." I can find no previous record of any aphid on this plant. Haddonfield, 1963, alatae in MT; 23–31 July, 2; 1–15 Aug., 5; 16–31 Aug., 1; 1–15 Sept., 7; 16–30 Sept., 1; 1–15 Oct., 3; (MDL coll.); 24 Aug.–2 Sept. 1965, 25 alatae in MT (MDL coll.).

New Jersey—"Heavy flight noted throughout State during past week. Control recommended for peppers and tomatoes." (Ins.-Dis. Newsltr. in CEIR 15(32): 897, 6 Aug. 1965). New Jersey—"Increasingly important on broccoli in southern area; controls recommended." (Ins.-Dis. Newsltr. in CEIR 15(34): 968, 20 Aug. 1965).

Ridgewood, 27 Oct. 1965, the buds and stems moderately infested in a large house of 'mums (Schweinfurth's Florists), (MDL & DDL coll.). Barrington, 31 Dec. 1965, a large greenhouse of 'mums very lightly infested. The propagation foreman told me that occasional spraying readily held the aphids in check. Summit, 30 Oct. 1965, a very few apterae on an indoor plant of Jerusalem cherry (MDL coll.).

P. E. Marucci wrote me on 8 Oct. 1965 "I am sure *Myzus persicae* often invades strawberries. Last year a very heavy infestation of peppers overflowed into adjacent strawberries and the population was so high that the grower found it necessary to spray for them."

On 20 May 1965 E. A. Richmond found a number of plants of *Duranta repens* moderately infested in the Mall, a large enclosed shopping center at Cherry Hill. The writer and Dr. Richmond examined these plants together on 28 Aug. At this time no aphids could be found but the leaves were rather heavily infested with a whitefly. I find only one previous record of the occurrence in the USA of this aphid on this plant. In 1900 Gillette and Taylor published Colorado Agr. Exp. Sta. Bull. 133 entitled "A few orchard plant lice." In the discussion of *Myzus persicae* a list of plants is given on which this aphid had been found establishing colonies in the greenhouses (presumably at Ft. Collins). One of the plants listed is *Duranta plumieri* (now *repens*). It has been reported elsewhere from Egypt and Israel.

Neoceruraphis viburnicola (Gillette), (formerly in *Anuraphis*), Snowball Aphid. Haddonfield, 13 Nov. 1963, 1 viviparous alate and several oviparae on a large *Viburnum opulus* (MDL coll.). Moorestown, 21 May 1965, a *Viburnum* sp. heavily infested with heavily parasitized aphids (HWA coll.); many para-

sites emerged within the next four days in a covered box and were identified by Paul Marsh, USNM as *Lysephlebius testaceipes* (Cresson).

Neoprociphilus aceris (Monell). Chatham, 21 May 1963 on sugar maple, woolly aphids (Weber coll.).

Ovatus crataegarius (Walker), Mint Aphid. Medford, 28 July 1963, 34–40 apterae; 18 May 1965, 3 alatae, several "pupae" and apterae; 6 June 1965, several alatae and apterae, 4 of the latter obviously parasitized; a small dipterous larvae also present—all on mint and coll. by Quinden.

Periphyllus californiensis Shinji. Haddonfield, 9–15 May 1965, 540 alatae in MT most of which came to the yellow pan in the first 4 days. The total number of aphids in the pan during the week was 1336 of which this aphid constituted about 40%. 16–22 May 1965, 15 alatae of this aphid in the MT out of a total of 647 aphids. This species was described from California and has been recorded elsewhere from Washington and Pennsylvania and once before, with a query, in New Jersey. It is recorded as feeding on Japanese maple.

Periphyllus negundinis Thomas, Boxelder Aphid. Moorestown, 24 Sept. 1963, scarce on a large boxelder (MDL & HWA coll.); 21 May 1965, a boxelder heavily infested and leaves sticky with honeydew (HWA coll.).

Phyllaphis fagi (Linnaeus). Bound Brook, 31 May 1963 on beech (Weber coll.—CFS det.). Haddonfield 1963—the copper beech at 213 Rhoads Ave. only very slightly infested when first observed on 28 June and continued so until into Oct. at which time somewhat more were present and 9 alatae were obtained; 1965—in mid-May this tree was heavily infested and sticky with honeydew; alatae scarce on leaves but infested leaves placed in a closed box soon produced many alatae.

Rhopalosiphum maidis (Fitch), Corn Leaf Aphid. Bridgeton, 30 July 1963, a heavy infestation on the stalks of corn (Sohl coll.).

Rhopalosiphum nymphaeae (Linnaeus), Waterlily Aphid. Saddle River, 17 June 1965, a heavy infestation on pond lilies in a greenhouse (Wm. Tricker, Inc.), (Condon coll.), Chatsworth, 26 Sept. 1965 on *Nuphar advena*, a number of plants considerably infested (HWA coll.).

Rhopalosiphum serotinae Oestlund. Waterford, 26 May 1963 on *Solidago* sp., 17 apterae (HWA coll.).

**Schizolachnus piniradiatae* (Fabricius). Boonton, 22 July 1964 on *Pinus resinosa* (Kegg coll.).

**Therioaphis maculata* (Buckton), Spotted Alfalfa Aphid. In regard to the first find of this aphid in New Jersey L. Donald DeBlois, Entomologist, Division of Plant Industry, N. J. Dept. Agr. wrote me on May 6, 1965 as follows: "The collections were made in the course of a survey for this insect during the fall of 1964 in 95 alfalfa fields throughout New Jersey. Rough sorting of the collections was done here and final identifications were made by Louise

Russell. The spotted alfalfa aphid collections were made by one of our inspectors, G. Robert Glass. One alate and one apterous viviparous female was taken in Greenwich in Cumberland County on September 24, 1964. We will be making extensive surveys throughout the State to determine the extent of the infestation."

1965—Cape May County: Woodbine 29 Nov., 7 apterae. Cumberland County: Canton 23 Sept., 100 apterae; Greenwich 11 apterous viviparae, 1 ovipara; Jones Island 17 Nov., 4 apterae; Rhoadstown 23 Sept., 9 apterae; Shiloh 23 Nov., 5 apterae. Gloucester County: Jefferson 10 Dec., 1 aptera; Mullica Hill 23 Nov., 1 aptera; Pitman 23 Nov., 1 aptera. Salem County: Alloway 21 Sept., 1 aptera; Centerton 20 Sept., 4 apterae; Elmer 20 Sept., 10 apterae; Hancock's Bridge 23 Sept., 8 apterae. All collections were made on alfalfa by G. R. Glass and submitted by L. D. DeBlois both of the N. J. Dept. Agr. Trenton, N. J. Determinations by Louise M. Russell, Ent. Res., USDA, Washington, D. C.

(*Therioaphis trifolii* (Monell), Yellow Clover Aphid. Ben Puttler wrote me on 11 Jan. 1966 that he has taken *Aphelinus semiflavus* Howard from this aphid in New Jersey.)

FOOD PLANT LIST*

Acer negundo (Boxelder)
Periphyllus negundinis
Acer rubrum var. *trilobum*
Drepanaphis acerifolii
Drepanaphis carolinensis
Acer saccharum (Sugar or Hard Maple)
Drepanaphis acerifolii
Neoprociphilus aceris
**Achillea millefolium* (Common Yarrow)
Macrosiphoniella millefolii
Alfalfa—see *Medicago*
Ambrosia trifida (Giant Ragweed)
Dactynotus ambrosiae
**Anthurium* sp.
Myzus persicae
Apocynum cannabinum (Dogbane)
Macrosiphum euphorbiae
**Aquilegia longissima* (Longspur Columbine)
Aphis gossypii
Arctium sp. (Burdock)
Aphis fabae
Arctium minus (Common Burdock)
Aphis fabae
**Aronia atropurpurea*
Aphis spiraecola
Artemisia vulgaris (Mugwort)
Capitophorus glandulosus
Aspen—see *Poplus grandidentata*
Aster novae-angliae (New England or Hardy Purple Aster)
Dactynotus anomalae
**Aster simplex*
Dactynotus sp.
**Azalea viscosa* (Swamp Azalea)
?Aphis gossypii
Beech—see *Fagus*
Betula alba (European White Birch)
Euceraphis lineata
Hamamelistes spinosa
Betula lenta (Black Birch)
Calaphis betulaecolens group
**Bidens coronata* var. *trichosperma*
Dactynotus chrysanthemi
Birch—see *Betula*
Blackeyed Susan—see *Rudbeckia hirta*
Blueberry—see *Vaccinium corymbosum*
**Boehmeria cylindrica*
Masonaphis sp.
Boxelder—see *Acer negundo*
Brassica oleracea var. *botrytis* (Broccoli)
Brevicoryne brassicae

* Plants marked with an asterisk (*) are additions to the two previous lists.

Myzus persicae
Brassica oleracea var. *capitata* (Cabbage)
Brevicoryne brassicae
Broccoli—see *Brassica oleracea* var. *botrytis*
Burdock—see *Arctium*
Cabbage—see *Brassica oleracea* var. *capitata*
Campsis (*Tecoma*) *radicans* (Trumpet Creeper)
Aphis gossypii
Capsicum frutescens (Redpepper)
Myzus persicae
Carnation—see *Dianthus*
Carya sp. (Hickory)
Monellia costalis
Monellia nigropunctata
Castanea dentata (American Chestnut)
Calaphis castaneae
Catalpa sp.
Aphis gossypii
Chaenomeles sp. (Flowering Quince)
Aphis pomi
Cherry, Sour—see *Prunus cerasus*
Chestnut—see *Castanea*
Chinese Scholar Tree—see *Sophora japonica*
Chrysanthemum sp.
Macrosiphoniella sanborni
Myzus persicae
Cleome spinosa
Myzus persicae
Columbine—*Aquilegia*
Comptonia (*Myrica*) *peregrina* var. *asplenifolia* (Sweetfern)
Cepegillettea myricae
Corn—see *Zea*
Cowlily—see *Nuphar advena*
Crab, Flowering—*Malus* sp.
Crataegus sp. (Hawthorn)
Brachycaudus crataegifoliae
Eriosoma crataegi
**Crataegus mollis*
Eriosoma crataegi
Currant—see *Ribes*
Dandelion—see *Taraxacum*
Dianthus caryophyllus (Carnation)
Myzus dianthi
Dock, Curled—see *Rumex crispus*
Dogbane—see *Apocynum*
**Duranta repens* (Golden Dewdrop)
Myzus persicae
Elaeagnus umbellata
Capitophorus elaeagni
Elm—see *Ulmus*
English Ivy—*Hedera*
Euonymus europaeus (European Spindletree)
Aphis fabae
Macrosiphum euphorbiae
**Eupatorium rugosum* (White Snakeroot)
Dactynotus eupatorifoliae
Evening Primrose—see *Oenothera*
Fagus sp. (Beech)
Phyllaphis fagi
Fagus sylvatica var. *purpurea* (Copper or Purple Beech)
Phyllaphis fagi
Firethorn—see *Pyracantha*
Quince, Flowering—see *Chaenomeles*
**Forsythia* sp.
Aphis gossypii
Fragaria sp. (Strawberry)
Myzus persicae
Geranium—see *Pelargonium*
Golden Dewdrop—see *Duranta*
Goldenrod—see *Solidago*
Hawthorn—see *Crataegus*
Hedera helix (English Ivy)
Aphis pseudohederae
**Helianthus annuus* (Common Sunflower)
Aphis helianthi
Hibiscus syriacus (Rose-of-Sharon)
Aphis gossypii
Hickory—see *Carya*
Ipomoea batatas (Sweet Potato)
Myzus persicae
Jerusalem Cherry—see *Solanum pseudocapsicum*
Juglans nigra (Black Walnut)
Monellia caryae
Monellia caryaella
**Juglans regia* (English or Persian Walnut)
Chromaphis juglandicola
Lactuca sp. (Lettuce)
Dactynotus sonchellus
Lettuce—see *Lactuca*
**Leucothoe racemosa*
Aphis gossipyi
Linden—see *Tilia*
Liriodendron tulipifera (Tuliptree)
Macrosiphum liriodendri

Lycopersicon esculentum (Tomato)
Macrosiphum euphorbiae
Myzus persicae
Lyonia (*Pieris*) *mariana* (Stagger bush)
Aphis spiraecola
**Magnolia virginiana* (Sweetbay)
Macrosiphum liriodendri
Malus sp. (Flowering Crab)
Aphis pomi
Maple, Hard or Sugar—see *Acer saccharum*
Medicago sativa (Alfalfa)
Acyrthosiphon pisum
Therioaphis maculata
Mentha sp. (Mint)
Ovatus crataegarius
Mentha spicata (Spearmint)
Macrosiphum sp.
Mint—see *Mentha*
Mockorange—see *Philadelphus*
Mugwort—see *Artemisia vulgaris*
Nasturtium—see *Tropaeolum*
**Nuphar advena* (Cowlily)
Rhopalosiphum nymphaeae
Nyssa sylvatica (Tupelo)
Aphis coreopsidis
Oak—see *Quercus*
Oenothera sp. (Evening Primrose)
Aphis oestlundi
Oenothera biennis (Common Evening Primrose)
Aphis oestlundi
**Pelargonium* sp. (Geranium)
Acyrthosiphon pelargonii
Peonia sp.
Aphis gossypii
**Philadelphus* sp. (Mockorange)
Aphis fabae
Pine—see *Pinus*
Pinkweed—see *Polyonum pennsylvanicum*
**Pinus resinosa* (Red Pine)
Schizolachnus piniradiatae
**Polygonum caespitosum*
Capitophorus hippophaes
**Polygonum caespitosum* var. *longisetum*
Capitophorus hippophaes
Polygonum pennsylvanicum (Pinkweed)
Capitophorus hippophaes
Populus grandidentata (Aspen)
Chaitophorus populicola
Prunus sp. (Kwanzan Cherry)
Myzus cerasi
Prunus cerasus (Sour Cherry)
Myzus cerasi
Pyracantha sp. (Firethorn)
Aphis spiraecola
Pyracantha coccinea var. *lalandi* (Laland Firethorn)
Aphis spiraecola
Quercus palustris (Pin Oak)
Myzocallis exultans
Myzocallis frisoni
Quercus rubra (Red Oak)
Myzocallis alhambra
Quercus velutina (Black Oak)
Myzocallis walshii
Ragweed—see *Ambrosia*
Red Clover—see *Trifolium pratense*
Redpepper—see *Capsicum*
Rheum rhaponticum (Rhubarb)
Aphis fabae
Macrosiphum euphorbiae
Rhubarb—see *Rheum*
Ribes sp. (Currant)
Cryptomyzus ribis
Rosa sp. (Rose)
Acyrthosiphon porosum
Macrosiphum euphorbiae
Macrosiphum rosae
Metopolophium dirhodum
Rosa palustris (Swamp Rose)
Macrosiphum euphorbiae
Rose of Sharon—see *Hibiscus*
Rudbeckia (*serotina*) *hirta* (Blackeyed Susan)
Dactynotus sp.
Dactynotus leonardi
Rumex crispus (Curled Dock)
Aphis rumicis
Salix sp. (Willow)
? *Chaitophorus viminicola*
Lachnus salignus
Snakeroot—see *Eupatorium rugosum*
**Solanum pseudocapsicum* (Jerusalem Cherry)
Myzus persicae
Solidago sp. (Goldenrod)
Dactynotus sp.
Rhopalosiphum serotinae
Solidago rugosa
Dactynotus gravicornis
Dactynotus tissoti
**Sophora japonica* (Chinese Scholar Tree)

Aphis gossypii
Spiderflower—see *Cleome*
Spindle Tree, European—see *Euonymus*
Spiraea sp.
Aphis spiraecola
**Spiraea prunifolia* (Bridalwreath Spiraea)
Aphis spiraecola
Staggerbush—see *Lyonia*
Strawberry—see *Fragaria*
Sunflower—see *Helianthus*
Sweetbay—see *Magnolia virginiana*
Sweetfern—see *Comptonia*
Sweetpotato—see *Ipomoea*
Taraxacum officinalis (Common Dandelion)
Acyrthosiphon solani
Dactynotus taraxaci
**Tilia europaea* (European Linden)
Myzocallis tiliae
Tomato—see *Lycopersicon*
Trifolium pratense (Red Clover)
Acyrthosiphon pisum
Tropaeolum sp. (Nasturtium)
Aphis fabae
Trumpet creeper—see *Campsis*
Tulipa sp.
Macrosiphum euphorbiae
Tulip Tree—see *Liriodendron*
Tupelo—see *Nyssa*
Ulmus sp. (Elm)
Georgiaphis ulmi
Myzocallis ulmifolii
Urtica sp. (Nettle)
Acyrthosiphon sibericum
Vaccinium corymbosum (cult. Highbush Blueberry)
Aphis gossypii
Masonaphis azaleae
Viburnum sp.
Neoceruraphis viburnicola
Willow—see *Salix*
Yarrow—see *Achillea*
Zea mays (Corn)
Rhopalosiphum maidis

Acknowledgments

As in the past a number of persons, in addition to the writer (MDL), made several to a number of collections each. These included again: Drs. Harry W. Allen (HWA) and E. Avery Richmond (EAR) of Moorestown, Gregory G. Rohwer of Medford, Marie C. Quinden of Medford Lakes, Donald D. Leonard (DDL) of Ridgewood and David L. Winters (DLW) of Haddonfield. Several members of the Staff of the Division of Plant Industry, New Jersey Department of Agriculture collected—Wm. F. Condon, Addison Driver, Frank N. Pagliaro, Geo. L. Pope, Francis S. Stinson, W. A. Junghans, J. D. Kegg, and Paul V. V. Weber as well as B. K. Buck and Irene H. Sohl of the Plant Pest Control Division, A.R.S., U. S. Department of Agriculture.

Determinations, other than those by the author, were made by: Miss Louise M. Russell (LMR), Ent. Res. Div., A.R.S., U.S.D.A.; Dr. A. Tom Olive (ATO), Wake Forest College, Winston-Salem, N. Car.; Dr. Clyde F. Smith (CFS), North Carolina State University, Raleigh, N. Car.; Prof. John O. Pepper (JOP), Pennsylvania State University, University Park, Pa.; Prof. Theo. L. Bissell, University of Maryland, College Park, Maryland; and Dr. Archie N. Tissot (ANT), University of Florida, Gainesville, Florida. Dr. Stanwyn G. Shetler, Dept. Botany, U. S. National Museum, Washington, D. C. kindly made several determinations of plants.

To all of the above—those who collected and those who determined—I extend my sincere thanks for their help.

Dr. John B. Schmitt has been kind enough to oversee the preparation of the final typescript of this paper.

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Further Studies on the Internal Anatomy of the Meloidae. III. The Digestive and Reproductive Systems as Bases for Tribal Designation of *Pseudomeloe miniaceomaculata* (Blanchard)* (Coleoptera: Meloidae)

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Abstract: The digestive and reproductive systems of *Pseudomeloe miniaceomaculata* (Blanchard) has been described. On the basis of such internal anatomical features as V-shaped folds in the stomodaeal intima, absence of a basal spermathecal diverticulum, a tubular female accessory gland, an irregularly convoluted first pair and a recurved or bent second pair of male accessory glands, this genus is placed in the tribe Eupomphini of the subfamily Meloinae. The inclusion of *Pseudomeloe* in Eupomphini now extends the distribution of this tribe to South America as well.

In 1928, Van Dyke defined the tribe Calospastini (= Eupomphini) and stated that "the tribe is restricted to North America." Gupta (1965) showed that all the members of this tribe shared several internal anatomical features. On examination, the South American blister beetle, *P. miniaceomaculata* was found to possess all the characteristic tribal features of Eupomphini, as defined by the present writer (1965). The purpose of the present paper is to describe the internal anatomy of this beetle, and to establish its inclusion in the tribe Eupomphini. The beetles were collected and identified by Dr. Antonio Martinez, Buenos Aires, Argentina, and were kindly made available to the author by him.

MATERIALS AND METHODS

For technical details, the reader is referred to the earlier work (Gupta, 1965). In the present paper, descriptions have been kept to the minimum, and are meant to supplement the diagrams, and point out important features. In the drawings of the reproductive systems, only the organs of one side have been shown. In the drawing of the male reproductive system, the second pair of accessory glands has been stippled to distinguish it from others. Phase contrast photomicrographs of the stomodaeal intima are included for the first time in this series of papers. All photomicrographs were taken by Leitz dark phase microscope at magnifications of 250× and 400×. For this purpose, the intima was lightly stained in azocarmine.

DESCRIPTIONS

DIGESTIVE SYSTEM: EXTERNAL (Fig. 1):

Esophagus much broadened posteriorly; ventriculus with few remnants of transverse wrinkles; lobes of pyloric valve barely visible externally; six malpighian tubules arising

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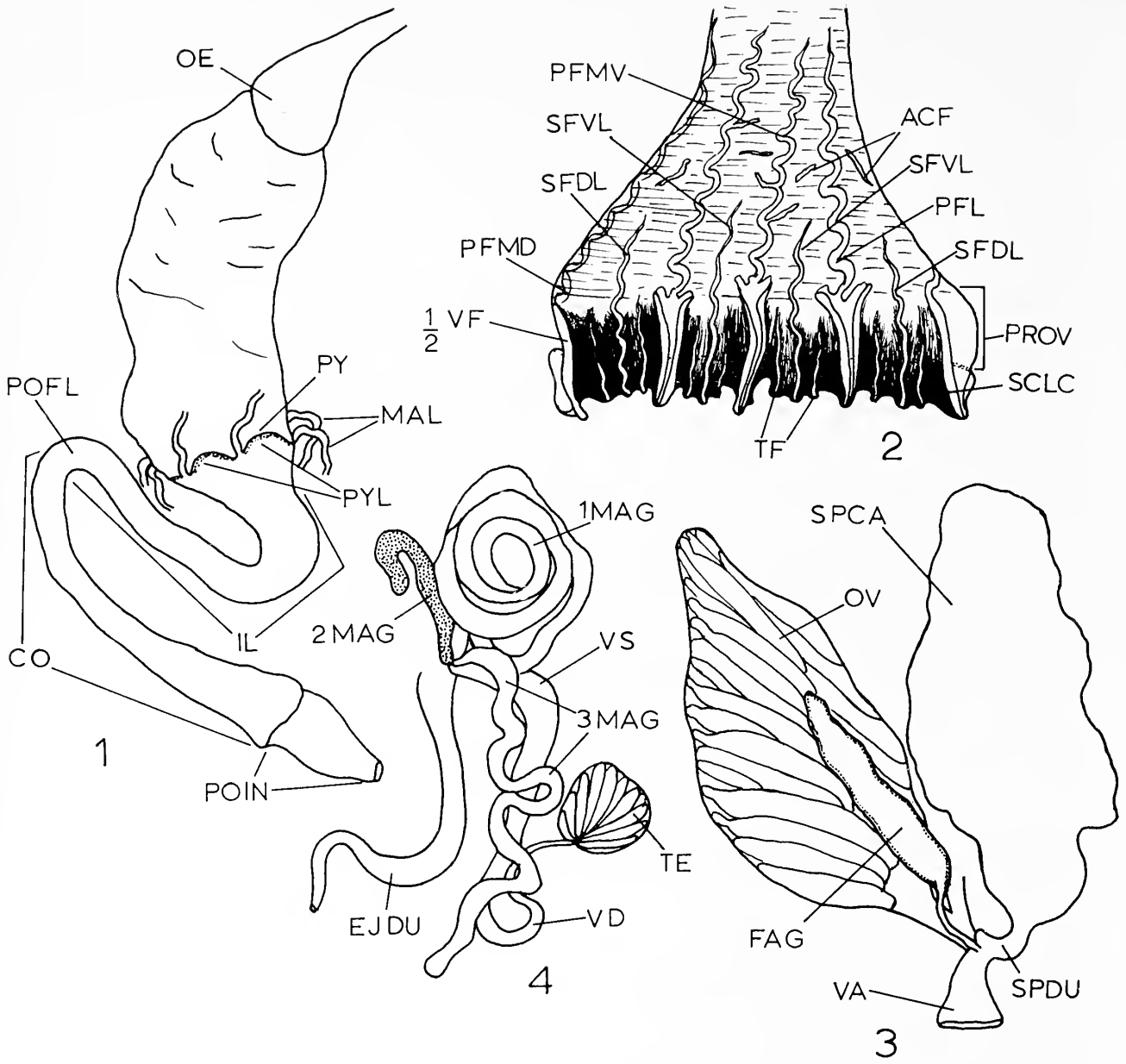
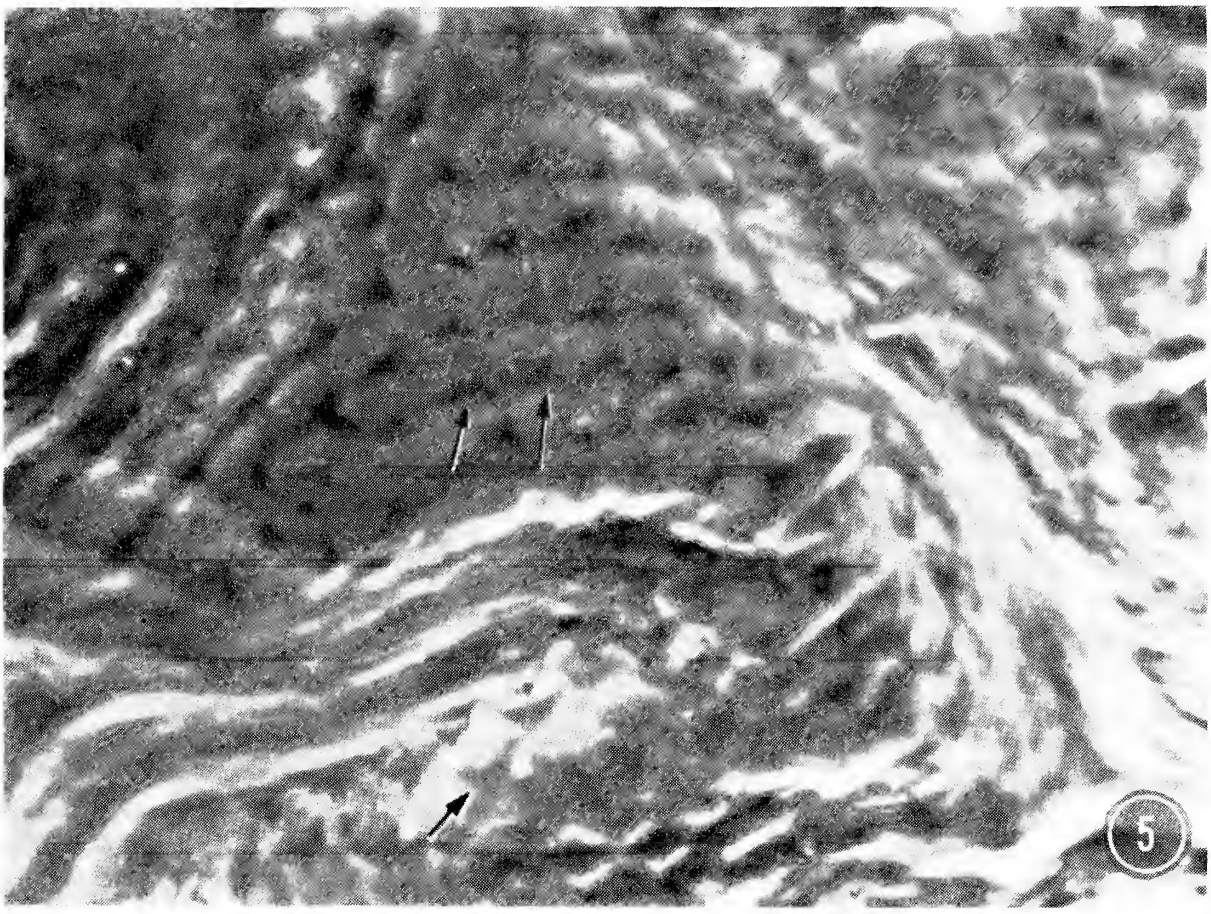


FIG. 1. Lateral view of alimentary canal.
FIG. 2. Internal view of stomodaeum.
FIG. 3. Female reproductive system, dorsal view.
FIG. 4. Male reproductive system, ventral view.

ABBREVIATIONS USED IN FIGURES

ACF . . . . . accessory folds
CO . . . . . colon
EJDU . . . . . ejaculatory duct
FAG . . . . . female accessory gland
IL . . . . . ileum
1MAG . . first pair of male accessory gland
2MAG . second pair of male accessory gland
3MAG . third pair of male accessory gland
MAL . . . . . malpighian tubules
OE . . . . . esophagus
OV . . . . . ovary
PFL . . . . . lateral primary fold
PFMD . . . . median dorsal primary fold
PFMV . . . . median ventral primary fold
POFL . . . . . posterior flexure
POIN . . . posterior intestine or rectum
PROV . . . . . proventriculus
PY . . . . . pylorus
PYL . . . . . lobes of pyloric valve
SCLC . . . . . sclerotized channel
SFDL . . . . . dorsolateral secondary fold
SFVL . . . . ventrolateral secondary fold
SPCA . . . . . spermathecal capsule
SPDU . . . . . spermathecal duct
TE . . . . . testis
TF . . . . . tertiary fold
VA . . . . . vagina
VD . . . . . vas deferens
VF . . . . . V-shaped fold
VS . . . . . vesicula seminalis



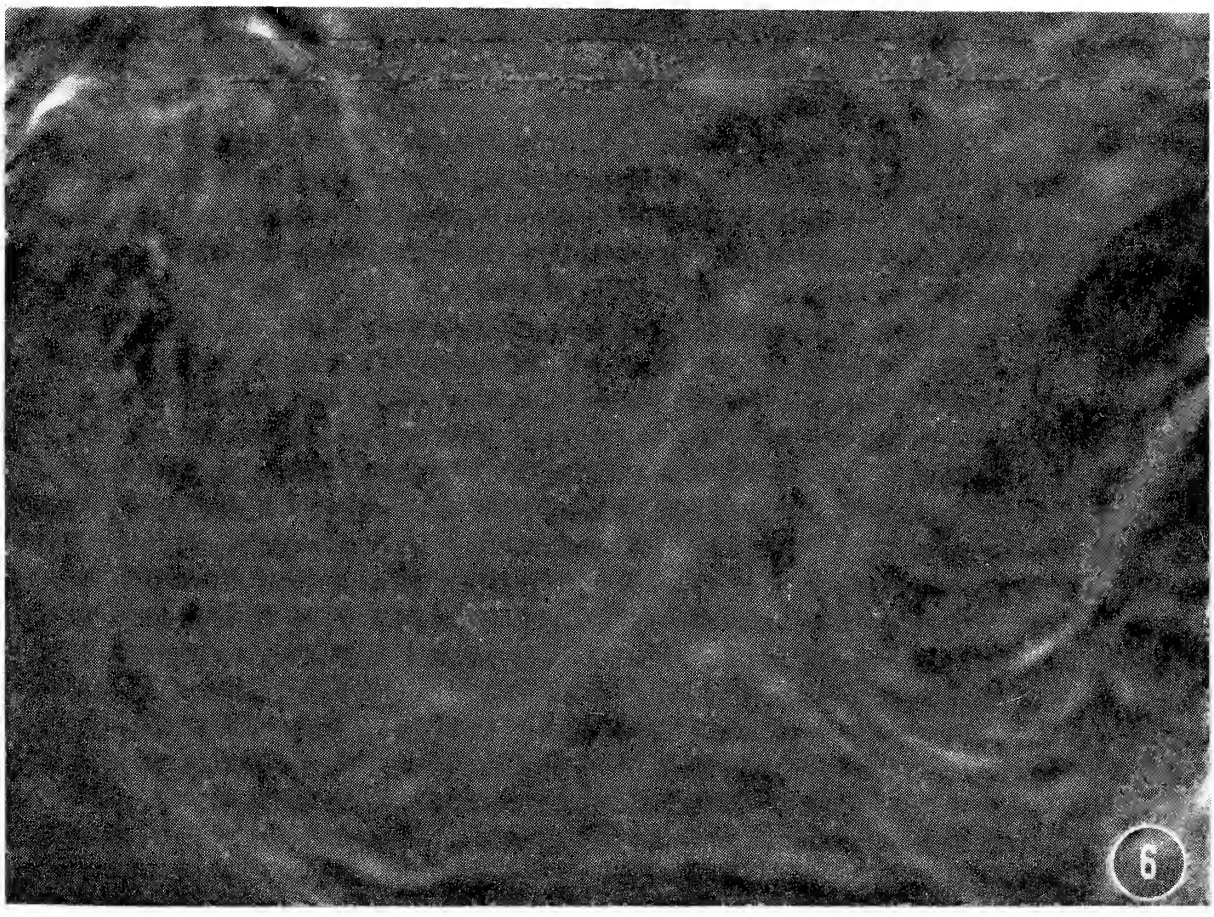


FIG. 5. Magnified view of stomodaeal intima showing emarginate thickenings provided with microscopic spines (arrows).

FIG. 6. Magnified view of portion of median ventral primary fold showing stout spines.

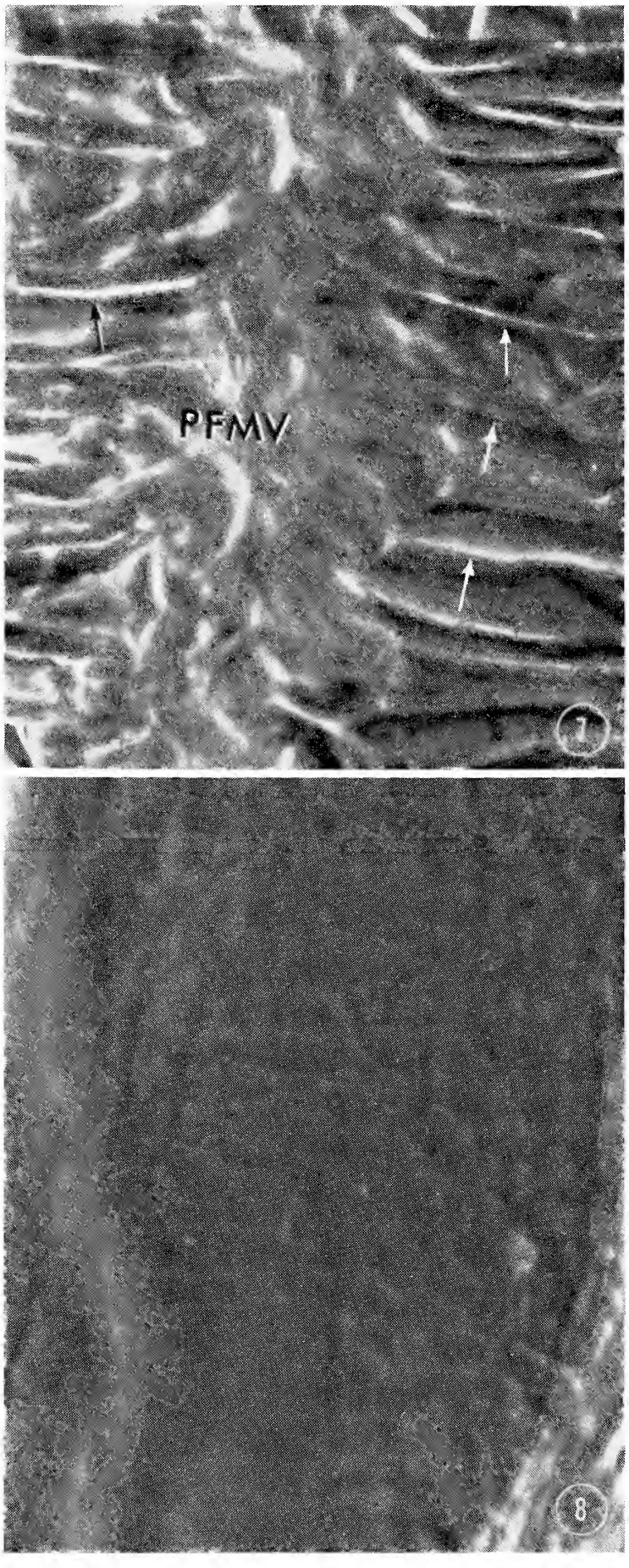


FIG. 7. Magnified view of portion of median primary fold and transverse corrugations (arrows).

FIG. 8. Magnified view of portion of sclerotized channel showing irregular rectangular and polygonal patterns.

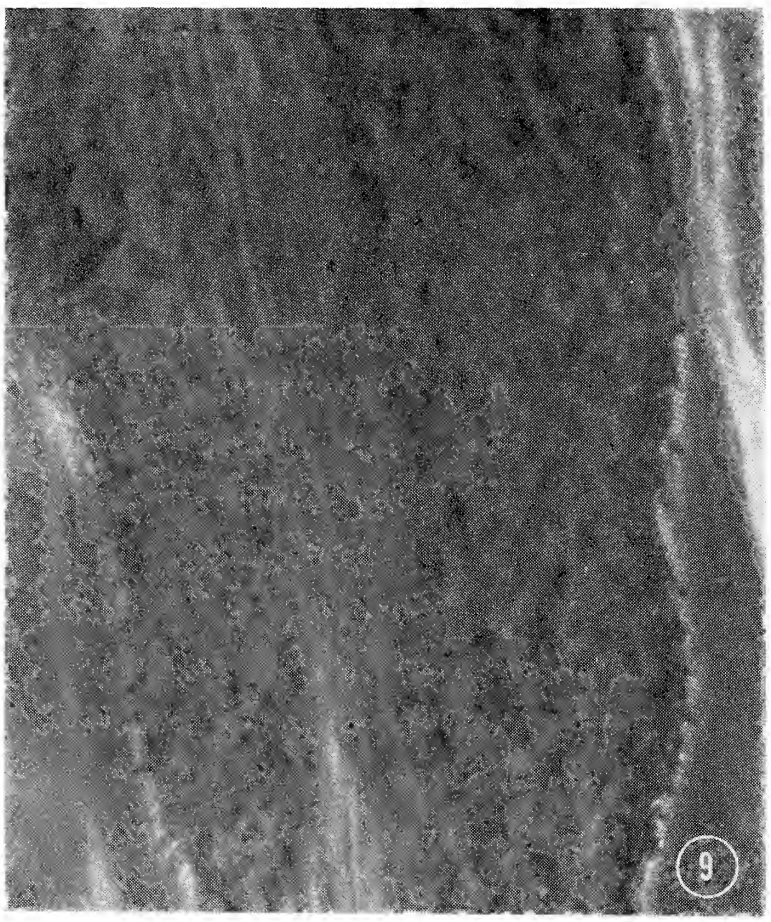
separately, their posterior attachment at inner bend of posterior flexure, basal swelling absent. INTERNAL (Figs. 2, 5–10): Stomodaeal intima with 4 primary, 4 V-shaped, 4 secondary and 8 tertiary folds, several irregularly arranged accessory folds present in regions of esophagus and proventriculus; transverse corrugations discontinuous; V-shaped folds continued posteriorly into primary stomodaeal lobes and flanking sclerotized channels, latter more sclerotized than those flanked by secondary and tertiary folds, latter flanking sclerotized channels between secondary and V-shaped folds in proventricular region, surface of stomodaeal intima with emarginate thickenings provided with microscopic spines, spines on primary, V-shaped and secondary folds stout, spines also present on apices of stomodaeal lobes, surface of sclerotized channels with irregular rectangular and polygonal pattern without spines. Stomodaeal valve with 4 primary lobes, secondary and tertiary lobes poorly developed.

REPRODUCTIVE SYSTEM: FEMALE (Fig. 3):

Spermathecal capsule robust, constricted near base, portion beyond constriction broadened, rather wrinkled, tapering distally, portion below constriction rounded and smooth, spermathecal duct short and curved; accessory gland tubular, elongate, tapering distally, and with a short duct; vagina very short. MALE (Fig. 4): Testes rather large, spherical, vas deferens narrow near testis, vesicula seminalis rather narrow; first pair of accessory gland ovally or spherically coiled, second pair smallest and recurved distally, recurved portion shorter than basal portion, third pair larger than second and convoluted; ejaculatory duct slightly broader beyond middle, very strongly bowed and bent distally.

MATERIAL EXAMINED: 7 specimens (in 8% formaldehyde), Pcia. de Buenos Aires, Partido de Puan, Estacion Felipe Sola, I-31-1966 (A. Martinez).

TRIBAL DESIGNATION: Fairmaire and Germain first established the genus *Pseudomeloe* in 1863 (Borchmann, 1917). Beauregard (1890) grouped this genus, among others, with *Meloe, Megetra* and *Cysteodemus* in the category of "Meloites." Later, Borchmann (1917) and Blackwelder (1945) also grouped *Pseudomeloe* with several presently recognized eupomphine genera in the tribe Meloini. Denier's (1935) tribe Lyttini also consisted of *Pseudomeloe* and such genera as *Tetraonyx, Pyrota, Lytta, Meloe* and several of the current eupomphine genera. As far as is known, there is no mention of the inclusion of *Pseudomeloe* in the tribe Calospastini (= Eupomphini), after this tribe was first established by Van Dyke in 1928. He included *Calospasta* (= *Eupompha*), *Tegrodera, Gynaecomeloe, Cysteodemus, Megetra, Pleurospasta, Phodaga, Negalius, Cordylospasta* and *Brachyspasta* in this tribe. Gupta (1965) demonstrated that members of this tribe, as constituted by Van Dyke, show such common features as V-shaped folds in the stomodaeal intima, a spermathecal capsule without a basal diverticulum, a tubular female accessory gland, an irregularly convoluted first pair of male accessory glands, and a recurved or bent second pair. He further stated that on the basis of the number of V-shaped folds, and tertiary intimal folds, the tribe can be divided into 2 groups: one group with 3 V-shaped folds and 6 tertiary folds (*Phodaga* and *Negalius*), and the other with 4 V-shaped folds and 8 tertiary folds (*Eupompha, Tegrodera, Gynaecomeloe, Cysteodemus, Megetra* and *Pleurospasta*). He did not study *Cordylospasta* and *Brachyspasta*.



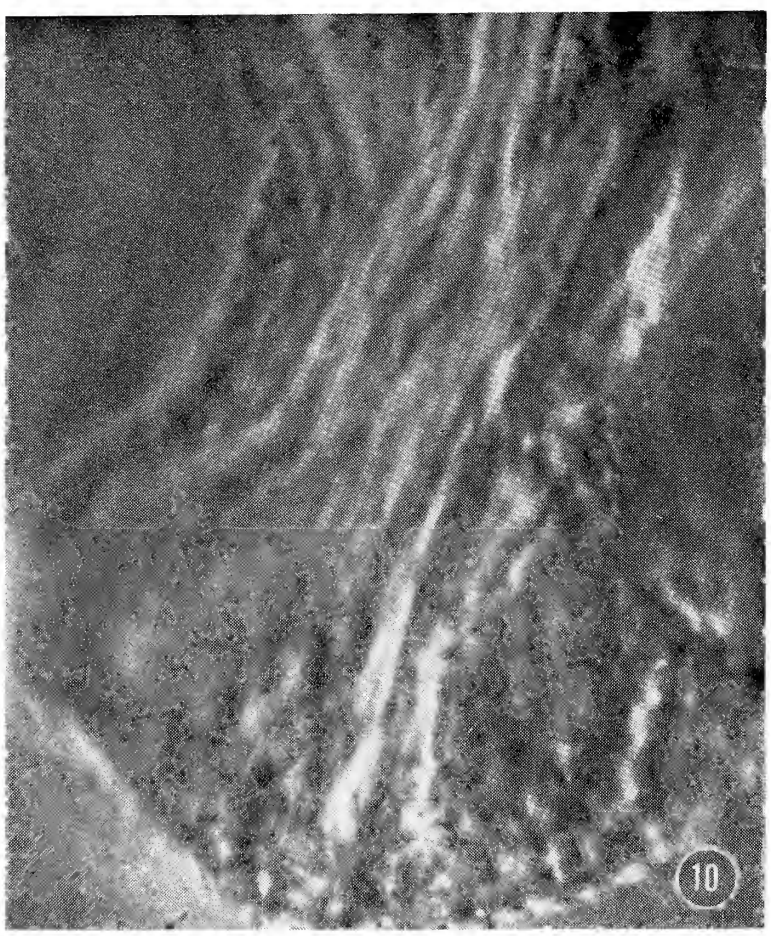


FIG. 9. Magnified view of portion of V-shaped fold showing spines.

FIG. 10. Magnified view of tip of one of the primary stomodaeal lobes showing spines.

Examination of the internal anatomy of *Pseudomeloe* revealed that it possesses all the characteristic features of Eupoinphini, as defined by Gupta, and belongs to the group with 4 V-shaped and 8 tertiary folds. Its inclusion is the tribe Meloini cannot be justified since it does not possess a well-developed vesicular spermathecal diverticulum, and a reduced 1st pair of male accessory glands, features which are characteristic of the tribe Meloini. Similarly, the presence of V-shaped folds and the absence of a well-developed spermathecal diverticulum precludes its inclusion in Lyttini. The placement of *Pseudomeloe* in Epicautini, Tetraonycini, and Pyrotini on the basis of V-shaped folds alone cannot be justified inasmuch as it does not possess several of the important features of these three tribes. That *Pseudomeloe* appropriately belongs to the Eupomphini seems certain, and its inclusion in this tribe thus extends the latter's distribution to South America was well.

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BOOK REVIEW

Insect Behaviour. Symposium No. 3, Royal Entomological Society (P. T. Haskell, ed.). Bartholomew Press, Dorking, 1966. 113 p., £2.50.

In this book are published the papers presented at the Third Symposium of the Royal Entomological Society, held September 23–24, 1965 in London. The papers are: (1) Orientation behaviour in insects and factors which influence it, by G. Birukow; (2) The role of rhythms in insect behaviour, by P. S. Corbet; (3) Flight behaviour, by P. T. Haskell; (4) Feeding behaviour, by V. G. Dethier; (5) Sexual behaviour, by A. Manning; (6) Insect communication, by J. D. Carthy; (7) Behaviour of social insects, by E. O. Wilson; (8) Some outstanding questions in insect behaviour, by J. S. Kennedy. The discussion that took place at the symposium is published at the end of each paper.

These relatively brief, illustrated papers review much of the pertinent literature appearing for the most part since 1955. They are of somewhat uneven quality, some papers being better organized and better written than others. Some papers deal with their subjects only on a relatively broad, elementary level but others present data and interpretations not as well summarized elsewhere. The final paper, by J. S. Kennedy, is especially valuable to the general reader because, in a few pages, it discusses in an interesting way the salient problems in insect behavior. A thought-stimulating discussion follows this paper.

This hardcover book is aesthetically printed, with few typographical errors. It is recommended for all persons interested in animal physiology, behavior, and ecology.

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The University of Kansas, Lawrence

Proceedings of the New York Entomological Society

(Meetings held in Room 129 of the American Museum of Natural History unless otherwise indicated.)

Meeting of October 4, 1966

President Richard Fredrickson presided; 19 members and 3 guests were present. Dr. Fredrickson reported on the status of the proposed merger with the Brooklyn Society. At the special meeting, held on June 14th, 12 members were present and 68 affirmative proxies had been received; thus, our Society has approved the merger. He was authorized to proceed with the negotiations. The following were proposed for student membership: Richard Arnold of Hinsdale, Illinois, and Mrs. Winifred B. Trakimas, Francis C. Ford, and Dominick J. Pirone, three graduate students at Fordham University.

PROGRAM. **Summer Activities of Members.** Richard Fredrickson described a short field trip he had made to Blue Ridge, Va. Lucy Clausen spoke of the great increase in earwigs in the Bronx. This was corroborated by Jacob Huberman and Edwin W. Teale. Dominick Pirone reared some 2000 walking stick insects, and reported that from a 3 inch walking stick a 13 inch gordian worm emerged. He also drew attention to the Britten Sanctuary near Croton, N.Y. which has 127 acres available for collecting. David Kander described the ravages of cherry tree borers, and Ann Birdsey of a web worm invasion in Brooklyn. Aaron Nadler, a lawyer by profession and an active amateur entomologist, told of collecting psocids and curating his own collection at the Museum. Edwin Teale made some brief remarks about his 11,000 mile trip through England, Betty White about her trip to the Grand Teton Mountains, and David Miller about his trip to Jamaica, W.I. Patricia Vaurie commented on the effects of the severe drought around Easton, Pa. Excellent slides of a variety of insects were shown by Albert Poelzl and on the emergence of a dragon fly by Robert Buckbee. Mr. and Mrs. Sidney Hessel and Mr. and Mrs. Bernard Heineman attended the meeting of the Lepidopterists' Society in Ottawa, Canada in early June.

LUCY HEINEMAN, *Sec.*

Meeting of October 18, 1966

The meeting was called to order by President Fredrickson in Room 319; 24 members and 30 guests were present. The four student members proposed at the last meeting, Mrs. Winifred B. Trakimas and Messrs. Richard Arnold, Francis C. Ford, and Dominick J. Pirone, were elected to membership. Dr. L. L. Pechuman of the Department of Entomology, Cornell University, Ithaca, N. Y. was proposed for life membership and Sergio Orminati of City College was proposed for student membership.

PROGRAM. **Army Ants—A Study in Social Behavior.** Dr. T. C. Schneirla of the Department of Animal Behavior, American Museum of Natural History gave a brief résumé of his studies of the army ants made at the laboratory on Barro Colorado Island in the Panama Canal over the past number of years. He told of the arrangements to have the activities of these ants filmed by the Encyclopedia Britannica Films during March 1966. This film, which has the same title as our program, is in color and has a running time of 20 minutes. It is equipped with a sound track with an explanatory narrative and such appropriate forest background sounds as those of ant birds. The main subjects of the film are the bivouacs or temporary nests, the mass raids, and the emigrations of the swarm-raider, *Eciton burchelli,* with supplementary scenes of emigrating and responding

to the queen involving the related species, *E. hamatum*. Reactions of the workers to chemical trails and to the odor of their queen are shown both in field behavior and in terms of simple laboratory and field tests. Mr. John Walker of E. B. F., the photographer answered many questions about the technical problems in the forest filming.

LUCY HEINEMAN, *Sec.*

Meeting of November 1, 1966

The meeting was called to order in Room 319 by President Fredrickson; 28 members and 8 guests were present. Dr. L. L. Pechuman was elected a life member and Mr. Sergio Orminati a student member in the Society. Miss Alice Gray informed the group that the Junior Society now has fourteen members and there are two applicants for the 15th and final place. The Junior Society had a successful summer which included field trips and a spelonking trip on which the expedition captured some cave insects.

PROGRAM. **The Insects of the Galapagos Islands.** Dr. Robert L. Usinger, President of the Entomological Society of America illustrated his talk with a map of the islands and slides. (An abstract follows.)

LUCY HEINEMAN, *Sec.*

THE INSECTS OF THE GALAPAGOS ISLANDS

The Galapagos International Scientific Project was organized by the Extension Division of the University of California at Berkeley under a grant from the National Science Foundation. Transportation was arranged through the United States Maritime Commission, using their ship, the "Golden Bear." Financial assistance was provided by the National Science Foundation and also by the Belvedere Foundation of San Francisco. Logistical support was supplied by the United States Navy, Army and Air Force. The Associates in Tropical Biogeography of the University of California provided funds for some personnel and equipment. The Shell Oil Company provided funds for extra fuel for the "Golden Bear."

The expedition was in the field for about two months—January, February and March of 1964. Sixty scientists participated and another seventy or eighty persons visited the islands soon after we arrived for the dedication of the Darwin Memorial Research Laboratory.

Entomological work spanned all of the life zones, from the strand through the lowland cactus forests which are very arid up to the moist middle elevations and then to the Miconia forest of the highlands and finally to the grass and fern zone at the top. This whole span of zones was represented back of the laboratory on a trail that was used intensively by the expedition. Other trips were taken to the other islands in the archipelago, either by ship or by helicopter.

The composition of the insect fauna is characteristic of oceanic islands and in marked contrast to a continental archipelago such as the British Isles. The British Isles have about three times as many families, ten times as many genera and thirty-two times as many species as the Galapagos, and it is significant that endemism in the Galapagos, although high, consists mostly of single species in each genus. In contrast to this, the much older Hawaiian fauna commonly has many species in each of the endemic genera showing adaptive radiation and subspeciation on the various islands. In the Galapagos there is only incipient subspeciation, a few groups such as the grasshoppers showing size and color differences in the populations on each of the different islands. By comparison, other more rapidly evolving groups such as the cacti and composite plants (*Scalesia*) and the iguanas, tortoises and birds show clear-cut differences at the subspecies and even at the species level between the various islands.

A few of the special characteristics of Galapagos insects are the concealing coloration of many of the Cerambycids and moths that rest on the lichen-covered rocks and tree trunks. Lichens are a characteristic feature of the Galapagos landscape. Also there is a great scarcity of aquatic insects because standing or running water is extremely rare. Only the dragonflies have flourished with endemic as well as introduced species. Other interesting aquatics include a few water beetles and an endemic mosquito in fresh water in the epiphytic plants in the forest, related to the lowland salt marsh mosquito, and various insects associated with the salt water lagoons.

Pollination was a subject of special interest to the entomologists on the expedition. Only one bee, the Darwin carpenter bee, is found in the islands and evidence was obtained by screening flowers of many native and introduced plants to indicate that the old endemic Galapagos plants are mostly self-pollinated. It is only the introduced and more recent plants that seem to require insect pollination and this coincides with the idea that the carpenter bee was introduced after some of the early plants. Of course, sphinx moths and some other insects and some of the birds no doubt play a role in pollination as well. Interestingly enough, the carpenter bee brought with it its Meloid parasite, *Cissites*, and this, too, has evolved into an endemic species.

In general, and despite Darwin's observations made in September and October of 1835 when the dry season made a veritable desert of the islands, we found the insect fauna to be relatively rich. February is the height of the rainy season and many of the islands were green. Light collecting was especially productive with moths and Cerambycid beetles comparing in numbers, though not in species, to light trap catches in mainland areas. Darwin said that "Excepting Tierra del Fuego, I never saw so poor a country" and G. R. Waterhouse, upon examining the insects which Darwin collected, reported that there was nothing in their appearance which would have led him to imagine that they had come from under the Equator. Beebe reported that his field work was the most arduous and uncomfortable of any that he had experienced and Melville described the islands as vast cinder heaps. Fortunately, due to the favorable season, we encountered none of these difficulties and had a very productive entomological experience on the islands.

Robert L. Usinger

Meeting of November 15, 1966

Dr. Richard Fredrickson presided; 32 members and 9 guests were present. Mr. Orville Steward of the Bayard Cutting Arboretum, Oakdale, Long Island was proposed for regular membership and his son, Roger Steward, for student membership. Mrs. John Buck, the wife of the speaker of the evening, was introduced. She has assisted her husband in much of his scientific work, and she has accompanied him on expeditions.

program. **Synchronous Flashing of Fireflies.** Dr. John B. Buck, Chief of the Laboratory of Physical Biology of the National Institutes of Health, Bethesda, Maryland illustrated his talk with interesting slides and diagrams. Although his talk referred largely to fireflies in the Orient, he drew many interesting comparisons between the oriental fireflies and those of the United States. (An abstract follows.)

Lucy Heineman, *Sec.*

SYNCHRONOUS FLASHING OF FIREFLIES

Many observers have described long-lasting synchronous rhythmic flashing by huge swarms of fireflies in riverbank trees in the tropical Orient, but neither mechanism nor meaning have been explained. From observations of such trees in Sarawak and Thailand

in October, 1965*, photometric and cinematographic recordings of the flashing of individuals and populations, and study of captive specimens in the darkroom we established that: (1) The tree fireflies all belong to undescribed species of *Pteroptyx*. (2) Synchrony in Sarawak was disturbed by the concurrent presence of three species: In Thailand there were two but one was in great excess, permitting impressive displays of synchrony. Only males participate. (3) The period of the rhythm of flashing is about 560 msec, 95% of the cycles falling within ± 5 msec of this figure. (4) Analysis of cinematographic records of mass flashing indicates that the synchronizing individuals flash within less than ± 16 msec of each other. (5) In the buildup of synchrony in darkroom populations the coordination between two individuals was shown to depend on visual feedback, to operate over a range of less than 6 feet and to involve a progressive approach of the individual flash times until coincidence occurred, after which the two rhythms were locked together. (6) Since the coincidence is far closer than the minimal eye-lantern "reaction time" the synchrony must depend on a regulating mechanism controlled by the results of the *preceding* mass flash, rather than a direct individual-to-individual response. (7) The firefly trees represent quasi-permanent congregations in which fireflies remain in the tree by day, and are joined nightly by recruits from the surrounding swampland. (8) The tree congregations are viewed as a mass-mating substitute for the pair courtships which are usual in roving-type fireflies. Such congregations are made necessary by the impossibility of line-of-sight signaling in the impenetrable Nypa-mangrove vegetation. Presumably the mated females disperse back over the land for egg-laying. The synchronous flashing enhances the effectiveness of the trees as mating beacons.

JOHN B. BUCK

Meeting of December 6, 1966

Dr. Richard Fredrickson presided; 25 members were present as were 13 guests. The president appointed two committees: the auditing Committee consisting of Messrs. Albert Poelzl, Kumar Krishna, and A. B. Klots; and the Nominating Committee consisting of Messrs. David Miller, Robert L. Buckbee, and Bernard Heineman. Mr. Orville Steward and Roger Steward were elected regular and student members respectively in the Society. Dr. A. B. Klots told of an article by Miss Miriam Rothschild, the British entomologist, that will appear in an early issue of Natural History. Miss Rothschild has been working with larvae of the Monarch butterflies. They give off a volatile substance which, if sniffed a great deal, puts one in the conscious state of feeling you have already experienced this situation before and therefore you appear to be predicting the future, perhaps somewhat like L. S. D.

PROGRAM. **Sensory Codes and Feeding Behavior.** Dr. Vincent Dethier, Professor of Zoology at the University of Pennsylvania, described work done largely in Holland using the tobacco horn-worm as the experimental animal. Excellent slides and diagrams were used to illustrate the talk. (An abstract follows.)

LUCY HEINEMAN, *Sec.*

SENSORY CODES AND FEEDING BEHAVIOR

The principal chemoreceptors of lepidopterous larvae are located on the maxillae and antennae. The maxilla bears, in addition to numerous mechanoreceptors and some olfactory

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* The American Philosophical Society and the National Geographic Society provided travel grants for this investigation.

receptors, two sensilla styloconica that are organs of taste. Each sensillum styloconicum contains five bipolar neurons. The dendrites of four of these have been traced to the tip of the sensillum where they are exposed to the air. There are indications that they may subdivide and branch apically.

The sensilla styloconica respond to a wide variety of solutions, but the responses of the two are not identical. Differences can be expressed in number of cells firing, frequency of impulses per cell, and/or total frequency of all impulses per sensillum. In *Protoparce sexta* the medial sensillum contains cells sensitive as follows: one to water and salt, one to sucrose and glucose, one to acid. The lateral sensillum contains cells sensitive as follows: one to water, one to salt, one to glucose, and possibly one to inositol. In *Galleria mellonella* the medial sensillum contains a cell sensitive to water, one to salt, and one to sucrose; the lateral sensillum has a water cell and a salt cell. In *Philosamia cynthia* the medial sensillum has two cells sensitive to salt and one to glucose; the lateral sensillum has one cell sensitive to water, one to salt, one to sucrose, and one to glucose.

In *Protoparce* the sap of plants fires a number of cells in each sensillum. Sap of acceptable food plants appears to cause a higher frequency of firing in the cells of the medial sensillum than in those of the lateral sensillum while the sap of unacceptable plants, in general, causes a higher frequency of firing in the lateral sensillum. Some plants are exceptions to this rule. There is evidence from these findings that both "feeding stimulants" and "deterrents" play a role in food-plant discrimination. The detailed information that the caterpillar receives from its maxillary gustatory receptors allows for participation by nutrients as well as token stimuli.

The third segment of the maxillary palpus bears olfactory receptors. In *Hyalophora gloveri* complex responses were obtained to odors of wild cherry, potato, tomato, parsley, cabbage, privet, and willow. Responses to benzaldehyde and salicylaldehyde showed a long and pronounced after effect. Geraniol stimulated some cells while citronellal did not.

The three large sensilla basiconica on the antennae of caterpillars are olfactory organs. One contains four bipolar neurons, one has five, and the other has seven. The dendrites of these cells break up into fine arborizations upon entering the cuticular peg and are in direct communication with the outside via a multitude of minute pores.

Records obtained with micro metal electrodes reveal a background activity in these cells. This activity is depressed by air and may be either depressed or enhanced by odors. Each cell responds to more than one odor but not in the same manner. Furthermore, not all cells exhibit identical response patterns although there is some overlap. For the caterpillar plant odors are obviously coded as complex patterns.

Food-plant discrimination cannot be explained solely in terms of acceptance or rejection via the maxillary taste receptors but must also involve the wealth of olfactory information provided by the antennae and maxillae.

VINCENT DETHIER

Meeting of December 20, 1966

President Fredrickson presided; 22 members and 13 guests were present. The president announced that on the following afternoon there would be a meeting at the office of the Society's attorney at which time he, the secretary or assistant secretary, and the president and secretary of the Brooklyn Society would sign the agreement merging the two societies. The merger will have to be reviewed by the courts. Mr. Anthony J. W. Owston was proposed as a regular member and Mr. Michael Boshes of City College as a student member. Dr. Schmidt asked if anyone could advise him as to where he could get information about

a flea trap. Dr. Klots said that there was a picture of a medieval one in the article by Miss Miriam Rothschild in a recent issue of The Scientific American. Dr. Edwin W. Teale remarked that in the recent warm spell there were myriads of snow fleas at his home in Connecticut.

PROGRAM. **Naturalists in South America.** Mr. Heineman showed colored slides of a recent trip to South America, and Mrs. Heineman described and commented on them.

LUCY HEINEMAN, *Sec.*

Meeting of January 3, 1967—The Annual Meeting

The meeting was called to order by Dr. David Miller in place of President Fredrickson who was ill. The Vice-president was not able to be present because of a class. Dr. Miller asked for nominations to elect a chairman for the evening; he was duly elected to conduct the meeting for the evening. Nineteen members and seven guests were present. Mr. Raymond Brush, the Treasurer, reported a favorable balance for the fiscal year, 1966. In the absence of the Editor, the Associate Editor, Dr. Forbes, announced that the December 1966 issue of the Journal is expected very soon. He said more manuscripts would be welcomed. The Nominating Committee, consisting of Messrs. Miller, Heineman, and Buckbee, chairman, submitted the following slate for the coming year:

President	— Dr. Richard Fredrickson
Vice-president	— Dr. David Miller
Treasurer	— Mr. Raymond Brush
Assistant Treasurer	— Mrs. Patricia Vaurie
Secretary	—
Assistant Secretary	— Mr. Albert Poelzl

Trustees (to serve two years)—Dr. Elsie Klots, Mr. Bernard Heineman Publication Committee—Drs. Kumar Krishna, Asher Treat, Pedro Wygodzinsky. The chairman called for nominations for the office of Secretary from the floor. He stated that Mrs. Heineman has consented to continue for the month of January. No nominations were forthcoming and the slate was elected as presented. Dr. Miller continued to chair the meeting as the newly elected vice-president. Dr. Wygodzinsky announced that there are two vacancies in the Entomology Department of the Museum. One is for a scientific assistant and the other is for a technical artist. Both are for two years, and they are covered by grants. Dr. Forbes exhibited a copy of the December 9 issue of Medical World News. The cover is a picture of our member, Dr. Roman Vishniac, and the feature article is on Dr. Vishniac's remarkable photography. Many magazines have carried articles on Dr. Vishniac's photography, but this is the first time his photograph has appeared on a cover. Mr. Anthony J. S. Owston and Mr. Michael Boshes were elected regular and student members, respectively. Miss Ann Young of the City College of New York who has worked with Mr. Topoff, our speaker of the evening, at the Southwest Research Station was introduced. Mr. Nicholas Shoumatoff, a former president of the Society, was introduced. He has now returned to the United States from a period of employment in England.

PROGRAM. **Behavioral and Physiological Studies in the Army Ant, *Neivamyrmex*.** Mr. Howard Topoff, a student at City University and the Department of Animal Behavior of the Museum illustrated his interesting talk with charts and slides. (An abstract follows.)

LUCY HEINEMAN, *Sec.*

BEHAVIORAL AND PHYSIOLOGICAL STUDIES IN THE ARMY ANT, *NEIVAMYRMEX*

Social organization and behavior in the phyletic level that is characteristic of insects is influenced predominantly by the intensity of stimuli originating from reproductive, feeding, and reciprocal stimulative processes.

In the army ant genus *Neivamyrmex* qualitative differences in the intensity of raiding during the nomadic and statary phases are also reflected quantitatively in the sharp increase in oxygen consumption at the onset of the nomadic phase, followed by a marked decrease as the statary phase is initiated.

Thresholds of responses to a given intensity of light as well as to the changing olfactory stimuli which emanate from the brood, queen and workers, increase during the nomadic phase and decrease during the statary.

The populational characteristics of three genera of doryline ants (*Neivamyrmex, Eciton,* and *Aenictus*) were compared with a discussion of the trophic factors that influence caste determination in the army ants in particular, and in the social insects in general.

Howard R. Topoff

Meeting of January 17, 1967

President Richard Fredrickson presided; 22 members and 7 guests were present. Mr. Howard R. Topoff of the City University of New York was proposed and duly elected as Secretary of the Society, succeeding Mrs. Lucy Heineman. Dr. Jerry Vanderberg of the Department of Preventive Medicine, New York University Medical School was proposed for regular membership. Miss Betty White described a rare but delightful occasion she had comparing a photograph of a parasitic wasp from the book "Living Insects Of the World" with one that flew into her kitchen; they were identical.

PROGRAM. Dr. Robert Traub, Research Professor at the University of Maryland School of Medicine, presented two talks: **Ecology of Scrub Typhus in Unusual Habitats in Pakistan** and **Examples of Convergent Evolution in Fleas.** In the first talk Dr. Traub discussed the tremendous increase in interest in scrub typhus, especially in relation to successful military efforts in tropical habitats. He reported on his interesting and perplexing findings that this disease, which predominates in ecologically disturbed tropical environments, has recently been found infecting the small mammal populations of primary forests, xerophytic forests, subalpine habitats in the Himalayas, and even in true alpine meadows as high as 11,000 feet. In the second talk Dr. Traub discussed the convergence of adaptations possessed by fleas, for attaching to their hosts. Particular mention was made of the fact that fleas associated with birds and arboreal mammals usually possess longer and more sharply pointed comb spines than fleas which parasitize ground-dwelling mammals.

Howard R. Topoff, *Sec.*

Meeting of February 7, 1967 was cancelled because of a heavy snowfall.

Meeting of February 21, 1967

Dr. Richard Fredrickson presided; 19 members and 2 guests were present. Dr. Jerry Vanderberg was elected to regular membership. Dr. J. G. Butte of the State University of New York at Farmingdale was proposed for regular membership. Dr. Asher Treat

called attention to the paper of Dr. Carol Williams, in the February 3 edition of Science, noting that the female of the polyphemus moth will not produce a sex attractant pheromone until she is stimulated by an extract of oak leaves.

PROGRAM. **Trap-Nesting Wasps and Bees and Their Associates.** Dr. Karl Krombein, chairman, Department of Entomology of the Smithsonian Institute illustrated his talk with slides. (An abstract follows.) [*Editor's note*: This whole project is reported in detail in a book by Dr. Krombein, "Trap-Nesting Wasps and Bees: Life Histories, Nests, and Associates," Smithsonian Press, 579 pp., 29 pls., 1967.]

TRAP-NESTING WASPS AND BEES AND THEIR ASSOCIATES

The speakers discussed the field project he carried on from 1953 to 1964 investigating the biology of solitary wasps and bees which can be induced to nest in wooden traps. The traps were made from straight-grained pieces of white pine, each containing a boring 6″ long and ⅛, 3/16, ¼ or ½″ in diameter. The traps were made into bundles containing one or two traps of each diameter. The bundles were placed in the field in situations where populations of solitary wasps and bees were nesting in abandoned borings of other insects in wood such as on dead branches and tree trunks, on sound oak branches bearing insect galls, and on structural lumber. Nests were obtained from trap settings in western New York, the area around Washington, D. C., coastal North Carolina, Archbold Biological Station in Florida, and the Southwestern Research Station in Arizona. The nests were opened in the laboratory to record the details of the nest architecture and to preserve samples of the food stored for the larvae; periodic reexamination of the nests provided information on the developmental stages of the wasps and bees, and their associated predators, parasites and symbionts. Nine new species and subspecies of wasps and bees were described from these nests, as well as three new species of chalcid parasites, and two new genera and 17 new species of parasitic mites. Life history data were obtained for 75 predaceous wasps and 43 non-parasitic bees, and 83 associated parasites and predators (28 of them parasitic wasps or bees). Dr. Krombein illustrated his talk with a number of Kodachrome and black and white transparencies showing the nest architecture of a number of species, the life history of a typical vespid wasp, nesting behavior of the bee *Osmia lignaria,* certain aspects of the competition between three species of *Trypargilum* for nesting sites and spider prey, and examples of some of the mite, beetle, fly and wasp parasites associated with the host wasps and bees.

KARL KROMBEIN

Meeting of March 7, 1967

Dr. Fredrickson presided; 14 members and 7 guests were present. Dr. J. G. Butte of the State University of New York at Farmingdale was elected a regular member, and Miss Ann Young, a graduate student at the City University of New York, was proposed for student membership. Miss Alice Gray of the Department of Entomology at the Museum displayed toy insects made in Hong Kong.

PROGRAM. **Ecology of the Cave-Entrance Fauna.** Professor Richard Graham of the Department of Physiology of Rutgers University discussed ecological zonation in caves with particular reference to the cave entrance as a persistent community.

HOWARD R. TOPOFF, *Sec.*

Meeting of March 21, 1967

President Richard Fredrickson called the meeting to order; 23 members and guests were present. Miss Ann Young of the City University of New York was elected to student membership.

PROGRAM. **Mimicry in Butterflies.** Dr. Michael G. Emsley, Assistant Curator of Insects of the Philadelphia Academy of Natural Sciences was the speaker of the evening. (An abstract follows.)

Howard R. Topoff, *Sec.*

MIMICRY IN BUTTERFLIES

"At the close of the last century a confusingly large number of named forms of *Heliconious erato* and *Heliconious melpomene* were described, many of them as descrete species. We now know that these two species show pronouncd geographic variation with monomorphic forms occupying Central America, South America west of the Andes, northern South America, the valley systems of the eastern Andes, the Amazon Basin and southeastern Brazil. Where the monomorphic populations meet there is a high degree of polymorphism which has led to the large number of described forms. The most remarkable feature of this situation is that *erato* and *melpomene* vary so greatly over their range they maintain a mutually similar appearance everywhere they occur. The closeness of their similarity makes a convincing case that mimicry in butterflies is a real phenomenon.

Unfortunately, though Dr. Brower and his co-workers have tried extremely hard to obtain convincing, experimental proof of the values of what we call warning coloration and its imitation by palatable mimics, the evidence is still far from complete. Any theory concerned with the explanation of the color pattern of butterflies in relation to their predators must also take into account that color is probably the prime factor in species recognition and in the releasing of courtship behavior."

Michael G. Emsley

NEW MEMBERS

The following persons have been elected to the Society since the membership list was published in the June 1966 issue (vol. 74, pp. 112–115). The class of membership other than regular member is designated by the letter in parentheses: L—Life, St.—Student.

(St) Arnold, Richard, 735 McKinley Lane, Hinsdale, Illinois 60521
Bartolone, Pat J., 1661 East 172nd Street, Bronx, N.Y. 10472
Benton, Allen, State University College, Fredonia, N.Y. 14063

(St) Boshes, Michael, Department of Animal Behavior, American Museum of Natural History, 77th Street and Central Park West, New York, N.Y. 10024
Butte, J. G., State University of New York, Farmingdale, N.Y. 11735
Durden, Beatrice V., Carnegie Museum, Pittsburgh, Penna. 15213
Emsley, Michael G., Academy of Natural Sciences, Philadelphia, Penna. 19103

(St) Ford, Francis C., 650 Yonkers Avenue, Yonkers, N.Y. 10704

(St) Friedman, Kenneth, 33-05 90th Street, Jackson Heights, N.Y. 11372

(St) Kanter, David F., 154-04 25th Avenue, Flushing, N.Y. 11354

(St) Mesibov, Robert, 1905 Birge Terrace, Madison, Wisconsin 53705
Nadler, Aaron M., 101 Ocean Parkway, Brooklyn, N.Y. 11218

(St) Novak, John A., Kent State University, Kent, Ohio 44240

(St) Orminati, Sergio, 200 Eighth Avenue, New York, N.Y. 10011
Owston, Anthony J. W., 345 East 56th Street, New York, N.Y. 10022

(L) Pechuman, L. L., Department of Entomology, Cornel University, Ithaca, N.Y. 14850

(St) Pirone, Dominick J., 120 Esplanade, Mt. Vernon, N.Y. 10553
Pogany, Margaret, Simon & Schuster, Inc., 630 Fifth Avenue, New York, N.Y. 10020
Ruckes, Herbert, Jr., Biology Department, Manhattan Community College, New York, N.Y.
Spear, Philip, National Pest Control Association, 250 West Jersey Street, Elizabeth, N.J. 07202
Steward, Orville, c/o Bayard Cutting Arboretum, P.O. Box 66, Oakdale, N.Y. 11769

(St) Steward, Roger, c/o Bayard Cutting Arboretum, P.O. Box 66, Oakdale, N.Y. 11769
Stibick, J. N. L., Department of Entomology, Purdue University, Lafayette, Indiana 47907
Stien, Harry, 12 Highland Drive, Ardsley, N.Y.

(St) Topoff, Howard R., Department of Animal Behavior, American Museum of Natural History, 77th Street and Central Park West, New York, N.Y. 10024

(St) Trakimas, Winifred B., 137 Stratford Street, Roslyn Heights, N.Y. 11577
Vanderberg, Jerry, 333 East 14th Street, New York, N.Y. 10003
Watson, Kennith, 53 Kenefick Avenue, Buffalo, N.Y. 14220

(St) Young, Ann, 512 East 79th Street, New York, N.Y. 10021

INVITATION TO MEMBERSHIP

The New York Entomological Society was founded in 1892 and incorporated the following year. It holds a distinguished position among scientific and cultural organizations. The Society's **Journal** is one of the oldest of the leading entomological periodicals in the United States. Members and subscribers are drawn from all parts of the world, and they include distinguished professional naturalists, enthusiastic amateurs, and laymen for whom insects are only one among many interests.

You are cordially invited to apply for membership in the Society or to subscribe to its **Journal** which is published quarterly. Regular meetings are held at 8:00 P.M. on the first and third Tuesdays of each month from October through May at the American Museum of Natural History, the headquarters of the Society. A subject of general interest is discussed at each meeting by an invited speaker. No special training in biology or entomology is necessary for the enjoyment of these talks, most of which are illustrated. Candidates for membership are proposed at a regular meeting and are voted upon at the following meeting.

CLASSES OF MEMBERSHIP AND YEARLY DUES

Active member: Full membership in the Society, entitled to vote and hold office; with **Journal** subscription $9.00

Active member without **Journal** *subscription* 4.00

Sustaining member: Active member who voluntarily elects to pay $25.00 per year in lieu of regular annual dues.

Life member: Active member who has attained age 45 and who pays the sum of $100.00 in lieu of further annual dues.

Student member: Person interested in entomology who is still attending school; with **Journal** subscription 5.00

(Student members are not entitled to vote or to hold office.)

Student member without **Journal** *subscription* 2.00

Subscription to **Journal** *without membership* 8.00

APPLICATION FOR MEMBERSHIP

Date .....

I wish to apply for ..... membership (see classes above).

My entomological interests are: .....

If this is a student membership, please indicate school attending and present level.

Name .....

Address .....

.....

(Zip Code *must be* included)

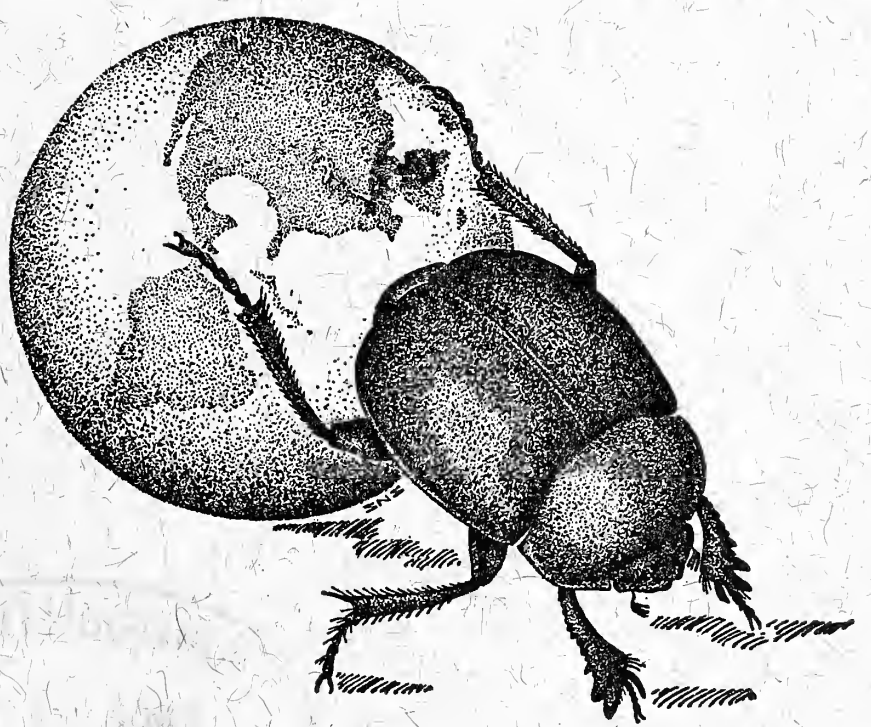
— Send application to Secretary —

Vol. LXXV September 1967 No. 3

Journal

of the

New York Entomological Society



Devoted to Entomology in General

The
New York Entomological Society

Organized June 29, 1892—Incorporated February 25, 1893
Reincorporated February 17, 1943

The meetings of the Society are held on the first and third Tuesday of each month (except June, July, August and September) at 8 P.M., in the AMERICAN MUSEUM OF NATURAL HISTORY, 79th St., & Central Park W., New York 24, N. Y.

Annual dues for Active Members, $4.00; including subscription to the Journal, $9.00.

Members of the Society will please remit their annual dues, payable in January, to the Treasurer.

Officers for the Year 1967

President, Dr. Richard Fredrickson
College of the City of New York 10031

Vice-President, Dr. David Miller
College of the City of New York 10031

Secretary, Mr. Howard Topoff
American Museum of Natural History, New York 10024

Assistant Secretary, Mr. Albert Poelzl
230 E. 78th Street, New York 10021

Treasurer, Mr. Raymond Brush
American Museum of Natural History, New York 10024

Assistant Treasurer, Mrs. Patricia Vaurie
American Museum of Natural History, New York 10024

Trustees

Class of 1967
Dr. Jerome Rozen, Jr.
Mr. Robert Buckbee

Class of 1968
Dr. Elsie Klots
Mr. Bernard Heineman

Mailed October 6, 1967

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Journal of the New York Entomological Society

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CONTENTS

A New Liphistiid Spider from China (Araneae: Liphistiidae)

Willis J. Gertsch
The American Museum of Natural History, New York, N.Y.

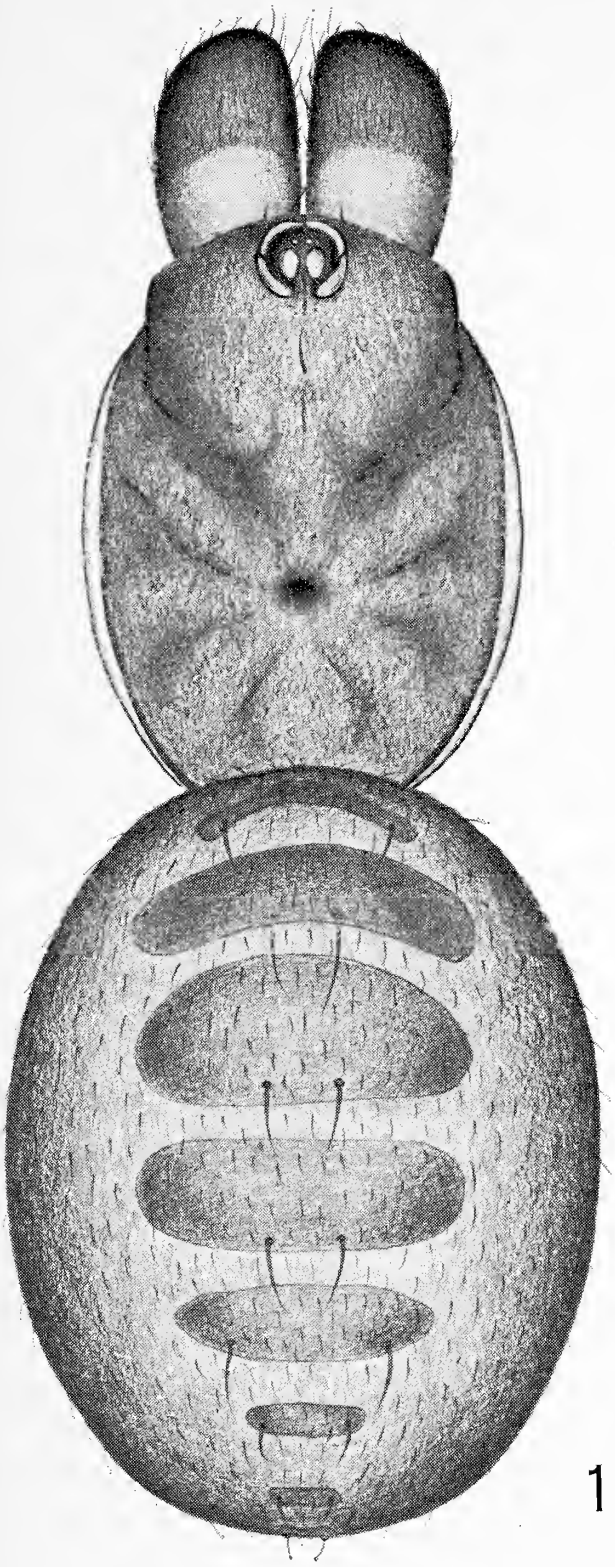
Abstract: A new species of liphistiid spider, *Heptathela* **bristowei**, is described on the basis of a female from Szechuan, China. In a discussion the author concludes that the family Heptathelidae cannot be maintained and that the species with a posterior colulus (*Heptathela*) be given only generic ranking.

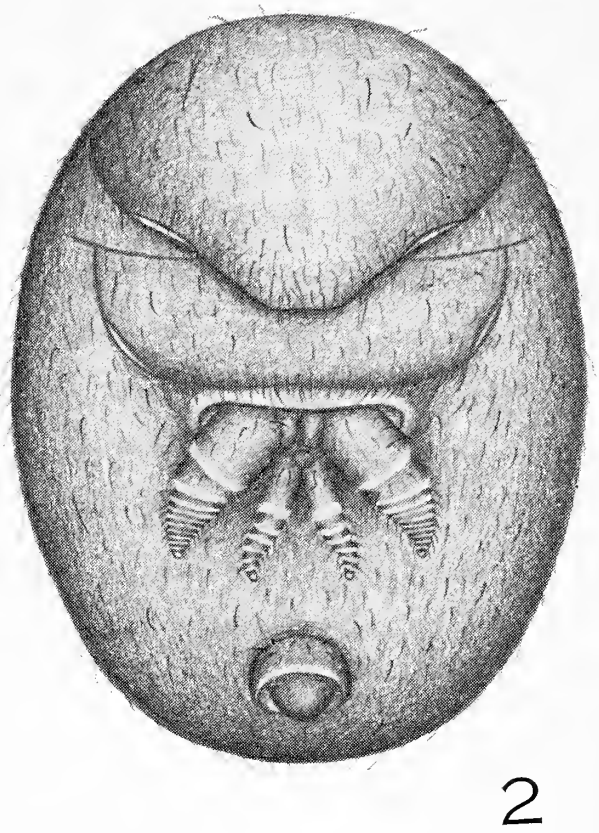
Family Liphistiidae

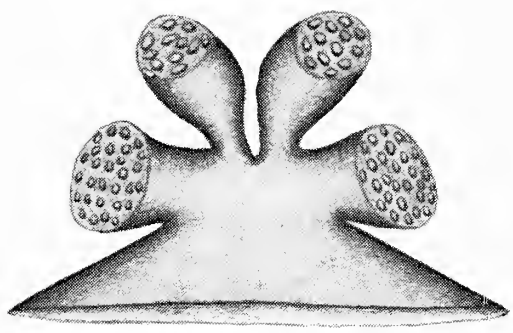
This small family comprising our most generalized spiders was reviewed by Bristowe (1932), who gave comparative data on the then known seven species of *Liphistius* and two species of *Heptathela*. In 1939 Petrunkevitch raised the latter genus to full family status on the basis of characters found in the internal anatomy of a female of *Heptathela sinensis* Bishop and Crosby (1933). The new family Heptathelidae was relegated to synonymy by Gertsch (1949, p. 265) but was recognized by Vachon (1958, p. 431), who contributed important new information on the postembryonic development of *Heptathela kimurai* Kishida.

The family Heptathelidae was based on the following principal features: reduction of the posterior median spinnerets to a functionless vestige, a posterior colulus; reduction of the number of ostia in the heart from five to four pairs; loss of the endocheliceral venom glands. In *Liphistius* all eight spinnerets are still retained, the heart has five pairs of ostia, and the venom glands, although reduced in size, are still present. Such regressive changes as those credited to *Heptathela* may have great systematic importance or almost none at all. It should be mentioned that these internal differences are based on knowledge of only half a dozen specimens of at most three or four species. Except for the loss of the posterior median spinnerets, the genus *Heptathela* shows such close correspondence to *Liphistius* that it seems undesirable to accord it more than generic distinction.

An even more conservative position was taken by Schenkel (1953, p. 1) when he described a species, that should now be listed as *Liphistius schensiensis* Schenkel, under the following trinomial: *Liphistius* (*Heptathela*) *sinensis* (Bishop and Crosby), var. *schensiensis*, n. var. Since his specimen had eight spinnerets, instead of the seven credited to *sinensis*, he concluded that this feature was not constant. Further, he saw no need to give even subgeneric recognition to *Heptathela* (misspelled *Heptathele*). Whereas it must be conceded that the two genera are remarkably alike, it seems desirable to continue to hold them separate on the basis of the differences in the posterior median







FIGS. 1–3. *Heptathela* **bristowei**, n. sp., female. 1. Carapace and abdomen, dorsal view. 2. Abdomen, ventral view. 3. Epigynum, dorsal view.

spinnerets. Thus, *Liphistius schensiensis* Schenkel is the eighth species of its genus and the species described below is the third for *Heptathela*.

No mention of the internal seminal receptacles of any female liphistiid was made by Bristowe (1932) or any of the principal students who considered the systematics and morphology of the group. This organ (for which I use

the term epigynum in its broadest connotation) is of the "haplogyne" type. In the Atypoidea (Gertsch, 1949, p. 126, 1128, etc.), there are four primary seminal receptacles. The epigynum of *Liphistius malayanus* Abraham was illustrated by Schiapelli and Gerschman (1962, pl. 2, figs. 5–6) and shows the four, rather small receptacles, flanking a central pouch, as well as a central cluster of globular organs. The epigynum of *Heptathela bristowei* is of the same general type and is similar to that of *kimurai*, the type of the genus. Whereas most of the typical tarantulas (Ctenizoidea) have epigyna with a single seminal receptacle on each side, a few exceptions have been illustrated by Schiapelli and Gerschman (1962, pl. 4, figs. 1–3).

Heptathela **bristowei**, n. sp.
Figures 1–3

This interesting species is dedicated to Mr. W. S. Bristowe, colleague and eminent author of "The World of Spiders," and one who has contributed much to knowledge of the biology and taxonomy of the liphistiid spiders.

DIAGNOSIS: This species resembles *Heptathela sinensis* Bishop and Crosby, from Tsinan, Shantung, China, but is readily separated by the following features: The pars cephalica is proportionately narrower in front and its greatest width is only four-fifths the distance to the cervical groove, instead of having these ratios equal. The four median eyes, encircled by the narrowly oval lateral eyes, are closer together. The cervical groove is considerably larger and deeper. The fourth femora are provided below on the retrolateral margin with a double row of short spinules, instead of eight spines. The tergal plates on the abdomen are smaller in size and the first lung plate is of different form, as shown in the figures.

FEMALE HOLOTYPE: Total length, including chelicerae, 19.5 mm.

	Carapace	Sternum	Labium	Maxilla	Abdomen
Length	7.0	3.5	1.0	3.0	10.0 mm.
Width	5.7	2.4	2.0	1.5	8.0 mm.

Carapace orange to reddish brown; pars cephalica dusky and pars thoracica with dusky streaks radiating from median groove; eye tubercle black. Chelicerae dull reddish brown, pale at base above. Sternum, labium and appendages quite uniform dull orange brown. Abdomen gray; tergites dusky brown.

Dorsal view of carapace and abdomen as shown in fig. 1.

Structure typical, essentially like that of *sinensis*. Carapace quite smooth, bare except for tiny setae lying flat on pars cephalica, a middle line of about six stout setae running through and behind median eyes, a series of four setae on clypeal margin, with median pair much longer, and a line of small setae margining carapace. Carapace broadly rounded in front, sharply angled at corners, gently rounded on sides and truncated behind. Pars cephalica strongly elevated, highest just behind eyes; cervical groove deep rounded depression smaller than eye turret, situated back five-eighths of length; pars thoracica low, convex, with transverse grooves.

Eyes all close together, set on rounded tubercle of typical height. Clypeus inclined forward, narrow, equal to about radius of posterior median eye. Ratio of eyes: ALE : AME : PLE : PME = 62 : 6 : 48 : 35. Front eye row slightly procurved; lateral eyes large, narrowly oval, nearly touching in front; median eyes minute, lying in front of posterior

median eyes. Posterior eye row moderately recurved; oval median eyes close together, separated by one-fourth their narrow diameter, about as far at narrowest point from larger oval lateral eyes. Median ocular quadrangle broader than long, narrowed in front, with anterior eyes minute.

Sternum an elevated sclerite with steep sides, covered with coarse setae, without trace of sigilla. Labium free, separated from sternum by deep, transverse groove, set with black setae. Maxilla truncated at apex, with setae over most of surface and brush of soft hairs along inside margin. Chelicera about 3 mm. long as seen from above, smooth at base, expanded toward apex and set with coarse setae, rounded at apex above claw and without rake; fang of median length, rather stout, lying in indistinct groove margined on prolateral side by row of eight, close-set, black teeth, three of these larger, and on retrolateral side with thin brush of soft reddish hairs.

	I	II	III	IV	Palpus
Femur	4.7	4.1	4.3	6.1	4.3 mm.
Patella	2.7	2.6	2.7	3.1	2.4 mm.
Tibia	3.0	2.7	2.7	4.2	3.0 mm.
Metatarsus	3.0	3.2	3.5	5.8	—
Tarsus	1.7	2.0	2.1	2.7	3.7 mm.
Total	15.1	14.6	15.3	21.9	13.4 mm.

LEG FORMULA: 4312. All legs short, clothed sparsely above with hairs and weak spines and below and on sides with more numerous, stouter spines. First and second legs with rows of stout ventral spines on tibiae, metatarsi and tarsi, those on anterior segments nearly lateral in position. Femora with ventral hairs and weak spines; fourth femora with 20 or more stout spinules below in double row near retrolateral edge. Pedipalp with stout sublateral spines; tarsus set with even row of seven heavy spines on lateral margins; palpal claw with single tooth at base. Paired claws of legs with two teeth near base; unpaired claws quite straight, unarmed below.

ABDOMEN (figs. 1–2): Globose, covered evenly with tiny setae. Ten tergites visible on dorsum with lateral measurements of these, in millimeters, from front to rear as follows: 3.5; 4.3; 4.2; 4.2; 3.3; 1.8; 1.1; 0.8; 0.7; 0.6; thus, sixth and succeeding tergal plates greatly reduced in size; each tergal plate with pair of prominent alveoli on caudal edge, bearing long spines. First lung plate gradually produced behind to evenly rounded projection, without special angles or evident grooving. Spinnerets of average size; posterior colulus a small tubercle bearing three tiny setae.

EPIGYNUM (fig. 3): Consisting of four receptacles; lateral receptacle of each pair larger than inner one.

TYPE DATA: Female holotype from Wanhsien, Yen-Ching-Kao, Szechuan, China, February, 1922 (W. Granger), in the American Museum of Natural History.

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Activities of Respiratory Enzymes During the Metamorphosis of the Face Fly, *Musca autumnalis* De Geer[1]

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Abstract: The activities of alcohol, succinic, malic, glucose, glutamic, alpha-glycerophosphate, lactic, and isocitric dehydrogenases, the malic enzyme, and cytochrome oxidase were determined during the metamorphosis of the face fly, *Musca autumnalis*.

Total alpha-glycerophosphate, alcohol, malic, and succinic dehydrogenases as well as the malic enzyme exhibited U-shaped activity. Greatest activity was shown by the malic dehydrogenase. Isocitric dehydrogenase activity was high initially and remained high until the 2-day pupa, and thereafter showed a progressive decline. Glucose dehydrogenase activity was low and remained fairly steady during the entire pupal stage. Alcohol dehydrogenase decreased steadily during the first days of metamorphosis, reached a low value on the third day, and then increased to reach its highest value in the adult stage. Succinic dehydrogenase exhibited a similar pattern, but the level of activity was not as high as most of the other dehydrogenases. Glutamic dehydrogenase showed low activity in the larval stage. It decreased during the first several days of the pupal life and completely disappeared by the fourth day. The activity of lactic dehydrogenase was very low throughout metamorphosis. Malic enzyme exhibited high activity in the larva, prepupa, and again in the adult stage. Cytochrome oxidase activity was also U-shaped during metamorphosis.

The O_2 consumption of holometabolous insects follows a U-shaped curve during metamorphosis. This phenomenon was first described by Krogh (1914) for the mealworm, *Tenebrio molitor*, and subsequently has been confirmed by the following investigators employing a variety of insect species: Clare, 1925; Fink, 1925; Bodine and Orr, 1925; Ludwig, 1931; Dobzhansky and Poulson, 1935; Wolsky, 1938; Sacktor, 1951; Ito, 1954; Cotty, 1956; and Ludwig and Barsa, 1956.

Since the causative factors responsible for the U-shaped respiratory curve are not fully understood, various explanations have been advanced. Krogh (1914) and Fink (1925) believed the changes in O_2 consumption to be associated with different degrees of tissue organization. The activity of cytochrome oxidase has been investigated as a rate-limiting factor in respiratory metabolism. Wolsky (1938), Williams (1950), Ludwig (1953) and Diamantis (1962) found U-shaped activity curves for cytochrome oxidase during the pupal stages of the fruit fly *Drosophila melanogaster*, the moth *Platysamia cecropia*, the Japanese beetle *Popillia japonica*, and the flour moth *Ephestia kühniella*, respectively. A correlation between succinic dehydrogenase activity and respiratory metabolism has been described by Wolsky (1941) for *Drosophila melanogaster*, Ito (1954) for *Bombyx mori*, Ludwig and Barsa (1955) for *Popillia japonica* and for *Tenebrio*

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molitor (1958). Agrell (1949) described total dehydrogenase activity and the activities of malic, citric, and glutamic dehydrogenases as U-shaped during the metamorphosis of the blow fly, *Calliphora erythrocephala*. Ludwig and Barsa (1958) found malic and succinic dehydrogenases and the malic enzyme activities to be U-shaped during the metamorphosis of *Tenebrio molitor*. In 1959, they found that with the house fly alcohol and alpha-glycerophosphate dehydrogenases also followed U-shaped curves. Diamantis (1962) described similar activity for alpha-glycerophosphate I and II, malic, isocitric and succinic dehydrogenases and the malic enzyme. His report of the U-shaped activity of isocitric dehydrogenase is at variance with the findings of Ludwig and Barsa (1959) for the house fly. They reported the isocitric dehydrogenase showed a steady decrease during metamorphosis. Diamantis (1962) also found low glutamic dehydrogenase activity at all stages, whereas Ludwig and Barsa (1959) found that it disappeared early in the pupal stage.

In the present investigation a study was made of cytochrome oxidase and the various dehydrogenases during the metamorphosis of the face fly *Musca autumnalis*.

MATERIALS AND METHODS

The insects used in this study were obtained from the United States Department of Agriculture Research Center, Beltsville, Maryland. They were reared in screened cages measuring 30 × 30 × 30 inches. The temperature of the rearing room was 25 ± 2°C and the relative humidity varied between 35–60 per cent. The light source consisted of two 160-W General Electric F 40 CW fluorescent lamps that gave a light intensity of approximately 150 ft-c measured at the top of the cages. The optimum photoperiod was found to be 16 hours extending from 6 a.m. to 10 p.m.

A mixture of skimmed milk and 5 per cent sucrose solution in a 2:1 ratio was placed daily in a petri dish containing a centrally located piece of absorbent cotton which served as a resting place for the flies when they were feeding. Approximately 10 ml of citrated bovine blood was placed in a second dish and 3 ml of 5 per cent maltose solution was also added to this receptacle. Fresh cow dung was placed in a third dish to serve both as a source of food and as an oviposition medium. Each day after being removed from the cages, the dishes of manure were set aside for 48 hours and then examined for the presence of larvae. If larvae were found, the manure was transferred to a porcelain tray (15 × 10 × 3 inches) containing a large central mass of dung surrounded by a fairly thick layer of vermiculite into which the larvae migrated just prior to pupation. These trays were covered with a layer of cheesecloth and placed on shelves in the rearing room. Following pupation, the insects were gently removed to a small dish which was put in one of the rearing cages to await emergence.

The activities of alcohol, succinic, malic, glucose, glutamic, alpha-glycerophosphate, lactic, and isocitric dehydrogenases and the malic enzyme were determined by the Thunberg method as given by Umbreit, Burris and Stauffer (1957, p. 130). The insects were washed in an alcohol solution, according to the procedure followed by Cotty (1956) to remove surface bacteria before homogenization. Insects were homogenized by means of a motor-driven glass homogenizer for 1 minute in 0.03 M phosphate buffer, except in the case of isocitric dehydrogenase, where veronal buffer was used since the phosphate ion interferes with the activity of this enzyme. The buffers were adjusted to a pH of 7.4. A 3 per cent homogenate (1 ml) was incubated at 30°C for 30 minutes, and when NAD or NADP was used, the homogenate was pre-incubated with 0.5 ml of 0.2 per cent NAD or with 0.5 ml of 0.1 per cent NADP to oxidize the endogenous substrate. The smaller concentration of NADP was used because the addition of larger amounts did not increase enzyme activity. The homogenate was then placed in the side arm cap of the Thunberg tube. In the body of the tube were placed 1 ml of 1/10,000 per cent methylene blue, 1 ml of substrate (0.004 M), and a sufficient amount of buffer to bring the final volume to 6 ml. In measuring the activity of malic dehydrogenase, 0.5 ml of 0.24 M KCN was added to prevent inhibition by the oxalacetate formed (Green 1936). In determining the succinic dehydrogenase activity, 0.5 ml of a mixture of 0.005 M $CaCl_2$ and 0.005 $Alcl_3$ was added. NADP was used in the studies of the malic enzyme and of isocitric dehydrogenase. In the former determinations, 0.5 ml of 0.033 M $MgSO_4$, and in the latter, 0.5 ml of 6×10^{-3} M $MnCl_2$ was added. These supplementary solutions were added before the final dilution of the homogenate. The tubes were evacuated for five minutes and were then inverted to add the homogenate contained in the side arm to the mixture in the main portion of the tube, thus bringing the final concentration of homogenate to 0.5 per cent. Following this the tubes were placed in a constant temperature bath at 30°C, and the time required for 90 per cent reduction of methylene blue to occur was determined by visually matching the color with that of a standard tube. This standard contained all of the components of the other tubes except that the methylene blue was diluted to $\frac{1}{10}$ the usual concentration and the homogenate had been previously inactivated by boiling. A control tube containing all the components of the experimental tube except the substrate was used in each determination.

Activities of dehydrogenase enzymes were expressed as 1/time in minutes for 90 per cent decoloration of methylene blue. These activities were determined by subtracting the rate of control from that of the experimental tube.

The activity of cytochrome oxidase, expressed as $\triangle$ log $(CyFe^{++})$/minute, was determined during the same stages of metamorphosis and was measured on tissue homogenates in a final concentration of 1:10,000. The insects were homogenized in 0.03 M phosphate buffer which had a pH of 7.4. The spectrophotometric method of Cooperstein and Lazarow (1951) was used to measure the cytochrome oxidase activity.

TABLE 1. Dehydrogenase activity expressed as 1/time in minutes for 90% decolorization of methylene blue during the metamorphosis of the face fly, *Musca autumnalis*. Readings were made at 30°C. (GPD is alpha-glycerophosphate dehydrogenase.)

	Dehydrogenase									
Stage	Malic	Glu-cose	Alcohol	Lactic	Iso-citric	Glu-tamic	Suc-cinic	GPD I	GPD II	Malic Enzyme
Larva	0.375	0.006	0.055	0.024	0.345	0.008	0.019	0.061	0.005	0.120
Prepupa	0.328	0.004	0.050	0.022	0.316	0.006	0.016	0.050	0.006	0.114
Pupa, 1 day	0.280	0.004	0.040	0.018	0.322	0.006	0.008	0.020	0.008	0.105
Pupa, 2 day	0.252	0.006	0.031	0.015	0.282	0.003	0.008	0.011	0.010	0.082
Pupa, 3 day	0.228	0.010	0.022	0.009	0.230	0.002	0.005	0.005	0.010	0.060
Pupa, 4 day	0.230	0.009	0.038	0.006	0.218	——	0.005	0.004	0.012	0.096
Pupa, 5 day	0.260	0.006	0.046	0.010	0.202	——	0.009	0.018	0.012	0.104
Pupa, 6 day	0.345	0.005	0.058	0.005	0.180	——	0.012	0.029	0.025	0.110
Pupa, 7 day	0.425	0.005	0.062	0.007	0.156	——	0.024	0.058	0.032	0.112
Adult, just emerged	0.785	0.002	0.069	0.007	0.131	——	0.030	0.074	0.035	0.130

OBSERVATIONS

The changes in the activities of the dehydrogenase enzymes during the metamorphosis of the face fly are shown in Table 1. Each value is an average of ten determinations.

Total alpha-glycerophosphate, alcohol, malic, and succinic dehydrogenases as well as the malic enzyme exhibited U-shaped activity. Greatest activity was shown by the malic dehydrogenase with a considerable rise observed in the newly emerged adult. Alpha-glycerophosphate dehydrogenase I (requiring NAD) decreased steadily from the larval stage to the fourth day and then rose gradually during the remainder of the pupal stage. Alpha-glycerophosphate II (not requiring NAD) appeared at the first day of the pupal stage and it showed a steady increase with the highest activity being detected in the adult fly. Isocitric dehydrogenase activity was high initially and remained high until 2-day pupa and thereafter showed a progressive decline. Glucose dehydrogenase activity was very low; it remained fairly steady during the entire pupal stage and decreased slightly in the newly emerged adult. Alcohol dehydrogenase decreased steadily during the first days of the metamorphosis, reaching a low value on the third day, and then increased to reach its highest value in the adult stage. Succinic dehydrogenase exhibited a similar pattern but the level of activity was not as high as most of the other dehydrogenases. The activity of lactic dehydrogenase was low throughout metamorphosis. Malic enzyme exhibited high activities in the larva, prepupa and again in the adult stage. Glutamic dehydrogenase showed low activity in the larval stage. It decreased during the first several days of pupal life and completely disappeared by the fourth day.

Cytochrome oxidase activity was also U-shaped during metamorphosis as indicated in Table 2. Each value here is also an average of at least ten determinations. The larval and prepupal stages were characterized by high activity with a

Table 2. Cytochrome oxidase activity during the metamorphosis of *Musca autumnalis*. Homogenate concentration is 1:10,000.

Stage	Enzyme Activity △ log [$CyFe^{++}$] / min.		
	Minimum	Maximum	Average
Larva	0.051	0.103	0.084
Prepupa	0.043	0.088	0.061
Pupa, 1 day	0.024	0.042	0.032
Pupa, 2 day	0.014	0.038	0.021
Pupa, 3 day	0.009	0.022	0.014
Pupa, 4 day	0.008	0.017	0.010
Pupa, 5 day	0.027	0.048	0.041
Pupa, 6 day	0.052	0.089	0.076
Pupa, 7 day	0.112	0.151	0.127
Adult, newly emerged	0.124	0.221	0.178

progressive decrease until the fourth day and then a steady increase to a high of 0.178.

DISCUSSION

The U-shaped activities of malic dehydrogenase and the malic enzyme agree with the results reported for these enzymes during the metamorphosis of the mealworm and of the house fly (Ludwig and Barsa, 1958 and 1959). These findings also agree with those of Agrell (1949) for the blow fly, *Calliphora erythrocephala*, and of Diamantis (1962) for the Mediterranean flour moth, *Ephestia kühniella*. Isocitric dehydrogenase activity in the face fly was slightly lower than that found in the house fly (Ludwig and Barsa, 1959), but similar in that it uniformly decreased during metamorphosis. This differs from the results reported by Agrell (1949) for the blow fly and Diamantis (1962) for the Mediterranean flour moth, both of whom found that isocitric dehydrogenase exhibited U-shaped activity. Isocitric dehydrogenase in the presence of NADP and Mn^{++} catalyzes the oxidation of isocitrate through oxalosuccinate to alpha-ketoglutarate. The high activity of malic dehydrogenase is similar to that reported for the house fly by Ludwig and Barsa (1959) and for the flour moth by Diamantis (1962). Malic dehydrogenase and the malic enzyme both catalyze the oxidation of l-malate. The end products with the malic enzyme are pyruvate and CO_2, whereas with malic dehydrogenase the end product is oxaloacetate. The high activities of malic dehydrogenase and the malic enzyme coupled with the rather low rate for total lactic dehydrogenase adds additional support to the belief that lactate does not accumulate in insects, but rather pyruvate is reduced to malate which in turn is oxidized to oxaloacetate. The U-shaped activity curves for alcohol and alpha-glycerophosphate I dehydrogenase agree with the results obtained by Ludwig and Barsa (1959) with the house fly, but alpha-glycerophosphate II was found during all stages of metamorphosis in the face fly as contrasted with the house fly where it does not appear until near the end of the

pupal stage. The activity curve for succinic dehydrogenase corroborates reported results of a number of other insects including *Drosophila melanogaster* (Wolsky, 1941), *Calliphora erythrocephala* (Agrell, 1949), *Musca domestica* (Ludwig and Barsa, 1959), *Tenebrio molitor* (Ludwig and Barsa, 1958), *Ephestia kühniella* (Diamantis, 1962). The low activity of this enzyme indicates that it could be a determining factor in the U-shaped respiratory curve that is characteristic of the metamorphosis of holometabolous insects.

The U-shaped pattern of cytochrome oxidase activity here reported for *Musca autumnalis* agrees with what has been found in the fruit fly, *D. melanogaster* by Wolsky (1938), in the house fly, *M. domestica* by Sacktor (1951), in the Japanese beetle, *P. japonica* by Ludwig (1953), in the moth, *Platysamia cecropia* by Williams (1950), and in the flour moth, *Ephestia kühniella* by Diamantis (1912). This would indicate that most of the oxidation during metamorphosis is mediated through the cytochrome system.

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Some Synonyms in American Spiders[1]

Wilton Ivie[2]

Abstract: New synonyms of one genus and twenty-four species, as well as twenty-one new combinations and a few other notes pertaining to American spiders, most of them in the family Linyphiidae, particularly the sub-family Erigoninae, are recorded.

The following notes, concerned with new synonymy and new combinations in the nomenclature of American spiders, are presented herewith so that they may become part of the published record. Many of these notes were accumulated while examining the collections of The American Museum of Natural History, the Museum of Comparative Zoology at Harvard, Cornell University, Ithaca, New York, and parts of the type collections of the University of Utah and The United States National Museum. Cross references are given under the respective genera and families for the names mentioned in the text. Under the literature references, only those not included in Bonnet's Bibliographia Araneorum are cited.

Family CLUBIONIDAE

Genus *PHRUROTIMPUS* Chamberlin and Ivie, 1935.

Phrurotimpus alarius (Hentz), 1847.

Phrurotimpus annulatus Chamberlin and Ivie, 1944. New Synonym.

Phrurotimpus borealis (Emerton), 1911.

Phrurolithus utus Chamberlin and Ivie, 1933. Synonym.

Family SALTICIDAE

Genus *LYSSOMANES* Hentz, 1844.

Lyssomanes viridis (Walckenaer), 1837.

Tetragnatha lutea Walckenaer, 1841. New Synonym.

Family THERIDIIDAE

Genus *DIPOENA* Thorell, 1870.

PSELOTHORAX Chamberlin, 1948 (Erigonidae). New Synonym.

Dipoena atopa (Chamberlin). New Combination.

Pselothorax atopus Chamberlin, 1948.

Dipoena daltoni Levi, 1953. New Synonym.

Family TETRAGNATHIDAE

Genus *TETRAGNATHA* Latreille, 1804.

Tetragnatha lutea Walckenaer. See *Lyssomanes viridis* (Salticidae)

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Family LINYPHIIDAE

Sub-Family Erigoninae

Genus *ACARTAUCHENIUS* Simon, 1884.

Acartauchenius columbiensis Crosby. See *Maso polita.*

Genus *CERATICELUS* Simon, 1884.

Ceraticelus anomalus Gertsch and Ivie. See *Idionella anomala.*

Ceraticelus desertus Gertsch and Ivie. See *Idionella deserta.*

Ceraticelus formosus (Banks). See *Idionella formosa.*

Ceraticelus guttatus Chamberlin and Ivie. See *Idionella anomala.*

Ceraticelus micropalpus (Emerton).

Ceraticelus durus Chamberlin and Ivie, 1939. New Synonym.

Ceraticelus nesiotes Crosby. See *Idionella nesiotes.*

Ceraticelus parvulus (Fox). See *Ceratinella parvula.*

Ceraticelus rugosus Crosby. See *Idionella rugosa.*

Ceraticelus titivillitium Crosby and Bishop. See *Idionella titivillitium.*

Ceraticelus tuganus Chamberlin. See *Idionella tugana.*

Genus *CERATINELLA* Emerton, 1882.

Ceratinella brunnea Emerton, 1882.

Ceratinella placida Banks, 1892. New Synonym.

Ceratinella formosa Banks. See *Idionella formosa.*

Ceratinella parvula (Wm. Fox).

Erigone (*Ceratinella*) *parvula* Fox, 1891.

Ceratinella sphaerula Emerton, 1911. New Synonym.

Ceraticelus parvulus: Crosby and Bishop, 1925.

Genus *CERATINOPS* Banks, 1905.

Ceratinops obscura (Chamberlin and Ivie). New Combination.

Masonetta obscura Chamberlin and Ivie, 1944.

Genus *CERATINOPSIS* Emerton, 1882.

Ceratinopsis disparata (Dondale). New Combination.

Grammonota disparata Dondale, 1959. This species is very close to, if not identical with, *Ceratinopsis labradorensis* Emerton, 1925.

Ceratinopsis tybeensis Chamberlin and Ivie. See *Masonetta floridana.*

Genus *CORNICULARIA* Menge, 1868.

Cornicularia lepida Kulczynski, 1885. Kamchatka.

Cornicularia pacifica Emerton, 1923. New Synonym.

Cornicularia selma Chamberlin. See *Scylaceus selma.*

Genus *EPERIGONE* Crosby and Bishop, 1928.

Eperigone trilobata (Emerton).

Bathyphantes tristis Banks, 1892. Synonymy suggested by Hackman, 1954; confirmed by examination of type material.

Genus *EPICERATICELUS* Crosby and Bishop, 1931.

Epiceraticelus fluvialis Crosby and Bishop.

Scylaceus amylus Chamberlin, 1948. New Synonym.

Genus *ERIDANTES* Crosby and Bishop, 1933.

Eridantes erigonoides (Emerton).

Erigone percisa Keyserling, 1886. New Synonym.

Genus *ERIGONE* Audouin, 1827.

Erigone atra (Blackwall), 1833.

Erigone praepulchra Keyserling, 1886. Synonym.
Erigone matei Keyserling. See *Ostearius melanopygius.*
Erigone minutissima Keyserling. See *Scylaceus pallidus.*
Erigone nigrianus Keyserling. See *Ostearius melanopygius.*
Erigone percisa Keyserling. See *Eridantes erigonoides.*
Erigone rostratula Keyserling. See *Scylaceus pallidus.*
Genus *EULAIRA* Chamberlin and Ivie, 1933.
Eulaira microtarsus (Emerton). See *Hillhousia microtarsus.*
Genus *GONEATARA* Bishop and Crosby, 1935.
Goneatara nasuta (Barrows). New Combination.
Souessa nasuta Barrows, 1943.
Genus *GRAMMONOTA* Emerton, 1882.
Grammonota disparata Dondale. See *Ceratinopsis disparata.*
Grammonota sclerata Ivie and Barrows. See *Idionella sclerata.*
Genus *HILAIRA* Simon, 1884.
Hilaira balia Crosby and Bishop, 1929. South America.
Microneta maculata Mello-Leitao, 1940. New Synonym.
Genus *HILLHOUSIA* F. P.-Cambridge, 1894.
Hillhousia microtarsus (Emerton). New Combination.
Tmeticus microtarsus Emerton, 1882.
Eulaira microtarsus: Chamberlin and Ivie, 1945.
Sciastes microtarsus Bishop and Crosby, 1938.
Genus *IDIONELLA* Banks, 1893. Type: *formosa.*
Idionella anomala (Gertsch & Ivie). New Combination.
Ceraticelus anomalus Gertsch and Ivie, 1936. Male.
Ceraticelus guttatus Chamberlin and Ivie, 1939. Female. New Synonym.
Idionella deserta (Gertsch and Ivie). New Combination.
Ceraticelus desertus Gertsch and Ivie, 1936.
Idionella formosa (Banks).
Ceratinella formosa Banks, 1892.
Ceraticelus formosus: Crosby and Bishop, 1925.
Idionella nesiotes (Crosby). New Combination.
Ceraticelus nesiotes Crosby, 1924.
Idionella rugosa (Crosby). New Combination.
Ceraticelus rugosus Crosby, 1905.
Idionella sclerata (Ivie and Barrows). New Combination.
Grammonota sclerata Ivie and Barrows, 1935.
Ceraticelus formosus: Crosby, 1937 (in part; male, not female).
Idionella titivillitium (Crosby and Bishop). New Combination.
Ceraticelus titivillitium Crosby and Bishop, 1925.
Idionella tugana (Chamberlin). New Combination.
Ceraticelus tuganus Chamberlin, 1948.
Genus *ISLANDIANA* Braendegaard, 1932.
Islandiana falsifica (Keyserling). New Combination.
Erigone falsifica Keyserling, 1886.
Tmeticus alatus Emerton, 1919. New Synonym.
Islandiana alata: Ivie, 1965.
Genus *MASO* Simon, 1884.
Maso polita Banks, 1896.

Acartauchenius columbiensis Crosby, 1905. New Synonym.

Genus *MASONCUS* Chamberlin, 1948.

Masoncus conspectus (Gertsch and Davis). New Combination.

Tapinocyba conspecta Gertsch and Davis, 1936.

Masoncus nogales Chamberlin, 1948. New Synonym.

Genus *MASONETTA* Chamberlin and Ivie, 1939.

Masonetta floridana (Ivie and Barrows), 1935.

Ceratinopsis tybeensis Chamberlin and Ivie, 1944. New Synonym.

Masonetta obscura Chamberlin and Ivie. See *Ceratinops obscura.*

Genus *OEDOTHORAX* Bertkau, 1883.

Oedothorax melacra Chamberlin. See *Ostearius melanopygius.*

Genus *OSTEARIUS* J. E. Hull, 1911.

Ostearius melanopygius (O. P. Cambridge).

Linyphia melanopygia O. P. Cambridge, 1879.

Erigone matei Keyserling, 1886. New Synonym.

Erigone nigrianus Keyserling, 1886. New Synonym.

Oedothorax melacra Chamberlin, 1916. New Synonym.

Scolopembolus melacrus: Bishop and Crosby, 1938.

Genus *PSELOTHORAX* Chamberlin, 1948. See *DIPOENA*, (Theridiidae).

Pselothorax atopus Chamberlin. See *Dipoena atopa,* (Theridiidae).

Genus *SCIASTES* Bishop and Crosby, 1938.

Sciastes microtarsus (Emerton). See *Hillhousia microtarsus.*

Sciastes ogeechee Chamberlin and Ivie. See *Souessoula parva.*

Sciastes terrestris (Emerton). See *Porrhomma terrestris* (Linyphiinae)

Genus *SCOLOPEMBOLUS* Bishop and Crosby, 1938.

Scolopembolus melacrus (Chamberlin). See *Ostearius melanopygius.*

Genus *SCYLACEUS* Bishop and Crosby, 1938.

Scylaceus amylus Chamberlin. See *Epiceraticelus fluvialis.*

Scylaceus pallidus (Emerton), 1882.

Erigone minutissima Keyserling, 1886. New Synonym.

Erigone rostratula Keyserling, 1886. New Synonym.

Scylaceus pallas Chamberlin, 1948. New Synonym.

Scylaceus selma (Chamberlin). New Combination.

Cornicularia selma Chamberlin, 1948.

Genus *SISICOTTUS* Bishop and Crosby, 1938.

Sisicottus atypicus Chamberlin and Ivie. See *Souessoula parva.*

Genus *SOUESSA* Crosby and Bishop, 1936.

Souessa nasuta Barrows. See *Goneatara nasuta.*

Genus *SOUESSOULA* Crosby and Bishop, 1936.

Souessoula parva (Banks), 1899.

Sciastes ogeechee Chamberlin and Ivie, 1944, female. New Synonym.

Sisicottus atypicus Chamberlin and Ivie, 1944, male. New Synonym.

Genus *TACHYGYNA* Chamberlin and Ivie, 1939.

Tachygyna gargopa (Crosby and Bishop). New Combination.

Microneta gargopa Crosby and Bishop, 1929.

Genus *TAPINOCYBA* Simon, 1884.

Tapinocyba conspecta Gertsch and Davis. See *Masoncus conspectus.*

Genus *TMETICUS* Menge, 1886.

Tmeticus alatus Emerton. See *Islandiana falsifica.*

Tmeticus microtarsus Emerton. See *Hillhousia microtarsus.*
Tmeticus terrestris Emerton. See *Porrhomma terrestris* (Linyphiinae).

Sub-Family Linyphiinae

Genus *ALLOMENGEA* Strand, 1912.
Allomengea pinnata (Emerton). New Combination.
Microneta pinnata Emerton, 1915.
Microneta plumosa: Emerton, 1915 (lapsus in caption of figure for *M. pinnata.*)
Linyphia ontariensis Emerton, 1925. New Synonym.
Helophora ontariensis: Blauvelt, 1936; Chamberlin and Ivie, 1947.
Allomengea scopigera (Grube).
Linyphia sitkaensis Keyserling, 1886. New Synonym.
Genus *BATHYPHANTES* Menge, 1866.
Bathyphantes pacificus Banks. See *Linyphantes pacificus.*
Bathyphantes tragicus Banks. See *Linyphantes tragicus.*
Bathyphantes tristis Banks. See *Eperigone trilobata.*
Genus *LEPTHYPHANTES* Menge, 1866.
Lepthyphantes sabulosus (Keyserling), 1886.
Lepthyphantes appalachia Chamberlin and Ivie, 1944. New Synonym.
Type locality of *sabulosus* given as Salt Lake City, Utah; probably incorrect.
Genus *LINYPHANTES* Chamberlin and Ivie, 1942.
Linyphantes aeronautica (Petrunkevitch). New Combination.
Microneta aeronautica Petrunkevitch, 1929.
Linyphantes orcinus (Emerton). New Combination.
Microneta orcina Emerton, 1917.
Linyphantes pacificus (Banks). New Combination.
Bathyphantes pacificus Banks, 1905.
Linyphantes tragicus (Banks). New Combination.
Bathyphantes tragicus Banks, 1898. Baja California.
Genus *LINYPHIA* Sundevall, 1804.
Linyphia melanopygia O. P. Cambridge. See *Ostearius melanopygius* (Erigoninae).
Linyphia ontariensis Emerton. See *Allomengea pinnata.*
Linyphia sitkaensis Keyserling. See *Allomengea scopigera.*
Genus *MICRONETA* Menge, 1868.
Microneta aeronautica Petrunkevitch. See *Linyphantes aeronautica.*
Microneta gargopa Crosby and Bishop. See *Tachygyna gargopa.*
Microneta maculata Mello-Leitao. See *Hilaira balia* (Erigoninae)
Microneta orcina Emerton. See *Linyphantes orcinus.*
Microneta pinnata Emerton. See *Allomengea pinnata.*
Microneta plumosa Emerton. See *Allomengea pinnata.*
Genus *PORRHOMMA* Simon, 1884.
Porrhomma terrestris (Emerton). New Combination.
Tmeticus terrestris Emerton, 1882.
Sciastes terrestris: Bishop and Crosby, 1938 (Erigoninae).

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Hackman, Walter. 1954. The Spiders of Newfoundland. Acta Zool. Fennica, No. 79, pp. 1–99, 121 figs., 5 maps.

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Biology of *Dufourea* and of its cleptoparasite, *Neopasites* (Hymenoptera: Apoidea)

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Abstract: The biologies of four species of *Dufourea* [*D. mulleri* (Cockerell), *D. malacothricis* Timberlake, *D. pulchricornis* (Cockerell), and *D. trochantera* Bohart] are described and compared. The biology of the nomadine bee parasite, *Neopasites,* family Anthophoridae, is also described. Two species of the parasite are associated with their hosts [*Neopasites* (*Micropasites*) *cressoni* Crawford with *D. mulleri,* and an undescribed species of the subgenus *Neopasites* with *D. trochantera*]. The suspected association of an additional species, *Neopasites* (*Neopasites*) *fulviventris* (Cresson), on *D. dentipes* Bohart and an undescribed *Dufourea* species is included. The subfamilies of Halictidae are compared on the basis of biological features in a summary table.

The family Halictidae (composed of Halictinae, Nomiinae, and Dufoureinae) is well represented in the biological literature. Most of the information, however, concerns halictines and nomiines. Previous biological studies of the Dufoureinae have been restricted to six species within two Old World genera: *Rophites canus* Evers (Enslin, 1921; Malyshev, 1925a), *Rophites hartmanni* Friese (Malyshev, 1925a), *R. quinquespinosus* Spinola (Stockhert, 1922), *Systropha planidens* Giraud and *S. curvicornis* Scopoli (Malyshev, 1925b), and *S. punjabensis* Batra and Michener (Batra and Michener, 1966). The holarctic genus, *Dufourea*, has not been studied biologically, even though it is widely distributed and contains the greatest number of species in the subfamily. The biologies of four *Dufourea* species (*D. mulleri* (Cockerell), *D. malacothricis* Timberlake, *D. pulchricornis* (Cockerell), and *D. trochantera* Bohart) are reported.

The biology of the New World *Neopasites* (= *Gnathopasites*) is also described. It and its Old World counterpart, *Biastes*, comprise the nomadine tribe Biastini which are cleptoparasitic primarily on the Dufoureinae. *Biastes* attacks the nests of *Rophites, Systropha*, and presumably the eucerine *Tetralonia* (Popov, 1951), and *Neopasites* attacks those of *Dufourea.*

The literature search for this paper was made with the assistance of the Bibliography of Apoid Biology under the direction of Dr. Charles D. Michener, the University of Kansas, Lawrence.

Dufourea mulleri (Cockerell)

Description of Habitat: Bohart, Torchio, and Nabil Youssef studied the biology of this species at Tubac, Santa Cruz County, Arizona, between April

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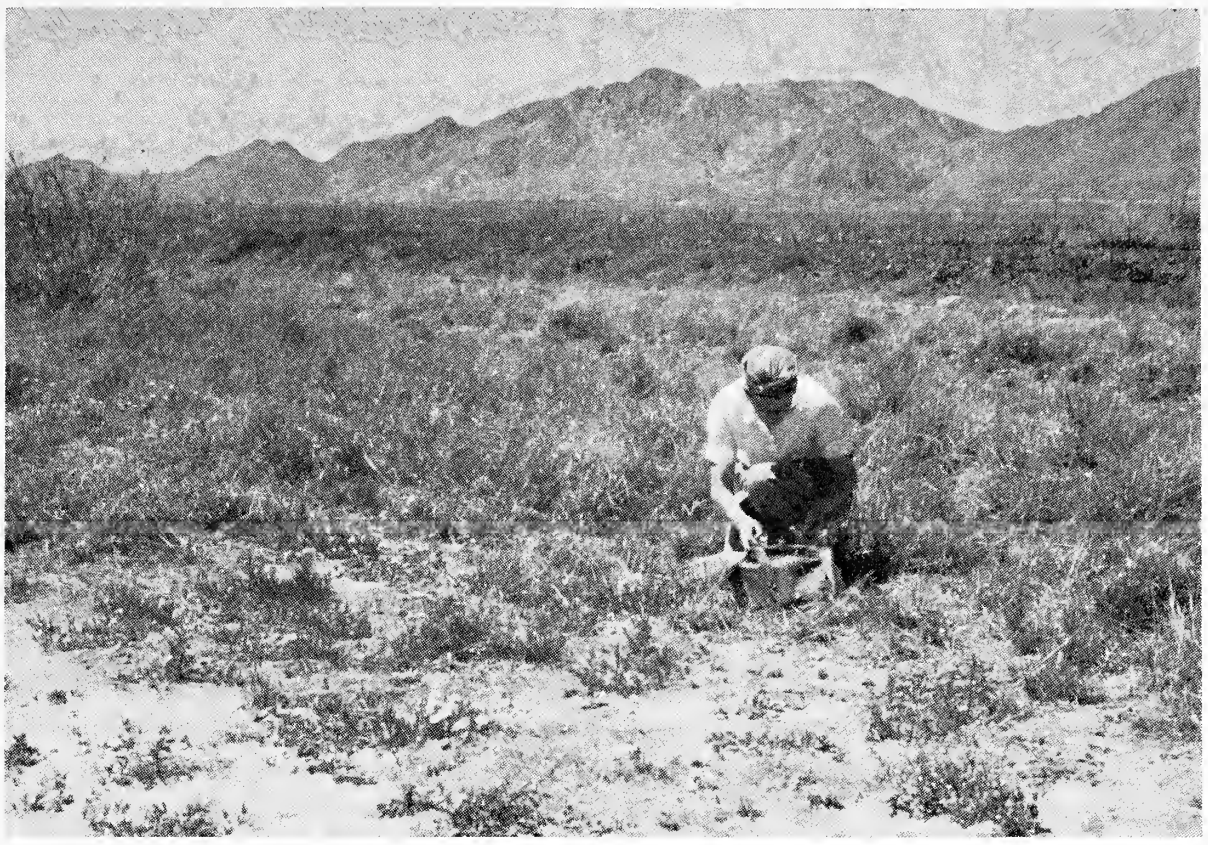


Fig. 1. Nesting area of *Dufourea mulleri* (Cockerell) at 3 miles south-southwest of Rodeo, Hidalgo County, New Mexico.

13 and 17, 1965. Torchio returned to this site on April 27, 1965, and found nesting had been completed. On April 26, 1966, he revisited the nesting site and discovered the nesting population greatly reduced over the previous year. Rozen studied the species 3 miles S.S.W. of Rodeo, New Mexico (Fig. 1) (actually in Cochise County, Arizona), between May 1 and 5, 1965. Rozen and Favreau revisited this site between April 26 and May 5, 1966, at which time the species was more abundant and nested in various areas along the road between this point and Apache, Arizona.

The Tubac site was located adjacent to a gravelly creek bottom which carried water during short periods each year. *Phacelia* of two species, *Lesquerella, Malacothrix, Acacia greggii* Gray, a tall crucifer, and several grass species were the predominant plants growing along the creek. The surrounding area is typical of the Lower Sonoran. The Rodeo site, a recently disturbed, nearly flat area, half a mile long, was adjacent to a highway running in a S.S.W. direction through the wide San Simon Valley. The nest area was occupied by low, sparsely scattered herbs, including the pollen plant, *Phacelia popei* T. & G. var. *arizonica* (Gray) Voss, and a *Lepidium* species. The vegetation adjoining the nest area was dominated by *Prosopis* and other xerophilous plants. The soil surface at both nesting sites was unshaded and ranged from horizontal or nearly so near Rodeo to gently sloping (up to 15°) at Tubac. At Tubac, nesting took place in two soil types. One had a 6 mm. layer

of dry, loose powder covering a hard-packed, sandstone-like layer composed of brownish soil interspersed with large gravel particles. The hard-packed layer extended below the cell level and contained some moisture below 4.6 cm. The second soil type was light brown, coarsely grained, and loosely packed to 5 cm. below its surface. Large, extremely hard-packed clods found below the surface layer were separated from each other by air spaces or narrow bands of loosely-packed soil. The soil was dry until well below the cell level. The nesting site near Rodeo was sandy and loosely packed from its surface to a depth of 3–4 cm., below which it became hard-packed and pebble-free. Moisture at the cell level varied from slight to moderate, depending upon the depth. Soil temperatures recorded from this site at a depth of 10 cm. on April 24, 1966, were: 9:30 a.m., 69°F; 10 a.m., 69°F; 12:30 p.m., 78°F; 3:15 p.m., 80°F. The time is Rocky Mountain Standard time and the day was clear and warm.

Although nests were scattered over extensive areas at both locations, nest concentrations also occurred. The most dense concentrations numbered ½ nest/sq. ft. at Tubac and 4 nests/sq. ft. near Rodeo. Apparently, the species can be regarded as weakly gregarious. Only a single female occupied a nest.

Nest Architecture

ENTRANCE HOLE: Some nest entrances occurred in flat, bare ground, but more frequently they were at the lower edges of slight depressions or at the bases of pebbles or rocks. Soil excavated from the nests was deposited on one side of the entrance, forming an asymmetrical tumulus. The typical tumulus at Tubac was heart-shaped and measured 33 mm. long by 27 mm. wide. A weakly defined trail 4 mm. wide, 2 mm. deep, and 18 mm. long extended from the entrance hole to near the apical angle of the tumulus. It was formed as the female swept excavated soil away from the entrance while she backed away repeatedly over the same terrain. At the terminus of the trail, the excavated soil was kicked back and away with rapid, flicking leg movements. The tumulus was continually reshaped and enlarged throughout the period of nesting activity.

Entrances were generally kept closed at Tubac but remained open near Rodeo. Possibly the divergent behavior at each location is simply a reflection of adaptability to nesting in different soil types. At Tubac the very loose surface powder tended to fill the entrance holes each time bees entered or left. Returning foragers, however, were able to orient to their respective entrance holes very successfully. They literally dove into the powdered layer, as do some *Nomadopsis* species, and rapidly moved soil about until they found and entered their burrow. The soil near Rodeo was sufficiently granular and hard-packed to allow the entrance holes to remain open. Entrances always lacked turrets.

BURROWS: The main burrow, circular in cross section, was 3.5 mm. in diameter and descended in a meandering fashion. There were no obvious constrictions at or near the entrance hole. The burrow walls were not lined but, at least at the Tubac site, they appeared darker in color and were more tightly packed than the surrounding soil. Their permeability to water was equal to that of the surrounding soil. A vestibule measuring 7 mm. in diameter was found in one nest at Tubac. It was constructed as a pocket in the wall of the main burrow 11 mm. below the soil surface. The main burrow was never plugged and it terminated in a nearly horizontal cell.

Lateral burrows were originated along a 15 mm. zone about halfway down the main burrow. The unlined laterals (as many as 9 per nest) radiated horizontally from the main burrow for distances ranging from 5 to 38 mm. Circular in cross section, they had the same diameter as the main burrow except where they narrowed to 3 mm. just before joining the cell. Each lateral was plugged tightly before a new one was excavated.

CELLS: The cells (Figs. 2–6), which were ovoid and broadly rounded distally, were placed from 10 to 40 degrees from the horizontal with the anterior end highest. Their length varied from 6.0 to 8.0 mm. and their width from 4.5 to 5.0 mm. They were carved from the surrounding soil and their inner surfaces had no apparent "built-in" wall. They were, however, lined with a dull varnish that was nearly transparent upon drying. This lining, less than 0.05 mm. in thickness, filled the space between the sand grains and could not be peeled from the walls of their cells. The lining permitted a moderately rapid absorption of water when a droplet was placed on it. At the Rodeo site a very thin layer of dull, extremely fine, silt-like material coated the depressions between the grains of sand. Cells were located between 5 and 10 cm. from the ground surface, with the uppermost cell being excavated first and the lowermost cell last. Cells from previous years were not reconditioned and reused.

The unlined cell cap was composed of a moderately packed soil plug which had 3 indistinct spiral rings and a small central micropyle on its concave inner face.

Although only one cell per lateral burrow was found at Tubac, two cells (and in one case, three cells) in linear series were commonly found at the end of the lateral burrows near Rodeo. The passage between these cells varied in length from 2.0 to 5.0 mm., and was filled with rather loosely packed soil between the firm rear wall of one cell and the firm cap of the other.

Provisioning and Development

D. mulleri provisioned its nests with pollen from two *Phacelia* species at Tubac. One species produced blue pollen and the other, yellow. Since the pollen balls were always either one color or the other, it appears that the bees visited only one host plant species while provisioning a cell. *Phacelia popei* T. and G.

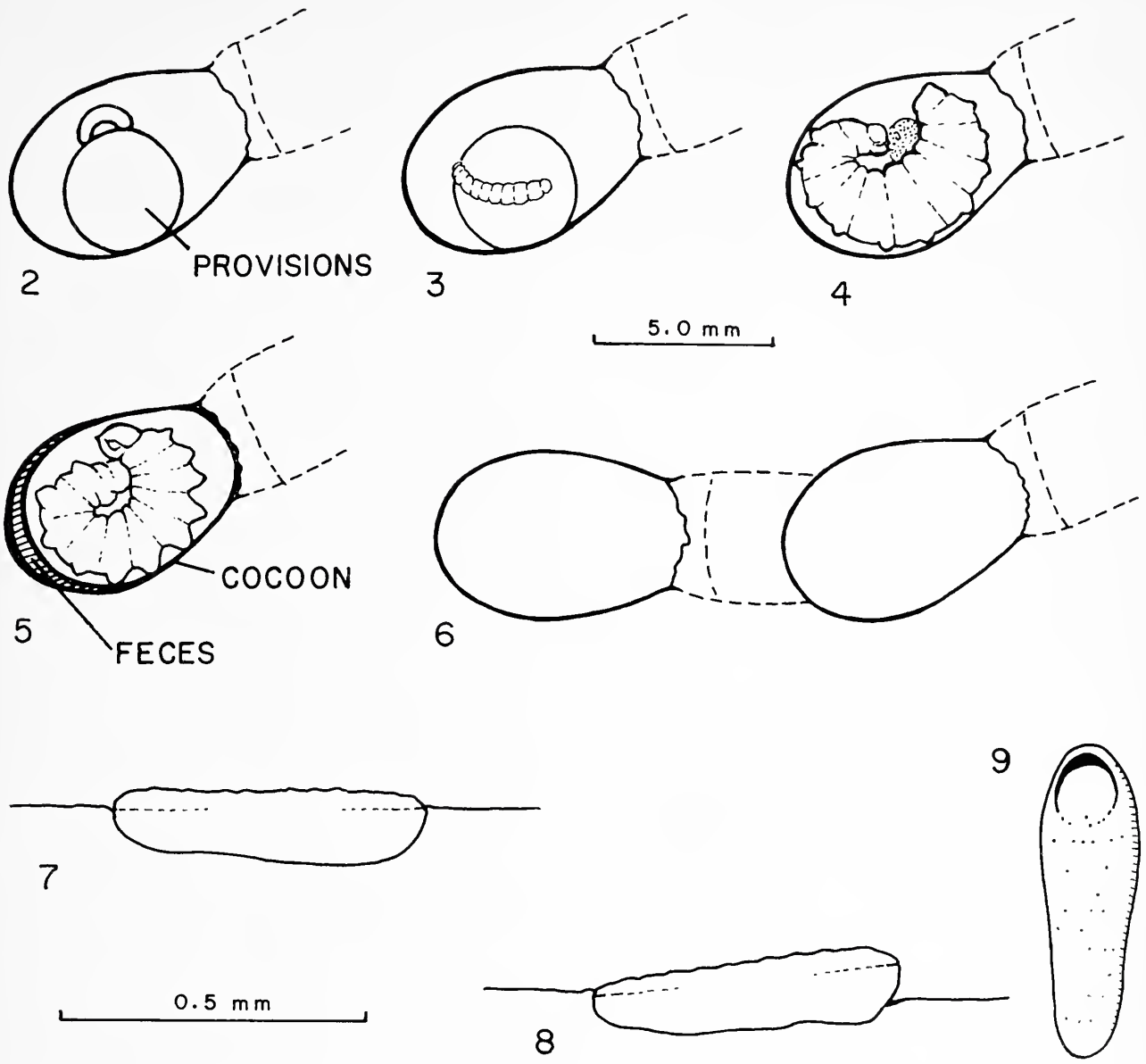
var. *arizonica* (Gray) Voss was the only pollen host near Rodeo. Its dry pollen remained bluish in color while on the bee's scopae but changed to lavender after it was molded into the provisions. The color of the pollen ball faded to a light tan by the time the first instar hatched from the egg.

Approximately three pollen loads were required to complete one pollen ball. The first load, after being transported to the cell, was mixed with nectar and shaped into a small but complete sphere. Each additional load was added to the existing sphere until it became a moist but firm, homogeneous, spherical ball, averaging about 3.5 mm. in diameter and ranging from 2.75 to 3.75 mm. The ball was placed near, but not at, the posterior end of the cell (Fig. 2). The pollen balls of this species resembled those of the panurgine genera *Nomadopsis* and *Calliopsis* in shape and consistency, but lacked a waterproof covering.

The shiny, whitish, strongly arched egg (Fig. 2) was approximately 1.9 mm. long and rested on top of the provision in the sagittal plane of the cell. Both ends were weakly attached to the provisions so that eggs were easily displaced when cells were excavated. In contrast, the eggs of some bees (e.g., certain Panurginae) are attached securely by their posterior ends while the anterior tip rises in the cell or merely touches the provision. In *mulleri* the broader anterior tip of the egg faced the cell closure.

Immediately before the first instar hatched, the egg chorion adhered to the embryo, so that the rather small head and body segmentation were visible on the still strongly arched egg. After hatching, the larva fed and crawled about on the provisions (Fig. 3). The first-stage larva, as well as subsequent ones, was equipped with a pair of dorsolateral tubercles on most body segments, with a somewhat protruding venter on the ninth abdominal segment, and with a posterodorsally directed tenth abdominal segment which could be contracted and expanded somewhat. These modifications assisted the larva as it crawled; by appressing the protruding ninth segment to the pollen ball and the expanded tenth to the cell wall, the larva stationed the posterior part of the body so that it could push its front part forward. While moving forward and bending the anterior portion of its body up and down, the larva fed on the pollen ball and left a wide, shallow groove in its wake. Because the feeding larva circled its provisions in random directions, the ball remained nearly spherical almost until it disappeared (Figs. 3–4).

After consuming the pollen ball, but before defecating, the larva began spinning a cocoon which, when completed, tightly adhered to the cell walls. When the outer layer of the cocoon was completed, the larva extruded long semi-moist, pale yellow fecal pellets which were applied to the posterior one-half to two-thirds of the cocoon in short strips more or less parallel to the long axis of the cell. During or after the late stages of defecation, the larva applied additional silk over the inner face of the outer cocoon layer and feces



Figs. 2–6. Cells of *Dufourea mulleri* (Cockerell): 2. With pollen ball and egg, side view. 3. With pollen ball and young larva, side view. 4. With nearly mature larva, side view. 5. With postdefecating larva, cocoon, and feces, side view. 6. In linear series, top view.

Figs. 7–9. Eggs of *Neopasites* (*Micropasites*) *cressoni* Crawford: 7. Embedded nearly flush with cell wall, lateral view. 8. Embedded at an angle with cell wall, lateral view. 9. After hatching, showing semicircular split at anterior end, dorsal view.

until a complete inner cocoon layer was formed. This very thin inner layer completely isolated the larva from its feces. Most of the fecal pellets, although flattened into ribbons by the pressure of the larva, were still distinguishable.

The completed cocoon (Fig. 5) was composed of two layers and assumed the same shape and dimensions as the cell. The parchment-like outer layer was dull, light brown on both of its surfaces but somewhat darker across its anterior face, where it was thicker. The inner layer was composed of a clear matrix interspersed with silk strands. It was very thin and tightly appressed to the inner face of the outer layer except where it incorporated and covered the fecal cake. The exposed surface of this layer was glossy. The cocoon was not

supplied with a nipple, but individual thread-like silk strands were detected. Soft and easily collapsed anteriorly, it was more rigid where the feces gave it additional support.

After the cocoons were spun, cells were difficult to find because they no longer broke open easily during excavation. Although the cocoons imparted extra strength to the cells, the mature larvae may also have secreted a hardening substance that permeated the soil adjacent to the cell. In any event, the wall of a cell occupied by a cocoon seemed much tougher than that of a cell containing an egg, an early instar, or an immature of *Neopasites,* which does not spin a cocoon.

Adult Activity

D. mulleri and *Neopasites cressoni* Crawford began flying between 9:00 a.m. and 9:30 a.m. M.S.T. on a warm clear day, and were still active at 2:30 p.m. Males of *D. mulleri*, presumably in search of mates, were often seen flying swiftly from host plant to host plant. Mating, observed only once, occurred near some host plants and was completed in 5 seconds. The bees did not fly *in copula* and mating was never observed at the nesting site.

Associates

Eurystylops (Strepsiptera) was discovered at Tubac as mature females in the abdomens of adult bees and as first instar larvae on the eggs. In one area of the same site, 90 percent of the bee cells contained dead first instars and were infested with a mold complex, including the genus *Rhizoctonium*.[3] The biology of *Neopasites cressoni*, which attacked *D. mulleri* at both nesting sites, is described near the end of this paper.

One burrow of *D. mulleri* possessed a unique feature in that it branched at the 2.5 cm. level. The branch, 2.5 mm. in diameter, led to two somewhat smaller cells containing a predefecating and a postdefecating larva belonging to the panurgine genus *Perdita*. They may well have been *Perdita sexmaculata* Cockerell, as this species was the only one abundant in the area at that time. Although the *Dufourea* female was still provisioning its part of the nest whereas the *Perdita* was not, it is impossible to say which had first started the nest because some offspring of both females had become mature larvae.

Dufourea trochantera Bohart

Description of Habitat

This species, which is closely related to *D. mulleri*, was discovered by Torchio nesting gregariously at Newton Dam, Cache County, Utah, on May 27, 1966. The nesting site was located on a 10-foot high, south-facing embankment inclined about 55° from horizontal. The site was made available recently when two

[3] Identified by G. M. Baker, Botany Dept., Utah State University.

roads converging near the nesting site were cut below the natural terrain of the hillside leading to the reservoir. Nests were mostly confined to an unvegetated 10-foot wide area of the embankment, and most entrances were situated toward the crest of the slope. A few nests were established at the top edge of the embankment where the grade was almost horizontal.

Flowering plants growing in the vicinity of the nesting site were: *Cirsium lanceolatum* (L.), Hill, *Oenothera* sp., *Brassica* sp., *Sphaeralcea* sp., *Salix* sp., *Penstemon* sp., and *Phacelia leucophila* Torr. *D. trochantera* was utilizing *Phacelia leucophila* as its pollen and nectar source.

The surface layer of the nesting site was composed of a fine, black powdered soil, ranging from 5 to 10 mm. in depth. Below this the black, clay soil became extremely hard-packed and contained numerous pebbles and rocks of varying sizes. The soil was dry to below the cell level.

Nest Architecture

ENTRANCE HOLE: Entrance holes were inclined at 45° angles from the horizontal regardless of the slope characteristics. All entrances, including those on the horizontal surface, faced south to southwest and were kept open. At times, however, winds disturbed the surface layer sufficiently to cause closure of some nests. Returning females associated with these nests landed near the plugged entrances and dug until the burrows were re-exposed.

Nesting females kicked excavated soil from the entrances of nests located on steep slopes until indistinct tumuli were deposited below the nests as long strips of soil. If entrances were located on the horizontal surface, each nesting female dragged excavated soil from the nest repeatedly over the same course until a trough or trail was formed. A typical tumulus measured 36 mm. long and 13 mm. wide. The trough was 3 mm. wide and extended about half the length of the tumulus. No obvious constriction or expansion of the burrow occurred at or near the entrance hole.

BURROWS: The unlined, unplugged main burrows were 3.5 mm. in diameter. They descended to depths ranging from 3 to 5 cm. When unobstructed, they spiraled downwards but were often forced to detour around pebbles and rocks. In two of the 25 nests excavated, an unlined vestibule was placed as a carved outpocket on a sharp turn of the main burrow. One of these measured 14 mm. wide by 9 mm. deep, and the second measured 7.5 mm. in diameter.

The lateral burrows were also unlined and of the same diameter as the main burrow. They originated along the main burrow at different points and meandered for distances of 4 to 42 mm., where they terminated at cells between 5 and 10 cm. below the surface. The laterals were tightly plugged after the cells were capped. We were unable to determine whether the main burrow terminated at a cell and was subsequently plugged for several centimeters or whether it divided into two or more laterals that were eventually plugged.

CELLS: Cells of this species were remarkably similar in shape, form, and manner of construction to those of *D. mulleri*. The cell lining differed from that of *D. mulleri* in its somewhat greater impermeability to water.

The cell cap, 3 mm. in diameter and composed of a moderately well-packed soil plug, was slightly concave. The unvarnished inner face had two to three indistinct rings surrounding a central micropyle, while the flat outer face had a smooth, unvarnished surface.

Most of the lateral burrows terminated at single cells, but others (about 25 percent) led to two cells in linear series. The cells were usually subhorizontal but sometimes dipped to as much as 30° below the horizontal. The passages between those cells in linear series were plugged with soil that varied from loosely to tightly packed.

Provisioning and Development

The provisions of this species were similar to those of *D. mulleri* except for their tan color and slightly smaller average size (2.85 to 3.25 mm.).

The eggs appeared to be slightly smaller than those of *D. mulleri* (1.8 mm. long by 0.4 mm. wide) but the samples may have been too small for a reliable comparison.

Embryonic development, hatching, and larval shape and mobility all appeared to be identical with the same features in *D. mulleri*.

Cocoon formation and structure were quite similar to those of *D. mulleri*. However, the following differences appeared to be consistent: (1) The outer cocoon layer was somewhat thicker and darker brown toward the anterior end, and there was a very thin, translucent zone about 2 mm. wide anterior to the fecal cake; (2) the fecal pellets composing the fecal cake were more completely fused into a single sheet.

Adult Activity

During warm, sunny weather, *D. trochantera* began flying at about 8:30 a.m. M.S.T. By 1:30 p.m. almost all flight ceased. Pollen loads were acquired in from 5 to 18 minutes and the time spent within the nest between loads varied from 2.5 to 36 minutes. This variation in time spent in the field and within the nest appeared to have no correlation with the time of day.

Associates

In the course of about 15 hours of observation at the nesting site, only two adults of an undescribed species in the subgenus *Neopasites* were seen. Surprisingly, four of the approximately 40 host cells examined contained quiescent, postdefecating larvae of the parasite. The limited biological information obtained agreed with that of *Neopasites cressoni* discussed in a separate section below. One cell of *D. trochantera* contained four dipterous larvae which were consuming the provision. Unfortunately, this cell was lost in transit from the field to the laboratory.

In 1962 a series of *Neopasites* adults were collected at a *D. trochantera* site on the Independence Lake Road, Sierra County, California, by M. E. Irwin. We compared specimens from both the California and Utah sites and found them to be distinct but undescribed species.

Dufourea malacothricis Timberlake

This species, smaller than *D. mulleri,* was collected from flowers of *Malacothrix* near Rodeo between April 26 and May 5, 1966. It was somewhat less common than *D. mulleri,* with which it flew, and only two nests were discovered by Favreau and Rozen, one at the Rodeo site (described above) and the other in an open area 3 miles north of Apache, Cochise County, Arizona.

Nest Architecture

ENTRANCE HOLE AND BURROW: The nest entrance and main burrow near Rodeo remained opened and bore an asymmetrical tumulus. The main burrow was 2.25 mm. in diameter and meandered a short distance before it was lost in the excavation.

The second nest occurred on unshaded, nearly horizontal terrain with a 2 cm.-deep surface layer composed of rather loosely packed soil. The soil below was compacted sand free of pebbles. The cells were 10 and 12 cm. deep where the soil was moist. The unlined main burrow, 3.0 mm. in diameter, descended in a meandering fashion to a number of unlined and completely plugged lateral burrows of the same diameter. These laterals were horizontal or somewhat descending and were 4.0 to 4.5 mm. long, although one extended 10 mm.

CELLS: Twelve cells were uncovered from the seven laterals associated with the one nest. Two cells were placed singly and the other 10 were grouped into linear series of two each. The distance between pairs in a series varied from 1.0 to 2.0 mm. All cells were inclined from 10 to 15 degrees from the horizontal with the rear of the cell lower than the front. They were identical in shape to those of *D. mulleri* and had the same type of lining and construction. The lining, however, was even less waterproof than that of *D. mulleri* in that it almost immediately absorbed a droplet of water. Cells varied from 5.0 to 5.5 mm. in length and from 3.5 to 4.0 mm. in maximum diameter. They were closed with a spiral plug, as in the case of *D. mulleri,* and the oldest cell was closest to the surface.

Provisioning and Development

The pollen balls of *D. malacothricis* differed from those of *D. mulleri* only in being yellow and in having a smaller diameter (2.75 to 3.0 mm.). The smaller eggs (1.75 mm. long) were identical in shape and placement with those of *D. mulleri,* and developing larvae practiced the same feeding habits. Unfortunately, no cocoons of this species were obtained.

Associates

The one nest excavated was free of parasites and predators even though *Neopasites cressoni* occurred in the area.

Dufourea pulchricornis (Cockerell)

Description of Habitat

Bohart and Torchio found this species collecting pollen from *Lesquerella gordoni* (A. Gray) Wats. on the edge of a dry creek bed 14 miles E. of Tucson, Arizona, on April 12, 1965. One active nest was located on a small sandy strip near the center of the gravelly creek bottom. The uneven surface of the strip was sparsely covered with grass and about 10 percent of it was covered by driftwood and other flotsam.

Nest Architecture

ENTRANCE HOLE: The nest was located near the base of several converging grass plants but it was reasonably well exposed. The burrow entrance was open, faced west, and angled into the soil surface. A small bell-shaped enlargement surrounded the entrance to several millimeters below the surface but it was probably an abnormal structure caused by the collapse of the adjacent, loose, dry sand and its subsequent removal by the nesting bee.

A well established asymmetrical tumulus, continually reshaped and enlarged by the nesting female, was present in front of the entrance hole. A shallow trail, 4 mm. wide, extended 3 cm. from the entrance, whereupon it made a 90° turn to the north and continued for an additional 8 mm. The moraine on either side of the trail was quite wide (8 mm.) and contained many pebbles and large sand particles. The trail and associated moraines of the tumulus were formed in the manner described for *D. mulleri*.

BURROWS: The main difference between the burrow system of *D. pulchricornis* and that of other species of *Dufourea* described here was the subdivision of lateral burrows into sublaterals. Unfortunately, the only nest available for study was incomplete and portions of the architecture were lost during excavation. Nevertheless, architecture differed sufficiently to justify description here.

The main burrow was unlined, unplugged, and 3 mm. in diameter. It maintained about a 20° angle from horizontal for 10 mm., whereupon it made a subhorizontal spiral and proceeded vertically. It branched into two lateral burrows about 7 mm. below the surface, but one branch was soon lost. The remaining lateral was difficult to follow because it was partially plugged (possibly in the process of being completely plugged), but it eventually divided into a number of plugged sublaterals radiating short distances from the lateral burrow. Each sublateral terminated at a single cell. The four cells eventually uncovered were 9 cm. below the surface and positioned 3 to 4 mm. apart.

CELLS: The cells were subspherical (5.75 mm. long and 5.0 mm. wide) and varied in position from subhorizontal to a 70-degree inclination from horizontal

with the posterior portion lower. As in the other *Dufourea* studied, the cells were carved from the substrate, but they lacked water-resistant walls as determined by the droplet test.

The cell cap was composed of an unlined, tightly-packed soil plug 3.5 mm. wide and 3.0 mm. long. The inner face of the plug was concave and possessed three distinct rings surrounding a 1 mm. wide, central micropyle. The outer face of the cell plug could be distinguished from the plugged sublateral burrow only by its greater compaction.

Provisioning and Development

The pollen ball closely resembled that of *D. mulleri* in shape and diameter but differed in being yellow and somewhat drier. In subhorizontal cells, the pollen balls were positioned as were those of *D. mulleri* but they were at the bottom of the more vertical cells.

Adult Activity

The female whose nest we studied completed three pollen-carrying trips between 10:30 and 11:07 a.m., and began a fourth trip at 11:10 a.m. The speed with which she collected pollen and deposited it into a cell was remarkable, considering that the day was overcast and the air temperatures never rose above 70°F. From the above data, it appeared that each pollen ball required at least four pollen loads for its completion.

Approximately 100 pollen-collecting females were observed between 8:30 and 9:30 a.m., but an hour's search throughout the area yielded but one nest. Consequently, *D. pulchricornis* was not gregarious under the conditions we encountered.

Neopasites (*Micropasites*) *cressoni* Crawford

Flight Activity

This species of nomadine parasitic bee was encountered both at the Tubac site and at the Rodeo site. The females, more abundant than the males, flew low over the ground in a meandering fashion. They began flying as early in the day as their hosts and continued after the hosts ceased. Their flight, suggestive of that of *Oreopasites* and *Holcopasites*, was moderately slow and included frequent stops at apparent nest entrances of the host bee. Several times, two, three, four, or even five females hovered over a nest entrance, though such congregations occurred only where the cuckoo bees were most numerous. They often landed on flat, unshaded surfaces, probably to rest or sun themselves. Males were seen several times at the Rodeo site; their flight was higher and seemed somewhat faster than that of the females.

Mating was not observed, but one of us (Torchio) observed it in *N.* (*Neopasites*) *fulviventris* Cresson at Arroyo Seco, Monterey County, California, in

1959. The males utilized a small, bare, powdered surface area as a gregarious mating site. It was separated from the nesting area of its suspected host, *Dufourea dentipes* Bohart, by about 21 meters. Males patrolled the area or landed on it for long periods. Mating was observed in four instances, each occurring on the ground. Copulation lasted from 3 to 10 seconds.

Oviposition

Over 30 eggs and egg chorions of *N. cressoni* were encountered in cells of *D. mulleri* at the Rodeo site (by Rozen and Favreau), and all except one were deposited in the cell wall, as is the case with the other nomadine parasitic bees whose biology has been studied. Only once was an egg discovered embedded in the provisions; as there were already six eggs in the wall of this cell, we can only imagine that the female responsible for the seventh egg might have been at a loss to know what to do with it.

It is not known how many eggs are normally deposited in a cell; usually one or two were discovered though as many as eight were found in a single cell. The last figure may be abnormally high, for the female *Dufourea* probably left the cell open, thereby giving numerous *Neopasites* access to the cell. Frequently deep, rough scratches were observed in a cell which suggested that the host female, upon finding the *Neopasites* eggs in the cell wall, dug them out; Rozen has observed similar marks in the cell wall of *Nomadopsis* in areas infested with *Oreopasites*.

Eggs were deposited while the cells were being provisioned. The female *Neopasites* made a groove in the cell wall and inserted the egg, so that it rested with its exposed length flush with or a little higher than the cell wall (Fig. 7). Occasionally the egg was tilted at a slight angle so that one end projected farther than the other (Fig. 8). In all cases the lining of the cell abutted the egg, so that there was never a crack between the cell lining and the egg. This fact indicated that the female *Neopasites* cemented the crack with fine soil, and, in certain cases, some cement-like material adhered to the exposed part of the egg. The eggs seemed to be placed in almost any part of the cell though they were not ordinarily found near the entrance.

The small eggs (Figs. 7–9) had an unusual appearance. About 0.6 mm. long, they were elongate, with the exposed surface being somewhat flattened, whereas the embedded part bowed out; they were thus rather boat-like in shape. The exposed chorion was stiff, thick, opaque white with faint, transverse corrugations. The chorion below the cell surface was thin, fragile, transparent and without ridges. At hatching, the exposed chorion ruptured (Fig. 9) in a semicircular to nearly circular line at the anterior end of the egg and the first-stage larva crawled out, leaving the chorion and attached door intact.

Like the egg, the first-stage larva was very small, being considerably less than half the size of the *Dufourea* egg. The head was conspicuous, con-

Table 1. The three subfamilies of Halictidae compared on the basis of known biological differences.

Subfamily	Entrance of nest burrow constricted	Cell lined with soil	Cell lined with secretion	Cell elongate	Cell asymmetrical	Cell horizontal or slanting (not vertical)	Provision shaped from first pollen load	Provision spherical	Provision retains shape throughout consumption	Larva motile	Cocoon present	Overwinters as fertilized female	With social representatives	Some cleptoparasitic
Dufoureinae	−	−	+−	−	−	+	+	+	+	+	+	−	−	−
Halictinae	+	+	+−	+	++−	++−	−	−	−	−	−	++−	++−	+
Nomiinae	+	+	+	++	−	−	−	−	−	−	−	+—	+—	−

stricted behind, and possessed elongate sharp-pointed mandibles. The tip of the abdomen was a bilobed pygopod-like structure used for crawling. These active larvae destroyed the host egg (or perhaps early stage larva) and also their siblings so that only one parasite larva survived in a cell.

The older larvae of *Neopasites* (Rozen, 1966) appeared rather similar to those of their host because of the elongate body form and because of the protruding ninth abdominal venter and the somewhat dorsally projecting terminal segment. However, it lacked dorsolateral tubercles, and therefore could be easily distinguished from its host. Like the host larva, it wandered over the pollen ball and fed, after which it defecated. At least in some instances, not all of the provisions were consumed. The feces were deposited on the wall toward the lower rear of the cell. A cocoon was not spun; the rigid, quiescent larva overwintered.

Although the undescribed *Neopasites* associated with *D. trochantera* from Utah was not observed as thoroughly as *N. cressoni*, its biology (as deduced from the fecal pattern, shape of pollen residue, adult searching behavior) and the gross appearance of the larvae did not appear to differ.

DISCUSSION

Two of us (Torchio and Bohart) have attempted to analyze the systematic relationship of the three subfamilies of Halictidae on the basis of available biological data (Table 1). Limited biological information on three genera of Dufoureinae (*Rophites, Systropha*, and *Dufourea*) indicates that this is a homogeneous and distinctive taxon. Of the three subfamilies of Halictidae, the adults of the Nomiinae are the least diverse structurally. Nevertheless, as indicated in Table 1, the Dufoureinae are equally homogeneous biologically. The Halictinae, with the most diverse biological characteristics, are, as adults, comparable to Dufoureinae in structural diversity. The distinctiveness of the

Dufoureinae is apparent from the number of biological characteristics by which it differs from the other subfamilies (Table 1). On the basis of these characteristics, it would appear that the Halictinae and Nomiinae are more related to each other than either is to the Dufoureinae.

When the genus *Dufourea* is revised, the four species discussed in this paper will probably be placed in two subgenera, *D. malacothricis* in one and the other three species in another. Of this second group, *D. mulleri* and *D. trochantera* will be treated as closely related species and *D. pulchricornis* as a more distinctive form. However, these two subgenera have a closer affinity to each other than do more divergent subgenera as represented by such species as *D. spinifera* (Viereck) or *D. maura* (Cresson).

If biological characteristics always verified species relationships based on morphological features, one would expect *D. malacothricis* to demonstrate the most unique nest architecture of the four species discussed. The nest of *D. pulchricornis*, however, is the most distinctive since it is the only species with sublaterals and unlined cells. As might be expected, the biologies of *D. mulleri* and *D. trochantera* are very similar.

Neopasites appears to be a specific parasite on Dufoureinae, but specificity within the genus is incomplete (i.e., *N. fulviventris* on *D. dentipes* and an undescribed *Dufourea* species).[4] Furthermore, at least two undescribed species of *Neopasites* are known to parasitize one *Dufourea* species (*D. trochantera*). Biological similarities within both the host and parasite genera may account for this, although more information is obviously needed.

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[4] R. M. Bohart, R. O. Schuster, and R. Brumley collected *N. fulviventris* adults at a nesting site of *Dufourea* n. sp. on April 8, 1966, in Jacolitos Canyon, 3 miles south of Coalinga, Fresno County, California.

BOOK REVIEW

Handbook of the Mosquitoes of North America. Robert Matheson. Second Edition: Revised and Amplified (Facsimile of the Edition of 1944) Hafner Pub. Co. 272 pp. text, 41 figures, 33 plates.

Matheson's "Handbook" first appeared in 1944 and was at once recognized as invaluable to students of North American mosquitoes. Unfortunately it has been out of print for many years. This review describes the recently republished volume made available by the Hafner Publishing Co.

Examination of the volume quickly disclosed that it is not a "new edition, revised and amplified" but is just a reprinting of the first edition. The rapid accumulation of knowledge in every scientific field makes it difficult to assess the current value of any text over 15 years old.

In general, Chapters I and II on anatomy and biology continue to be of value. Data accumulated since 1944 on the behavior of mosquitoes (particularly adults) outdate the sections on "Habits of Adults" and "Hibernation." In the former section a considerable amount of new information has been reported on swarming behavior and migratory flights. In the latter section diapause is not mentioned.

Chapter III on "Mosquitoes in Relation to Human Welfare" is still excellent source material. Advances in malaria eradication make the map and most of the data obsolete. The section on "Human Encephalitis" is of historical value only.

Chapter IV, "The Problem of Mosquito Reduction," is of value only in the area of basic water management. Chemical control, with the exception of the use of fuel oil and paris green, has changed completely. This is highlighted by the statement: "At present a new and very effective preparation, known commercially as DDT, is being tried . . ."

Chapter V on collecting and preserving material is clearly and concisely presented and still timely.

The systemic account of the mosquitoes of North America is excellent. The keys and descriptive material are well done. Obviously, recent data on species distribution and newly recognized species could not be anticipated. The illustrations and plates have lost little in reprinting and are of good quality.

The disappointment in finding that this is just a reprinting rather than a revision was somewhat mitigated by having the "Handbook" available again. This book is still a "must" for students interested in mosquitoes.

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Behavior of the German Cockroach, *Blattella germanica* (L.), in Response to Surface Textures[1]

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Abstract: Experiments were conducted to determine the influence of various horizontally orientated textured surfaces on the congregating behavior of the German cockroach, *Blattella germanica* (L.). Various grades of sandpaper and sheets of sandpaper with the sand removed were used as testing surfaces. When these sheets were stacked in battery jars with spaces between them for the cockroaches to congregate, and the jars contained no food or water, the cockroaches showed a preference for the smoother surfaces. However, when food and water were supplied to these same jars, strong preferences for a surface of any one texture no longer existed. When, instead of being stacked, the textured surfaces were placed on the same horizontal level and the food and water were added, this species showed a strong tendency to congregate on the smoother surfaces.

The research reported in this paper deals with the behavioral responses of the German cockroach *Blattella germanica* (L.) to the texture of the surfaces upon which they congregate. In our studies, we are attempting to investigate the influence or single environmental variables on the behavior of this species, with our long-term goal being the collating of all related research. From this, it is hoped to gain a better understanding of what environmental factors influence the distribution and behavior of this species, and the interaction of these factors in the "total" environment.

In our experimental designs, we have attempted to analyze group behavior. We have chosen this line of investigation, instead of experimenting with single cockroaches, due to the broad range of variation shown by individuals of this species.

Many authors have explored the response of the German cockroach to environmental factors. In testing attractiveness of food, Pettit (1940) found that he was unable to duplicate the results of preference tests, finding that almost any food substance seemed attractive to them at some time. He did note, however, a preference for bananas, beer, milk, and bread over fresh fruits, greens, and meats.

In response to light, members of this species are photonegative and seldom

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[2] Now with the Department of Entomology, Pennsylvania State University, University Park, Pennsylvania.

[3] The author wishes to express his thanks to B. R. Wilson for his constructive criticism offered throughout the course of this work.

venture forth during daylight; they are most active in early evening, less active in late evening and early morning, and relatively inactive during the day (Wille, 1920).

Ledoux (1945), in studying the gregariousness of the German cockroaches, found them to be chemopositive to odors produced by others of this species. To confirm this work, (Berthold and Wilson, 1967) placed adult German cockroaches in containers offering a choice of resting surfaces: those impregnated with odors from prior German cockroach occupation, and new surfaces free of cockroach odor. A statistically significant majority of the cockroaches tested (82%) chose to congregate on the odorous surface.

Fletcher (1961), who studied the attractancy for cockroaches of 18 esters, found that benzyl acetate exhibited some attractancy for male German cockroaches and that octyl acetate was attractive to both sexes; he also found that the number of positive responses to these two compounds increased directly with increased concentration.

In response to moisture, Gunn and Cosway (1938) found that dessicated German cockroaches spend more time in regions of high moisture, but under normal, nondessicated conditions, spend more time in low-moisture regions. Roth and Willis (1952) further demonstrated that this hygro-selective ability is lost when the 13th antennal segments of the males and the 11th of the females are removed. Gunn (1935) also found that German cockroaches preferred a temperature around 35° C.

Ledoux (1945) observed the cockroach to be thigmopositive, resting and hiding in places that provide contact above and below. Berthold and Wilson (1967) further found that this selection of constricted spaces in which the cockroaches rest can be highly selective; approximately 85% of those tested chose to congregate in spaces 3/16 of an inch in height rather than in spaces 2, 4, 5, 6, 7, or 8/16 of an inch in height.

MATERIALS AND METHODS

Five grades of sandpaper (Behr-Manning, Mohawk Flint) were used: extra fine, fine, medium, coarse, and extra course. To produce a sixth surface texture, sheets of sandpaper were soaked in warm water to remove the sand particles and allowed to air-dry. This surface was chosen rather than a material such as glass in order to eliminate the possibility of introducing such other variables as surface odor, light reflection, or heat conduction. Squares of these six sandpapers (10-cm on a side) were then glued, textured side up, to 6-mm-thick Masonite plaques of the same size.

The cockroaches were exposed to the sandpaper surfaces as follows:

Dry-washed sand was poured into battery jars (23 cm high, 15 cm diameter) with enough sand being added to produce uniformly flat bottoms in the jars. A thin band of vaseline was applied around the inner openings of the jars to

prevent the cockroaches from escaping. A plaque with no sandpaper was then slightly embedded (3 mm) in the sand, on top of which a plaque was placed, textured side up. Three 4.5-mm spacers were then placed on top of the plaque, and on top of the spacers a window glass plate (10 cm on a side) was placed. The glass forces the cockroaches to walk on the surfaces being tested. The next sandpaper-surfaced-plaque was then placed on top of the glass plate, and the procedure—spacers, glass plate, textured surface—is repeated until each of the six surfaces was present. A plain plaque was placed on top of the last glass plate.

Since we knew (Berthold and Wilson, 1967) that some type of behavior-influencing gradient is present when the German cockroach is kept in battery jars, a Latin square design (Steel and Torrie, 1960) was employed to determine the vertical position of the six different surfaces in each of six battery jars.

In the first series of tests, 20 adult male and 20 adult female cockroaches were placed in each of the six jars for a 24-hour test period (10 hours of light, 14 hours of dark). In a replication of this test, new surfaces and clean glass plates were used.

The second series of tests followed the same procedure except that the cockroaches were given food and water.

Cockroaches on the surfaces were counted by the following method (Berthold and Wilson, 1967): Squares of aluminum (20 cm sides) were folded down the center to produce two rectangular sides (10 by 20 cm) at right angles to each other. At the end of the testing period, these folded squares were gently slipped down opposite corners of the stack of plaques and pressed together, confining the cockroaches to whatever surface they are congregating at the time. Carbon dioxide was then pumped into the jar to anesthetize the cockroaches. Next, the aluminum device was removed, the testing apparatus disassembled, and the number of cockroaches on each surface recorded. Results were analyzed by use of the F-test (Dixon and Massey, 1957).

The third series of tests which utilized a different type of testing device placed all six differently textured surfaces on the same horizontal level and with food and water. This device consists of a glass-bottomed rectangular glass enclosure 56 cm long, 25 cm wide, and 10 cm high. A thin band of vaseline was applied around its upper inside edges to prevent the cockroaches from escaping. Six such enclosures were used. The six textured surfaces were placed symetrically in each enclosure, and the overall arrangement was determined by a Latin square design.

Three 4.5-mm wood spacers were then placed on top of each textured surface to support a 10-cm-square window-glass plate. On top of the glass plates, plain Masonite plaques were placed, and on top of each plaque a piece of dry dog biscuit and a petri dish bottom containing water-soaked cotton were placed.

TABLE 1. German cockroach response to various horizontally orientated surface textures.

Replications	Surfaces*						
	a	b	c	d	e	f	Total
Surfaces stacked in battery jars with no food or water.							
1	89	31	11	14	20	19	184
2	101	20	21	23	34	18	217
Total	190	51	32	37	54	37	401
Surfaces stacked in battery jars with food and water.							
1	37	25	39	32	60	6	199
2	71	21	27	35	34	35	233
Total	108	46	66	67	94	51	432
Surfaces on same horizontal level with food and water.							
1	62	4	6	8	11	14	105
2	48	21	17	9	3	0	102
Total	110	25	23	17	18	14	207

* Key: a—sandless sandpaper; b—very fine sandpaper; c—fine sandpaper; d—medium sandpaper; e—coarse sandpaper; f—very coarse sandpaper.

Adult cockroaches, 20 males and 20 females, were placed in each container and left undisturbed for 24 hours (10 hours of light and 14 hours of dark).

The number of cockroaches on each surface at the end of the 24-hour period was determined by placing an aluminum divider (much like a large ice cube tray divider) in the enclosure dividing it into six cockroach-tight compartments. The cockroaches are anesthetized by carbon dioxide pumped into the enclosure; each textured-surface-complex was then disassembled and the number of cockroaches in it recorded. Results were analyzed by the chi-square (χ^2) statistic (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Results for the three series of tests are presented in Table 1.

Analysis of the results of the first series (battery jars with no food and water) yield F-test values of 7.21 for the treatment effect and 0.61 for the arrangement effect. With 1/9 degrees of freedom and interrelating in an F-test table, the texture of surfaces in this series is shown to influence where this species congregate; the margin of possible error is 2.5%. Preference for a plain paper surface is indicated. The position of the surfaces in the jars apparently has no effect (0.01% margin of error).

Analysis of the results on the second series of tests (food and water included in the jars) indicates that the presence of food and water produces a marked change in the behavior observed in the absence of these factors. F-test

analysis of these data yields values of 4.08 and 6.69 (1/9 degrees of freedom) for the effects of type of surface and position of the surfaces, respectively. Interrelation indicates that, statistically, there is only a weak chance (margin of error greater than 10%) that surface textures under these conditions influence where this species congregates. Surface position in the jars apparently does have an influence on where cockroaches congregate (margin of error 5%).

Analysis of the third series of tests (glass-enclosures with food and water) indicates a tendency for this species of cockroach to congregate on the smoother-textured surfaces. Chi-square (χ^2) analysis of the data ($\chi = 220$; 5 degrees of freedom) indicates a probability of less than 0.05% that this is a random distribution.

In nature, if the cockroach is to survive in its multi-factor environment, it has to pattern its behavior. For example, the German cockroach is said to be photonegative, which might be considered a primary response, but, if he is prevented from obtaining water for a period of time, he will go into lighted places to obtain it. Hence a "primary" response has been relegated to a "secondary" status until the physiological need for water is satisfied.

The research reported in this paper may possibly fit into this concept, that is, that behavioral responses vary in degree in accordance with the environmental conditions then existing. In nature, water (also humidity) and food, plus other factors such as temperature, light and lebido, are dominant factors influencing the behavior of this species. Gunn and Cosway (1938) observed distinct cockroach behavior patterns associated with humidity, and there is the possibility, though at the present time we have made no measurements, that the presence of water in the battery-jar-tests produces a behavior-influencing gradient. If this is so, then in the jars containing no water, it would have been negligible, and in the glass enclosures it would have been constant.

With the major behavior-influencing factors now held relatively constant, other factors previously secondary may become primary. Such is the case with surface texture, and it seems reasonable to postulate that the smoother surfaces are more "comfortable" than the rougher ones for the congregating cockroaches.

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Two New Species of *Crambus* Fabricius from Western North America (Lepidoptera: Pyralididae)†

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Abstract: Crambus **bigelovi** (type locality Pinedale, Wyoming) and *C.* **harrisi** (type locality Guadalupe Mts., New Mexico) are described as new, characterized and differentiated from related species. The male and female genitalia of both species are figured.

Crambus **bigelovi**, new species

FOREWING: Length, holotype ♂, 12 mm.; allotype ♀, 11 mm.; paratypes, 11, 12 and 12.8 mm. Outer margin slightly concave below apex. Ground color brown, lustrous, with a somewhat brassy luster, especially costally and basally. Dark apical triangle narrow. Costal edge brown, basally about half as wide as white discal stripe. White discal stripe entire, tapering very gradually to a very sharp point, ending before subterminal line, dorsally and terminally outlined by a narrow, dark brown line; with only a slight outward tooth, or indication of a tooth, at fold. Postmedian area somewhat shaded with white, especially in cells M_1–M_3. Short, longitudinal, intervenous light streaks distad of cell only slightly indicated, that in cell R_5 the most prominent. A light shade between discal white streak and subterminal line in cells R_5 and M_1. Subterminal line bluntly angled at about vein M_1. Terminal space with a pale area from about middle of cell M_1 to about middle of cell M_3. Short, dark, intervenular marginal dashes in cells M_1–Cu_{1b}. A narrow, dark brown terminal line. Fringe brown, subapically whitish basally. Hindwing pale brownish white, slightly darker apically, fringe whitish. Palpi, head and thorax light brown, thorax whitish centrally, collar and tegulae somewhat brassy lustrous.

MALE GENITALIA (Fig. 1): Uncus long, slender and mostly cylindrical in cross section, blunt ended, with a series of short, dorsal spines on terminal third, otherwise with short, fine setae. Gnathos heavy, straight, blunt ended, slightly exceeding uncus. Tegumen relatively broad, laterally parallel sided. Vinculum broad, cephalically emarginate. Pseudosaccus about half as long as cephalo-caudal width of vinculum. Cucullus of valva lightly sclerotized, broad basally, tapering gradually to a blunt, dorsad-turned end. Costa of valva well sclerotized, with a short, flattened, pointed process curving mesad and dorsad. Sacculus of valva short, with a slender, pointed, recurved, heavily sclerotized process that is longer than process of costa. Aedeagus longer than cephalo-caudal width of vinculum plus length of valva, with a stout coecum penis and three cornuti of which the most basal is strongly curved and longer than either of the others. (The paratype has an additional, short, slender cornutus distad of the basal one.)

FEMALE GENITALIA (Fig. 2): Papillae anales bilobed, the dorsal lobe very lightly sclerotized, the ventral lobe more heavily sclerotized and with a pronounced, but slender, apophysis posterior. Eighth segment well sclerotized, lacking apophyses anteriores, ventrally joining structures around ostium. Ostium with a strongly projecting sclerotized cup, open dorsally; inside this, and considerably off-center dextrad, a rounded, projecting, heavily sclerotized papilla covered with very small spines. Antrum entad from this heavily sclerotized and covered with coarse sclerotized granulations. Ductus bursae strongly sclerotized, with a

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number of sharp ridges in its walls which grow more pronounced entad, near cephalic end strongly curved sinistro-dorsad, then dextro-ventrad. A curved, lightly sclerotized duct between ental end of ductus bursae (at ductus seminalis) and corpus bursae, suddenly enlarging in a short cervix bursae. Corpus bursae large, broadly ovoid, with two rather lightly sclerotized signa, each a group of small scobinations. Seventh abdominal segment undifferentiated.

TYPE MATERIAL: Holotype ♂, Pinedale, Sublette Co., Wyoming, 8 July 1939, leg. A. B. Klots. Paratype ♂, Cooke City, Park Co., Montana, July 27, 1959, leg. F., P. & B. Rindge. Allotype ♀, Moran, Teton Co., Wyoming, July 19, 1938, leg. Grace H. & John L. Sperry. Paratype ♀, Moran, Teton Co., Wyoming, July 26, 1938, leg. Grace H. & John L. Sperry. Paratype ♀, Lake Creek Camp, Park Co., Wyoming, 13 mi. S. E. of Cooke City, Montana, 6900 ft. alt., July 24, 1959, leg. F., P. & B. Rindge. All type material in American Museum of Natural History.

Crambus **bigelovi** appears to be more nearly related to *C. praefectellus* Zincken than to any other species. Its discal white stripe is not as narrow, or as widely separated by brown from the costal margin, as that of *C. praefectellus*. It resembles *praefectellus* in having a pale shade between the end of the discal white stripe and the subterminal line, and a white patch between the subterminal line and the margin in the lower half of cell M_1, the whole of cell M_2 and the upper half of cell M_3. It is much paler than *C. praefectellus oslarellus* Haimbach, the subspecies that extends northward through Colorado, and is very dark, richly colored and brassy-lustrous; in fact, **bigelovi** looks more like the Eastern *C. p. praefectellus,* which extends from the Atlantic coast westward into North Dakota. In the male genitalia *C. praefectellus* has the cucullus much longer, relative to the costa and costal process, and more strongly hooked dorsad. *C. praefectellus* has only two cornuti, the basal one slender and curved like the basal one of **bigelovi**, and the terminal one stout, with a heavy, ovoid base, like the terminal one of **bigelovi**, but lacks the intermediate cornutus (or cornuti) of **bigelovi**. In the female genitalia *praefectellus* has an only slightly protruding trough about the ostium, and lacks the spined papilla within this; but has an area of scobination within the ostium like that of **bigelovi**. If **bigelovi** and *praefectellus* are, indeed, closely related, it may be significant that they are not sympatric.

Crambus **bigelovi** is named for David Bigelow of the Buffalo Museum of Science, a collecting companion of the author's in Wyoming in 1939.

Crambus **harrisi**, new species

FOREWING: Length, holotype ♂, 11.8 mm.; allotype ♀, 10.4 mm. Outer margin only very slightly concave below apex. Ground color light brown, darkest dorsad of Cu stem and Cu_{1b}, proximally somewhat brassy. Apical dark triangle narrow, curving to apex, lighter, more yellow brown proximally. A narrow, white, subapical triangle on costa and a similar one subapically on outer margin. White discal streak broad, entire, separated

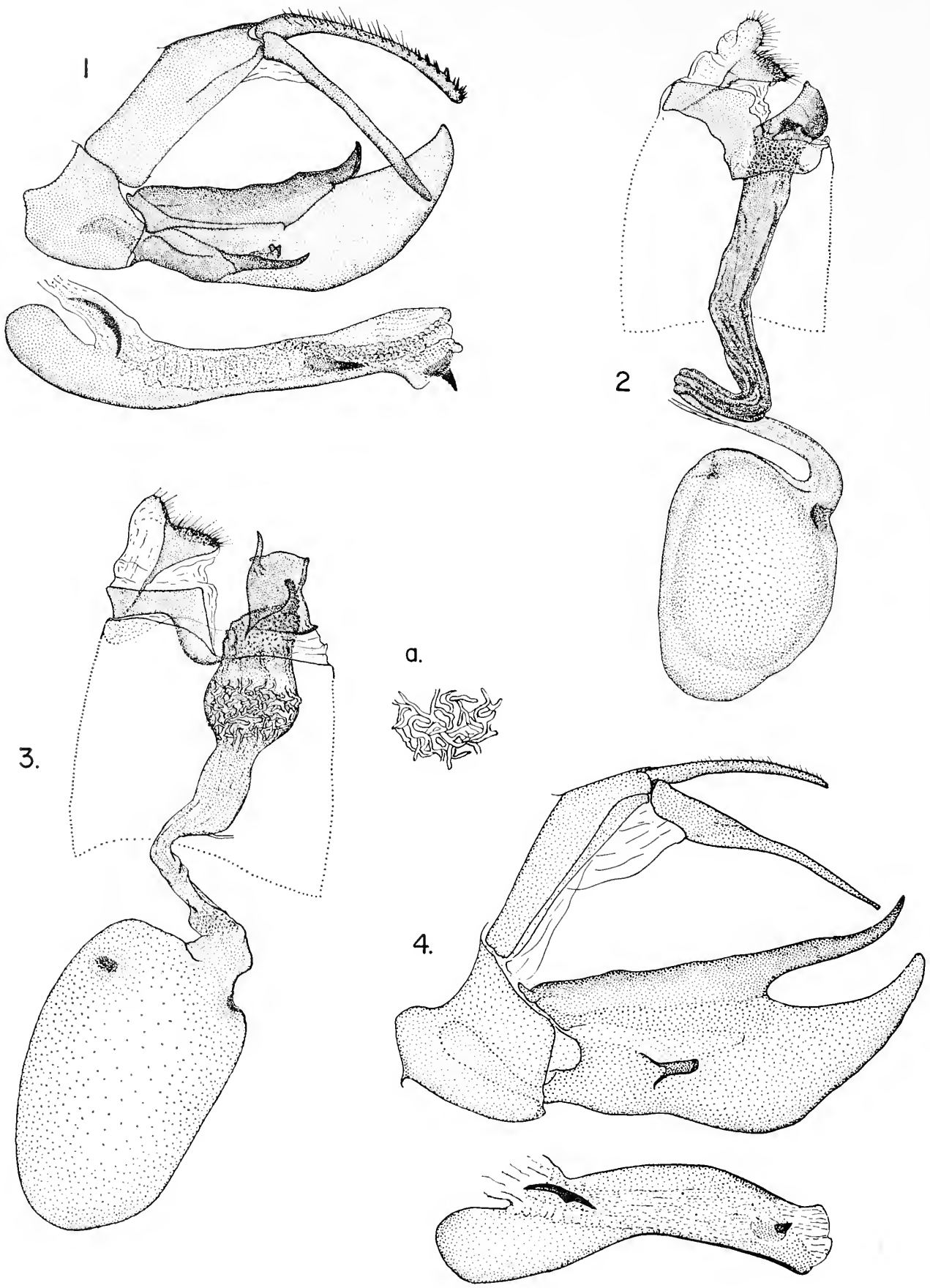

FIG. 1. Left lateral aspect, male genitalia, *Crambus* **bigelovi**, n. sp., showing ental aspect of right valva, and aedeagus removed and shown beneath. Drawn from holotype. FIG. 2. Left lateral aspect, female genitalia, *Crambus* **bigelovi**, n. sp., with a single spermatophore in the bursa copulatrix. Drawn from allotype. FIG. 3. Left lateral aspect,

from costa by brown only very narrowly basally, more broadly separated distally; tapering gradually and symmetrically to a sharp point well inside subterminal line; with only a slight indication of a projecting tooth at fold. Postmedial area yellowish brown somewhat speckled with darker brown scales, lightest distad of terminal part of discal streak; narrow, shining, plumbeous streaks running distad from white discal streak in cells R_5, M_3, Cu_{1a} (inconspicuous) and Cu_{1b} (more conspicuous). Dorsal area below anal vein white or whitish, but extreme dorsal margin brownish. Subterminal line shining, plumbeous, evenly curved opposite end of discal streak. Terminal space speckled with dark brown and whitish scales, with fine, black, intervenous dashes between subterminal line and margin in cells M_1, M_2, M_3, Cu_{1a} and Cu_{1b}, the first and last of these the shortest. Fringe shining, light brown, lighter basally, especially subapically. Terminal line dark brown, very thin, widest subapically, but essentially complete to tornus. Hindwing light brownish, slightly darker terminally and apically, fringe whitish. Palpi, head and thorax brown, slightly lighter dorsally. Tegulae brassy. Frons rather flatly rounded.

MALE GENITALIA (Fig. 4): Tegumen narrow, tapering ventrad. Uncus slender, tubular, shorter than gnathos, with very short, fine setation. Gnathos broad basally, long, slender, tubular, distally gradually tapered. Vinculum large and broad, deeply emarginate cephalically. Pseudosaccus large, more than ¾ as long as cephalocaudal width of vinculum, clavate. Costa of valva long, well sclerotized, with a long, slender, tapering, dorsad and mesad curving, free process that exceeds cucullus caudally. Cucullus broad basally, strongly tapering and curved dorsad, with abundant, fine, setation on mesal face. Sacculus of valva small and lightly sclerotized, with a short, flat, well sclerotized free process that curves mesad terminally. Aedeagus thick, blunt, shorter than valva, somewhat curved ventrad, a little more sclerotized ventro-distally; with a small, slender, strongly curved basal cornutus and a very short, heavily sclerotized distal one that arises from a short, discoid base.

FEMALE GENITALIA (Fig. 3): Papillae anales bilobed, the ventral lobes well sclerotized and tapering internally to pronounced, but slender, apophyses posteriores. Eighth segment well sclerotized dorsally and laterally, but not ventrally, lacking apophyses anteriores. Extending caudad from ostium is a well sclerotized trough, complete laterally and ventrally but open dorsally; from each dorso-caudal corner of this a sharp, slightly curved spine projects caudad. Within this trough is a shorter, rounded, heavily sclerotized, scobinate trough, also open dorsally; from the ventro-caudal edge of this extends a short tongue, concave dorsally and convex ventrally, bearing many very small spines. Entad from this the antrum is more lightly sclerotized, and then broadens to form a bulbous chamber with many complex vermiculations in its wall. Ductus bursae entad of this lightly sclerotized and narrowing markedly to point of exit of ductus seminalis. A curved, very lightly sclerotized duct between ental end of ductus bursae (at ductus seminalis) and corpus bursae, suddenly enlarging in a short cervix bursae. Corpus bursae large, broadly ovoid, with two rather lightly sclerotized signa, each a group of small scobinations. Eighth abdominal segment undifferentiated.

TYPE MATERIAL: Holotype ♂ and allotype ♀, near Dark Canyon, Guadalupe Mts., Eddy Co., New Mexico, July 23, 1959, leg. A. B. Klots. Paratype ♂.

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female genitalia, *Crambus* **harrisi**, n. sp. a. Details of vermiculations in wall of antrum. Drawn from allotype. FIG. 4. Left lateral aspect, male genitalia, *Crambus* **harrisi**, n. sp., showing ental aspect of right valva, and aedegus removed and shown beneath. Drawn from holotype.

Tlalpan, D. F., Mexico, July 15, 1901, with label "38512." Holotype and allotype in American Museum of Natural History; paratype in U. S. National Museum.

The holotype and allotype were taken during the day in a rather dry, grassy area, characterized by scattered alligator barked juniper (*Juniperus pachyphloea* Torrey). "*Crambus*" *bolterellus*" Fernald was taken in the same spot. In a somewhat higher area, characterized by many *Pinus scopulorum* Engelman intermixed with the juniper, *Crambus cyrilellus* Klots was taken in some numbers. The paratype, although worn, is definitely conspecific, the genitalia being diagnostic.

Crambus **harrisi** resembles *C. cyrilellus* Klots and *C. leachellus* Zincken in general appearance, having the white discal streak entire, broad and narrowly separated by brown from the costa. *C. cyrilellus* has a distinct white patch in the lower part of cell M_1, the whole of cell M_2 and the upper part of cell M_3 between the subterminal line and the outer margin; *C.* **harrisi** lacks this. *C. cyrilellus* is much more lustrous, and has the short, intervenous dashes running outward from the discal streak much more pronounced and lustrous. The pale shade along the dorsal margin of the forewing of *C.* **harrisi** is not present in *C. leachellus*. In the male genitalia, *C.* **harrisi** differs greatly from *C. cyrilellus* (Klots, 1942, p. 6–8, fig. 7) which has the uncus blunt, thick and bearing heavy spines; a very heavy, abruptly curving process of the costa, and two thin, straight cornuti. In the male genitalia *C.* **harrisi** is also very unlike *C. leachellus* (Klots, 1939, p. 58–59, fig. 2) which has the costal process short, not nearly reaching the tip of the cucullus, and has an enormous, coiled coecum penis and only one cornutus. In the female genitalia *C. cyrilellus* has a large, almost flat, terminally toothed plate protruding strongly ventrad of the ostium; and *C. leachellus* has the ostium protruding only slightly caudad as a simple cup, and has a coiled ductus bursae many times the length of the abdomen (Klots, 1939, fig. 8).

Crambus **harrisi** is named for Mr. Bruce Harris, in 1959 with the New Mexico Department of Game and Fish, in appreciation of his help in locating excellent collecting areas in the Guadalupe Mts.

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Peromyscopsylla hamifer hamifer (Rothschild): an Addition to the Entomological Fauna of New York State [1]

Allen H. Benton[2]

The most complete list of fleas of New York, that of Geary (1959), includes 43 species recorded from the state. Several species known to occur in nearby states may be expected to occur in New York, and the total number of flea species in the state should be about 50.

Collections of the New York State Museum and Science Service, made by Dr. Paul Connor, have done much to clarify the distributional patterns of New York fleas. The first new species for the state to be found in their collections is a single male specimen of *Peromyscopsylla hamifer hamifer* (Rothschild) taken from a lemming mouse, *Synaptomys cooperi*, near Sevey, St. Lawrence County, on August 18, 1965.

Since this species has been recorded from several other northeastern states (Figure 1), it was expected that it would eventually be found in New York. This specimen, however, was unusual in two respects. It was taken in late summer, whereas all specimens previously reported from the eastern United States were taken from September to May, and it was found on a lemming mouse, whereas 24 of 33 specimens for which I have found data have been taken from the meadow mouse, *Microtus pennsylvanicus*.

Since *Microtus* is one of the most abundant of small mammals in the east, it has seemed strange that *P. hamifer* has not appeared more frequently in collections. The present record suggests the possibility that the flea may be a parasite of lemming mice, with meadow mice only a secondary or accidental host. Since lemming mice are very rarely collected in any numbers, and even less commonly in the colder months, the apparent rarity of the species would be explained if it were a parasite of this host. Further, if it is a flea which seldom leaves the nest of the host, its apparent rarity is even easier to explain.

A comparable case is that of *Conorhinopsylla stanfordi* Stewart. The type host of this flea is the red squirrel, *Tamiasciurus hudsonicus*, but despite the abundance of this host and its frequent collection, specimens of the flea were very rare in collections prior to 1950. Since that time, abundant evidence has shown that this is a nest parasite of the flying squirrel, *Glaucomys volans* (and possibly *G. sabrinus* as well), and large numbers can be collected by anyone willing to take the trouble to examine nests of this squirrel.

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[1] I am grateful to Dr. Robert Traub and Mr. G. H. E. Hopkins for information on eastern North American specimens of this flea. My studies on eastern fleas have been supported by the Research Foundation of State University of New York.

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Any collector who can examine winter nests of *Synaptomys cooperi* or of *Microtus pennsylvanicus* may contribute to the solution of the problem of the host relationship of this flea species.

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New and Little Known Species of *Serica* (Coleoptera: Scarabaeidae) X[1]

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Abstract: In this paper twelve new species are described: **adversa, alabama, aviceps, barri, bruneri, diablo, floirdana, frosti, heteracantha, howdeni, pullata, sericeoides,** and one new subspecies: *perigonia* **eremicola**. Ten previously described species are figured: *alleni, anthracina, castanea, ensenada, mackenziei, oliveri, peregrina, pilifera, rossi,* and *sericea.* Four species names are reduced to synonymy: *joaquinella* to *oliveri*; *mendota* to *pruinipennis*; *michelbacheri* to *fimbriata*; and *searli* to *alleni.* The spelling "*atricapilla*" is corrected to *atracapilla,* and *trociformis blatchleyi* is given specific standing. Supplementary distribution notes are given beyond those recorded in paper #IX of this series.

The present study is based upon the examination of about 3,000 specimens of *Serica.* For the privilege of working over this material the writer is much indebted to the following entomologists: Hugh Leech, Henry Howden, Bob Woodruff, Paul Hurd, Saul Frommer, O. L. Cartwright, Ross Arnett, S. W. Frost and William Barr. Appreciation is also expressed for the capable and painstaking work of Miss Francoise S. Demogeot in making the accompanying drawings.

Serica **adversa** n. sp.

MALE: Length 8 mm; width 4 mm. Scarcely, or not, distinguishable from *sculptilis* by external characters.

Dark brown, bare and shining with conspicuous, fine, dense puncturation, a little fine hair on the elytral margin, basal portion of the legs and under surface. Clypeus feebly tumid below the middle, sides only moderately elevated, without clypeal notches, punctures fine and very dense, becoming a little stronger and less crowded on the front. Antennal club about equal to the dorso-ventral diameter of the eye. Elytral striae emphasized by about three dense, confused rows of fine punctures. Only the narrow crests of the intervals free from punctures.

The genital armature of the male (fig. 39) differs from that of *sculptillis* by being heavier, stronger, with relatively longer, broader claspers, and a much thicker and differently shaped apex of the stalk. In *sculptilis* the apex of the stalk is narrowed (dorso-ventrally) to a remarkable degree. In **adversa** the right (longer) clasper is more strongly bowed than the left, and more so than in *sculptilis.*

TYPE: ♂. San Joaquin Mountains near Laguna, Orange Co., California, VII-29-63, light trap. Deposited in the Canadian National Collection.

PARATYPES: 10 ♂♂ same data, 1 ♂ San Diego, IV-17-34.

The *sculptilis* complex is not easily disposed of, but apparently **adversa** will prove to be a distinct species. There are several other puzzling forms.

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[1] Scientific Paper No. 2987 College of Agriculture, Washington State University, Pullman. Project No. 9043.

Serica **alabama** n. sp.

Remarkably like *sericea*, but averaging a little smaller, and having the pronotum of the female pruinose like that of the male, not shining as in *sericea*. The genital armature of the male (fig. 13) has smaller, shorter claspers, which are much more curved or sinuate in outline than in the *sericea* male. The distribution pattern, Ohio to Alabama, indicates a distinct species.

TYPE: ♂. Raleigh, N.C., June 9, 1953, G. H. Nelson; deposited in the collection of the California Academy of Sciences.
PARATYPES: Ohio: Hocking Company, 1; Ashland Company, 1; Athens Co., 4; Adams Company, 3; Ross Company, 1. Georgia: Atlanta, 4; Kennesaw Mountain, 3; Athens, 1. Tennessee: Grassy Cove, 1; Knoxville, 2. Kentucky: Louisville, 1. Alabama: Hagler, 1; Ft. Payne, 2; Montgomery, 4; Verbena, 1. North Carolina: Raleigh, 3.

Serica alleni Saylor **New Synonymy**

1939. *Serica alleni* Saylor, Jour. Wash. Acad. Sci., **29,** pp. 454, 457.
1939. *Serica searli* Saylor, same paper, pp. 454, 459.

Specimens from a variety of localities suggest a radiating cline not readily broken into valid subspecies. The form called *searli* by Saylor (fig. 20) approaches *porcula* Casey, and is distinguishable from that species chiefly by its coarser, heavier genital armature and more arcuate claspers. The form designated as *alleni* (figs. 21, 22) is an average type. Figure 20 is from a specimen taken at the same place, the same day as the holotype of *searli*, and figures 21 and 22 are from a paratype of *alleni* given to me by Mr. Saylor. Figure 23 is from a specimen taken by Henry Howden at Wofford Heights, Ken Co., California, VI-12-14, 1961, at light. A series of 19 specimens before the writer shows various intergradations that make a separation into species or subspecies most unreliable. Calling them all *alleni* is at present the best solution.

Serica atricapilla Kirby **Emendation**

According to the International Code whenever possible the original spelling must be used. Therefore *atracapilla* replaces *atricapilla* now widely used.

Serica **aviceps** n. sp.

MALE: Length 9 mm; width 5 mm. Color varying a little between the middle shades of dull brown, faintly shining, not pruinose or "dusted," with only a faint trace of iridescence. Clypeal margins rather strongly and abruptly elevated with a shallow but well-marked clypeal notch; surface finely and evenly, densely punctured, the punctures continuing over the front, almost concealing the clypeal suture. Antennal club slightly longer than the dorso-ventral diameter of the eye. Puncturation of the pronotum fine, shallow and rather dense especially toward the sides. Striae of elytra line-like, impressed and with a dense row of punctures, intervals moderately convex, variable in width and puncturation. Elytral surface microscopically shagreened and iridescent.

Genital armature (figs. 29, 30) suggesting that of *oliveri*, but the right clasper is concave and truncate subapically, then suddenly flexed toward the center in a "bird-head" like tip. The left clasper, viewed ventrally, has only a suggestion of the double tip characteristic of *oliveri*.

TYPE: ♂. Fresno, California, June 8, 1937. R. W. Dawson deposited in the collection of the California Academy of Sciences.
PARATYPES: Fresno 1 ♀; Fowler 2 ♂♂, 2 ♀♀; Wood Lake, Tulare Company 1 ♂; Sequoia N. P. 1 ♂; Vernalis 2 ♂♂; Visalia 1 ♂; Coalinga 1 ♂.

Serica **barri** n. sp.

MALE: Length 7.5 mm; width 4 mm. However specimens taken the same day in the same population are as small as 6 mm in length, and from less favorable locations, 5 mm. Color a middle shade of brown dulled by a thin, light gray dust and a trace of fine, pale pubescence, most evident on the bases of the front and middle legs and on the elytral margin. A lightly sclerotized, delicate species from desert areas.

Antennal club of male 1.5 times the dorso-ventral diameter of the moderate-sized eye. Antennal club of the female distinctly smaller, only a little longer than the eye measurement. Clypeus very densely punctured, margins well elevated; a fine clypeal notch, evident in some specimens, obsolete in others. Elytral striae shallow with a single, irregular, dense row of punctures; intervals feebly convex with a few scattered, small punctures near the striae.

The genital armature of the male (figs. 24, 25) somewhat resembling that of *deserticola*, but the upper margins of the claspers are elevated. On the right clasper the median ridge connects with the elevated margin at the apex forming a slight hood. This is the most distinctive feature of the species. On the shorter, left clasper the median ridge extends into a sub-falcate "beak," the elevated margin ending with the beak.

TYPE: ♂. Sand Dunes, St. Anthony, Idaho, VII-5-1966; deposited in the collection of the California Academy of Sciences.
PARATYPES: Same locality, 131 ♂♂, 8 ♀♀; Arches Monument, Utah, June 19, 1949, C. P. Alexander, 2 ♂♂; Wadsworth, Story Co., Nevada, V-28-1939 1 ♂; Kayenta, Arizona, VI-12-1933 1 ♂.

The southwestern specimens show more prominent or exaggerated characters in the genital armature, but seem definitely to belong here.

Serica blatchleyi Dawson **New Status**

1910. *Serica trogiformis blatchleyi* (not Uhler). Coleoptera of Indiana, p. 958.
1932. *Serica trociformis blatchleyi* Dawson, Jour. N.Y. Ent. Soc., **XL,** p. 545.

Early in my studies of the genus *Serica*, I thought that the character of the genital armature of the male could be used as the final criterion in judging species. It was at once evident that external characters often failed to distinguish unquestioned species (*atracapilla* and *elusa* for example). Later it became apparent that the genital armatures do not always differentiate recognizably between obvious species (*sericea* and *tristis* for example). Horrible thought, maybe some perfectly distinct species cannot be recognized either way!

In this case I believe the larger, smooth, convex, shining pronotum of

trociformis Burmeister, and the smaller, pruinose, impressed pronotum of *blatchleyi* Dawson indicate distinct species. Through the years I have never seen specimens indicating either continuity of range, or intergradation of characters.

Serica **bruneri** n. sp.

A small, relatively broad species; length 5–7 mm; width 3–4 mm. Color dark brown to nearly black, thus bearing a superficial resemblance to *anthracina* LeConte. But it differs from that species markedly by having much larger antennae, the club about twice the dorso-ventral diameter of the eye, and about the same length as the 5-segmented stem. The whole upper surface bears sparse, shaggy, semi-erect, light brown, more or less deciduous, hairs which on the elytra tend to follow the sharp, line-like striae, but are not definitely so limited. Intervals of elytra closely and strongly punctured. Pronotum and clypeus similarly punctured. Clypeus broad, almost rectangular, slightly concave with well reflexed anterior and lateral margins, no clypeal notch, and clypeal suture a minute line. Under surface with sparse, brown hair, becoming very prominent on the anterior coxae and femora and somewhat so on the middle and hind femora.

The genital armature of the male (fig. 3) resembles that of *anthracina* (fig. 6) but is smaller and more slender. A striking difference is seen in the mid-ventral chitinous point of the stalk, long in *anthracina* and holding the claspers almost straight ahead, short in **bruneri** letting the claspers flex ventrally.

TYPE: Near Blanca, Colorado, June 19, 1944, B. Rotger C. R., deposited in the collection of the California Academy of Sciences.
PARATYPES: 31 ♂♂ taken in the area from Ft. Garland to Glanca and to the Great Sanddunes National Monument in Colorado.

This species is dedicated to the memory of Professor Lawrence Bruner with whom the writer, as a student, spent a never-to-be-forgotten summer collecting insects in the type locality.

Serica **diablo** n. sp.

MALE: Length 7 mm; width 4 mm. Color dark castaneus, surface bare and shining, finely, rather evenly and densely punctate. Clypeus finely and densely punctured, the punctures separated by their own diameter or less, front less densely and finely punctured, the intervals between the punctures of both minutely shagreened. Clypeal margins roundly and strongly reflexed, broadly and moderately emarginate in front, lateral incisures obsolete. The antennae of the male moderate in size, the club about as long as the stem and equal to the dorso-ventral diameter of the eye.

Pronotal punctures of only moderate size, separated by one to two diameters, the shagreen of the surface nearly obsolete, being largely confined to the punctures. Elytra "corrugated," the striae relatively broad and densely punctured, the intervals narrow and largely impunctate.

The female very much like the male; antennae of the same size but with the club narrower at its origin; the posterior margin of the last sternite not emarginate and the abdomen more fully rounded.

To more fully delineate the remarkable pattern of the right clasper of the genital armature, two specimens were used in the drawings (figs. 17, 18). This clasper can rotate laterally 90° or more. The horn-like process can turn across the end of the armature and lock under

the margin of the left clasper. The varying positions of the claspers greatly modify the superficial appearance of the armature. The variation in the shape of the stalk in the three figures is not to be taken seriously. It is due to several factors; angle of view on an asymmetrical object, distortion of a tubular structure in drying, and some actual variation in the specimens. The drawings were made with great care by the aid of a check-micrometer, so little is to be attributed to that source.

TYPE: A mated pair bearing the label: Mt. Diablo, Contra Costa Co., California, V-30-54, on *Adenostoma fasciculatum*, W. E. Ferguson, collector. The type will be deposited in the collection of the California Academy of Sciences. PARATYPES: 32 ♂♂ and 34 ♀♀ with the same data as the type; Sequoia N.P. 1 ♂; Santa Barbara Co. 1 ♂; Santa Lucia Mountains 1 ♂.

Serica fimbriata LeConte **New Synonymy**

1856. *Serica fimbriata* LeConte, Jour. Acad. Nat. Sci. Phil., (2) **III,** p. 275.
1947. *Serica fimbriata* Dawson, Jour. N.Y. Ent. Soc., **LV,** pp. 229, 230, Pl. XV.
1948. *Serica michelbacheri* Saylor, Proc. Calif. Acad. Sci., (4) **XXIV,** pp. 345, 346, Pl. 14.

The holotype of *michelbacheri* has been examined and found to be a perfectly typical specimen of *fimbriata* LeConte.

Serica **floridana** n. sp.

MALE: Length 7 mm; width 4 mm. Color light chestnut brown, glabrous, shining, no bloom or iridescence. Clypeus plain, moderately punctured, margins rather strongly and abruptly elevated, the front margin nearly straight and separated from the side margins by narrow but deep and distinct notches. Punctures of the front strong along the suture and grading off to an impunctate occiput. Eyes large and prominent, and antennal club equal to the dorso-ventral diameter of the eye.

Pronotum with the sides nearly straight and parallel in the posterior 3/5, then rounded to the width of the head through the eyes. Puncturation shallow, irregular, with the punctures separated by one to three diameters. Elytra with strong striae emphasized by numerous strong, deep punctures, the narrow crests of the intervals nearly impunctate.

Female easily recognized, eyes and antennal clubs smaller by 1/6 and last ventral sternite almost straight across instead of emarginate medially.

The genital armature of the male shows several distinctive characters (figs. 4, 5); the broad, asymmetrical stock with its apical portion abruptly narrowed, and the claspers frequently flexed deeply against the ventral side and rotated to the left. The rim of the left clasper is densely covered with minute, black setae or bristles, arising from punctures which gives the surface a roughened appearance. This is an unusual character in the genus.

TYPE: ♂. Interlachen, Florida, April 2, 1931, H. & A. Howden; deposited in the Canadian National Collection.

PARATYPES: Florida, Interlachen, 11 ♂♂, Gainesville, 3 ♂♂. North Carolina: Kill Devil Hills, Dare Co., May 1952, Arnett, 15 ♂♂, 27 ♀♀. Alabama: Mobile, 2 ♂♂, 1 ♀. Georgia: Baker Co., June, 1956, 1 ♂. Mississippi: Hattiesburg, May 10, 1944, C. D. Michener, 1 ♂. New Jersey: Atsion, June 27, 1946, J. W. Green, 1 ♂.

Serica **frosti** n. sp.

MALE: Length 7 mm; width 4 mm. Color light chestnut brown with a thin rainbow iridescence, nearly devoid of pubescence except for some fine, brown hair on the front and middle legs. Antennae of male with club longer than the diameter through the eye, the proportion about 5.5 to 4.5. In the female both eyes and antennae are smaller, using the same scale, the proportion is 4.5 to 4.3. The sexes can be readily separated by the size of the antennal club. Clypeus rather coarsely and closely punctured; front margin strongly elevated and broadly, feebly arcuate, the side margins less elevated thus suggesting the position of a clypeal notch at the junction with the front margin. Pronotum with rather coarse punctures separated by about two diameters, closer at the sides. Elytra with line-like striae, rather deeply impressed and crowded with a confused row of fine punctures, intervals convex and impunctate at the crest.

The male genital armature (fig. 38) somewhat resembles that of *pusilla* but the stalk is longer and the claspers are always directed far ahead. This position is due to the mid-ventral point of the stalk contacting the sclerotized base of the claspers, thus inhibiting a downward flexure. This limitation of position does not occur in *pusilla* where the claspers have great freedom of motion, and consequently assume many positions.

TYPE: ♂. Archbold Biological Station, Lake Placid, Florida, R. W. Dawson, February 10, 1966; deposited in the collection of the California Academy of Sciences.

PARATYPES: about 200 from the same locality, taken during February and March.

The writer is indebted to Dr. S. W. Frost for these specimens, attracted to his light trap, and is dedicating the species to him. In his light-trap papers this species is listed under the name *Serica errans* Blatchley (a synonym of *pusilla*). Despite the local abundance of **frosti,** I know of no other records of it, while *pusilla* and *aspera*, somewhat similar species, have rather wide distributions.

Serica **heteracantha** n. sp.

MALE: Length 8 mm; width 4.5 mm. Light golden brown, dulled by a gray pollen, most noticeable on the elytra. Clypeus broad, especially apically, with very dense, fine punctures separated by less than their own diameter; margins reflexed without a clypeal notch, broadly arcuate medially; apical third of the disc slightly tumid medially, emphasizing the transverse depression before the reflexed apical margin; front with finer, much more sparse, punctures, occiput becoming impunctate; intervals of elytra convex, separated by sharp line-like striae, punctures fine and rather numerous, especially on the broader intervals.

Only the genital armature of the male (fig. 35) gives reliable evidence for separating this species from the numerous similar California species. On this basis *stygia* is the only known species which resembles it. The lateral view of the armature of *stygia* shows only one strong medial tooth, in **heteracantha** this median tooth is small and accompanied by a strong subapical tooth. Other angles of view show very striking differences between the armatures of the two species, but the characters figured are constant and quite sufficient for differentiating the two species.

TYPE: ♂. Jacumba, California, V-18-41, D. J. & J. N. Knull; deposited in the collection of the California Academy of Sciences.

PARATYPES: 10 ♂♂, 5 ♀♀ bear the same data; 2 ♂♂ Hurkey Cr., San Jacinto Mountains, California.

Serica **howdeni** n. sp.

MALE: Length 8 mm; width 4.8 mm. Dark brown, glabrous and shining, densely covered with moderate-sized punctures; clypeal margins strongly reflexed and deeply but narrowly notched between the anterior and lateral margins; the anterior margin nearly straight; clypeal disc slightly depressed marginally and slightly tumid medially; antennal club of male nearly as long as the stem of the antenna; striae of elytra deep, with three to four confused rows of strong, semi-confluent punctures; ventral surface of thorax strongly and densely punctured, of abdomen less so.

The genital armature of this species (figs. 1, 2) shows several distinctive characters. Most unusual is the deep, diagonal groove crossing the face of the right clasper. Next is the minutely setulose upper portion of the left clasper. To more clearly indicate these characters, drawings of both claspers from quite different angles are added.

TYPE: ♂. Tyler, Texas, March 2, 1953, S. E. Bennet, light trap, deposited in the Canadian National Collection.

Serica oliveri Saylor **New Synonymy**

1939. *Serica oliveri* Saylor, Proc. Ent. Soc. Wash., **41,** pp. 56, 57.
Serica joaquinella Saylor, same pages as above.

Both of Saylor's descriptions were based on single specimens; *joaquinella* on an undersized, teneral specimen in poor condition. Both of his types and 30 good additional specimens are before the writer, which makes it clear that *joaquinella* is a synonym. The outstanding, definitive character of the species, the double tip of the left clasper (fig. 11), is not mentioned, and not shown in Saylor's drawings. In some positions of the left clasper the outer lobe of the tip obscures the inner, unless you look for it. His statement: "The genitalia of *S. oliveri* are most similar to those of *S. solita,*" is misleading and confusing, as is also his comparison of *joaquinella* to a bicolored *anthracina*, and its armature to that of *caliginosa.*

Specimens examined from Antioch, Delhi, Fowler, Fresno and Merced, California.

A considerable amount of variation occurs in the armature, especially in the end of the right clasper (fig. 10).

Oliveri, due to its dark color, robust stature and strongly pruinose elytra resembles **pullata,** here described as new, but the genitalia of the two species are strikingly dissimilar (figs. 10, 11, 9, 12).

Serica peregrina Chapin and *Maladera castanea* (Arrow)

Two species of Serica-like beetles have been accidentally introduced into the United States from Japan. They became established in New York and New Jersey in the early 1920's. Most abundant and best known is *Maladera castanea* (Arrow) also called the Asiatic Garden Beetle (fig. 36). Early confusion and disagreement about the scientific name caused it to be listed both

as *Autoserica* and *Aserica*. Less abundant, but definitely established, is *Serica peregrina* Chapin (fig. 37).

With both species the genital armatures are so radically different from any American species as to make them instantly recognizable.

Serica perigonia **eremicola** n. subsp.

When variants reach a confusing degree of development and are correlated with geographical distribution it seems desirable to designate them as subspecies. A well-known entomologist has said (perhaps not seriously): "A species *is* what the taxonomist *thinks* it is, until he changes his mind." So **eremicola** *is* a subspecies! The greatly expanded margin of the left clasper (figs. 7, 8) is its distinctive character. I believe that the finger-like end ("appendix") of the right clasper is *the* diagnostic character of the species *perigonia*.

TYPE: ♂. Mexico, Baja, California, Norte, Arr. Santo Domingo, 5.7 miles, E. Hamilton ranch dam site, 23-IV-1963, H. B. Leech & P. H. Arnaud, Jr.; deposited in the collection of the California Academy of Sciences.
PARATYPES: 29 ♂♂ and 21 ♀♀ with the same data.

Serica pilifera Horn

1894. *Serica pilifera* Horn, Proc. Cal. Acad. Sci., (2), **IV,** p. 397.

The identity of the type specimen, and the species, has long been in question. A single female in the Horn collection was thought to be the holotype. Since females in the genus *Serica* are difficult (sometimes impossible) to identify with certainty, the species was left in doubt. A recent letter from Dr. Leech helps to clarify both questions. He writes: "This male, which you dissected some years ago, is from Santa Maria, Baja California, and is undoubtedly the true type. The lectotype label was put on by E. P. Van Duzee, but not validated by publication. As you know, Horn returned the first set of the Baja California material to the California Academy of Sciences, and these beetles were saved by the late Miss Alice Eastwood after the 1906 earthquake, and before the fire which destroyed our general collections. It is only because Mr. Cresson believed all types to have been lost in the fire, that the Philadelphia Academy claimed to have the types, based on the duplicates which Horn retained when he studied our Baja California specimens."

Drawings made from this lectotype male are here presented (figs. 28, 31). Due to the age and condition of this specimen it is difficult to compare it with fresh material in high condition. L. W. Saylor compared a single recently collected male with the *pilifera* type (before I dissected it) and named it as a new species, *ensenada*. He says: "Related to *pilifera* Horn, from Santa Maria, and differs mainly by the more strongly reflexed clypeal apex, the absence of the lateral clypeal notch, and much more densely pilose surface." After comparing the two types, I fail to see a significant difference in these characters.

The genital armatures of the two types differ markedly in degree but not in basic pattern. In both forms the stalk of the armature is asymmetrical, distinctly longer on the left side and shorted on the right, so that the claspers are flexed toward the short side. A part of the apparent variation is due to the position of the claspers, which can be strongly flexed laterally and also apically. The most important characteristics in the armature of *ensenada* (figs. 26, 27) as compared to that of *pilifera* (figs. 28, 31) are the long, stream-lined, left clasper, and the blunt apex of the stalk on the left side. In Horn's type of *pilifera* the left clasper is broad and abruptly abbreviated in the terminal third, and the left side of the stalk is semi-falcate in outline.

Six typical males and six females are at hand from "3 miles above Rosario," which would be two-thirds of the way down the Baja peninsula. Three additional specimens are at hand which are somewhat intermediate between the two types, but are referred to *pilifera* by the writer due to the features just noted.

Serica ensenada Saylor

1948. *Serica ensenada* Saylor, Proc. Cal. Acad. Sci., (4), **XXIV,** p. 346, Pl. 14, fig. 1.

Saylor's holotype was used in making the accompanying figures (26, 27). The status of his species can best be determined when more material is available. See notes above under *pilifera*.

Serica porcula Casey

1884. *Serica porcula* Casey, Contr. to Desc. and Syst. Coleopterology of N. A. II, p. 177.
1947. *Serica porcula* Dawson, Jour. N.Y. Ent. Soc. **LV,** pp. 231–232, Pl. XVII.

Typical *porcula* occurs from the Mojave Desert in California across Arizona and New Mexico, and northward with scattered records from desert areas in Colorado to southeastern Wyoming. Specimens from all this area show little variation in the form of the genital armature. See my plate recorded above. An allied species complex in California presents a very different situation, discussed under *adversa* and *alleni* early in this paper.

Serica pruinipennis Saylor

1935. *Serica pruinosa* Saylor, Jour. Ent. & Zool., pp. 1, 2.
1936. *Serica pruinipennis* Saylor, Jour. Ent. Zool., **28,** p. 4. **New name**
1939. *Serica mendota* Saylor, Jour. Wash Acad. Sci., **29,** 454 and 457–458. **New Synonymy**
1952. *Serica pruinipennis* Dawson, Jour. N.Y. Ent. Soc., **LX,** p. 73, Pl. XIII.

When Mr. Saylor described *pruinosa* (*pruinipennis*) he overlooked the partial "4th leaf" in the antennal club. Later when working on a good series of specimens from Mendota, California he discovered it, and was thus led to

describe a new species, "*mendota.*" The abbreviated lamella of the antennal club is a remarkable character otherwise unknown in the nearly 100 species of North American *Serica*. At its maximum development, occurring in the males, this 4th lamella reaches nearly half the length of the lamellate club, and at its minimum development, occurring in the females, may be reduced to a mere vestige, easily overlooked.

Serica **pullata** n. sp.

MALE: Length 8 mm; width 4.3 mm. Color piceous black dulled by a gray bloom. Bare above, sparsely clothed with short, ferruginuous hair beneath, becoming longer and conspicuous on the front and middle legs.

Antennae ferruginuous, club longer than the diameter of the eye, the proportion about as 4 to 3. Club of female antennae shorter, about equal to the diameter of the eye. Clypeus finely and densely punctured, front more coarsely and sparsely punctured, grading off to an impunctate occiput. Surface in the punctate areas minutely shagreened. Clypeal margin clear around strongly elevated, nearly straight in front and without a trace of lateral notches. Pronotum with fine, close but irregular puncturation, and shagreened surface, but dulled by the opaque, gray bloom. Elytra with fine striae just wide enough for a single row of fine punctures, intervals relatively wide, feebly convex and nearly impunctate, surface dull.

Genital armature large for the size of the beetle, plain and generalized in design (figs. 9, 12). With the aid of the genital armature this species is easily separated from *oliveri*, (figs. 10, 11) without it the similarity is baffling and the determination unreliable.

TYPE: ♂. Desert Springs, L. A. Co., California, May 19, 1954. On *Acamptopappus*, P. D. Hurd.
PARATYPES: Desert Springs, May and June, 6 ♂♂, 6 ♀♀. Hesperia, California, May 20, 1948, G. P. Mackenzie, 1 ♂, 4 ♀♀.

Serica **sericeoides** n. sp.

If a series of specimens were at hand, one might be able to point out tangible, external characters for differentiating *sericeoides* (figs. 14, 15) from *sericea* (fig. 16), but with only a single male of *sericeoides* for comparison that is not feasible. The male genital armature shows good characters: the terminal portion of the stalk is thinner and more delicate, the claspers relatively short and straight with sharp, laterally divergent tips. These characters indicate an undescribed species.

TYPE: ♂. Jackson Co., Alabama, June 19, 1934, H. P. Loding; deposited in the collection of the California Academy of Sciences.

Serica texana LeConte

Described in 1856, it took nearly a century to match his type with a single male from Lee County, Texas, previously recorded by the writer. Thus *texana* has been one of the rarest sericas in collections. Now Henry Howden sends me specimens from Texas as follows: Bastrop State Park, April 6–7, 1959, 16 ♂♂, 5 ♀♀, Fredericksburg, April 18, 1959, 3 ♂♂, 2 ♀♀. These localities are reasonably close to the type locality.

Additions to the previously published state lists of *Serica* in Jour. N.Y. Ent. Soc., **LX**(2), pp. 74–77:

Alabama: **alabama, floridana**.
Arizona: **barri**.
California: **adversa, aviceps, diablo, heteracantha, pullata,** *rossi*,
delete the following formerly listed: *joaquinella*, *mendota*.
Colorado: *porcula*, **bruneri.**
Connecticut: *imitans*.
Florida: **floridana, frosti**.
Georgia: **floridana, alabama**.
Idaho: **barri**.
Kentucky: **alabama**.
Louisiana: *texana*, *contorta*, delete: *atratula monita*.
Maryland: *castanea*.
Massachusetts: *perigrina*.
Mississippi: *vespertina accola*, **floridana**.
New Jersey: **floridana,** *perigrina*.
North Carolina: **floridana, alabama**.
Nevada: **barri**.
Ohio: **alabama**.
Pennsylvania: *castanea*.
South Carolina: *castanea*, *opposita*.
Tennessee: **alabama**.
Texas: *aspera*, **howdeni,** *parallela*.
Utah: **barri**.
Virginia: *carolina*.

MEXICO

Baja California: *laguna*, *watsoni*, *fimbriata*, *prava*, *perigonia* **eremicola**.
delete: *michelbacheri*, *sculptilis*.

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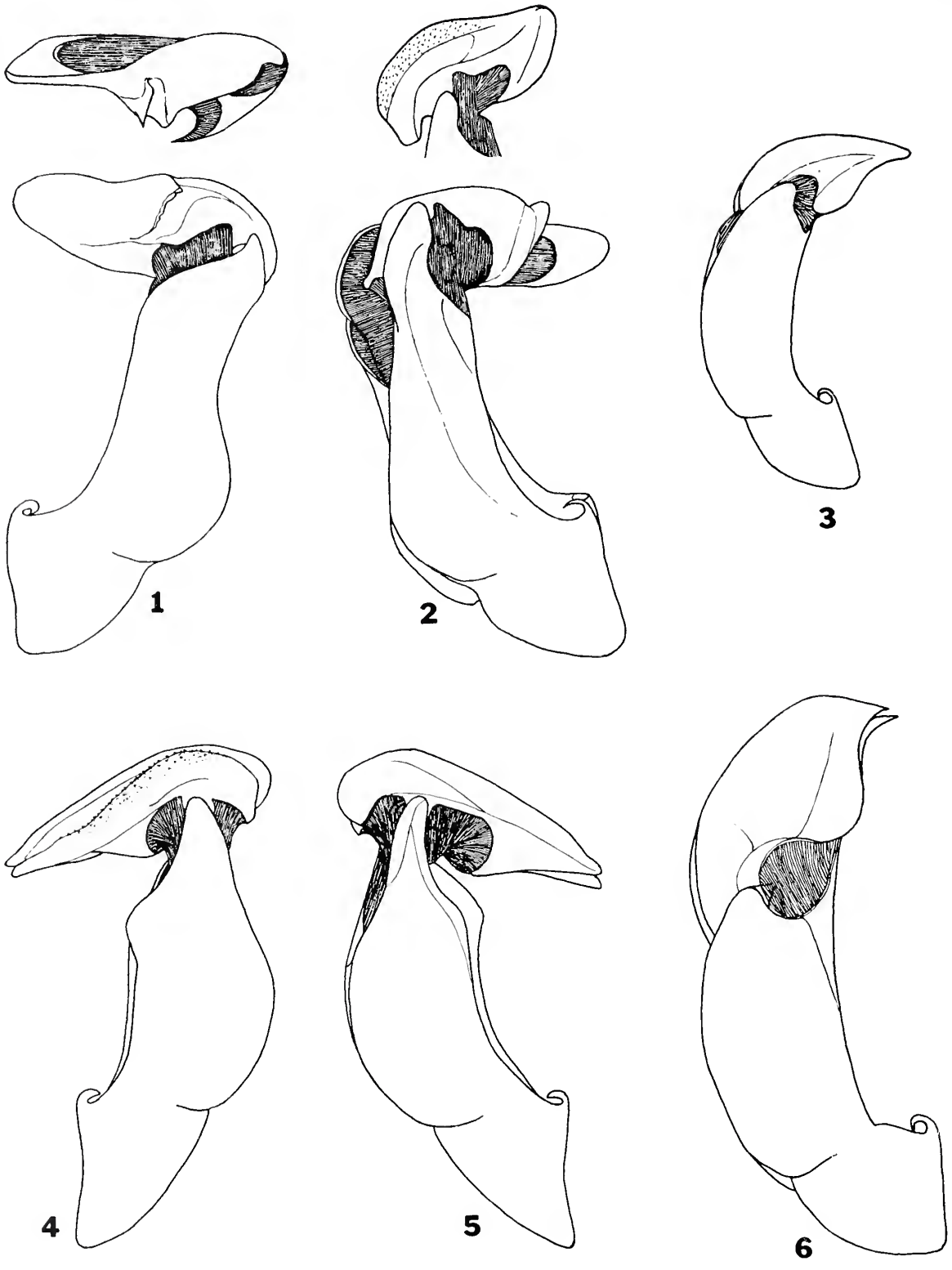
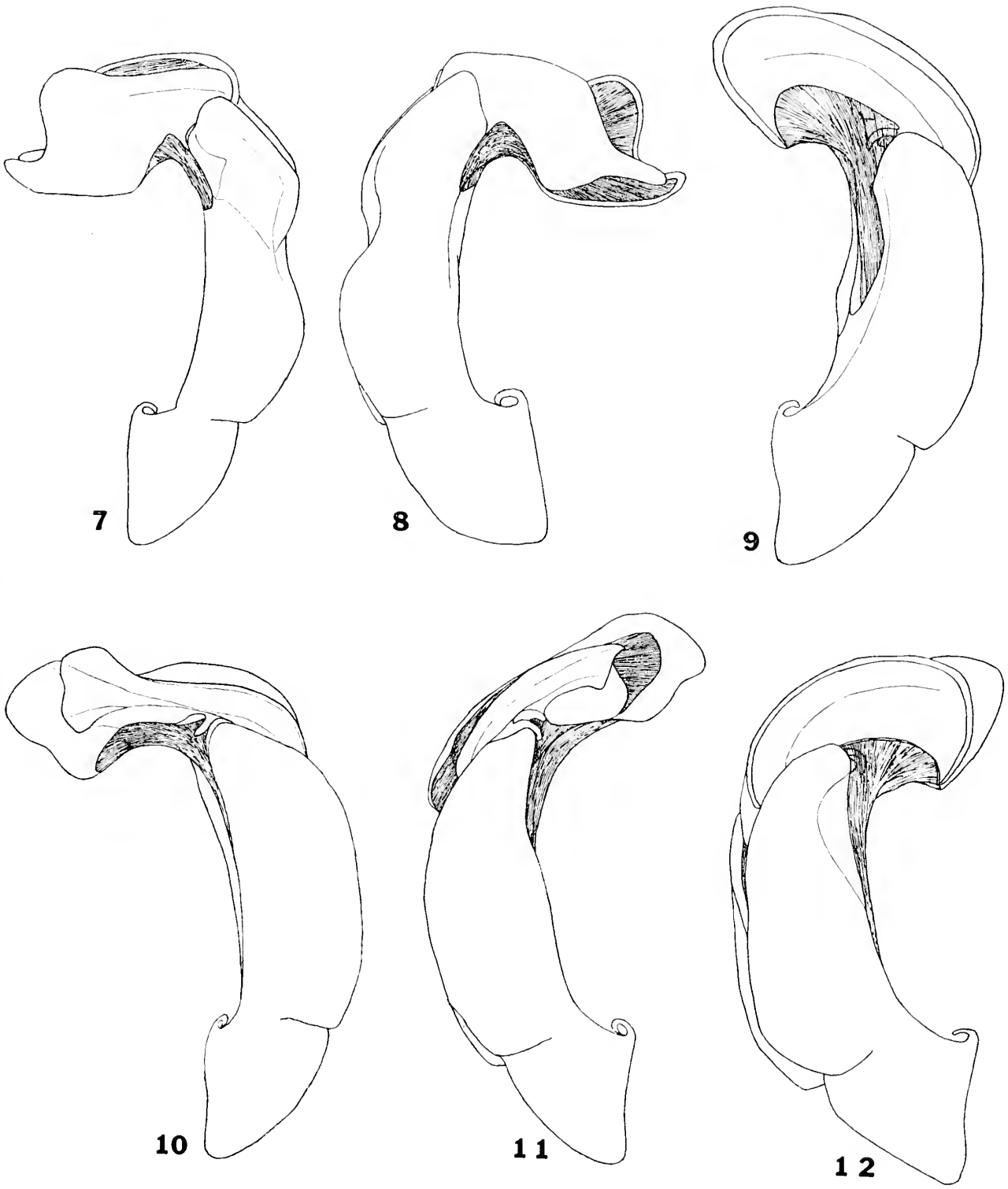
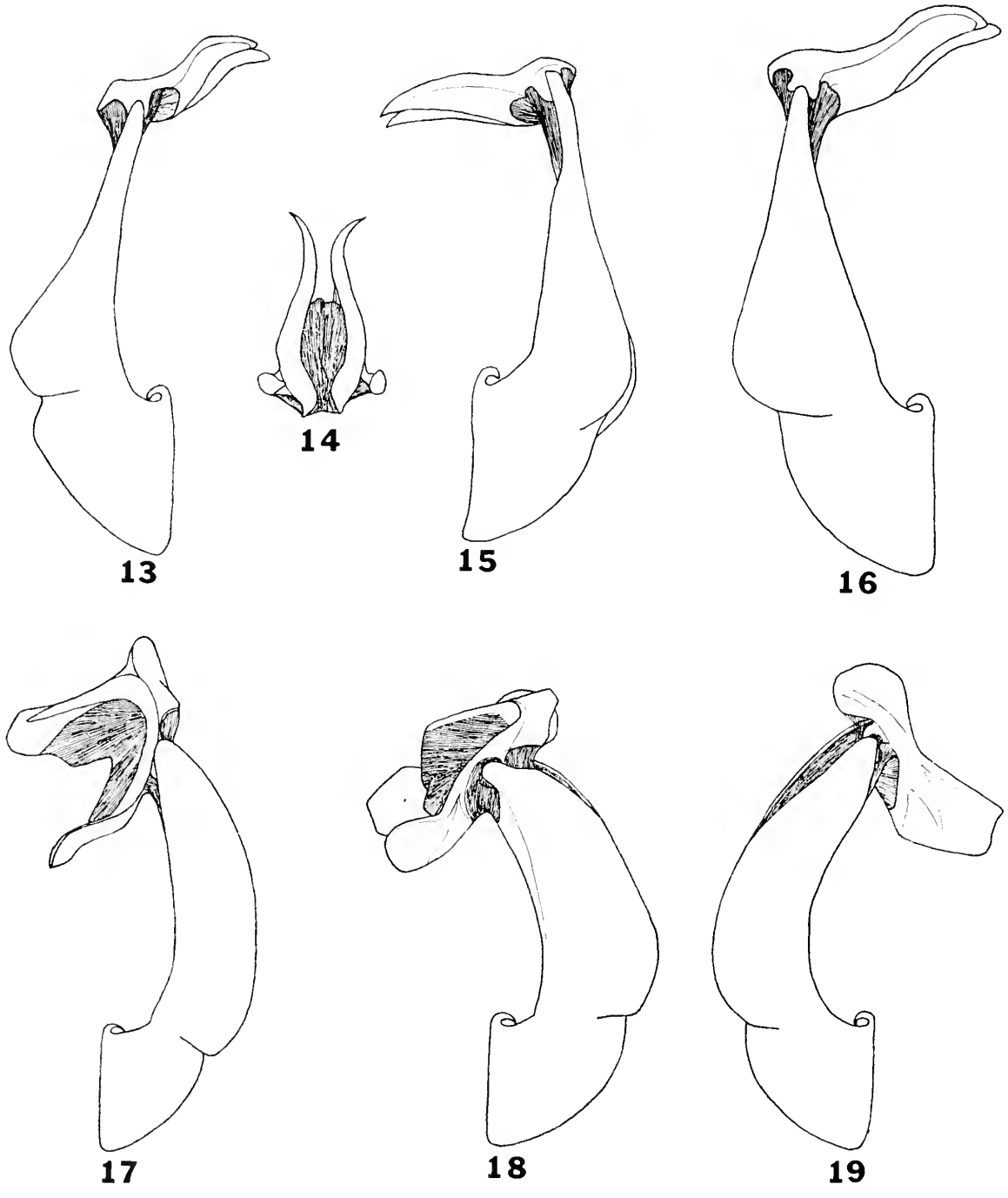


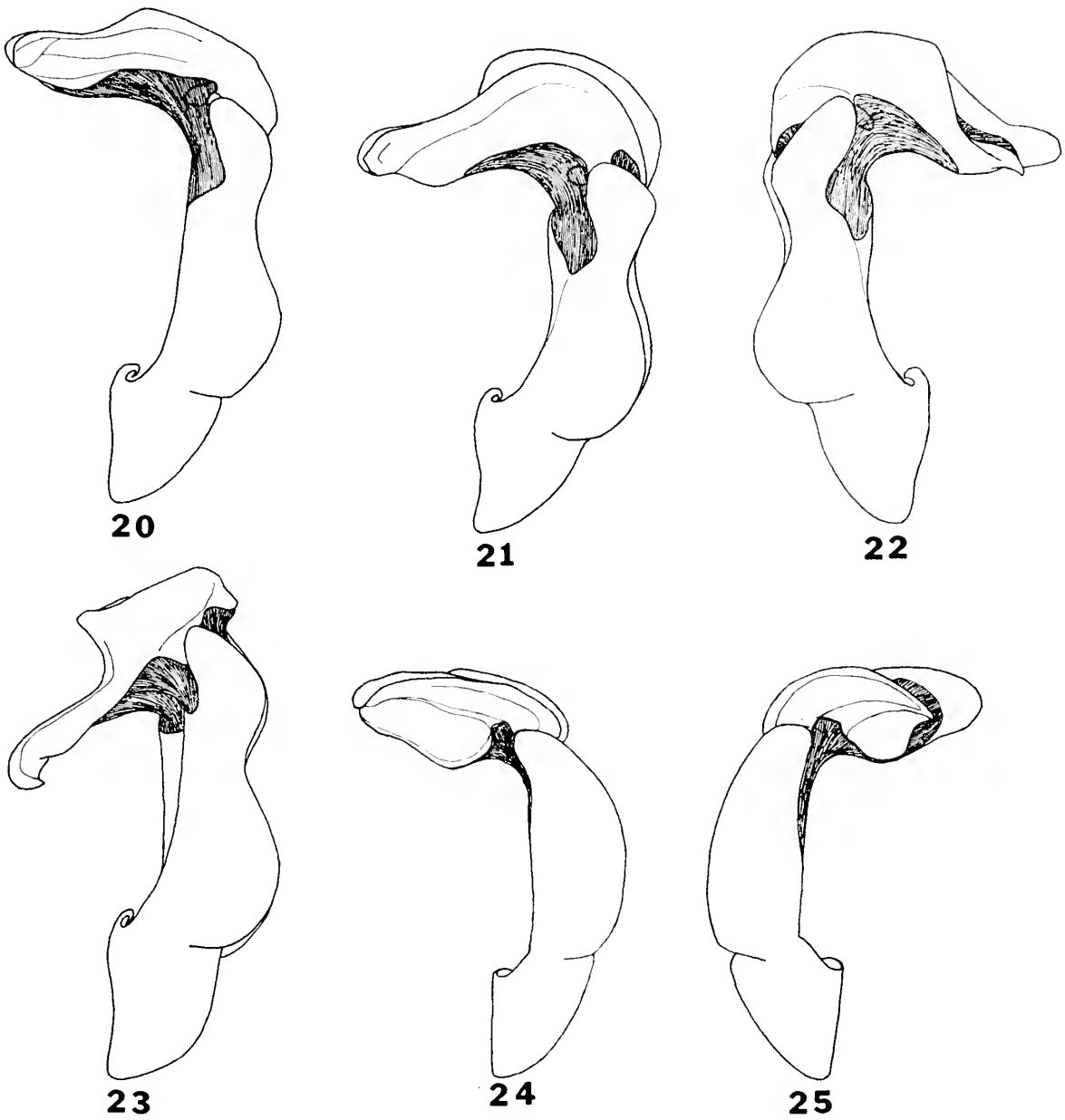
FIGS. 1–6. 1, 2. **howdeni**; 3. **bruneri**; 4, 5. **floridana**; 6. *anthracina*.



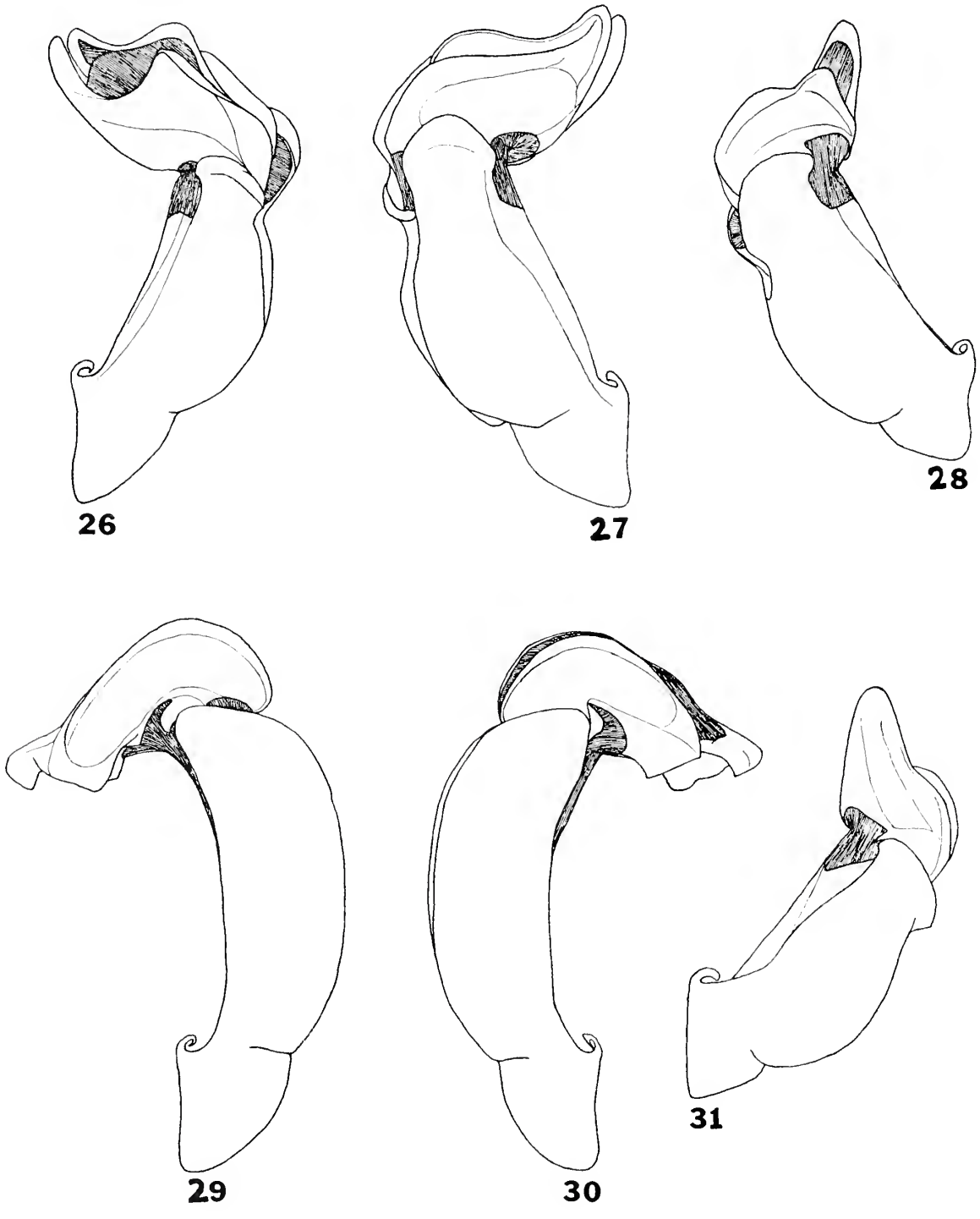
FIGS. 7–12. 7, 8. *perigonia* **eremicola**; 9, 12. **pullata**; 10, 11. *oliveri*.



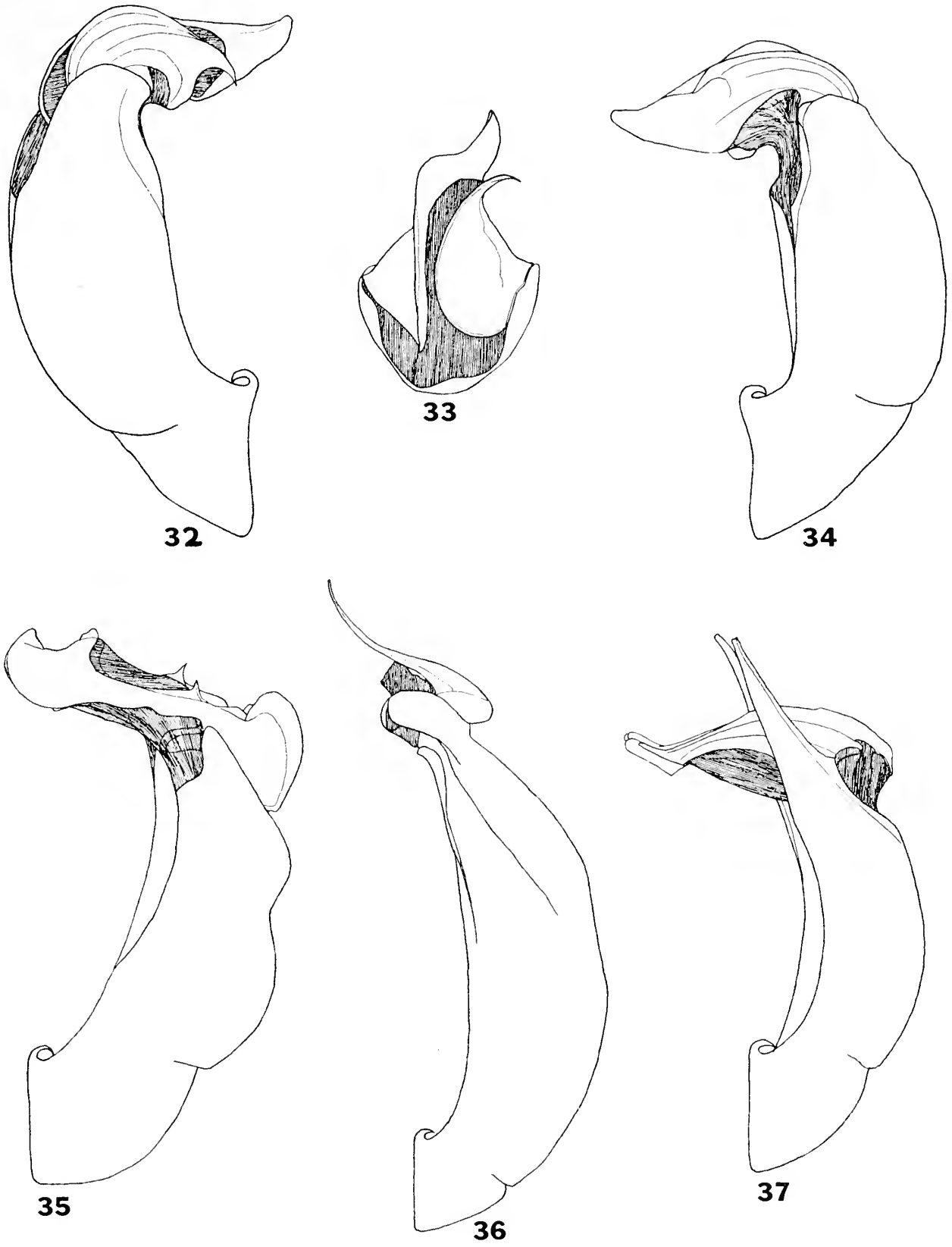
FIGS. 13–19. 13. **alabama**; 14, 15. **sericeoides**; 16. *sericea*; 17–19. **diablo**.



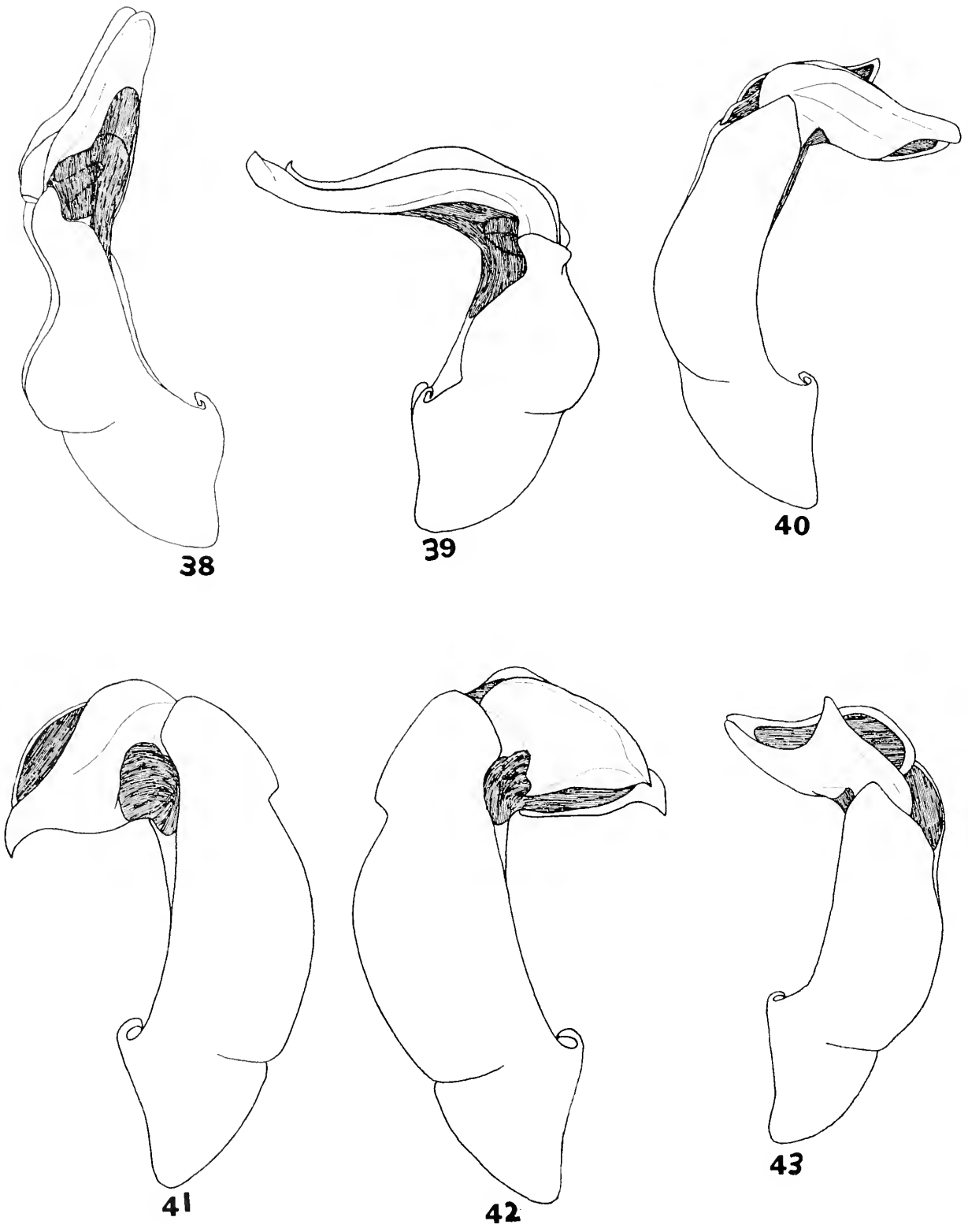
Figs. 20–25. 20–23. *alleni*; 24, 25. barri.



FIGS. 26–31. 26, 27. *ensenada*; 28, 31. *pilifera*; 29, 30. **aviceps**.



Figs. 32–37. 32–34. *rossi*; 35. **heteracantha**; 36. *castanea*; 37. *perigrina*.



FIGS. 38–43. 38. **frosti**; 39. **adversa**; 40, 43. *mackenziei*; 41, 42. *serensia*.

Observations of *Epicordulia princeps* (Hagen) (Odonata: Corduliidae) at a Light

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Abstract: The occurrence of *Epicordulia princeps* (Hagen), a crespuscular dragonfly common to the central and northeastern United States, at a street light was studied on successive evenings from June 18 to July 4, 1966 (11:00 PM to 1:30 AM—CST) in Chicago, Illinois. Both sexes were usually present with males always predominating. Curiously, the dragonflies repeatedly aggregated (loosely) on a certain portion of the illuminated surface (of stone wall) throughout the study period. Dragonflies arrived and departed singly with either process usually being accomplished, for all individuals present, within 20 minutes. It was not clear if the dragonflies, when attracted to the light, were actually foraging or whether perched (resting) on nearby trees and other suitable resting sites. An anomalous behavior of curving the abdomen upwards when perched on the wall was observed.

Corbet (1963), summarizing a large number of published studies, describes two general activity patterns in dragonflies: (1) regular flight activity from mid-morning through late afternoon (i.e., during the non-extreme daylight hours), and (2) regular flight activity at sunrise and sunset (eocrespuscular activity). Under the latter, crespuscular dragonflies are those which fly only at sunset, although probably the majority of these are also active at sunrise but have not yet been observed (due to a general deficit of extensive dawn studies) and for this reason, they are better known than eocrespuscular forms (Corbet, 1963). Generally, these dragonflies, the majority of which are tropical, possess extremely large compound eyes and dark bodies, are strong, rapid fliers and forest-dwelling (Williamson, 1923). Some crespuscular dragonflies are attracted to lights after sunset (Corbet, 1963).

Epicordulia princeps (Hagen) is a crespuscular dragonfly common to the central and northeastern United States with a flying season from early May through mid-September (as recorded in Ohio) (Needham and Westfall, 1955). The only other known species of the genus is *regina*, restricted to the southeastern United States and easily distinguished from *princeps* by wing markings (Needham and Westfall, 1955). There are apparently no published accounts of either species being attracted to lights after sunset and this paper reports some observations delegating such behavior to *princeps*.

OBSERVATIONS

On the evening of June 18, 1966, 4 individuals of *princeps* were seen resting on a stone wall illuminated by a street light, 8 feet away, on The University of Chicago campus. The wall, off-white in color, was 10 feet high and had a roughly-textured surface. Using a step ladder, the insects were easily picked up by hand and in this way, sex was determined quickly by examining genitalia.

TABLE 1. Occurrence of *E. princeps* on successive evenings in 1966.

Date	Females	Males	Total
June 18	1	3	4
June 19	0	5	5
June 20	0	0	0
June 21	2	6	8
June 22	2	5	7
June 23	1	6	7
June 24	1	4	5
June 25	1	3	4
June 26	0	0	0
June 27	0	0	0
June 28	2	6	8
June 29	2	6	8
June 30	1	5	6
July 1	1	4	5
July 2	0	5	5
July 3	1	2	3
July 4	0	3	3

The dragonflies were then returned to their approximate positions on the wall and thereafter left undisturbed (but observed) for the remainder of the evening. This preliminary observation was made at 11:25 PM (CST) and no more dragonflies arrived after that, with observation lasting until 2:18 AM. However, the 4 individuals had flown away before this time. For successive evenings thereafter, the illuminated section of wall was examined for *princeps* for a period of 2½ hours, from 11:00 PM to 1:30 AM, and the observed maximum frequencies are tabulated by sex in Table 1. In addition, on each evening, the times of arrival and departure were recorded for the dragonflies.

DISCUSSION

Evenings prior to the final observation date (July 4) for which no entries were made, were not cases of bad weather but simply instances of non-appearance. In addition, routine searches were made at other nearby illuminated areas but *princeps* never appeared. After July 4, the dragonfly did not appear at the study site for 24 consecutive evenings and after this, observations were terminated altogether. General climatic conditions had not changed very much after July 4. For some unknown reason, males always predominated (Table 1). After the first 2 evenings of observation, it became evident that the dragonflies tended to aggregate in a loose fashion within a certain area (with usually 5–8 inches to nearest neighbor) of about 10 square feet on the wall, and on the second evening, a faint crayon line was drawn to define this "preferred" area of illumination. On future evenings, all individuals perched within this circumscribed area. The reason for this repeated preference of a certain portion of the larger general area of illumination is not clear. Careful examination of the preferred area during daylight revealed nothing unusual. The dragonflies

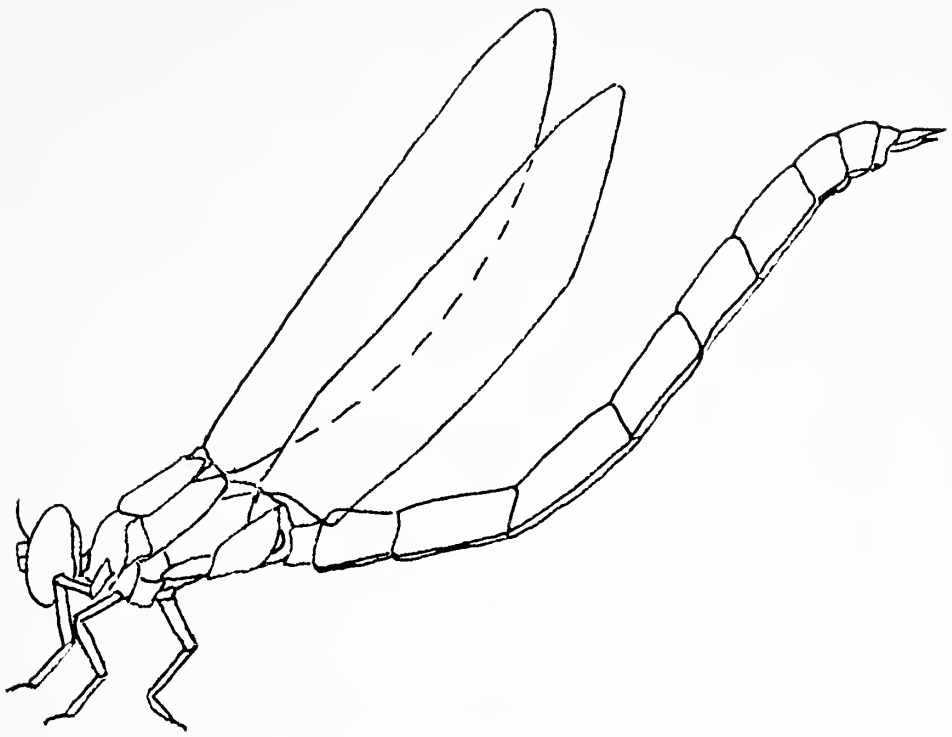

Fig. 1. Unusual position of the abdomen observed in both sexes of *E. princeps*.

were always positioned vertically on the wall with the anterior end upwards. Furthermore, the dragonflies never appeared to be disturbed when picked up (one at a time) for sex identification, for they always retained the motionless, resting position (wings held vertically to the long axis of the body) when returned. In reference to usual departure, most individuals left the wall (flew away) within 20 minutes, usually between 1:00–1:30 AM and never before 12:40 AM nor later than 1:55 AM. Arrival was similar to departure—individuals arrived singly and almost invariably between 11:00–11:40 PM.

It is interesting to note that *both* sexes were seen together with the absence of the usual breeding behavior exhibited by most dragonflies whenever both sexes are present at breeding sites during daylight hours. Corbet (1963) mentions that some dragonflies may fly in small groups comprised of both sexes when hunting food (as witnessed during daylight). Wright (1944) reports that in *princeps*, both sexes may fly together during daylight. Group hunting for food raises an interesting question concerning the observations presented here: were the dragonflies perched on a nearby tree or some similar resting site and merely attracted to the light or were they actually foraging during these late hours? Corbet (1963) mentions the likelihood of some crespuscular dragonflies flying well after sunset. Assuming that at least some of the same individuals were present on more than one evening, *a priori*, it seems unlikely that they always chose the same resting area every night and were therefore always attracted to the same light source. Rather, it is conceivable that the aerial region surrounding this light source was particularly attractive for foraging and that *princeps* was attracted to the light while in flight rather than at

rest. Foraging within close proximity of the attracting light source could have been enhanced by the following existing conditions: (1) intense attraction of other aerial insects to the light source, (2) abundance of small shrubs of many types near the light source which may have supported many aerial insects, and (3) small, shallow pools of water behind the wall which usually had minute aerial insects flying above them. This suggestion of foraging after dark is difficult to prove but nonetheless warrants mentioning. While the particular light source attractive to *princeps* was no different than other street lights in the area, possibly the surrounding, immediate conditions had something to do with the observed preference for it.

It was also observed that all individuals of *princeps* on any evening had their abdomens curved steeply upwards away from the wall, as schematically depicted in Figure 1. Extensive survey of dragonfly literature failed to uncover any previous observation of this curious behavior. Abdomens were held in this position throughout the perching period and its purpose (if any) is not at all clear.

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Undescribed Species of Crane Flies from the Himalaya Mountains (Diptera: Tipulidae), XV[1]

Charles P. Alexander
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Abstract: Six new species of Eriopterine crane flies are described, these being *Gnophomyia* (*Gnophomyia*) **diacaena** n. sp., from Assam; *Gonomyia* (*Lipophleps*) **pentacantha** n. sp., Kumaon; *Toxorhina* (*Ceratocheilus*) **bistyla** n. sp., Assam; *T.* (*C.*) **fulvicolor** n. sp., Assam; *T.* (*C.*) **fuscolimbata** n. sp., Assam; and *T.* (*C.*) **simplicistyla** n. sp., Assam.

Part XIV of this series of papers was published in the *Journal of the New York Entomological Society*, **75:** 24–28, 1967. All specimens were taken by Dr. Fernand Schmid to whom my very sincere thanks are extended for this extraordinarily rich series of crane flies.

Gnophomyia (*Gnophomyia*) **diacaena** n. sp.

Allied to *eupetes*; head and thorax brownish black, sparsely pruinose; antennae of male elongate, about one-half the wing; femora obscure yellow, tips blackened; wings very weakly darkened, R_{2+3+4} subequal to R_{1+2} or a little longer than R_{2+3}, *m-cu* about its own length beyond fork of *M*; male hypopygium with two small acute spines at near midlength of the gonapophyses.

MALE: Length about 5 mm; wing 5.8 mm; antenna about 3 mm.

Rostrum and palpi black. Antennae elongate, about one-half the wing, black throughout; flagellar segments elongate, nearly cylindrical, longest verticils unilaterally arranged, slightly shorter than the segments, with other smaller verticils and abundant still shorter setae; terminal segment about three-fourths the penultimate. Head brownish black.

Thoracic dorsum almost uniform dull black, sparsely pruinose, lateral angles of pronotal scutum yellowed. Pleura dull leaden black, dorsopleural region, posterior pleurites and extreme dorsal pleurotergite vaguely yellowed. Halteres blackened, base of stem narrowly yellow. Legs with fore coxae brownish black, remaining coxae yellowed, base of middle pair darkened; trochanters yellow; femora obscure yellow, slightly darker on upper surface, tips blackened; tibiae and basitarsi brownish yellow, tips narrowly darkened, outer tarsal segments dark brown. Wings very weakly darkened, without stigma, base more yellowed; veins brown. Macrotrichia on longitudinal veins beyond general level of origin of *Rs*, lacking on *M*, present on outer ends of Cu_1, *2nd A*, and more than the outer half of *1st A*. Venation: Sc_1 ending shortly before level of vein R_2; *Rs* in direct longitudinal alignment with R_5, *r-m* at its fork; R_{2+3} a little shorter than R_{1+2}; cell *1st* M_2 long and narrow, subequal to distal section of M_3; *m-cu* its own length beyond fork of *M*.

Abdomen brown, hypopygium brownish black. Male hypopygium with the outer dististyle a yellow broad-based spine, inner style at apex expanded into a small oval blade, setae subterminal. Aedeagus relatively short, gonapophyses longer, each appearing as a long slender rod that narrows very gradually into a spine, inner margin at near midlength with two small acute points.

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[1] Contribution from the Entomological Laboratory, University of Massachusetts.

HOLOTYPE: ♂, Luanglong Khunou, Manipur, Assam, 2,500 feet, May 28, 1960 (Schmid).

The most similar described species is *Gnophomyia* (*Gnophomyia*) *eupetes* Alexander, of Sikkim, differing most evidently in hypopygial structures, as the bispinous gonapophyses.

Gonomyia (*Lipophleps*) **pentacantha** n. sp.

MALE: Length about 2.8 mm; wing 3.3 mm.

Characters as in *nissoriana*, differing in the hypopygial structure. Inner dististyles of the two sides asymmetrical, one with the elongate rod about as in *nissoriana*, terminating in a short blackened spine and with a very long nearly apical seta; style of the opposite side with the rod much shorter, entirely pale, without the elongate seta. Phallosome distinctive, stout, broadened outwardly, on either side with a strong curved arm or rod, directed cephalad and then laterad, at apex more expanded and bearing five strong pale spines, with interpolated much longer yellow setae. In *nissoriana* the arms are more evenly curved and more slender, with long setae but lacking the five major spines, as described.

Closely related to *Gonomyia* (*Lipophleps*) *nissoriana* Alexander (Philippine Jour. Sci. 61: 142–143, pl. 1, fig. 21 (venation), pl. 2, fig. 32 (♂ hypopygium); (1936), described from the Khasi Hills, Assam, now known from Kumaon, Nepal, Kameng, and South India. I earlier had considered the present material as representing *nissoriana* but from the hypopygial structure it evidently is distinct.

HOLOTYPE: ♂, Tapoban, Pauri Garhwal, Kumaon, 7,300 feet, July 28, 1958 (Schmid).

Toxorhina (*Ceratocheilus*) **bistyla** n. sp.

General coloration of thorax dark brown to black, praescutum with three stripes, pleura with a major light gray area; wings light brown, unpatterned; male hypopygium with two dististyles or profound branches.

MALE: Length, excluding rostrum, about 5.5–6 mm; wing 5.2–6 mm; rostrum about 4–4.5 mm.

Rostrum elongate, black. Antennae black throughout. Head gray, posterior vertex more infuscated medially; no corniculus.

Cervical region brownish black; pronotum dull orange brown. Mesonotal praescutum dull gray with three stripes, the lateral pair darker, borders clearer gray; posterior sclerites of notum brownish black, sparsely pruinose, parascutella and posterior callosities of scutal lobes obscure yellow. Pleura black, ventrally with a large light gray area that includes most of the sternopleurite, metapleura and meron more obscure gray; dorsopleural membrane light brown. Halteres light yellow. Legs with fore coxae brown, remaining pairs orange yellow; trochanters dark brown; remainder of legs brown. Wings light brown, prearcular and costal fields a trifle more yellowed; veins pale brown, brownish yellow in the brightened areas; no darkened pattern. Venation: R_5 deflected strongly caudad, especially in the holotype, terminating at wing tip; M_{3+4} shorter than M_4. No supernumerary crossvein in cell R_5 as occurs in some specimens of **fuscolimbata.**

Abdomen dark brown, ninth segment paler. Male hypopygium generally as in **fuscolimbata**, differing in details. Basistyle without a modified tubercle, as found in various species. Two dististyles or profound branches; beak of outer branch narrow, inner branch only moderately curved, at extreme outer lateral area with an elongate-oval blade or style, its tip obtuse.

HOLOTYPE: ♂, Bilo La, Kameng, North East Frontier Agency, Assam, 6,000 feet, June 10, 1961 (Schmid). Paratopotype, ♂, pinned with type.

The most similar species is *Toxorhina* (*Ceratocheilus*) **fuscolimbata** n. sp., from the high mountains of Manipur, Assam, which is most readily separated by the patterned wings. The hypopygia of the two species are generally similar but differ in details, especially of the dististyles.

Toxorhina (*Ceratocheilus*) **fulvicolor** n. sp.

General coloration of thorax fulvous cinnamon, pleura obscure yellow; rostrum about one-fourth longer than the body or wing; wings weakly tinged with brown, prearcular and costal fields light yellow; abdomen fulvous, posterior borders of tergites narrowly brown; interbase large, irregular in outline; dististyle single, terminal, large, on outer margin before midlength with a darkened knob, the long beak yellow, slender; arms of phallosome long.

MALE: Length, excluding rostrum, about 5 mm; wing 4.8 mm; rostrum about 6.5 mm.

Rostrum dark brown, longer than the wing or remainder of body. Antennae with scape and pedicel light yellow, flagellum brownish black. Head grayish white, including the posterior orbits, posterior vertex narrowly brown; anterior vertex subequal in width to the diameter of the antennal pedicel.

Cervical region and pronotum brownish yellow. Mesonotal praescutum and scutum fulvous cinnamon without well-defined pattern; scutellum pale brown, posterior border and parascutella yellow; postnotum fulvous yellow, central part of mediotergite vaguely darkened. Pleura obscure yellow. Halteres yellow. Legs with coxae and trochanters yellow; remainder of legs obscure yellow, appearing brownish yellow from the abundant brown bifid setae. Wings weakly tinged with brown, prearcular and costal fields light yellow; veins pale brown. Macrotrichia on both sections of R_5 and sparsely on *Rs*, lacking on anterior branch of *Rs*; trichia on distal section of M_{1+2} and sparsely on M_3. Venation: Sc_1 ending shortly beyond origin of *Rs*, anterior branch of the latter long, exceeding *Rs*; vein R_5 deflected strongly caudad, ending at wing tip; *m-cu* at fork of *M*.

Abdomen fulvous, the posterior borders of tergites narrowly brown, hypopygium yellowed. Male hypopygium with basistyle provided with long black setae, especially along mesal face and as a loose pencil on margin, this not on a basal tubercle as in *mesorhyncha* and some others. Interbase large, its outline irregular. Dististyle single, terminal, outer margin before midlength with an obtuse darkened slightly corrugated knob; slightly more than outer half of style a long straight yellow blade, the sides parallel, tip obtuse. Arms of phallosome long, sinuous.

HOLOTYPE: ♂, Khaorum, Manipur, Assam, 3,750 feet, August 28, 1960 (Schmid).

Various other regional species, including *Toxorhina* (*Ceratocheilus*) *luteibasis* Alexander, *T.* (*C.*) *mesorhyncha* Alexander, *T.* (*C.*) *monostyla* Alexander, and *T.* (*C.*) *tuberifera* Alexander, are generally similar to the present fly, differing evidently in details of coloration and in hypopygial structure, including the basistyle, interbase and dististyle.

Toxorhina (*Ceratocheilus*) **fuscolimbata** n. sp.

Size medium (wing over 5 mm); mesonotal praescutum light brown medially, the sides broadly darker brown, the color continued caudad onto the scutal lobes, pleura striped

black and yellow; halteres light yellow; legs brownish yellow, appearing darker because of abundant black setae; wings pale brown with darkened seams over several of the veins, anterior branch of *Rs* long; male hypopygium with outer dististyle a strongly curved hook; arms of aedeagus short.

MALE: Length, excluding rostrum, about 5 mm; wing 5.4 mm; rostrum about 4 mm.

FEMALE: Length, excluding rostrum, about 6.5–7 mm; wing 5.2–5.6 mm; rostrum about 3.5–3.8 mm.

Rostrum brownish black. Antennae black; pedicel very large, flagellum short. Head in front brownish gray, more infuscated behind; anterior vertex broad, about two and one-half times the diameter of scape.

Cervical region brownish black, pronotum brown. Mesonotal praescutum with central region light brown, more laterally dark brown, this pattern continued caudad across the suture over the scutal lobes, lateral praescutal borders obscure yellow; scutellum and postnotum brownish black. Pleura with a broad black dorsal stripe, more ventrally whitish yellow, including the dorsal sternopleurite and posterior pleurites, ventral sternopleurite grayish brown. Halteres light yellow. Legs with fore coxae dark brown basally, tips yellowed, mid-coxae less darkened basally, hind coxae yellow; trochanters brownish black; remainder of legs brownish yellow but appearing darker from the abundant vestiture. Wings tinged with brown, base more yellowed; costal border and seams over various veins slightly darker than the ground, the centers of the cells on either side of the cord paler; veins brown, the more basal ones yellowed. Macrotrichia on *Rs* and both branches, very abundant on R_5, with fewer on M_3 and outer two sections of M_{1+2}. Venation: Sc_1 ending opposite origin of *Rs*, in cases to near midlength; anterior branch of *Rs* long, from two and one-half to three times *Rs*; cell *1st* M_2 large, subequal in length to distal section of M_{1+2}; *m-cu* shortly beyond fork of *M*, in cases to about one-third its length. In the paratype an adventitious crossvein in cell R_5; in the holotype with such a vein in the left wing only, in the allotype lacking such veins.

Abdomen dark brown, including the male hypopygium, genital segment of female more yellowed. Male hypopygium with two dististyles, the large outer style very strongly curved into a semicircle, narrowed very gradually to the acute tips; inner style extended into a paddlelike blade, its outer margin bearing a slender lobe. Arms of aedeagus short, slender, divergent.

HOLOTYPE: ♂, Hkayam Boum, Manipur, Assam, 7,500 feet, June 20, 1960 (Schmid). Allotype, ♀, Chingsao, Manipur, 3,800 feet, June 13, 1960 (Schmid). Paratype, ♀, Sirhoi Kashong, Manipur, 7,500 feet, June 10, 1960 (Schmid).

Toxorhina (*Ceratocheilus*) **fuscolimbata** differs from all other regional species in the conspicuously patterned wings. It is more like *T.* (*C.*) *capnitis* Alexander, of Thailand, which differs in the coloration of the body and in the details of venation, as the short anterior branch of *Rs* which is less than twice *Rs* itself.

Toxorhina (*Ceratocheilus*) **simplicistyla** n. sp.

General coloration of head gray; thorax blackened, heavily pruinose; halteres yellow; wings subhyaline, unpatterned, cell M_2 open by atrophy of *m*; male hypopygium with mesal face of basistyle produced into a lobe that bears eight powerful black bristles; dististyle single, a narrow yellow blade, curved gently to the obtuse tip, outer margin with a small erect spur; arms of phallosome very short, slightly divergent.

MALE: Length, excluding rostrum, about 6 mm; wing 4.8 mm.

Rostrum broken. Antennae black, scape pruinose. Head above light gray, center of posterior vertex broadly brownish gray.

Cervical region brownish black, prothorax paler. Mesonotum with praescutal disk blackish, sides broadly light gray; scutal lobes similarly blackened, posterior callosities yellowed; remainder of notum light gray, posterior part of mediotergite vaguely darkened. Pleura blackened, sparsely pruinose; dorospleural membrane dark brown, paler anteriorly. Halteres yellow. Legs with coxae dark brown, tips narrowly yellowed; trochanters brown; remainder of legs medium brown, outer tarsal segments darker. Wings subhyaline, unpatterned; veins brown. Distal sections of veins R_5 and M_{1+2} with sparse trichia, more crowded outwardly. Venation: Sc_1 ending shortly beyond origin of Rs; anterior branch of Rs relatively long, a little shorter than basal section of R_5, one-half longer than Rs; cell M_2 open by atrophy of m; m-cu before fork of M.

Abdomen brownish black, pruinose. Male hypopygium with posterior tergal border convexly rounded. Mesal face of basistyle with a conspicuous lobe provided with eight powerful black setae, with three similar bristles more distally on face of style. Blade of interbase very narrow, simple. Dististyle single, subterminal, appearing as a very gently curved yellow blade that narrows gradually to the obtuse tip, on outer margin at near two-fifths the length with a small erect to slightly reclinate spur. Phallosome with central mass protruding caudad, arms of aedeagus very short, slightly divergent.

HOLOTYPE: ♂, Nakhu, Kameng, North East Frontier Agency, Assam, 4,800 feet, July 3, 1961 (Schmid).

Other regional species that have the dististyle single and with the same general conformation as in the present fly include *Toxorhina* (*Ceratocheilus*) *mesorhyncha* Alexander, *T.* (*C.*) *tuberifera* Alexander, and some others, having cell *1st* M_2 of the wings closed and with the hypopygial details distinct. *T.* (*C.*) *monostyla* Alexander has cell M_2 of the wings open, as in the present species, but with the hypopygial structure quite distinct.

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Vol. LXXV DECEMBER 1967 No. 4

Journal

of the

New York Entomological Society

Devoted to Entomology in General

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New York Entomological Society

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VOLUME LXXV DECEMBER 22, 1967 No. 4

CONTENTS

Apomyelois bistriatella: A Moth Which Feeds in an Ascomycete Fungus (Lepidoptera: Pyralidae)

Jerry A. Powell[1]
University of California, Berkeley

Abstract: *A. bistriatella* (Phycitinae), a moth formerly recorded in the eastern United States, has been found to occupy diverse situations in California, feeding in the larval stage on stromata of *Hypoxylon occidentale* (Xylariaceae). The moth was not recovered in extensive sampling of Polyporaceae, while records indicate that other species and perhaps other genera of Xylariaceae are used.

During the past several years a large number of collections of wood-rot fungi from the western United States and Mexico have been processed for insect material. Early phases of the program were conducted primarily by J. F. Lawrence, now of the Museum of Comparative Zoology, Harvard University, who surveyed primarily for Ciidae (Coleoptera). In the last three years an increasing emphasis has been placed on moths, the larvae of which inhabit these fungi. An analysis of host ranges of the Microlepidoptera (Oecophoridae, Oinophilidae, Tineidae) has been prepared (Lawrence and Powell, 1967). A summary of all productive fungus species involved in our collections is given in that paper.

Although Polyporaceae (Basidiomyceteae) comprised about 90 per cent of the 480 lots processed, an assortment of other wood-rot fungi was included. Thus, several Thelephoraceae species including some 20 collections and a few lots of Agaricaceae, where these had developed somewhat hardened sporophores, were involved. All of these are members of the Basidieomyceteae, and the only other fungus involved was *Hypoxylon occidentale* Ellis and Everhart,[2] (Ascomyceteae:Xylariaceae). The sporophores, or stromata, of this species are carbonous appearing, hemispherical, about 2 to 4 cm in diameter (Plate I) and are commonly seen on recently killed *Quercus agrifolia* throughout the coastal foothills of California. Although several species of Tineidae and Oecophoridae were reared from this fungus, it was concluded that it is only an incidental host because the stromata are hard and dry during several months each year. None of the ciidae use *H. occidentale.*

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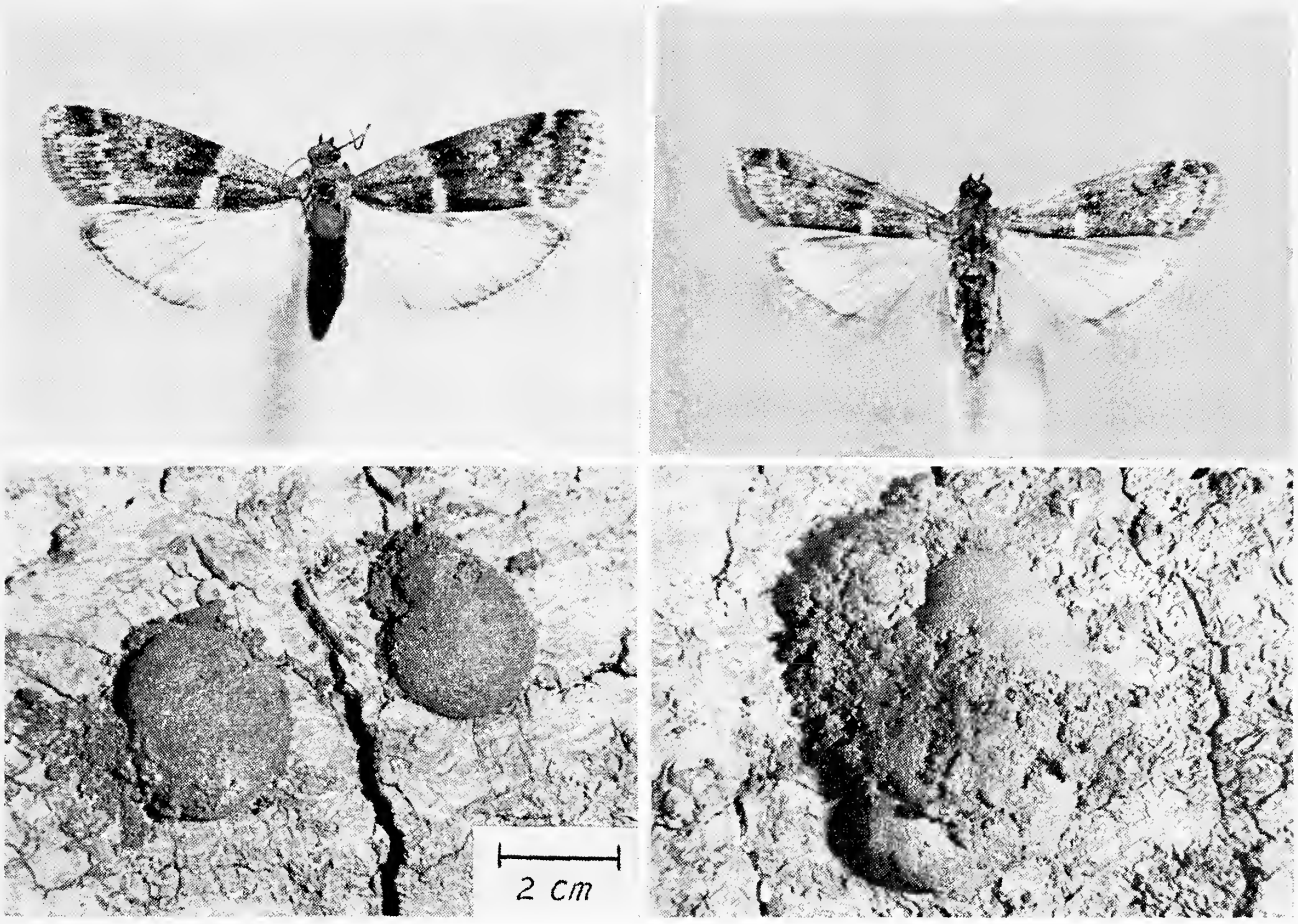
[1] Research conducted in part as a by-product of National Science Foundation grant project GB-4014.

[2] *Hypoxylon occidentale* has been treated as a synonym of *H. thouarsianum* (Lev.), a widespread Neotropical and Nearctic species described from the Galapagos Islands (Miller, 1961). For the present discussion the name *occidentale* will be used for the California-Oregon segregate.



Upper: *Apomyelois bistriatella* (Hulst), female (left) and male (right) from Lone Pine, California, reared from *Hypoxylon*. Actual size: ♀ 23.5 mm, ♂ 21.0 mm, wing expanse. Lower: Stromata of *Hypoxylon occidentale* (Ascomyceteae, Xylariaceae) on bark of *Quercus agrifolia* from Berkeley, California, showing frass exudations due to feeding of the moth larvae. The 2 cm scale applies to both lower photos.

In the fall of 1961 a collection of *Hypoxylon occidentale* produced two adults of a large phycitid moth. It was assumed that these individuals had only an incidential association with *Hypoxylon*, perhaps using it as a scavenger or for a pupation site, since Heinrich (1956) lists no American Phycitinae as fungus feeders. However, subsequent collections of this moth, *Apomyelois bistriatella* (Hulst), indicate that *Hypoxylon* is a normal host for the larvae. Moreover, *Apomyelois* was not encountered in any other of the wood-rot fungi which we processed, indicating that the moth is specific to *Hypoxylon*.

Apomyelois bistriatella (Hulst)

Dioryctria bistriatella Hulst, 1887, Ent. Americana, **3**:136.
Apomyelois bistriatella; Heinrich, 1956, U. S. Natl. Mus., Bull. **207**:43. (taxonomy).

The genus *Apomyelois* was proposed by Heinrich (1956) to accommodate the single, widespread but poorly known species, *bistriatella* Hulst, originally described from Washington, D. C. Heinrich had material of the species repre-

senting several widely scattered stations in the eastern United States and Canada. There was no information on the biology of this moth. Records in the California Insect Survey, University of California, Berkeley, show this species to be widespread ecologically and geographically on the West Coast.
ADULT: The moths are rather large, relative to many Phycitinae, having a wingspread of 20 to 24 mm. The forewing is dark gray, dusted with whitish, especially on the costal half, and is crossed by two white lines, one at the basal one-third, and a less distinct, somewhat sinuate one beyond the end of the cell (Plate I). Western specimens compare well with Heinrich's characterization of the species, both in external features and in genitalia form of both sexes. A pair of 60-year-old specimens from Ottawa, Canada, and Massachusetts, sent to me from the U. S. National Museum are paler and have less well defined markings, especially in the terminal area of the forewing. However, these differences probably are a function of the age of the eastern specimens. The eastern male has a more deeply cleft gnathos (possibly the slide upon which Heinrich's figure was based) than California examples (four preparations examined). If any of these differences are to be considered sufficient to warrant proposal of a nomenclature designation of the west coast race, this will have to be shown through comparison with typical material in series. The series from Inyo County, California, shows considerable variation in wing color and in size.
BIOLOGY: The life history of this insect is not clearly defined, and it may vary with climatic condition. In eastern areas flight records are available for May, June and July in the north and for March in Florida. Records of field collected adults in the California Insect Survey suggest that the species is multivoltine, the flight perhaps varying with weather conditions and growth of the host. In coastal areas of California the moths have been taken in late April, July, September, and October, and the larvae in May and October producing adults in June and November. At 3500 feet elevation in the Sierra Nevada adults have been collected in June and August.

Stromata of *Hypoxylon* appear in fall after the first rains and grow then and during winter. At this time they are relatively soft, having a consistency similar to damp charcoal, and can be crushed between one's fingers. Even in late spring, well after winter rains have ceased, visible moisture can be squeezed from sporophores situated in damp areas. During the dry season, however, the stromata harden and desiccate. In summer at most localities where *Quercus agrifolia* serves as a host the hemispherical sporophores are so hard they usually can neither be dislodged nor crushed by hand. Nonetheless, the entostroma is somewhat softer in texture and it appears that at least the larger larvae are able to feed at nearly any time of the year.

Neither eggs nor young larvae have been observed. Larger larvae fed in irregular galleries, usually beneath the thin, crust-like, perithecia-bearing sur-

face layer. Often the galleries were somewhat blotch-like, not extending through the whole depth of the entostroma. At times side tunnels radiated outward or more deeply towards the substrate. No evidence of a direct opening to the exterior was noted, and the burrows became filled with frass. The frass sometimes extrudes irregularly from the surface of the stromata (Plate I). In the field, the thin surface layer often later collapses or is broken away by external agencies, resulting in a characteristic shallow hollowed out area around the apex of the dome of the stroma. I have noted these evidences of larval feeding at a number of California stations in addition to those from which the moths were reared.

No larvae were found to burrow into the bark subtending the *Hypoxylon*, although they may sometimes wander under normal conditions and seek out crevices, insect burrows, etc. for pupation. In the laboratory pupation usually took place in the burrows, either just under the thin, ectostromal layer and parallel to it, or occasionally in a deeper gallery, perpendicular to the surface. Some individuals formed the loose silken cocoons amongst debris in the rearing container, between *Hypoxylon* pieces, etc. One individual pupated in an abandoned cerambycid gallery some 4 cm from the emergence hole of the beetle. This exit was also successfully used by the moth upon emergence.

GEOGRAPHICAL DISTRIBUTION: Available records show a disjunct range, in eastern North America from Ontario and Wisconsin to the District of Columbia and Iowa, in Florida (Heinrich, 1956) and in California. The diverse ecological situations occupied by the species in California are not representative of austral or boreal distributional patterns typical of many insects. Probably *Apomyelois bistriatella* occurs over much of temperate North America at intermediate elevations.

Specimens of *Hypoxylon* collected from *Populus* at Lone Pine were not submitted for identification, having been assumed to be *H. occidentale*. For *H. thouarsianum*, including *occidentale*, however, Miller (1961) states that *Celtis*, *Piersea* and *Quercus* are known hosts. Thus it may be that the Inyo County fungus was a different species. The range of *H. thouarsianum* in the eastern United States does not extend north of North Carolina (Miller, 1961), indicating that at least one additional host is involved.

Hypoxylon species with relatively bulky stromata (as opposed to species with little or no development of entostromal tissue) may be generally used. In addition, I have seen herbarium specimens of *Daldinea*, a related genus of Xylariaceae, with evidences of lepidopterous feeding, suggesting the possibility that *Apomyelois* uses ascomycetes other than *Hypoxylon*.

CALIFORNIA MATERIAL EXAMINED: Contra Costa Co.: Pleasant Hill, 1 ♀ IX-15-58 (W. E. Ferguson); Orinda, 1 ♀ X-11-61, at 15 watt blacklight (P. A. Opler); Walnut Creek, 1 ♀ VIII-5-65, 1 ♀ VIII-23-66 (J. Powell). Inyo Co.: 5 mi. W. Lone Pine 25 ♂♂, 33 ♀♀ VI-13-65, r. f. *Hypoxylon* on poplar, emgd.

VII-6 to VIII-1-65 (J. T. Doyen Collr; JAP 65 G5). Marin Co.: 1 mi. SE Inverness, 1 ♂, 1 ♀ X-8-61, r. f. *Hypoxylon occidentale* on *Quercus agrifolia*, emgd. XI-7 and XI-20-61 (C. W. O'Brien collr.; JFL 979); Inverness, 1 ♂ IX-8-62, at light (C. A. Toschi). Santa Barbara Co.: Prisoner's Harbor, Santa Cruz Island, 2 ♀ ♀ V-1-66, r. f. *Hypoxylon occidentale* on *Quercus agrifolia*, emgd. VI-7 and VI-13-66 (J. Powell, A. Slater, J. Wolf collrs.; JAP 66E4); Central Valley, Santa Cruz Is., 1 ♂ IV-28-66, at light (J. Powell). Sonoma Co.: Hacienda, 1 ♀ VII-9-61 (C. Slobodchikoff). Tuolumne Co.: Twain Harte, 1 ♀ VI-19-59, 1 ♀ VIII-18-60 (M. Lundgren).

Specimens are deposited in the collections of the California Insect Survey and U. S. National Museum.

Acknowledgments: Thanks are extended J. F. Lawrence, Museum of Comparative Zoology, who provided some of the early data for this study, and to J. T. Doyen and C. W. O'Brien, University of California, Berkeley for field collections. Further field and laboratory observations were made by P. A. Rude, A. J. Slater, and J. Wolf, assistants with the National Science Foundation project (GB-4014) which supported part of the study. Identifications of the *Hypoxylon* were provided by I. I. Tavares, University of California, Berkeley, Herbarium. Specimens of the moth were examined by W. D. Duckworth, U. S. National Museum, Washington, D. C., and acknowledgment is also made for use of comparative material which was sent from that institution.

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RECEIVED FOR PUBLICATION JUNE 5, 1967

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The Library of Congress with the support of the National Science Foundation has set up a National Referral Center for Science & Technology (Library of Congress, Washington, D.C. 20540). The Referral Center is designed to provide a single place for advice on where and how to obtain information of any facet of the physical, biological, social, or engineering sciences. It serves as the intermediary to direct persons or organizations seeking information on specific topics to those who can furnish the information, and there is no charge. The Center does not provide technical details nor bibliographic assistance.

Melanism in New Jersey *Catocala* Schrank (Lepidoptera, Noctuidae)

Joseph Muller
Lebanon, New Jersey

Abstract: Brief discussions, counts, and descriptions are given of reared melanic forms of *Catocala micronympha* Guen. and *C. minuta* W. H. Edwards.

In the Spring of 1966, seventy-five *Catocala micronympha* were reared from eggs laid by 4 females obtained in July, 1965 at black lights in Lebanon, New Jersey. The female parents were all more or less brownish black or melanic. All but 6 of these reared individuals were more or less melanic. They may be characterized best by comparison with the 9 figures of *C. micronympha* given by Barnes and McDunnough (1918, Mem. Amer. Mus. Nat. Hist., n. ser., Vol. **III**, part 1, Pl. 9, figs. 22–30). Of the specimens figured there, one is a brownish black form, *gisela* Meyer, and the other 8 are brown and grey with a complete absence of black. Among the reared specimens 6 are of the *gisela* form, and several are like *gisela* but have the white sordid rather than clear. Twelve specimens resemble the form *hero* Henry Edwards, but have the wing bases greyish rather than brownish and the apices of the fore wings black rather than brown. Forty-two specimens are all black with only a faint whitish subterminal line; and the remainder of the specimens are more or less evenly grey-black. Dr. A. E. Brower of Augusta, Maine has commented (in litt.) that *gisela* is a genetic form of *C. micronympha* known long before any appreciable melanism appeared in the genus, and that now we have melanic specimens of *gisela*.

Thirty-one specimens of *C. minuta* W. H. Edwards were reared from pupae, also collected in Lebanon. Compared with the forms figured by Barnes and McDunnough (loc. cit. figs. 1–6) 20 specimens resemble fig. 5, which is mostly dark brown, but are darker and show no brown; and 11 specimens resemble f. *parvula* W. H. Edwards (fig. 2) but have the brown replaced by blackish grey, and the inner margin black.

In 1960 I described the melanic f. *broweri* of *C. connubialis pulverulenta* Brower from Lebanon (Jour. Lepid. Soc., **14:** 177). Until 2 years ago this was the commonest form at Lebanon. Since then, however, both *broweri* and the nominate form, *pulverulenta*, have almost disappeared from this area, being replaced by *C. micronympha* which was first seen here about five years ago.

This region of New Jersey Hunterdon County, is mostly farm land with hilly areas of deciduous woods. Industries are 30–60 miles distant. Many melanic forms of various species of Lepidoptera, especially of *Catocala*, have been taken here, which indicates that air pollution extends this far. However, melanic forms of *Catocala* are also numerous in northern New Jersey where

there are mountains and continuous, dense woods mixed with huge hemlocks and pines. In the latter case it is thought that the Lepidoptera have become adapted to their surroundings, and that industrial air pollution does not extend this far.

On the other hand, no melanic forms of *Catocala* have been collected in the dense pine woods of the pine barrens of southern New Jersey, although many nights have been spent there sugar-baiting and light-collecting.

During the last 6 seasons many different ways have been tried to mate the normal and melanic forms. Most of the females mated do lay eggs, but these have always collapsed and failed to hatch.

RECEIVED FOR PUBLICATION DECEMBER 16, 1966

Insect Attractants

Two acrylic auto paints have been reported to be effective attractants for sap beetles in Science, **156:** 946–947 (May 19, 1967).

Biological Notes on *Dioxys pomonae pomonae* and on its Host, *Osmia nigrobarbata* (Hymenoptera: Megachilidae)

Jerome G. Rozen, Jr.[1] and Marjorie S. Favreau[1]

Abstract: Biological observations on the parasitic bee *Dioxys pomonae pomonae* Cockerell are presented covering the following points: searching habits of female, oviposition, elimination of immatures of the host, feeding habits, and cocoon. Additional observations, including nest structure, are given for the host bee *Osmia nigrobarbata* Cockerell.

With the exception of a paper by Micheli (1936), apparently nothing was known heretofore concerning the biology of the cleptoparasitic bee genus *Dioxys* beyond the host associations of some of the species (Hurd, 1958; Jaycox, 1966). For this reason, we present the following observations concerning *Dioxys pomonae pomonae* Cockerell, a North American representative of this distinctive Holarctic genus. Brief notes are also given on the biology of the host bee, *Osmia* (*Acanthosmioides*) *nigrobarbata* Cockerell. An accompanying paper (Rozen, 1967) describes the immature stages of *D. pomonae pomonae*.

We would like to thank the following people for identifications of adults associated with this study: Dr. Paul D. Hurd, Jr., University of California, Berkeley; Dr. Elbert R. Jaycox, University of Illinois, Urbana; and Dr. Charles D. Michener, the University of Kansas, Lawrence. The literature search was aided by the Bibliography of Apoid Biology under Dr. Michener's supervision. This study was carried out at the Southwestern Research Station of The American Museum of Natural History, Portal, Arizona.

DESCRIPTION OF NESTING AREA: All observations were made at 3 miles north of Apache, Cochise County, Arizona, between April 28 and May 5, 1966. The *Osmia* burrows were widely scattered over nearly horizontal ground sparsely covered by low vegetation consisting of *Malacothrix*, *Gaillardia*, *Phacelia*, a number of grasses, and other low-growing plants (Fig. 1). Several possible hosts of *Dioxys* were active including *Osmia* (*Acanthosmioides*) *nigrobarbata* Cockerell (determined C. D. Michener) and *Anthidium emarginatum* (Say) (determined E. R. Jaycox). Both the *Osmia* and *Anthidium* collected pollen from *Astragalus*. Three species of *Dioxys* flew in the area: *D. productus subruber* (Cockerell), *D. pomonae pomonae* Cockerell, and *D. pacificus pacificus* Cockerell (all identified by P. D. Hurd). Females of *D. pomonae pomonae* were seen both entering and waiting by the burrows of *Osmia nigrobarbata*, and a female was reared from an *Osmia* cell. The hosts of the other species are not known.

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[1] Dept. Ent., Amer. Mus. Nat. Hist.

FIG. 1. Nesting area of *Osmia nigrobarbata* Cockerell.

OBSERVATIONS ON THE BIOLOGY OF *Osmia nigrobarbata*: Nests of this species were widely scattered and entrances were usually found at the bases of low plants or at the edge of shallow depressions. The burrows entered the ground at a slight angle from the horizontal and each tumulus was piled on one side of the entrance. Burrows were open and their direction was unpredictable, for some turned sharply to the side or downward. They were short, measuring only a few inches long, and the cells were situated within two or three inches of the surface. Some cells were encountered barely below the loose, dry surface layer of soil.

The nearly horizontal cells are constructed from a mastic of plant tissue. The source of this material is unknown, but because it was uniform for all cells encountered, it must be gathered from a particular plant. At first bright green, its color fades, so that cells several months old are nearly brown. The cell wall, approximately 0.5–1.0 mm thick, is quite hard; the inside cell dimensions are approximately 8.0 mm long and 5.0 mm in maximum diameter. The cell closure consists of the same plant material as that of the wall and is nearly flat on the inside and concave on the outside.

The arrangement of the cells is extremely variable. Some single cells were found which were probably the beginning of a nest series; the other cells were

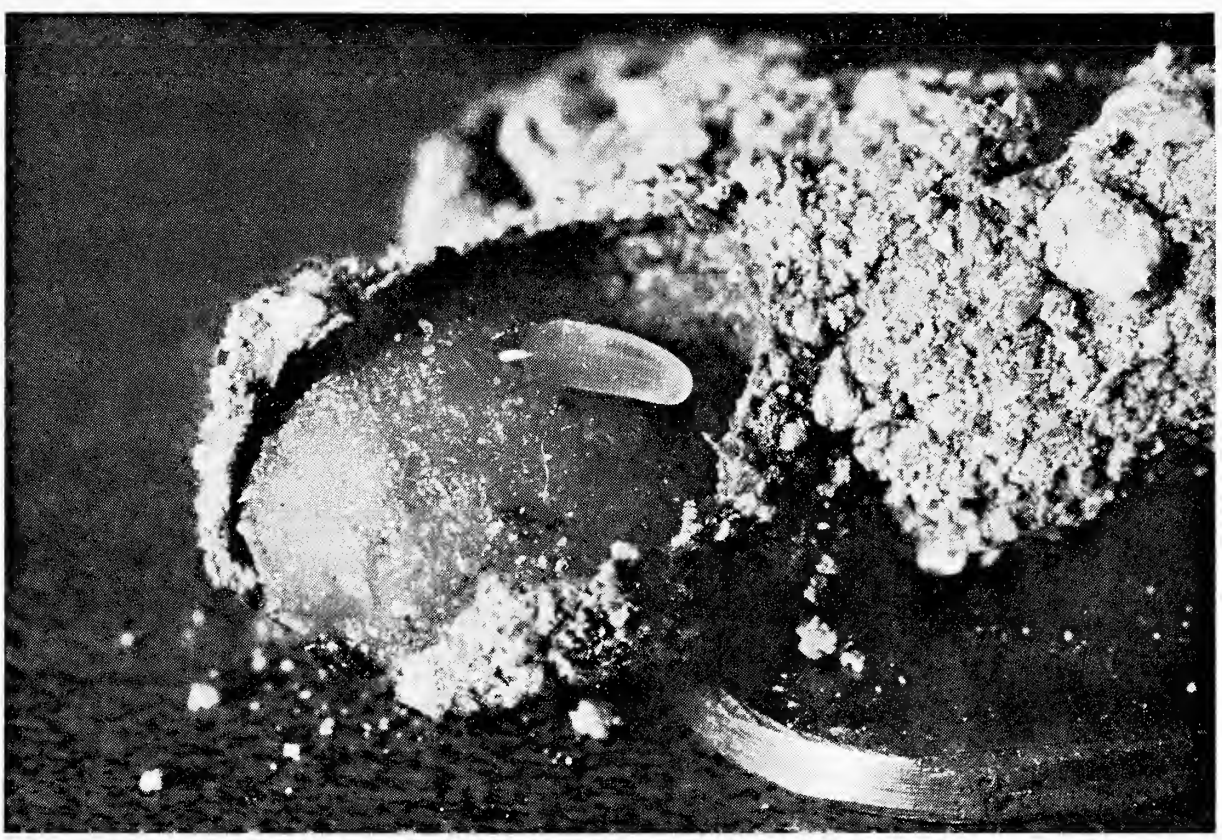
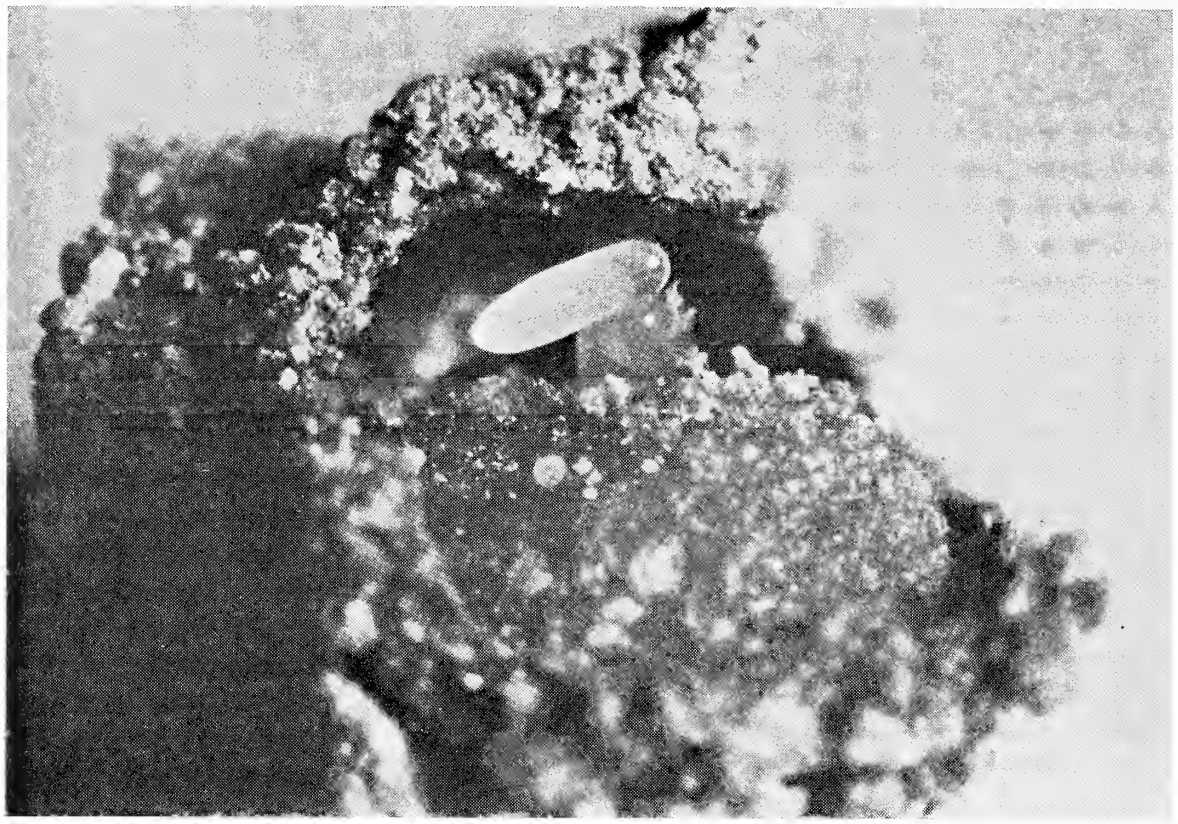
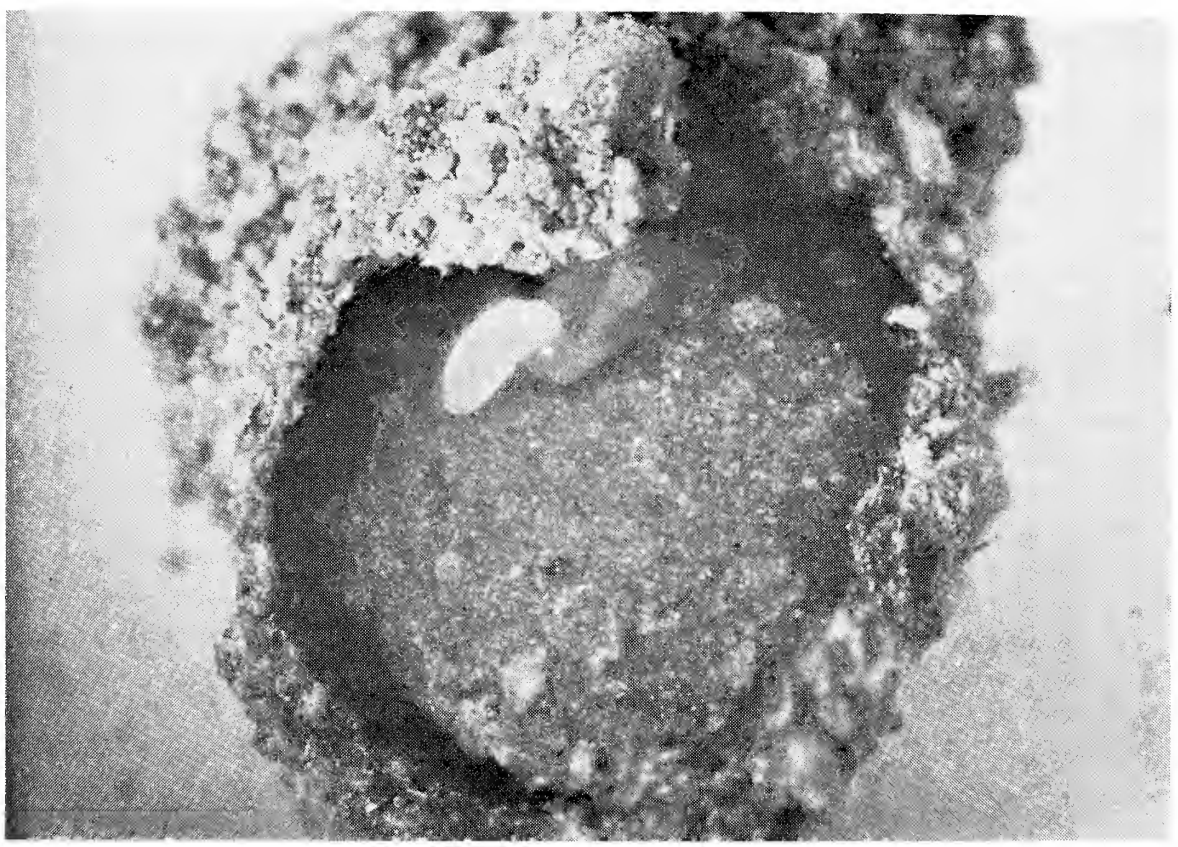


Fig. 2. Nests of *Osmia nigrobarbata* Cockerell. Swellings represent individual cells.
Fig. 3. Opened cell of *Osmia nigrobarbata* Cockerell showing food loaf and egg, from side.

arranged in a basically linear series that branched in an infinite number of ways (Fig. 2). Cells in the series were all interconnected so that four or five cells could often be removed from the ground without their separating. Each cell was a complete unit in that the rear end (or side) of one cell was not the





FIGS. 4, 5. Cell of *Osmia nigrobarbata* Cockerell, with front end removed. 4. Freshly deposited egg of *Dioxys pomonae pomonae* Cockerell adhering to anterior end of the *Osmia* egg. 5. Same cell, viewed from above, just before *Dioxys* egg hatched. Notice chorion adhering closely to the *Dioxys* embryo.

cap of the previous cell. Hence in a series, individual cells could be broken off without any of the cells being damaged. The strings of cells lay approximately horizontally in the ground.

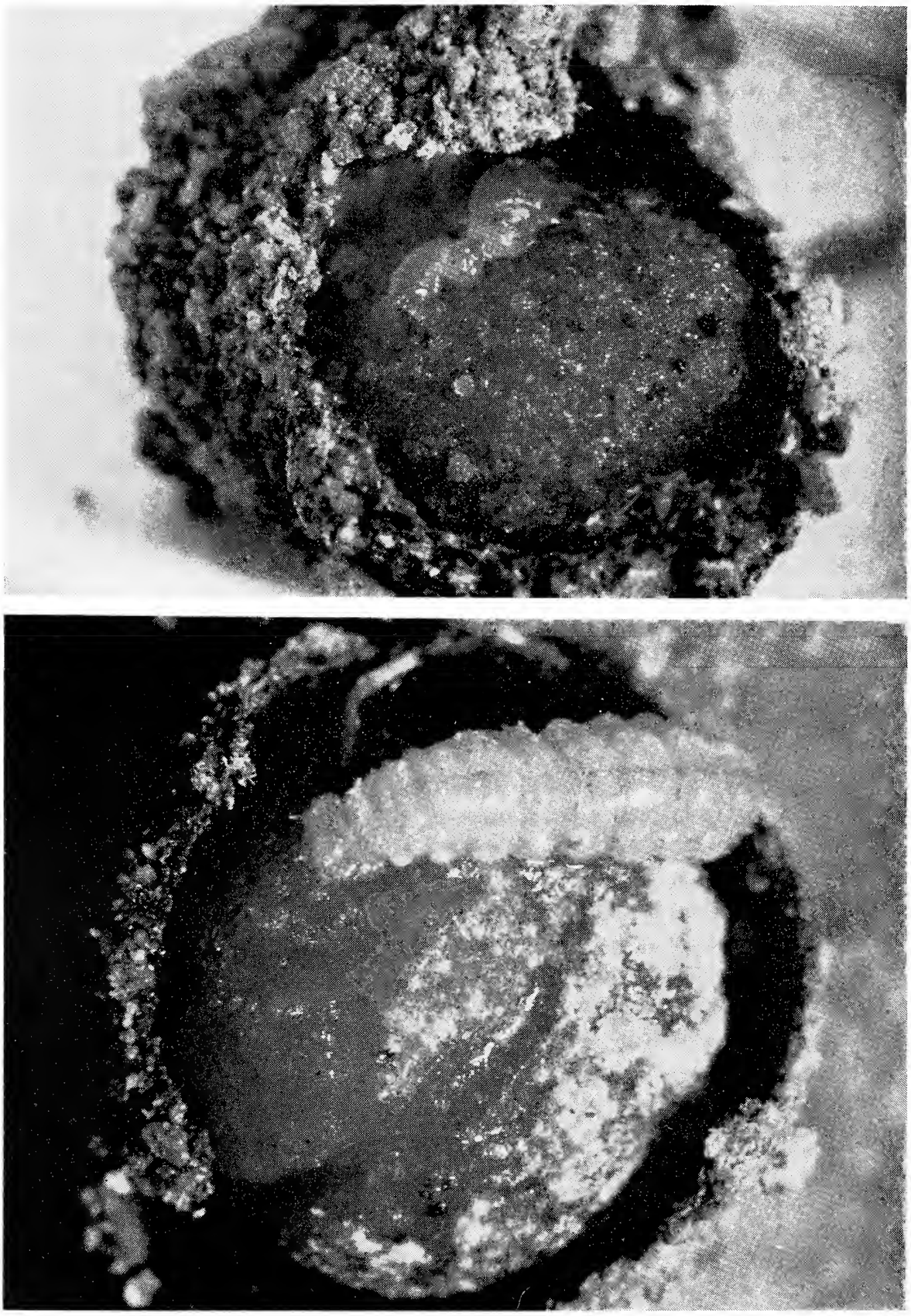
Only one female was responsible for a cell series, and each cell was constructed, provisioned, and closed before the next one was started.

Provisions of nectar and pollen were formed into a large, elongate, moist loaf (Fig. 3) occupying most of the cell. All eggs were uniformly placed on top of the provisions, forward of the center, in the sagittal plane of the cell. The eggs were laid either on the surface of provisions or with the rear of the egg slightly embedded. The anterior end rested on or, perhaps more frequently, projected into the lumen of the cell and pointed toward the cell closure.

The mature larva of *Osmia* spins a well-developed cocoon which consists of a loosely woven, tan outer layer and a tough (leathery), polished (on the inner surface) inner layer that is almost black. The cocoon lacks a nipple at the anterior end.

BIOLOGICAL NOTES ON *Dioxys*: The females of *D. pomonae pomonae* and *pacificus pacificus* fly slowly close to the surface of the ground and stop briefly at spots that presumably have certain characteristics of the nest entrances of the hosts. The flight appears "deliberate" and unhurried. Occasionally a female suddenly flies swiftly a short distance and then again starts her slow searching. Although the path meanders, it tends to lead in one direction, so that the female travels a considerable distance. As the *Osmia* nests were widely scattered over a number of acres, this behavior pattern of *D. pomonae pomonae* appears to be functional. In contrast, the meanderings of such parasitic bees as *Oreopasites*, *Holcopasites*, and *Neopasites* carry the bee back and forth over a limited area; this restricted search pattern appears to be an adaptation to the gregarious nesting habits of host species. Now and then, the *Dioxys* females land on the ground and clean their wings and antennae as do females of the nomadine genera. Once, after finding a burrow of *Osmia*, a female of *D. pomonae pomonae* examined the entrance, then retreated a few inches, and sat on a twig where it waited, as if for the departure of the host female. Several other times a female was noticed entering an *Osmia* burrow but came out within a half a minute.

Over 470 cells of *Osmia* were opened during our search for the immatures of *Dioxys*, with the result that we found seven larvae and two eggs of the parasite. One egg (Fig. 4) adhered loosely to the anterior end of the host egg. A small slit in the cell wall above the posterior end of the *Dioxys* egg apparently marked the spot through which the egg was inserted into the sealed cell. The other egg was partly embedded lengthwise in the under surface of the pollen-nectar mass so that somewhat more than half of it was visible. The chorion is shiny and translucent white. Resembling the host egg in almost all respects, the egg of *Dioxys* is somewhat smaller: length, 1.5–1.8 mm, width, 0.6 mm.



FIGS. 6, 7. Cells of *Osmia nigrobarbata* Cockerell. 6. Same cell as in Figs. 4 and 5. First instar *Dioxys* with its large head next to *Osmia* egg, which has been recently killed. 7. Intermediate stage larva of *Dioxys pomonae pomonae* Cockerell.

Each of the *Dioxys* larvae was found in a cell with a dead egg, first instar, or second instar of *Osmia*. The host is killed with the sharp mandibles which are present during the first three larval stages (Rozen, 1967). One first instar larva was discovered on the underside of the pollen-nectar loaf, whereas the other larvae, presumably second instars, rested on the side or top part of the food. The egg found adhering to the *Osmia* egg hatched in the laboratory, and the first instar immediately killed the host egg (Figs. 4–6). However, at least the first and second instars were active and, if touched with forceps, opened their jaws widely and actively moved the anterior part of their bodies from side to side. These actions, plus the large, sharp-pointed mandibles of the first three instars, suggest that the host may be eliminated by the second or third instar as well as the first. Never more than one *Dioxys* was found in a cell; the female *Dioxys* probably deposits only a single egg in a nest. In contrast, females of many of the Nomadinae lay more than one egg per cell.

As with most other bee larvae, the duration of the feeding period is short, lasting for two to three weeks. The larva, while feeding, moves about on the provisions (Fig. 7). Four larval instars were observed (but see Rozen, 1967). The fourth instar begins to defecate before it finishes feeding; the feces are extruded as elongate semisolid pellets.

The thin outer layer of the cocoon is composed of very loose strands of silk to which some of the fecal pellets adhere. Defecation is completed before the next layer is deposited. The second layer, black in color, is comparable to the inner, leathery layer of the *Osmia* cocoon but is thicker and imparts a greater rigidity to the finished case. The innermost face of the one *Dioxys* cocoon examined consisted of yet another layer, at least toward the anterior end of the cocoon. Loose and light brown, it formed a cellophane-like coating even though some individual silk strands were detected. Except toward the rear where the inner layer adhered more or less closely to the rigid layer, the inner face did not possess the polished, nearly black surface of the *Osmia* cocoon. The cocoon of *D. pomonae pomonae* possessed a distinct nipple at the anterior end, so that the shape of the cocoon was identical to that of *Dioxys cincta* (Jurine) (Micheli, 1936, Fig. 6).

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A Revision of the Termitophilous Tribe Termitodiscini (Coleoptera: Staphylinidae) Part I. The Genus *Termitodiscus* Wasmann; its Systematics, Phylogeny, and Behavior[1]

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Abstract: The genus *Termitodiscus* Wasmann is redescribed, illustrated, and a key differentiating this genus from the other two genera of the tribe is provided. All of the previously described species of the genus are redescribed and new characters illustrated. Six new species are herein described, *T.* **coatoni** from South Africa, *T.* **emersoni** from the Congo Republic, *T.* **krishnai** from Burma, *T.* **latericius** from South Africa, *T.* **sheasbyi** from Southwest Africa and *T.* **vansomereni** from Kenya. Distribution maps are presented which show the distribution of all species. Diagrams are presented showing the relationships among the species using both the phylogenetic and the phenetic approach. A summary of the host relationships is presented showing 100% host specificity to species of *Odontotermes* of the species now known. Observations on the behavior and distribution of selected species within the nests are presented which support the interpretation of the species as integrated termite guests whose principal adaptation to life within the nest is that of avoidance. The relationship of the tribe Termitodiscini with the Myrmedoniini is documented and discussed.

INTRODUCTION AND TAXONOMIC HISTORY

The termitophilous tribe Termitodiscini was reorganized as a tribe of the subfamily Aleocharinae by Seevers (1957) to contain the genera *Termitodiscus* Wasmann, *Termitogerrus* Bernhauer, and *Discoxenus* Wasmann. Prior to Seevers' revision, the group had been recognized as a separate subfamily of the Staphylinidae. I here concur with Seevers' judgment that there is no character or group of characters which could separate them absolutely as a subfamily distinct from the Aleocharinae. I shall show that the group probably arose from some free-living or loosely integrated termitophile of the aleocharine tribe Myrmedoniini. Seevers did not attempt to revise the species due to the paucity of material available. Since that time, a lot of new material has been collected due to the field efforts of Dr. William Coaton and his colleagues of the Plant Protection Research Institute, Pretoria; Dr. Alfred E. Emerson, University of Chicago; Dr. Kumar Krishna, American Museum of Natural History, New York; Dr. A. de Barros Machado and his colleagues, Museu do Dundo, and myself. Most of the new material belongs to the genus *Termitodiscus*, so that this revision is confined to that

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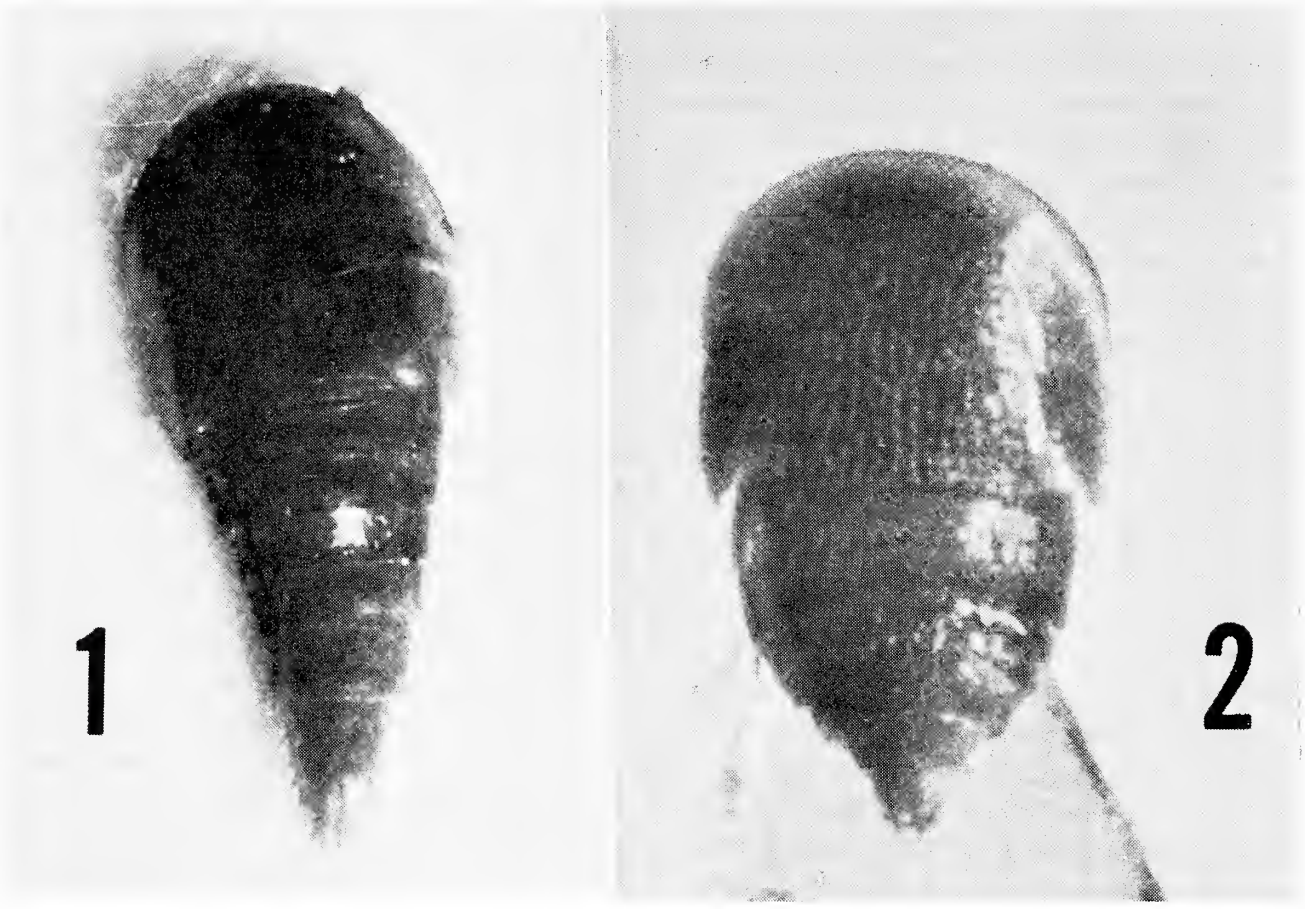
genus and revision of the other two genera will be deferred until a reasonable amount of new material becomes available. The careful study of new material has revealed characteristics which make it necessary that the key to the genera provided by Seevers be revised and this is done here. While collecting *Termitodiscus* in the field, various observations were made on their behavior, particularly in relation to their termite hosts, which bear on the integration of the termitophiles into the termite colonies. These observations and their interpretation are presented in this paper. The remainder is organized into the following sections: (1) Methods and materials; (2) Key to the genera of the tribe; (3) Redescription of the genus; (4) Key to species; (5) Descriptions of the species; (6) Relationships of the species; (7) Behavorial observations; (8) Host specificity; (9) Relationship of the tribe to the aleocharine tribe Myrmedoniini; (10) Acknowledgments; (11) Literature cited.

METHODS AND MATERIALS

Most of the routine methods used in my laboratory have been described several times, most recently by Koblick and Kistner, 1965, and Kistner, 1966. The only major change has been the substitution of a Nikon F camera with 55 mm, 50 mm, 35 mm, and 28 mm lenses plus bellows and extension tubes for the Exacta equipment used in the past. For ultra close-up photos of minute insects, this has proven superior because the corners are not chopped off the pictures and the lenses are easier to reverse to eliminate spherical aberration.

The special techniques involved in the computer analysis of the relationships between the species are discussed later. The programs themselves are not included as most laboratories have developed their own and our programs are changed just about every time we use them. Current print-outs in Fortran II will be sent to anyone requesting them.

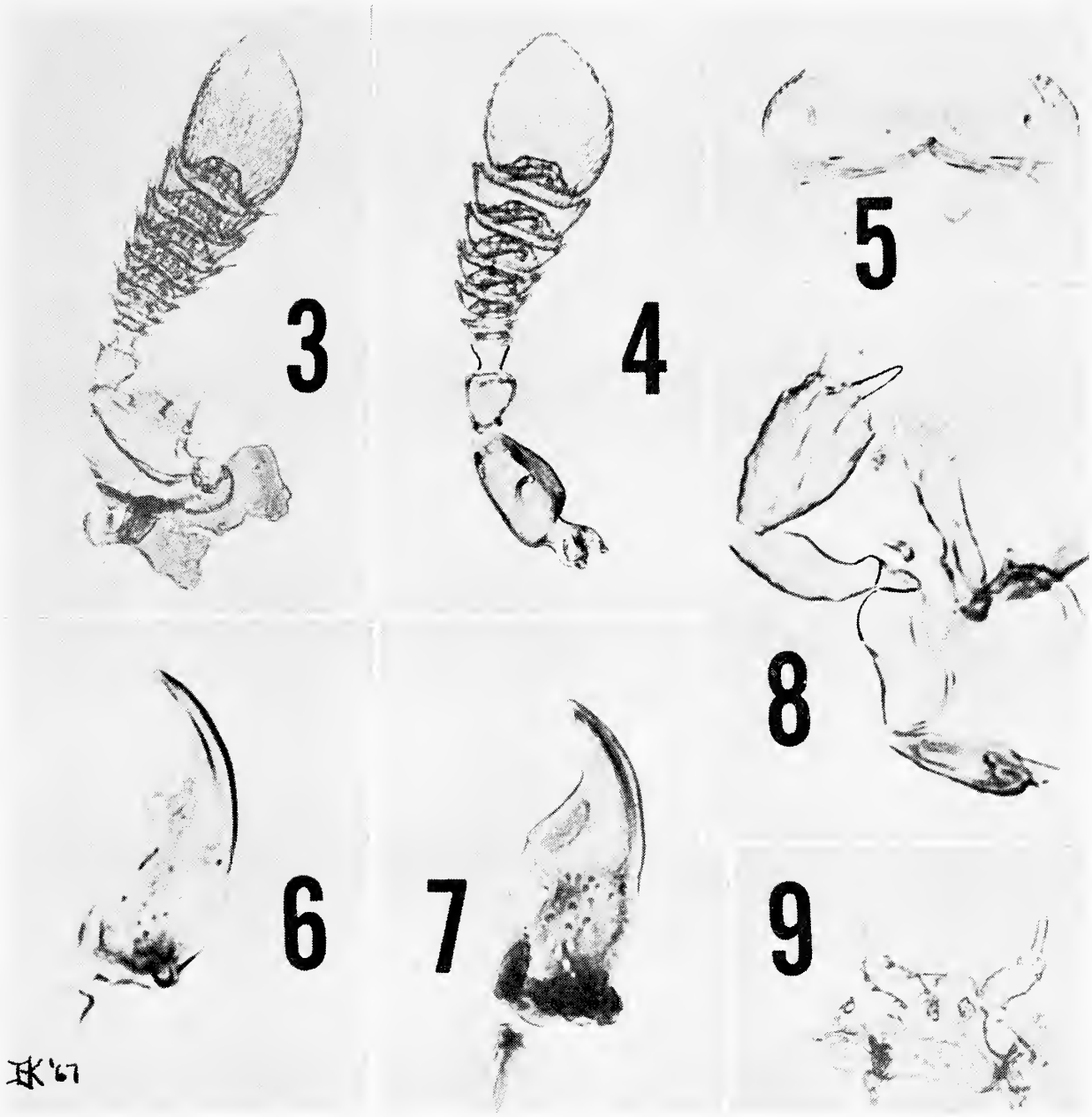
The field techniques used vary according to the way in which the *Odontotermes* hosts make their nests. Some species such as *Odontotermes taprobanes* Walker and *Odontotermes culturarum* Sjoestedt make well defined nests of which the bulk is located above the level of the surrounding ground. The queens are usually located at or near the ground level with the fungus gardens arranged in semispherical layers above the royal cell. The fungus gardens immediately above the royal cell usually yield the most specimens of *Termitodiscus*, but the other fungus combs may yield *Termitodiscus* or other species of associated insects. We try to keep the layers separate as we dig in, but individual idiosyncracies of the nests prevent absolute accuracy. The fungus gardens are removed and taken back to the laboratory or other dwelling where the fungus is carefully pulverized over a yellow plastic tray. The yellow contrasts well with the termites and the termitophiles and permits the investigator to see the termitophiles and to aspirate them up or to pick them up with a camel's hair brush. It takes about 4 to 5 times as long to sort through the fungus gardens of



FIGS. 1–2. Overall appearance of dorsal surface of beetle: 1. *Termitodiscus braunsi* Wasmann; 2. *T. escherichi* Wasmann, Cotype. Scale arbitrary, see descriptions for measurements.

a productive nest than to dig it up, so it pays to at least assay the fungus in the field before taking it back. Unless collecting is extremely poor in general, I usually abandon a nest if I don't see at least a few specimens of termitophiles during the field assay.

Other species of termites such as *Odontotermes montanus* Harris or *Odontotermes transvaalensis* Sjoestedt build nests which are completely or almost completely submerged under the ground, often with little evidence on the surface of their position. Working with such nests can be extremely productive but is often extremely frustrating because a sizable investment of time and labor has to be made before one can tell if there are any termitophiles there or not, or even if the nest is there or not. The procedure we used and which is also used by Dr. Coaton and his colleagues is to dig a trench about 4 feet wide, 6 feet long and 4 feet deep to the side of where you think the nest is. Then dig in toward the nest from the side until you (hopefully) hit it. If you dig in from the top, you eventually fall into the nest which complicates the sorting process and partially destroys the ecological data. After you reach the fungus gardens, the fungus is gathered and sorted as above. I might add that I have dug until I could not throw the dirt out of the hole over my head and still not reached the nest, so I usually keep an open mind about abandoning a hole if nothing shows up quickly. A gung-ho attitude of, "I'm going to find that nest if

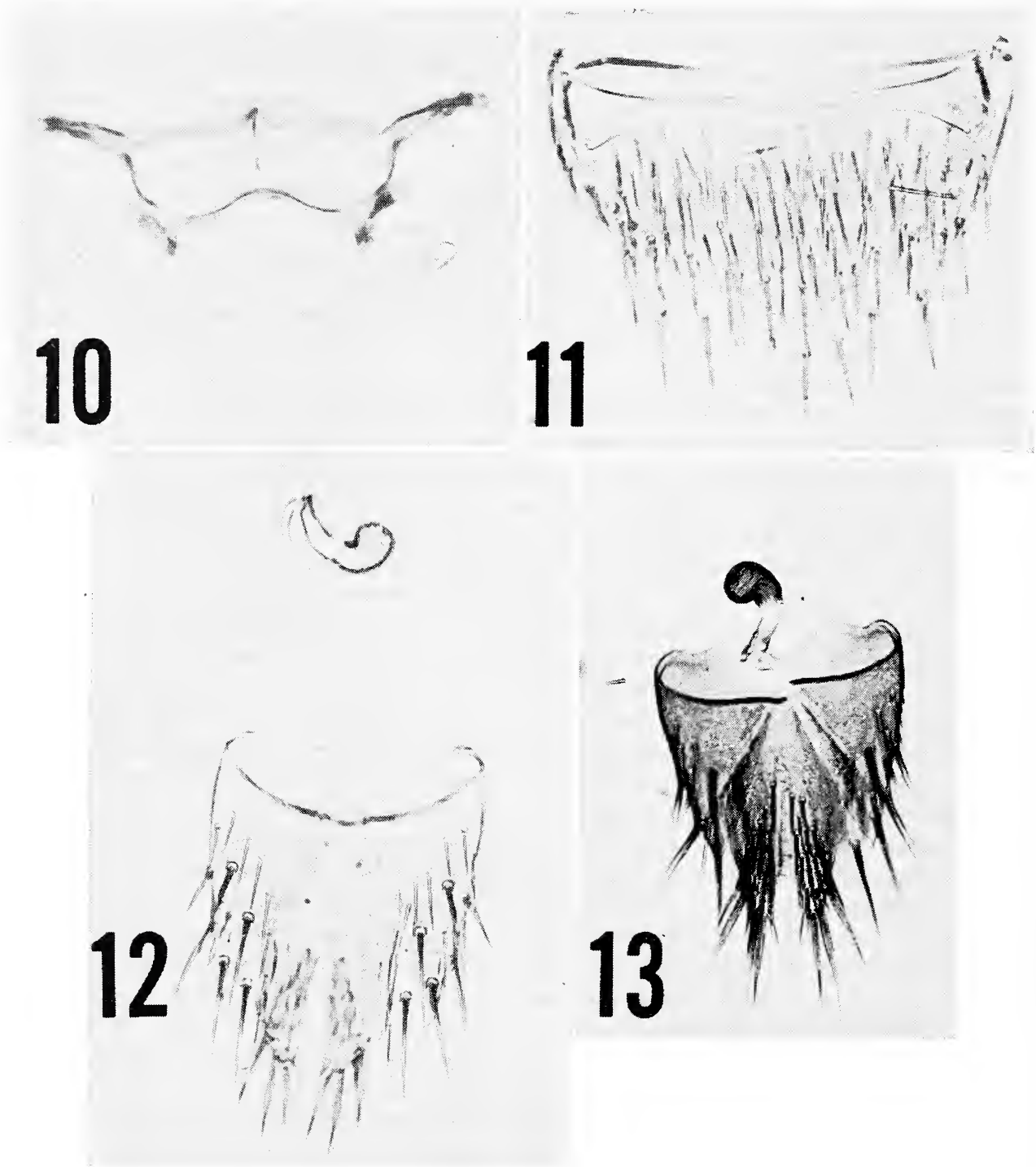


FIGS. 3–9. Antennae and mouthparts: *Termitodiscus escherichi* Wasmann: 3. 10-segmented antenna; 8. Maxilla; 9. Labrum and mentum. *T. angolae* Seevers: 6. Mandible. *T. machadoi* Seevers: 4. 9-segmented antenna; 5. Labrum; 7. Mandible. Scale arbitrary, photos were taken at 100 × magnification.

it kills me," (my original attitude) just will not make economic sense in the long run. It is thus more productive to abandon a potentially dry hole while the investment in time and labor is still minimal and put that time and labor into another potential nest. The judgment necessary to make that decision came hard for us and is still based on so many subjective factors that finding the nests and then the termitophiles is still in the realm of art rather than science.

KEY TO THE GENERA OF THE TRIBE

1. Mesocoxae widely separated; antennae 9, 10, or 11 segmented, short, very slightly visible from above; antennae segments other than 1 and 2 compressed and incrassate 2

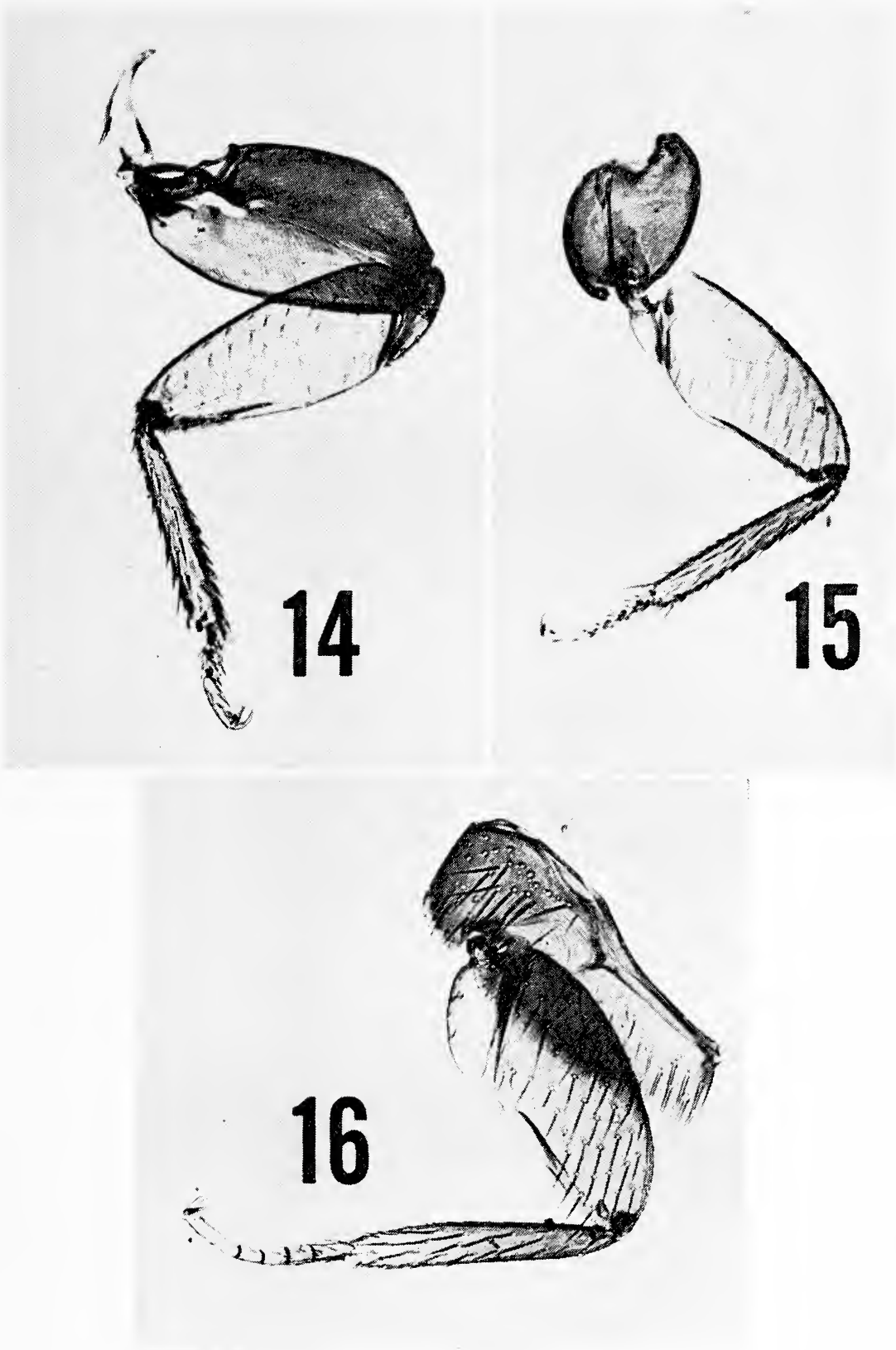


FIGS. 10–13. *Termitodiscus escherichi* Wasmann: 10. Prosternum and mesothoracic peritremes; 11. Abdominal segment VIII; 12. Abdominal segment IX and spermatheca. *T. transvaalensis* Silvestri: 13. Abdominal segment IX and spermatheca. Scale arbitrary, photos taken at 100 × magnification.

Mesocoxae narrowly separated; antennae 11-segmented, elongated, easily visible from above; antennal segments 3-11 with the sides meeting each other and covering the petiolar connections ..... *Discoxenus* Wasmann

2. Antennae 9 or 10-segmented; antero-lateral margin of pronotum slightly flared; mesosternum slightly declivous in middle ..... *Termitodiscus* Wasmann

Antenna 11-segmented; antero-lateral margin of pronotum not flared; mesosternum almost vertical at the middle and thus scarcely visible from below ..... *Termitogerrus* Bernhauer



FIGS. 14–16. Legs of *Termitodiscus transvaalensis* Silvestri; 14. Proleg; 15. Mesoleg; 16. Metaleg. Scale arbitrary but equal for all legs; photos taken at 100 × magnification.

NOTE: *Termitogerrus* seems to be confined to Central and West Africa as careful searches of *Macrotermes* nests in South Africa and the Orient have not revealed this genus so far. *Discoxenus* has only shown up in *Odontotermes* nests from the Orient in spite of careful searches of *Odontotermes* nests in Africa. The revision of these two genera will be delayed until there are far more new specimens available for study.

REDESCRIPTION OF THE GENUS

Genus *Termitodiscus* Wasmann

Termitodiscus Wasmann 1899, Deutsch. Entomol. Zeitschr., **1899:** 147; 1912, Zeitschr. Wissensch. Zool., **101:** 92; 1916, Zool. Jahrb. System., **39:** 179; Cameron, 1932, Fauna of Brit. India, Staph., **3:** 317; Silvestri, 1947, Arch. Zool. Ital., **31:** 125; Seevers, 1957, Fieldiana Zool., **40:** 259; 1965, Publ. cult. Companh. Diam. Angola, **69:** 129. Type species: *Termitodiscus heimi* Wasmann (Blackwelder, 1952: 377).

Overall body shape limuloid, broad and flat as in figs. 1 and 2. Head broad and short, subtriangular in form with the foramen magnum totally ventral in position. Eyes present, well developed and forward and laterally directed. Antennae inserted between the eyes with grooves developed on the genae for the reception of the large basal antennal segments. Submentum and gula extremely short. Antennae 9 or 10-segmented, shaped as in fig. 3 and 4. Labrum short, shaped as in fig. 5. Mandibular shape somewhat variable by species but the form is relatively constant, two extremes shown in figs. 6 and 7, note the one central and one apical tooth with the short stubby prostheca (barely visible in the photographs below the central tooth). Maxillae shaped as in fig. 8, palpi 4-segmented. Labium and mentum extremely small, shaped as in fig. 9, palpi 3-segmented.

Pronotum semi-circular in shape (figs. 1 and 2) such that there is no distinction between anterior and lateral margins which are henceforth referred to as the anterolateral margins. Prosternum small, carinate in the middle, shaped as in fig. 10. Mesothoracic peritremes reduced in size but present and shaped as in fig. 10. Mesosternum and metasternum both short, metasternum somewhat shorter than the mesosternum. Mesothoracic coxal cavities relatively widely separated by a smooth mesothoracic and metathoracic process. Leg axis short compared to the width of the body. Proleg shaped as in fig. 14, with a large coxa but without flanges on the femur to accept the tibia in repose. Mesoleg shaped as in fig. 15, without femoral flanges. Metaleg shaped as in fig. 16, without well developed femoral flanges. Tarsal formula 4-5-5.

Abdomen flattened, overall shape tapering gradually from segment III to segment IX. Apparent differences as in figs. 1 and 2 due to relative telescoping of segments. Segment II represented by a very reduced tergite only. Segments III–VII entire with 2 pairs of paratergites each. Segment VIII represented by the tergite and sternite only which may or may not be pointed as a secondary sexual character, shaped as in fig. 11. Abdominal segment IX trilobed with 2 lateral portions and split median portion, shaped in the female as in figs. 12 and 13. The male has longer asymmetrical projections from the anterior border of the venter. Median lobe of the male genitalia variable by species. Lateral lobe of the male genitalia somewhat variable by species but always of the same general form as in figs. 17 and 18.

KEY TO SPECIES OF TERMITODISCUS

1. Pronotum with an even covering of setae 2
   Pronotum without setae or with at most a single row along the posterior border 7
2. Antennae with 9 segments 3
   Antennae with 10 segments 4
3. Male genitalia shaped as in fig. 27, with a median spine ..... **sheasbyi** n. sp.
   Male genitalia shaped as in fig. 23, without a median spine ..... *machadoi* Seevers
4. Size very small, pronotum length 0.33–0.38 mm 5
   Size larger, pronotum length 0.47–0.55 mm 6
5. Pronotal setae rather sparse, male genitalia shaped as in fig. 24 ..... **krishnai** n. sp.
   Pronotal setae dense, male genitalia unknown ..... *minutus* Cameron

6. Male genitalia shaped as in fig. 25, with a lateral ventral spine on each side ..... *heimi* Wasmann
   Male genitalia shaped as in fig. 22, without latral ventral spines on each side ..... *escherichi* Wasmann
   Male genitalis unknown but most probably unlike either *heimi* or *escherichi*, from colonies of *Odontotermes* (*Hypotermes*) *obscuriceps* Wasmann in Ceylon (see description) ..... *butteli* Wasmann
7. Elytra and abdomen with setae having bifurcated tips 8
   Elytra and abdomen with setae having straight tips 11
8. Size small; pronotum length, 0.36–0.41 mm 9
   Size larger; pronotum length, 0.47–0.55 mm 10
9. Sternites with 2 macrochaetae at each lateral edge; male genitalia shaped as in fig. 19 ..... *angolae* Seevers
   Sternites without macrochaetae except for sternite VII which has 1 on each side; male genitalia shaped as in fig. 28 ..... *splendidus* Wasmann
10. Spermatheca shaped as in fig. 33 ..... **emersoni** n. sp.
    Spermatheca shaped as in fig. 38 ..... **vansomereni** n. sp.
11. Pronotum with a single row of very fine setae along posterior border ..... *transvaalensis* Silvestri
    Pronotum without any setae whatsoever 12
12. Abdominal tergites III–VII with no macrochaetae, male genitalia shaped as in fig. 21 ..... **coatoni** n. sp.
    Abdominal tergites III–VII with some macrochaetae 13
13. Macrochaetotaxy of abdominal tergites III–VII, 4, 4, 4, 4, 4; male genitalia shaped as in fig. 26 ..... **latericius** n. sp.
    Macrochaetotaxy of abdominal tergites III–VII, 6, 6, 6, 6, 6; male genitalia shaped as in fig. 20 ..... *braunsi* Wasmann

DESCRIPTION OF THE SPECIES

Termitodiscus angolae Seevers

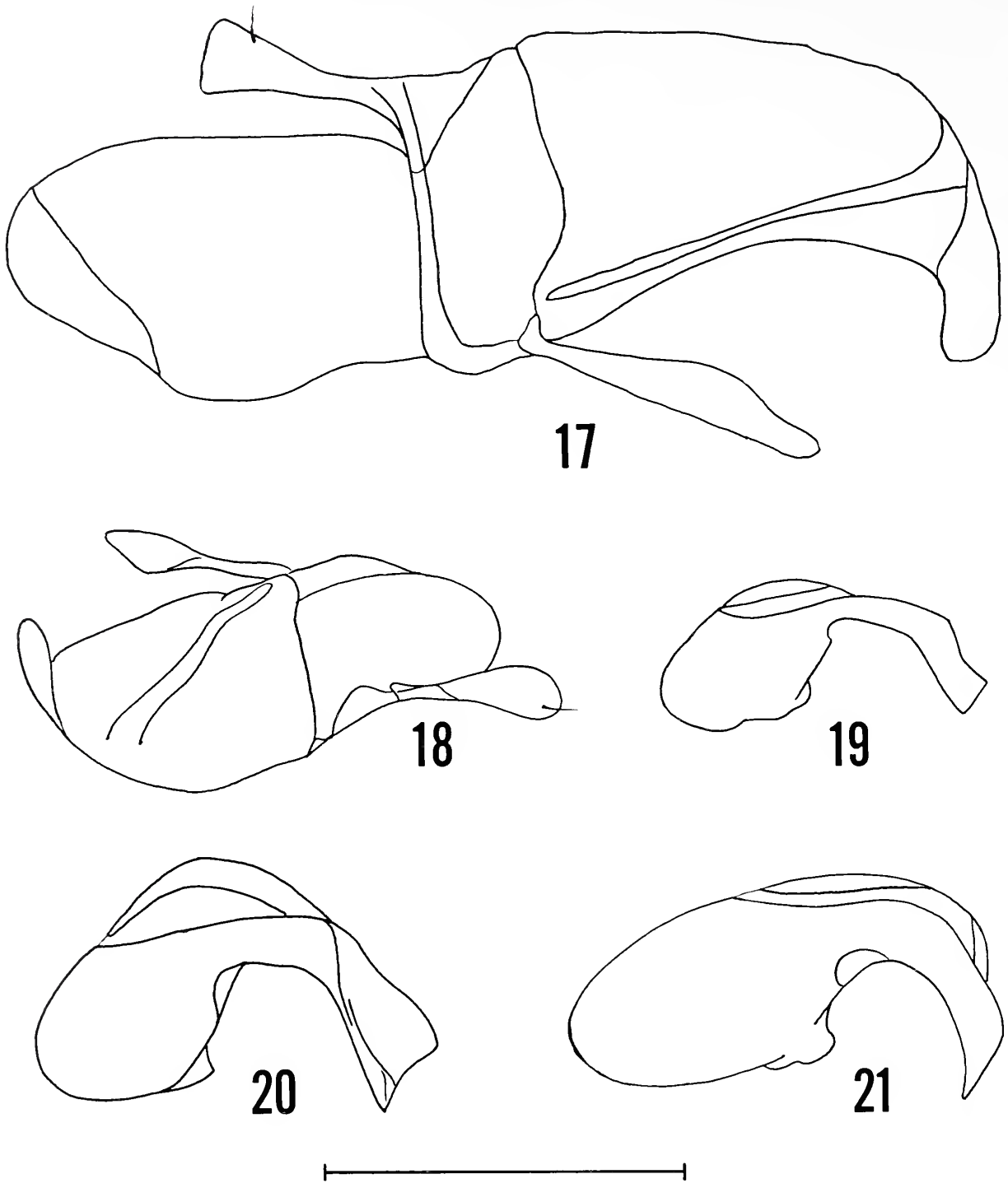
Figs. 6, 19, 44

Termitodiscus angolae Seevers, 1965, Publ. cult. Comph. Diam. Angola, **69:** 134, figs. 6 and 7. Museu do Dundo (Angola: Dundo, R. Capemba, ex fungus gardens of *Odontotermes nolaensis* Sjoestedt, April, 1962, Coll. Machado and Sanjinje).

Most closely related to *T.* **emersoni** n. sp. from which it is distinguished by its smaller size and the shape of the male genitalia. Related to *T. splendidus* Wasmann through its similar size, but separable therefrom by the abdominal chaetotaxy.

Color light yellowish brown throughout with the antero-lateral edges of the pronotum and elytra a little lighter than the rest of the body. Dorsal surface of the head and pronotum smooth and shiny without setae of any kind but with fine punctures evenly but sparsely scattered about. Dorsal surface of the elytra and abdomen with an even covering of yellow, recumbent, short, stiff setae with bifurcated tips. No tergal macrochaetotaxy. Sternites III–VII with a double row of black macrochaetae on each lateral edge. Sternite VIII with the one row of black macrochaetae on each lateral edge and with the mesial row toward the middle. Apex of tergite VIII pointed in the female. Median lobe of the male genitalia shaped as in fig. 19. Antennae 9-segmented.

MEASUREMENTS: Pronotum length, 0.33 mm; elytra length, 0.18 mm; pronotum width, 0.51. Number measured, 1.



FIGS. 17–21. Male genitalia: Lateral lobes: 17. *Termitodiscus escherichi* Wasmann; 18. *T.* **vansomereni** n. sp. Median lobes: 19. *T. angolae* Seevers; 20. *T. braunsi* Wasmann; 21. *T.* **coatoni** n. sp. Scale is equal to 0.25 mm.

MATERIAL EXAMINED: 3 specimens of the type series (C.N.H.M., D.K.). Distribution shown in fig. 44.

Termitodiscus braunsi Wasmann
Figs. 1, 20, 31, 43

Termitodiscus braunsi Wasmann, 1912, Zeitschr. Wiss Zool., **101:** 94—Naturhistorisch Museum, Maastricht (Republic of South Africa: Orange Free State, Bothaville, with *Odontotermes transvaalensis* Sjoestedt); Seevers, 1957, Fieldiana Zool., **40:** 262 (key, list).

Most closely related to *T.* **latericius** n. sp. from which it is distinguished by the 9-seg-

mented antennae, abdominal macrochaetotaxy, and the shape of the male genitalia and spermatheca.

Color light reddish brown throughout with the antero-lateral edges of the pronotum and elytra still lighter, approaching yellowish brown. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head and pronotum without setae of any kind. Dorsal surface of the elytra and abdomen with an even covering of yellow, erect setae with straight nonbifurcated tips. Macrochaetotaxy of abdominal tergites II–VII as follows: II, 0; III, 6; IV, 6; V, 6; VI, 6; VII, 6. Tergite VIII with two rows of 4 macrochaetae each. Sternites III–VII with a row of two setae on each side. Spermatheca shaped as in fig. 31. Median lobe of the male genitalia shaped as in fig. 20. Antennae 9-segmented.

MEASUREMENTS: Pronotum length, 0.47–0.52 mm; elytra length, 0.23–0.24 mm; pronotum width, 0.80–0.85 mm. Number measured, 10.

MATERIAL EXAMINED: Republic of South Africa: Orange Free State, 1, Holotype, *T. braunsi* Wasmann, det. E. Wasmann, Bothaville, Coll. Brauns, bearing label, "*Termes rubricola* Wasmann," (N.H.M.). Transvaal: 8, 36 mi. ex Pretoria-Warmbad, 18 February 1963, Coll. J. Sheasby, T-12 (N.C.I., D.K.); 1 (coll.), 34 mi. ex Pretoria-Pienaars River, 8 March 1963, Coll. J. Sheasby, T-37, (N.C.I.); 3, Rooikop, Rus de Winter, 30 June 1963, Coll. J. Sheasby, T-102 (N.C.I., D.K.); 7, 32 miles ex Pretoria-Pienaars River, 7 August 1963, Coll. J. L. Sheasby, T-132 (N.C.I., D.K.); 4, 30 mi. ex Pretoria-Pienaars River, 8 January 1964, Coll. J. L. Sheasby, T-238 (N.C.I., D.K.); 1, Rooikop, Rus de Winter, 19 March 1964, Coll. J. L. Sheasby, T-325 (N.C.I.) 2, 7 miles ex Pienaars River—Rus de Winter, 20 May 1964, Coll. J. L. Sheasby, T-345 (N.C.I., D.K.); 7, Rooikop, Rus de Winter, 10 March 1965, Coll. J. L. Sheasby, T-379 (N.C.I., D.K.); 1, 30.5 mi. ex Pretoria-Warmbad, 17 March 1966, ex fungus gardens, Coll. W. Coaton, J. L. Sheasby, and D. Kistner, No. 1438 (D.K.).

NOTES: All of the hosts of the Transvaal specimens listed above were identified as *Odontotermes transvaalensis* Sjoestedt by Dr. W. G. H. Coaton. The accession numbers of the termites, should future workers wish to check the hosts are as follows (in the same order as the data above): S-6, S-16, S-22, S-30, S-56, TM. 13360, TM. 14169, & unaccessioned, all in the National Isoptera Collection of South Africa. The last numbered 1439, nest T-160, in the collection of D. Kistner. The distribution of the species is shown in fig. 43.

Termitodiscus butteli Wasmann
Fig. 44

Termitodiscus butteli Wasmann, 1916, Zool. Jahrb. System., **39:** 181, pl. 4, fig. 10, pl. 5, fig. 10a, Naturhistorisch Museum, Maastricht (Ceylon: Peradeniya, ex fungus gardens of *Odontotermes* (*Hypotermes*) *obscuriceps* Wasmann, Coll. by von Buttel-Reepen, December 1911); Seevers 1957, Fieldiana Zool., **40:** 262 (key and list).

Closely related to *T. escherichi* Wasmann and *T. heimi* Wasmann from which it is distinguishable only by its smaller size (1.4 mm vs. 1.6–1.9 mm). See notes below.

Color yellowish brown throughout, yellower toward the antero-lateral edge of the pronotum than elsewhere. Dorsal surface of the head, pronotum, and elytra smooth and shiny with

fine punctures evenly but sparsely scattered about. Dorsal surface of the head without setae of any kind. Dorsal surface of the pronotum, elytra, and abdomen with an even covering of fine yellow, recumbent, short, stiff setae with bifurcated tips. Macrochaetotaxy of abdominal tergites II-VII: 0, 0, 0, 0, 0, 0. Macrochaetotaxy of sternites and abdominal segment VIII unknown. Male genitalia and female spermatheca unknown. Antennae 10-segmented.

MEASUREMENTS: Pronotum length, 0.45–0.46 mm; elytra length, 0.22–0.23 mm; pronotum width, 0.85–0.92 mm. Number measured, 2.

MATERIAL EXAMINED: Type and cotype (N.H.M.); 1 cotype (B.M.N.H.). The distribution is shown in fig. 44.

NOTES: Because dissection material was not available, sufficient characters are not known to distinguish this species from either *T. heimi* or *T. escherichi.* The overall size difference was taken from the original description, but actual measurements made are all on the low side of the range for *T. escherichi.* I found and dissected one nest of *O. obscuriceps* in Kandy, Ceylon, but unfortunately did not get any specimens. No new material of this species has been collected since the original capture. The clustering program on the basis of the characters available show that it is very closely related to *heimi* and *escherichi* (1.000 correlation) and I do not believe that new material will greatly alter the association although it would undoubtedly lower the coefficient of relationship. Because *heimi* and *escherichi* are now well known, it should be easy to place this species, once material from *O. obscuriceps* colonies from reasonably close to Peradeniya is available.

Termitodiscus **coatoni** n. sp.

Figs. 21, 32, 43

Most closely related to *T. transvaalensis* Silvestri from which it is distinguished by the absence of a row of fine setae on the posterior edge of the pronotum, its 9-segmented antennae, its abdominal macrochaetotaxy, and the shape of the male genitalia and spermatheca.

Color reddish brown throughout with the antero-lateral edge of the pronotum lighter than the rest of the body, approaching yellow. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head and pronotum without any setae of any kind. Dorsal surface of the elytra and abdomen with an even covering of yellow setae with nonbifurcated straight tips. Macrochaetotaxy of abdominal tergites II–VIII as follows: 0, 0, 0, 0, 0, 0, 2. Macrochaetotaxy of abdominal sternites III–VIII as follows: III, 2; IV, 2; V, 2; VI, 4; VII, 4; VIII, 6, all lateral except for the mesial 2 on VIII. Female tergite VIII evenly rounded on posterior edge. Spermatheca shaped as in fig. 32. Median lobe of male genitalia shaped as in fig. 21. Antennae 9-segmented.

MEASUREMENTS: Pronotum length, 0.48–0.51 mm; elytra length, 0.21–0.25 mm; pronotum width, 0.80–0.85 mm. Number measured, 10.

HOLOTYPE: 1 male, No. 12515, South Africa, Transvaal, Rooikop, Rus de Winter, 19 March 1963, Coll. J. L. Sheasby No. T-47. In the National Collection of Insects, South Africa.

PARATYPES: South Africa: Transvaal: 20, same data as holotype (N.C.I., D.K.); 4, 14 mi. ex Pretoria-Pienaars River Dam, 9 August 1960, Coll. W. G. H. Coaton, TM7433 (N.C.I., D.K.); 6, Pretoria West, 14 August 1963, Coll. Rorke No. T-145 (N.C.I., D.K.).

NOTES: The hosts of all the captures were determined as *Odontotermes badius* (Haviland) by Dr. W. G. H. Coaton. The accession numbers of the termites are S-18, TM7433, and S-32 respectively and the specimens are in the National Collection of Isoptera, South Africa. The distribution of the species is shown in fig. 43.

Termitodiscus **emersoni** n. sp.
Figs. 33, 44

Most closely related to *T. angolae* Seevers from which it is distinguished by its larger size. Also related to *T.* **vansomereni** n. sp. from which it is distinguished by the shape of the female spermatheca.

Color reddish brown throughout, with the antero-lateral edges of the pronotum lighter than the rest of the body, approaching yellow. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head and pronotum without any setae of any kind. Dorsal surface of the elytra and abdomen with an even covering of fine, yellow, recumbent, stiff, short setae with bifurcated tips. No macrochaetae on abdominal tergites II–VIII. Macrochaetotaxy of abdomenal sternites III–VIII, 4, 4, 4, 4, 4, 4, all lateral in position. Spermatheca shaped as in fig. 33. Male unknown. Antennae 9-segmented.

MEASUREMENTS: Pronotum length, 0.47 mm; elytra length, 0.24–0.25 mm; pronotum width, 0.80–0.85 mm. Number measured, 2.

HOLOTYPE: 1 female, No. 12228, Congo Republic, Kivu, Keyberg, 25 April 1948, Coll. Alfred E. Emerson. In the collection of the author.

PARATYPE: 1 female, same data as the holotype (D.K.).

NOTES: The host colony was identified as *Odontotermes patruus* Sjoestedt by Dr. A. E. Emerson. Specimens of the host colony are in the Emerson collection of the American Museum of Natural History, New York. The distribution of the species is shown in fig. 44.

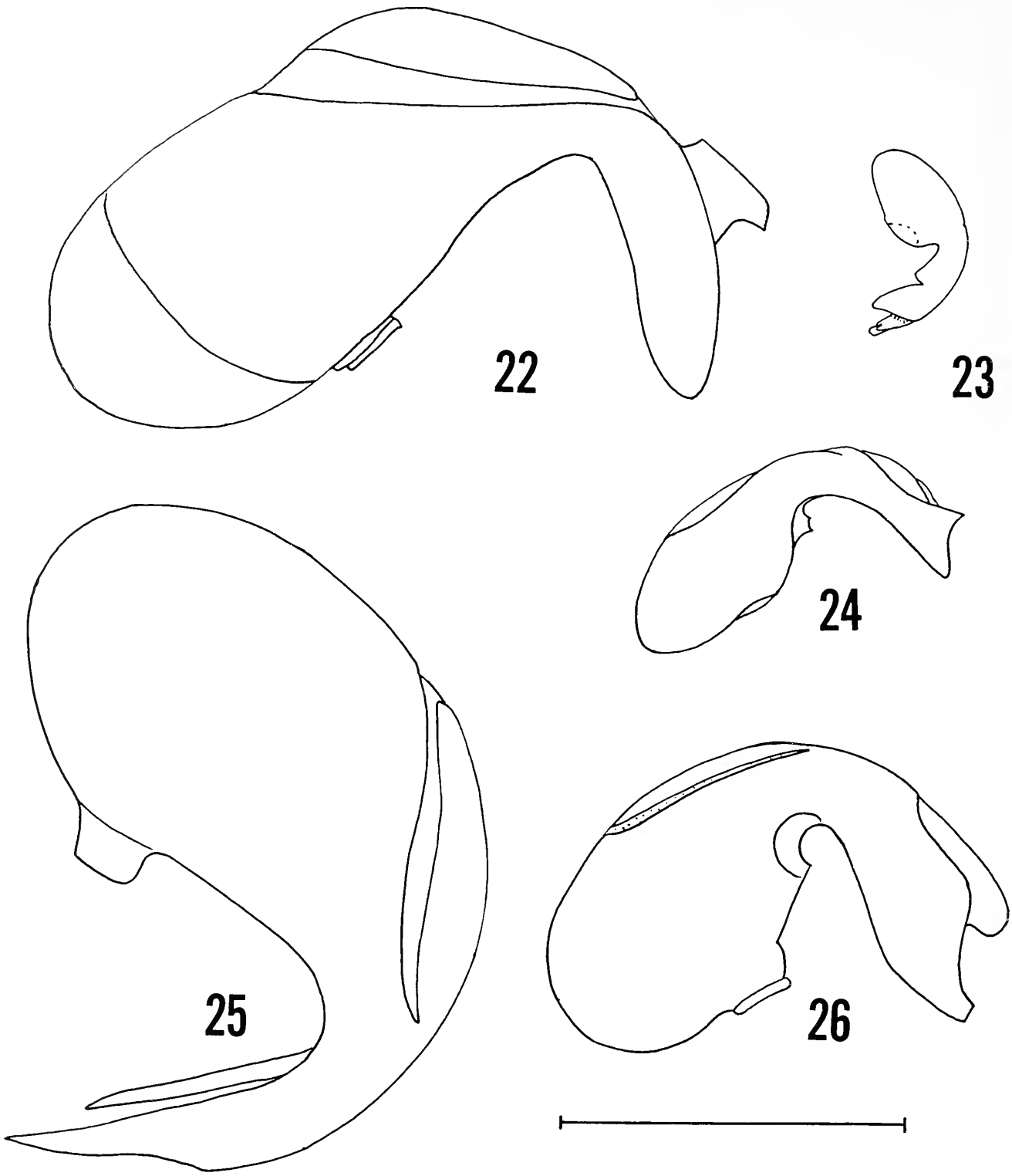
Termitodiscus escherichi Wasmann
Figs. 2, 3, 8, 9, 10, 11, 12, 17, 22, 44

Termitodiscus escherichi Wasmann, 1911, Termitenleben auf Ceylon: 231 Naturhistorisch Museum, Maastricht (Ceylon, Perandeniya, with *Odontotermes redemanni* Wasmann); 1912, Zeitschr. wissensch Zool., **101:** 94 (no additional data added); 1916, Zool. Jahrb. Syst., **39:** 181, pl. 4, fig. 9, pl. 5, fig. 9a (key); Cameron, 1932, Fauna Brit, India, Staphyl., **3:** 318 (key); Seevers, 1957, Fieldiana Zool., **40:** 260 (key).

Termitodiscus escherichi var. *picea* Wasmann, 1916, Zool. Jahrb. Syst., **39:** 181 Naturhistorisch Museum, Maastricht (Ceylon, Peradeniya, with *Odontotermes ceylonicus* Wasmann, 8 January 1912, Coll. H. von. Buttel-Reepen); Seevers, 1957, Fieldiana Zool., **40:** 260 (synonymized variety).

Most closely related to *T. heimi* Wasmann from which it is distinguished by the lack of ventral spines on the median lobe of the male genitalia and presence of 2 more macrochaetae on the sternites of each of abdominal segments VI, VII, and VIII, as well as the shape of the median lobe of the male genitalia.

Color light reddish brown throughout, with the antero-lateral edges of the pronotum lighter than the rest of the body, approaching yellow. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head without any setae of any kind. Dorsal surface of the pronotum, elytra, and abdomen with an even covering of fine, yellow, recumbent, stiff, short setae with



FIGS. 22–26. Median lobes of male genitalia: 22. *Termitodiscus escherichi* Wasmann; 23. *T. machadoi* Seevers; 24. *T.* **krishnai** n. sp.; 25. *T. heimi* Wasmann; 26. *T.* **latericius** n. sp. Scale is equal to 0.25 mm and applies to all figures except fig. 23. Fig. 23 after Seevers (1965).

bifurcated tips. Macrochaetotaxy of abdominal tergites II–VIII: 0, 0, 0, 0, 0, 0, 4. Macrochaetotaxy of abdominal sternites III–VIII: 2, 2, 4, 6, 6, 4. Median lobe of male genitalia without ventral spines, shaped as in fig. 22. Spermatheca shaped as in fig. 12. Antennae 10-segmented.

MEASUREMENTS: Pronotum length, 0.45–0.50 mm; elytra length 0.22–0.25 mm; pronotum width, 0.90–1.00 mm. Number measured, 15.

MATERIAL EXAMINED: Ceylon: Holotype and Cotype, *T. escherichi* Wasmann, det. E. Wasmann, Peradeniya, with *Odontotermes redemanni* Wasmann (N.H.M.); Holotype, *T. escherichi* var. *picea* Wasmann, det. E. Wasmann, Peradeniya, with *Odontotermes ceylonicus* Wasmann (N.H.M.); 161, Sigiriya, ex fungus gardens of nest T22, 25 August 1960, Coll. D. H. and A. C. Kistner (D.K.); 2, Sigiriya, ex fungus gardens of nest T24, 25 August 1960, Coll. D. H. and A. C. Kistner (D.K.); 2, Sigiriya, ex fungus gardens of nest T23, 24 August 1960, Coll. D. H. and A. C. Kistner (D.K.); 4, Sigiriya, ex fungus gardens of nest T21, 24 August 1960, Coll. D. H. and A. C. Kistner (D.K.). The distribution of the species is shown in fig. 44.

NOTES: The termite hosts of our Sigiriya captures were identified as *Odontotermes taprobanes* Walker by Dr. A. E. Emerson who stated that *O. redemanni* Wasmann is a synonym of that species. The specimens of the hosts are deposited in the Emerson collection of the American Museum of Natural History, New York. The royal cells of the above colonies were all located, opened, and were devoid of termitophiles.

Termitodiscus heimi Wasmann
Figs. 25, 34, 44

Termitodiscus heimi Wasmann, 1899, Deutsches Entomol. Zeitschr. **1899:** 147, pl. 1, fig. 1a–f; Naturhistorisch Museum, Maastricht (India: Ahmednagar District, Wallon, and Sangamner with *Odontotermes obesus* Rambur and *Odontotermes wallonensis* Wasmann); 1912, Zeitschr. wissensch. Zool., **101:** 93, pl. 5, fig. 4; 1916, Zool. Jahrb. Syst., **39:** 181, pl. 4, fig. 8a–b, pl. 5, fig. 8c; Cameron, 1932, Fauna Brit. India, Staphyl., **3:** 318 (key); Silvestri, 1947, Arch. Zool. Ital., **31:** 127, fig. 1 (1–7); Seevers, 1957, Fieldiana Zool., **40:** 260 (key). *Termitodiscus heimi* var. *vicinior* Silvestri, 1947, Arch. Zool. Ital., **31:** 127, fig. 2, (India: Barkuda Island, with *Odontotermes* sp.); Seevers, 1957, Fieldiana Zool., **40:** 260 (synonymized variety).

Most closely related to *T. escherichi* Wasmann from which it is distinguished by the presence of ventral spines on the median lobe of the male genitalia and the presence of 2 less macrochaetae on the sternites of each of abdominal segments VI, VII, and VIII, as well as the shape of the median lobe of the male genitalia.

Color light reddish brown throughout, with the antero-lateral edges of the pronotum lighter than the rest of the body, approaching yellow. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head without setae of any kind. Dorsal surface of the pronotum, elytra, and abdomen with an even covering of fine, yellow, recumbent, stiff, short setae with bifurcated tips. Macrochaetotaxy of abdominal tergites II–VIII, 0, 0, 0, 0, 0, 0, 2. Macrochaetotaxy of abdominal sternites III–VIII: 2, 2, 4, 4, 4, 2, all on the lateral edges. Median lobe of the male genitalia with 2 ventral spines, 1 on each side, shaped as in fig. 25. Spermatheca shaped as in fig. 34. Antennae 10-segmented.

MEASUREMENTS: Pronotum length, 0.50–0.55 mm; elytra length, 0.25–0.26 mm; pronotum width, 0.95–1.07 mm. Number measured, 10.

MATERIAL EXAMINED: India: Holotype and 1 cotype, Ahmednagar District, Wallon, with *Odontotermes obesus* Rambur (N.H.M.); 11, Bombay Province, Wallon, Coll. J. B. Heim, with *Odontotermes obesus* (D.K.); 4, Bombay

Province, Khandala, ex fungus gardens to nest T20, 21 August 1960, Coll. D. H. and A. C. Kistner (D.K.); 11, Khandala, with *Odontotermes obesus*, 1913, Coll. J. Assmuth (D.K.). The distribution is shown in fig. 44.

NOTES: Host colony T20 was determined as *Odontotermes obesus* Rambur by Dr. A. E. Emerson and the termite specimens are deposited in the Emerson Collection of the American Museum of Natural History, New York. No specimens were found in the royal cell of this nest either.

Termitodiscus **krishnai** n. sp.
Figs. 24, 35, 44

Most closely related to *T. minutus* Cameron from which it is presently distinguishable only by the more sparse setae on the pronotum, elytra, and abdomen of *T.* **krishnai**. When dissection material of *T. minutus* is available other characters will undoubtedly emerge.

Color yellowish brown throughout, with the antero-lateral edges of the pronotum lighter than the rest of the body. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head without setae of any kind. Dorsal surface of the pronotum, elytra, and abdomen with an even covering of fine, yellow, recumbent, stiff, short setae with bifurcated tips. Macrochaetotaxy of abdominal tergites II–VIII, 0, 0, 0, 0, 0, 0, 2. Macrochaetotaxy of abdominal sternites III–VIII, 0, 0, 0, 0, 0, 2. Median lobe of the male genitalia shaped as in fig. 24. Spermatheca shaped as in fig. 35. Antennae 10-segmented.

MEASUREMENTS: Pronotum length, 0.33–0.38 mm; elytra length, 0.17–0.18 mm; pronotum width, 0.63–0.64 mm. Number measured, 2.

HOLOTYPE: 1 male, No. 12518, Burma, 21 mi. ex Mandalay, 23 October 1961, Coll. K. Krishna. In the collection of the author.
PARATYPE: 1 female, same data as the holotype (D.K.).

NOTES: The host of the above specimens was identified as *Odontotermes hainanensis* (Light) by Dr. Kumar Krishna. The specimens of the host are deposited in the American Museum of Natural History, New York. The distribution of the species is shown in fig. 44.

Termitodiscus **latericius** n. sp.
Figs. 26, 36, 44

Most closely related to *T. braunsi* Wasmann from which it is distinguished by its 10-segmented antennae, the tergal macrochaetotaxy, the shape of the spermatheca, and the median lobe of the male genitalia.

Color reddish brown throughout, with the antero-lateral edges of the pronotum lighter than the rest of the body, approaching yellow. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head and pronotum without setae of any kind. Dorsal surface of the elytra and abdomen with an even covering of long yellow setae with non-bifurcated tips which are not recumbent but not erect either. Macrochaetotaxy of abdominal tergites II–VIII: 0, 4, 4, 4, 4, 4, 2. Sternites III–VII with 2 macrochaetae on each lateral edge. Sternite VIII with 1 macrochaeta on the lateral edge and 1 about half way toward the middle on each side. Tergite VIII with the posterior edge pointed. Median lobe of the male gentalia shaped as in fig. 26. Spermatheca shaped as in fig. 36. Antennae 10-segmented.

MEASUREMENTS: Pronotum length, 0.47–0.55 mm; elytra length, 0.22–0.25 mm; pronotum width, 0.70–0.85 mm. Number measured, 10.

HOLOTYPE: 1 male, No. 12506, Republic of South Africa, Transvaal, 33 mi ex Pretoria-Pienaars River, 22 February 1965, Coll. J. L. Sheasby, No. T378. In the National Collection of Insects, South Africa.

PARATYPES: Republic of South Africa, Transvaal: 10, Pretoria, Waverly, 20 February 1963, Coll. J. L. Sheasby, No. T17 (N.C.I., D.K.); 4, Pretoria, Derdepoort, 4 March 1963, Coll. J. L. Sheasby, No. T31 (N.C.I., D.K.); 5, Derdepoort, 9 July 1963, Coll. J. L. Sheasby, No. T110 (N.C.I., D.K.); 1, Derdepoort, 20 January 1964, Coll. J. L. Sheasby, No. T258 (N.C.I.); 2, 9 mi ex Pretoria-Pienaars River, 2 March 1964, Coll. J. L. Sheasby, No. T306 (N.C.I., D.K.); 1, Derdepoort, 6 March 1964, Coll. J. L. Sheasby, No. T313 (N.C.I.).

NOTES: The host colonies of all the above specimens were determined as *Odontotermes latericius* (Haviland) by Dr. W. G. H. Coaton. The host specimens are in the South African National Collection of Isoptera under the following accession numbers: S-7, S-14, S-23, S-59, S-65, S-66, unaccessioned (T378). The distribution of the species is shown in fig. 44.

Termitodiscus machadoi Seevers
Figs. 4, 5, 7, 23, 44

Termitodiscus machadoi Seevers, 1965, Publ. Cult. Comph. Diam. Angola **69:** 136, figs. 8, 9, Museu do Dundo, Angola (Angola, Dundo, R. Capemba, 23 March 1962, from nest of *Odontotermes interveniens* Sjoestedt, Coll. A. De Barros Machado).

Most closely related to *T.* **sheasbyi** n. sp. from which it is distinguished by its slightly smaller size and the absence of ventral spines from the median lobe of the male genitalia as well as by the shape of the median lobe of the genitalia.

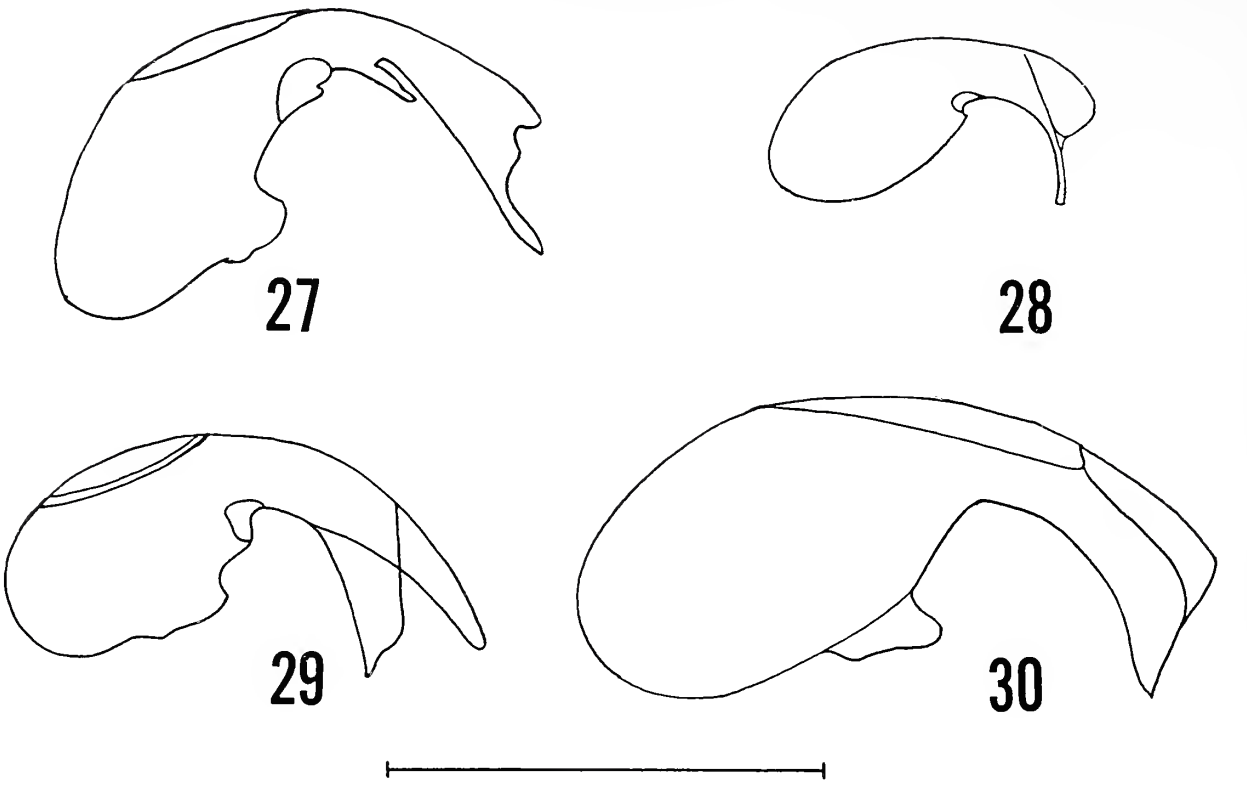
Color reddish brown throughout, with the antero-lateral edges of the pronotum lighter than the rest of the body, approaching yellow. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head without setae of any kind. Dorsal surface of the pronotum, elytra and abdomen with an even covering of fine, yellow, recumbent, stiff, short setae with bifurcated tips. No macrochaetae on either sternites or tergites. Median lobe of the male genitalia shaped as in fig. 23. Spermatheca unknown. Antennae 9-segmented.

MEASUREMENTS: Pronotum length, 0.41–0.43 mm; elytra length, 0.30–0.22 mm; pronotum width, 0.76–0.80 mm. Number measured, 3.

MATERIAL EXAMINED: 6 paratypes (F.M.N.H., D.K.). The distribution of the species is shown in fig. 44.

Termitodiscus minutus Cameron
Fig. 44

Termitodiscus minutus Cameron, 1926, Trans. Entomol. Soc. London, **74:** 171—British Museum (N.H.), London (India: Dehra Dun, in nest of termites, Coll. M. Cameron); 1932, Fauna Brit. India, Staphyl., **3:** 319 (key); Seevers, 1957, Fieldiana Zool., **40:** 262 (key, list).



FIGS. 27–30. Median lobes of male genitalia: 27. *Termitodiscus* **sheasbyi** n. sp.; 28. *T. splendidus* Wasmann; 29. *T. transvaalensis* Silvestri; 30. *T.* **vansomereni** n. sp. Scale is equal to 0.25 mm.

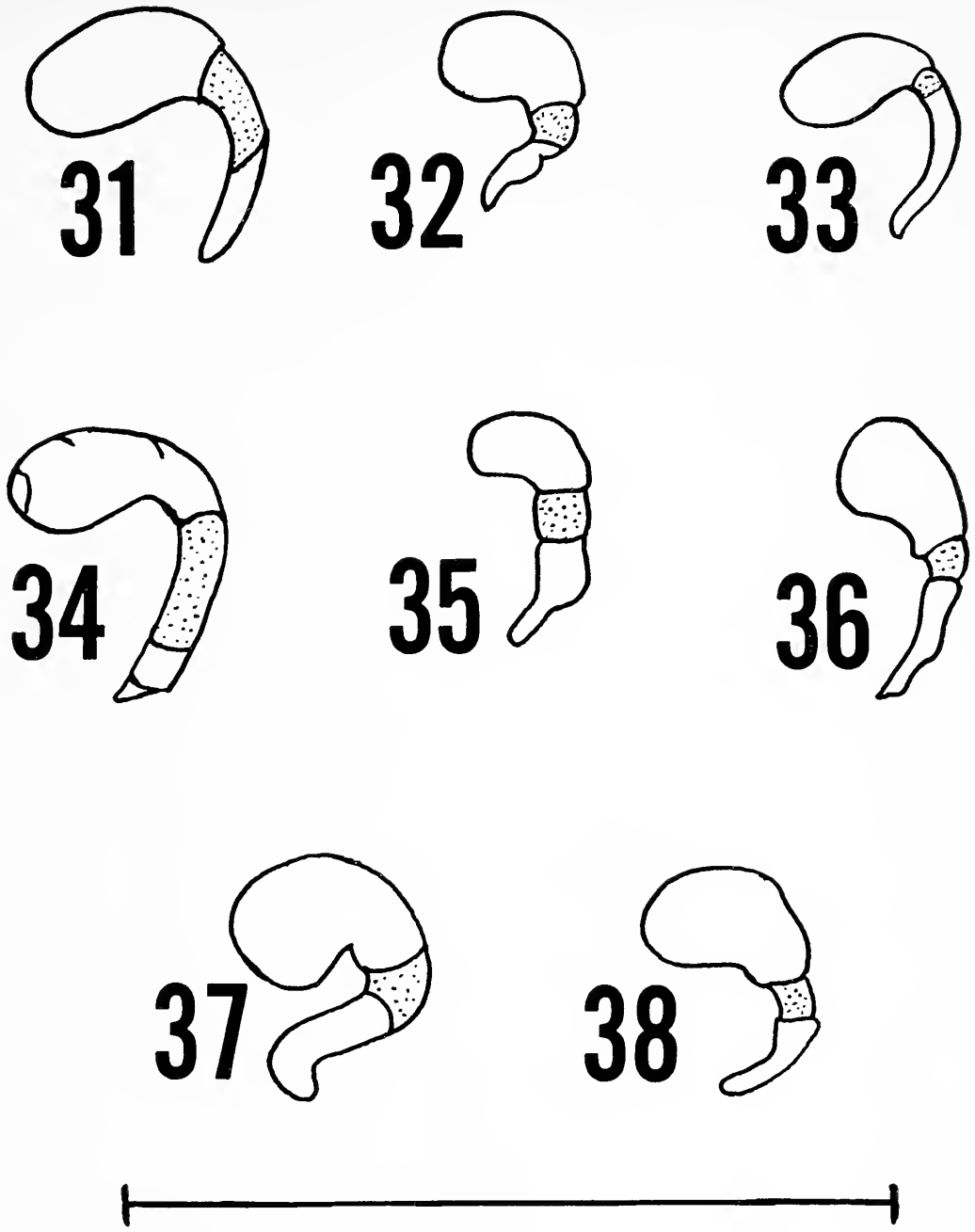
Most closely related to *T.* **krishnai** n. sp. from which it is presently distinguishable only by the presence of more setae with bifurcated tips on the pronotum, elytra, and abdomen. In this regard, it is also closely related to *T. escherichi* and *T. heimi* from which it is distinguished by its much smaller size. When dissectable material is ultimately available, more definitive characters are almost certain to be found as the range of the host of *T.* **krishnai** does not extend to Dehra Dun.

Color yellowish brown throughout, with the antero-lateral edges of the pronotum lighter than the rest of the body, approaching yellow. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head without setae of any kind. Dorsal surface of the pronotum, elytra, and abdomen with an even covering of fine, yellow, recumbent, stiff, short setae with bifurcated tips. No macrochaetae on any of the tergites. Macrochaetotaxy of the sternites unknown. Male genitalia and spermatheca unknown. Antennae 10-segmented.

MEASUREMENTS: Pronotum length, 0.33 mm; elytra length, 0.18 mm; pronotum width, 0.66–0.70 mm. Number measured, 2.

MATERIAL EXAMINED: Holotype plus 1, India, Uttar Pradesh, Dehra Dun, 19 March 1924, Coll. M. Cameron, from the nest of a termite (B.M.N.H.).

NOTES: A search of the termite collection of the British Museum (N.H.) by Mr. W. A. Sands did not yield any *Odontotermes* bearing data corresponding to the type label. If there is any sample of the termites associated with these specimens, they might be at the Forest Research Institute at Dehra Dun, but other than that possibility, only further collections are likely to yield the host data. The distribution of the species is shown in fig. 44.



Figs. 31–38. Spermathecae: 31. *Termitodiscus braunsi* Wasmann; 32. *T.* **coatoni** n. sp.; 33. *T.* **emersoni** n. sp.; 34. *T. heimi* Wasmann; 35. *T.* **krishnai** n. sp.; 36. *T.* **latericius** n. sp.; 37. *T. transvaalensis* Silvestri; 38. *T.* **vansomereni** n. sp. Scale is equal to 0.25.

Termitodiscus **sheasbyi** n. sp.
Figs. 27, 44

Most closely related to *T. machadoi* Seevers from which it is distinguished by its slightly larger size and the presence of a ventral spine from the median lobe of the male genitalia as well as by the shape of the median lobe of the male genitalia.

Color reddish brown throughout with the antero-lateral edges of the pronotum lighter than the rest of the body, approaching yellow. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head without setae of any kind. Dorsal surface of the pronotum, elytra, and

abdomen with an even covering of fine, yellow, recumbent, stiff, short setae with bifurcated tips. No tergites with macrochaetae. Macrochaetotaxy of abdominal sternites III–VIII: 0, 0, 0, 0, 0, 8. Median lobe of the male genitalia with a spine on the median ventral posterior border, shaped as in fig. 27. Female unknown. Antennae 9-segmented.

MEASUREMENTS: Pronotum length, 0.45 mm; elytra length, 0.18 mm; pronotum width, 0.75–0.90 mm. Number measured, 3.

HOLOTYPE: 1 male, No. 12503, South West Africa, 30 miles ex Tsumeb-Tsinsabis (15°, 45–59′ S., 17°, 45–59′ E.), 26 September 1966, Coll. J. L. Sheasby, No. T502, ex fungus gardens. In the National Collection of Insects, South Africa.

PARATYPES: 2 males, same data as holotype (N.C.I., D.K.).

NOTES: The host of the above species was determined as *Odontotermes* (c.f.) *latericius* (Haviland) by Dr. W. G. H. Coaton. The sample bears the accession number TM.20457 and is in the National Isoptera Collection, South Africa. The distribution of the species is shown in fig. 44.

Termitodiscus splendidus Wasmann
Figs. 28, 43

Termitodiscus splendidus Wasmann, 1899, Deutsch. Entolmol. Zeitschr. 1899: 401. Naturhistorisch Museum, Maastricht (Republic of South Africa: Natal, Shivyre, with *Odontotermes vulgaris* Haviland, Coll. Haviland); 1912, Zeitschr. wissensch. Zool., **101:** 94, pl. 5, fig. 5; Seevers, 1957, Fieldiana Zool., **40:** 262 (key, list). The (c.f.) designation given in the determination was used to indicate morphological similarity to *latericius* from South Africa. The nest however was constructed differently.

Not very closely related to any other species but bears similarity to *T.* **vansomereni**, *T.* **emersoni**, and *T. angolae* by having setae with bifurcated tips on the elytra, but distinguishable by its smaller size, the abdominal macrochaetotaxy and the shape of the male genitalia. Related to the *sheasbyi-machadoi* group through its size, macrochaetotaxy of the abdomen, and the antennal segmentation but separable therefrom by the lack of setae on the pronotum as well as genitalic characters.

Color light reddish brown throughout with the antero-lateral edges of the pronotum just about the same color as the rest of the body. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head and pronotum without setae of any kind. Dorsal surface of the elytra and abdomen with an even covering of fine, yellow, recumbent, stiff, short setae with bifurcated tips. No tergites with macrochaetae. Macrochaetotaxy of abdominal sternites III–VIII: 0, 0, 0, 0, 0, 2. Median lobe of the male genitalia small, shaped as in fig. 28. Spermatheca unknown, as the female dissected lacked a spermatheca for some inexplicable reason. Antennae 9-segmented.

MEASUREMENTS: Pronotum length, 0.36–0.41 mm; elytra length, 0.17–0.19 mm; pronotum width 0.67–0.70 mm. Number measured, 2.

MATERIAL EXAMINED: Holotype and 2 cotypes on a single pin, top specimen herewith designated hololectotype, Natal (Shivyre), November 1898, Coll. G. D. Haviland, with *Odontotermes vulgaris* Haviland (N.H.M.); 2, same locality, host and collector, 16 February 1898 (D.K.).

NOTES: The distribution of the species is shown in fig. 43.

Termitodiscus transvaalensis Silvestri
Figs. 13–16, 29, 37, 43

Termitodiscus transvaalensis Silvestri, 1947, Arch. Zool. Ital., **31:** 129, fig. 3, (Transvaal, ex nest of *Odontotermes angustatus* Rambur, Coll. C. Fuller); Seevers, 1957, Fieldiana Zool., **40:** 262 (key, list).

Not very closely related to any other species. Closely related to *T.* **vansomereni** through its size and abdominal macrochaetotaxy, but separable therefrom by its straight-tipped setae and its 10-segmented antennae. Closely related to *T.* **latericius** n. sp. but separable therefrom by the macrochaetotaxy of the abdominal tergites. Separable from all species by the presence of a row of fine setae with straight tips at the posterior edge of the pronotum as well as the shape of the male genitalia.

Color reddish brown throughout, with the antero-lateral edges of the pronotum lighter than the rest of the body, approaching yellow. Dorsal surface of the head, pronotum, and elytra smooth and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head without setae of any kind. Dorsal surface of the pronotum generally without setae, but bearing one row of fine, short yellow setae at the posterior border. Dorsal surface of the elytra and abdomen with an even covering of fine yellow setae with straight, non-bifurcated tips. Macrochaetotaxy of abdominal tergites II–VIII: 0, 0, 0, 0, 0, 0, 2. Macrochaetotaxy of abdominal sternites III–VIII: 6, 6, 6, 4, 4, 4, 4. Median lobe of male genitalia shaped as in fig. 29. Spermatheca shaped as in fig. 13. One aberrent spermatheca was shaped as in fig. 37, whereas other members of the same population matched fig. 13. Antennae 10-segmented.

MEASUREMENTS: Pronotum length, 0.47–0.51 mm; elytra length, 0.24–0.26 mm; pronotum width, 0.80–0.87 mm. Number measured, 10.

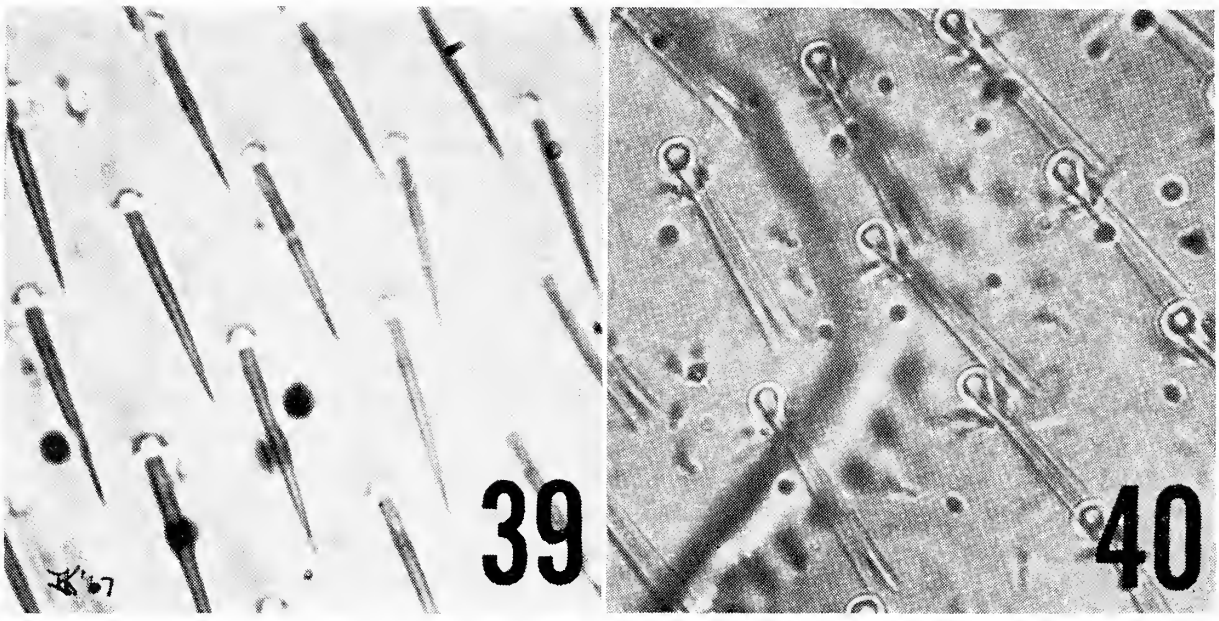
MATERIAL EXAMINED: South Africa: Transvaal: 3, 3 mi. ex Morgenson-Standerton, 10 September 1963, Coll. J. L. Sheasby, No. T160 (N.C.I., D.K.); 5, 3 mi. ex Morgenson-Standerton, 10 September 1963, Coll. J. L. Sheasby, No. T161 (N.C.I., D.K.); 1, 10 mi. ex Morgenson-Standerton, 11 September 1963, Coll. J. L. Sheasby, No. T167 (N.C.I.); 2, 13 mi. ex Morgenson-Ermelo, 12 September 1963, Coll. J. L. Sheasby, No. T168 (N.C.I., D.K.). Cape Province: 11, 6 mi. ex Sterkstroom-Tarka, 8 October 1963, Coll. J. L. Sheasby, No. T206 (N.C.I., D.K.); 13, 10 mi. ex Cala-Indwe, 7 October 1963, Coll. J. L. Sheasby, No. T202 (N.C.I., D.K.).

NOTES: The hosts of all of the above specimens were determined as *Odontotermes angustatus* (Rambur) by Dr. W. G. H. Coaton. The hosts bear the accession numbers S-37, S-40, S-41, TM 13045, TM 13059, and are in the National Collection of Isoptera, South Afirca. The distribution of the species is shown in fig. 43.

Termitodiscus **vansomereni** n. sp.
Figs. 18, 30, 38, 44

Most closely related to *T.* **emersoni** n. sp. and *T. angolae* Seevers from which it is distinguished by its larger size, the abdominal macrochaetotaxy and the shape of the male genitalia. Closely similar to *O. transvaalensis* Silvestri from which it is distinguished by the presence of setae with bifurcated tips.

Color light reddish brown throughout, with the antero-lateral edges of the pronotum lighter than the rest of the body. Dorsal surface of the head, pronotum, and elytra smooth



FIGS. 39–40. Setae on elytra: 39. Straight tipped setae, *Termitodiscus transvaalensis* Silvestri; 40. Bifurcated tipped setae, *T. escherichi* Wasmann. Scale is arbitrary, photos were taken at 440 ×.

and shiny with fine punctures evenly but sparsely scattered about. Dorsal surface of the head and pronotum without setae of any kind. Dorsal surface of the elytra and abdomen with an even covering of fine, yellow, recumbent, stiff, short setae with bifurcated tips. Tergites with no macrochaetae. Macrochaetotaxy of abdominal sternites III–VIII: 6, 6, 6, 6, 6, 6,. Median lobe of the male genitalia shaped as in fig. 30. Spermatheca shaped as in fig. 38. Antennae 9-segmented.

MEASUREMENTS: Pronotum length, 0.50–0.53 mm; elytra length, 0.26–0.30 mm; pronotum width, 0.85–0.95 mm. Number measured, 10.

HOLOTYPE: 1 male, No. 12224, Kenya, Karen, 18 June 1966, ex fungus gardens of nest T185, Coll. G. R. Cunningham-Van Someren, No. 1559. In the Collection of D. H. Kistner.

PARATYPES: 54, same data as the holotype (D.K.).

NOTES: The host of the above specimens was determined as *Odontotermes montanus* Harris by Mr. W. A. Sands. The termite sample is in the collection of the British Museum (Natural History), London. This nest was being raided by *Dorylus* (*Dorylus*) *helvolus* L. at the time of excavation. The distribution of the species is shown in fig. 44.

RELATIONSHIPS OF THE SPECIES AND HOST SPECIFICITY

In the early days of describing species, various authors made a big point about the relative size of the last joint of the antennae in relation to the length of the rest of the segments as well as the absolute length of the entire specimen. Careful slide preparations have revealed that this is an almost useless character as the size of the terminal segment is always proportionate to the rest of the antenna. Figures 3 and 4 show this well, even though the number of antennal segments vary. The length of the entire specimen is another useless character

as the abdomen is able to be telescoped a great deal. Hence both of these characters were dropped.

In searching for new characteristics, microscopic examination revealed the following: Not all the species had 10-segmented antennae as was previously supposed. I first discovered this on *T. machadoi*. I then remembered that Silvestri had shown a 10-segmented antenna on both *T. transvaalensis* and *T. heimi*. This worried me as I have never known Silvestri to be wrong on a question of fact. Sure enough, both of the species studied by Silvestri had 10-segmented antennae. I then surveyed the antennae of all the species and could find no correlation of the antennal segmentation with any other character. Hence this character is here interpreted as a species specific character, and a new genus is not erected on this basis. Selection has obviously been working to compress the antennae of this beast, so a segment has been lost now and then on what appears to be a hit or miss basis. I believe that the segment has been lost between segment 3 and 5 and on one species, *T.* **vansomereni**, one can see what appears to be a fine line of fusion on the third segment.

Close study of the setae revealed that there are two types. One type is a perfectly ordinary kind with straight pointed tips as shown in fig. 39. The other type has bifurcated tips as shown in fig. 40. The difference between the setae was noted by Seevers (1957, p. 260) as being feebly notched. He interpreted this as being only in the Indian species which was not true. Among the species described at that time, *T. splendidus* also had such setae.

Using traditional phylogenetic methods, it is possible to construct a phylogeny of the species groups as shown in fig. 4. Group A consisting of *T. braunsi*, *T.* **latericius**, *T.* **coatoni**, and *T. transvaalensis* would be interpreted as the most primitive species because they have setae with straight tips which is the usual situation in the Staphylinidae and particularly true in the primitive groups. Where deviations have occurred as in *Phyllodinarda* (see Kistner 1965), the deviations are of a different nature than for *Termitodiscus* and can therefore be assumed to be of independent origin. Of the four species, *T. transvaalensis* is probably the most primitive as it still has a short row of setae on the pronotum whereas the others lack pronotal setae entirely. Again, the complete absence of setae on the pronotum of a Staphylinid is an unusual condition and is therefore interpreted as being a derivative condition. This view is reinforced by the fact that groups C, D, and E have pronotal setae, albeit modified, and modified setae had to be derived from some pre-existing setae, hence I am supposing that the common ancestor had to have setae, most likely unmodified setae on its pronotum. None of the presently known species quite fills the bill, but *T. transvaalensis* comes closest. *T.* **latericius** is more closely related to *T. transvaalensis* in that it has 10-segmented antennae whereas the other species (*T. braunsi* and *T.* **coatoni**) have 9-segmented antennae.

Groups B, C, D, and E are all related in having setae with bifurcated tips.

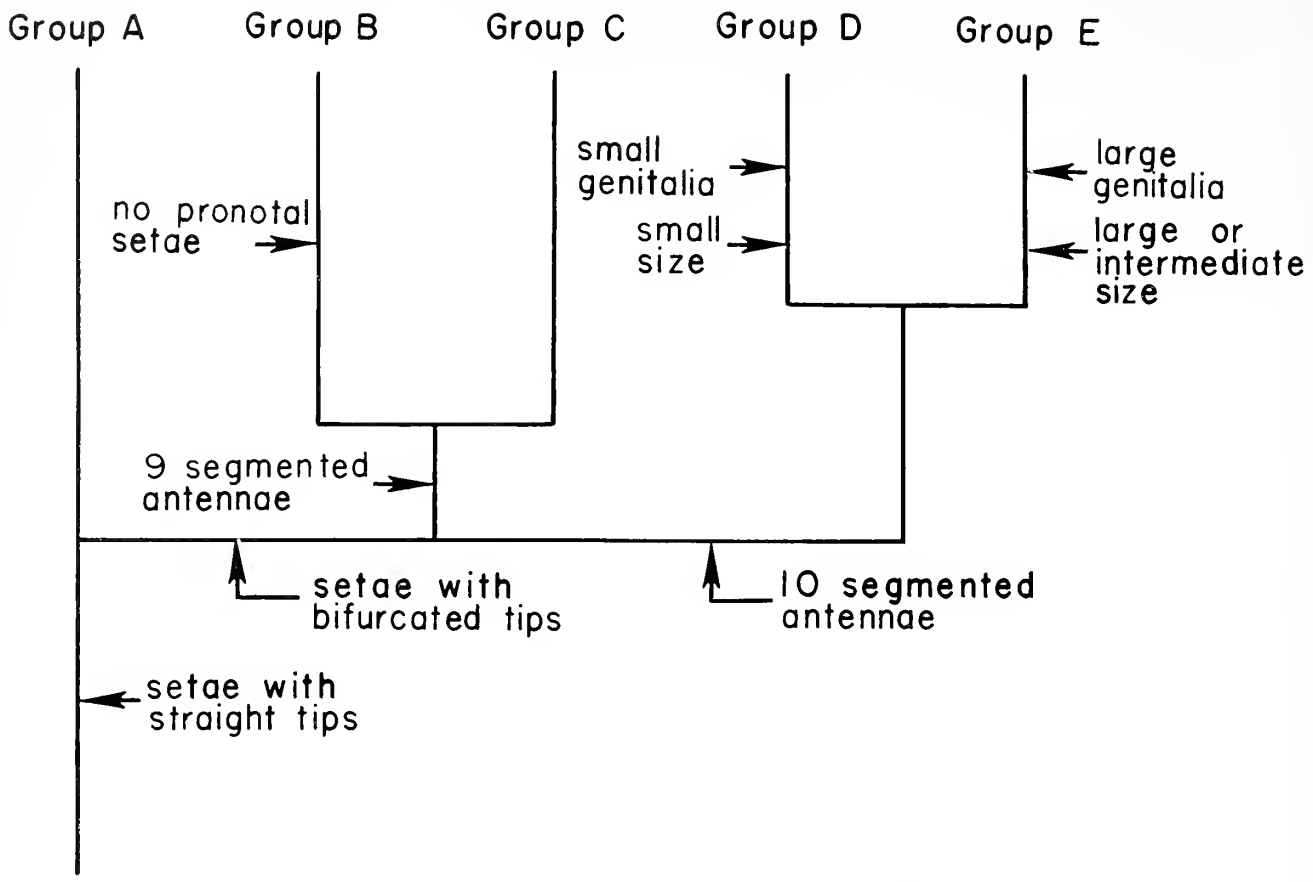


FIG. 41. Proposed phylogeny of species groups of *Termitodiscus* using traditional methods. Group A includes *T. braunsi*, *T.* **latericius**, *T.* **coatoni**, and *T. transvaalensis*. Group B includes *T. angolae*, *T.* **emersoni**, *T.* **vansomereni**, and *T. splendidus*. Group C includes *T. machadoi* and *T.* **sheasbyi**. Group D includes *T.* **krishnai** and *T. minutus*. Group E includes *T. butteli*, *T. escherichi*, and *T. heimi*.

Slide preparations of most of the species revealed that the bifurcated tips are all of the same type. *T. minutus* and *T. butteli* were not so examined but the dry preparations revealed no differences.

Group B has no pronotal setae, but the elytra and abdomen have the bifurcated setae. All the members of this group (*T. angolae*, *T.* **emersoni**, *T. splendidus*, and *T.* **vansomereni**) have 9-segmented antennae which would link them to part of group A, and also to group C.

Group C has setae with bifurcated tips on the pronotum as well as the elytra and abdomen. A careful examination of the diagram (fig. 41) will reveal that we are assuming that the common ancestor of B, C, D, and E had setae on all three regions, that this became bifurcated, and then was lost on the pronotums of group B. Thus group C would be more primitive than group B.

Groups D and E share with group C the property of having setae with bifurcated tips but differ in having 10-segmented antennae. Hence I interpret that groups D and E were split off earlier in the evolution of the groups before segment reduction. Groups D and E are very closely related to one another but differ in size and in the size of the genitalia (where known).

It is obvious from the foregoing that I did not use characters such as the macrochaetotaxy of the abdomen or the various characters of the male genitalia (other than gross size) in the construction of the phylogenetic tree. These characters, while useful for discriminating species, are presently of no use in determining phylogenies, as there is no way of determining or guessing the primitive and derivative states of such characters. Should an ancestral type be found in nature, it might be possible to judge this in the future, but this is not so at present.

Computer methods were then used to see if a more precise statement of the relationships of the species could be constructed. To do this, it was necessary to develop a list of unit characters following the general outline of Sokal and Sneath (1963). After eliminating characteristics which were redundant or invariant, the following list of 31 characters was used and coded 0 for absence, 1 for presence, and 3 for no comparison. The no comparisons arose when a male character was listed and the species was known only from a female or the material studied could not be dissected to yield the desired comparison.

List of characters used for numerical analysis

1. Pronotum with setae with bifurcated tips
2. Elytra with setae with bifurcated tips
3. Abdomen with setae with bifurcated tips
4. Tergite VIII of male pointed
5. Male genitalia small
6. Pronotum with posterior edge with 1 row of straight tipped setae.
7. Ten antennal segments
8. Male genitalia with median spines
9. Tergite VIII of female pointed
10. Pronotum length, 0.47–0.55 mm
11. Pronotum length, 0.43–0.45 mm
12. Pronotum length, 0.33–0.41 mm
13. Elytra length, 0.25–0.30 mm
14. Pronotum width twice pronotum length
15. No macrochaetae on tergites II–VII
16. Tergal macrochaetotaxy (II–VII) 0, 6, 6, 6, 6, 6
17. Tergal macrochaetotaxy (II–VIII) 0, 4, 4, 4, 4, 4
18. No macrochaetae, sternite III
19. 2 macrochaetae, sternite III
20. No macrochaetae, sternite IV
21. 2 macrochaetae, sternite IV
22. No macrochaetae, sternite V
23. 2 macrochaetae, sternite V

24. 4 macrochaetae, sternite V
25. No macrochaetae, sternite VI
26. 2 macrochaetae, sternite VI
27. 4 macrochaetae, sternite VI
28. No macrochaetae, sternite VII
29. 2 macrochaetae, sternite VII
30. 4 macrochaetae, sternite VII
31. Pronotum with setae of any type

The distribution of these characteristics in the 15 species is given in Table 1. These data were then loaded into an IBM 1620 computer with a program to produce the simple matching coefficients described by Sokal and Michener (1958). The output of this program was then used to cluster the data using the weighted pair-group method described by Sokal and Sneath (1963).

The results of these analyses are presented in fig. 42. Only the matrix values where the groups join are indicated. The perfect correlation between *T. butteli* and *T. heimi* (and for that matter between *T. butteli* and *T. escherichi* also) is due to the large number of no comparisons in the original data. It is also probable that the correlation between *T.* **krishnai** and *T. minutus* will not be as high when dissection material of *T. minutus* is available.

It will be noted that there are some major discrepancies between the phylogenetic diagram and fig. 42. The most serious discrepancies are the clustering of *T.* **vansomereni** with *T. transvaalensis*, and the clustering of *T. splendidus* with the cluster *T. sheasbyi-T. machadoi*. Less serious but still important is the clustering of *T.* **latericius** to *T. braunsi* rather than to *T. transvaalensis*. All of these are due to a weighting of size and chaetotaxy factors as equal to kinds of setae and antennal segmentation.

TABLE 1. Distribution of unit characters in *Termitodiscus* species. Characters are arranged sequentially from left to right.

Species No.	Species name	Characters
01	*T. angolae* Seevers	01111000100100100001010100100100
02	*T. braunsi* Wasmann	00011000110010010010101001001000
03	*T. butteli* Wasmann	11133013310011100333333333333331
04	*T.* **coatoni** n. sp.	00011000010010100010101000010010
05	*T.* **emersoni** n. sp.	01133003010010100010101001001000
06	*T. escherichi* Wasmann	11110010110011100010100100000001
07	*T. heimi* Wasmann	11110011110011100010100100010011
08	*T.* **krishnai** n. sp.	11111010100101100101010001000011
09	*T.* **latericius** n. sp.	00001010110010001010101001001000
10	*T. machadoi* Seevers	11101000001001100101010010010001
11	*T. minutus* Cameron	11133013000101100333333333333331
12	*T.* **sheasbyi** n. sp.	11101001010001100101010010010001
13	*T. splendidus* Wasmann	01101000000100100101010010010000
14	*T. transvaalensis* Silvestri	00001110010010100000000000000000
15	*T.* **vansomereni** n. sp.	01111000010010100000000000000000

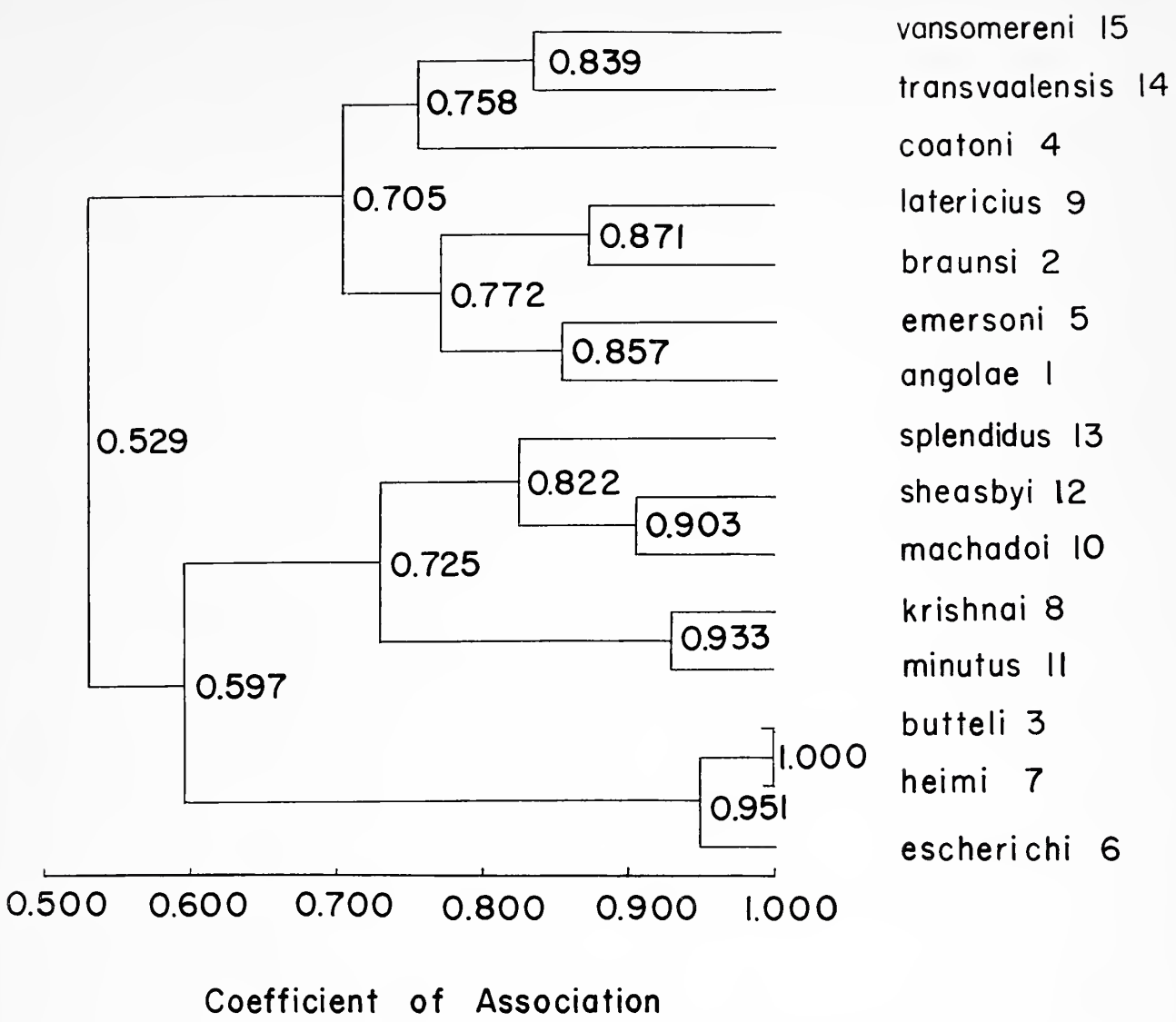


Fig. 42. Diagram of the phenetic relationships between the species of *Termitodiscus*.

The realtionships diagrammed in fig. 42 are probably less accurate as a phylogenetic scheme than the relationships shown in fig. 41. However, the information in fig. 42 is very useful as purely taxonomic information. It took only 45 minutes to put the problem through the computer and that 45 minutes saved hours of time in constructing the keys to species.

As the species are known now, there is complete host specificity. The host information is summarized in Table 2. If we make the assumption that the rates of evolution of the termites and termitophiles are about the same and that there were no accidental host changes in evolutionary history, both handsome assumptions, then we should expect that the termites would be related to each other in the same manner as the termitophiles. Thus we would expect *Odontotermes heimi* and *Odontotermes taprobanes* to be more closely related to each other than to *Odontotermes hainanensis*. We would expect the species *O. latericius* from S. W. Africa that is the host of *T.* **sheasbyi** to be more closely related to *O. interveniens* than to *O. latericius* from South Africa. It will be

TABLE 2. Host relationships of *Termitodiscus*.

Termitophile	Host
T. angolae Seevers	*Odontotermes nolaensis* Sjoestedt
T. braunsi Wasmann	*Odontotermes transvaalensis* Sjoestedt
T. butteli Wasmann	*Odontotermes* (*Hypotermes*) *obscuriceps* Wasmann
T. **coatoni** n. sp.	*Odontotermes badius* Haviland
T. **emersoni** n. sp.	*Odontotermes patruus* Sjoestedt
T. escherichi Wasmann	*Odontotermes taprobanes* Walker
T. heimi Wasmann	*Odontotermes obesus* Rambur
T. **krishnai** n. sp.	*Odontotermes hainanensis* Light
T. **latericius** n. sp.	*Odontotermes latericius* Haviland
T. machadoi Seevers	*Odontotermes interveniens* Sjoestedt
T. minutus Cameron	not known
T. **sheasbyi** n. sp.	*Odontotermes latericius* Haviland
T. splendidus Wasmann	*Odontotermes vulgaris* Haviland
T. transvaalensis Silvestri	*Odontotermes angustatus* Rambur
T. **vansomereni** n. sp.	*Odontotermes montanus* Harris

interesting to see whether either of the arrangements given here corresponds with the relationships between the species of *Odontotermes*, when this genus is revised.

BEHAVIORAL OBSERVATIONS

Two species were studied closely in the field, *T. heimi* and *T. escherichi*, especially to see what transpired when the termitophile came into contact with the termite host. To do this, living specimens of the termitophiles and their hosts were placed in petri dishes with moist filter paper on the bottoms and some pieces of fungus gardens. The termitophiles and termites were observed after a couple of hours had elapsed to give them time to accommodate to the container.

The chief behavorial adaptation of the termitophile appeared to be avoidance. The termitophile is small in relation to the size of the termite workers or soldiers, it has good eyesight whereas the termite does not, and it is fast on its feet whereas the termite is slow and clumsy. In every termitophile-termite encounter, the termitophile was able to maneuver out of range of the mandibles before the termite was even aware of its existence. We maneuvered some termites into position with a camel's hair brush and then tried to prevent the termitophile from escaping with another camel's hair brush, but in every instance, the beetle was able to crawl under or around the termite without getting caught or even attracting attention. We were thus unable to acquire any insight into the possible adaptive function of the limuloid body shape.

These same observations were confirmed in a limited way on *T. braunsi* in South Africa. However, future studies should be directed to see if there is any difference in the behavior of those forms with setae with bifurcated tips and those with straight tips.

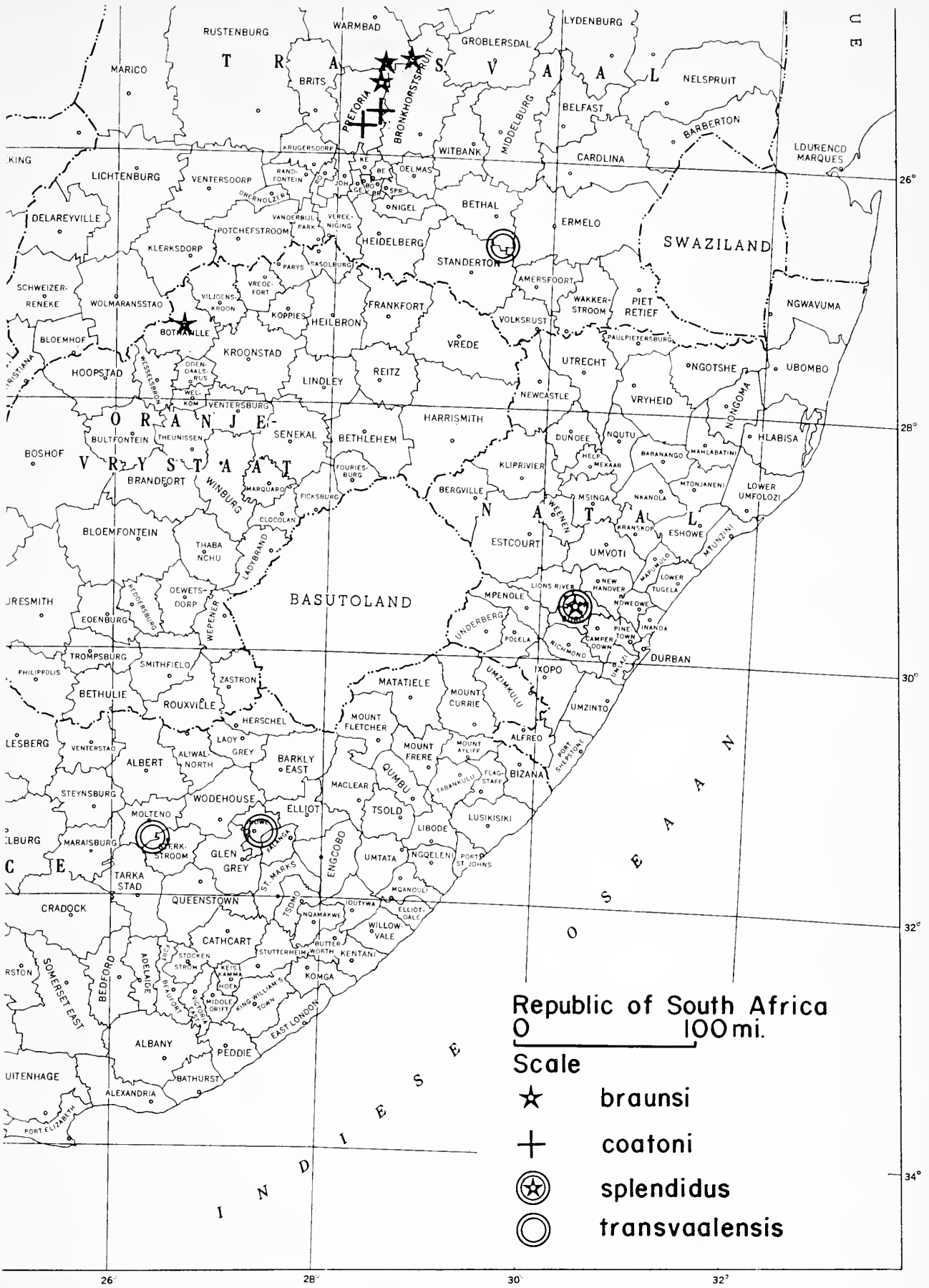


FIG. 43. Distribution of certain South African species of *Termitodiscus*.

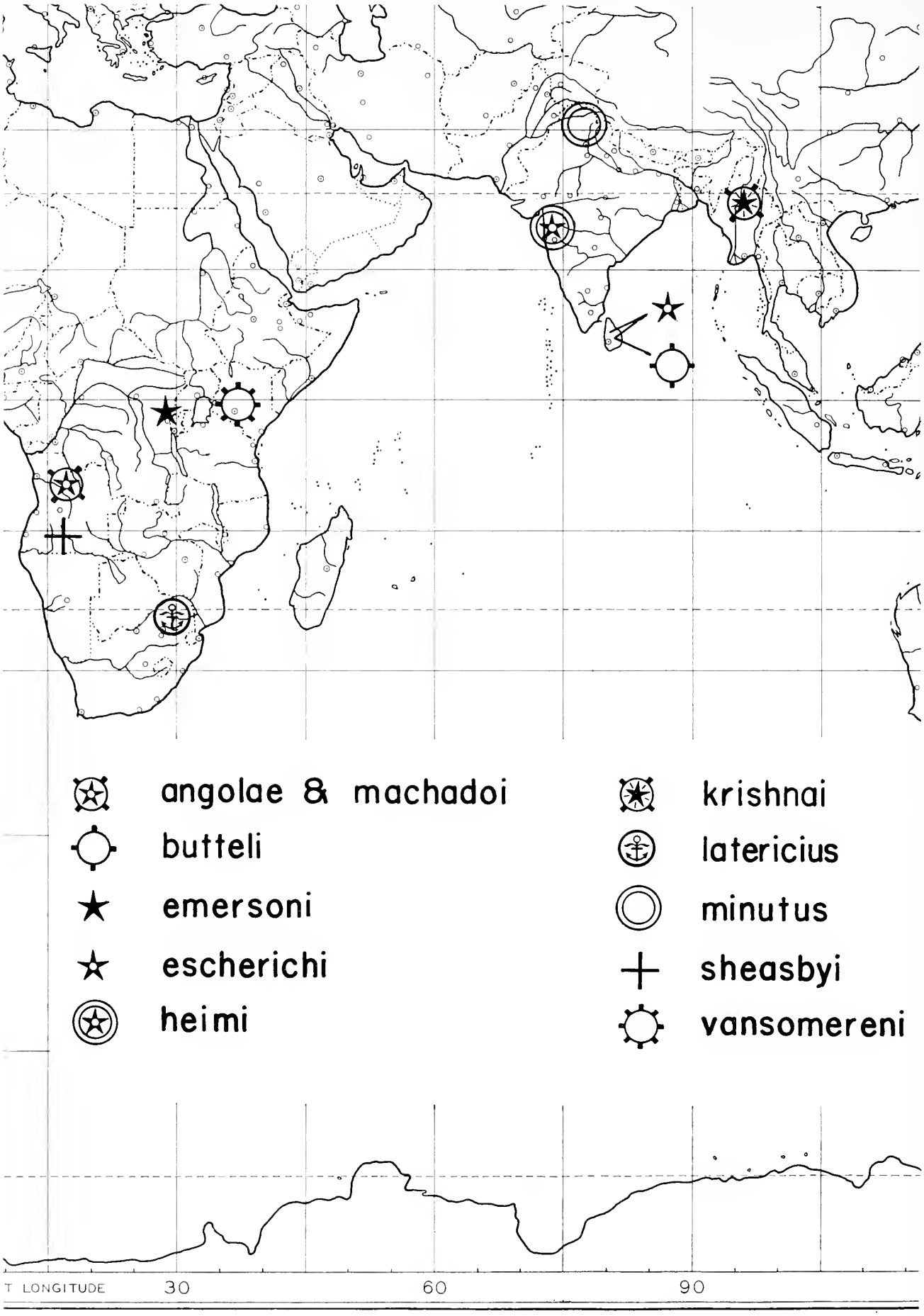


FIG. 44. Distribution of certain species of *Termitodiscus*.

Observations in the field of *T. heimi* and *T. escherichi* revealed that both species ate the fungus in the fungus gardens. Subsequent gut smears confirmed this.

The above observations should be combined with another field observation before any conclusions are drawn. Invariably, the most *Termitodiscus* were found in the fungus gardens immediately adjacent to the royal cell. These are the fungus gardens which contain the most eggs and young termites and hence there is more termite activity.

Termite activity decreases in the more peripheral fungus gardens and one seldom finds termitophiles in these. Termitophiles were never taken in the royal cells of *Odontotermes*.

Because of their association with the termites in areas of high termite activity, their perfect host specificity, and the fact that no accidental capture of *Termitodiscus* outside the termite nest has ever been made, I am interpreting the genus as integrated termitophiles whose principal adaptation to the termite hosts is avoidance of direct contact.

Wasmann (1895 and elsewhere) erected the category of "trutztypus" or defensive forms and placed the genus *Termitodiscus* in that category in 1912 and 1916 based on the morphology alone. There is no evidence that the termitophiles lead a harried existence in the nest. The avoidance of the termites under observation never led to a confrontation even when we tried to manipulate one. What seems to prevail is a kind of wary but completely dependent coexistence on the part of the termitophile and an unawareness on the part of the termites.

Relationship of the Tribe to Other Aleocharinae

The closest free-living aleocharine tribe to the Termitodiscini is the tribe Myrmedoniini. The following characters link the two tribes: (1) Nature of the teeth on the mandibles; (2) Structure of the legs; (3) Tarsal formula; (4) Structure of the prosternum; (5) The tri-lobed nature of the ninth abdominal segment.

The only termitophilous tribe that is close to the Termitodiscini is the subtribe Termitondina of the Myrmedoniini which may share common origins. More material of the Termitondina will be necessary before these relationships can be checked.

The relationship of the Termitodiscini to the Myrmedoniini does not destroy the tribal status of the Termitodiscini; it merely gives some idea of what the ancestral type must have been like.

Acknowledgments

A study like this is only possible with the cooperation and active interest of many people. For help in my field work, I cheerfully thank Dr. W. G. H. Coaton, Plant Protection Research Institute, Pretoria, South Africa; Dr. R. Lawrence and his son, Natal Museum, Pieter-

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For providing specimens collected by themselves and colleagues, I wish to thank particularly, Dr. W. G. H. Coaton. He and his colleagues, particularly Mr. J. L. Sheasby, have amassed a termitophile collection over the past six years for the Republic of South Africa and its dependency, Southwest Africa which is without equal for any other area of the world. For other specimens, I thank Dr. Alfred E. Emerson, University of Chicago, Dr. Kumar Krishna, American Museum of Natural History, and Mr. G. R. Cunningham-Van Someren.

I am also grateful to individuals for providing facilities and space during type study trips and also for cordial hospitality while in their institutions. These are Professor J. K. A. Van Boven, Université de Louvain, Belgium, also Curator of the Wasmann Collection at the Naturhistorisch Museum, Maastricht (N.H.M.); Mr. P. Basilewsky, Chef de la Section d'Entomologie, Musée Royal de l'Afrique Centrale Tervuren (M.R.A.C.); Mr. J. Balfour-Browne, British Museum (Natural History), London (B.M.N.H.), and Dr. Rupert L. Wenzel, Field Museum of Natural History, Chicago (F.M.N.H.). The initials given above indicate the institution wherein specimens cited are deposited. Specimens deposited in the collection of the author are indicated (D.K.) while those in the National Collection of Insects, Pretoria, South Africa are indicated (N.C.I.).

Termite host identifications are all credited in the text but I am extremely grateful to Dr. W. G. H. Coaton, Dr. A. E. Emerson, Dr. Kumar Krishna, and Mr. W. A. Sands, Termite Research Unit at the British Museum (Natural History) for taking the time to make the determinations.

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The Immature Instars of the Cleptoparasitic Genus *Dioxys* (Hymenoptera: Megachilidae)

Jerome G. Rozen, Jr.[1]

Abstract: The last-stage larva of *Dioxys pomonae pomonae* and *D. productus productus?* are described taxonomically and compared with the previously published account of the larva of *D. cincta* (Jurine). The three other larval instars and the pupa of *D. pomonae pomonae* are also described and the adaptive significance of some of the anatomical features of the larvae are discussed. A preliminary key is presented to distinguish among the genera of parasitic megachilid bees on the basis of the last larval instar.

The purposes of this paper are (1) to describe taxonomically the immature instars of the parasitic bee genus *Dioxys* and (2) to compare the external anatomy of the four larval instars of *Dioxys pomonae pomonae*. At the end, a key is given that may help in the identification of mature larvae of parasitic Megachilidae.

Cleptoparasitism (social parasitism) has evolved in at least three separate cases in the family Megachilidae. *Coelioxys*, usually a parasite of *Megachile* but also associated with *Centris*, *Anthophora*, and probably others, obviously arose from a *Megachile*-like ancestor. *Stelis*, *sensu lato* (including *Euaspis* and *Parevaspis*) and *Dioxys* (and related genera) presumably evolved from separate lineages in the Anthidiini. Most *Stelis*, *sensu lato*, apparently attack megachilids, although some (and perhaps all) species of the subgenus *Odontostelis* attack *Euglossa* (Friese, 1925; Bennett, 1966). The biology and larvae of *Stelis* are sufficiently diverse to raise the question whether this genus is monophyletic (Rozen, 1966). Insofar as known, all members of the *Dioxys* complex parasitize the Megachilinae (Hurd, 1958; Jaycox, 1966), but our lack of knowledge of their immature stages and biology does not permit us to speculate on the origin of parasitism in this group. I hope that data recorded here, as well as biological information presented in the accompanying report (Rozen and Favreau, 1967) will eventually be used for this purpose.

The number of larval instars in bees has been open to question because of the difficulty in rearing these animals. However, Hackwell and Stephen (1966) claim on the basis of carefully accumulated data that the halictid *Nomia melanderi* Cockerell has five instars. These men observed that the egg chorion encased the entire first instar except for most or all of the head capsule and that the first and second instars were similar in size. The first and second instars moved their mandibles back and forth and occasionally consumed liquid and pollen grains. Rozen (1964) stated that the embryo of the anthophorid

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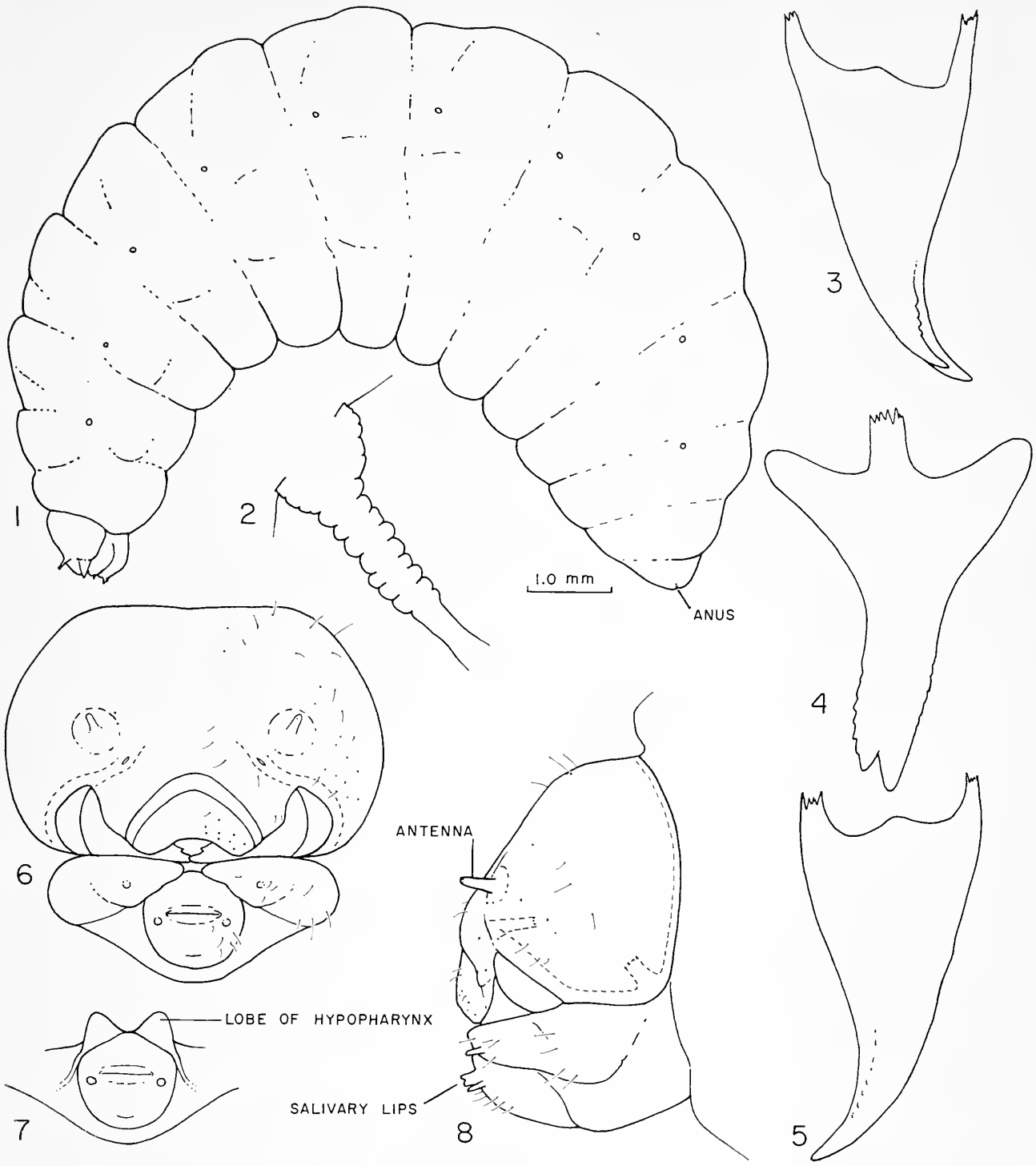


Figs. 1–8. Mature larva of *Dioxys pomonae pomonae* Cockerell. 1. Predefecating larva, lateral view (setae not shown). 2. Spiracle. 3–5. Right mandible, dorsal, inner, and ventral views, respectively. 6. Head, front view. 7. Labium, with mandibles removed, showing hypopharyngeal lobes, front view. 8. Head, lateral view. Scale refers to Fig. 1.

Svastra obliqua obliqua (Say) ingested liquid just before the chorion was cast off; shortly after eclosion a transparent embryonic cuticle was shed. The "first instar" of *Nomia melanderi* and the late "embryo" of *Svastra obliqua obliqua* are probably the same stage. If this is true, then the cryptic early stage may be a widespread phenomenon among bees, as *Nomia* and *Svastra* belong to separate families and as this stage has also apparently been observed

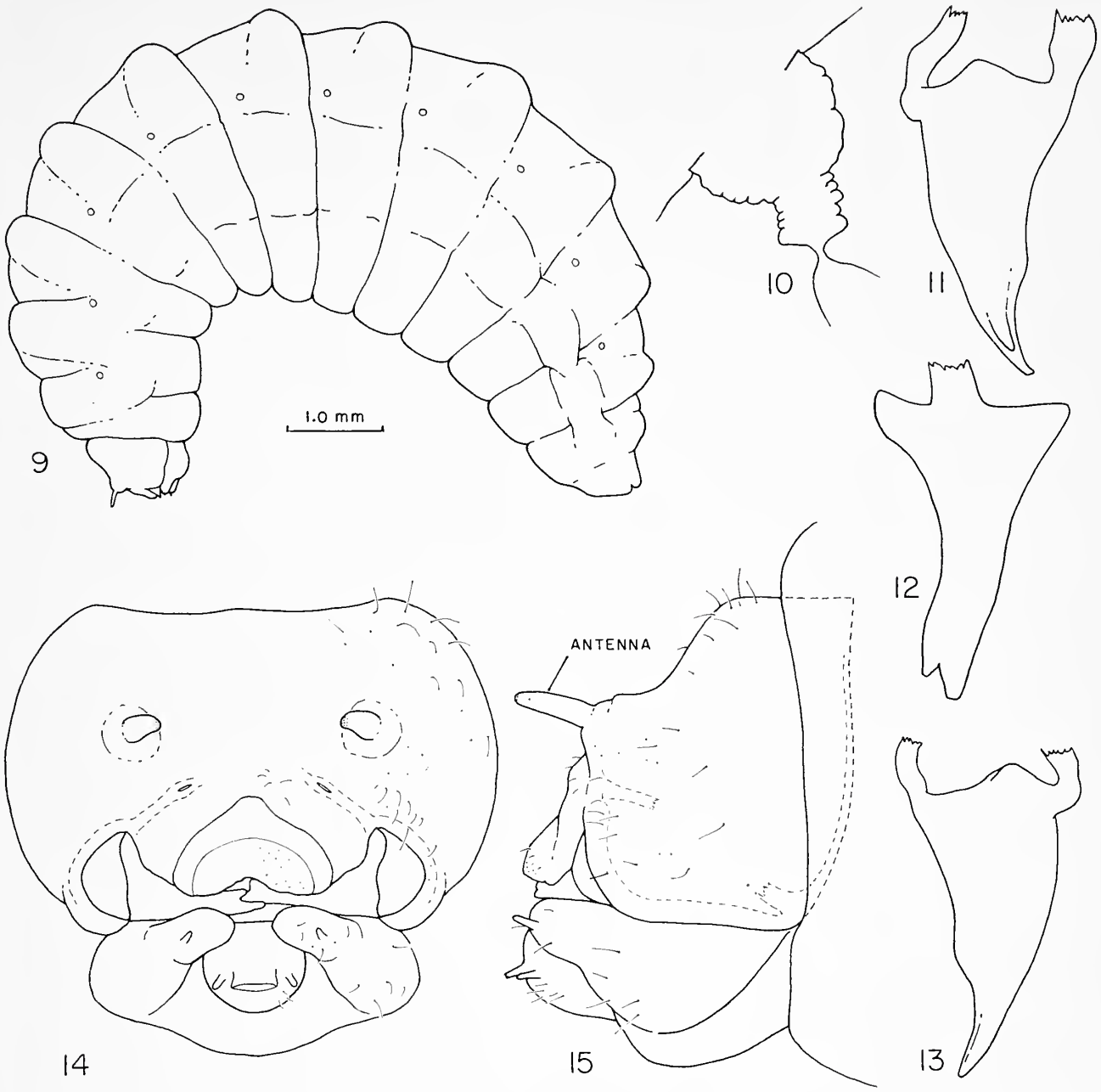
in the Panurginae (Rozen, 1967). Whether it represents the first instar, perhaps especially adapted to the task of ingesting fluid prior to casting off the chorion, or whether it is a late embryo can be determined only by further studies. In the case of *Dioxys pomonae pomonae* four distinct larval instars were observed. The early cryptic stage was not noticed though it may have been present. For the purpose of this paper, the "first instar" is the first actively moving stage, to which the chorion no longer adheres.

The specimens of *Dioxys productus productus?* described below were kindly made available by Dr. Elbert R. Jaycox, University of Illinois, Urbana. Dr. Paul D. Hurd, Jr., University of California, Berkeley, identified the adult *Dioxys*. The literature search was facilitated by the Bibliography of Apoid Biology directed by Dr. Charles D. Michener, the University of Kansas, Lawrence. Mrs. Marjorie Favreau ably assisted me in the field investigations and laboratory work which culminated in this study. My wife, Barbara, helped prepare the scientific illustrations, and Mrs. Rose Ismay carefully typed the manuscript.

MATURE LARVAE

Only a single account of an immature of this genus occurs in the literature; Micheli (1936) provided a useful description of the mature, fourth-stage larva of the European *Dioxys cincta* (Jurine), the type of the genus. Grandi (1934) reported on an unknown bee larva associated with *Chalicodoma muraria* (Fabricius), and although Michener (1953a) tentatively assigned it to *Dioxys*, the hairy mandible identifies it as a *Coelioxys*. I am describing here the mature larvae of two other species of *Dioxys*, *D. pomonae pomonae* and *D. productus productus?*.

The three known species have a number of features that may prove diagnostic for the genus. Unlike mature larvae of other megachilids, which are heavily pilose, those of *Dioxys* possess only widely scattered setae on the postcephalic region. The setae, sparse on the thorax, are even sparser on the abdominal segments. The bidentate mandibles (Figs. 3–5, 11–13) of the three species lack the apical concavity and cusp of other members of the family (except for some *Stelis*, Rozen, 1966) and differ from those of other Anthidiini (except some *Stelis*, *ibid.*, and *Trachusa*, Michener, 1953a) in that there are no small teeth on the margin between the apical teeth; of the three forms, only *D. pomonae pomonae* (Figs. 3–5) has such teeth on the upper and lower mandibular edges. The antennae of *D. cincta* apparently are not abnormally large for a megachilid but those of *D. pomonae pomonae* (Fig. 8) are distinctly greater in size than those of members of other genera. The antennae of *D. productus productus?* (Fig. 15), however, are the largest of any bee larva that I have seen. Antennal size therefore is helpful, both for species separation and, in some cases, for identification of the genus.



Figs. 9–15. Mature larva of *Dioxys productus productus* (Cresson)? 9. Larva, lateral view (setae not shown). 10. Spiracle. 11–13. Right mandible, dorsal, inner, and ventral views. 14, 15. Head, frontal and lateral views. Scale refers to Fig. 1.

In other respects, the fourth instar of *Dioxys* seems to possess the features of other members of the family. Whether the distinctive characters mentioned above warrant placing the genus in a separate tribe as contemplated by Michener (1944) after studying the adults, is open to question. In general the larvae of megachilids appear so similar that it is difficult to imagine that larval features will be of much assistance in arranging the higher classification of the family.

Dioxys pomonae pomonae Cockerell
Figures 1–8

HEAD: (Figs. 6–8) Integument with numerous scattered long setae and without spicules; antennae, labrum, pleurostomal ridges, hypostomal ridges, mandibles, cardines, stipites, palpi,

and base of prementum conspicuously pigmented. Tentorium complete and well developed; posterior pits conspicuous and normal in position; posterior thickening of head capsule and hypostomal ridge well developed; pleurostomal ridge and lateral arms of epistomal ridge moderately developed but not so sharply defined as hypostomal ridge; epistomal ridge fading just mesiad of anterior tentorial pits; longitudinal thickening of head capsule, cleavage lines, and parietal bands not evident; head constricted behind as in *D. productus productus?* but dorsolateral angles of capsule less produced. Antennal papilla elongate, apparently more so than that of *D. cincta* (Micheli, 1936) but papilla distinctly smaller than that of *D. productus productus?*; papilla slightly shorter than three times basal diameter; each papilla arising from inconspicuous prominence; these prominences distinctly less pronounced than those of *D. productus productus?*. Labrum without tubercles and with apical margin emarginate medially. Mandible (Figs. 3–5) without conspicuous setae, more elongate than that of *D. cincta* (Micheli, 1936), and apically bidentate with ventral tooth longer; margin between apical teeth smooth (i.e., nonserrate); dorsal apical edge with small but distinct teeth; ventral apical edge with inconspicuous serrations; apical concavity and cusp not present. Maxilla with basal part somewhat enlarged and with apex produced adorally; galea absent; palpus elongate but shorter and narrower than antennal papilla; cardo and stipes sclerotic. Labrum projecting, divided into prementum and postmentum and bearing salivary opening at apex; salivary opening a transverse slit with projecting lips; labial palpi perhaps slightly more slender than maxillary palpi; hypopharynx (Fig. 7) with prominent lobe on each side of maxilla.

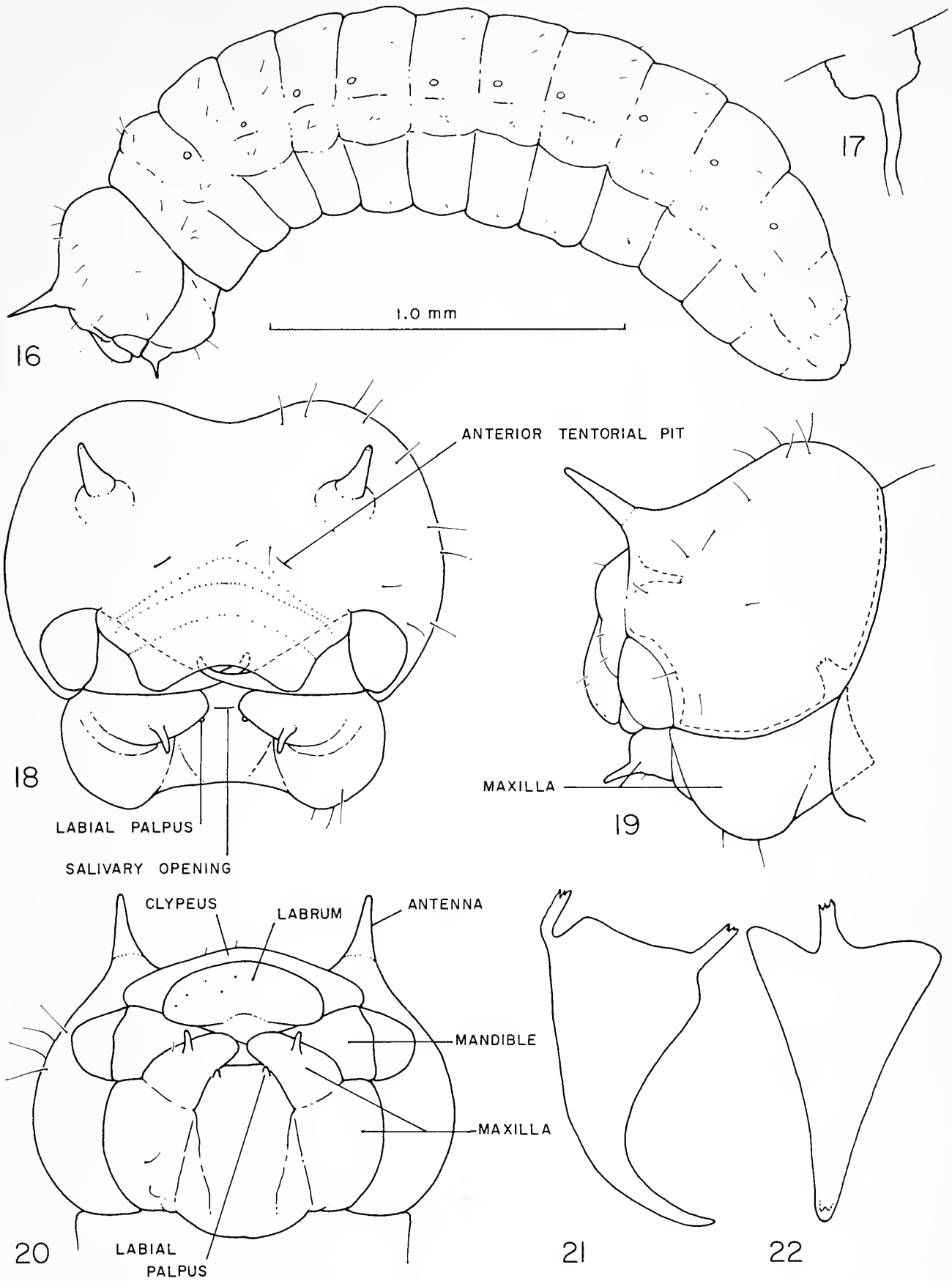
BODY: Form (Fig. 1) moderately robust; most body segments divided dorsally into low cephalic annulet and elevated caudal annulet on postdefecating larva; annulations on predefecating form indistinct; caudal annulets on postdefecating form low medially so that larva appears to have paired transverse dorsolateral tubercles; middorsal tubercles absent; lateral tubercles (below spiracles) well developed (at least on postdefecating form). Integument soft; scattered setae (not shown in illustration) found on caudal annulets, lateral tubercles, and venter; these setae approximately as dense as those of *D. productus productus?*, but much sparser than those of host *Osmia nigrobarbata* and other megachilids. Spiracular atrium (Fig. 2) large, with ridges; atrium projecting somewhat above body wall and with rim; peritreme present but narrow so that opening appears large; primary tracheal opening without distinct collar; subatrium normally long. Tenth abdominal segment moderate in length and with anus situated dorsally.

MATERIAL STUDIED: One postdefecating larva, 3 miles north of Apache, Cochise County, Arizona, April 30 through May 4, 1966; larva preserved October 14, 1966; from nest of *Osmia nigrobarbata* Cockerell (J. G. Rozen and M. Favreau); two predefecating mature larvae, same data except preserved at time of collection.

Dioxys productus productus (Cresson)?
Figures 9–15

These larvae were discussed by Jaycox (1966).

HEAD: (Figs. 14, 15) As described for *D. pomonae pomonae* except for following: Dorsolateral angles of head produced, apparently as in *D. cincta* (Micheli, 1936), and more so than in *D. pomonae pomonae*. Antennal papilla enormously elongate, being a little over three times longer than basal diameter; each papilla arising from restricted but pronounced prominence. Mandible (Figs. 11–13) like that of *D. pomonae pomonae* except dorsal and ventral apical edges without teeth or serrations.



Figs. 16–22. First instar of *Dioxys pomonae pomonae* Cockerell. 16. Larva, lateral view. 17. Spiracle. 18–20. Head, frontal, lateral, and ventral views, respectively. 21, 22. Right mandible, dorsal and inner views. Scale refers to Fig. 16.

BODY: (Fig. 9) As described for *D. pomonae pomonae* except spiracular subatrium short (Fig. 10).

MATERIAL STUDIED: One mature larva, Smithfield, Cache County, Utah, June 30, 1962, from *Anthidium* nest in small plastic tube; fixed July 2, 1962 (E. R. Jaycox); one mature larva, same locality, June 31, 1961; from nest of *Anthidium*; fixed July 19, 1962 (E. R. Jaycox).

OTHER INSTARS

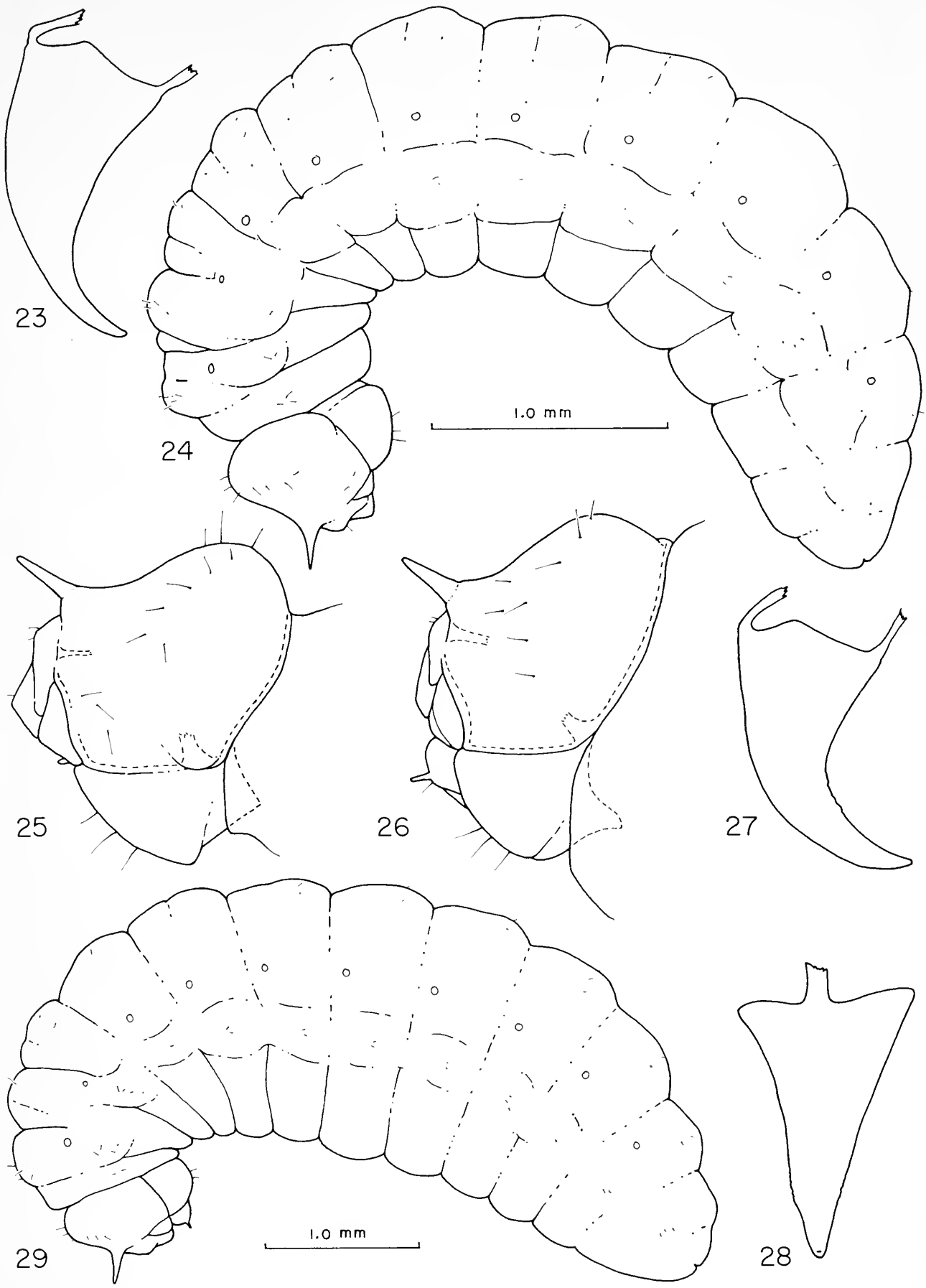
None of the other immature instars of this genus has been described before; all of the following belong to *Dioxys pomonae pomonae*.

First-Stage Larva of *Dioxys pomonae pomonae* Cockerell
Figures 16–22

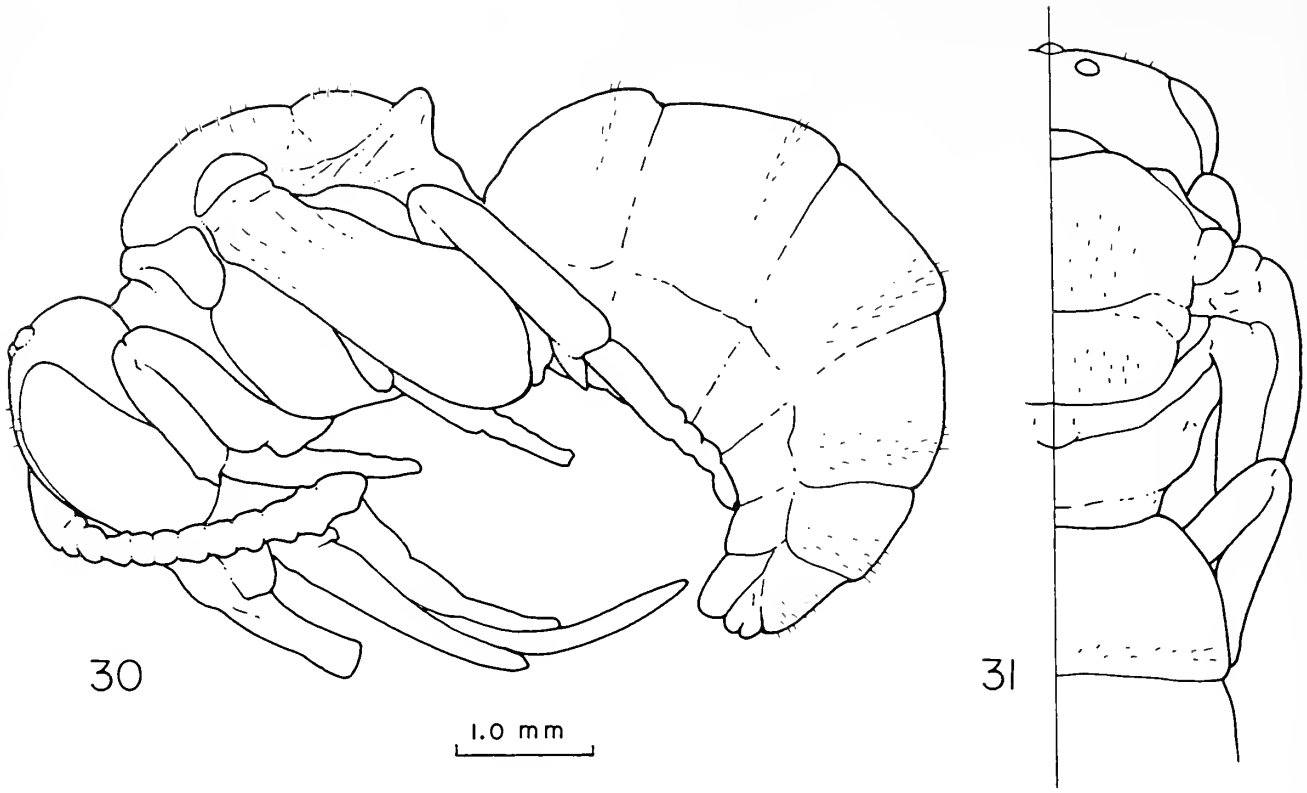
HEAD: (Figs. 18–20) Head hypognathous, not prognathous as in *Coelioxys*. Integument slightly pigmented and, unlike that of host, with scattered long setae. Tentorium complete, including thin dorsal arms; posterior tentorial pits normal in position; posterior thickening of head capsule and hypostomal ridge slender but evident; pleurostomal ridge weak except at mandibular articulations; epistomal ridge scarcely evident, both mesiad and laterad of anterior tentorial pits; these pits well developed; longitudinal thickening of head capsule faint; cleavage lines and parietal bands not evident; head somewhat constricted behind; genal area, unlike that of *Coelioxys*, not produced anteroventrally into long tubercle-like projection. Antennal papilla greatly elongate, length about four times basal diameter; each papilla arising from conspicuous prominence. Labrum without tubercles and with apical margin emarginate medially and with sensilla. Mandible (Figs. 21, 22) elongate, without conspicuous setae, and with apex simple, tapering, curved, and pigmented. Maxilla with basal part greatly enlarged and sclerotized (Fig. 19); apical part directed adorally; palpus elongate; galea absent. Labium, unlike that of other bee larvae, not extending ventrally so far as maxillae; labium recessed, not divided into prementum and postmentum, and apparently somewhat sclerotized though not so strongly sclerotized as that of first instar of *Coelioxys*; salivary opening a small transverse slit; palpi shorter than maxillary palpi, about as long as basal diameter.

BODY: Form (Fig. 16) moderately slender and straight; some body segments possibly with intrasegmental lines; middorsal tubercles absent; distinct lateral tubercles (i.e., "ventral lateral tubercles" of *Odontostelis*, Rozen, 1966) conspicuous on most segments. Integument with scattered setae (in contrast with integument of first instar of host which lacks setae); setae on anterior part of body longer than those on posterior part; on most abdominal segments setae situated on posterior part of segment dorsally, at apices of lateral tubercles, and widely scattered on venter; integument finely spiculate in numerous areas, including most of the tenth abdominal segment. Spiracles moderately large except for second pair which are distinctly smaller than others; atrium (Fig. 17) not projecting above body wall, with a peritreme, and slightly wider than deep; atrial wall apparently with indistinct ridges; primary tracheal opening apparently without collar. Tenth abdominal segment without large lobes or other modifications; anus slightly dorsal in position.

MATERIAL STUDIED: One first-stage larva, 3 miles north of Apache, Cochise County, Arizona, April 30, 1966; from nest of *Osmia nigrobarbata* (J. G. Rozen and M. Favreau).



Figs. 23–29. *Dioxys pomonae pomonae* Cockerell. 23. Right mandible of second instar, dorsal view. 24. Second instar, lateral view. 25. Head of second instar, lateral view. 26. Head of third instar, lateral view. 27, 28. Right mandible of third instar, dorsal and inner views. 29. Third instar, lateral view. Scales refer to Figs. 24 and 29, respectively.



FIGS. 30, 31. Pupa of *Dioxys pomonae pomonae* Cockerell, lateral and dorsal views.

Second-Stage Larva of *Dioxys pomonae pomonae* Cockerell
Figures 23–25

HEAD: (Fig. 25) As described for first instar except for following: Posterior thickening of head capsule, hypostomal ridges, pleurostomal ridges, epistomal ridge, and longitudinal thickening of head capsule slightly more evident. Mandible (Fig. 23) not quite so slender and slightly shorter in relation to size of head.
BODY: (Fig. 24) As described for first instar.

MATERIAL STUDIED: One second-stage larva, 3 miles north of Apache, Cochise County, Arizona, April 30, 1966; from nest of *Osmia nigrobarbata* (J. G. Rozen and M. Favreau).

Third-Stage Larva of *Dioxys pomonae pomonae* Cockerell
Figures 26–29

HEAD: (Fig. 26) As described for first instar except for following: Internal ridges of head capsule more distinct than those of second instar. Mandible (Figs. 27, 28) stouter than that of either first or second instar and shorter in relation to size of head. Both dorsal and ventral subapical inner edges faintly and indistinctly dentate.
BODY: (Fig. 29) As described for first instar.

MATERIAL STUDIED: One third-stage larva, 3 miles north of Apache, Cochise County, Arizona, May 4, 1966; from nest of *Osmia nigrobarbata* (J. G. Rozen and M. Favreau).

Pupa of *Dioxys pomonae pomonae* Cockerell
Figures 30–31

Length, 6.75 mm; body curved so that tip of tongue almost touching tip of metasoma.
HEAD: Scape and frons without tubercles; vertex without tubercles except for low mounds of ocelli; scattered small, unpigmented setae occurring mesiad of upper inner orbits but not above level of anterior ocellus; setae less abundant than those on head of *Stelis bilineolata* (Rozen, 1966).
MESOSOMA: Lateral angles of pronotum somewhat produced; posterior lobes not produced; mesepisternum, mesoscutum, mesoscutellum, and axillae without tubercles and not produced; metanotum produced as distinct median rounded tubercle; slightly pigmented setae present on mesoscutum and mesoscutellum but not on axillae; these setae fewer than those of *Stelis bilineolata* and somewhat longer than those of head; tegula not produced; wing without tubercles; fore tibia with apical tubercle; mid and hind tibia each with somewhat smaller apical tubercle; other leg segments without distinct tubercles.
METASOMA: Terga I–VI with apical bands of short, unpigmented setae rising from minute tubercles; sterna without tubercles or setae; terminal spine absent.

MATERIAL STUDIED: One live female pupa, 3 miles north of Apache, Cochise County, Arizona, larva collected May, 1966, pupated approximately September 1, 1966; from cell of *Osmia nigrobarbata* Cockerell (J. G. Rozen and M. Favreau).

DISCUSSION

The larvae of most nonparasitic bees superficially seem to change merely in size as they develop. Indeed, the four instars exist in the same environment, and their behavior, concerned primarily with feeding, is quite uniform. It would be surprising, therefore, if marked differences occurred from one instar to the next. A number of workers have noticed, however, changes with respect to the various tubercles on the postcephalic region in some groups. The tubercles seem to be associated with the feeding habits of the larva; the changes are presumably adaptations to the modifications in the shape, consistency, and size of the pollen mass as it is being consumed. Conspicuous changes also appear in the larvae of cocoon-spinning bees; such features as long palpi, projecting labiomaxillary region, and protruding salivary lips, that appear in the later instars are adaptations to cocoon spinning.

More pronounced differences among instars have been noted with certain parasitic bees, such as the Nomadinae. The mode of parasitism in this group indicates that the first instar kills the egg or larva of the host and subsequent instars consume the pollen-nectar mixture. The first instar is equipped with a pigmented, more or less prognathous head capsule and greatly elongate, sickle-shaped mandibles with which it destroys the host's offspring. The tip of the abdomen, at least in some cases, is modified into a pygopod-like structure enabling the larva to move about in search of its prey. Not only is the host's egg or larva eliminated but also sibling larvae, for a female nomadine often lays more than one egg in a cell. The second and subsequent instars are much more

"normal," lacking most of the specialized modifications of the first stage. This pattern of parasitism seems to be the most common in the Apoidea and has arisen *de novo* a number of times.

Another mode of parasitism occurs in the subgenus *Odontostelis* (Bennett, 1966) and apparently in *Sphecodes*; the adult cuckoo bee removes the host egg or young larva before depositing her own egg, and the first instar hatches as a "normal" type.

In *Dioxys* still another pattern of parasitism seems to be represented: the host's offspring may be killed by the first, second or third instar of the cuckoo bee. Not only the first instar but also the second and third possess large sickle-shaped mandibles, and at least the first and second instars display an aggressive behavior when touched with forceps (Rozen and Favreau, 1967). None of the instars has an obvious pygopod-like structure for pushing itself around the cell or on the pollen mass. These facts suggest that the larva, because of a slow mobility, may pass through several stages before it encounters and eliminates the host larva. Also, the egg of *Dioxys* is apparently inserted through the cell wall, probably after the cell is closed. Hence parasitism of a cell may take place over a considerable period of time. The first three instars of *Dioxys* are equipped to kill eggs of other *Dioxys* when and if they are introduced into an already parasitized cell. The ability of the intermediate instar to eliminate host and siblings may also be found in *Coelioxys* (Michener, 1953b) and in those *Stelis* which have apically simple mandibles in the last larval stage (Rozen, 1966).

The changes that occur from one larval instar to the next in *Dioxys pomonae pomonae* involve the change in body size and form (Figs. 1, 16, 24, 29); the width of the head capsule of the four instars is as follows: first, 0.65 mm (one datum); second, 0.875 mm (one datum); third, 0.95 mm (one datum); fourth, 1.10–1.13 mm (three data). The antennae become relatively smaller with each instar though they are still large even in the fourth instar. The mandibles become shorter in relation to head size and the denticles on the upper and lower subapical edges first appear in the third stage. However, the dorsal apical tooth is a feature solely of the last instar as are the projecting enlarged labium, the division of the labium into a prementum and a postmentum, the protruding salivary lips, and the annulations of the spiracular subatria. The basal part of the maxilla is greatly enlarged in the first instar, a condition that holds for the second and third stages and persists to some extent in the last larval instar. The internal ridges of the head, including the stipites and the cardines, appear to become successively more pronounced with each instar.

In other respects the larval instars of *D. pomonae pomonae* are remarkably similar. Even the setae which become shorter in relation to the body size, from instar to instar, maintain the same general distribution on the body through all instars. Indeed, the overall constancy of the external anatomical features is

a more surprising result of the study than are the changes that take place in the development of the larva.

Key to Some Genera of Cleptoparasitic Megachilidae, Based on the Mature Larvae

Although this key is based only on the few species that I have examined, it may be of some value in separating the genera of megachilid cuckoo bees. Mature megachilid larvae, as a group, can be recognized because of the setae found on the postcephalic region; only the anthophorid genus *Allodape* and its relatives also bear conspicuous setae.

1. Mandible with more than four conspicuous setae on outer surface (Michener, 1953a, Figs. 160–161); gena, at least usually, produced into downward-pointing tubercle immediately behind posterior mandibular articulation (Michener, 1953b, Fig. 26) ..... *Coelioxys* (two species)

   Mandible with at most one or two inconspicuous setae (Figs. 3, 5, 11, 13); gena without tubercle (Figs. 8, 15) 2

2. Body setae widely scattered and few; dorsal body setae restricted to caudal annulets on middle segments; vertex depressed medially; basal part of maxilla somewhat enlarged (Figs. 8, 15) ..... *Dioxys* (two species)

   Body setae abundant; dorsal body setae numerous on both the caudal and cephalic annulets of middle segments; vertex not abnormally depressed medially; basal part of maxilla normal in size (Rozen, 1966, Figs. 5, 10) ..... *Stelis* (three species)

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RECEIVED FOR PUBLICATION JUNE 13, 1967

Exchange Opportunities in Eastern Europe

The National Academy of Sciences invites applications from American scientists who wish to visit Poland, Romania, and Yugoslavia for varying periods during the 1967–68 academic year. Through arrangements with the academies of these countries, the NAS will be able to select Americans for one-month survey visits or for research visits of from 3 to 12 months.

Applicants for all programs must be U.S. citizens and have a doctoral degree or its equivalent in physical, biological, or behavioral sciences, mathematics, or engineering sciences. Applicants should specify which country they wish to visit since combined visits to two or more cannot be conveniently arranged. Participants will receive transportation to and from the foreign country. Those making research visits of 3 months or longer will receive grants to offset the loss of salary. Those making visits of 5 months or longer may also receive support for travel of dependents. Allowances from the receiving academy vary according to individual programs. Full information and applications may be obtained from the National Academy of Sciences, Office of the Foreign Secretary (USSR/EE), Washington, D.C. 20418.

Proceedings of the New York Entomological Society

(Meetings held in Room 129 of the American Museum of Natural History unless otherwise indicated.)

Meeting of April 4, 1967

Dr. Fredrickson presided; 23 members and 7 guests were present. Dr. Pinter of Harvard University, an expert on spiders, was introduced as a guest.

PROGRAM. **Entomological Wanderings in Africa.** Dr. Jerome Rozen, Chairman of the Department of Entomology at the Museum, described his recent trip to Africa where he searched for nests and immature stages of bees. The trip included short visits to Egypt and Nairobi, and a more extensive excursion in South Africa. He described the terrain in these areas, and commented on the flora, the fauna, and some points of interest along the way. His talk was illustrated with many colored slides.

HOWARD R. TOPOFF, *Sec.*

Meeting of April 18, 1967

President Fredrickson presided; 15 members and 4 guests were present. Dr. Alexander Klots reported for the Auditing Committee, stating that the records of the Society for 1966 were examined, and the accounts were found to be accurate and complete. The report was accepted, and the Committee was thanked. Dr. Michael Emsley of the Philadelphia Academy of Natural Science was proposed for active membership in the Society. Mrs. Betty Slater, wife of the speaker of the evening, was introduced.

PROGRAM. **Zoogeography, Classification, and Evolution of the Chinch Bugs.** Dr. James A. Slater, Chairman of the Department of Zoology and Entomology, University of Connecticut, gave a résumé of the classification of chinch bugs and indicated their general importance. He spoke about the zoogeography and the evolution of these insects. He pointed out that there is a close relationship between the chinch bug fauna in South America and that in Africa; this opened a discussion of continental drift. Dr. Slater's talk was illustrated with slides.

HOWARD R. TOPOFF, *Sec.*

Meeting of May 2, 1967

President Fredrickson called the meeting to order; 21 members and 7 guests were present. Dr. Michael Emsley of the Philadelphia Academy of Natural Sciences was elected to active membership, and Dr. Allen Benton of the State University College at Fredonia, New York was proposed for membership.

PROGRAM. **Coding of Chemical Informtaion by Insects.** Dr. Edward S. Hodgson of the Department of Zoology, Columbia University, illustrated his talk with slides. (An abstract follows.)

HOWARD R. TOPOFF, *Sec.*

CODING OF CHEMICAL INFORMATION BY INSECTS

Recent developments in studies of the chemical senses of insects were described. The electron microscope has shown that sensory structures typically have pores which allow

chemical stimuli direct access to receptor neurons. Electrical events in receptor excitation are best studied in sensilla on mouthparts of flies. Four taste receptor types have been identified: receptors for cations, anions, sugars, and water. Only the anion receptor mediates rejection responses under all conditions. Sensitivity of the chemoreceptors is affected by internal hormonal state as well as by external stimuli.

E. S. HODGSON

Meeting of May 16, 1967

The meeting was called to order by Vice-president David Miller in the absence of the President; 16 members and 7 guests were present. Dr. Allen Benton of the State University College at Fredonia, New York was elected to membership. Dr. James Forbes, the Society's delegate to the 11th Annual Conference of Biological Editors which was held at the Barbizon-Plaza Hotel, May 7–9, presented his report. Some of the problems and the topics considered by the Biological Editors this year were what constitutes primary publication, costs of printing journals, the use of key words in the titles of articles for properly designating their contents, and unreferred publications. He feels that the participation in these meetings over the past years has improved the quality of our **Journal**. He thanked the members for the opportunity to represent them.

PROGRAM. **Of Mice, Malaria, and Mosquitoes.** Dr. Jerome Vanderberg of the Department of Preventative Medicine of the New York University Medical School illustrated his talk with slides. (An abstract follows.)

HOWARD R. TOPOFF, *Sec.*

OF MICE, MALARIA, AND MOSQUITOES

Studies in the Department of Preventative Medicine during the past several years have been aimed at developing a model system of mammalian malaria which could be easily maintained and studied in the laboratory. The rodent malarial parasite, *Plasmodium berghei*, is a suitable organism in this regard, and the parasite can be transmitted through the mosquito, *Anopheles stephensi*, under controlled conditions. An important factor determining the success of this transmission is the temperature at which infected mosquitoes are kept. An inbred strain of mice from the Jackson Memorial Laboratory (Strain A/J) is a highly susceptible host for this parasite. By utilizing this system it has been possible to perform studies on basic physiology and morphogenesis of the malarial parasite, and in the applied area attempts have been made to develop a vaccine for malaria.

J. VANDERBERG

INDEX TO SCIENTIFIC NAMES OF ANIMALS AND PLANTS

VOLUME LXXV

Generic names begin with capital letters. New genera, subspecies, and varieties are printed in italics. This index does not include the genera and subgenera of the Tortricidae and Phaloniidae, pp. 2–11; the aphids and their food plants, pp. 72–92; synonyms in American spiders, pp. 126–131.

INVITATION TO MEMBERSHIP

The New York Entomological Society was founded in 1892 and incorporated the following year. It holds a distinguished position among scientific and cultural organizations. The Society's **Journal** is one of the oldest of the leading entomological periodicals in the United States. Members and subscribers are drawn from all parts of the world, and they include distinguished professional naturalists, enthusiastic amateurs, and laymen for whom insects are only one among many interests.

You are cordially invited to apply for membership in the Society or to subscribe to its **Journal** which is published quarterly. Regular meetings are held at 8:00 P.M. on the first and third Tuesdays of each month from October through May at the American Museum of Natural History, the headquarters of the Society. A subject of general interest is discussed at each meeting by an invited speaker. No special training in biology or entomology is necessary for the enjoyment of these talks, most of which are illustrated. Candidates for membership are proposed at a regular meeting and are voted upon at the following meeting.

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