VELVET MITES FROM NORTHERN MICHIGAN DECIDUOUS FOREST

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ABSTRACT

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Among 25 species of velvet mites collected in Michigan's Upper Peninsula, 13 species and one genus were found to be new to science. Six species were described based on all developmental stages, including laboratory reared specimens. Three species were described in both larval and adult stages. Description of three more species was based on larvae only. One species was described in the adult form. Larval and adult forms of several species (*Abrolophus welbourni n. sp.*, *Trombidium auroraense*, *Eutrombidium locustarum*, *Leptus solitarius n. sp.*, *L. sylvestratilis n. sp.*, *Erythraeus michiganensis* n. sp., and *Podothrombium fucium* n. sp.) were correlated by laboratory and field observations. Based on laboratory rearing and field collections, larvae of a species previously placed in *Hauptmannia* were shown to belong in the genus *Abrolophus*.

The life histories of 11 species were documented in field and laboratory studies. Three life cycle types were distinguishable according to overwintering life stages: 1) diapausing tritonymphs; 2) eggs; and 3) diapausing protonymphs.

A list of arthropod hosts accepted by 18 species of mites was compiled from field observations and laboratory tests. Mechanisms of coexistence for larvae of *Trombidium auroraense*, *Leptus sylvestratilis* and *Eutrombidium locustarum* sharing a single host resource (*Melanoplus differentialis*) were documented.

Diel activity patterns of the larvae of two dominant mite species were observed

in the field by means of pit-trapping. These patterns were found to be partly related to relative humidity, an observation confirmed by the laboratory response of species to different relative humidities. The duration of developmental stages of three dominant species (*T. auroraense*, *E. locustarum* and *L. sylvestratilis*) was documented under laboratory conditions. A life table was drawn up for the above three species based on 3 years of laboratory rearing.

In memory of unforgettable years in East Lansing, Michigan State University,

in memory of the good American people in my life.....

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Special thanks are given to my all committee members, Drs. R. J. Snider, R. M. Snider, F. Stehr and J. Atkinson, especially my major professor Dr. R. J. Snider. Without their encouragement and advice through the years, I would not have been able to finish the degree in the States since the roads here are very slippery for a Chinese. I am also thankful to Dr. Calvin Welbourn, Ohio State University, for checking my species determinations and classification; and to Mr. Mark Thogerson for his help on computer work.

PREFACE

Mention of "Project ELF" will be made at several points in this dissertation in reference to a long-term ecological monitoring project in Michigan's Upper Peninsula, (funded by the U. S. Navy*) and led by Richard J. Snider and Renate M. Snider. While I was actively participating in this project's research, I was also able to gather much of the data presented below. Most of my results were derived from personal collections and experiments, but Project ELF supplied additional specimens and information which augmented my own database. Project ELF information pertaining to velvet mites was obtained mainly by pit-trapping at weekly intervals from May through October (ref. Snider and Snider, 1987 for details); additional specimens stemmed from heat-extraction of soil and litter samples.

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INTRODUCTION

Velvet mites (Trombidioidea and Erythraeoidea: Acarina) are currently composed of three superfamilies, six families, 18 subfamilies, 132 genera and 1018 species worldwide (Welbourn, 1987). Thirty-eight species have been described from North America (Smiley, 1968; Treat, 1975; Treat et. al, 1979; Fain et. al, 1987; V. Grandjean, 1977; Southcott, 1988, 1991; Welbourn, 1987, 1988, 1991).

Unfortunately, the classification of this group remains unsettled. Vercammen-Grandjean (1973) proposed six subfamilies and Robaux et. al (1976) added a seventh in the family Trombidiidae. Southcott (1966) derived the family Chyzriidae from Trombellidae. Vercammen-Grandjean (1973) added Protoerythraeidae to Erythraeidae. Welbourn (1987) estimated at least five families in this group. A major cause for the taxonomic controversy is that many species have been described based on only one life stage, either larvae or adults, so that a long list of synonyms exists for these species (Krantz, 1978; Southcott, 1966, 1979; Treat, 1980; Welbourn, 1987).

A few species have been described based on field collected adults and larvae hatched from their eggs (Welbourn, 1991; Rosa and Flechtman, 1980; Treat, 1980). Because of their different seasonal appearance and habitat requirements, it is often difficult to collect all instars. More species descriptions based on all instars, or at least on larvae and adults, are needed for accurate identification (Southcott, 1961a, b; V. Grandjean, 1973; Krantz, 1978; Welbourn, 1983, 1991).

More than 50 of the currently known 185 acarine families contain species which have been reported as parasitic. Trombidia (excluding Trombiculidae) parasitize or prey upon a wide variety of arthropods, including some economically important insect pests. Host species are currently known for about 20 percent of the 1,000 named taxa. Post-larval prey are known for only 2 percent of all described Trombidia. Most genera attack only one host order or family, and often only one genus. For some genera, it is impossible to determine host preference as long as there is only one described species and one host record (Welbourn, 1983).

Information on feeding behavior, host selectivity of larvae, fecundity of adults, host-parasite relations and responses to environmental variables is rare since most species reared in the laboratory cannot be brought to oviposit (Treat, 1975; Southcott, 1946, 1961; Rosa and Flechtman, 1980; Welbourn, 1991).

In North America, Treat (1975) summarized information on *Leptus* (Erythraeidea: Trombidia) and their insect hosts, particularly Noctuidae, in Massachusetts. Houseweart et al. (1980) reported that 28 percent of nearly 2,300 male spruce budworm moths, *Choristoneura fumiferana* (Clemens)(Tortricidae: Lepidoptera), collected in pheromone traps over a 3-day period, were parasitized by larvae of two species of *Leptus*.

The work of Putman (1970), Cadogan and Laing (1977) and Childers and Rock (1980) in the field and laboratory showed that *Balaustium putmani* Smiley, 1968 (Erythraeidea: Trombidia) were active predators of small insects and mites as well as vegetarians feeding on plant pollen in orchards. The non-parasitic larvae, however, could not survive in the laboratory if fed only on pollen. Adults were predators on eggs of the

oriental fruit moths, *Grapholitha molesta* (Busck)(Olethreutidae: Lepidoptera) and *Lamphygma frugiperda* (Abbott and Smith)(Noctuidae: Lepidoptera) as well as other insects and mites in North Carolina apple orchards (Childers and Rock, 1981).

Severin (1944) documented the occurrence of post-larval instars of *Eutrombidium locustarum* Miller, 1934 (Trombidioidea: Trombidia) in egg chambers of grasshoppers, where they fed on eggs. In laboratory studies, deutonymphs fed on 1 to 14 eggs, and an adult consumed 5 to 20 eggs during its lifetime.

Huggans and Blickenstaff (1966) found *E. locustarum* to be continuously active from May through October in Missouri, with five species of *Melanoplus* (Acrididae: Orthoptera) serving as major hosts. The species was reported by Severin (1944) to produce 1,027 to 9,542 eggs. Huggans and Blickenstaff (1966) obtained about 200,000 *E. locustarum* eggs in two months. Unfortunately, neither of these reports specify the fecundity of the species per single female. Fecundity of *B. putmani*, a non-parasitic velvet mite, was reported as 175 eggs per female in up to six batches over a 20-day period (Putman, 1970).

Treat (1975) obtained eight deutonymphs and one male adult of *Leptus*, collectively comprising three undetermined species, from reared larvae attached to *Oligia exhausta* (J. B. Smith)(Noctuidae: Lepidoptera). The behavior of the three deutonymphs was recorded in detail. No other laboratory rearing of all instars of parasitic velvet mites has been done since then.

Objectives of the present study were:

1. to identify the species of velvet mites collected in a deciduous forest in Michigan's

Upper Peninsula, and to describe those which were new to science; and whenever possible, to correlate adult, nymphal and larval stages of each species, using specimens obtained by Project ELF and by additional field collections combined with laboratory rearing.

2. to document life history parameters for as many species as possible, including developmental rates, fecundity, and host preferences of parasitic larvae, through field observations as well as laboratory experiments.

PART I. CLASSIFICATION

PART I. CLASSIFICATION

1. MATERIALS AND METHODS

The description of nine species is based on laboratory-reared larvae, deutonymphs and adults, parent females of which were field collected in 1989, 1990 and 1991. Description of the other four species is based on field-collected larvae; no post-larval instars of these species were found. Additional specimens stemmed from samples obtained for Project ELF, especially with respect to deutonymphs and adults.

The methods used in Project ELF included pitfall traps and extaction of litter and soil samples (Snider & Snider, 1986, 1987). Two other methods were used to obtain mite larvae (attached to insects) from the study site:

1). sweep net: every other day, insects were collected from bushes, trees, grasses, and other ground vegetation around the site;

2). light traps: from mid-June to mid-August, on warm, mild nights, an auto-trouble light was used from sundown to midnight. The light trap consisted of a 12-w light tube suspended over a white sheet of fabric.

In addition, hand-collecting of adults was very useful during their main period of activity. This method was very effective along paths and edges of the forest where ground cover was scarce.

Laboratory rearing:

Wharton (1946) showed that a mixture of plaster-of-Paris and powdered charcoal provided the best substrate for rearing chiggers and other mites. Other researchers (Michener, 1946; Melvin, 1946; Farrell & Wharton, 1948; Huber, 1958;

Lipovsky, 1953) suggested various improvements in chigger culturing techniques. The general consensus was that a mixture of plaster-of-Paris and powdered charcoal (USP grade) in a 9:1 by weight or 12:1 by volume ratio is best for rearing chiggers and all other terrestrial Parasitengona. Following Dr. Snider's suggestion for rearing Collembola (Snider, 1973), I preferred to use a 1:1 by volume mixture, with a few grooves in the substrate to provide a retreat for the mite or a site for egg deposition. For some species, a piece of moss with soil or a piece of bark was supplied as a shelter for the mites.

In the laboratory, various rearing containers were found to be adequate for mites and their hosts. Many parasitic larvae attached to hosts were reared in glass jars with fine screen covers. Grasshoppers and moths were kept in large insect rearing cages with fine screen sides.

Prey for mites, particularly for deutonymphs and adults, consisted of Collembola and their eggs as routine food year-round, and other soft-bodied insects collected from the site were supplied as seasonal food.

Food sources for insect hosts with mite larvae attached were different from species to species. Water, 5% honey solution and tissue paper were provided as food and shelter for moths, and fresh grass and water served as food for grasshoppers. Replacement of old food was necessary every day.

For non-parasitic larvae of *Balaustium discessus* n. sp., as well as for its deutonymphs and adults, pollen from different plant species in spring and summer was provided. Small insects and leaf mites were used as seasonal food as well.

From spring to fall, insect rearing containers were placed in incubators at constant

14 ± 1.5 °C and an 8-hour light cycle. During winter, diapausing mites were placed in a cold room at -4 ± 1.5 °C until the following spring.

Classification:

Terminology and description format follow those of Southcott (1987, 1988, 1989) and Welbourn (1983,1991). Legs were measured from coxal field to the base of pretarsal claws. All measurements are given in micrometers. The diameter of the eyes includes that of the lens and the surrounding rings. The "standard data" proposed by Southcott (1961) for the scutum or prodorsal sclerite are followed. Another measurement used, following Fain et. al. (1987), is the perpendicular distance between the base of anterior sensillae and anterior scutum edge at the midline (ASBM). Number of dorsal idiosomal setae of adults and deutonymphs is given as number of setae per 1000 μm, based on three separate counts in different body areas randomly selected per mite.

2. SITE DESCRIPTION:

Characteristics of the study area discussed in 2. 1. through 2. 3. were excerpted from Snider and Snider (1987).

2.1. Location and climatic conditions:

The study site was located in Michigan's Upper Peninsula, Dickinson County, on Turner Road near Channing (T44N, R29W, S25), at an altitude of approximately 420 m.

Area climate is temperate continental of the cool summer type. Yearly average temperature is 5.4 °C, with an average high of 26 °C and an average low of -15 °C (30-year means). Annual mean precipitation is 768 mm, evenly distributed, and snowfall

occurs from September to May.

2.2. Soils:

The soil in the site was developed on coarse- to medium-textured glacial till, and boulders were commonly encountered at or near the soil surface. According to the American system (Anonymous, 1975), the soil could be classified as Alcona series (Alfic Haplorthods, coarse-loamy, mixed, frigid), a naturally well-drained Spodosol (podzol). Texture of A and upper B horizons are listed in Table 1. Macronutients, organic matter and other soil characteristics are listed in Table 2.

Table 1. Texture and thickness off the upper soil profile at the study site: means±SE (N=20).

Horizon	Thickness	% sand	% silt	% clay
A	5-15, sl*	58.6±0.9	24.9±0.7	16.4±0.3
B	0-12, sl	58.7±1.1	23.2±1.4	18.9±0.3

*sl=sandy loam

Table 2. Macronutrients (Kg/ha), pH and percent Organic Matter of the soil in the study site.

variable	A horizon	Upper B horizon
pH	5.8±0.06	5.8±0.05
P	12.1±2.8	17.8±1.6
K	104.1±4.9	71.5±3.3
Ca	3120.4±152.5	1542.6±103.5
Mg	245.0±12.0	133.2±7.1
% OM	9.3±0.7	2.0±0.2

Note: means±SE, N=40 except % OM (N=10). Upper B samples taken 5 to 15 cm below A.

2.3. Vegetation:

Based on combined understory and canopy data, *Acer saccharum* Marsh was dominant, with *Tilia americana* L. subdominant. Among minor stand elements, *Ostrya virginiana* (Mill) and *Ulmus americanus* L. were common in the site's understory. Poplars consisted mainly of *Populus grandidentata* Michx (Table 3).

Table 3. Densities and importance values (relative density + relative dominance + relative frequency) of tree and understory species in the study site.

Species	Importance values	Density/2400 m² C	Density/2400 m² US	Mean basal area±SE C	Mean basal area±SE US
Acer saccharum	169.1	113	360	236±10	37±2
Tilia americana	62.8	47	19	367±65	61±6
Ulmus americana	26.9	3	20	189±8	40±6
Populus spp.	21.6	-	-	-	-
Ostrya virginiana	9.2	1	11	-	66±14
Betula lutea	8.3	-	-	-	-
Prunus serotina	1.5	-	-	-	-

note: C=canopy; US=understory.

The shrub association was dominated by leatherwood, *Dirca palustris* L. Small poplars were also frequent at the site. Nine ground cover species were present in more than 50 % of the 100 subplots surveyed at the site: *Maianthemum canadense*, sedges, *Osmorhiza claytonii*, *Polygonatum commutatum*, *Acer saccharum*, *Botrychium virginianum*, *Taraxacum spp.*, *Viola pubescens* and *Trillium grandiflorum*.

2.4. Host insects:

During early spring, when forest understory vegetation was still scarce, leafhoppers, treehoppers and flies were dominant insect hosts for parasitic mite larvae. From May to July, mosquitoes, leaf beetles, deer flies and crane flies became very abundant. Nymphs of grasshoppers appeared in June. From late June to September,

several species of *Melanoplus* (Acrididae: Orthoptera) served as primary hosts for four parasitic larval mites. From early July to mid-August, several moth species and other important insect hosts for *Leptus* (Erythraeidea: Trombidia) and other mites were dominant on calm, warm summer nights. Seasonal host occurrence is listed in Table 4.

Table 4. Seasonal occurrence of insect hosts for velvet mites collected in the field (based on 1990-1992 data).

Species	Common name	Host frequency	Season
Aphis rumicis	aphid	principal	
A. forbesi	aphid	principal	spring
Macrosiphum	aphid	principal	spring
pisi			spring
Scaphoideus	leafhopper	principal	
luteolus			spring
Corythucha	elm lace bug	secondary	
ulmi			spring
Musca sp.	fly	secondary	
			spring
Dysaphis	apple aphid	secondary	
plantaginea			spring
Eriosoma	woolly aphid	secondary	
lanigerum			spring
Phyllotreta	flea beetle	secondary	
nemorum			summer
Culicoides	mosquito	principal	
piliferus Drosophila			summer
	fruit fly	principal	
melantaginea	crane fly	principal	summer
Tipula maxima			summer
Crambus	lawn moth	principal	
pedices			summer
Grapholitha	peach moth	principal	
molesta			summer
Melanoplus	grasshopper	principal	
differentialis			summer
M. confusus	grasshopper	secondary	
M. bivittatus	grasshopper	secondary	summer
			summer
A. rumicis	aphid	secondary	
A. pomi	aphid	secondary	summer
Toxoptera	pear aphid	secondary	summer
piricola			summer

Table 4. continued.

Species	Common name	Host frequency	Season
Melanoplus differentialis	grasshopper	principal	Fall
M. confusus	grasshopper	principal	Fall
M. bivittatus	grasshopper	principal	Fall
Aphis rumicis	aphid	secondary	Fall
A. pomi	aphid	secondary	Fall
Musca sp.	fly	secondary	Fall
Drosophila melanogaster	fruit fly	secondary	Fall

3. RESULTS:

3.1. Systematic list of velvet mite species collected in Michigan's Upper Peninsula:

Class Arachnida	
Order Acariformes	Krantz, 1978
Suborder Actinedida	Lindquist, 1976
Supercohort Promatides	Krantz, 1978
Cohort Eleutherengonina	Krantz, 1978
Subcohort Parastitengonae	Krantz, 1978
Phalanx Trombidia	Leach, 1815
Superfamily Trombidioidea	
Family Trombidiidae	Krantz, 1978
Subfamily Trombidiinae	Michael, 1884
Genus *Trombidium*	Fabricius, 1775
T. auroraense	Vercammen-Grandjean, 1977
Subfamily Allothrombiinae	Thor, 1935
Genus *Allothrombium*	Berlese, 1903
A. carum n. sp.	Yao, unpublished
Subfamily Podothrombinae	Thor, 1935
Genus *Podothrombium*	Berlese, 1910
P. fucum n. sp.	Yao, unpublished

Family Eutrombidiidae	Thor, 1935
Genus *Eutrombidium*	Verdun, 1909
E. locustarum	Miller, 1934
Genus *Hexathrombium*	Cooveman, 1944
H. bicomarum n. sp.	Yao, unpublished
Family Tananpodidae	Berlese, 1902
Genus *Eothrombium*	
E. scutelleta	Newell, 1957
Superfamily Calyptosomatoidea	Southcott, 1961
Family Calyptosomatidae	Southcott, 1961
Genus *Calypstoma*	Southcott, 1961
C. nivalis n. sp.	Yao, unpublished
Superfamily Erythraeoidea	Grandjean, 1947
Family Erythraeidae	Robinean-Desvoidy, 1828
Subfamily Erythraeinae	Southcott, 1957
Genus *Erythraeus*	Latreille, 1806
E. michiganensis n. sp.	Yao, unpublished
E. septemsetalis n. sp.	Yao, unpublished

Subfamily Leptinae Southcott, 1957

Genus *Leptus* Latreille, 1796

L. sylvestratilis n. sp. Yao, unpublished

L. solitarius n. sp. Yao, unpublished

Subfamily Callidosomatinae Southcott, 1961

Genus Abrolophus Berlese, 1891

A. welbourni n. sp. Yao, unpublished

A. channingensis n. sp. Yao, unpublished

Genus *Charletonia* Oudemans, 1910

C. cularia n. sp. Yao, unpublished

Subfamily Balaustiinae Southcott, 1957

Genus *Balaustium* van Heyden, 1826

B. nonasum n. sp. Yao, unpublished

B. kewdalli Welbourn, 1991

A new genus and new species separated from Cuteria

Welbourn & Yao, unpublished

3.2. Description of species:

subfamily Leptinae:

Leptus sylvestratilis n. sp.

Type series:

Holotype: 1 larva reared from an egg deposited by a female collected from forest floor on April 30, 1991, hatched on June 15, 1991, then attached to *Melanoplus differentialis* for one day. Removed from host tarsus and mounted on slide on June 16,1991. Twenty larval paratypes reared from eggs deposited by same female. Twenty additional larvae reared from eggs deposited by two other females collected in the same location on May 4 and 6, 1991, hatched on June 13 and 19, 1991. Five deutonymphs and five paratype adults reared from larvae and deutonymphs in the laboratory.

Larval description (measurements are of holotype with mean, range and number of measured paratypes in parentheses):

Color: in life red. Idiosoma ovoid, length 320 (330,290-350,30) and width 270 (285,250-310,30); overall length from tip of mouthparts to posterior pole of idiosoma 487 (490,460-520,30) (Fig. 1).

Prodorsal sclerite (Fig. 2): with anterior margin slightly concave, anterior corners round; shape approximately an equilateral triangle; anterolateral borders lightly convex, posterolateral borders slightly concave; posterior pole of scutum with slight median notch.

AW 98 (96,90-105,30); PW 125 (122,107-129,30); AM 44 (45,43-48,30); SS 73 (71,68-76,30); AL 69 (70,68-74,30); PL 75 (72,68-76,30); L 125 (127,120-131,30); W

127 (128,124-130,30); AAS 44 (42,39-47,30); ISD 84 (83,80-86,30); SBa 12 (12,9-13,30); SBp 19 (18,17-21,30); LX 31 (32,30-34,30); ASBa 19 (18,17-21,30); ASBM 12 (12,10-14,30).

Anterior trichobothria on anterior portion of sclerite. Prodorsal setae rather clavate, with acute projecting barbs throughout most of length. AL setae arise anteriorly and medial to PL setae. Trichobothria fine, tapering, sparsely ciliate in distal half.

Eyes 1+1, cornea circular, 23 um across. Dorsal setae 54 (55,43-63,30) in length from 53 (54,49-59,30) anteriorly to 57 (56,53-61,30) posteriorly.

Palps (Fig. 3): palpal setal formula fPp=0-B-B-BBB-6Bω; palpal tibia with 3 B (Fig. 3a, c, d); palpal tarsus (Fig. 3b), with 5 B 19-21 in length, additional 1 B in length of 32 with basal setules at 0.23 of the tarsus, 1 ω 21 at 0.23, 1 ζ 23 at 0.92.

Ventral idiosoma (Fig. 4): intercoxal setae between coxal field I well ciliated, 46 (47,41-49,30); intercoxal setae II similar, 46 (46,45-48,30) long; 2 pairs of ciliate setae between area of coxal fields II-III, anterior pair 28 (27,26-29,30) in length, posterior 40 (41,38-43,30) long. Posterior opisthosomal setae about 18 in number, in length of 36 (38,36-40,30). Coxal field seta 1b pointed, 78 (79,78-84,30) long, ciliated; seta 2b blunted, ciliated, 34 (35,28-37,30); seta 3b blunted, ciliated, 51 (52,48-55,30).

Legs: slender, normal; leg length include trochanter and tarsus. Leg setae well setulose, pointed and ciliated.

Leg I (Fig. 5a): length 656 (657,650-710,30); coxal field I with 1 branched seta (B) 79 (76,73-82,30) long; trochanter 1B 61 (62,59-64,30); basifemur 2B 44-75; telofemur with 5B 40-52; genu 8B 44-54,with 1 sigma (σ) 38 (38,35-39,30) at 0.53 (0.50,0.49-0.55,30),

1 microseta (k) 3.84 (3.84,3.2-4.0,30) at 0.89 (0.89,0.87-0.92,30); tibia 14-15B 42-54, 2 phi (ϕ) 33 (33,31-36,30) and 19 (19,17-21,30) respectively at 0.55 (0.53,0.51-0.55,30) and 0.85 (0.86,0.84-0.89,30), 1 microseta (k) 7.67 (8,7-9,30) at 0.93 (0.91,0.89-0.95,30); tarsus 25 B 13.43-42.20, 1 omega (ω) 40 (41,38-44,30) at 0.62 (0.61,0.60-0.64,30); 1 dorsal eupathidium (ζh) 27 (25,23-27,30) at 0.93 (0.92,0.89-0.95,30) with setules and ventral eupathidium (ζp) with setules 15 (15,14-17,30) at 0.96 (0.96,0.94-0.99,30) respectively.

Leg II (Fig. 5b): length 552 (558,495-574,30); coxal field with 1B 35 (33,30-36,30); trochanter 1B 52 (53,49-54,30); basifemur 2B 75 (75,70-77,30) and 44 (41,40-46,30); telofemur 5B 36-56; genu 8B 58-59, no sigma seta observed, 1 k 6-9 at 0.89-0.94; tibia 15B 31-40, 2 ϕ 25 (23,21-25,30) and 13 (13,11-14,30) respectively at 0.11 (0.13,0.10-0.15,30) and 0.84 (0.86,0.83-0.89,30); tarsus 23B 13-44, 1 ω 19 (18,17-20,30) at 0.51 (0.52,0.50-0.54,30) and 1 ζ 23 (22,20-25,30) at 0.93 (0.94,0.92-0.97,30).

Leg III (Fig. 5c): length 666 (670,650-690,30); coxal field with 1B 52 (52,50-54,30); trochanter 1B 58 (58,55-60,30); basifemur 1B 69 (68,67-70,30); telofemur 5B 42-45; genu 8B 46-54, no specialized setae observed; tibia 14B 38-50, 1 ϕ 31 (32,29-35,30) at 0.03 (0.03,0.02-0.03,30); tarsus 23B 19-44, 1 ζp 17 (18,16-19,30) at 0.97 (0.96,0.95-0.98,30).

Deutonymph:

Color: in life dark red with black setae and scattered white setae. Dorsal setae arranged densely around the edge of body segments.

Idiosoma: ellipsoid, 810 (860,810-870,20) long by 620 (650,610-660,20) wide. One eye,

35 (35,34-36,20) on each side of prodorsal sclerite anteriorly in a circular sclerite. Dorsal setae range from 15,25 anteriorly to 40 posteriorly.

Prodorsal sclerite (Fig. 6): 310 (312,308-316,20) long by 30 (30,28-32,20) wide midway between AM and ASE, with 2 pairs of trichobothria. AM 55 (56,54-56,20) with 6 setae at the anterior end; ASE 60 (61,58-62,20).

Gnathosoma: anterior edge of gnathosoma with fingerlike fringe and approximately 30 nude setae. Anal valves with 12-16 setae (Fig. 7).

Palps (Fig. 8): palpal tibial claw entire, palpal trochanter with setae; palpal femur with 45-49 setae; palpal genu with 36-38 setae; palpal tibia with 16-18 setae; palpal tarsus with 12-14 setae, 1 ω and 5-7 eupathidia.

Legs: all legs with 2 types of setae. Most setae oriented parallel or nearly so to legs, with small base, long setules and in length from 35 to 40. Second type eupathidial, usually oriented perpendicular to leg with large base, short setules, and ranging in length from 20 to 35.

Leg I: length from coxae to tarsus 930 (935,928-936,20); coxal setae 16-18; trochanter and basifemur of all legs without solenidia. Dorsal solenidia present on all remaining segments of legs, except on tarsus I where they are lateral; telofemur with 2 θ on distal area at 0.47 (0.48,0.46-0.49,20) and 0.62 (0.62,0.61-0.63,20); genu with 2 σ dorsally 35 (35,33-36,20) and 40 (39,39-41,20) at 0.39 (0.39,0.38-0.41,20) and 0.56 (0.55,0.52-0.56,20) respectively, 1 σ at ventral 40 (40,39-43,20) long; tibia with 4 ϕ, 2 ventral ϕ 30 (31,29-32,20) and 27 (27,27-30,20) at 0.51 (0.52,0.51-0.54,20) and 0.67 (0.66,0.65-0.68,20), 1 dorsal ϕ 40 (40,39-42,20) at 0.14 (0.14,0.13-0.15,20), and 1 lateral ϕ 50

(51,49-52,20) at 0.63 (0.62,0.62-0.64,20), 7 nude setae present on dorsal side; tarsus with 7 dorsal ω and 8 lateral ω, 2 ζh at 0.97 (0.98,0.96-0.99,20).

Leg II: length 680 (685,680-692,20); telofemur with 1 θ 30 (30,29-31,20) at 0.84 (0.85,0.83-0.89,20); genu with 2 σ 30 (28,27-31,20) and 25 (26,24-27,20) at 0.92 (0.91,0.90-0.93,20) and 0.96 (0.97,0.96-0.98,20) respectively; tibia with 1 ϕ 30 (30,29-32,20) at 0.81 (0.82,0.80-0.83,20); tarsus with 1 ζh 35 (36, 34-37,20) at 0.94 (0.95,0.93-0.96,20), 1 ζp 25 (26,24-27,20) at 0.92 (0.92,0.91-0.94,20),1 ζ 16 (17,16-19,20) at 0.62 (0.63,0.61-0.64,20).

Leg III: length 670 (670,668-676,20); telofemur with 4 θ 22 (23,21-24,20), 16 (17,15-18,20), 23 (22,21-24,20) and 14 (15,14-17,20) at 0.47 (0.48,0.46-0.48,20), 0.53 (0.54,0.52-0.56,20), 0.66 (0.65,0.64-0.67,20) and 0.72 (0.72,0.71-0.74,20) respectively; genu with 1 σ 32 (32,31-34,20) at 0.90 (0.91,0.89-0.93,30) and 5 nude setae; tibia with 3 ϕ 35 (36,34-37,20), 30 (30,29-32,20) and 35 (35,34-36,20) at 0.85 (0.84,0.84-0.86,20), 0.83 (0.83 (0.83,0.81-0.85,20) and 0.93 (0.92,0.91-0.93,20); tarsus with 1 ω 39 (39,38-41,20) at 0.89 (0.88,0.86-0.89,20) and 1 ζ 25 (24,23-26,20), 3 nude setae.

Leg IV: length 975 (976,973-978,20); telofemur with 2 θ 40 (40,39-43,20), and 40 (40,39-42,20) at 0.50 (0.50,0.49-0.52,20) and 0.81 (0.81,0.80-0.83,20); genu with 4 σ 35 (36,34-36,20), 40 (40,39-42,20), 30 (31,29-32,20); 45 (45,44-46,20) at 0.52 (0.52,0.51-0.53,20), 0.75 (0.75,0.74-0.76,20), 0.82 (0.82,0.81-0.83,20) and 0.89 (0.88,0.87-0.90,20) respectively; tibia with 1 ϕ 30 (30,29-31,20) at 0.85 (0.84,0.83-0.86,20); tarsus 2 ω 35 (35,34-37,20) and 44 (45,44-46,20) at 0.86 (0.85,0.84-0.87,20) and 0.89 (0.88,0.87-0.90,20).

Adult female:

Color: in life dark red with black setae and scattered white setae on dorsal idiosoma.

Idiosoma: ellipsoid, 1075 (1100,1035-1200,5) long and 930 wide (970,920-1000,5). One eye 40 (40,39-42,5) in diameter at each side of prodorsum. Most dorsal setae catkin-like,well setulose, length from 12 to 25 anteriorly, and 12 to 28 posteriorly. Genital valves with 57-64 setae; anal valves with 10 setae (10,8-12,5)(Fig. 9).

Prodorsal sclerite (Fig. 10): 375 (378,370-380,5) long and 10 (10,10-12,5) wide midway between AM and SS. AM 35 (35,34-37,5) long and SS 87 (84,83-88,5) long with 4-6 setae at the anterior end.

Gnathosoma: anterior end with fingerlike fringe and 30-40 nude sensory setae. Four long nude setae located at each side, 37 to 40 in length.

Palps (Fig. 11): palpal trochanter with 8-10 setae; palpal femur with 74-76 setae and 3 microsetae; palpal genu with 58-62 setae and 1 σ; palpal tibia with 10-12 setae, 3 ϕ and 5 microsetae, tibial claw entire; palpal tarsus with 8B, 2 ω and 18-20 eupathidia at anterior area of tarsus.

Legs: all legs with setulose setae, oriented parallel to leg, covering most areas of legs; eupathidial setae oriented perpendicular to leg segments.

Leg I: 1300 (1320,1180-1460,5) in length; basifemur with 1 θ 50 (51,50-53,5)at 0.73 (0.74,0.73-0.76,5); telofemur with 3 θ 45 (45,44-46,5), 30 (31,29-33,5), 35 (36,34-36,5) at 0.49 (0.48,0.47-0.49,5), 0.80 (0.79,0.78-0.81,5) and 0.82 (0.81,0.81-0.83,5), 5 nude setae; genu with 6 σ 30 (30,30-32,5), 50 (52,50-53,5), 40 (40,39-41,5), 50 (50,50-52,5),

40 (40,40-43,5) and 30 (30,30-32,5) at 0.22 (0.21,0.20-0.25,5),0.52 (0.52,0.51-0.54,5), 0.67 (0.66,0.65-0.68,5), 0.78 (0.78,0.77-0.80,5), 0.80 (0.81,0.79-0.83,5) and 0.91 (0.90,0.90-0.93,5); tibia with 9 ϕ 45 (46,45-47,5),35 (35,34-36,5), 25 (25,25-27,5), 35 (36, 34-36,5), 25 (25,25-26,5), 50 (50,50-51,5), 50 (49,48-51,5), 45 (45,45-46,5) and 40 (40,40-42,5) at 0.18 (0.18,0.18-0.19,5), 0.27 (0.26,0.25-0.27,5), 0.33 (0.32,0.31-0.34,5), 0.54 (0.55,0.54-0.56,5), 0.64 (0.64,0.63-0.65,5), 0.71 (0.70,0.70-0.72,5), 0.89 (0.90,0.89-0.91,5), 0.95 (0.95,0.94-0.96,5) and 0.96 (0.96,0.95-0.97,5) and 0.96 (0.96,0.96-0.97,5) respectively, 1 k present and 4 nude setae; tarsus with 10 scatted ω and 1-4 ζ.

Leg II: length 905 (910,850-930,5); basifemur with 1 θ 30 (30,28-32,5) at 0.68 (0.67,0.67-0.69,5); telofemur with 2 θ 28 (28,27-29,5) and 32 (31,30-32,5) at 0.46 (0.45,0.45-0.47,5) and 0.90 (0.89,0.89-0.90,5); genu with 5 σ 25 (25,24-26,5), 25 (25,25-26,5), 32 (31,30-32,5), 26 (25,25-27,5) and 35 (35,35-37,5) at o.19 (0.18,0.17-0.19,5), 0.57 (0.56,0.55-0.57,5), 0.91 (0.90,0.90-0.92,5), 0.87 (0.86,0.86-0.89,5), and 0.96 (0.95,0.95-0.97,5); tibia with 4 ϕ 25 (25,25-26,5), 24 (24,24-26,5), 25 (25,25-26,5) and 38 (37,37-38,5) at 0.27 (0.27,0.26-0.28,5), 0.45 (0.46,0.45-0.46,5), 0.84 (0.83,0.83-0.85,5) and 0.95 (0.94,0.94-0.96,5) respectively; tarsus with 2 ω distally 23 (22,22-23,5), 19 (19,18-19,5) at 0.80,0.80-0.82,5) and 0.81 (0.81,0.81-0.82,5), 2 ζh 32 (31,31-32,5) and 39 (38,37-39,5) at 0.81 (0.81,0.81-0.83,5) and 0.94 (0.94,0.94-0.96,5), 1 ζp 23 (22,22-24,5) at 0.97 (0.97,0.97-0.98,50.

Leg III: length 940 (930,900-940,5); basifemur without θ; telofemur with 3 θ 45 (45,45-50,5), 30 (30,30-33,5), and 45 (45,45-46,5) at 0.50 (0.50,0.49-0.50,5), 0.57 (0.56,0.55-

0.57,5), 0.86 (0.85,0.85-0.86,5); genu with 1 σ 35 (35,35-36,5) at 0.90 (0.90,0.90-0.92,5); tibia with 2 ϕ 40 (38,36-42,5),35 (35,35-37,5) at 0.43 (0.44,0.43-0.46,5), 0.72 (0.71, 0.71-0.74,5); tarsus with 2 ʃh 40 (40,39-42,5), 45 (46,44-47,5) at 0.75 (0.74,0.72-0.75,5) and 0.89 (0.89,0.89-0.91,5) respectively, 1 ʃp 30 (30,30-32,5) at 0.93 (0.92,0.90-0.93,5).

Leg IV: length 1685 (1687,1680-1695,5); basifemur with 1 θ 55 (56,54-56,5) at 0.79 (0.79,0.78-0.80,5); telofemur with 2 θ 45 (48,45-50,5) at 0.89 (0.88,0.88-0.90,5), 50 (51,50-52,5) at 0.39 (0.38,0.37-0.39,5); genu with 4 σ 35 (35,35-37,5), 55 (56,55-57,5), 45 (46,45-47,5), and 60 (60,59-62,5) at 0.24 (0.24,0.23-0.25,5), 0.47 (0.47,0.46-0.48,5), 0.54 (0.54,0.54-0.56,5), and 0.87 (0.87,0.86-0.88,5) respectively; tibia with 5 ϕ 55 (56,55-57,5), 45 (46,45-47,5), 50 (50,50-51,5), 40 (40,40-41,5), 50 (50,50-52,5)at 0.48 (0.47,0.46-0.48,5),0.61 (0.61,0.60-0.63,5), 0.62 (0.63,0.62-0.64,5), 0.87 (0.87,0.87-0.89,5) and 0.93 (0.93,0.92-0.95,5); tarsus with 1 ω 28 (29,28-29,5) at 0.93 (0.94,0.93-0.95,5), 2 ʃh 39 (38,38-39,5), 55 (56,54-56,5) at 0.71 (0.72,0.70-0.73,5) and 0.92 (0.92,0.91-0.93,5), 1 ʃp 40 (41,40-43,5) at 0.90 (0.90,0.89-0.91,5).

Etymology:

The specific epithet is derived from *sylvestra-*, meaning "forest", and *tilis,* meaning "found in", which characterized this forest-dwelling species well.

Distribution of types:

The holotype, 20 larval and 5 adult female paratypes are in Department of Zoology, Michigan State University, East Lansing, MI. One larval, and one adult female paratypes will be deposited in each of the following institutions: Field Museum of

Natural History, Chicago, IL; British Museum (Natural History), London, U. K.; and Shanghai Museum of Natural History, Shanghai, PRC.

Figs. 1-11. *Leptus sylvestatilis* n. sp. (larva, deutonymph and adult female):

1. dorsal idiosoma;

2. prodorsal sclerite;

3a-d. palpals;

4. ventral idiosoma;

6. prodorsal sclerite and eyes of deutonymph;

7. anal valves of the nymph;

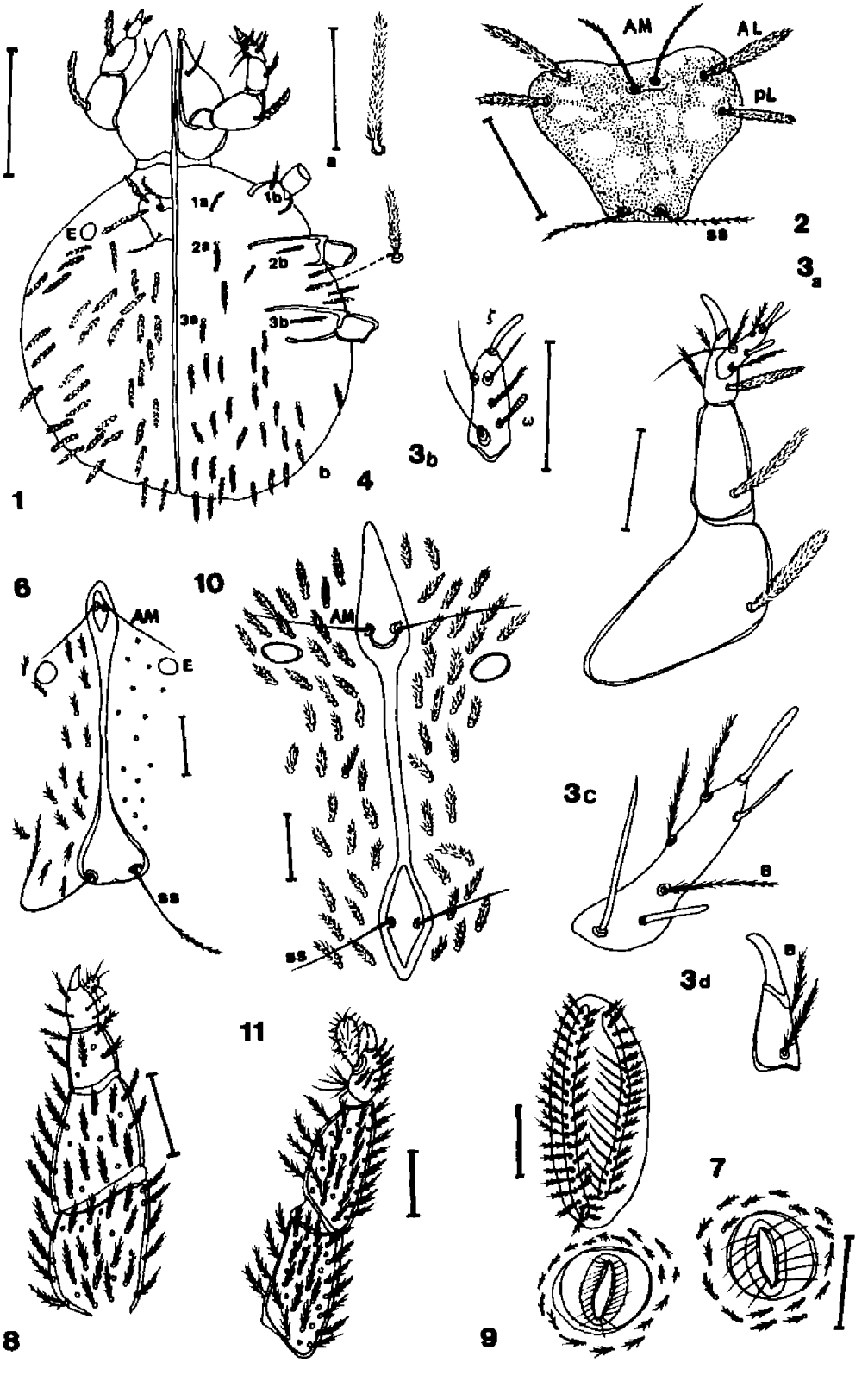
8. nymph palpals;

9. adult genital and anal valves;

10. adultal sclerite;

11. adult palpals.

Scale lines for Figs. 1, 3a, 6, 7, 8, 9, 10, 11 each represent 100 μm; scale lines for Figs. 2, 3b, c, d, 4a each represent 50 μm.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Leptus solitarius n. sp.

Type series:

Holotype: 1 larva collected from a moth, *Apamea lignicolora* Guenee, on August 5, 1991. Thirty paratypes collected from other moths, crab spiders, and other insects from early July to late August in 1990 and 1991. Five deutonymphs and five adults were reared from the larvae attached to these hosts.

Larval description:

Idiosoma (Fig. 14):

Color: in life yellow. Holotype 595 (863,590-930,30) long by 385 (492,385-560,30) wide; 1 eye 21 (23,21-26,30) on each side of prodorsal sclerite with a circular sclerite around. Length from tip of mouthpart to pole of idiosoma 770 (919,570-1245,30). Number of dorsal setae 102 (98,87-106,30) in length from 44.12-47.95 anteriorly to 46.03-55.62 posteriorly (Fig. 12a, b).

Palpal setae formula (Fig. 13): palpal femur and palpal genu with 1 B seta each, palpal tibia with 3 B stae and 1 tibia claw, palpal tarsus with 5 B setae, 1 nude seta, 1 ω and 1 ζ. Palpal setae formula = 0-B-B-BBB-5BN$\omega\zeta$ in length of 86-61-25,38-17-33 (0.23), 21 (0.68)-21 (0.23)-23 (0.92).

Prodorsal sclerite (Fig. 14): anterior corners pointed, anterior margin straight, posterior margin concave (Fig. 18). Standard data listed in Table 5.

Leg I (Fig. 15a): length 765 (787,745-836,30) from trochanter to pretarsal claw, coxal field I with 1B 96 in length (96,93-98,30); trochanter with 1B 75 (75,72-80,30); basifemur with 2B 86 (87,82-89,30), 111 (108,103-116,30); telofemur with 5B 59-76,

genu with 8B 63-88, 1 σ 42 (40,38-44,30) at 0.50 (0.50,0.47-0.54,30), 1 k 6 (6,5-8,30) at 0.93 (0.94,0.90-0.96,30); tibia with 14B 34-69, 2 ϕ 36 (35,32-37,30) at 0.05 (0.05,0.03-0.06,30), 23 (22,20-25,30) at 0.87 (0.86,0.83-0.88,30); tarsus with 23-25B 55.6-65 in length posteriorly, and 32-40 in length anteriorly, 1 ω 40 (41,38-43,30) at 0.54 (0.52,0.49-0.56,30), 1 $\hbar$ 23 (24,21-26,30) and 1 $\hbar$p 17 (17,16-18,30) at 0.93 (0.92,0.90-0.94,30).

Leg II (Fig.15b): length 769 (770,750-820,30) from trochanter to pretarsal claw, coxal field II with 1B 34 (34,30-36,30); trochanter with 1B 67 (68,66-70,30); basifemur with 2B 100 (96,93-100,30) and 94 (93,90-96,30); telofemur with 5B 59-73; genu with 8B 61-90 in length, no σ setae observed but 1 k 6-8 at 0.91-0.94; tibia with 14B 34-36 anteriorly,67-78 posteriorly, 2 ϕ 36 (36,34-37,30) at 0.05 (0.05,0.03-0.06,30), 23 (21,18-24,30) at 0.87 (0.85,0.83-0.88,30); tarsus with 25B 40-45 anteriorly, 67-73 posteriorly, 1 ω 23 (24,22-26,30) at 0.47 (0.48,0.46-0.52,30), 1 $\hbar$ 23 (23,22-25,30) at 0.91 (0.92,0.90-0.94,30) and 1 $\hbar$p 19.18 (19,18-22,30) at 0.98 (0.96,0.95-0.99,30).

Leg III (Fig.15c): length 853 (855,847-870,30); coxal field with 1B 54 (55,52-56,30); trochanter with 1B 67 (68,66-70,30); basifemur with 2B 100 (98,96-101,30) and 94 (95,93-96,30); telofemur with 5B 63-73; genu with 8B 61-90 in length; tibia with 14B 38-45 anteriorly and 65-80 postiorly, 1 ϕ 36 (36,35-38,30) at 0.04 (0.05,0.03-0.06,30); tarsus with 22-23B 24-30 anteriorly and 59-71 posteriorly, 1 $\hbar$p 17.26 (18,16-20,30) at 0.96 (0.97,0.95-0.98,30).

Deutonymph:

Color: in life brown. Idiosoma 836 (877,736-922,5) long by 504 (527,482-544,5) wide. Dorsal setae 25-38 in length, ventral setae 33-38 long. Anal valves 60 (62,57-65,5) with 6 setae 31-33 long at each side (Fig. 16).

Prodorsal sclerite (Fig. 17): 283 (293,274-311,5) long by 36 (37,32-39,5) wide; AW 46 (47,43-50,5) with 6 setae at front end 46-50 long; SM 69 (70,67-73,5), SS 102 (104,100-113,5), SBa 13 (14,12-15,5), SBp 13 (13,12-15,5), LX 59 (61,57-64,5), ISD 249 (252,237-273,5). Eyes 1 + 1 27 across.

Leg I: 965 (973,886-985,5), coxal field 225 (228,217-236,5); trochanter 96 (97,94-98,5); basifemur 117 (121,113-132,5); telofemur 157 (153,147-168,5) with 1-2 θ at 0.38-0.85; genu 198 (201,188-212,5) with 4 σ at 0.44-0.88; tibia 219 (221,211-243,5) with 11-12 ϕ at 0.12-0.91, and 1 k at 0.89-0.92; tarsus 178 (182,165-193,5) with 12-15 ω at 0.79-0.94 and 2 ζh 47.95 each at 0.94 and 0.97 respectively.

Leg II: 646 (658,637-729,5), coxal field 184 (188,172-198,5); trochanter 71 (72,70-74,5); basifemur 100 (102,97-108,5); telofemur 102 (105,100-112,5) with 1 θ at 0.86-0.88; genu 142 (144,138-155,5) with 2 σ at 0.88-0.91, without k; tibia 144 (150,136-162,5) with 4-5 ϕ at 0.12-0.85; tarsus 88 (89,85-91,5) with 1 ζh 35 (35,32-36,5) at 0.91 (0.92,0.90-0.94,5), no ω observed.

Leg III: 716 (722,708-735,5), coxal field 125 (126,118-135,5); trochanter 77 (78,75-80,5); basifemur 102 (105,101-110,5); telofemur 105 (107,102-115,5) with 3 θ at 0.26-0.87; genu 165 (168,157-176,5) with 3 σ at 0.45-0.85, without k; tibia 171 (174,166-182,5) with 1-2 ϕ at 0.81-0.84, 2-3 nude setae at 0.08-0.24; tarsus 96 (97,93-98,5) with

1 ζh 38 (38,36-39,5) at 0.90 (0.91,0.89-0.93,5), 1 dorsal ζ at 0.79-0.83, no ω observed. Leg IV: 955 (948,932-975,5), coxal field 225 (230,220-243,5); trochanter 92 (94,92-96,5); basifemur 129 (132,119-142,5); telofemur 152 (157,148-166,5) with 3-4 θ at 0.11-0.86; genu 227 (233,221-238,5) with 2-3 σ at 0.53-0.91, 8 nude setae at 0.53-0.84 dorsal area; tibia 237 (247,228-253,5) with 1 φ at 0.16-0.19; tarsus 118 (122,115-133,5) with 1 ζh 38.36 (39,35-40,5) at 0.89-0.92, without ω.

Adult female:

Color: in life brown with black setae as well as white scattered setae. Idiosoma from the tip of mouthpart to posterior pole 2250 (2475,2138-2755,5) long by 1523 (1623,1477-1738,5) wide. Dorsal setae 54-56 in length; ventral setae 27-38, anal valves 84 (86,83-90,5) with 25-27 setae 33-38, genital valves 443 (452,433-468,5) with 87-102 setae (Fig. 18).

Prodorsal sclerite (Fig. 19): 573 (582,566-611,5) long by 77 (78,74-90,5) wide; AW 81 (82,80-85,5) with 8 setae at the front edge 61-73 long; SM 111 (115,108-121,5); SS 148 (152,138-162,5); SBa 31 (31,30-34,5); SBp 31 (32,30-35,5); ISD 451 (457,438-477,5); LX 88 (90,86-93,5).

Leg I: 1924 (1986,1877-1997,5), coxal field 264 (267,255-285,5); trochanter 146 (144,138-157,5); basifemur 347 (355,328-389,5) with 1 θ at 0.66-0.70; telofemur 320 (325,307-355,5) with 5-6 θ at 0.65-0.72; genu 384 (394,366-410,5) with 6-7 σ at 0.58-0.93; tibia 368 (377,352-410,5) with 8-9 φ at 0.17-0.89, 19-20 nude setae at 0.23-0.76; tarsus 359 (363,344-382,5) with 8-11 ω at 0.80-0.93, 2 dorsal ζ at 0.76-0.81, 1 dorsal ζ at 0.37-0.42, 4 ζh at 0.94-0.99, 7 ventral ζ at 0.16-0.96, 29-32 fumulus at 0.18-0.91,

majorly distributed at one side, many small setae with big bases at the other side.

Leg II: 1234 (1263,1187-1435,5), coxal field 241 (244,237-253,5); trochanter 150 (154,142-163,5); basifemur 146 (152,137-162,5) with a long seta at 0.78-0.83; telofemur 209 (212,207-228,5) with 1 θ at 0.81-0.84; genu 272 (279,263-297,5) with 3-4 σ at 0.05-0.91, 7-8 nude setae at 0.24-0.84; tibia 274 (278,265-294,5) with 4-5 ϕ at 0.53-0.96, 6 nude setae at 0.27-0.72; tarsus 184 (187,176-193,5) with 1-2 ω at 0.74-0.78, 4 fumulus at 0.29-0.45, 2 ζ at 0.85-0.95, 2-3 ζp at 0.90-0.97.

Leg III: 1306 (1327,1284-1359,5), coxal field 227 (228,217-233,5); trochanter 129 (132,122-136,5); basifemur 167 (172,158-180,5); telofemur 205 (207,202-214,5) with 1 θ at 0.92-0.95; genu 300 (306,287-311,5) with 3-4 σ at 0.78-0.94; tibia 309 (314,302-327,5) with 3-4 ϕ at 0.50-0.88, 4-5 nude setae at 0.16-0.56; tarsus 196 (196,193-204,5) with 1-2 ω at 0.67-0.86, 2 fumulus at 0.28-0.87, 1 ζh at 0.94-0.97, 2-3 ζp at 0.90-0.97.

Leg IV: 2083 (2064,2033-2185,5), coxal field 260 (266,257-271,5); trochanter 155 (158,153-162,5); basifemur 326 (332,318-341,5) with 1 θ at 0.91-0.93; telofemur 362 (369,347-383,5) with 2-3 θ at 0.74-0.92; genu 451 (455,438-472,5) with 4-5 σ at 0.23-0.94, 3-4 nude setae at 0.35-0.49; tibia 453 (458,442-473,5) with 3-4 ϕ at 0.29-0.87, 5-6 nude setae at 0.11-0.38; tarsus 336 (341,328-355,5) with 2 ζh at 0.89-0.94, no ω and fumulus observed.

Etymology:

The species name *solitarius* is derived from a Latin word meaning lonesome.

Fig. 5a-c. *Leptus sylvestratilis* n. sp. (larva): leg I-III from genu to tarsus. Scale line for the figure is 50 μm.

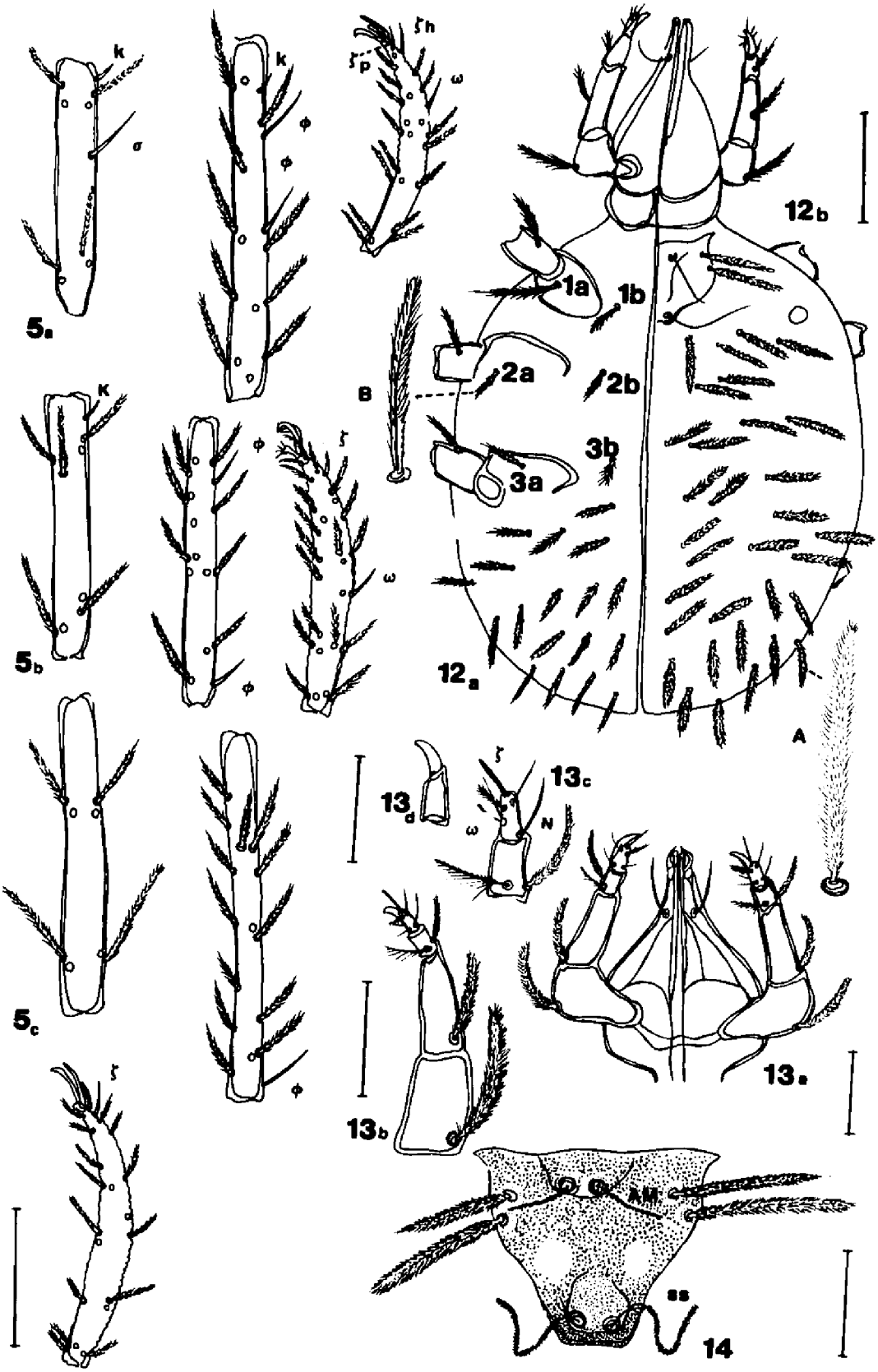
Figs. 12-14. *Leptus solitarius* (larva):

12a, b, dorsal and ventral idiosoma;

13a, b, c, d gnathosoma and palpals;

14. prodorsal sclerite.

Scale lines for Figs. 12a, b, 13a represent 100 μm; scale lines for 13b, c, d and 14 each represent 50 μm.


5a
5b
5c
12a
12b
1a
1b
2a
2b
3a
3b
13a
13b
13c
13d
14
A
AM

Figs. 15-19. *Leptus solitarius* n. sp. (larva, deutonymph and adult female):

15a-c. leg I-III from genu to tarsus (larva);

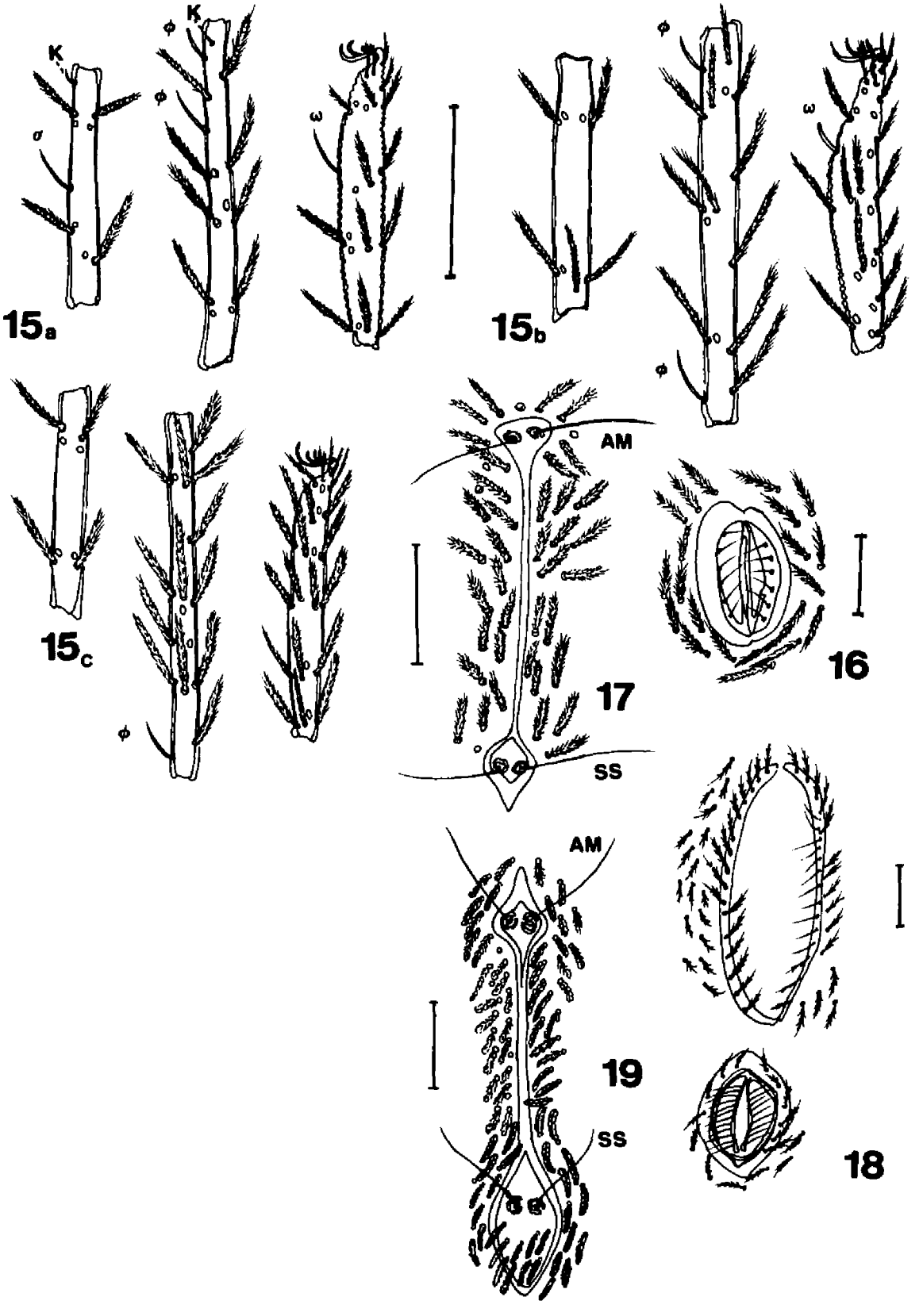
16. anal valves (nymph);

17. prodorsal sclerite (nymph);

18. genital and anal valves (female);

19. prodorsal sclerite (female).

Scale lines for Fig. 15a-c, 16, 17, 18, 19 each represent 100 μm.


K
K
15a
15b
15c
AM
17
SS
16
AM
19
SS
18

Distribution of Types:

The holotype, 20 larval, 20 deutonymphal and 5 adult female paratypes are in Department of Zoology, Michigan State University, East Lansing, MI. One larval, deutonymphal and female paratype will be deposited in each of the following institutions: Field Museum of Natural History, Chicago, IL; British Museum (Natural History), London, U. K.; Shanghai Museum of Natural History, Shanghai, PRC.

Discussion:

Based on data published in many papers, some acarologists use the number of leg solenidia as a major feature to split the genus into four or five groups (Table 5). Other characters, such as the number of solenidia on the palpal genu, are also considered additional criteria for identification.

Differences between the two species of *Leptus* in Michigan's UP and the other five known north and central American species are listed below (Table 6).

It is not difficult to separate *L. sylvestratilis* from *L. nearticus* since shape, size and other prodorsal sclerite characters, number of both dorsal and ventral setae, length of legs and specialized leg setae differ significantly (Table 6). *Leptus sylvestratilis* differs from *L. ariel* in having two sensory setae on tibia I instead of one, and a square sclerite.

Table 5. Morphological features of five groups of *Leptus* larvae (adapted from Beron, 1975; Fain et al, 1987).

leg/group	group I	group II	group III	group IV	group V
genu	Ge I 5 σ	Ge I 2 or 5 σ	Ge I,II each 1 σ	Ge IIno σ	GeI 1σ
tibia	Ti I 1 ϕ	Ti I 3,5,7 ϕ	Ti I,II each 1 ϕ	Ti I,II 2ϕ	TiI 3ϕ
no. sp.	1	3	1	many	1

The species also differs from *L. treati* by the combination of following characters: 1). anterior corners of the sclerite round, anterior margin almost straight, posterior pole not concave; 2). number of dorsal setae less than that of *L. treati*; 3). AL, PL sclerite setae shorter than those of *L. treati*; 4). deutonymph and adult differ from *L. treati* in having white patches of setae; 5). host preference differs from *L. treati* in that *L. sylvestratilis* parasitizes several species of grasshoppers instead of the spruce budworm.

Table 6. Morphological differences between two UP *Leptus* and five other *Leptus* in America

Character/sp	*ariel* *Holo.	$\bar{x}$	*clarki* Holo.	$\bar{x}$	*indianensis* Holo.	$\bar{x}$	*nearcticus* Holo.	$\bar{x}$	*treati* Holo.	$\bar{x}$	*sylvestratilis* Holo.	$\bar{x}$	*solitarius* Holo.	$\bar{x}$
AW	80	82	96	96	82	82	80	82	82	79	97	96	94	64
PW	96	94	112	112	100	100	93	91	99	92	124	86	105	77
AM	38	35	70	75	51	-	41	42	40	42	44	30	51	33
SS	55	53	82	79	81	-	60	61	68	72	72	50	69	49
AL	49	49	65	62	88	-	70	75	63	61	69	42	71	51
PL	55	54	60	56	86	-	75	80	75	72	74	49	78	62
ISD	58	57	57	59	-	-	96	93	53	58	84	58	67	51
L	85	82	91	91	-	-	105	108	86	94	124	87	118	91
W	105	103	125	127	-	-	101	105	107	100	126	86	120	84
SBa	11	11	13	15	-	-	12	11.5	15	12	11	9	13	26
SBp	12	13	18	17	-	-	15	15	-	-	19	9	17	11
A-P	14	15	16	17	-	-	18	16	18	17	44	12	13	-
ASBM	9	9	9	9.5	-	-	25	28	-	-	6	-	13	6
AAS	34	35	42	40	-	-	31	28	-	-	11	27	40	28
DS	49	-	102	-	82	-	94	-	73	68	54	55	102	98
VS	20	-	32	-	34	-	38	-	31	-	26	26	34	36
leg length														
I	501	-	772	-	906	-	664	723	538	539	655	-	765	-
II	507	-	736	-	735	-	644	679	526	516	552	-	769	-
III	584	-	897	-	921	-	742	793	601	609	665	-	853	-

Table 6. (cont'd).

Character/sp	*ariel* $\bar{x}$	*clarki* $\bar{x}$	*indianensis* $\bar{x}$	*nearcticus* $\bar{x}$	*treati* $\bar{x}$	*sylvestratilis* $\bar{x}$	*solitarius* $\bar{x}$
solenidia							
	I II III	I II III	I II III	I II III	I II III	I II III	I II III
genu σ	1 - -	1 - -	1 - -	1 - -	1 - -	1 - -	1 - -
tibia ϕ	1 2 1	2 2 1	3 2 1	2 2 1	2 2 1	2 2 1	2 2 1
B setae							
Tf	4 5 5	4 5 5	- - -	5 5 5	5 5 5	5 5 5	5 5 5
Ti	14 15 14	14 15 13	- - -	14 16 16	14 15 15	14 15 14	14 15 15
Ta	22 20 20	23 22 18	- - -	26 30 30	25 23 23	25 23 23	24 21 24
Host & Location	bees Guatemala	ants ID	opilionids IN	opilionids IN	spruce moth MA	grasshoppers MI	moths etc. MI

The morphology of *L. solitarius* is similar to the description of *L. ignotus* (Beron, 1967) in many features, such as scutum shape, host preference, number of setae between coxal field III and characters of palpals. However, some important features separate the species from *ignotus*: longer legs, more dorsal setae, larger scutum and presence of some specialized setae (Table 7).

Table 7. Major differences between *L. ignotus* and *L. solitarius:* leg length, number of solenidia and dorsal setae, and measurements of sclerite.

Species	Legs			Solenidia			Dorsal	Sclerite			
	1	2	3	Ge	Ti	Ta	setae	AW	PW	L	W
				1 2 3	1 2 3	1 2 3					
ignotus	515	505	555	1 1 -	2 2 1	1 1 -	73	74	85	92	96
solitarius	765	769	853	1 - -	2 2 1	1 1 -	116	94	105	118	98

The larvae of the genus were described from Europe in 1763 by Berlese under various generic names, such as *Acarus* L., 1758, *Phyncholophus* Duges, 1834 and *Achorolophus* Berlese, 1891 (Oudemans, 1929,1937; Southcott, 1961). The first European larval *Leptus* described which now can be recognized is *Leptus ignotus* by

Oudemans, 1903. Between 1902 and 1911, Oudemans described 11 species of *Leptus* larvae worldwide (classified in *Achorolophus*), including some North American specimens placed in *Leptus ignotus*. In 1914, he stated that he had examined hundreds of specimens of this species, which he synonymized with *L. opilionis* (O. F. Muller,1776) from Denmark and *L. phalangii* (de Geer, 1778). He also proposed a further provisional synonymy with *Pediculeus coccineus* Scopoli, 1763 from Yugoslavia. He also regarded a species described as *L. groenlandicus* Tragardh, 1904 from Greenland as a synonym of *ignotus*.

Evans (1910) and Bruyant (1911) indicated that larvae parasitizing Phalangida in Scotland and France respectively could be placed in *Leptus*, but since there was still some confusion, the generic name *Achorolophus* Berlese, 1891 continued to be used for these larvae for a number of years. Paoli (1937) described *Achorolophus dubius* as a parasite of acridid Orthoptera and a bombyliid dipteran from Italy.

Turk (1945) described *Leptus (Achorolophus) killingtoni* from several species of Odonata in England. Schweizer (1951) referred some larvae from Switzerland to "*Achorolophus ignotus*". Andre (1953) described an ectoparasitic mite of scorpions in France as *L. pyrenaeus*. In 1956, Feider reported *L. phyllotretae* as an ectoparasite of Chrysomelidae (Coleoptera) in Romania. He described *L. galerucae*, an ectoparasite of Curculionidae and other Coleoptera, and succeeded in rearing a deutonymph.

Beron (1967) (Bulgaria) described six new species: *L. echinopus* on Collembola, *L. josifovi* on Coreidae (Heteroptera), *L. meloidarum* on Meloidae (Coleoptera), *L. orthopterarum* on Tettigoniidae (Orthoptera), *L. slivovi* on Lymantriidae (Lepidoptera)

and *L. southcotti* on Collembola. He assigned another species to *L. ignotus* (Oudemans) and reclassifed it as *L. holmiae* n. sp. Haitlinger (1987) described three new species from Poland: *L. clethrionomydis* on a rodent, *L. mariae* (free-living) and *L. zbelutkaicus* (free-living). He later identified the last as a synonym of *L. ignotus* (Oudemans).

Treat (1975) recorded many specimens as ectoparasites of Lepidoptera, chiefly Noctuidae, and commented that there were at least three different species. Fain et al. (1987) described two species from Indiana, USA as ectoparasites of Phalangida: *L. indianensis* and *L. nearcticus*. Southcott (1989) described *L. ariel* from Guatemala, ectoparasitic on the European honey bee, *Apis mellifera* L.; another North American species, *L. clarki*, was also described by him as an ectoparasite upon a harvester ant in the same year.

Welbourn (1990) described an ectoparasite of a spruce budworm moth, *L. treati* from both larvae and adults, but in 1991, Southcott redescribed it and named it *L. welbourni*. About 90 species of larval *Leptus* have been described on a world basis since 1900. Many adults of the species have also been described since before 1900. In only a few instances have correlations between larvae and post-larval instars been made (Evans, 1910; Bruyant, 1911; Southcott,1946,1961; Feider, 1967; Treat, 1975; Welbourn, 1991).

In 1992, Southcott revised 18 European and 17 North American species from larvae and nymphs, but some of the data he used for identification still are not sufficient to key out species correctly. Further efforts are necessary since adequate standards and information on the correlation between larvae and adults is still rare.

Key to the larval *Leptus* of the Americas (modified from Southcott, 1991)

1. Palp genu with two setae. Posterolateral scutal setae (PL) off scutum

.....*L. lomani* (Oudemans,1902)(Chili)

Palp genu with one seta. PL not off scutum.....2

2. Genu I with 5 σ.....3

Genu I with 1 σ or no σ.....4

3. Genu II with 1 σ. Telofemur I without solenoidalae

.....*L. stieglmayri* (Oudemans,1905)(Brazil)

Genu II without σ. Telofemur I with 3 solenoidalae

.....*L. schedingi* (Oudemans,1905)(Chili)

4. Genu I without σ.....*L.gagzoi* (Oudemans,1901)(Panama)

Genu I with 1 σ.....5

5. Tibia I with 3 φ.....*L. indianensis* Fain et. al,1987(Indiana,USA)

Tibia I with 1 or 2 φ.....6

6. Genu II with 1 σ.....7

Genu II without σ.....8

7. AL scutalae longer than shield width. Two ventral idiosomal setae between coxae III

.....*L. oudemansi* (Karppinen,1958)(Surinam)

AL scutalae about half as long as shield width. Four ventral setae in area between coxae II and III.

Tibia I with 1 solenoidala.....*L. sieversi* (Oudemans,1911)(Venezuela)

8. Dorsal setae about 50.....9

Dorsal setae more than 70.....10

9. Dorsum with 44 setae, length of legs more than 1000 μm. AL,PL setae not at equal length, 49 and 55 μm seperately, parasite of honey bee

.....*L. ariel* Southcott 1989 (Guatemala)

Dorsum with 50 setae, length of legs more than 400 μm, AL, PL setae 47 and 51 μm seperately, parasite of grasshoppers

.....*L. sylvestratilis* n. sp. (Michigan,USA)

10. Dorsum with 73 setae, anterior corners of sclerite pointed, PW 92 μm, PSE seta 72 μm, parasite of spruce moths.....*L. treati* Welbourn 1991 (Maine,USA)

Dorsum with 99 setae, anterior corners of sclerite round, PW 78 μm, PSE seta 54 μm, parasite of moths.....*L. solitarius* n. sp. (Michigan,USA)

Dorsum with 94 setae, anterior corners of sclerite pointed, PW 96 μm, PSE seta 62 μm, parasite of opilionids.....*L. nearcticus* Fain et al. 1987 (Indiana,USA)

Dorsum with 102 setae, anterior corners of sclerite round, PW 112 μm, ASE, PSE 70 and 80 μm in length seperately, parasite of ants

.....*L. clarki* Southcott 1989 (Idaho,USA)

Subfamily Erythraeinae:

***Erythraeus michiganensis* n. sp.**

Type series:

Holotype: 1 larva hatched on July 4, 1991 from eggs deposited by a female collected on the forest floor on May 20, 1991. Fifteen paratypes hatched on July 4, 5, and 7, 1991 from the egg mass deposited by the same female. Additional 15 paratypes hatched on July 30, 1991 from eggs laid by other females collected in same location. Five deutonymphs were laboratory reared from larvae and five adults collected at Turner Road, Channing.

Larval description:

Color: in life yellowish-brown. Idiosoma ovoid, 587 (634,544-820,30) long by 322 (425,310-526,30) wide between leg II and 348 (368,310-428,30) wide between leg III (Fig.20a). Eyes 2 pairs set on each side of dorsal cupules, anterior one 19 (19,17-21,30) long by 21 (21,19-23,30) wide, posterior eye 17 (18,16-19,30) by 17 (17,16-19,30) wide (Fig. 20c). Dorsal setae 57-59, anterior setae 59-73 in length, 77-82 at posterior region (Fig. 20d). One pair (1a) 79 (79,75-82,30) of intercoxal setae between coxal field leg I,and 1 pair (3a) between coxal field leg III, 58 (58,56-62,30); seta 1b on coxal field leg I, 111 (123,108-131,30); coxal field leg II and III each with 1 seta (2b and 3b) in 69 (72,65-75,30) and 75(75,72-76,30) respectively; after coxal leg III, 21 (22,20-25,30) ventral setae, 54-63 anteriorly and 50-69 posteriorly (Fig. 20b).

Prodorsal sclerite (Fig. 21): anterior margin slightly concave at the middle, posterior pole sharply concave. AW 42 (43,40-44,30); PW 88 (89,85-94,30); W 148 (152,138-167,30);

L 102 (105,98-108,30); ASE 57.54 (58,56-60.30); PSE 90 (92,87-94,30); AL 109 (110,105-117,30); A 61 (62,59-64,30); AAS 15 (16,13-17,30); SBa 12 (12,11-14,30); SBp 13 (14,12-15,30); PL 88 (89,85-92,30); ASBp 23 (23,21-25,30); ASBa 31 (32,29-34,30); ASBM 8 (8,5-9,30); LX 23 (23,20-24,30); ISD 63 (64,62-65,30).

Gnathosoma (Fig. 22a, b, c, d): palpal setal formula fPp=0-B-B-BBB-5B2Nωζ; palpal tibial claw 2 pronged; palpal tarsus with 2 nude setae, 1 ω 13 (14,12-15,30), 1 eupathidum 40 (41,40-44,30) with 1 companing seta, 5 barbed setae 27-31, including 1 long seta 69.

Leg I (Fig. 23a): 1126 (1204,1067-1320,30); coxae 82 (83,80-85,30) with 1B; trochanter 84 (86,82-87,30) with 1B 92 (94,90-96,30); basifemur 165 (168,159-172,30) with 3B 73-77 anteriorly, 105-109 posteriorly; telofemur 146 (153,143-165,30) with 5B 86-88 posteriorly and 79-92 anteriorly; genu 226 (238,221-244,30) with 8B 86-100 posteiorly and 84-90 anteriorly, 1 σ 27 (27,24-30,30) at 0.62 (0.60,0.58-0.64,30), 1 k 6 (6,4-7,30) at 0.93 (0.95,0.92-0.97,30); tibia 300 (312,287-338,30) with 16B 86-93 long, 2 φ 26 (27,24-29,30) and 27 (27,25-29,30) at 0.58-0.90, 1 k 6 (6,4-7,30) at 0.94 (0.95,0.92-0.97,30); tarsus 162 (165,157-174,30) with 18-19B 78-94 long, 1 ω 17 (17,15-19,30) at 0.63 (0.62,0.60-0.66,30), 1 ʒp 25 (26,23-28,30) at 0.93 (0.94,0.92-0.97,30).

Leg II (Fig. 23b): 1007 (1040,1002-1108,30); coxae 107 (107,106-118,30) with 1B 69 (70,67-75,30); trochanter 83 (84,91-86,30) with 1B 71 (72,68-75,30); basifemur 148 (150,143-160,30) with 3B 96-98 posteriorly, 79-84 anteriorly; telofemur 136 (140,132-148,30) with 5B 73-94; genu 184 (187,182-193,30) with 8B 75-81 posteriorly, 77-82

anteriorly, without σ seta,1 k 8 (8,6-9,30) at 0.93 (0.94,0.92-0.97,30); tibia 299(295,292-308,30) with 15B 81-82 posteriorly, and 73-84 anteriorly, 2 ϕ 21 (23,21-27,30) and 23 (25,21-28,30) at 0.06 (0.08,0.05-0.12,30) and 0.90 (0.90,0.88-0.92,30); tarsus 157 (160,155-167,30) with 23-25B 59-69 posteriorly, 12-38 anteriorly, 1 ω 17 (18,16-20,30) at 0.75 (0.74,0.71-0.77,30), 1 ζh 33 (34,30-35,30) at 0.93 (0.93,0.90-0.95,30), 1 ζp 19 (21,18-24,30) at 0.98 (0.98,0.96-0.99,30).

Leg III (Fig. 23c): 1246 (1275,1208-1360,30); coxae 113 (117,109-123,30) with 1B 75 (76,72-78,30); trochanter 77 (77,73-79,30) with 1B 73 (73,70-76,30); basifemur 176 (178,175-184,30) with 3B 73-109; telofemur 176 (178,172-180,30) with 5B 110-117 posteriorly, and 104-109 anteriorly; genu 223 (232,210-238,30) with 8B 129-130 posteriorly, and 85-96 anteriorly; tibia 415 (418,409-426,30) with 15B 104-111 posteriorly, 88-100 anteriorly, 1 ϕ 21 (23,19-26,30) at 0.04 (0.05,0.03-0.08,30); tarsus 182 (184,180-187,30) with 24B 59-69 posteriorly, 10-39 anteriorly, 1 ζp 19 (20,18-21,30) at 0.98 (0.97,0.96-0.99), no ω and ζ observed.

Deutonymph:

Idiosoma: color in life brown, ovoid with 2 pairs of eyes set on each side of prodorsum, anterior eyes 25 (23-26) long by 25 (23-26) wide, posterior eyes 25 (23-26) long by 25 (23-26) wide; anterior setae 54-56 in length, posterior setae 54-61 in length. Ventral setae 61-79 anteriorly, 61-73 in length posteriorly. Genital valve with 4-6 setae (29-38); anal valve with 3-5 setae (23-35).

Gnathosoma: anterior end of gnathosoma with fringe. Palpal trochanter 54 (55,52-57,20) with 8 setae, 5 short ones 48-52 in length, 3 long setae 67-75, palpal femur 178

(180,175-185,20) with 19 setae 54-75 in length, palpal genu 92 (94,90-96,20) with 8 setae 48-115; palpal tibia 120 (124,119-130,20) with 3 setroke spines, claw entire and 8 setae 48-54; palpal tarsus 81 (82,79-84,20) with 4B setae 29-42 in length, 4-6 ω 15-17 at 0.71, 0.75, 0.83 and 0.97 (Fig. 24a, b, c, d).

Prodorsal sclerite (Fig. 25): anterior end with 5-6 long setae 132-150, SM 132 (134,130-138,20), SS 151 (154,148-162,20), AW 73, PW 56, AL 121, PL 52, 6 setae (67-92) between SM and SS.

Legs: all legs with two types of setae, one type short 38-70, the other type long 55-118. Leg I: 2032 (2100,1989-2300,20) long, coxal field 316 (335,300-380,20) with 10-12 setae 88-150, trochanter 115 (120,110-136,20) with 8 setae 77-92 dorsally, and 94-121 ventrally; basifemur 252 (262,245-270,20), 20-21 setae 73-104 long; telofemur 439 (443,427-450,20), 33-36 setae 94-104 anteriorly, and 88-92 posteriorly; genu 437 (440,428-460,20), 38-40 setae 84-88 dorsally, and 90-94 ventrally, 1 σ 27 (26,25-31,20) at 0.80 (0.82,0.77-0.84,20); tibia 510 (514,507-522,20), 26-28 setae 71-77 anteriorly, and 84-88 posteriorly, 7 ϕ 29 (28,25-30,20) at 0.11 (0.10-0.14,20), 35 (35,33-36,20) at 0.19 (0.17-0.22,20), 33 (33,30-34,20) at 0.27 (0.24-0.30,20), 35 (35,33-36,20) at 0.37 (0.35-0.38,20), 38 (38,36-40,20) at 0.50 (0.47-0.52,20), 40 (42,40-44,20) at 0.71 (0.68-0.73,20), 38 (38,35-39,20) at 0.78 (0.76-0.80); tarsus 278 (282,268-289,20), with 2 types of setae, long setae in length of 56-61, the short one 29-48, 3 ζ setae 56 (56,52-58,20) at 0.92 (0.87-0.95,20), 77 (78,74-79,20) at 0.96 (0.95-0.98,20), 65 (65,62-67,20) at 0.98 (0.96-0.99,20), 1-2 famulus 7 each (8,6-9,20) at 0.89 (0.87-0.90,20) and 0.95 (0.94,0.92-0.96,20), 30-32 ω in 3 rows and 2 types, long one 29-31, short one 12-15.

Leg II: 1467 (1500,1300-1621,20) long. coxal field 311 (315,310-325,20) with 9 setae 88-102 anteriorly, and 54-69 posteriorly; trochanter 157 (160,155-168,20) with 10 setae 75-84 anteriorly, 75-84 posteriorly; basifemur 150 (152,147-158,20), 13-15 setae 65-79; telofemur 284 (290,250-330,20), 28-31 setae 75-77 anteriorly, 65-81 posteriorly; genu 182 (186,178-190,20), 26-32 setae 99-103 anteriorly, and 63-75 posteriorly, 1 σ 21 (21,19-24,20) at 0.06 (0.07,0.05-0.08,20) and 1 k 7 (7,6-9,20) at 0.90 (0.89,0.87-0.93,20); tibia 484 (488,476-510,20) with 43-45B setae 77-88 anteriorly, 75-79 posteriorly, 2 ϕ 23 (24,22-26,20) at 0.04 (0.03-0.04,20), 27 (28,25-29,20) at 0.07 (0.06,0.04-0.09,20); tarsus 203 (207,200-212,20),two types of setae: barbed setae 81-83 anteriorly, 77-88 posteriorly, featherlike setae 35-44 anteriorly, and 48-61 posteriorly, 6 ω in two forms: 3 long and acute 15-22 at 0.46-0.65, 3 short and round 12-13 each at 0.57,0.65 and 0.67, 5 ζ 71 (71,70-72,20) at 0.80, 71 (70,69-73,20) at 0.79 (0.78-0.82,20), 81 (81,79-83,20) at 0.93 (0.92,0.90-0.95,20), 40 (41,40-42,20) at 0.96 (0.96,0.94-0.97,20), 48 (48,46-50,20) at 0.98 (0.97,0.96-0.99,20).

Leg III: 1827 (1842,1790-1880,20) long, coxal field 289 (290,278-320,20), 6 setae 54-86 anteriorly, 59-94 posteriorly; trochanter 148 (150,146-164,20), 6-8 setae 88-94 anteriorly, 36-54 posteriorly; basifemur 240 (247,238-255,20),13-14 setae 46-63 in length; telofemur 359 (360,340-375,20), 28-32 setae 74-77 anteriorly, 79-81 posteriorly; genu 330 (330,314-340,20), 29-32 setae 99-104 anteriorly, and 75-92 posteriorly, 1 σ 23 (22,20-25,20) at 0.05 (0.06,0.05-0.08,20); tibia 525 (534,510-550,20), 44-46 setae 73-94 anteriorly, 67-90 posteriorly, 2 ϕ 23 (23,20-25,20) at 0.03 (0.03,0.03-0.04,20), 29 (29,26-33,20) at 0.07 (0.068,0.060-0.072,20), 1 k 8 (7,5-9,20) at 0.89 (0.91,0.88-

0.94,20); tarsus 225 (230,218-243,20), barbed setae 31-75 anteriorly, 75-82 posteriorly, featherlike setae 31-56 anteriorly, 27-42 posteriorly, 2 ω 13 (15,12-17,20) at 0.63 (0.64,0.60-0.66,20), 12 (12,11-14,20) at 0.74 (0.75,0.73-0.76,20), 5 ζ: 71 (71,70-73,20) at 0.78 (0.77,0.75-0.80,20), 69 (69,67-70,20) at 0.84 (0.82,0.79-0.86,20), 84 (85,82-86,20) at 0.93 (0.93,0.90-0.95,20), 2 ζ 47-49 in length at 0.96 and 0.97 respectively, 1 famulus 7 (7,5-9,20) at 0.86-0.89.

Leg IV: 2982 (2975,2856-3210,20), coxal field 315 (320,290-320,20), 7 setae 48-59 anteriorly, 63-77 posteriorly; trochanter 143 (142,138-146,20), 6 setae 86-90 anteriorly, 44-61 posteriorly, basifemur 273 (270,265-284,20), 22-25 setae 82-98 anteriorly, 59-73 posteriorly, telofemur 689 (690,658-705,20), 43-45 setae 100-105 anteriorly, 84-94 posteriorly; genu 585 (590,560-610,20), 32-34 setae 98-107 anteriorly, 81-94 posteriorly, 1 σ 21 (23,19-25,20) at 0.07-0.09; tibia 1003 (1020,987-1030,20), 80-82 setae 92-111 anteriorly, 100-109 posteriorly, 3 φ 29 (29,26-31,20) at 0.02 (0.01-0.03,20), and 27 (25,23-29,20) at 0.03 (0.03,0.03-0.05,20), 25 (23,22-27,20) at 0.04 (0.04,0.03-0.07,20); tarsus 290 (290,282-300,20), barbed setae 65-69 anteriorly, 31-75 posteriorly, featherlike setae 42-50 anteriorly, 69-73 posteriorly, 2 ζ 81 (81,78-84,20) at 0.90 (0.89,0.88-0.93,20), 82 (84,79-85,20) at 0.96 (0.95,0.93-0.97,20), without ω.

Adult female:

Color: in life brown. Idiosoma 2162 (2534,2100-3150,10) long by 1606 (1600,1400-1948,10) wide. One pair of eyes AW 59 (60,57-64,10), AL 35 (36,33-37,10), PW 54 (53,51-56,10), PL 38 (40,37-43,10). Dorsal setae 2 types, long setae 69-84, short setae 29-46.

Prodorsal sclerite (Fig. 26): SS 161 (167,158-170,10); AM 125 (126,117-130,10); AL 167 (170,162-170,10); PL 86 (88,84-90,10); AW 100 (101,96-107,10); PW 77 (78,74-80,10); L 608 (614,602-622,10); SBa 21 (23,20-25,10); SBp 12 (13,10-15,10). Anterior area with 13 long setae 123-165, area between AM and SS with 22 setae 129-144.

Ventral short setae 40-73 and long setae 113-188 anteriorly, 42-109 posteriorly. Genital valves with 64-67 setae 54-69; anal valves with 22-25 setae 44-42.

Gnathosoma (Fig. 27): palpal trochanter 86 (88,83-90,10) with 11 setae 59-117; palpal femur 249 (250,237-253,10) with 38-42 setae 44-81; palpal genu 167 (168,162-170,10) with 23-25 setae 61-67 ventrally, 107-125 dorsally; palpal tibia 178 (180,174-188,10) with 12-14 setae 48-50 anteriorly,and 61-79 posteriorly, tibia claw entire with 5 teeth; palpal tarsus 129 (130,125-137,10), 20 setae 62-64 anteriorly, 46-56 posteriorly, 10-11 ω 17-25 in length, 9-10 ζ at 0.42-0.95.

Leg I: 2151 (2460,2100-2846,5) long from trochanter to tarsus, coxal field 401 (456,400-480,5), anterior setae 121-161 in length, posterior setae from 129 to 146; trochanter 205 (238,200-264,5), 135-144 anteriorly, 65-77 posteriorly; basifemur 355 (354,328-369,5), 54-86 anteriorly, and 67-69 posteriorly; telofemur 407 (455,400-518,5), 56-63 anteriorly, 69-73 posteiorly, with 6 nude setae 46-69 long at 0.35-0.96; genu 573 (523,475-592,5), 100-105 anteriorly and 54-71 posteriorly, 10 nude setae: 1 in length of 63 (60,58-65,5) at 0.18 (0.17,0.16-0.19,5), 3 N 52 (52,48-53,5) at 0.50 (0.50,0.48-0.52,5), 44 (42,40-45,5) at 0.59 (0.57,0.56-0.60,5), 88 (86,84-89,5) at 0.65 (0.64,0.62-0.66,5), 3 N at anterior area 46 (46,44-47,5) at 0.77 (0.75,0.74-0.78,5), 79 (77,75-79,5) at 0.82 (0.84,0.80-0.85,5), 38 (38,35-39,5) at 0.84 (0.84,0.82-0.85,5), 3 N at front edge

Figs. 20-24. *Erythraeus michiganensis* n. sp. (Larva and deutonymph):

20a-b. dorsal and ventral idiosoma (larva);

20c-d. dorsal, ventral setae and eyes (larva);

23a-c. leg I-III genu-tarsus (larva);

24a. palpals (deutonymph);

24b. palpal genu, tibia and tarsus (deutonymph);

24c. palpal tibia (deutonymph);

24d. palpal tarsus (deutonymph).

Scale lines for Figs. 20a-b, 23a-c, 24a each represent 100 μm; scale lines for Figs. 20c-d, 21, 24b, c, d each represent 50 μm.

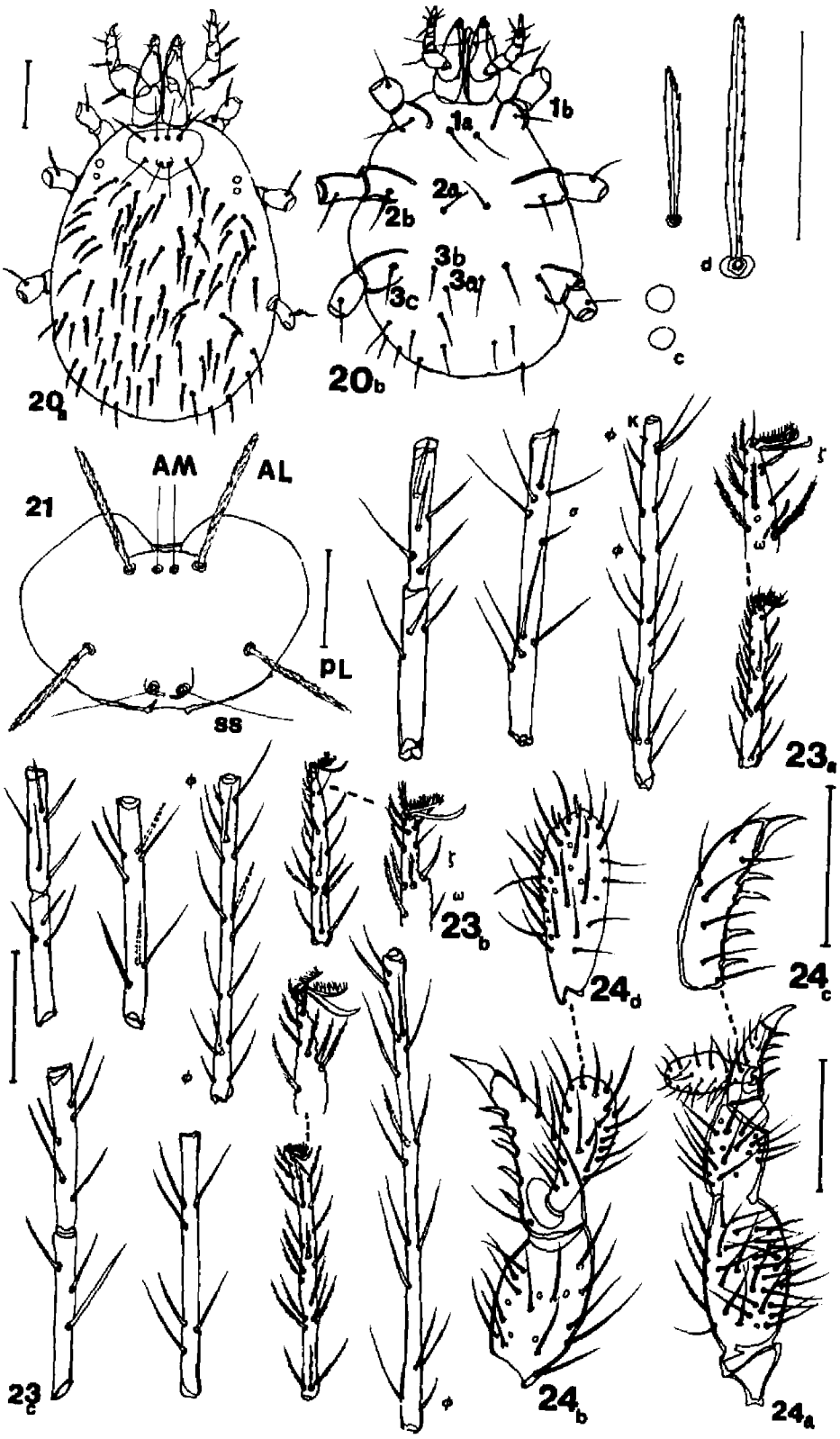

20a
20b
1a
1b
2a
2b
3a
3b
3c
c
d
21
AM
AL
PL
SS
23a
23b
23c
24a
24b
24c
24d

Fig. 22a-d. *Erythraeus michiganensis* n. sp. (larva):

22a-b. dorsal and ventral view of gnathosoma;

22c-d. palpals, palpal tibia and palpal tarsus.

Scale line for Fig. 22a-b represents 100 μm; scale lines for Fig. 22c-d represent 50 μm.

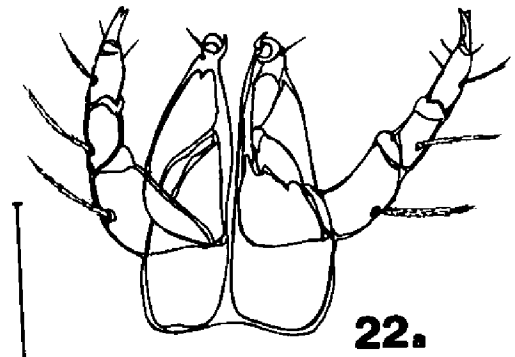
Figs. 25-26. *Erythraeus michiganensis* n. sp. (deutonymph and female): prodorsal sclerite. Scale line represents 100 μm.

Fig. 27-28. *Erythraeus septemsetalis* n. sp. (female):

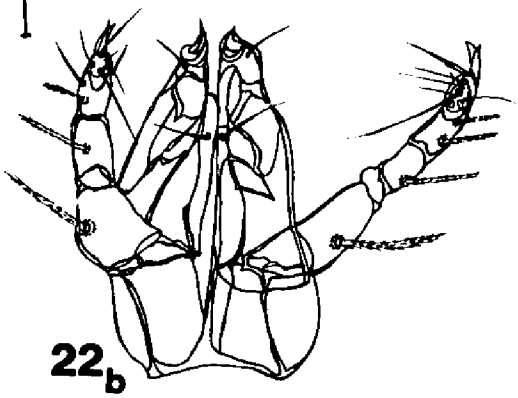
27. palpals;

28. prodorsal sclerite.

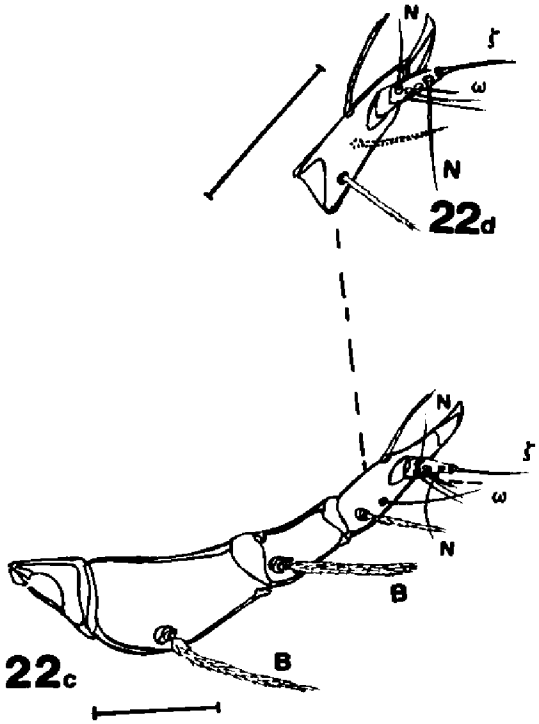
Scale line for Fig. 27 represents 50 μm; scale line for Fig. 28 represents 100 μm.



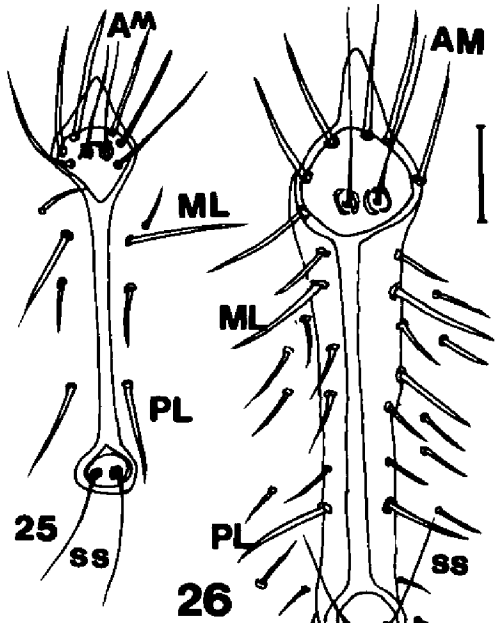
22a



22b

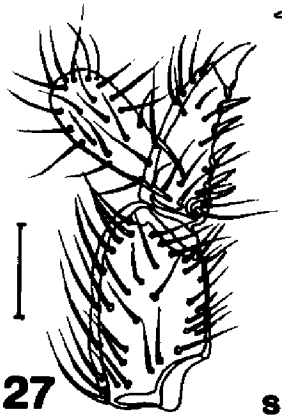


22c 22d

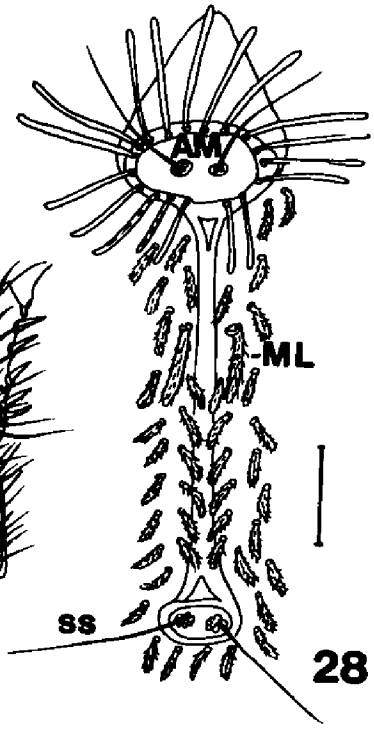


25

26



27



28

88 (86,85-90,5) at 0.91 (0.90,0.88-0.92,5), 44 (42,40-44,5) at 0.93 (0.93,0.92-0.94,5), 88 (88,86-90,5) at 0.95 (0.95,0.94-0.97,5), 2 σ 21-25 at 0.02-0.04, 1 k 12 (12,10-13,5) at 0.93 (0.92,0.90-0.94,5); tibia 618 (645,600-736,5), 63-69 anteriorly, 50-52 posteriorly, 14-16 ϕ: 5 ϕ at basal 25 (25,23-27,5) at 0.24 (0.24,0.22-0.25,5), 29 (28,26-29,5) at 0.25 (0.25,0.24-0.26,5), 24 (24,22-26,5) at 0.25 (0.25,0.23-0.26,5), 29 (28,26-29,5) at 0.34 (0.34,0.32-0.35,5), 25 (25,24-27,5) at 0.45 (0.45,0.44-0.46,5), 5 ϕ at middle 31 (30,28-32,5) at 0.51 (0.50,0.49-0.52,5), 29 (28,26-29,5) at 0.58 (0.58,0.57-0.59,5), 25 (24,23-25,5) at 0.63 (0.62,0.60-0.64,5), 29 (29,27-32,5) at 0.72 (0.72,0.70-0.73,5), 27 (26,25-29,5) at 0.74 (0.73,0.72-0.75,5), 5 ϕ at front 33 (34,32-35,5) at 0.83 (0.84,0.82-0.85,5), 27 (27,27-32,5) at 0.93 (0.93,0.92-0.94,5), 27 (26,24-29,5) at 0.96 (0.96,0.94-0.98,5), 29 (27,26-31,5) at 0.96 (0.96,0.95-0.97,5), 29 (28,26-29,5) at 0.98 (0.98,0.95-0.99,5), 1 k 12 (11,10-13,5) at 0.88 (0.87,0.85-0.89,5); tarsus 487 (480,470-490,5), 40-48 anteriorly, 48-52 posteriorly, 43-46 long ω 23-29 at 0.28-0.92, 19-20 short ω 11-13 at 0.48-0.94, 3 ζh 56 (56,54-57,5) at 0.98 (0.97,0.96-0.97,5), 71 (72,70-74,5) at 0.99 (0.99,0.99-0.996,5), 27 (27,25-28,5) at 0.99 (0.99,0.99-0.995,5), 3 ζp 44 (44,42-45.5) at 0.99 (0.99,0.98-0.99,5), 54 (54,52-55,5) at 0.98 (0.97,0.96-0.99,5), 31 (31,30-33,5) at 0.99 (0.99,0.99-0.995,5).

Leg II: 2192 (2340,2006-2680,5), coxal field 481 (450,425-490,5), 88-171 anteriorly, and 88-144 posteriorly; trochanter 256 (234,216-268,5), 77-111 anteriorly, and 77-78 posteriorly; basifemur 203 (235,200-260,5), 65-69 anteriorly, 54-58 posteriorly; telofemur 384 (398,378-414,5), 56-63 anteriorly, 56-58 posteriorly, with 4 N 53 (54,52-55,5) at 0.64 (0.64,0.62-0.66,5), 52 (52,50-54,5) at 0.66 (0.66,0.64-0.67,5), 61 (62,60-

63,5) at 0.89 (0.89,0.86-0.90,5), 48 (48,46-49,5) at 0.98 (0.98,0.96-0.99,5); genu 424 (420,413-430,5), 84-102 anteriorly, 46-61 posteriorly, 4 N 38 (37,36-39,5) at 0.46 (0.45,0.44-0.47,5), 54 (54,52-55,5) at 0.77 (0.77,0.75-0.78,5), 69 (69,68-70,5) at 0.77 (0.77,0.76-0.79,5), 69 (69,68-70,5) at 0.90 (0.90,0.89-0.92,5), 2 σ 31 (31,29-33,5) at 0.12 (0.12,0.11-0.13,5), 27 (27,25-28,5) at 0.26 (0.26,0.25-0.27,5); tibia 560 (580,550-605,5), 71-77 anteriorly, 52-58 posteriorly, 2 huge setae 92-111 at 0.57-0.67, 4 huge setae at anterior edge in length from 96 to 115, 10-11 ϕ 25-33 at 0.02-0.69; tarsus 365 (370,358-374,5), anterior setae 50-63 in length, 48-58 posteriorly, 12-13 ω 23-29 at 0.54-0.93, 3 ζh 59-67 at 0.91-0.97, 2 ζp 59 (59,58-59,5) at 0.94 (0.95,0.94-0.97,5), 63 (64,62-65,5) at 0.98 (0.98,0.97-0.99,5), 9 ζ at ventral 50-52 at 0.53-0.98 region.

Leg III: 2650 (2550,2348-2780,5), coxal field 432 (410,393-450,5), 61-109 anteriorly,and 104-171 posteriorly, trochanter 223 (210,200-230,5), setae length from 77 to 111, basifemur 353 (300,198-360,5), anterior setae 56-65, posterior setae 54-58, telofemur 468 (466,450-480,5), 61-69 anteriorly, and 58-61 posteriorly, 3 N 54 (54,53-56,5) at 0.42 (0.42,0.40-0.43,5), 34 (35,33-36,5) at 0.60 (0.60,0.59-0.63,5), 58 (57,55-58,5) at 0.90 (0.89-0.93,5); genu 456 (460,445-471,5), anterior setae 69-71, 52-59 posteriorly, with 2 σ 20 (21,19-23,5) at 0.03 (0.03,0.01-0.04,5), 25 (25,22-7,5) at 0.06 (0.06,0.04-0.08,5); tibia 752 (745,738-762,5), 61-77 anteriorly, 50-69 posteriorly, 4-5 ϕ 28 (28,26-29,5) at 0.02 (0.02,0.01-0.03,5), 28 (28,27-29,5) at 0.03 (0.03,0.02-0.05,5), 26 (25,23-26,5) at 0.09 (0.08,0.07-0.09,5), 21 (21,20-23,5) at 0.10 (0.09,0.09-0.12,5), 2 huge setae at midventral region 0.57-0.72, 107 and 133 in length; tarsus 399 (400,385-420,5), anterior setae 59-71, posterior setae 52-63, 3 ζh 73 (73,70-74,5) at 0.90

(0.90,0.88-0.92,5), 77 (77,75-78,5) at 0.92 (0.92,0.90-0.94,5), 90 (91,89-93,5) at 0.95 (0.95,0.93-0.96,5), 2 ʒp 63 (63,61-65,5) at 0.96 (0.96,0.05-0.97,5), 59 (59,52-55,5) at 0.97 (0.95-0.98,5), 59 (59,57-60,5) at 0.98 (0.98,0.96-0.99,5), 3 ω at middle to anterior reagion, 35-40 in length at 0.57-0.75.

Leg IV: 3610 (3200,3056-3760,5), coxal field 579 (480,437-584,5), anterior setae 55-77, posterior setae 90-130; trochanter 240 (215,191-254,5), anterior setae 44-46, posterior setae 65-90; basifemur 380 (338,279-385,5), 63-67 anteriorly, and 38-44 posteriorly; telofemur 452 (412,397-463,5), 67-84 anteriorly, 56-61 posteriorly, 4 N 40 (41,40-43,5) at 0.40 (0.40,0.38-0.44,5), 50 (49,46-50,5) at 0.65 (0.64,0.63-0.66,5), 81 (81,80-83,5) at 0.95 (0.95,0.93-0.96,5), 73 (73,70-74,5) at 0.96 (0.95,0.94-0.97,5); genu 425 (420,418-430,5), anterior setae 63-71, posterior setae 52-54, 3 N 48 (48,45-49,5) at 0.68 (0.67,0.65-0.70,5), 90 (90,89-93,5) at 0.95 (0.95,0.93-0.96,5), 90 (90,88-92,5) at 0.96 (0.96,0.95-0.97,5), 2 σ 23 (23,22-24,5) at 0.042 (0.04,0.03-0.05,5), 25 (25,22-25,5) at 0.026 (0.03,0.02-0.04,5); tibia 1335 (1335,1320-1358,5), anterior setae 65-92, posterior setae 54-56, 4 N 40 (40,38-43,5) at 0.16 (0.15,0.14-0.17,5), 46 (46,44-47,5) at 0.46 (0.45,0.43-0.46,5), 48 (46,43-48,5) at 0.54 (0.53,0.52-0.55,5), 52 (52,50-52,5) at 0.75 (0.75,0.73-0.76,5), 3 ϕ 25-31 at 0.02-0.07, 6 huge setae range from 150 (150,147-153,5) to 182 (178,176-184,5), 3 at anterior end (0.82-0.96), 3 at midventral 0.52-0.68; tarsus 539 (525,510-543,5), 59-61 anteriorly, 48-59 posteriorly, 1 ʒh 88 (88,85-89,5) at 0.96 (0.95,0.94-0.97,5), 3 dorsal ζ at 0.52-0.90, 68-86 in length, 9 ζ at ventral region 0.43-0.87, 35-63 in length, no ω observed.

Adult Male:

Color: in life brown. Idiosoma ovoid, 1813 (1920,1750-2100,5) long by 1396 (1450,1260-1605,5) wide. Two pairs of eyes set on an ocular sclerite, 111 (112,110-116,5) long and 71 (72,70-73,5) wide, AW 33 (33,31-34,5), AL 36 (36,34-37,5), PW 40 (41,40-43,5), PL 40 (41,39-42,5).

Ventral setae of two distinct types: long and truncate 109-123, and short and pointed setae 25-54; majority of setae short. Anal valves with two types of setae: long setae 123-137, short setae 54-61. Genital valves with 89-94 setae 61-69 in length.

Prodorsal sclerite: SS 163 (165,156-172,5); AM 122 (125,116-130.5); SBa 21 (21,19-22,5); SBp 19 (19,17-20,5); AL 125 (125,119-128,5); PL 96 (96,93-97,5); ISD 437 (440,435-448,5); L 577 (578,565-585,5); ASBa 79 (79,75-82,5), 10 long setae at anterior region, 117-159 in length, two types of setae 20-21 at area between SS and SM are short 59-86 and long one 104-129.

Gnathosoma: anterior end with fringe, palpal trochanter 48 (48,45-49,5) with 7-9 setae 61-71; palpal femur 359 (355,347-365,5) with 30-32 setae 73-94; palpal genu 150 (152,144-158,5) with 27-29 setae 61-92; palpal tibia 148 (151,146-156,5), and 5 ventrally projecting spines 19-23 in length, 19-20 setae 40-50, tibia claw entire 52 (52,50-53,5); palpal tarsus 132 (134,129-138,5), 21-23 setae 52-58, 9-10 ω setae 15-21 in length at 0.55-0.96, 11-12 ζ at 0.49-0.98.

Leg I: 2848 (2670,2430-3100,5), coxal field 462 (432,378-470,5), anterior setae 121-236, posterior setae 82-159; trochanter 213 (210,189-235,5), 44-117 anteriorly, 42-96 posteriorly; basifemur 361 (358,347-370,5), 69-79 anteriorly, 58-79 posteriorly, 1 N 42

(42,39-44,5) at 0.65 (0.65,0.63-0.66,5); telofemur 541 (534,498-560,5), anterior setae 71-86, posterior setae 65-75, 7 N 44 (44,42-46,5) at 0.40 (0.41,0.39-0.43,5), 42 (42,40-44,5) at 0.46 (0.45,0.43-0.47,5), 52 (52,51-54,5) at 0.57 (0.56,0.54-0.58,5), 56 (56,54-57,5) at 0.57 (0.57,0.55-0.58,5), 73 (73,71-74,5) at 0.65 (0.64,0.62-0.66,5), 73 (73,71-74,5) at 0.71 (0.72,0.70-0.73,5), 84 (85,82-86,5) at 0.89 (0.88,0.85-0.90,5); genu 600 (598,550-614,5), anterior setae 77-102, posterior setae 59-73, 13 N 38-98 in length at 0.28-0.98 region, 2 σ 29-35 at 0.11-0.49; tibia 641 (625,548-688,5), 69-77 anteriorly, 65-84 posteiorly, 8 N: 2 N posterioly 17-38 in length at 0.21-0.34, 3 N at middle, 44-48 at 0.55-0.64, 2 N at anterior region 0.78-0.79, 59-63 in length, 1 N at anterior end 0.92 (0.92,0.90-0.95,5), 73 (73,71-74,5), 5 ϕ at posterior region from 0.04-0.15 25-31, 1 ϕ at 0.23 (0.24,0.21-0.25,5) 17 (16,15-18,5); tarsus 493 (452,380-498,5), 61-67 anteriorly, 44-56 posteriorly, 4 ζ 54-92 at 0.87-0.98, 92-97 ω 58-61 at 0.23-0.96, 4 ζ at 0.92-0.97, 2 $\wp$ at 0.96-0.98.

Leg II: 2310 (2450,2130-2780,5), coxal field 489 (477,451-520,5), anterior setae 115-223, and posterior setae 100-163; trochanter 221 (223,219-242,5), 50-115 anteriorly, and 46-58 posteriorly; basifemur 292 (282,271-298,5), 59-73 anteriorly, 61-71 posteriorly, with 1 N 42 (41,40-44,5) at 0.65 (0.64,0.62-0.66,5); telofemur 412 (396,368-432,5), 65-92 anteriorly, 59-63 posteriorly, with 5 N: 2 at 0.25-0.28, 44-46, 1 at 0.40 (0.42,0.40-0.45,5) in length of 44 (44,42-46,5), 1 at 0.78 (0.77,0.75-0.78,5) 61 (62,60-64,5), 1 at 0.93 (0.93,0.92-0.94,5); genu 456 (455,430-478,5), 71-73 anteriorly, 54-58 posteriorly, 3 N 38 (38,35-39,5) at 0.51 (0.50,0.49-0.53,5), 65 (65,63-66,5) at 0.80 (0.80,0.78-0.82,5), 67 (66,64-69,5) at 0.91 (0.90,0.88-0.93,5), 2 σ at rear region from 0.08 to

0.20, 21-27, 4 huge setae at anterior region from 0.86 to 0.97, 90-125; tibia 552 (534,520-566,5), 9-10 N: 2 at 0.23-0.36, 38 each, 4 at middle 0.52-0.62, 44-48, 2 at anterior region 0.76-0.86, 52-71, 1 at anterior end 0.93 (0.93,0.92-0.95,5), 86 (85,83-86,5), 6 ϕ at rear region 0.05-0.16, 25-27, 2 huge setae at 0.34 and 0.35, 96-111, 2 at middle 0.52-0.60, 96-121, 1 at 0.78 (0.77,0.75-0.79,5), 113 (114,110-120,5), 2 at anterior end 0.94-0.95, 94-115; tarsus 376 (360,349-410,5), 61-73 anteriorly, 44-63 posteriorly, 2 ζ at 0.85-0.97, 54-94 in length, 3 ω at anterior end 0.91-0.98, 46-54, 6 ω at ventral 0.44-0.86, 46-52 in length.

Leg III: 2593 (2285,2187-2890,5), coxal field 539 (528,478-550,5), 90-117 anteriorly, and 71-180 posteriorly; trochanter 280 (266,257-297,5), 92-105 anteriorly, and 46-56 posteriorly; basifemur 198 (188,173-253,5), 61-73 anteriorly, 50-52 posteriorly, with 1 N 50 (48,46-52,5) at 0.91 (0.91,0.89-0.93,5); telofemur 493 (454,427-534,5), 59-82 anteriorly, 61-67 posteriorly, 3 N 44 (43,40-46,5) at 0.54 (0.53,0.52-0.56,5), 82 (83,80-85,5) at 0.92 (0.92,0.91-0.93,5), 86 (87,84-88,5) at 0.94 (0.94,0.92-0.95,5); genu 474 (475,470-480,5), 63-86 anteriorly, 42-58 posteriorly, 5 N 42 (43,38-44,5) at 0.37 (0.35,0.32-0.38,5),58 (58,55-59,5) at 0.80 (0.78,0.76-0.82,5), 104 (102,98-105,5) at 0.93 (0.93,0.90-0.95,5), 96 (96,93-97,5) at 0.94 (0.93,0.91-0.96,5), 100 (99,98-105,5) at 0.95 (0.96,0.94-0.97,5), 1 σ 21 (21,18-23,5) at rear 0.06-0.08; tibia 775 (750,725-780,5), 10 N: 1 at rear region 0.28 (0.27,0.24-0.30,5), 42 (42,41-43,5) in length, 1 at middle 0.51 (0.50,0.48-0.53,5) 40 (40,38-42,5), 6 at anterior region: 56 (55,53-56,5) at 0.72 (0.72,0.69-0.74,5), 59 (59,56-62,5) at 0.75 (0.74,0.72-0.76,5), 59 (59,57-60,5) at 0.79 (0.79,0.78-0.82,5), 58 (57,56-58,5) at 0.82 (0.83,0.80-0.85,5), 69 (70,68-73,5)

at 0.88 (0.88,0.86-0.89,5), 56 (56,53-58,5) at 0.89 (0.89,0.86-0.90,5), 90 (90,88-93,5) at 0.97 (0.97,0.95-0.98,5), 86 (85,84-87,5) at 0.98 (0.98,0.96-0.99,5), 5 huge setae at anterior region from 0.88 to 0.93, 92-132 in length, 4-5 ϕ at rear region 0.03-0.06, 21-31, 1 ϕ at 0.90 (0.92,0.89-0.93,5), 25 (25,23-26,5); tarsus 401 (388,357-412,5), 59-73 anteriorly, 50-56 posteriorly, 3 ζ 73 (73,72-75,5) at 0.92 (0.92,0.91-0.94,5), 75 (75,72-76,5) at 0.93 (0.94,0.92-0.95,5), 81 (81,79-82,5) at 0.97 (0.96,0.94-0.98,5), 2 ω 12-17 at 0.49-0.74.

Leg IV: 4078 (3658,3220-4358,5), coxal field 591 (520,479-624,5), 71-90 anteriorly, 50-198 posteriorly; trochanter 295 (264,236-312,5), 61-88 anteriorly, 25-46 posteriorly; basifemur 384 (355,327-398,5), 65-67 anteriorly, 54-61 posteriorly, with 1 N 50 (49,46-50,5) at 0.94 (0.93,0.92-0.95,5); telofemur 704 (679,624-715,5), 71-77 anteriorly, 56-73 posteriorly, 3 N 44 (44,42-46,5) at 0.70 (0.70,0.67-0.72,5), 84 (84,81-85,5) at 0.95 (0.95,0.92-0.96,5), 86 (86,83-88,5) at 0.96 (0.96,0.93-0.98,5); genu 775 (745,713-783,5), 71-86 anteriorly, 67-71 posteriorly, 6 N 42 (42,40-44,5) at 0.58 (0.56,0.54-0.59,5), 44 (44,42-47,5) at 0.74 (0.74,0.72-0.76,5), 58 (57,55-58,5) at 0.87 (0.86,0.85-0.88,5), 100 (97,95-99,5) at 0.95 (0.95,0.93-0.96,5), 98 (98,96-99,5) at 0.96 (0.96,0.94-0.97,5), 102 (98,96-104,5) at 0.96 (0.95,0.94-0.97,5), 3 σ at 0.03-0.05, 25-29; tibia 1408 (1320,1109-1523,5), 11-12 N at 0.20-0.93, 42-71, 4 ϕ at 0.02-0.04, 23-31, 5 huge setae 146-188 at 0.42-0.96; tarsus 512 (508,486-526,5), 65-73 anteriorly, 56-59 posteriorly, 2 ζh 88-86 at 0.98, 1 dorsal ζ 52-59 at 0.87-0.89, no ω observed.

Etymology:

The name was derived from the state of Michigan.

Distribution of Types:

The holotype, 20 larval, 10 deutonymphal, and 5 adult female paratypes are in Department of Zoology, Michigan State University, East Lansing, MI. One larval, deutonymphal and adult female paratype will be deposited in each of the following institutions: National Museum of Natural History, Washington, DC; British Museum (Natural History), London, U. K.; Department of Biology, Fudan University, Shanghai, PRC.

Erythraeus septemsetalis n. sp.

Type series:

The description is based on the morphology of five adults collected on 21 July, 1984 from a cedar bog near Sagola, Michigan; no larvae and nymphs are available.

Description:

Adult female:

Idiosoma: color in life dark brown. Idiosoma 2714 (2800,2478-3210,5) long by 2574 (2448,2168-2774,5) wide. Dorsal setae in two types, short and stout setae 36-38 long, long setae 71-81; ventral setae thin and smooth, 58-71 in length for short setae, 86-92 in length for long setae.

Palpals: palpal femur 209 (210,197-220,5); palpal genu 237 (223,216-257,5); palpal tibia 1781 (173,168-178,5), palpal tibia claw entire 50 (50,47-53,5) long with 5 spines at inner edge; palpal tarsus 132 (135,128-143,5).

Prodorsal sclerite (Fig. 28): SS 150 (148,144-152,5); SM 196 (197,188-202,5); AW 142

(143,139-145,5); PW 77 (77,73-78,5); 712 (708,703-721,5) long with 15 long setae at the front of the sclerite 71-123 in length.

Leg I: 3599 (3650,3267-3878,5), coxal field 537 (524,517-546,5); trochanter 236 (238,212-247,5); basifemur 435 (428,414-448,5), with 2 N 40-92 at 0.65-0.87; telofemur 620 (612,608-635,5) with 5 N 42-71 at 0.62-0.92; genu 852 (843,827-866,5) with 11-12 N 55-82 at 0.18-0.96, 2 σ 24-31 at 0.46-0.81; tibia 867 (870,855-897,5) with 10-12 ϕ 23-30 at 0.26-0.81, 24-26 N 46-70 at 0.16-0.92; tarsus 589 (590,575-611,5) with 157-162 ω 25-44 at 0.57-0.98, 12-13 ζ 56-79 at 0.82-0.98, 2 ζp 89-95 at 0.97-0.99.

Leg II: 2775 (2803,2576-2897,5), coxal field 591 (585,577-598,5); trochanter 280 (286,277-295,5); basifemur 330 (328,307-333,5) with 2 N 46-88 at 0.64-0.87; telofemur 510 (505,487-532,5) with 4 N 42-59 at 0.34-0.88; genu 570 (557,534-588,5) with 2 σ 23-33 at 0.04-0.06, 8-9 N 33-44 at 0.40-0.93; tibia 717 (708,695-723,5) with 4-5 ϕ 24-35 at 0.02-0.28, 12-14 N 34-59 at 0.12-0.94; tarsus 368 (358,313-377,5) with 17-19 ω 13-21 at 0.55-0.87, 5-6 dorsal ζ 42-69 at 0.71-0.92, 2 ζh 71-77 at 0.95-0.98, 2 ζ 52-57 at 0.96-0.98.

Leg III: 3420 (3277,3184-3579,5), coxal field 543 (540,527-563,5); trochanter 253 (244,218-267,5); basifemur 378 (358,343-388,5) with 3 N 50-88 at 0.62-0.83; telofemur 627 (616,608-647,5) with 2-3 N 38-52 at 0.30-0.57; genu 719 (707,678-732,5) with 3 σ 7-13 at 0.02-0.05, 6-7 N 31-42 at 0.60-0.97; tibia 1032 (1020,988-1137,5) with 3-4 ϕ 23-26 at 0.0.01-0.10, 9-10 N 35-58 at 0.43-0.97; tarsus 410 (408,388-422,5) with 8-9 ω 10-15 at 0.33-0.74, 5 dorsal ζ 42-48 at 0.71-0.95, 1 ζh 72-77 at 0.96-0.98, 3 ζp 48-58 at 0.96-0.98.

Leg IV: 5645 (5270,5108-5630,5), coxal field 735 (727,705-764,5); trochanter 280 (276,266-292,5); basifemur 702 (696,688-710,5) with 1 N 42-44 at 0.81-0.86; telofemur 1045 (1033,1012-1103,5) with 6-7 N 33-67 at 0.21-0.97; genu 1174 (1109,1078-1205,5) with 2 σ 21-25 at 0.02-0.03, 3-4 N 38-42 at 0.44-0.97; tibia 1868 (1815,1786-1903,5) with 3-4 ϕ 24-29 at 0.02-0.04, 14-15 N 38-69 at 0.31-0.91; tarsus 575 (571,522-590,5) without ω, 2 ζh 77-84 at 0.92-0.95, 2 ζp 52-71 at 0.96-0.98, 3 dorsal ζ 48-52 at 0.45-0.74.

Etymology:

The species name was derived from the sclerite of the adults, which has seven long setae on its anterior edge, distinguishing the species from others.

Discussion:

The genus was erected by Latreille in 1806 with the type species *Acarus phalangoides* de Geer, 1778. Southcott (1946) created the monotypic genus *Parerythraeus*, basing it on the type species *Parerythraeus gregoryi* Southcott, 1946. In further work (1961), he included *Parerythraeus tragardhi* = *Erythraeus dugesi* Tragardh, 1904 in the genus. About nine species were described from Europe and at least 5 species from the United States (Beron,1982,1988; Haitlinger,1987; Southcott, 1961; Turk, 1981).

Erythraeus septemsetalis differs from *E. michiganensis* in having larger AW (141:99), longer ASE (149:124), PSE (195:161), longer prodorsal sclerite (711:607) and longer legs (3598:2158, 2775:2191, 3419:2549,4470:3607). However, the most important characters which seperate the two species is the location of sclerite setae; in the former,

these setae are located on the prodorsal sclerite, in the latter, they are on the dorsal idiosoma.

Distribution of Types:

The holotype, 5 female paratypes are in Department of Zoology, Michigan State University, East Lansing, MI.

Subfamily Callidosomatinae:

***Abrolophus welbourni* n. sp.**

Type series:

Holotype: 1 larva collected on April 30, 1991 from a nymph of a leafhopper. Additional 30 paratypes collected from May 4-21, 1991 in the same location. Fifteen paratype deutonymphs reared from larvae in the laboratory. Five paratype adults collected in the field in July, 1991.

Larval description:

Color: in life yellow. Idiosoma ovoid 583 (592,544-612,30) long, 279 (269,255-297,30) wide; one pair of eyes on each side of prodorsum 17 (17,16-18,30), distance between eyes 82 (85,80-87,30). Dorsum hypertrichous with 57 (55,51-58,30) setae, 38 (38,35-39,30) anteriorly, 52 (52,50-55,30) posteriorly (Fig. 29a).

Ventral idiosoma with one pair (1a) of intercoxal setae between coxal field leg I, 46 (44, 42-47,30), one pair (1b) 50 (48,47-51,30) at coxal field I; one pair (2a) of intercoxal setae between coxal field leg II, 38 (34,32-38,30), One pair (2b) 38 (35,32-38, 30) at coxal field II; one pair of intercoxal setae (3a) 42 (43,42-46,30), one pair (3b) 44

(45,41-47,30) on coxal field III. Four setae located between coxal field II and III 28, 32, 34 and 16 respectively; after coxal field III 18 dorsal setae 29-46 (Fig. 29b).

Prodorsal sclerite (Fig. 30): anterior margin concave with lateral shoulders, widest at level of PL setae; two pairs of sensory setae trichobothrial, second pair near posterior margin. SS 44 (42, 38-47,30); AL 69 (63,52-70,30); PL 63 (59,55-67,30); AW 59 (56,54-60,30); MW 74 (72,69-77,30); PW 78 (74,72-80,30); SM 68 (63,57-71,30); ASBa 17 (16,15-18,30); ISD 40 (38,37-43,30); LX 9 (9,7-10,30); A 53 (49,46-56,30); AAS 17 (15,14-19,30); L 84 (80,78-88,30).

Gnathosoma (Fig. 31): palpal setal formula fPp=0-BB-BBB-6N-3N2Bω; palpal genu with 1 "knob"; palpal tibial claw entire 21 (22,18-25,30) with 1 small clawlike seta and 5 nude setae; palpal tarsus with 1 long seta 67 (62,58-68,30), 1 comblike seta 42 (42,38-44,30), one small leaflike seta 7 (8,6-9,30), 1 ω and 2 nude setae.

Leg I (Fig. 32a): 270 (286,266-348,30) long; coxal field with 1 branched seta (1B) 50 long (48,44-53,30); trochante 2B 50 (49,47-54,30), 57 (56,52-59,30); basifemur 4B (46-63); telofemur 5B (46-53,30); genu 11B, 1 σ 21 and 19 at 0.79 (0.80,0.79-0.84,30) and 1 k 4 (4,3-4,30) at 0.93 (0.94,0.88-0.96,30); tibia 13B, 2 φ 17 (16,15-20,30) and 23 (23,22-26,30) at 0.83 (0.84,0.80-0.87,30) and 0.89 (0.89,0.87-0.92,30), respectively, 1 k 6 (6,4-8,30) at 0.87 (0.88,0.85-0.90,30); tarsus with 1 ω 19 (20,18-23,30) at 0.77 (0.75,0.72-0.82,30); 1 famulus 4 (4,3-4,30) at 0.85 (0.85,0.81-0.89,30); 1 ʒh 42 (42,38-44,30) at 0.83 (0.83,0.80-0.85,30), 1 companion seta; 1 ʒp 17 (16,15-19,30) at

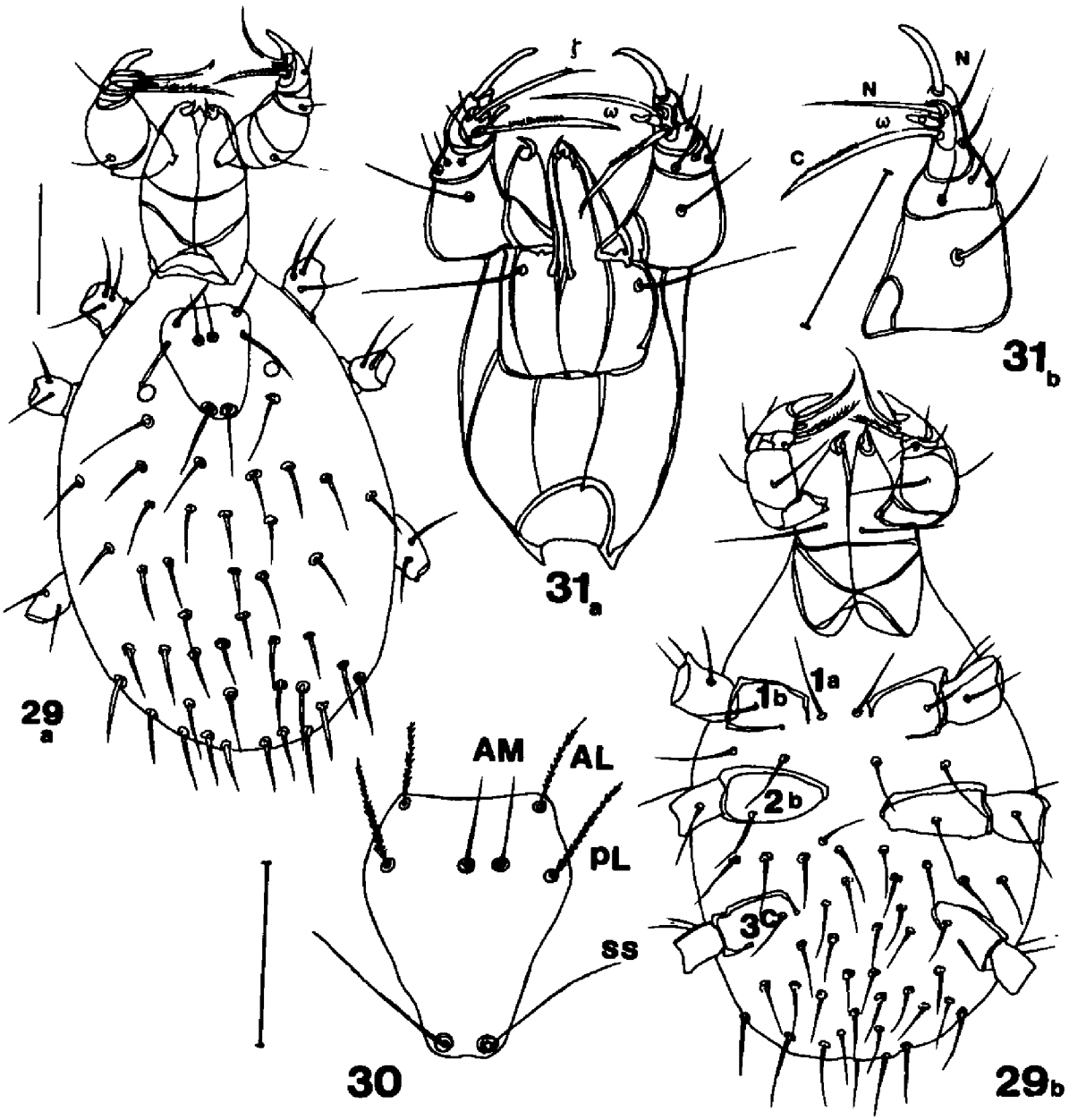
Figs. 29-31. *Abrolophus welbourni* n. sp. (larva):

29a-b. dorsal and ventral idiosoma;

30. prodorsal sclerite;

31a-b. gnathosoma and palpals.

Scale lines for Figs. 29, 31a represent 100 μm; scale lines for Figs. 30, 31b represent 50 μm.


29a
31a
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3c
29b

0.94 (0.93,0.90-0.98,30).

Leg II (Fig. 32b): 225 (238,217-288,30) in length, coxal field with 1B 44 (44,40-46,30); trochanter with 2B 36-42, basifemur 4B 42-58; telofemur 5B 33-44; genu with 9B 27-35, 1 σ 15 (15,12-17,30) at 0.76 (0.74,0.72-0.79,30), 1 k 4 (4,4-7,30) at 0.84 (0.85,0.81-0.88,30); tibia with 13B 40-46, 2 ϕ 13 (14 and 17 (16,15-19,30) at 0.79 (0.78,0.75-0.80,30) and 0.74 (0.73,0.70-0.76,30) respectively; tarsus with 23B 29-35; 1 ω 11 (11,9-13,30) at 0.52 (0.53,0.50-0.56,30), 1 ζ 34 (33,30-35,30) at 0.72 (0.72,0.69-0.74,30), 1 subterminal eupathid and 1 companion seta 4 (4,3-7,30) at 0.76 (0.75,0.73-0.79,30).

Leg III (Fig. 32c): 255 (284,247-322,30) long, coxal field with 1B 42 (43,41-47,30); trochanter with 2B 34-40; basifemur with 4B 36-42; telofemur with 5B 36-42; genu with 9B 38-44, 1 σ 17 (17,15-18,30) at 0.86 (0.85,0.83-0.87,30); tibia with 13B 38-46, 1 ϕ 19 (18,16-20,30) at 0.46 (0.46,0.40-0.48,30); tarsus with 18B 30-44, 1 ζp 21 (21,18-22,30) at 0.96 (0.95,0.94-0.99,30) and 1 subterminal eupathid 3 (3,3-5,30) at 0.94 (0.95,0.93-0.96,30).

Deutonymph:

Color: in life red. Idiosoma 735 (708,677-767,15) long by 609 (588,576-625,15) wide. Dorsal setae 31-36 in length; ventral setae 40-42. Anal valve with 7-8 setae (Fig. 33). Eyes 1 + 1, 13 across.

Palpals: palpal femur 77 (77,73-79,15), 5 setae 31-33 long, 1 long seta 73 (72,70-77,15) in length; palpal genu 48 (48,45-50,15) with 8 setae 27-33; palpal tibia 23 (22,20-25,15) with 9 setae 13-27 long, palpal tibia claw entire, 12 (11,10-13,15); palpal tarsus 23 (23,21-25,15) with 9 ω 10-19, 2 nude setae, 2 ζ 13-17 (Fig. 34).

Dorsal sclerite: 178 (188,164-203,15) long by 46 (43,37-56,15) wide, AM 107 (113,102-125,15) long, SS 48 (57,43-67,15) long.

Legs: Leg I 758 (755,731-778,15), coxal field 94 (95,92-98,15) with 4 setae 31-36; trochanter 50 (51,48-55,15) with 5 setae; basifemur 115 (113,108-127,15) with 6 setae; telofemur 130 (132,129-144,15) with 2 θ 36-38 at 0.83 and 0.85 respectively; genu 169 (165,157-182,15) with 5 σ 27-38 at 0.47-0.86; tibia 165 (166,157-170,15) with 9 ϕ 23-38 at 0.18-0.82, 1 k 6 (5,4-7,15) at 0.93 (0.94,0.92-0.95,15); tarsus 129 (129,117-134,15) with 8 ω 13-19 at 0.61-0.91, 3 ζh 35-38 at 0.67-0.95.

Leg II 418 (412,408-425,15), coxal field 98 (99,95-103,15); trochanter 61 (60,58-64,15); basifemur 54 (52,50-56,15); telofemur 67 (65,62-70,15) with 1 θ 36 (36,34-38,15); genu 88 (89,85-92,15) with 2 σ 13-33 at 0.72-0.89; tibia 86 (84,80-88,15) with 2 ϕ 17-21 at 0.21-0.40; tarsus 61 (67,57-72,15) with 1 ζh 33 (32,30-34,15).

Leg III 409 (405,388-432,15), coxal field 79 (79,76-80,15); trochanter 61 (63,60-65,15); basifemur 58 (59,54-63,15); telofemur 73 (72,70-77,15) with 1 θ 31 (31,28-34,15); genu 104 (110,102-125,15) with 2 σ 36-38 at 0.85 and 0.86, 2 p 19-21 at 0.37-0.70; tibia 119 (116,110-131,15) with 2 ϕ 21 each at 0.11-0.13; tarsus 61 (63,61-65,15) with 1 ζh 36 (37,34-38,15) at 0.88 (0.87,0.85-0.90).

Leg IV 760 (747,712-820,15), coxal field 115 (108,102-124,15); trochanter 46 (46,44-48,15); basifemur 88 (92,85-95,15); telofemur 155 (167,148-192,15) with 1 θ 44 (46,42-48,15) at 0.89 (0.88,0.86-0.92,15); genu 178 (188,165-197,15) with 3 σ 15-25 at 0.51-0.88, 2 p 27 each at 0.57-0.76; tibia 219 (223,207-265,15) with 2 ϕ 38-40 at 0.50 and 0.85; tarsus 73 (73,70-75,15) with 1 ζh 42 (42,38-46,15) at 0.86 (0.88,0.85-

0.92,15).

Adult female:

Color: in life red. Idiosoma 1471 (1642,1237-1785,15) long by 783 (797,756-810,15). Dorsal setae 42-50 long, ventral setae 44-50. Eyes 1 + 1 31 across. Anal valves with 8 setae; genetal valves 297 (304,286-332,15) long by 96 (98,87-103,15) wide with 62-64 setae 33-38 long (Fig. 36).

Palpals: palpal femur 148 (148,142-156,15) with 28-32 setae and 1 long seta; palpal genu 92 (95,88-98,15) with 25-26 setae; palpal tibia 33 (35,30-37,15) with 12 setae, palpal tibia claw 23 (28,21-36,15); palpal tarsus 58 (58,55-61,15) with 7 ω and 7-9 eupathidia and 4 nude setae (Fig. 37).

Prodorsal sclerite (Fig. 38): 412 (426,407-446,15) long, AW 119 (121,107-132,15); PW 61 (64,60-72,15); AM 100 (101,95-106,15); SS 129 (132,117-146,15); SBa 29 (29,25-32,15); SBp 21 (23,20-25,15); LX 67 (69,63-70,15); ISD 291 (297,255-314,15) and 3 extra setae anterior to AM setae.

Legs: Leg I 1617 (1723,1335-1827,15), coxal field 184 (178,138-192,15); trochanter 86 (87,82-90,15); basifemur 252 (262,244-278,15); telofemur 322 (332,307-354,15) with 2 N 26-29 at 0.36-0.77; genu 353 (363,342-385,15) with 9-10 σ 19-26 at 0.05-0.92, 1 k 6-9 at 0.96-0.98; tibia 316 (320,309-332,15) with 10-11 ϕ 19-23 at 0.07-0.63, 1 k 6-9 at 0.95-0.97; tarsus 287 (289,254-310,15) with 82-90 ω 13-19 at 0.54-0.98, 2-3 dorsal ζ 29-31 at 0.73-0.87, 2 ζh 32-34 at 0.96-0.98.

Leg II 1023 (1108,1008-1325,15), coxal 215 (223,208-237,15); trochanter 144 (147,138-153,15); basifemur 130 (138,122-145,15); telofemur 186 (187,175-197,15) with

1 N 25-29 at 0.41-0.44; genu 223 (228,211-242,15) with 7-8 σ 19-23 at 0.33-0.86, 1 k 6-9 at 0.92-0.95; tibia 215 (217,207-238,15) with 4-5 ϕ 15-19 at 0.08-0.89; tarsus 125 (129,118-136,15) with 1 ζh 31-33 at 0.94-0.96, 2-3 dorsal ζ 31-33 at 0.43-0.80, without ω.

Leg III 1157 (1178,1087-1232,15), coxal field 178 (177,155-183,15); trochanter 146 (147,133-168,15); basifemur 141 (148,136-154,15); telofemur 205 (210,187-223,15) with 1 N 27-31 at 0.76-0.88; genu 266 (273,218-310,15) with 6-7 σ 15-23 at 0.28-0.78; tibia 275 (288,253-297,15) with 4-5 ϕ 19-25 at 0.06-0.94; tarsus 123 (129,110-133,15) with 1 ζh 35-38 at 0.90-0.93, no ω observed.

Leg IV 1950 (1986,1908-1997,15), coxal field 285 (278,231-297,15); trochanter 139 (142,127-147,15); basifemur 215 (223,208-233,15); telofemur 430 (431,407-445,15) with 1-2 N 31-35 at 0.41-0.93; genu 480 (482,455-510,15) with 6-7 σ 23-29 at 0.21-0.80; tibia 520 (525,504-556,15) 5-6 ϕ 19-25 at 0.03-0.91; tarsus 169 (167,162-178,15) with 2 ζh 40-42 at 0.93-0.96, no ω observed.

Adult male:

Color: in life red. Idiosoma 1375 (1427,1180-1566,15) by 949 (937,878-952,15) wide. Dorsal setae 40-52 in length, ventral setae 36-44, anal valves with 16 setae, genetal valves with 88-97 setae.

Palpals: palpal femur 165 (168,157-171,15); palpal genu 98 (95,90-99,15); palpal tibia 35 (35,32-37,15), palpal tibia claw entire 15 (16,14-18,15); palpal tarsus 59 (61,57-66,15) with 12 ω, 6 ζ and 2 nude setae.

Figs. 32-38. *Abrolophus welbourni* n. sp. (larva, deutonymph and adult female):

32a-c. leg I-III (larva);

33. anal valves (deutonymph);

34. palpals (deutonymph);

35. prodorsal sclerite (deutonymph);

36. genital and anal valves (female);

37. palpals (female);

38. prodorsal sclerite (female).

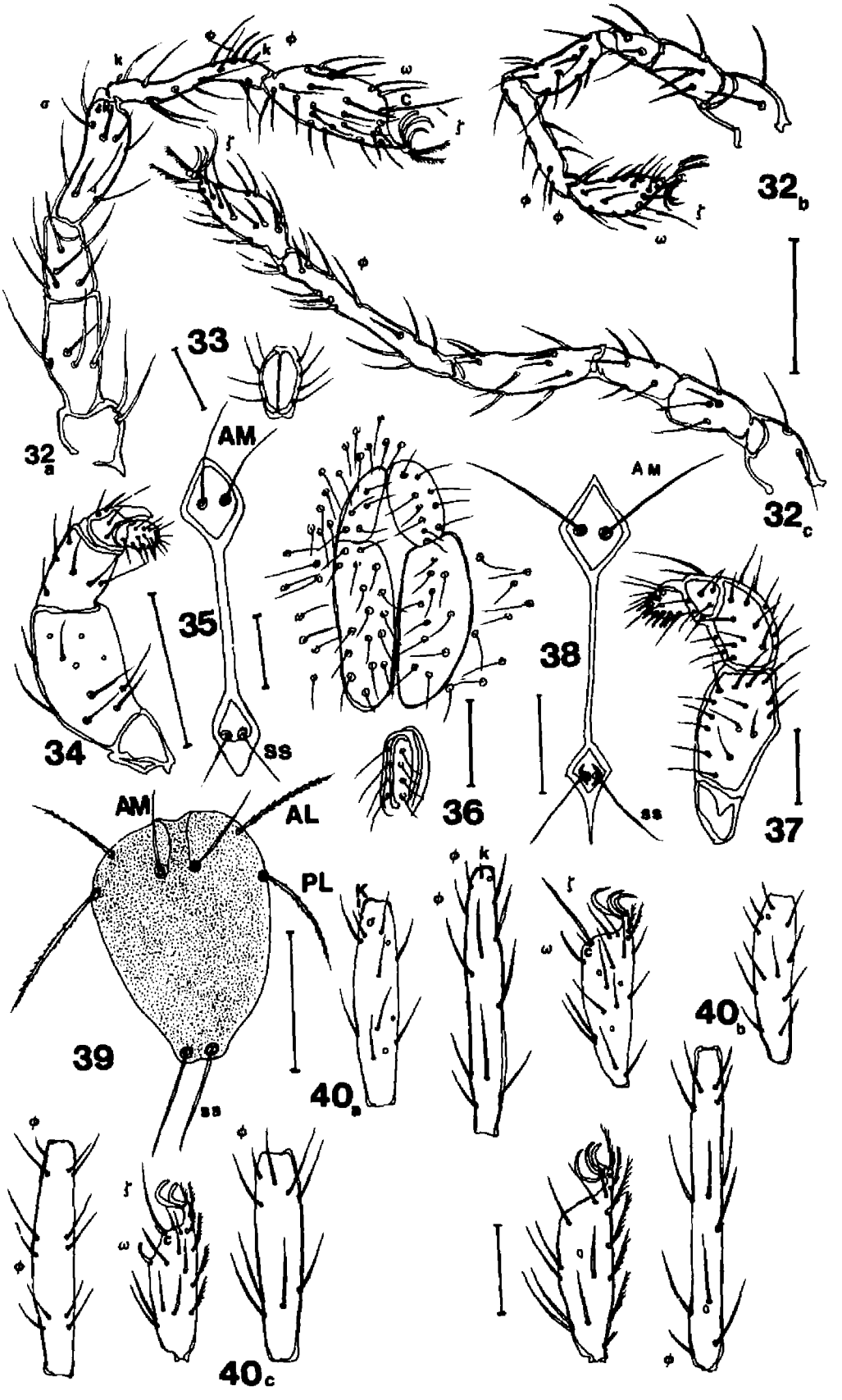
Scale lines for Figs. 32-38 represent 100 μm.

Figs. 39-40. *Abrolophus channingensis* n. sp. (larva):

39. prodorsal sclerite;

40a-c. leg I-III genu to tarsus.

Scale line for Fig. 39 represents 50 μm; scale line for Fig. 40a-c represents 100 μm.


32a
32b
32c
33
34
35
36
37
38
39
40a
40b
40c
AM
AL
PL
SS

Prodorsal sclerite: 337 (312,258-341,15) long, SM 84 (86,83-87,15); SS 111 (119,107-126,15); AW 111 (115,107-125,15); PW 50 (51,47-55,15); SBa 31 (32,28-35,15); SBp 21 (21,19-26,15); LX 73 (74,70-76,15); ISD 244 (253,232-265,15); 8 and 7 setae located at each side of the area between SM and SS.

Legs: Leg I 1460 (1530,1348-1653,15), coxal field 178 (180,166-189,15); trochanter 130 (133,129-142,15); basifemur 186 (185,173-198,15); telofemur 302 (311,297-342,15) with 1 N 21-26 at 0.57-0.62; genu 297 (299,286-312,15) with 12-13 σ 23-27 at 0.41-0.81, 1 k 8-10 at 0.95-0.97; tibia 272 (278,257-297,15) 12-14 ϕ 21-25 at 0.05-0.68, 1 k 7-9 at 0.94-0.96; tarsus 274 (276,255-288,15) with 87-92 ω 13-17 at 0.45-0.97, 2-3 ζh 40-42 at 0.96-0.98, 2-3 dorsal ζ 31-35 at 0.68-0.88, 1-2 ζp 33-35 at 0.97-0.99.

Leg II 950 (967,918-1007,15), coxal field 165 (167,158-172,15); trochanter 123 (128,118-139,15); basifemur 157 (159,147-163,15); telofemur 159 (152,147-163,15) with 1 N 19-23 at 0.38-0.46; genu 225 (228,217-246,15) with 7-8 σ 15-19 at 0.28-0.90, 1 k 8-10 at 0.89-0.92; tibia 173 (178,159-182,15) with 4-5 ϕ 17-21 at 0.07-0.54; tarsus 113 (110,107-121,15) with 1 ζh 31-33 at 0.95-0.96, 1-2 dorsal ζ 21-25 at 0.27-0.85, no ω observed.

Leg III 1068 (1048,1008-1123,15), coxal field 165 (163,159-172,15); trochanter 125 (128,117-133,15); basifemur 165 (163,157-172,15); telofemur 173 (179,162-188,15) with 1 N 19-23 at 0.46-0.49; genu 209 (217,199-232,15) with 7-8 σ 17-21 at 0.12-0.87; tibia 268 (272,255-287,15) with 4-5 ϕ 13-17 at 0.03-0.57; tarsus 129 (131,117-140,15) with 1 ζh 33-35 at 0.92-0.94, no ω.

Leg IV 1876 (1882,1723-1988,15), coxal field 260 (268,257-282,15); trochanter

130 (129,121-136,15); basifemur 194 (195,183-210,15); telofemur 397 (399,378-421,15) with 1-2 N 19-23 at 0.37-0.65; genu 366 (357,323-388,15) with 9-10 σ 23-27 at 0.17-0.94; tibia 432 (442,417-452,15) with 8-9 ϕ 19-25 at 0.03-0.91; tarsus 357 (362,327-388,15) with 1-2 ζh 33-35 at 0.91-0.95, no ω observed.

Etymology:

The species name honors Dr. W. Calvin Welbourn for helping me personally and for his contributions to Acarology, especially with respect to the classification of Trombidiidae and Erythraeidae.

Distribution of Types:

The holotype, 20 larval, 20 nymphal and 20 adult paratypes are in Department of Zoology, Michigan State University, East Lansing, MI. One larval, nymph and adult female paratypes will be deposited in each of the following institutions: Department of Biology, Fudan University, Shanghai, PRC; Field Museum of Natural History, Chicago, IL; National Museum of Natural History, Washington, DC.

Abrolophus channingensis n. sp.

Type series:

Holotype: 1 larva collected from the forest floor on May 15, 1991 parasitizing a nymph of a leafhopper, fifteen paratypes collected in the same locality, also parasitizing nymphs of leafhoppers of the same host species. Deutonymphs and adults unknown.

Larval description:

Idiosoma: ovoid, length 545 (557,523-588,15). Dorsal setae 46 (47,45-55,15) in length of 48-56. Ventral setae 42 (42,40-44,15) 31-38.

Prodorsal sclerite (Fig. 39): SM 33 (33,30-36,15), SS 65 (67,63-68,15), AL 44 (45,42-47,15),PL 52 (53,50-56,15), AW 59 (61,58-64,15), PW 69 (71,67-74,15), LX 21 (22,19-25,15), ISD 63 (65,62-67,15), ASBa 40 (42,38-44,15), AAS 17 (18,16-19,15), SBp 13 (14,12-15,15), SBa 12 (12,10-13,15). Eyes 1 + 1, 17 long by 17 wide.

Gnathosoma: palpal femur with 2 setae 35-50; palpal genu with 3 setae 15-23; tibia with 1 seta 21, palpal tibia claw entire; palpal tarsus with 1 long seta 69 (69,67-72,15), 1 cone-like seta 40 (41,38-43,15), 2 short setae 10 each, and 2 stout setae 6 each (Fig. 48).

Legs (Fig. 40a-c): Leg I 395 (388,343-421,10), coxal field 61 (62,60-64,10) with 1 seta 40 (40,38-43,10); trochanter 46 (46,44-48,10), with 2 setae 44 each; basifemur 59 (58,56-62,10) with 4 setae 42-56 long; telofemur 44 (45,42-46,10) with 8 setae 31-33; genu 82 (83,80-85,10) with 10 setae 29-35, 1 σ 15 (15,13-17,10) at 0.79 (0.78,0.77-0.80,10), 1 k 2 (2,1-3,10) at 0.88 (0.87,0.86-0.89,10); tibia 90 (89,87-93,10), 12 setae 38-40, 2 ϕ 21 (19-24,10) at 0.82 (0.82,0.80-0.84,10), 17 (18,16-19,10) at 0.88 (0.87,0.85-0.89,10), 1 k 4 (4,3-5,10) at 0.89 (0.88,0.87-0.90,10); tarsus 71 (71,68-73,10) with 22-23 setae 19-33, 1 ω 23 (22,20-23,10) at 0.61 (0.60,0.59-0.62,10), 1 ζh 47 (45,42-48,10) at 0.75 (0.73,0.70-0.75,10)(Fig. 40a).

Leg II 356 (360,350-370,10), coxal field 73 (73,70-74,10) with 1 seta 35 (34,33-36,10); trochanter 52 (52,50-54,10), with 2 setae 36-40; basifemur 50 (50,48-52,10), 4 setae 31-52; telofemur 36 (37,34-38,10) with 5 setae 35-36; genu 69 (69,67-70,10) with

9 setae 21-33, 1 σ 15 (15,13-17,10) at 0.76 (0.76,0.74-0.77,10); tibia 88 (89,86-90,10) with 11 setae 33-36, 2 ϕ 17 each at 0.51 and 0.85 respectively; tarsus 59 (59,58-60,10) with 16 setae 21-31, 1 ω 13 (13,11-15,10) at 0.62 (0.61,0.59-0.63,10), 1 ζh 36 (38,35-42,10) at 0.78 (0.77,0.75-0.79,10)(Fig. 40b).

Leg III 435 (440,416-452,10), coxal field 69 (68,66-70,10) with 1 seta 38 (38,37-41,10); trochanter 59 (59,58-62,10) with 2 setae 38 each; basifemur 61 (62,60-64,10) with 4 setae 35-38; telofemur 52 (52,50-54,10) with 11 setae 42-46; genu 88 (88,85-90,10), 8 setae 33-38, 1 σ 17 (17,15-18,10) at 0.80 (0.80,0.78-0.82,10); tibia 117 (118,112-134,10), 11 setae 42-46, 1 ϕ 19 (19,17-20,10) at 0.08 (0.08,0.06-0.09,10); tarsus 56 (56,54-57,10), 16 setae 31-42, without specialized setae (Fig. 40c).

Etymology:

The species was named after a small town, Channing in Northern Michigan, near which collections of this species were made.

Distribution of Types:

The holotype, 5 larval paratypes are in Department of Zoology, Michigan State University, East Lansing, MI.

Discussion:

The genus *Abrolophus* was described by acarologists based only on adults. Larvae and deutonymphs were unknown to science (Womersley, 1934, 1936; Nandmi Skhot,1968). Unfortunately, most descriptions were simple and incomplete.

These two species of the genus *Abrolophus* collected in Michigan represent the first records for North America, and also the first report correlating larval and adult

forms from laboratory rearing. The description of larvae attached to leafhoppers matched the morphological features of larval *Hauptmannia*, but adults emerged from reared nymphs were obviously adult *Abrolophus*. A careful comparison among hundreds of larvae and adults confirmed the above finding.

The same generic designation should therefore be used for both larvae and adults. However, the relationship between larvae described as *Hauptmannia* and deutonymphs and adults of *Abrolophus* can not be clarified until type specimens of previously described species can be reviewed.

The major difference separating the two *Abrolophus* species is the location of two specialized setae on tibia II; in *A. welbourni*, they are located at 0.74 and 0.79, and in *A. channingensis*, they are located at 0.51 and 0.85 respectively. In addition, the setae of the latter are longer than those of the former. Further laboratory rearing of species in the genus *Hauptmannia* as defined to date is very necessary.

Charletonia curalia n. sp.

Type series:

Holotype: 1 larva collected from the forest floor on May 21, 1989, fifteen paratypes collected on 8, 15 May, 1991, 8 May, 1990, 8 May, 1985 and 14 May, 1984. Nymphs and adults are not known.

Larval description:

Idiosoma (Fig. 41a, b): color in life yellow,420 (446,376-510,15) long by 217 (212,208-312,15) wide for newly hatched larvae. Body size of engorged larvae varied from 544-982 long and 344-566 wide. Dorsal setae 87 in irregular rows, lightly curved and ciliatious, small and adnate, 38-46 anteriorly, 42-46 posteriorly, and 1 pair of supracoxal setae in front of dorsal sclerite. Ventral setae 1a+2a+3a+3b+32, 1a 33 (32,30-34,15), 2a 46 (46,44-48,15), 3a 46 (46,43-47,15), 3b 46 (46,44-48,15), setae after leg III 28-34 in number, 42-46 in length. Eyes 1 + 1, 21 long by 21 wide, circular, without 2 dorsal sclerites in the area between eyes and prodorsal sclerite.

Palpal femular: 0+B+B+NBB+4BN$\omega\zeta$, 58-25-27,17-15-19, 14 at 0.28, 17 at 0.93, 38 at 0.14, 29 at 0.85 (Fig. 42a, b).

Prodorsal sclerite (Fig. 43): broader than long, somewhat pentagonal with rounded angles and with a slightly concave anterior margin; AL,ML and PL equaldistant; AM anterior to ML, and behind AL; SS arise at the edge of posterior pole of sclerite, no distinct notch in posterior margin of sclerite.

AL 49 (48,45-50,15), ML 56 (55,52-56,15), PL 59 (59,56-60,15), SM 48 (46,45-49,15), SS 52 (52,50-53,15), AW 65 (65,63-66,15), MW 81 (81,78-85,15), PW 100 (98,96-102,15), W 102 (103,100-106,15), L 96 (95,93-96,15),ISD 65 (66,63-67,15), SBa 12 (11,10-13,15), SBp 17 (17,15-19,15), ASBa 25 (25,23-26,15), MAS 36 (36,34-38,15), PAS 52 (53,50-55,15), ASBM 0, A-M 19 (19,16-20,15), M-P 21 (21,20-23,15), LX 6 (6,4-7,15), AAS 31 (31,29-33,15), ASBa/ISD 0.38 (0.37,0.35-0.39,15), AW/AL 1.36 (1.3,1.1-1.5,15), AW/M-P 2.27 (2.3,2.15-2.37,15), AW/ISD 1.0 (1.0,0.8-1.2,15),

ISD/A-P 1.78 (1.7,1.5-1.9,15), AL/AAS 1.56 (1.5,1.4-1.8,15), Ti I/AW 1.94 (1.9,1.7-2.0,15), Ti II/AW 1.69 (1.6,1.4-1.9,15), Ti III/AW 2.44 (2.36,2.2-2.8,15), Ti III/Ge III 1.5 (1.5,1.2-1.7,15), Ti II/Ge II 1.29 (1.3,1.18-1.33,15), Ti I/Ge I 1.20 (1.2,1.1-1.32,15), Ti II/PW 1.09 (1.1,1.0-1.3,15).

Legs (Fig. 44a,b,c): Leg I 525 (520,487-588,15),coxal field 59 (59,55-64,15), 1b 56 (55,53-58,15); trochanter 48 (46,45-49,15), 1B 46 (47,44-48,15); basifemur 81 (80,78-83,15), 4B 40-48; telofemur 63 (64,62-65,15), 5B 35-38 anteriorly, posterior one 36 (36,34-37,15); genu 105 (107,102-112,15), 12B 31-36 anteriorly, 35-36 posteriorly, 1 σ 31 (31,28-33,15) at 0.67 (0.66,0.65-0.68,15), 1 k 6 (5,5-7,15); tibia 127 (134,118-146,15), 17B 21-31, 2 ϕ 38 (38,36-39,15) at 0.67 (0.67,0.64-0.69,15), 38 (38,36-39,15) at 0.87 (0.86,0.85-0.88,15), 1 k 4 (3,3-5,15) at 0.89 (0.88,0.85-0.90,15); tarsus 102 (108,98-112,15), 27B 29-31, 1 ω 40 (40,38-43,15) at 0.48 (0.48,0.45-0.50,15), 1 companion seta at 0.66 (0.67,0.64-0.68,15), 1 famulus at 0.85-0.87, 1 ζh 36 (36,34-37,15) at 0.64 (0.65,0.62-0.67,15), 1 ζp 13 (13,12-15,15) at 0.97 (0.97,0.95-0.98,15), barbed setae 12-23 in length (Fig. 44a).

Leg II 465 (458,434-488,15), coxal field 73 (74,71-76,15), 2b 59 (59,56-60,15), 2c 35 (34,33-36,15); trochanter 46 (47,44-49,15), 1B 42 (42,40-44,15); basifemur 73 (74,71-75,15), 4B 31-36 in length; telofemur 56 (56,53-58,15), 5B 27-31 from anterior region to posterior region; genu 84 (85,82-86,15), 12B 29-31, 1 k 6 (5,4-7,15); tibia 109 (109,98-107,15), 18B 29-31, 2 ϕ 29 (28,25-29,15) at 0.12 (0.12,0.11-0.14,15), 15 (15,13-16,15) at 0.84 (0.85,0.82-0.86,15); tarsus 96 (98,92-102,15), 27B 31-33, 1 ω 23 (23,22-25,15) at 0.58 (0.58,0.55-0.60,15), 1 famulus at 0.87-0.90, 1 ζp 13 (13,12-15,15)

at 0.94 (0.95,0.92-0.97,15), barbed setae 17-27 (Fig. 44b).

Figs. 41-44. *Charletonia curalia* n. sp. (larva):

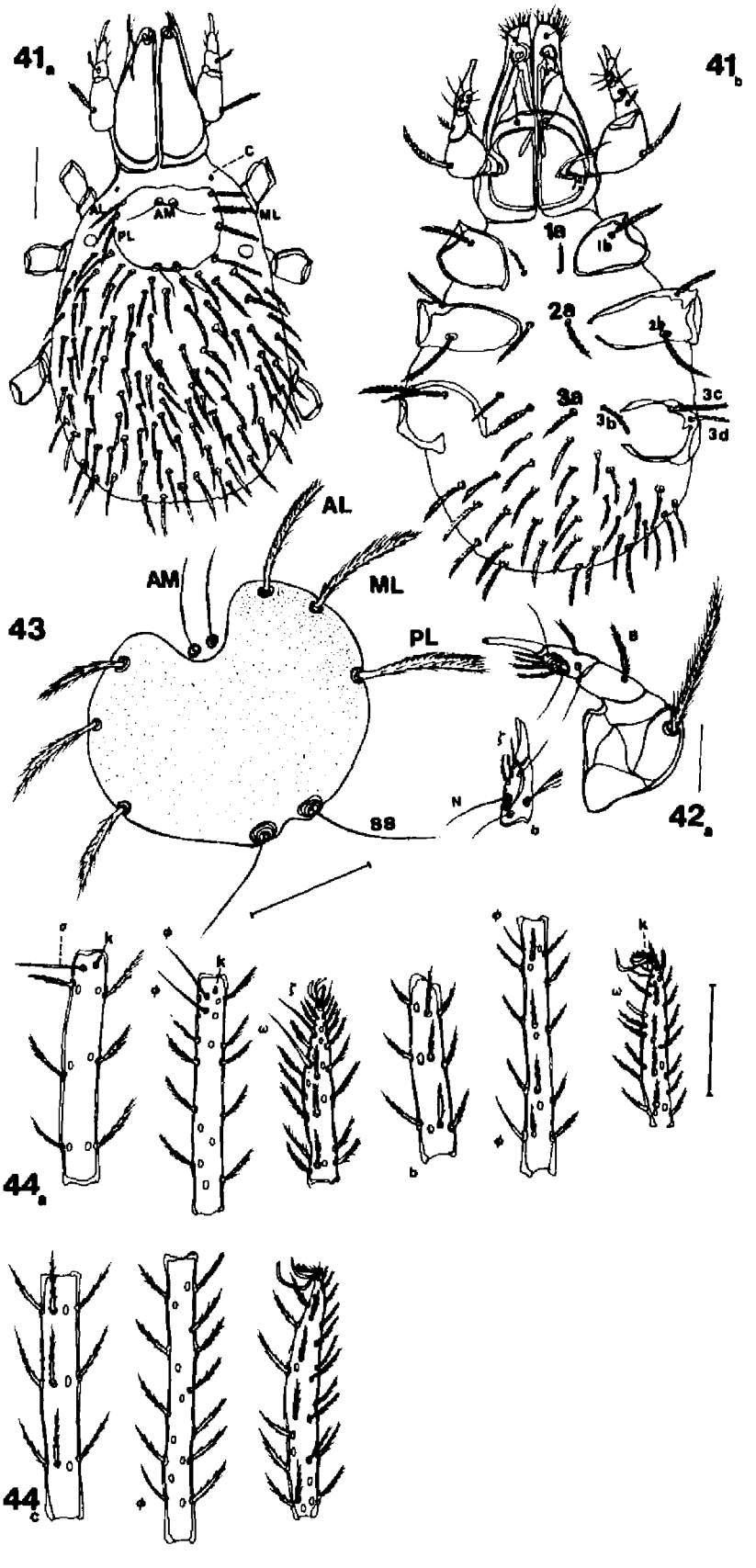
41a-b. dorsal and ventral idiosoma;

42a-b. palpals and palpal tibia and tarsus;

43. prodorsal sclerite;

44a-c. leg I-III genu to tarsus.

Scale lines fir Figs. 41a-b, 44a-b represent 100 μm each; scale lines for Fig. 42a-b, 43 represent 50 μm.


41a
41b
C
AL
AM
ML
PL
1a
1b
2a
2b
3a
3b
3c
3d
43
AL
AM
ML
PL
SS
N
42a
44a
44c

Leg III 575 (553,522-612,15), coxal field 71 (72,70-74,15), 3c 52 (52,50-54,15), 3d 40 (40,38-43,15); trochanter 54 (54,52-55,15), 1B 44 (44,41-45,15); basifemur 81 (80,78-84,15), 2B 42-58; telofemur 73 (73,70-75,15), 5B 31-35; genu 100 (99,96-104,15), 12B 35-38 anteriorly, 35-36 posteriorly, without solenidia; tibia 163 (165,153-187,15), 18B 35-36 anteriorly, 33-36 posteriorly, 1 ϕ 27 (26,24-28,15) at 0.07 (0.06,0.05-0.08,15); tarsus 107 (107,102-119,15), 28B 33-35, 1 subterminal seta at 0.97-0.99, no ω and ω (Fig. 44c).

Etymology:

The species name was derived from a Latin word, *curalium,* for the red coral color which impressed me when I collected a leafhopper with the mite larva attached.

Discussion:

This genus is an important, difficult and large one. In a major generic study, Oudemans (1910a, b) placed three of nine species of larval *Charletonia* in *Charletonia*, but later (1910c,1912) he placed them in *Erythraeus* Latreille, 1806.

Later still, other species were described from larvae by Kishida (1929), Womersley (1934), Feider (1954) and Lawrance (1940) under *Erythraeus*, by Paoli (1937) under *Balaustium* von Heyden, 1826, and by Kawashima (1958) and Kitahara & Takara (1964) under *Callidosoma* Womersley, 1936.

In addition, Ishii (1954) reared deutonymphs of an undetermined *Sphaerolophus* species from larvae found on grasshoppers in Japan, and sent drawings of both larvae and nymphs to Southcott. Southcott (1966) later discussed the possible synonymy of the two generic names, but preferred "to leave the adults and larvae in their own generic

categories."

Southcott (1966) also revised the taxonomy of the genus and studied Oudemans' collections from Holland and northern Germany. He stated that all specimens considered by Oudemans under "*Erythraeus* larval" came under the definition of *Charletonia*. At that time, the genus was thus left with 32 species, comprising 5 European, 7 African, 5 Asian, and 16 Australasian forms. No North or South American material was known.

In 1979, Treat and Flechtmann described the first *Charletonia* from Brazil, *Charletonia rocciai*, an ectoparasite of the Amazon fly *Metagonistylum minense* Townsend, 1927 (Diptera, Tachinidae).

One year later, Rosa and Flechtmann illustrated that the morphological features of nymphs reared from larvae of *Charletonia rocciai* clearly represented the genus *Sphaerolophus* (Erythraeidae: Trombidia).

Meanwhile, Treat (1980) noticed that a deutonymph reared from a larva closely resembling *Charletonia singularis* Oudemans conformed to *Sphaerolophus cardinalis* (Koch) as redescribed by Franke (1940) and Witte (1977) in Germany. Treat suggested that "It appears probable that *Charletonia singularis* is the larval form of *cardinalis*."

Since then, subsequent descriptions of larvae have been published by Beron (1975), Treat & Flechtmann (1979), Treat (1980), Southcott (1983,1988,1991), Haitlinger (1984,1985,1986,1987) and Tsai & Chow (1988) as *Charletonia*.

Currently, the genus has over 50 species described as larvae, collected either free-living or as ectoparasites of arachnids and insects from every continent except Antarctica. Confirmation of the proposed synonymy (*Charletonia*=*Sphaerolophus*) was

given by four further larva to deutonymph rearings: in North America of adult *C. cardinalis* (Koch) with its larva *C. singularis* (Oudemans) by Treat (1980); and of *C. nishidai* by Southcott (1983); in South America of *C. rocciai* by Rosa & Flechtmann (1980); and of *C. oudemansi* by Southcott (1988). In addition, there are 22 species described as adults of *Sphaerolophus* for which the corresponding larvae and nymphs are yet to be obtained.

The species collected in Michigan resembles *Charletonia singularis* Oudemans closely. The latter was found on a noctuid moth, *Simyra henrici* (Grote), in Massachusetts. Some differences which distinguish *curalia*, *singularis*, and *rocciai* are listed in Table 7. Measurements used here follow Southcott's terms, such as ratios of length of tibia I over body width, length of tibia I over that of tarsus I and data for the prodorsal sclerite.

Table 8. Main character differences between three American *Charletonia* species: measurement of length of sclerite and leg segments; ratio of the length of leg segments and of sclerite.

characters	*curalia* (MI)	*singularis* (MA)	*rocciai* (BZ)
TiI/W	0.58	1.21-1.38	1.1-1.17
TiI/TaI	1.25	1.18	0.86-0.94
PW/AW	1.43	1.56-1.58	1.31-1.34
AW/AL	1.36	1.07	1.66
AW/ISD	1.0	0.92	1.32
AL/PL	0.80	1.03	0.96
MW	80	95	80-82
ASE	48	56-62	32
PSE	51	63-64	65
SBa	11	15	11
SBp	17	17	20
AL	47	57	47
Idiosoma	420	271	552
Leg IIBf	73	63	61
Ti	109	112	104
Leg III Cx	71	59	78
Bf	81	72	72

Charletonia curalia differs from *rocciai* in having smaller ratios of TiI/AW, AW/ISD, AL/PL, shorter PSE and idiosoma; larger TiI/TaI ratio, longer ASE, leg II, Bf II, leg III and Bf III. It differs from *singularis* in having smaller TiI/W, PW/AW, AL/PL ratios, shorter MW, ASE, PSE, SBa and AL; and in having larger idiosoma, TiI/TaI and AW/AL ratios, longer leg II, Ti II, leg III, CX III and Bf III.

Distribution of Types:

The holotype, 10 larval paratypes are in Department of Zoology, Michigan State University, East Lansing, MI. One larval paratype will be deposited in Field Museum of Natural History, Chicago, IL.

Subfamily Balaustiinae:

***Balaustium nonasum* n. sp.**

Type series:

Holotype and 15 paratype larvae collected from the forest floor on June 4, 6, 9, 11 of 1990. Five paratype adults collected from the same site.

Larval description:

Idiosoma (Fig. 45a, b): color in life red, 385 (390,375-423,15) long by 230 (247,228-257,15) wide, dorsal setae 83 (87,80-94,15) in number, 46-56 anteriorly, 46-48 posteriorly, ventral setae 1a + 2a + 3a + 22 (25,21-37,15) between coxal field II and III + 38 (34,31-38,15) after coxal field III, 1a 63-65, 2a 38-40, 3a 36-54, ventral setae 36-42. Eyes 1 + 1, 15 (16,15-17,15) long by 15 (16,15-18,15) wide. Palpal setae formula B-B-BB-NNN-B3N$\omega\zeta$ (Fig. 46a, b, c).

Prodorsal sclerite (Fig. 47): AM 63 (61,60-64,15), SS 84 (84,82-85,15), AL 40 (40,38-42,15), ML 36 (36,34-38,15), PL 46 (47,44-48,15), AW 43 (42,38-44,15), MW 44 (43,42-45,15), PW 59 (56,55-59,15), L 107 (109,103-117,15), LX 4 (4,3-5,15), ISD 65 (67,62-77,15), SBa 15 (14,13-15,15), SBp 17 (16,14-18,15), ASBa 6 (7,5-12,15).

Legs (Fig. 48a, b, c): Leg I 426 (430,418-450,15); coxal field 59 (55,53-59,15), 1B 54-

55,15; trochanter 48 (45,42-49,15), 3B 50-61; basifemur 65 (66,64-69,15), 4B 44-58; telofemur 65 (60,53-67,15), 6B 48-54; genu 79 (87,75-98,15), 11B 42-67, 1 σ 35 (30,23-36,15) at 0.80 (0.80,0.78-0.84,15), 1 k 6 (6,5-7,15) at 0.83 (0.87,0.80-0.90,15); tibia 98 (98,96-103,15), 13B 38-52, 1 ϕ 27 (25,24-27,15) at 0.76 (0.74,0.73-0.77,15), 1 k 6 (6,5-8,15) at 0.88 (0.86,0.84-0.87,15); tarsus 75 (77,73-84,15), 24-26B 31-40, 1 ω 42 (42,40-43,15) at 0.61 (0.57,0.55-0.63,15), 1 ʃh 48 (45,42-47,15) at 0.79 (0.78,0.75-0.79,15), 1 ʃp 23 (22,20-24,15) at 0.92 (0.91,0.90-0.94,15), 1 c 8 (11,7-13,15) at 0.79 (0.77,0.75-0.79,15), 9 ʃ 21-25 at 0.43-0.87 (Fig. 48a).

Leg II 351 (355,324-376,15), coxal field 79 (83,76-92,15), 1B 50 (50,46-56,15); trochanter 36 (45,34-53,15), 3B 42-57; basifemur 54 (51,48-55,15), 4B 44-54; telofemur 42 (41,40-43,15), 6B 40-54; genu 77 (76,73-78,15), 11B 42-67, 1 k 6 (6,5-7,15) at 0.90 (0.90,0.88-0.92,15); tibia 73 (75,71-80,15), 13B 36-52, 1 ϕ 19 (18,16-20,15) at 0.70 (0.72,0.70-0.77,15); tarsus 69 (69,67-73,15), 21-23B 21-48, 1 ω 19 (19,17-20,15) at 0.60 (0.56,0.51-0.62,15), 1 ʃh 38 (39,37-42,15) at 0.78 (0.75,0.73-0.80,15), 1 ʃp 23 (22,20-24,15) at 0.87 (0.88,0.85-0.90,15), 4 ʃ 23-25 at 0.47-0.87, 1 c 12 (11,9-13,15) at 0.73 (0.73,0.70-0.74,15)(Fig. 48b).

Leg III 407 (414,403-435,15), coxal field 84 (86,82-92,15), 1B 50-52; trochanter 40 (47,40-53,15), 3B 48-56; basifemur 61 (58,57-63,15), 3B 46-54; telofemur 50 (50,46-53,15), 6B 38-54; genu 90 (87,83-92,15), 9B 42-52, no solendia observed; tibia 98 (98,96-102,15), 13B 44-54, 1 ϕ 27 (25,24-27,15) at 0.12 (0.12,0.11-0.14,15); tarsus 69 (73,68-75,15), 18-21B 21-48, 1 ʃp 23 (22,20-23,15) at 0.89 (0.92,0.88-0.96,15), 1 ʃ at ventral region 0.25 (0.25,0.23-0.26,15), 25 (24,22-25,15) in length (Fig. 48c).

Deutonymph: unknown.

Adult female (Fig. 49-52):

Idiosoma measured from tip of mouthpart to posterior pole 1795 (1642,1478-1985,5) long by 936 (932,877-985,5) wide, two types of setae on the body: long smooth setae and shorter barbed setae, more long setae at rear, setal length 48-90 anteriorly, 54-81 posteriorly; ventral setae 82-178 anteriorly, 73-102 posteriorly in length. Genital valvels with many setae, anal valvel with a few setae (Fig. 49).

Eyes: 1 + 1 at each side, 38 wide, and 42 long. A pair of urnula next to eyes (Fig. 50).

Gnathosoma (Fig. 51a, b): palpal genu 178 (173,168-189,5) long, anterior setae 44-54 in length, posterior setae 42-46, 6 long setae at 0.35-0.56, 77-98 in length, 3 long setae at front edge 0.73-0.84, 48-77 long; palpal tibia 140 (138,134-147,5), anterior setae 36-52, posterior setae 35-52, tibia claw entire, 27 (25,23-27,5) long, 1 tooth at middle 0.50, 2 long setae 50-61 at 0.67, 0.89; palpal tarsus 56 (55,52-58,5), 15-17 ω 13-19 anteriorly, 21-23 posteriorly, at 0.38-0.99, among them, 4 long ω at rear 0.38-0.45, the rest in mid- to front region, 6-7 ζ at 0.33-0.78.

Prodorsal sclerite (Fig. 52): 316 (302,297-325,5) long by 140 (138,129-143,5) wide, with 6 front setae anterior to AM, 94-125, AM 102 (102,96-105,5), AL 102 (97,95-103,5), AW 56 (55,52-57,5), MW 123 (121,118-124,5), ML 109 (108,104-109,5), PL 90 (90,88-91,5), PW 190 (188,185-191,5), SS 139 (140,135-143,5), SBa 19 (18,16-19,5), SBp 19 (19,17-19,5), ISD 198 (195,187-203,5), LX 67 (67,65-69,5), ASBa 44 (44,40-46,5), A 63 (63,60-64,5), B 73 (74,72-76,5).

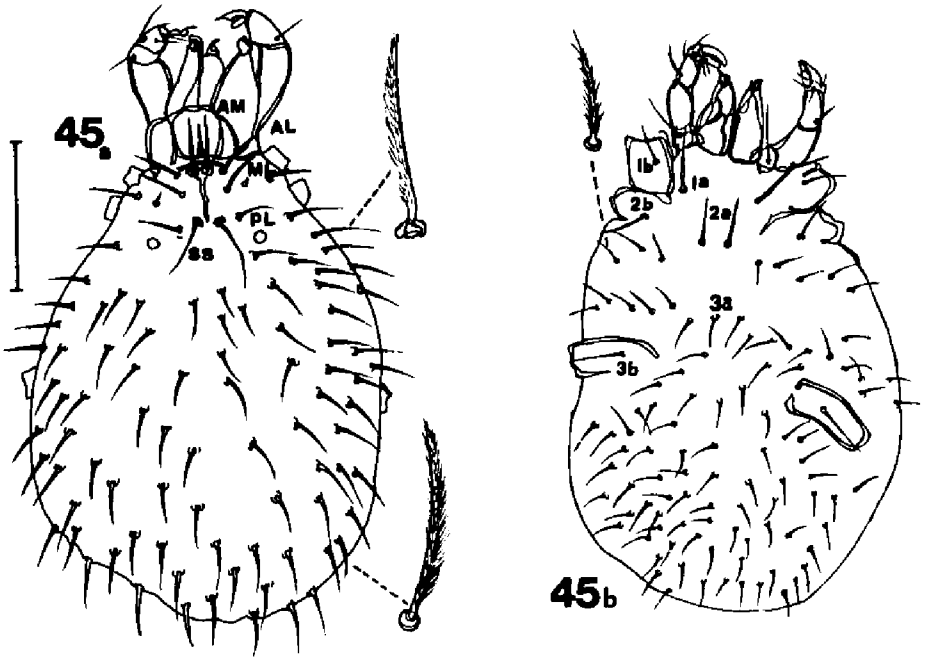
Figs. 45-47 *Balaustium nonasum* (larva):

45a-b. dorsal and ventral idiosoma (larva);

46a-d. palpals (larva);

47. prodorsal sclerite (larva);

Scale lines for Figs. 45a-b, 46a, 49, 50, 52 each represent 100 μm, scale lines for Fig. 46b-d, 47, 51 each represent 50 μm.


45a
AM
AL
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PL
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45b
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2b
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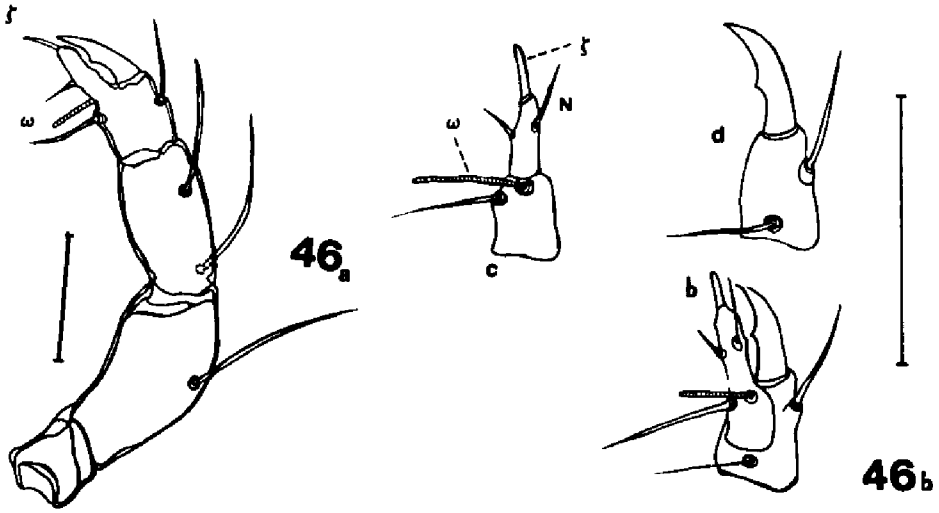
3a
3b


f
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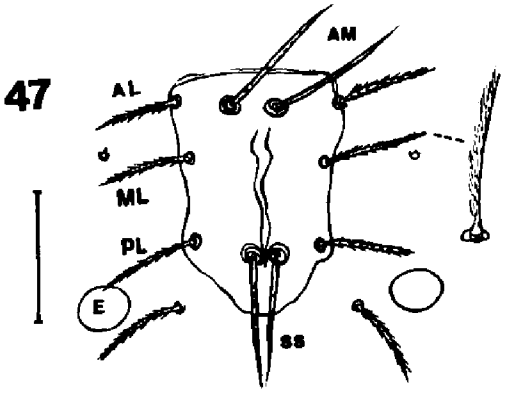
46b


47
AM
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Figs. 48, *Balaustium nonasum* n. sp. (larva):

48a-c. legs I-III (larva).

Scale line represents 100 μm.

Figs. 49-52. Balaustium nonasum n. sp. (adult female):

49. genital and anal valves (adult female);

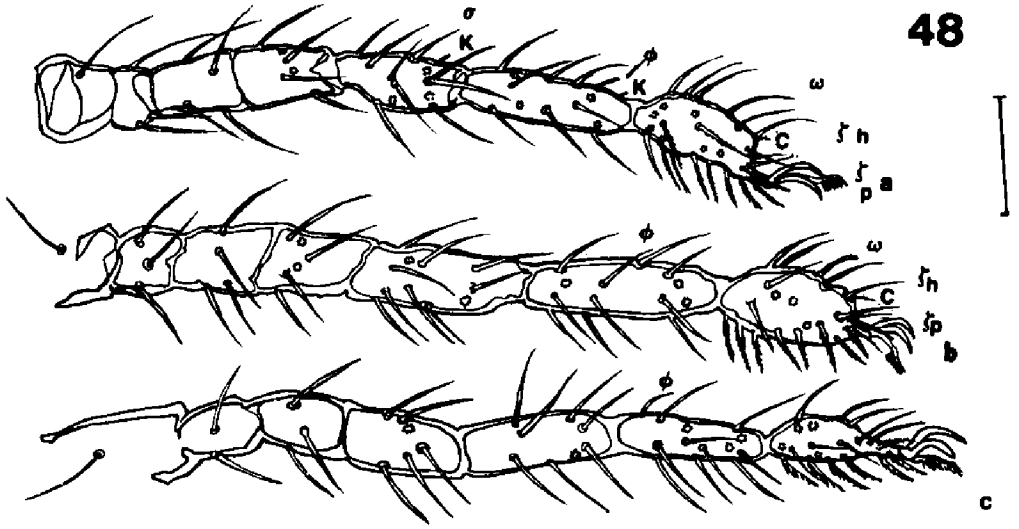
50. eye (E) and urnula (u)(adult female);

51a. palpals (adult female);

51b. palpal tarsus (adult female);

52. prodorsal sclerite (adult female).

Scale lines represent 100 μm.


48
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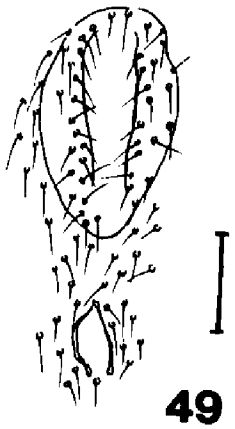
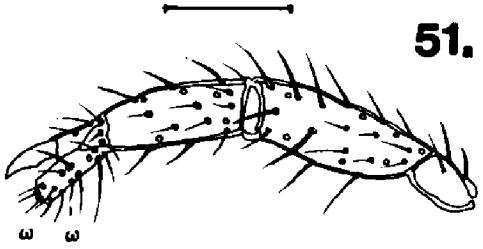
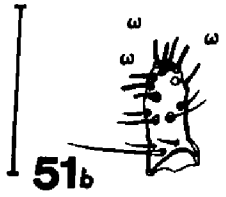

49


E
U
50


51a
ω
ω


ω
ω
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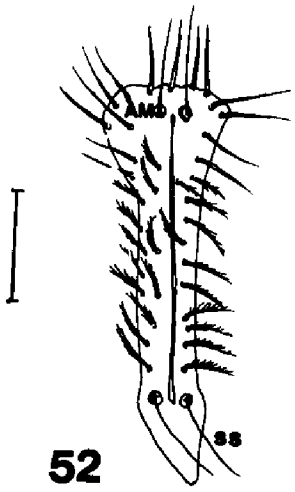
51b


Amb
ss
52

Leg I: 1482 (1384,1278-1780,5) long, coxal field 198 (194,185-213,5), 98-161 anteriorly, 69-79 posteriorly; trochanter 163 (166,157-173,5), setae 75-84 anteriorly, 48-54 posteriorly; basifemur 199 (194,187-216,5), setae 63-77 anteriorly, 61-81 posteriorly; telofemur 282 (238,219-298,5), setae 59-67 anteriorly, 61-79 posteriorlty, 3 N 65 (65,62-66,5) at 0.48 (0.46,0.42-0.49,5), 67 (67,64-68,5) at 0.71 (0.71,0.68-0.73,5), 69 (69,67-70,5) at 0.89 (0.88,0.85-0.90,5); genu 320 (318,307-348,5), setae 65-81 anteriorly, 59-65 posteriorly, 3 N 82 (83,80-86,5) at 0.53 (0.52,0.50-0.54,5), 67 (67,65-68,5) at 0.68 (0.67,0.65-0.69,5), 71 (71,69-72,5) at 0.85 (0.84,0.81-0.87,5), 8 σ 32-40 at 0.48-0.95; tibia 316 (309,302-323,5), setae 63-69 anteriorly, 71-81 posteriorly, 10 N 65-73 at 0.07-0.89, 4 ϕ 38-40 at 0.35-0.70, 3 k 6-8 at 0.60-0.80, 6 ϕ at ventral, 33-40 at 0.12-0.67; tarsus 199 (192,187-212,5), setae 42-44 anteriorly, 42-48 posteriorly, 1 ω 19 (19,17-20,5) at 0.80 (0.80,0.78-0.81,5), 17-19 ω 23-33 at 0.59-0.88, 4 ζ 58 (57,55-58,5) at 0.62 (0.61 0.60-0.62,5), 61 (62,60-64,5) at 0.77 (0.76,0.75-0.79,5), 59 (60,58-63,5) at 0.79 (0.78,0.76-0.80,5), 2 ζ 61-73 at 0.95-0.98, 2 ζp 42 each at 0.96, and 0.98, 16-18 ζ 29-40 at 0.11-0.82 ventrally.

Leg II: 1102 (1098,1089-1210,5), coxal field 244 (238,225-246,5), setae 73-77 anteriorly, 58 for a long seta at rear region; trochanter 135 (132,128-142,5), 77-82 anteriorly, 69-102 posteriorly, long setae 139 (137,130-142,5) at middle; basifemur 144 (140,137-148,5), 56-69 anteriorly, 48-59 posteriorly, with a long seta 94 at anterior region; telofemur 192 (187,179-194,5), 73-77 anteriorly, 50-58 posteriorly, with 1 N 61 (60,58-62,5) at 0.87 (0.86,0.85-0.88,5); genu 207 (204,200-210,5), 75-81 anteriorly, 54-59 posteriorly, 3 N 58 (57,55-59,5) at 0.55 (0.54,0.53-0.56,5), 52 (52,50-54,5) at 0.64

(0.63,0.60-0.65,5), 58 (57,55-58,5) at 0.89 (0.88,0.86-0.90,5), 2 σ 29 each at 0.50, and 0.87, 1 k 10 (10,8-11,5) at 0.73 (0.73,0.71-0.75,5); tibia 274 (270,258-288,5), 61-79 anteriorly, 67-81 posteriorly, 4 N 59-79 at 0.16-0.89, 1 ϕ 15 (15,14-17,5) at 0.72 (0.71,0.69-0.73,5); tarsus 150 (142,138-152,5), 50-58 anteriorly, 40-50 posteriorly, 5 ω 13-17 at 0.68-0.81, 3 ζ 52 (52,50-53,5) at 0.88 (0.86,0.85-0.89,5), 58 (57,55-59,5) at 0.91 (0.89-0.93,5), 69 (69,67-69,5) at 0.93 (0.92,0.90-0.94,5), 2-3 ζ 50-58 at 0.91-0.94 anteriorly, 1 ζ 50 (49,45-49,5) at 0.82 (0.81,0.80-0.83,5), 5-6 ζ 33-38 at 0.20-0.67 ventrally.

Leg III: 1188 (1153,1096-1230,5), coxal field 242 (238,212-247,5), setae 75-82 anteriorly, 178 for a long seta at rear; trochanter 130 (128,119-132,5), 73-102 anteriorly, 69-88 posteriorly; basifemur 127 (126,118-134,5), 55-66 anteriorly, 63-72 posteriorly; genu 278 (258,230-282,5), 67-84 anteriorly, 67-69 posteriorly, 2 N 61 (61,58-63,5) at 0.45 (0.45,0.43-0.46,5), 71 (71,69-72,5) at 0.57 (0.56,0.54-0.58,5), 2 σ 13-21 at 0.34-0.59; tibia 263 (257,238-265,5), 59-63 anteriorly, 58-69 posteriorly, 4 N 54-63 at 0.10-0.90, 4 ϕ 23-31 at 0.05-0.43; tarsus 127 (122,118-132,5), 42-48 anteriorly, 42-52 posteriorly, 2 ω 10-12 at 0.54, 0.65, 4 ζ 35-48 at 0.21-0.76, 2-3 ζ 48-52 at 0.86-0.90.

Leg IV: 1396 (1347,1307-1402,5), coxal field 276 (263,243-282,5), 54-65 anteriorly, long seta 79 in length; trochanter 88 (86,84-90,5), 79-98 anteriorly, 58-63 posteriorly; basifemur 182 (179,168-188,5), 65-77 anteriorly, 65-67 posteriorly, long setae 77 at anterior region; telofemur 301 (297,268-303,5), setae 84-90 anteriorly, 58-65 posteriorly, 4 long setae 86-106 at 0.48-0.71; genu 328 (315,308-333,5), setae 77-90 anteriorly, 61-

69 posteriorly, 3 N 79 (76,75-79,5) at 0.54 (0.53,0.50-0.56,5), 84 (83,80-85,5) at 0.29 (0.28,0.27-0.30,5), 90 (89,87-92,5) at 0.90 (0.88,0.87-0.93,5), 5 σ 35-36 at 0.17-0.75; tibia 355 (352,344-363,5), setae 67-71 anteriorly, 67-69 posteriorly, 4 N 86 (85,84-87,5) at 0.26 (0.25,0.23-0.27,5), 92 (92,90-94,5) at 0.57 (0.56,0.54-0.58,5), 84 (84,82-85,5) at 0.66 (0.65,0.63-0.67,5), 69 (67,65-69,5) at 0.76 (0.75,0.74-0.78,5), 4 ϕ 29-38 at 0.04-0.32; tarsus 142 (140,132-150,5), setae 56-71, 2 ζ 63-69 at 0.75, 0.86, 2 ζ 56-58 at 0.82-0.88 anteriorly, 1 ζ 35 (34,30-34,5) at 0.30 (0.30,0.28-0.34,5).

Discussion:

The cosmopolitan genus *Balaustium* was first described by Von Heyden (1826) with *Trombidium murorum* Hermann, 1804 as type species. In the last four decades, a number of reports of feeding behavior attracted much attention to several important studies both in field and laboratory.

However, our knowledge of the systematics of the genus is relatively incomplete. Descriptions of most species are brief and the diagnostic characters are so little known that it is impossible to say at the present time how many species are involved. Among 50 named species from all over the world, a number of them are likely to be synonymous.

Balaustium nonasum differs from *B. putmani* Smiley by a palpal tarsus which is not longer than the tibia, with 8 instead of 10-12 solenidia apically; crista without 9 "stout serrated setae anteriorly to the anterior sensory setae"; lack of fine distinct ornamentation of the striae anteriorly to the crista; and posterior sensory setae not arising from nose-like projections of scutum.

The species differs from *B. dowelli* Smiley by the presence of three to four long setae anterior to AM setae, seven pairs of setae on sclerite between AM and SS setae; tibia I with 10-12 long, slender, nude setae at ventral lateral, 7 long setae at dorsal leg.

Etymology: The species name was derived from a Latin word, *nonasum*, meaning without nose-like projections on sclerite.

Distribution of Types:

The holotype, 10 larval and 3 female paratypes are in Department of Zoology, Michigan State University, East Lansing, MI. One larval and female paratype will be deposited in Field Museum of Natural History, Chicago, IL.

A new genus and a new species separated from the related genus *Cuteria*

Type series:

Holotype: 1 larva collected on May 20,1991 from the forest floor. Fifteen paratypes collected from same location from May 16 to June 4, 1987 and 1991. Unfortunately larval hosts were not found with the mites. Fifteen paratype adults collected during July and August of 1990 and 1991. Laboratory rearing for deutonymphs failed.

Larval description:

Idiosoma: color in life yellow. Ellipsoid, 604 (655,600-730,15) long from mouthpart to pole of the body, 356 (325,310-370,15) wide between legs II and 284 (321,270-350,15) wide between legs III. Two pairs of eyes set in an ocular sclerite on each side of prodorsum, anterior eye 25 (26,23-27,15) long and 21 (20,18-24,15) wide, posterior

eye 21 (22,19-24,15) long and 25 (24,22-26,15) wide. Dorsum hypertrichous with 36 (38,34-40,15) dorsal setae in length from 69 to 73 anteriorly, and 69 to 84 posteriorly (Fig. 53a).

Ventral idiosoma with 1 pair (1a) of intercoxal setae between coxal field I, 71 (71,68-74,15), and one pair (3a) between coxal field III, 46 (47,44-49,15); seta 1b on coxal field leg I, 52 (53,50-55,15); coxal fields of legs II and III each with 1 seta (2b and 3b), 56 (57,54-58,15) and 59 (59,56-60,15) respectively; 18 setae behind coxal field III in length 50-58 anteriorly and 56-59 posteriorly (Fig. 53b).

Prodorsal sclerite (Fig. 54): 136 (138,134-139,15) long, 163 (165,157-170,15) wide, AW 61 (63,60-65,15), PW 146 (147,138-155,15), AM 38 (39,35-40,15), SS 90 (90,87-93,15), AL 161 (158,156-164,15), PL 81 (78,76-83,15), SBa 33 (33,31-35,15), SBp 23 (24,21-25,15), LX 35 (35,32-36,15), ISD 77 (78,74-79,15).

Palpals (Fig. 55a, b, 56a, b): palpal femur with 1 B seta 63 (57,52-73,15) long, palpal genu with 1 B seta 52 (52,48-58,15) long, paltibia with 1 B seta and 2 nude setae, tibial claw bifurcate, palpal tarsus with 4 nude setae, 1 ζ and 1 ω. Palpal formular = B+B+BNN+ω4NN, tip of mouthpart with fringes, 128 (132,117-143,15) long.

Legs (Fig. 57a, b, c):

Leg I from trochanter to pretarsus 887 (888,854-927,15) long, coxal field 109 (107,105-120,15) with 1B; trochanter 86 (85,83-88,15) with 1B 69 (72,68-75,15); basifemur 130 (132,129-134,15) with 3B 84-98; telofemur 107 (108,105-110,15) 5B 75-82; genu 188 (190,179-195,15) 8B 75-71, 1 σ 29 (29,26-31,15); tibia 280 (287,278-298,15) with 13B 58-81, 2 ϕ 36 (32,29-36,15) at 0.72 (0.72,0.70-0.74,15), 36 (34,29-

37,15) at 0.83 (0.83,0.82-0.85,15), 1 k 8 (7,6-8,15) at 0.92 (0.94,0.91-0.97,15); tarsus 163 (168,158-170,15) with 25B 23-40, 1 ω 31 (32,27-34,15) at 0.55 (0.53,0.50-0.56,15), 1 ʒh 40 (40,38-43,15) at 0.91 (0.92,0.89-0.93,15), 1 ʒp 31 (30,28-35,15) at 0.96 (0.96,0.93-0.98,15) and 1 ε 12 (11,10-14,15) at 0.91 (0.92,0.90-0.93,15)(Fig. 57a).

Leg II 957 (972,940-980,15) long, coxal field 105 (108,102-112,15) with 1B; trochanter 69 (72,68-74,15) with 1B 63 (63,60-65,15); basifemur 148 (150,145-160,15) with 3B 86-92; telofemur 139 (142,138-147,15) with 5B 36-81; genu 152 (154,150-158,15) with 8B 71-81, no specialized setae observed; tibia 280 (285,278-290,15) with 13B 63-73, 2 φ 29 (29,26-30,15) at 0.06 (0.05,0.05-0.07,15), 19 (20,18-23,15) at 0.92 (0.93,0.90-0.95,15); tarsus 159 (162,158-170,15) with 13B 75-90, 1 ω 21 (22,20-24,15) at 0.47 (0.48,0.45-0.50,15), 1 ʒh 40 (42,39-44,15) at 0.83 (0.84,0.80-0.85,15), 1 ʒp 31 (32,30-34,15) at 0.89-0.92 (Fig. 57b).

Leg III 1045 (1100,1000-1256,15) long, coxal field 125 (126,120-130,15) with 1B; trochanter with 1B 71 (72,70-75,15), 75 (76,73-78,15) long; basifemur 143 (144,140-152,15) with 3B 65-88; telofemur 135 (140,130-151,15) with 5B 82-94; genu 178 (180,172-187,15) with 8B 82-90, without σ; tibia 338 (340,335-353,15) with 13B 75-90, 1 φ 29 (29,27-30,15) at 0.04 (0.03,0.02-0.05,15); tarsus 180 (184,178-186,15) with 21B 29-61, without ω and ζ (Fig. 57c).

Deutonymph: unknown.

Adult female (Fig. 58-60):

Idiosoma: color in life yellowish brown to brown. Ellipsoid, 1026 (1104,1008-1270,15) long by 645 (650,638-680,15) wide between coxal leg II, 739 (750,727-780,15) wide

between coxal leg III. One pair of eyes set in a sclerite on each side of prodorsum, 38 (38,36-40,15) long by 27 (27,25-30,15) wide. Dorsum with setae 21-27 in length anteriorly, 19-29 in length posteriorly.

Gnathosoma: anterior end of gnathosoma with 5 pairs of nude setae 12-38 in length and fingerlike fringe.

Palpals: trochanter 46 (47,45-50,15) with 14 setae 25-42; femur 132 (135,130-141,15) with 38-45 setae 29-44; genu 86 (85,83-88,15) with 32-36 setae 23-52 long; tibia 63 (64,60-66,15) with 23-25 setae 17-35; tarsus 42 (43,40-44,15) with 27-29 setae 12-17.

Legs: Leg I 2187 (1997,1768-2238,5), coxal field 257 (238,226-266,5); trochanter 190 (185,157-191,5), setae 48-82 in length; basifemur 288 (284,253-297,5), 42-48 for most setae, 75 for a long seta; telofemur 394 (375,355-418,5), setae 46-59, 71 for a long setae, 1 N 54 (54,50-55,5) at 0.66 (0.64,0.62-0.67,5); genu 509 (488,476-508,5), setae 56-63 in length, 7 σ 42 (42,40-44,5) at 0.25 (0.25,0.23-0.26,5), 38 (38,35-39,5) at 0.26 (0.26,0.24-0.27,5), 42 (42,40-43,5) at 0.53 (0.53,0.51-0.54,5), 54 (54,52-55,5) at 0.68 (0.67,0.66-0.70,5), 35 (34,33-35,5) at 0.69 (0.68,0.67-0.70,5), 54 (54,52-55,5) at 0.84 (0.83,0.82-0.85,5), 52 (52,50-54,5) at 0.82 (0.83,0.80-0.84,5); tibia 486 (456,424-497,5), setae 56-71, 39 ϕ 25-48 at 0.23-0.88 region; tarsus 320 (316,296-340,5), two types setae at the region, barbed setae 13-19 in length, nude setae 17-19, 2 ζ 67 (67,64-69,5) at 0.87 (0.86,0.84-0.89,5), 50 (48,46-50,5) at 0.92 (0.91,0.90-0.93,5), 18 ω 38-40 in length at 0.26-0.88 region.

Leg II 1497 (1208,1094-1563,5), coxal field 212 (217,208-225,5); trochanter 152 (147,142-154,5), setae 48-69, long setae 90 at anterior end; basifemur 163 (160,154-

165,5), setae 52-75; telofemur 275 (267,259-278,5), 3 N 40 (40,38-42,5) at 0.64 (0.63,0.62-0.65,5), 54 (54,52-55,5), 56 (56,53-56,5) at 0.93 (0.93,0.91-0.94,5); genu 330 (327,310-340,5), setae 63-82 in length, 5 σ 44 (44,42-46,5) at 0.50 (0.51,0.49-0.54,5), 44 (44,42-45,5) at 0.66 (0.65,0.64-0.67,5), 46 (46,44-47,5) at 0.79 (0.78,0.76-0.79,5), 46 (46,42-46,5) at 0.86 (0.85,0.83-0.87,5), 50 (49,47-50,5) at 0.90 (0.91,0.89-0.93,5); tibia 357 (343,314-376,5), setae 52-71, 12 ϕ 15-52 at 0.38-0.83 dorsal, 2 ϕ 27-40 at ventral 0.71-0.87; tarsus 215 (208,197-226,5), 8 ζ 17-27 at 0.24-0.89 dorsal, 1 ζ 40 (40,38-42,5) at 0.94 (0.93,0.92-0.95,5), 1 ω 46 (46,44-47,5) at 0.74 (0.72,0.70-0.76,5).

Leg III 1567 (1365,1206-1783,5), coxal field 232 (238,225-244,5); trochanter 213 (207,198-231,5), setae 40-86; basifemur 150 (143,139-152,5), setae 42-56 from posterior to anterior area; telofemur 226 (217,205-234,5), setae 59-79, 4 N 46-56 in length at 0.51-0.75; genu 357 (322,305-378,5), setae 56-63, long setae 92-97, 2 σ 25-33 at 0.37-0.46; tibia 394 (347,328-412,5), 8 ϕ 36-58 at 0.52-0.90 dorsal, 3 ϕ 40-56 at 0.72-0.75

Figs. 53-56. a new genus and new species related to *Cuteria* (larva):

53a-b. dorsal and ventral idiosoma;

54. prodorsal sclerite;

55a. dorsal gnathosoma;

56a-b. palpals.

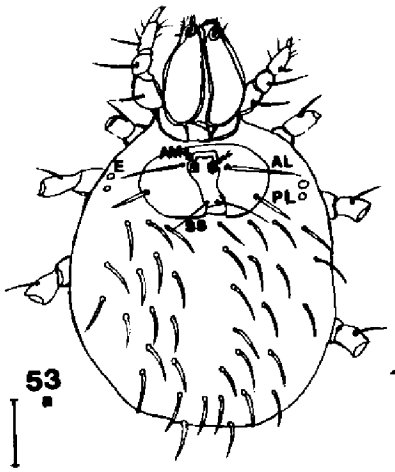
Scale lines for Fig. 53, 55a each represent 100 μm. Scale lines for Figs. 54, 56a-b each represent 50μm.

Figs. 55b. 57. a new genus and species related to *Cuteria* (larva):

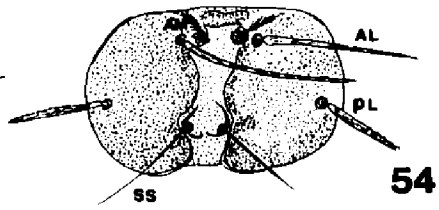
55b. ventral gnathosoma;

57a-c. legs I-III genu to tarsus.

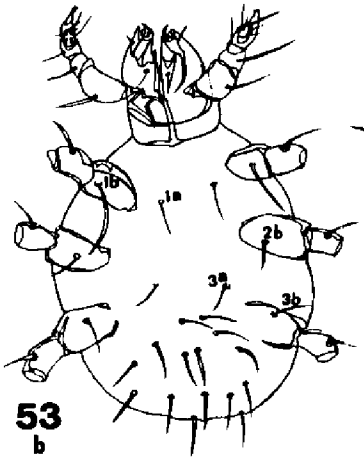
Scale lines for Figs. 56b, 57 each represent 100 μ.



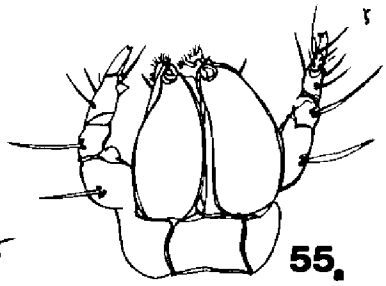
53a



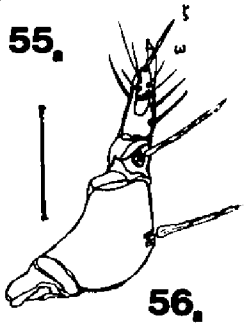
54



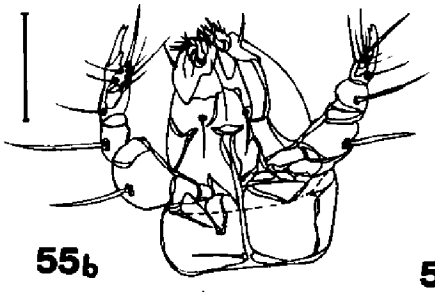
53b



55a

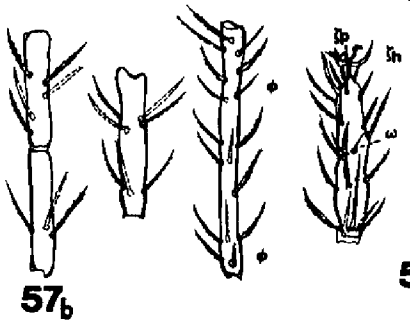


56a

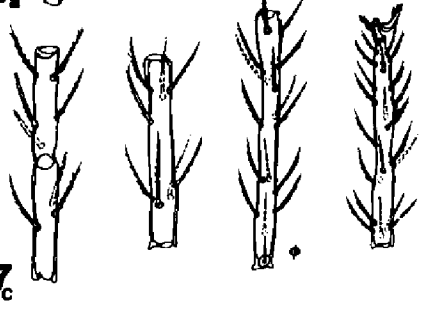


55b

57a



57b



57c

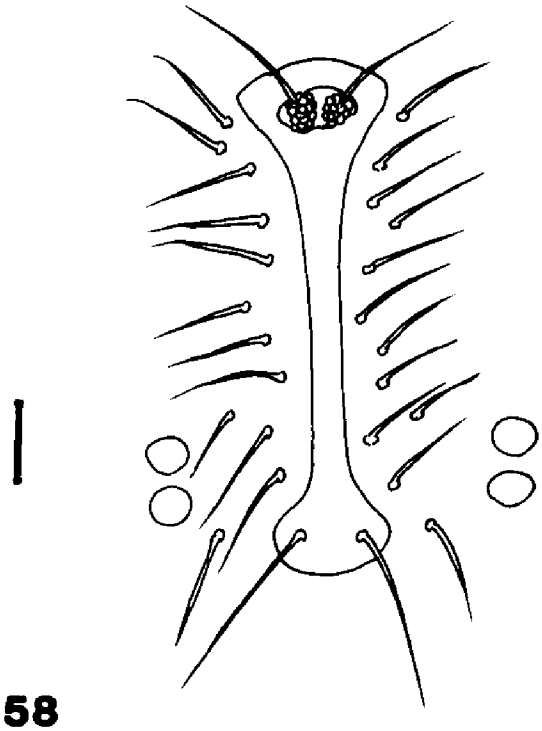
Figs. 58-60. a new genus and new species related to *Cuteria* (adult female):

58. prodorsal sclerite and eyes (female);

59. gnathosoma (female);

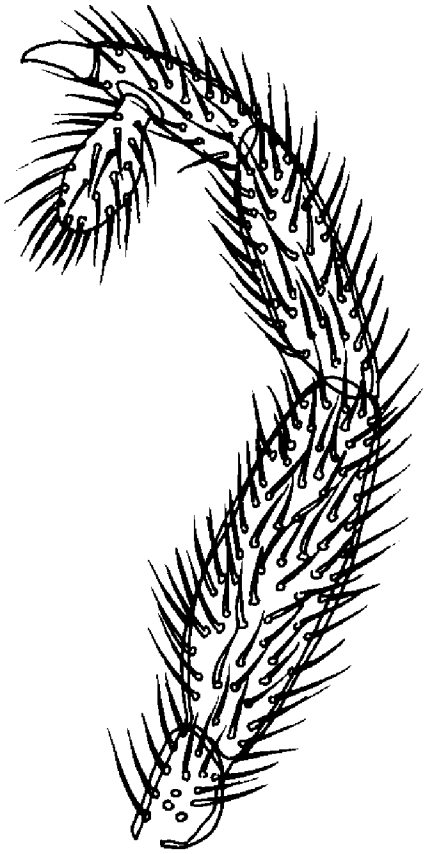
60. palpals (female).

Scale lines each represents 100 μm.



58

59



60

ventral; tarsus 226 (207,198-233,5), setae 65-71, 1 ω 46 (46,43-47,5) at 0.74 (0.73,0.72-0.75,5), 3 small ʃ 8-19 at 0.18-0.69, 1 ʃh 46 (44,42-47,5) at 0.97 (0.96,0.95-0.98,5), 1 ʃp 36 (36,34-37,5) at 0.98 (0.97,0.96-0.99,5).

Leg IV 1525 (1436,1279-1785,5), coxal field 274 (264,257-293,5); trochanter 163 (153,138-179,5), 48-50 posteriorly, long setae 73-76 anteriorly; basifemur 134 (128,120-141,5), 48-50 posteriorly, 69-72 for long setae anteriorly; telofemur 155 (148,136-162,5), 46-49 posteriorly, 67-69 anteriorly, 1 N 40 (40,38-42,5) at 0.48 (0.46,0.44-0.49,5), 2 N 44 (44,42-46,5) each at 0.91 (0.90,0.88-0.92,5) seperately; genu 322 (312,298-331,5), 54-56 posteriorly, 71-73 anteriorly, dorsal region with 3 σ 23 (23,21-25,5) at 0.13 (0.13,0.11-0.14,5), 25 (25,22-26,5) at 0.23 (0.23,0.21-0.24,5), 25 (24,22-25,5) at 0.33 (0.32,0.30-0.34,5), 3 large 52 (51,50-54,5) at 0.55 (0.54,0.51-0.56,5), 33 (33,31-34,5) at 0.64 (0.63,0.60-0.65,5), 58 (58,55-59,5) at 0.91 (0.90,0.88-0.93,5); tibia 591 (588,557-604,5),setae 73-84, 6 ϕ 21 (21,20-23,5) at 0.06 (0.05,0.04-0.07,5), 25 (25,23-26,5) at 0.10 (0.10,0.08-0.11,5), 38 (38,35-39,5) at 0.19 (0.18,0.17-0.20,5), 44 (44,42-46,5) at 0.30 (0.30,0.29-0.32,5), 56 (55,52-57,5) at 0.66 (0.65,0.62-0.67,5), 50 (49,46-50,5) at 0.89 (0.88,0.86-0.90,5); tarsus 1574 (1537,1429-1678,5), 5 ʃ 33-38 at 0.64-0.68, 1 ʃ 17 (17,15-18,5) at 0.31 (0.30,0.30-0.33,5) ventrally, 2 ʃh 58 (57,55-58,5) at 0.93 (0.93,0.90-0.94,5), 59 (59,57-60,5) at 0.97 (0.97,0.95-0.98,5), 1 ʃp 27 (27,24-28,5) at 0.99 (0.98,0.96-0.99,5), no ω observed.

Discussion:

The genus *Cuteria* was erected based on Algerian specimens by Cooreman (1956), with the type species *Cuteria fageli* which was a synonym of *Morieria curticristata* from

Austria, Switzerland and Greece. Southcott (1961) redescribed the genus *Cuteria* with several species.

The specimens differ from genus *Cuteria* in many characters. Main character is that on prodorsal sclerite of larvae, two short sensory setae located concaved ditches, which is not presented in other genera.

Subfamily Allothrombiinae

Allothrombium carum n. sp.

Type series:

The holotype hatched on July 5, 1991 from egg batches laid by a female on June 18, 1991. Fifteen paratypes came from the same egg batches as well as other clumps laid on May 28, June 15, 26, 28 and 30, 1991. Deutonymphs and adults are not available.

Larval description:

Color: in life red. Idiosoma 414 (426,402-468,15) long by 232 (228,212-247,15) wide. Nineteen dorsal setae 48-58 in length, ventral setae 3a 61 (62,60-67,15) + 9-10 setae behind coxal field III, 44-61 long (Fig. 61a, b).

Palpals: palpal femur 29 (29,26-31,15) with 1 seta 38 (37,35-39,15); palpal genu 12 (12,10-13,15); palpal tibia 13 (14,12-15,15) with 3 nude setae, palpal tibia claw bifurcate distally; palpal tarsus 13 (14,12-16,15), 2 setae 25-44, 1 ω 2 (2,1-3,15) and 1 nude seta 17 (16,15-18,15)(Fig. 62a, b).

Prodorsal sclerite: 127 (129,118-133,15) long by 121 (122,118-132,15) wide, AW 82

(83,80-86,15), PW 96 (96,93-99,15), SE 52 (53,50-55,15), AL 54 (55,51-57,15), PL 63 (64,61-65,15), SB 59 (58,55-61,15), A-P 35 (35,33-36,15), A-S 15 (15,14-17,15), LX 65 (66,61-66,15), ISD 52 (53,50-55,15). Eyes 2 + 2, 29 (29,26-31,15) long by 13 (13,12-15,15) wide (Fig. 63).

Legs (Fig. 64a-c):

Leg I 316 (318,309-327,15), coxal field 61 (63,60-65,15) with 1a 67 (68,62-70,15) and 1b 56 (56,52-58,15); trochanter 44 (45,42-46,15) with 1 seta 48 (48,45-50,15); femur 77 (78,75-80,15) with 4 setae 42-54; genu 42 (43,40-44,15) with 4 setae 29-40, 2 σ 25 each at 0.32 (0.31,0.29-0.33,15) and 0.50 (0.52,0.49-0.54,15); tibia 67 (67,65-69,15) with 5 setae 48-65, 2 ϕ 23 (23,22-25,15) and 25 (25,22-26,15) at 0.28 (0.27,0.25-0.29,15) and 0.83 (0.83,0.80-0.84,15), 1 k 4 (4,3-5,15) at 0.94 (0.95,0.92-0.96,15); tarsus 86 (87,84-88,15) with 13-14 setae 42-50, 1 ω 29 (29,27-30,15) at 0.49 (0.49,0.47-0.51,15), 1 ζ 31 (31,29-33,15) at 0.78 (0.77,0.75-0.80,15)(Fig. 64a).

Leg II 301 (302,298-310,15), coxal field 71 (72,70-74,15) with 2b 67 (67,64-68,15) and 2c 63 (64,61-65,15); trochanter 46 (47,45-48,15) with 1 seta 52 (53,50-54,15); femur 67 (68,65-69,15) with 3 setae 46-52; genu 38 (39,36-41,15) with 3 setae 38-44, 2 σ 21 (22,20-25,15) and 15 (16,14-17,15) at 0.45 (0.46,0.42-0.47,15) and 0.35 (0.33,0.32-0.36,15) respectively; tibia 65 (66,62-67,15) with 5 setae 44-65, 2 ϕ 19 (19,17-20,15) and 21 (21,20-24,15) at 0.23 (0.24,0.20-0.25,15) and 0.82 (0.83,0.80-0.85,15); tarsus 84 (85,82-86,15) with 13-14 setae 29-54, 1 ω 17 (17,15-18,15) at 0.41 (0.40,0.39-0.43,15), no ζ (Fig. 64b).

Figs. 61, 62, 64a *Allothrombium carum* n. sp. (larva):

61a-b. dorsal and ventral idiosoma;

62a-b palpals;

64a. leg I trochanter to tarsus.

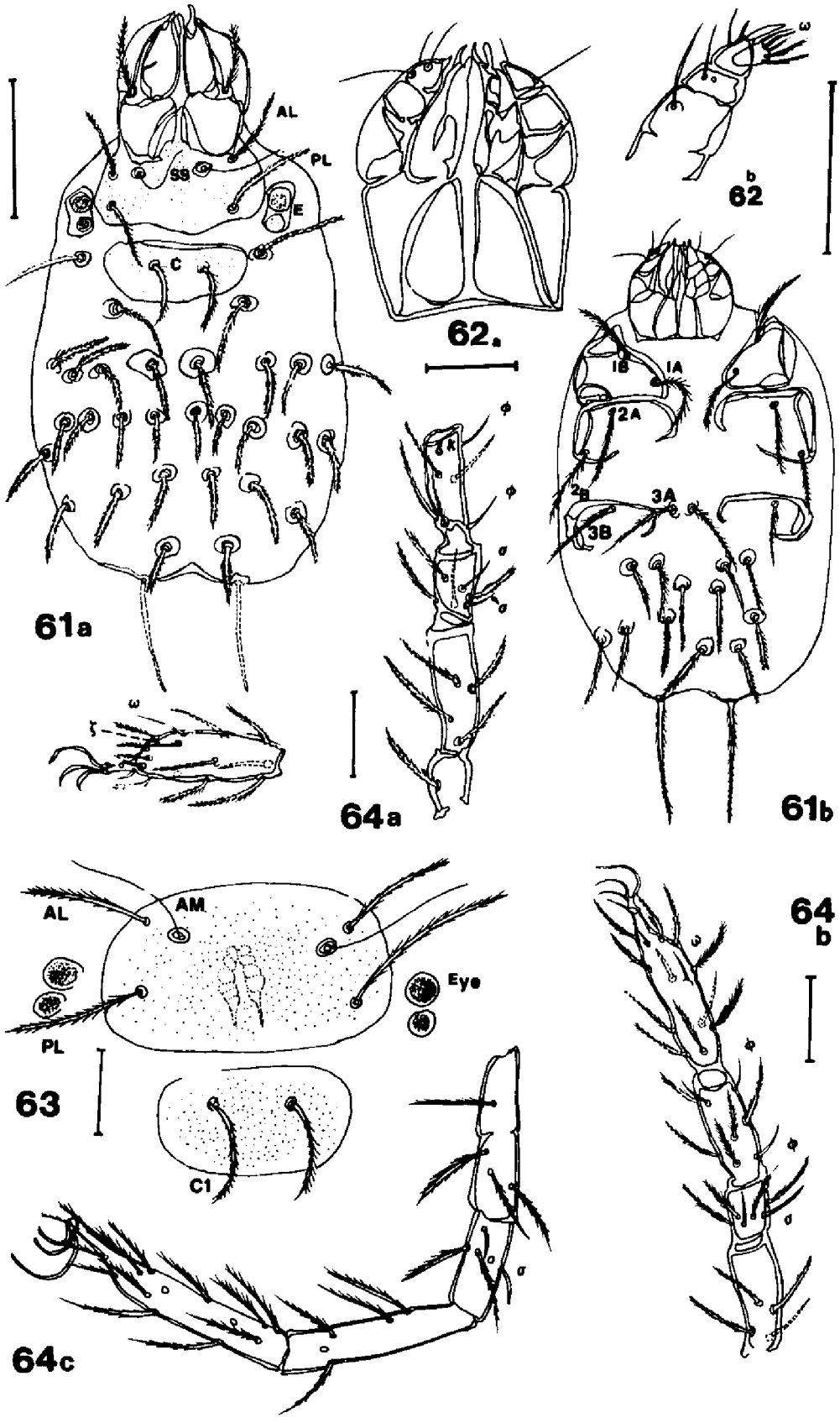
Scale lines for Figs. 61a-b, 62a, 64a each represent 100 μm; sclae line for Fig. 62b represents 50 μm.

Figs. 63, 64b-c. *Allothrombium carum* n. sp. (larva):

63, prodorsal sclerite;

64b-c, legs II-III femur to tarsus.

Scale lines each represent 100 μm.


AL
PL
SS
E
C
61a
ω
62.
62b
ω
1B
1A
2A
2B
3A
3B
61b
64a
64b
AL
AM
PL
Eye
63
C1
64c

Leg III 320 (322,315-333,15), coxal field 67 (67,65-69,15) with 3b 63 (64,61-65,15); trochanter 54 (55,52-57,15) with 1 seta 50 (51,47-53,15); femur 54 (54,51-55,15) with 2 setae 57-69; genu 42 (43,40-44,15) with 3 setae 38-44, 2 σ 23 (23,22-25,15) and 23 (22,20-24,15) at 0.31 (0.32,0.30-035,15) and 0.59 (0.60,0.57-0.63,15); tibia 77 (78,75-79,15) with 5 setae 52-77, without ϕ; tarsus 94 (95,92-97,15) with 11-13 setae 33-54 long, without ω and ζ (Fig. 64c).

Deutonymph: unknown.

Adult females:

Some specimens were collected in the field from May to June of 1991 and 1992 and they laid eggs in the laboratory. Unfortunately, the slides were not good enough for description. Additional specimens are needed to determine the relationship between the larvae described above and other life stages of the species.

Discussion:

The genus *Allothrombium* Berlese, 1903, is a heterogeneous assemblage of about 50 species, of which 16 have been described from both the Palaearctic and Ethiopian realms, 9 from the Australian, 3 from the Oriental, and 5 from the Neotropical region. Four species are listed by Thor and Willmann (1941) for South America.

Ewing (1909, 1917) described two species from the United States: *A. missouriense* (Ewing) 1909 from Missouri and *A. pulvinum* Ewing 1917 from Illinois.

Moss (1960) described *A. lerouxi* as a predator of small arthropods in Quebec apple orchards. Davis (1961) reported a new species, *A. mitchelli*, as a predator on the balsam woolly aphid, *Chermes piceae* Ratz. in North Carolina.

Most of these species are known only from descriptions of their nymph and adult stages. Only a few species have described larvae (Feider,1951; Robaux et al., 1987; Robaux, 1972).

Larvae of *A. carum* differ from *A. neapolitum* in having larger AL, AW, PW, SB and smaller SE, without ML; fewer femoral setae 4-3-2 instead of 5-5-4; from *A. fuliginosum* in having larger AL, AW, PW, SB and without ML, fewer setae on femur, genu, tibia and tarsus, Ge II and Ge III with 2 σ respectively, TiI, II with 2 ϕ each instead of 1 for *fuliginosum*, Ta III without 1 ω for the Michigan species; from *A. monspessulanum* in having larger PW, AW, SB and without ML, fewer femoral and tarsal setae. Details are listed in Table 9.

Etymology:

Allothrombium carum was repeatedly collected in both the Upper and Lower Peninsulas of Michigan during May 1990 and April 1991. It was found to be a predator and an ectoparasite on insect pests and other small arthropods. The velvety appearance of adults attracted my attention at once when found on white pine bark. The latin word, *carum*, meaning beloved, was used to describe this species that so much preferred pine bark.

Distribution of Types:

Holotype larva and other 15 paratype larvae are in Department of Zoology, Michigan State University, East Lansing, MI.

Table 9. Distinguishing characters of *Allothrombium carum* n. sp. and three other close species (larvae).

Species	Sclerite	Ge	Ti	Ta
	AW PW SB AP AL PLSS	1 2 3	1 2 3	1 2 3
		σ	ϕ	ω
A. neapolitum	75 81 45 36 39 62 79	2 2 2	2 2 2	1 1 -
A. fuliginosum	*	2 1 -	1 1 -	1 1 1
A. monspessulanum	75 77 47 27 44 58 47	2 2 2	2 2 -	1 1 -
A. carum	82 96 59 34 54 63 52	2 2 2	2 2 -	1 1 -

Subfamily Podothrombiinae Podothrombium fucum n.sp

Type series:

Holotype: 1 larva emerged on June 5, 1991 from eggs laid on April 28 by a female collected from the forest floor two days earlier. Twenty paratype larvae were obtained from the same egg clump. Ten additional larvae were obtained from eggs laid during spring of 1991 by other females. Five paratype females and five paratype males were collected in July of same year.

Larval description:

Color: in life red. Idiosoma 399 (388,367-412,30) long by 236 (242,228-257,30) wide. Dorsal setae 53 (55,52-57,30), 46-52 in length; C1 pair of setae on sclerite, ventral setae 31 (32,30-35,30) 38-42 long, 3a 52 (53,50-55,30) between coxal field III (Fig. 65a, b).

Palpals: palpal genu 31 (31,29-33,30) with 1 seta 27-29, palpal tibia 23 (24,22-26,30), palpal tibia claw entire 15 (16,14-17,30) with 2 nude setae 23-27, 1 short spine 8 (8,6-9,30); palpal tarsus 12 (12,10-14,30) with 4-5 barbed setae, 1 nude seta, 1 ω and 3 ζ or 2 ζ and 1 companion seta; palpal setal formula: B-B-BNS-4BNω3ζ(2ζ+1c)(Fig. 66).

Prodorsal sclerite (Fig. 67): 144 (147,138-152,30) long by 105 (108,102-114,30) wide, AM 63 (64,60-65,30), AL 59 (59,57-63,30), PL 63 (64,61-66,30), AW 19 (19,17-22,30), MW 79 (77,75-80,30), PW 86 (87,85-89,30), AA 69 (70,68-73,30), ASB 19 (20,18-23,30), PSB 40 (41,39-44,30), ISD 77 (77,74-78,30), A-P 96 (97,94-98,30).

Eyes 2 + 2, 35 (35,33-36,30) long by 21 (22,20-23,30) wide anteriorly and 12 (12,10-14,30) wide posteriorly.

Legs (Fig. 68a-c): Leg I 386 (388,353-412,30), coxal field 90 (92,88-95,30) with 1a 54

(55,52-57,30) and 1b 67 (67,64-69,30); trochanter 36 (37,34-39,30) with 1 seta 65 (66,63-67,30); femur 100 (102,95-110,30) with 5 setae 58-71; genu 67 (66,64-69,30) with 4 setae 48-61, 2 σ 27 each at 0.31 (0.32,0.30-0.35,30) and 0.60 (0.62,0.59-0.65,30), 1 k 8 (7,5-8,30) at 0.86 (0.85,0.84-0.88,30); tibia 77 (78,75-83,30) with 5-6 setae 50-61, 2 ϕ 27 (27,25-29,30) and 25 (26,24-27,30) at 0.42 (0.43,0.40-0.45,30) and 0.90 (0.92,0.88-0.94,30), 1 k 8 (8,6-9,30); tarsus 105 (108,102-114,30) with 25-27 setae 35-48, 2 ω 31 (32,29-34,30) and 35 (35,32-36,30) at 0.22 (0.23,0.20-0.25,30) and 0.62 (0.63,0.60-0.65,30), and 1 famulus respectively, 1ζh 38 (38,36-40,30) at 0.84 (0.85,0.82-0.86,30), 3 ζ 14-19 at dorsal 0.89-0.96 and 4 ζ at ventral region 0.60-0.65 (Fig. 68a).

Leg II 376 (372,361-393,30), coxal field 92 (93,90-96,30) with 2b 59 (59,56-60,30); trochanter 40 (41,39-43,30) with 1 seta 65 (66,62-68,30); femur 90 (92,89-94,30) with 4 setae 61-71; genu 58 (58,55-60,30) with 3 setae 54-56, 1 σ 21 (22,19-24,30) at 0.40 (0.41,0.39-0.43,30), 1 k 6 (7,5-8,30); tibia 77 (75,73-78,30) with 5 setae 48-61, 2 ϕ 21 (22,20-24,30) and 17 (17,16-19,30) at 0.38 (0.37,0.35-0.40,30) and 0.90 (0.91,0.89-0.93,30); tarsus 111 (113,107-125,30) with 19-21 setae 48-54, 1 ω 21 (21,20-24,30) at 0.67 (0.68,0.65-0.72,30) and 1 famulus at 0.78-0.83 (Fig. 68b).

Leg III 424 (433,417-453,30), coxal field 81 (82,78-86,30) with 3b 61 (62,60-64,30); trochanter 48 (48,46-50,30) with 1 seta 65 (66,62-67,30); femur 104 (107,101-116,30) with 4 setae 52-71; genu 59 (61,58-64,30) with 3 setae 44-58, 1 σ 23 (24,20-25,30) at 0.58 (0.57,0.55-0.60,30); tibia 92 (94,90-98,30) with 5 setae 56-77, without ϕ; tarsus 121 (124,118-135,30) with 18-21 setae 58-79, without ω and ζ (Fig. 68c).

Deutonymph: Color in life yellow to brown. Idiosoma 834 (776,677-932,5) by 485 (521,466-623,5) wide. Palpal femur with 7-9 setae, 48 (46,42-53,5) long; palpal genu 67 (68,59-73,5) long with 12-14 setae; palpal tibia 72 (78,66-83,5) long with 3 spines and 1 tibia claw; palpal tarsus 60 (63,60-73,5) long with 3-7 ω (Fig. 69). Prodorsal sclerite 133 (142,128-163,5) long with 8 setae above SS setae, 5 setae between eyes and SS setae (Fig. 70). Anal valvel with 8 setae total, 132 (142,130-164,5) long by 35 (38,31-54,5) wide (Fig. 71).

Adult female:

Color: in life brown. Idiosoma 1726 (1986,1677-1992,5) long by 987 (995,923-1012,5) wide. Palpal tibia with 5 teeth at inner edge and rows of spinelike setae at dorsal edge, 3 claws at front, one at middle derived from pulvillus; palpal tarsus with ω in rows (Fig. 72). Genital valves 368 (372,349-452,5) long with numerous setae; anal valves 118 (121,108-138,5) long with short setae around (Fig. 73a, b).

Prodorsal sclerite (Fig. 74): SE 136 (142,119-151,5), PW 102 (112,101-127,5), 11 setae at each side. Eyes 2+2, 121 (131,118-142,5) long by 105 (108,102-133,5) wide.

Legs: Leg I 3299 (3326,3078-3645,5), coxal field 242 (238,212-265,5); trochanter 157 (159,144-173,5); basifemur 370 (383,355-396,5); telofemur 514 (522,507-566,5) with 11-12 N at 0.27-0.99; genu 587 (593,533-626,5) with 22-23 σ at 0.08-0.96, 1 k 8-12 at 0.95-0.98; tibia 942 (938,918-975,5) with hundreds ϕ in rows in all regions; tarsus 729 (735,716-767,5) with hundreds ω in rows in all areas.

Leg II 2131 (2097,2018-2235,5), coxal field 298 (288,244-312,5), trochanter 148 (155,138-162,5); basifemur 261 (273,251-297,5); telofemur 320 (337,311-364,5) with

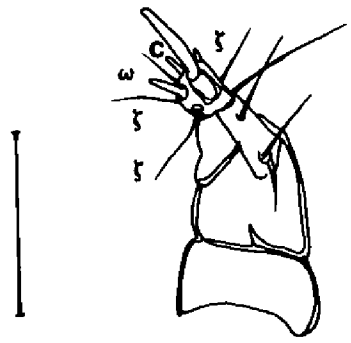
Figs. 65a, 66, 67. *Podothrombium fucum* n. sp. (larva):

65a. dorsal idiosoma;

66, palpal tibia and tarsus;

67, prodorsal sclerite.

Scale lines for Figs. 65a, 67 each represent 100 μm; scale line for Fig. 66 represents 50 μm.



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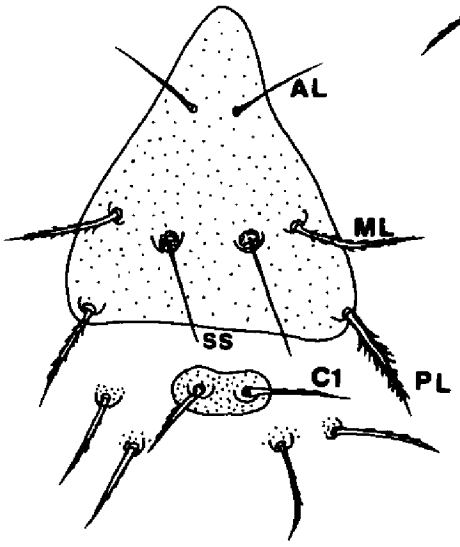

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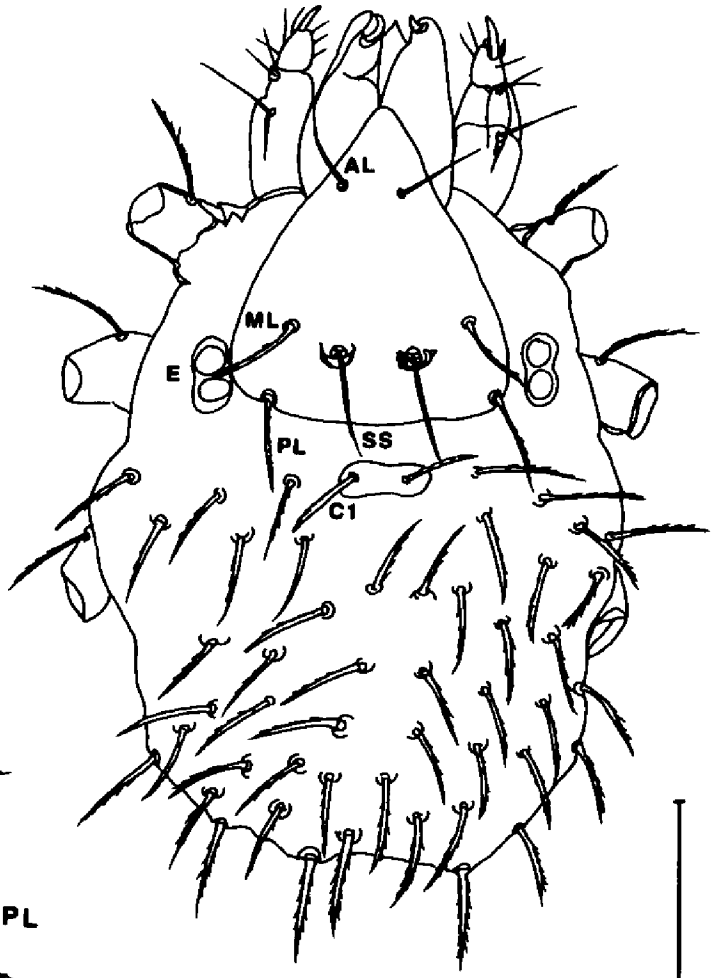


65

Figs. 65b, 68, 69, 70, 71. *Podothrombium fucum* (larva and deutonymph):

65b. ventral idiosoma (larva);

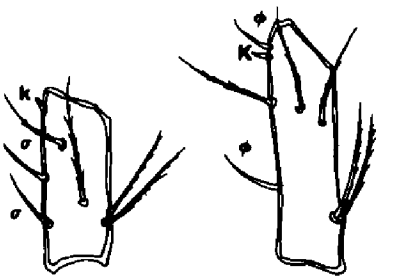
68a-c. legs I-III genu to tarsus (larva);

69. palpals (deutonymph);

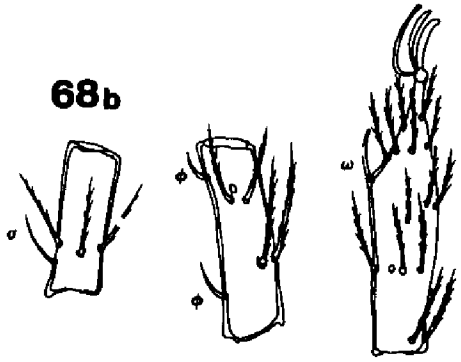
70. prodorsal sclerite (deutonymph).

Scale lines for Figs. 65b, 68a-c, 72, 73 each represent 100 μm.

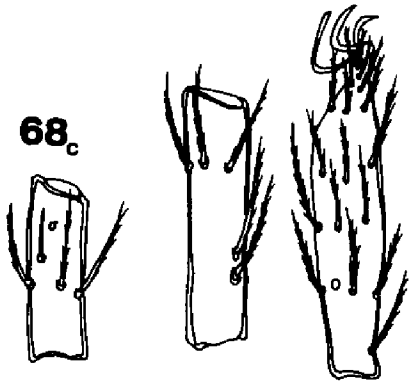
65b



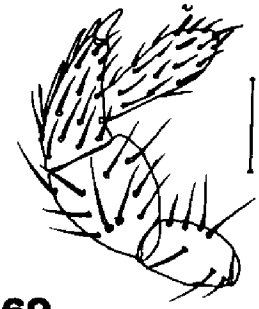
68a



68b



68c



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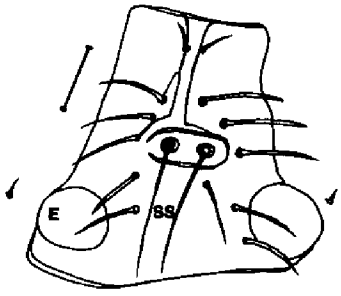

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71

3 N at 0.53-0.96; genu 364 (372,335-396,5) with 7-8 σ at 0.05-0.90, 1 k 10-13 at 0.95-0.97; tibia 589 (595,547-613,5) with hundreds ϕ; tarsus 449 (433,416-466,5) with hundreds ω on the segment.

Leg III 2037 (2017,2006-2535,5), coxal field 261 (266,232-288,5); trochanter 159 (162,152-167,5); basifemur 263 (269,247-289,5); telofemur 311 (323,308-347,5) with 6-7 N at 0.49-0.94; genu 326 (332,318-347,5) with 11-12 σ at 0.05-0.91; tibia 625 (637,615-665,5) with 29-30 ϕ at 0.06-0.94; tarsus 353 (355,332-366,5) with 19-21 ω at 0.27-0.93.

Leg IV 2766 (2832,2557-2993,5), coxal field 244 (247,227-256,5); trochanter 246 (252,228-267,5); basifemur 320 (327,318-343,5); telofemur 407 (412,402-452,5) with 4-5 N at 0.34-0.90; genu 462 (477,433-488,5) with 8-9 σ at 0.18-0.95; tibia 829 (843,817-866,5) with 23-24 ϕ at 0.02-0.96; tarsus 503 (508,501-525,5) with 17-18 ω at 0.24-0.96.

Adult male:

Color: in life brown. Idiosoma 1797 (1820,1563-1943,5) long by 915 (922,907-1012,5) wide. Genital and anal valves with more setae than females.

Palpals: palpal femur 272 (288,265-294,5); palpal genu 140 (143,137-158,5); palpal tibia 167 (170,158-183,5), palpal tibia claw entire 54 (55,52-58,5) long, 4 spines next to the claw, 5 spines at dorsal region; palpal tarsus 177 (180,167-192,5).

Prodorsal sclerite: 92 (95,90-98,5) long by 115 (118,108-126,5) wide, SE 104 (105,101-116,5); SB 40 (41,39-44,5); posterior end slightly concave, 9 setae at each side of the sclerite. Eyes 2 + 2, 121 (121,118-127,5) long by 102 (103,100-106,5) wide, AW 75

(76,73-78,5), PW 96 (97,93-99,5).

Legs: Leg I 3487 (3557,3178-3820,5), coxal field 297 (301,287-335,5); trochanter 190 (192,178-198,5); basifemur 445 (453,427-486,5); telofemur 525 (545,517-586,5) with 6-7 N 25-29 at 0.40-0.89; genu 608 (612,588-634,5) with 21-22 σ 23-29 at 0.23-0.91; tibia 986 (997,932-1033,30) with hundreds ϕ at all areas; tarsus 733 (747,718-788,30) with hundreds ω in rows.

Leg II 2254 (2473,2057-2783,30), coxal field 251 (262,236-288,30); trochanter 178 (188,164-198,30); basifemur 282 (297,255-312,30); telofemur 334 (342,302-378,30) 3-4 N 25-29 at 0.56-0.85; genu 378 (385,347-396,30) with 14-15 σ 23-31 at 0.11-0.97; tibia 589 (597,566-623,30) with hundreds ϕ; tarsus 493 (505,488-547,30) with hundreds ω at 0.15-0.95.

Leg III 2173 (2285,2109-3321,30), coxal field 253 (262,233-274,30); trochanter 167 (172,147-183,30); basifemur 238 (253,218-277,30); telofemur 318 (332,302-363,30) 3 N 25-29 at 0.44-0.97; genu 349 (367,328-388,30) with 7-8 σ 25-29 at 0.16-0.97; tibia 637 (647,618-683,30) with 24-25 ϕ 23-27 at 0.09-0.96; tarsus 464 (478,420-498,30) with 15-16 ω 21-25 at 0.10-0.88.

Leg IV 2906 (2981,2235-3217,30), coxal field 341 (364,327-385,30); trochanter 247 (253,217-268,30); basifemur 249 (255,219-277,30); telofemur 462 (473,422-497,30) with 5 N 25-29 at 0.33-0.96; genu 468 (483,455-522,30) 12-13 σ 23-29 at 0.03-0.92; tibia 949 (958,922-1012,30) with 26-30 ϕ 23-29 at 0.04-0.95; tarsus 529 (544,511-566,30) 10-11 ω 23-28 at 0.27-0.81.

Figs. 72-74. *Podothrombium fucum* (adult female):

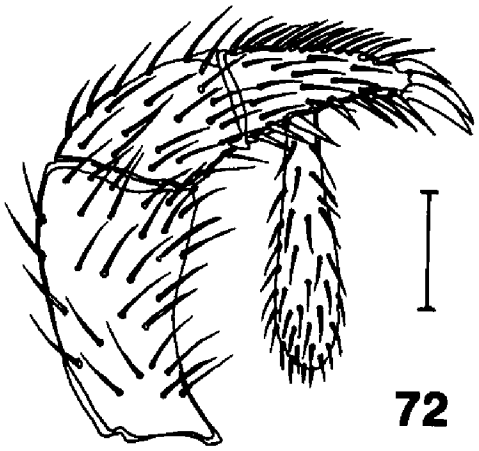
72. palpals;

73a. genital valves;

73b. anal valves;

74. prodorsal sclerite.

Scale lines for Figs. 72-74 each represent 100 μm.



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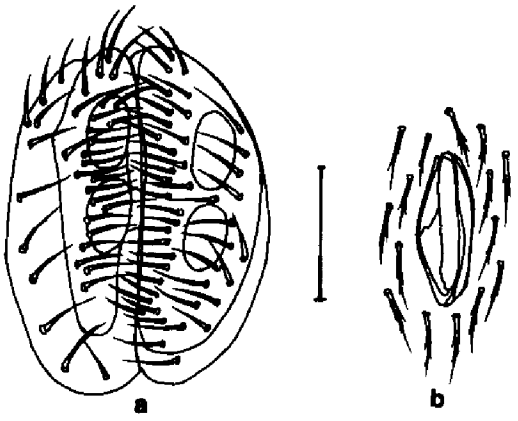

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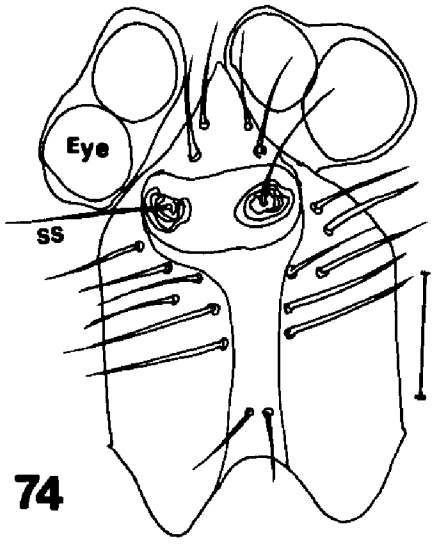

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Discussion:

The generic description by Berlese (1910) from Italy was based on adults of the type species *Podothrombium bicolor* (Hermann).

Since then 36 species have been described, mostly based on adults and deutonymphs (Oudemans, 1910; Feider, 1968; Robaux, 1977, 1982). Among only five of those species have adults been correlated with the larval forms (Robaux, 1982; Chang, 1989). Hosts of larvae were reported as aphids (Aphidae,Homoptera).

Podothrombium fucum is close to *P. paucisetarum* in having few dorsal and ventral setae and with respect to number of specialized genu setae. Significant differences which distinguish the species from *paucisetarum* include narrow AW, ASB of sclerite (19:83, 19:116), length of sclerite (143:160), and number of specialized setae ω on tarsus (1-1-0:2-1-0).

Etymology:

The species name is from a Latin word, *fucus*, meaning red or purple.

Distribution of Types:

The holotype, 25 larval, 5 nymph and 5 female paratypes are in Department of Zoology, Michigan State University, East Lansing, MI. One larval, nymph and female paratypes will be deposited in each of the following institutions: Field Museum of Natural History, Chicago, IL; Canadian National Collection, Ottawa, Ont; Shanghai Institute of Entomology, Shanghai, PRC.

Family Calyptostomatidae *Calyptostoma nivalis* n. sp.

Type series:

Holotype: 1 larva collected on May 24, 1988 from the forest floor, fifteen paratypes also collected from the same site on May 14, 16,19, 1990 and May 23, 27, 1991. Only one deutonymph collected from a pastureland at Sagola, Michigan on May 15, 1984 by Nancy Sferra. Five adult females collected from the forest floor between August and September of 1984.

Larval description:

Idiosoma (Fig. 75a, b, c):

Color: in life red, dorsal setae 256-264 in number, 38-42 anteriorly, 40-46 posteriorly, in 4 horizonal rows and 2 lateral zones; ventral idiosoma without setae, 51-53 setae located after coxal field III, 36-42 anteriorly, 40-44 posteriorly. Eyes 2 + 2, 77 long by 54 wide, AW 48, AL 27, PW 50, PL 40.

Prodorsal sclerite (Fig.76):

SS 139 on dorsal protuberance, 52 long, and 48 wide; AW 33, MW 69, PW1 88, PW2 96, AL 59, ML 33, PL1 46, PL2 40, SB 54, LX 4, A 21, B 17, C 27, L 121. Palpal tibia claw small with 4 leaflike setae and 2 nude setae (Fig. 77).

Legs (Fig.78a-c): Leg I 585, coxal field 175 with 39 setae, 35-42 anteriorly, 48-50 posteriorly; trochanter 56 with 3 setae 40-63 in length; basifemur 117 with 23-25 setae, 42-52 anteriorly, 44-46 posteriorly; telofemur 50, 15 setae 44-52; genu 94 with 37-39 setae, 38-42 anteriorly, 36-46 posteriorly, 3 σ 23 at 0.24, 27 at 0.42, 27 at 0.66, 1k 10 at 0.90; tibia 107 with 52-56 setae, 42-48 anteriorly, 40-48 posteriorly, 5 ϕ 25 at 0.27,

25 at 0.38, 23 at 0.47, 23 at 0.60, and 27 at 0.78; tarsus 161 with 86-89 setae, 33-58 anteriorly, 44-48 posteriorly, 1 ω 21 at 0.71, 2 ʃh 56 at 0.79, 40 at 0.83, 1 ʃp 25 at 0.93, and 4 ω 29 at 0.24, 31 at 0.43, 33 at 0.52, 31 at 0.63 (Fig. 78a).

Leg II 523, coxal field 159 with 43 setae, 40-48 anteriorly, 44-46 posteriorly; trochanter 58 with 5 setae 52- 65; basifemur 111 with 17-19 setae, 42-44 anteriorly, 44-58 posteriorly; telofemur 46 with 14-16 setae, 40-50 in length; genu 81 with 39-40 setae, 31-35 anteriorly, 21-36 posteriorly, 2 σ 23 at 0.27, 27 at 0.51; tibia 88 with 36-38 setae, 31-40 anteriorly, 29-44 posteriorly, 2 φ 27 at 0.21, 25 at 0.52; tarsus 139 with 68-72 setae, 44-54 anteriorly, 44-50 posteriorly, 1 ω 29 at 0.58, 2 ʃh 58 at 0.57, 54 at 0.69 (Fig. 78b).

Leg III 591, coxal field 161 with 32 setae, 38-52 anteriorly, 46-56 posteriorly; trochanter 67 with 3 setae 63-71; basifemur 127 with 13-15 setae, 52-58 anteriorly, 50-59 posteriorly; telofemur 50 with 10-12 setae, 48-50 in length; genu 84 with 33-35 setae, 38-42 anteriorly, 40-46 posteriorly, 3 σ 23 at 0.20, 27 at 0.42, and 25 at 0.60; tibia 115 with 36-38 setae, 36-48 anteriorly, 42-44 posteriorly, 1 φ 25 at 0.58; tarsus 148 with 67-69 setae, 33-56 anteriorly, 46-50 posteriorly, 1 ʃh 77 at 0.73, 1 ʃp 31 at 0.85 (Fig.78c).

Deutonymph:

Color: in life not recorded, presumed red. Body 830 long by 564 wide. Dorsal setae with a big base 27-35 in length, ventral setae long and smooth 38-42. Anal valves without setae (Fig. 79). Eyes 1 + 1, 58 long by 48 wide.

Palpals: palpal genu 111 with 2 long setae 59-63; palpal tibia 33 with 14-17 setae 25-38, no prominent tibia claw observed, only 3 needlelike setae at the tip 13-17 in length;

palpal tarsus 58 with 31-33 setae 29-35 (Fig. 80).

Prodorsal sclerite: SS 102, SB 38, L 201, AW 27, PW 63 (Fig. 81).

Legs: Leg I 564, coxal field 129, with smooth setae 40-48 in length; trochanter 52, with a few setae 46-50; basifemur 130 with setae 38-48; telofemur 58 with setae 33-36; genu 84 with setae 33-36, 3 σ 21-23 at 0.23, 0.41 and 0.66 respectively, 1 k 6 at 0.93; tibia 115 with setae 35-38, 5 ϕ 21-23 at 0.25, 0.50, 0.63, 0.86, 0.88 respectively; tarsus 125 with setae 36-38, 7-9 ω 19-23 at 0.34-0.71, 4 ζp 15-17 at 0.63-0.86, 2 claws entire without pulvillums.

Leg II 506, coxal field 127 with setae 42-50; trochanter 59 with setae 52-54; basifemur 127 with setae 48-50; telofemur 48 with setae 29-33; genu 65 with setae 21-25, 2 σ 19-21 at 0.23 and 0.32; tibia 88 with setae 31-33, 5 ϕ 19-23 at 0.24-0.78; tarsus 119 with 8 ω 21-27 at 0.11-0.56, 1 ζh 46 at 0.61, 5 long setae 41-44.

Leg III 503, coxal field 129 with setae 31-44; trochanter 48 with setae 40-56; basifemur 127 with setae 42-48; telofemur 48 with setae 40-44; genu 69 with setae 21-42, and 3 σ 21-27 at 0.25, 0.83 and 0.86; tibia 92 with setae 31-35, 5 ϕ 17-21 at 0.24,0.48 and 0.85; tarsus 119 with setae 40-42.

Leg IV 596, coxal field 142 with setae 42-50; trochanter 71 with setae 36-50; basifemur 121 with setae 42-50; telofemur 58 with setae 40-44; genu 90 with setae 35-36, 3 σ 27-29 at 0.23-0.85; tibia 125 with setae 33-39, 5 ϕ 23-27 at 0.24-0.82; tarsus 129 with setae 40-50.

Adult female:

Color: in life brown. Idiosoma ovoid, dorsal setae two types, 63-67 long for short ones,

and 77-90 long for long ones; ventral setae 90-100 in length (Fig. 82a, b).

Palpals: palpal genu 386 (388,367-407,5); palpal tibia 67 (67,64-69,5), palpal tibia claw 10 (9,8-11,5); palpal tarsus 56 (57,54-58,5) with 6 long setae 71-102 in length (Fig. 83).

Prodorsal sclerite: with SS 82 (84,81-87,5) and SS base 77 long by 157 wide (Fig. 84).

Genital valves with numerous setae; anal valves with five setae at each side (Fig. 85a, b).

Leg I 1588 (1672,1438-1726,5) long, coxal field 349 (352,318-366,5); trochanter 150 (152,138-157,5); basifemur 432 (445,417-466,5); telofemur 207 (212,201-224,5); genu 316 (322,310-334,5) with 12-14 σ 23-27 at 0.30-0.77; tibia 407 (418,404-427,5) with 14-16 ϕ 21-27 at 0.16-0.93; tarsus 508 (527,505-533,5) with 92-98 ω 25-29 at 0.11-0.95, 1 ζh 48-52 at 0.89-0.92.

Leg II 1272 (1321,1186-1457,5), coxal field 399 (404,388-432,5); trochanter 159 (162,153-172,5); basifemur 368 (377,358-397,5); telofemur 169 (175,148-182,5); genu 255 (264,237-288,5) with 3-5 σ 19-23 at 0.29-0.37; tibia 290 (292,276-298,5) with 5-6 ϕ 25-29 at 0.15-0.97; tarsus 399 (406,387-423,5) with 13-15 ω 23-29 at 0.17-0.95, without ζ.

Leg III 1747 (1824,1732-1988,5), coxal field 397 (405,388-415,5); trochanter 184 (188,168-197,5); basifemur 418 (427,412-466,5); telofemur 184 (188,177-192,5); genu 267 (273,255-287,5) with 3 σ 19-23 at 0.24-0.77; tibia 299 (307,287-317,5) with 5-6 ϕ 23-27 at 0.27-0.77; tarsus 395 (404,388-412,5) 2 ω 17-19 at 0.67-0.71, without ζ.

Leg IV 2135 (2247,2108-2749,5), coxal field 416 (423,409-433,5); trochanter 265 (269,255-273,5); basifemur 449 (454,432-475,5); telofemur 230 (241,212-267,5); genu

328 (331,315-354,5) without σ; tibia 372 (375,366-383,5) with 3-4 ϕ 19-23 at 0.21-0.53; tarsus 491 (488,475-507,5) with 2 ω 17-19 at 0.70-0.73.

Discussion:

The genus was erected by Cambridge in 1875. A few species described in Europe were placed in this genus (Miller,1776; Hermann, 1804). Their special morphological features easily place them in the family Calyptostomatidae, which is characterized by larval coxal fields possessing multiple setae. The new species represents a first generic record for North America.

Etymology:

The Latin species name, *nivalis*, refers to the prolonged snowy winters in Michigan's Upper Peninsula.

Distribution of Types:

The holotype and paratypes are in Department of Zoology, Michigan State University, East Lansing, MI.

Figs. 75-78a. *Calyptostoma nivalis* n. sp. (larva):

75a-b, dorsal and ventral idiosoma,

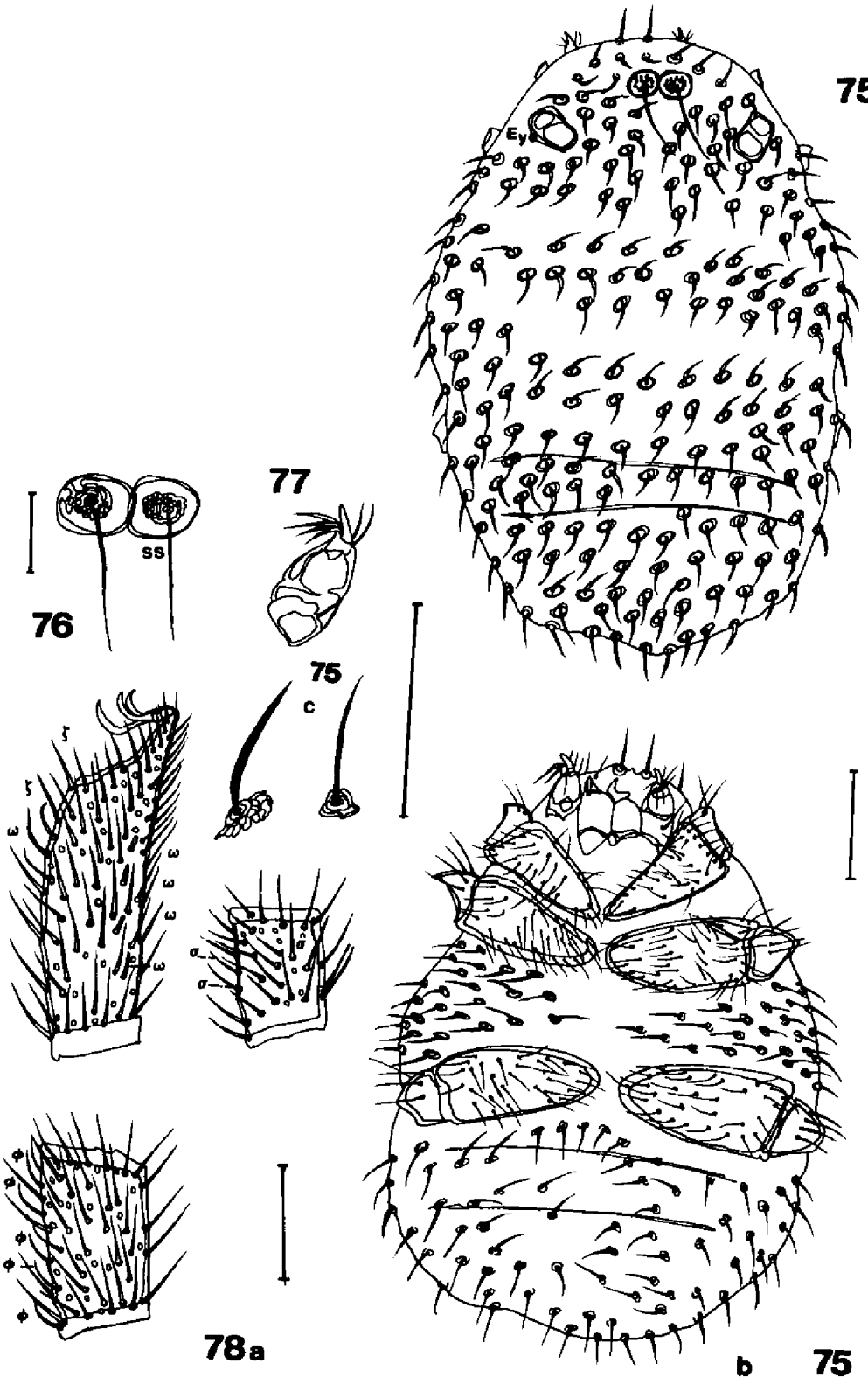
75c, dorsal and ventral setae;

76, dorsal sensary setae;

77, palpals;

78a, leg I genu to tarsus.

Scale lines for Figs. 75a-b, 76, 78a each represent 100 μm; scale line for Figs. 75c, 77 represents 50 μm.


75a
Eye
77
SS
76
75
c
78a
b
75

Figs. 78b-c, 79-82, 84-85. *Calyptostoma nivalis* n. sp. (larva, deutonymph and female):

78b-c, legs II-III (larva);

79, anal valves (deutonymph);

80, gnathosoma (deutonymph);

81, prodorsal sclerite (deutonymph);

82a-b, dorsal and ventral setae (female);

84, prodorsal sclerite (female).

Scale lines for Figs. 78b-c, 79, 80 81, 84, 85 each represent 100 μm; scale line for Fig. 82a-b represents 50 μm.

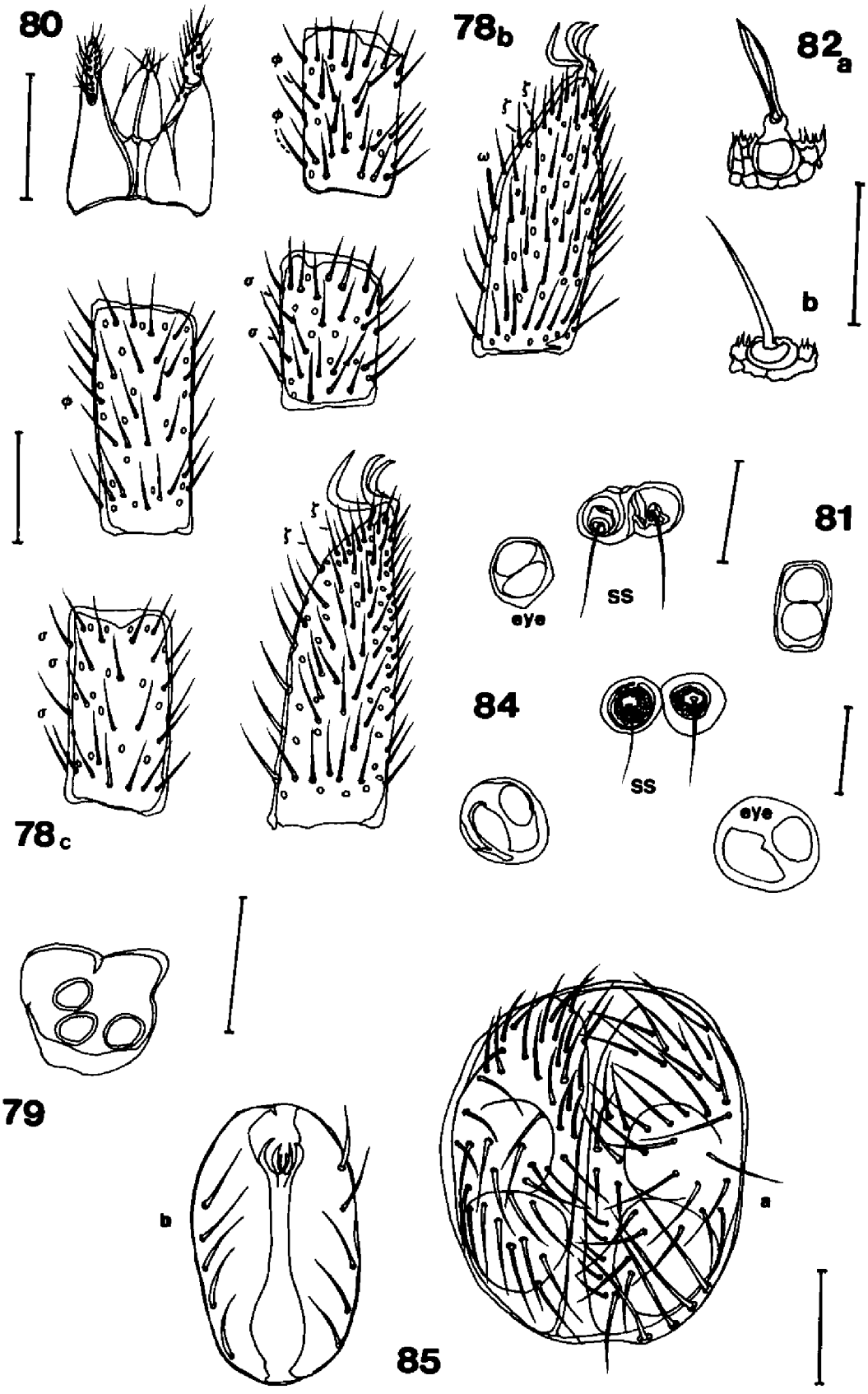
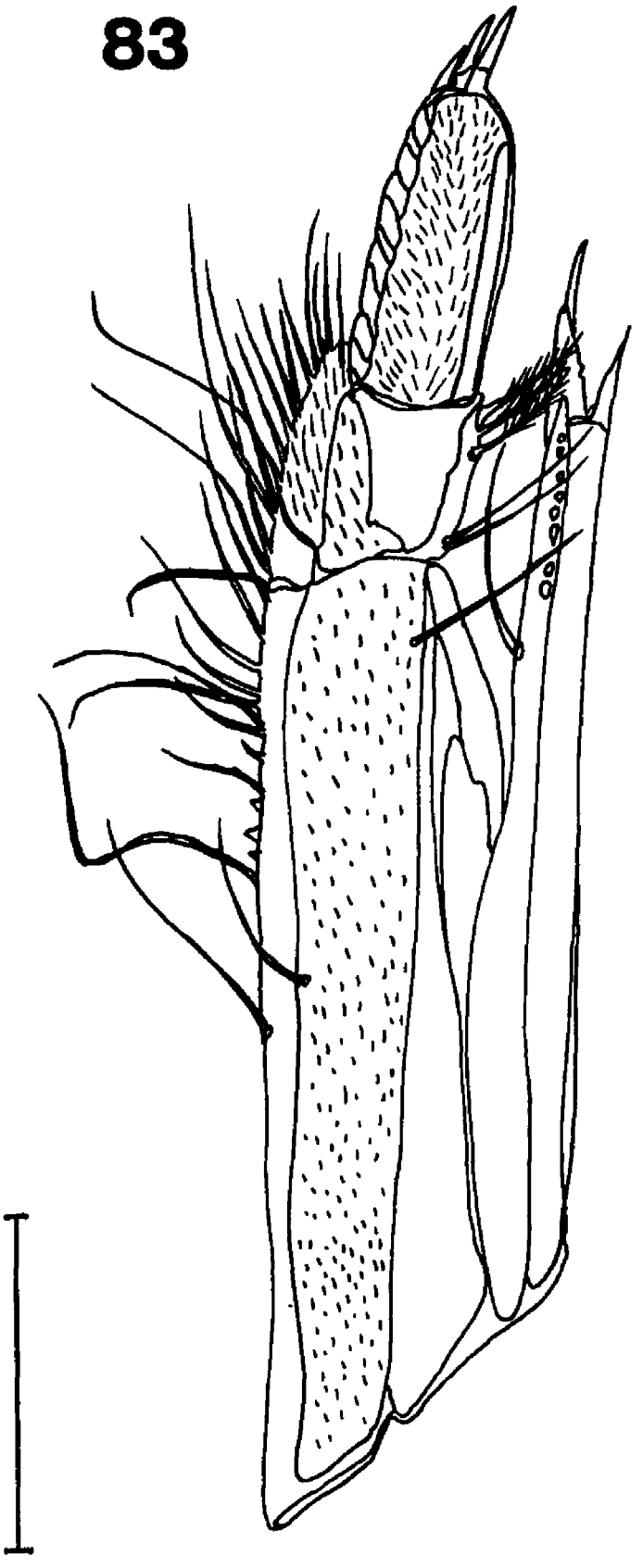

80
78b
82a
b
81
eye
SS
84
SS
eye
78c
79
b
a
85

Fig. 83. *Calyptostoma nivalis* n. sp. (female): palpals.

Scale line represent 100 μm.

83



Family Eutrombidiidae *Hexathrombium bicomarum* n. sp.

Type series:

Holotype: 1 larva collected on 15 May, 1991 from forest litter. Fifteen larval paratypes collected at the same location in 1988 and 1991. Host unknown. Nymphs and adults are also unknown.

Larval description:

Color: in life yellow to light brown. Idiosoma ovoid, 272 (285,266-331,15) long by 148 (157,142-170,15) wide. One pair of eyes set on each side of prodorsum, anterior eye 10 (9,8-11,15) long and 12 (11,10-13,15) wide, posterior eye 13 (14,12-15,15) long and 12 (12,10-14,15) wide (Fig. 86a, b). Gnathosoma 188 (192,174-216,5) long with 1 palpal genu seta, 3 palpal tarsus setae and 1 ζ without tibia claw (Fig. 87a, b).

Dorsal setae (Fig. 88): Dorsal setae 19, 56-63 in length anteriorly, setae C1 on sclerite (scutellum) 63 (64,61-65,15) long; scutellum 15 (16,13-17,15) long; PD 38 (39,37-40,15); SBa 75 (76,73-78,15); AW 200 (201,198-208,15); PW 180 (182,178-187,15); ABD 65 (66,63-68,15).

D1 pair of setae on sclerite 65 (67,62-69,15); scutellum 14 (14,12-16,15); PD 25 (26,22-27,15); SBa 65 (67,63-69,15); ABD 42 (44,41-16,15); AW 150 (151,146-156,15); PW 138 (140,137-143,15); L 38 (39,37-40,15).

E1 pair of setae on sclerite 73 (74,70-78,15); scutellum 13 (14,12-16,15); PD 27 (27,24-28,15); SBa 67 (68,65-72,15); ABD 25 (25,22-27,15); AW 117 (118,113-122,15); PW 101 (104,100-108,15);L 40 (42,39-45,15).

H1 setae on sclerite 75 (76,72-78,15) in length, H2 setae on seperate sclerite 76

(77,74-79,15); ABD 13 (14,13-16,15); SBa 29 (29,27-30,15); AW 56 (57,54-60,15); PW 40 (42,39-44,15).

Ventral setae (Fig. 89): with 1a of barbed intercoxal setae between coxal field leg I, 25 (26,23-27,15), and 1 pair (3a) between coxal field leg III, 29 (29,27-32,15); after coxal field leg III, 18B setae in length from 33-35 anteriorly and 40-46 posteriorly, setae 1b,2b and 3b in length from 12, 12 and 10 are modified (Fig. 87a,b). 1 preanal tuburical seta.

Prodorsal sclerite: AM 36 (37,33-38,15); SS 77 (77,73-78,15); AL 79 (79,74-82,15); PL 58 (58,53-60,15); L 165 (170,156-179,15); W 194 (198,180-210,15); AW 140 (147,138-156,15); PW 190 (193,185-198,15); AAS 69 (71,67-74,15); LX 77 (76,73-78,15); PPS 27 (27,24-29,15); SBa 82 (83,80-87,15); SBp 135 (139,134-142,15); ISD 101 (105,100-110,15); ASBa 3 (3,2-4,15); PSD 33 (34,30-36,15).

Legs (Fig. 90a, b, c): Length: leg I from trochanter to pretarsus 200 (201,193-208,15); leg II 159 (160,157-164,15); leg III 146 (148,142-152,15).

Leg I: coxal field with 1 modified, bifurcated seta and 1 nude seta; trochanter with 1B 25 (26,22-28,15); femur with 3B 27-36, 1 N 34 (36,32-38,15) at 0.16 (0.16,0.14-0.18,15); genu with 4B 35-36, 1 σ 25 (26,23-28,15) and 1 k 4 at 0.92; tibia with 6B 36-38, 2 ϕ 29 (30,27-34,15) at 0.50 (0.50,0.48-0.53,15) and 31 (32,28-34,15) at 0.89 (0.88,0.85-0.92,15) and 1k 4-6 at 0.91-0.93; tarsus with 16B 23-35, 1 ω 33 (34,31-36,15) at 0.47 (0.48,0.45-0.50,15), 1 famulus 23 (24,22-26,15) at 0.94 (0.94,0.92-0.95,15) (Fig. 90a).

Leg II: coxal field with 1 modified, bifurcated seta; trochanter with 1B 27 (27,25-29,15); femur with 4B 33-48, 1 N 31 (32,29-33,15) at 0.20 (0.22,0.18-0.25,15); genu

with 2B 27-36, 1 σ 25 (26,23-26,15); tibia with 5B 33-36, 2 ϕ 21 (21,20-22,15) at 0.40 (0.42,0.40-0.45,15) and 21 (22,19-23,15) at 0.71 (0.68-0.73,15); tarsus with 15B 23-31, 1 ω 21 (21,20-23,15) at 0.37 (0.37,0.35-0.38,15), and 1 fumulus (Fig. 90b).

Leg III: coxal field with 1 modified, bifurcated seta, smaller than setae on legs I and II; trochanter with 1B 31 (32,30-34,15); femur with 3B 31-39, 1 N 29 (29,28-32,15) at 0.13 (0.14,0.12-0.15,15); genu with 2B 37-44 and 1 σ 29 (29,27-33,15); tibia with 4B 33-40?; tarsus bifurcate with 8-9B 29-44, pretarsus with only emporium and modifided claw, 1 ζ 33 (33,30-35,15) at 0.71 (0.72,0.69-0.74,15), 1 lobe seta 48 (47,45-49,15) at 0.86 (0.85,0.84-0.87,15)(Fig. 90c).

Deutonymph and adult: unknown.

Etymology:

The species name is a Latin word, bi-, comarum, meaning two hairs on dorsal sclerite.

Discussion:

This is the second species of the genus ever collected in the world. The first was reported from Brussels by Cooreman (1949) as a new species and a new genus, *Hexathrombium spatuliferum*. *Hexathrombium bicomarum* differs in having 2 dorsal setae on a sclerite at the posterior pole of the idiosoma.

Distribution of Types:

The holotype and paratypes are in Department of Zoology, Michigan State University, East Lansing, MI.

Figs. 86-89. *Hexathrombium bicomarum* n. sp. (larva):

86a-b, dorsal and ventral idiosoma; 86c, eyes;

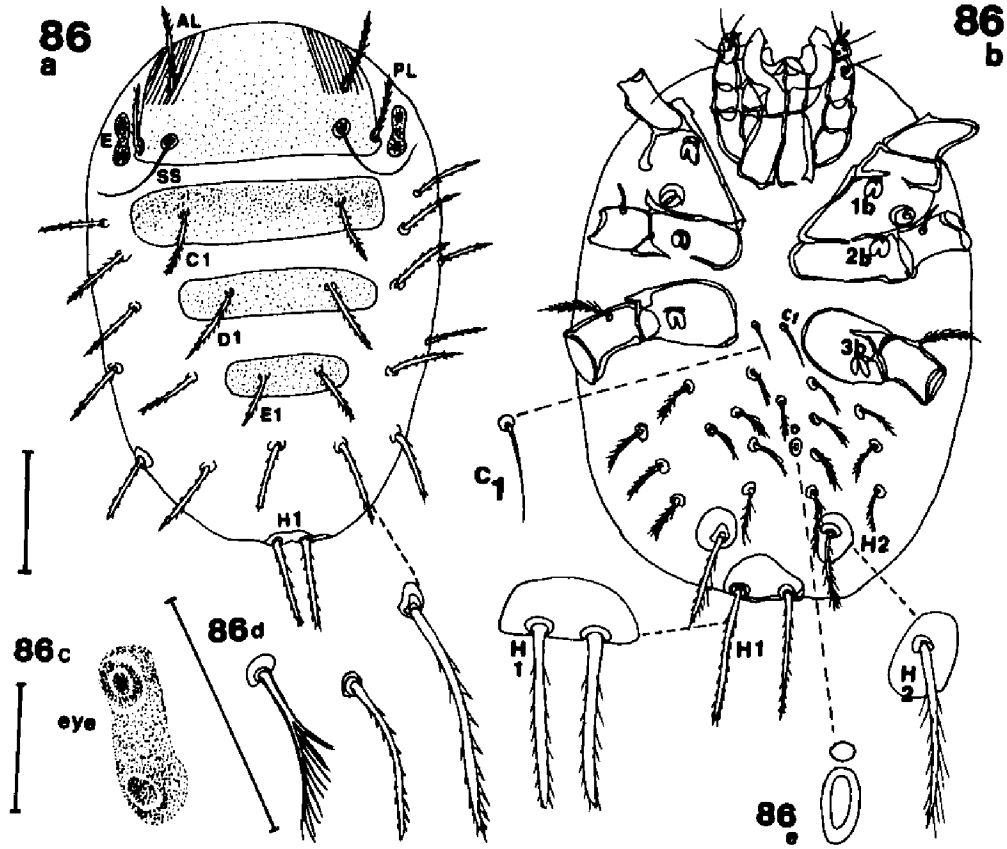
86d, dorsal and ventral setae; 86e, anal pore.

87a-b, gnathosoma and palpals;

88, dorsal sclerites and setae;

89, ventral coxal fields I-III.

Scale lines for Figs. 86a-b, 87a, 88, 89 each represent 100 μm; scale lines for Figs. 86d-e, 87b each represent 50 μm; scale line for Fig. 86c represents 40 μm.


86 a
AL
PL
E
SS
C1
D1
E1
H1
86 b
1b
2b
3b
C1
H2
H1
86c
eye
86d
86e

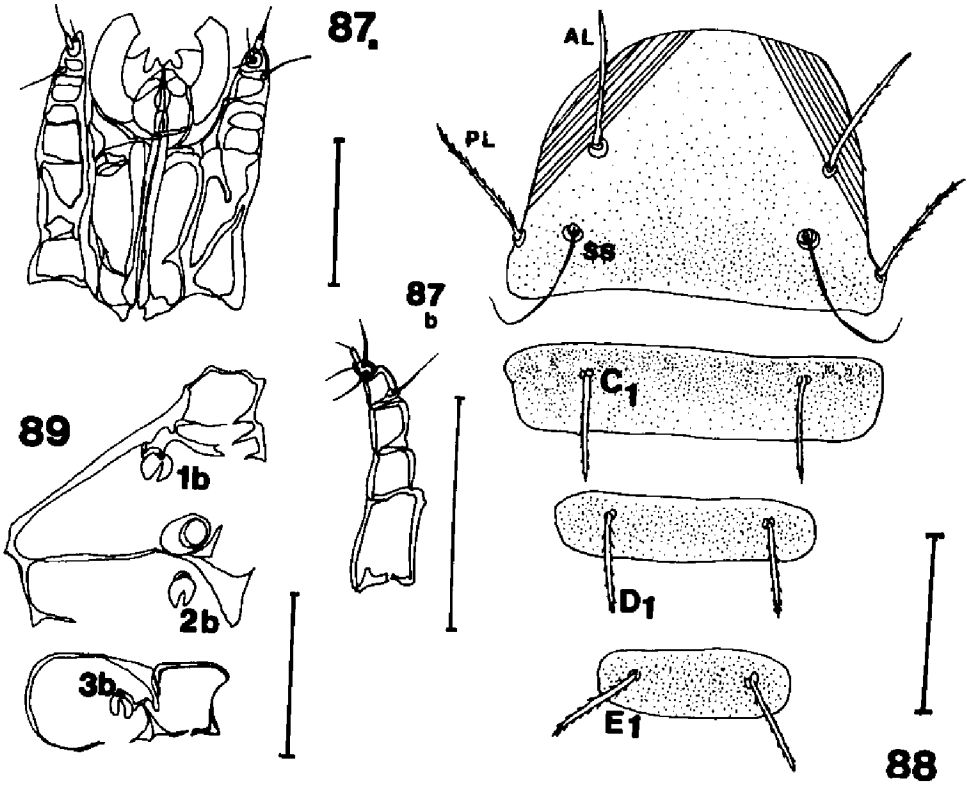
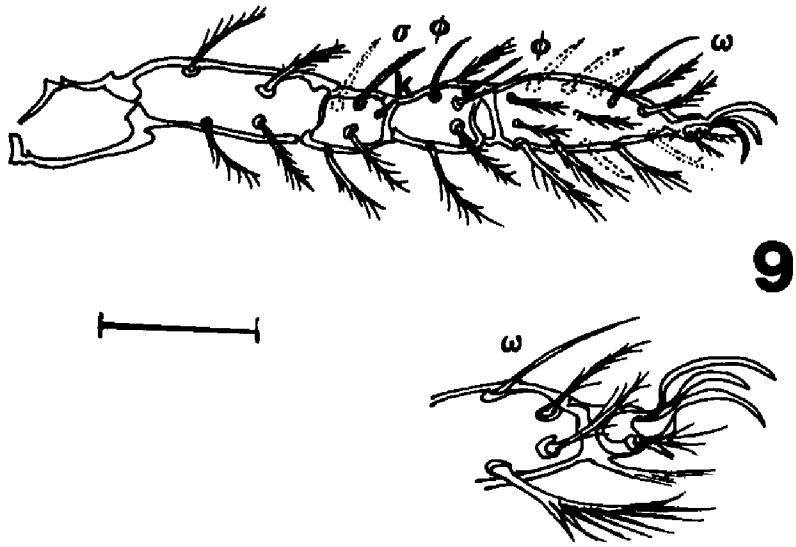
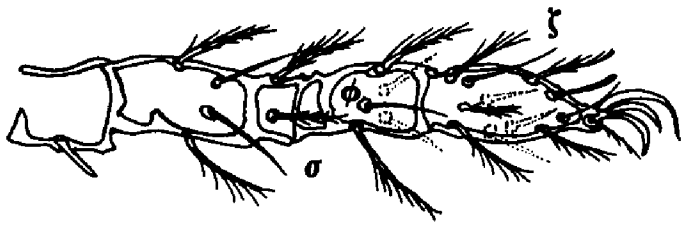

87a
87 b
AL
PL
SS
89
1b
2b
3b
C1
D1
E1
88

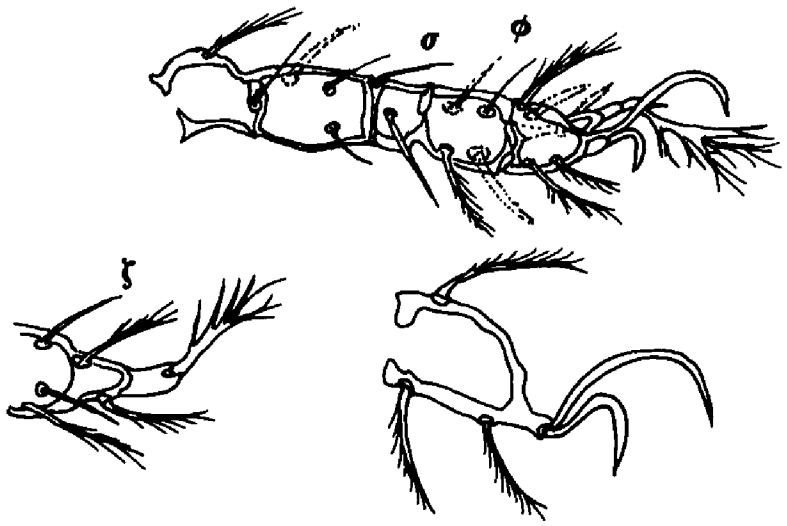
Fig. 90a-c. *Hexathrombidium bicomarum* n. sp. (larva): legs I-III, scale line for legs represents 100 μm, scale line for tarsus I, tibia III and tarsus III represent 50 μm.



90a



90b



90c

PART II: ECOBIOLOGICAL STUDIES

PART II. ECOBIOLOGICAL STUDIES

1. MATERIALS AND METHODS:

1. 1. REARING MITES FROM ADULTS:

Adults were collected from the forest floor, bushes and trees from May to August. Large body size often identified gravid females. Sometimes Project ELF data aided in determining when gravid females were likely to be present. Culture jars and other containers used for adult rearing, maintenance of humidity, laboratory conditions and food sources are described in Part I.

Only one adult mite was placed in a given vial, which was labeled with locality and date. After eggs had been laid, the female was transferred to a new culture jar to prevent cannibalism. Eggs were counted and labeled appropriately, and were checked daily to observe their developmental rate. Mold growing in the cultures was removed. When females died, they were preserved and labeled.

Once the larvae emerged, some were preserved in alcohol and labeled with information regarding the parent. Others were introduced to new containers with insect hosts collected in the field, and placed in an incubator at 14 $\pm$ 1.5 °C, and an 8:16 hour (light:dark) cycle.

Containers with larvae and potential hosts were checked every day, and the number of parasitized hosts and the number of parasites per host were counted. Hosts with mite larvae were isolated. When engorged larvae were found in the container, they were again transferred to a new culture vial. Once quiescent protonymphs appeared, the specimens were observed every other day until the deutonymphs emerged. The same food

supplied to adults was also used for nymphs. Some deutonymphs were preserved in alcohol and labeled, others were reared to adulthood.

1. 2. REARING MITES FROM HOSTS:

From spring to fall, hosts with attached larval mites were collected in the field. In early July, moths with larval *Leptus* parasites were collected by means of a light trap. Each live host was placed in a labeled container and supplied with appropriate foods (e. g., honey solution for moths, grass for grasshoppers).

Once the larvae dropped off the hosts, they were transferred to moist culture vials. Sometimes different larval species were found on a single host. If possible, they were moved to individual vials and labeled according to host, locality, date and attachment site. Subsequent rearing procedures were as described above.

In fall, when engorged larvae were obtained, they were moved to a cold, dark room at -4 $\pm$ 1.5 °C once they entered diapause. Duration of the diapause stage was recorded separately for each individual. When deutonymphs entered diapause, they were also moved to the same cold room for the winter, and duration of diapause larvae or deutonymph stage was recorded for every individual.

1. 3. FIELD OBSERVATIONS OF DIEL ACTIVITY:

On July 13 and 14 of 1990, a 24-hour field survey was performed to record diel activity of the species in the field by means of 10 pitfall traps which were activated at 1:00 pm, and emptied and replaced every 4 hours from 5:00 pm to 5:00 pm on the following day.

1. 4. HOST PREFERENCE STUDIES:

A. Field collection:

Pitfall traps, litter and soil core samples were used to collect many specimens in the field. In addition, a sweepnet was used from spring to fall to collect deutonymphs, adults and hosts parasitized by larvae. For moths and other night-active hosts, a light trap was used on warm summer nights, usually from late June to mid-August (for details see Part I). Hand-collecting yielded many adults during spring and summer, and was also useful for obtaining larger hosts such as grasshoppers.

Collected insects were checked and the number and species of hosts as well as the number of mites per host were recorded. Attachment sites on the hosts were also recorded as part of host preference information. Field collections were made every other day during the summer for three years.

B. Laboratory observations:

Food for mites and hosts, rearing containers and other laboratory procedures are described in Part I. When larvae hatched from an egg mass, they were transferred to glass jars as described above (see section 1.1.), and a given insect or other host species was introduced (usually 50 host individuals were collected in the field). One day later, the number of parasitized hosts and the number of mites per host was counted. The jars were checked frequently until there were no more larvae available. Sites of attachment on hosts were also recorded to provide detailed information on mite behavior.

1. 5. RESPONSE OF THREE SPECIES TO RELATIVE HUMIDITY:

Following the work of Snider (1968) a series of glycerin solutions was used to create relative humidities from 0 % to 100 % in 10 % increments. Small, tightly-closed plastic jars, with a fine screen separating the glycerin solution from the mites, were used as containers for the experiment. Ten replicates (one adult per jar) were set up at each humidity level. The number of surviving mites was counted every 3 hours until termination of the experiment at 72 hours. At very low humidities (0-30 %), the jars were checked more frequently, sometimes every half hour. Collembola and their eggs served as food.

2. RESULTS:

2. 1. LIFE HISTORIES OF 11 SPECIES:

Generally, life history of velvet mites includes one parasitic larva stage, two free-living stages, i. e. deutonymph and adult are active as predators; and three quiescent stages: prelarva or egg stage; prenymph or engorged larva stage and tritonymph stage, which is from egg to larva to protonymph to deutonymph to tritonymph, and then to adult.

Based on my own observations and on data obtained from Project ELF, the life histories of 11 species fell into three distinct groups (Type I, II and III) (Table 10).

Type I: these species overwinter as tritonymphs, become adults and oviposit in the spring. Larvae search for and parasitize hosts in early- to mid- summer. After engorgement, larvae develop to protonymphs and active deutonymphs, and their

tritonymphs enter diapause in late fall and overwinter.

Type II: eggs overwinter (many females are gravid in late fall), larvae appear in April through May of the following year. Predatory deutonymphs emerge during summer, and gradually mature to tritonymphs and finally to adults which mate and reproduce before the onset of winter.

Type III: this group is represented mainly by a small fraction of the *T. auroraense* population. These individuals deviate from the Type I life cycle in developmental rates. In the laboratory, a single egg mass may yield larvae over a period of up to one month. In the field, larvae may hatch as late as August or September, and spend the winter as engorged larvae or protonymphs. Deutonymphs appear in next spring and become adults in summer of the following year.

Table 10. Types of life histories of 11 velvet mite species: seasonal appearance of life stages. LV = larvae, PN = Protonymph, DN = Deutonymph, TN = tritonymph, Ad = adult.

Type	Spring	Summer	Fall	Winter
I	Ad	LV & PN	DN	TN
II	LV	DN & TN	Ad	Eggs
III	DN & TN	Ad & eggs	LV	PN

Type I and II life cycles are the most common; Type III may be a variation of Type I induced by variable developmental rates and by year-specific climatic conditions. A more detailed seasonal breakdown of developmental patterns in the field is provided in Tables 11 to 13.

Table 11. Type I life history: breakdown into seasonal events. Abbreviations as in Table 10.

Season	April	May	June	July	August	Sept/Oct.	Winter
Stage	Ad	eggs	LV	LV/PN	DN	DN/TN	TN

The species exhibiting a Type I life cycle are *L. sylvestratilis*, *L. solitarius*, *E. michiganensis*, *E. septemsetalis*, *E. locustarum*, *B. nonasum*, and *T. auroraense*.

Table 12. Type II life history: breakdown into seasonal events. GF = gravid females, other abbreviations as in Table 10.

Season	April	May	June	July	August	Sept/Oct.	Winter
Stage	LV	PN	DN	TN	Ad	GF/eggs	eggs

Species in this group are *A. welbourni*, *P. fucum*, *A. carum* and *C. cunarum*.

Table 13. Type III life history: breakdown into seasonal events. Abbreviations as in Table 10.

Season	April	May	June	July	August	Sept.	Winter
Stage	DN	TN	Ad	eggs	LV	PN	PN

Part of the population of *T. auroraense* belongs to the Type III group.

Two species which were commonly obtained from pit-traps during Project ELF (*A. welbourni and T. auroraense*) illustrate the year-to-year constancy of the above life histories (Table 14). Type I is exemplified by *T. auroraense*, with larvae appearing in summer and adults in spring; Type II is illustrated by *A. welbourni*, with larvae active in spring and adults appearing in mid-summer (Table 14).

Table 14. Seasonal appearance of life stages of two dominant species in 3 years, based on pit-trapping data of Project ELF. Data excerpted from Snider and Snider (1985, 1986, 1987).

species	year	Dates and Stages					
		LV		DN		Ad	
		range	peak	range	peaks	range	peaks
A. welbourni	85	5/7-28	5/7,13,21	6/4-7/1	6/17,25	7/16-9/17	7/23-8/12
	86	5/5-27	5/5,13,20	6/3-7/15	6/3,9,17	6/24-9/9	7/22,29
	87	5/6-21	5/6,12	6/9-7/13	6/9,7/10	7/7-9/15	7/13.28
T. auroraense	85	7/16-8/13	7/23,30	-	-	5/7-7/2	5/7,13,21
	86	7/8-8/5	7/22	-	-	5/5-6/9	5/5,13,20
	87	6/23-7/28	7/7	-	-	5/6-6/23	5/6,12,27

peaks = > 85% of all individuals trapped occurred on the dates listed; range = time period over which a given stage was commonly trapped; - = no data available.

2. 2. HOST AND PREY SELECTION:

Based on field collections in 1990 and 1991, larvae of *L. solitarius* parasitized moths and grasshoppers at approximately equal rates during July. Rates of parasitization in both host groups declined in August (presumbly because larval densities were lower) (Table 15).

The parasitization rates of larvae on these two major hosts did not vary much from year to year. For example, the parasitization rate on moths in July, 1990 was 7.9%, and 7.5 % for the same time in 1991. In grasshoppers, the rate was 6.8 % in July, 1990 and 7.7 % in 1991. In Table 14, "others" refers to other hosts, such as leafhoppers, crab spiders, flies, crane flies, beetles and other arthropods.

Hosts of *T. auroraense* included 16 insect species in 1990, including craneflies, houseflies, deerflies, mosquitoes and other insects in early July, 1990. Grasshoppers rarely carried mites at that time. As the density of grasshoppers gradually increased from late July to August, more and more larvae of *T. auroraense* paratisized grasshoppers instead of other insects (Table 16).

Hosts of six other mite species included mainly aphids, leafhoppers and other small insects. These mites are *A. welbourni*, *A. carum*, *B. nonasum*, *C. cunarum*, *E. michiganensis*, and *P. fucum*. Hosts of *E. locustarum* consisted exclusively of three species of grasshoppers in the genus *Melanoplus* (Table 17).

Table 15. Summary data of host records of *L. solitarius* larvae in 1990 and 1991; data are given as number of hosts carrying larvae/total number of hosts examined.

Date/Hosts	Moths		Grasshoppers		others	
1990	N	%	N	%	N	%
July						
10-18	21/191	11.0	3/51	5.8	0/44	0.0
24-30	6/149	4.0	5/65	7.6	1/36	2.8
July total	27/340	7.9	8/116	6.8	1/80	1.3
August						
1-13	1/100	1.0	3/58	5.2	1/26	3.8
21-30	0/43	0.0	2/210	0.9	0/39	0.0
August total	1/143	0.7	5/268	1.8	1/65	1.5
Total	26/503	5.2	13/384	3.4	2/145	1.4
1991						
July						
5-12	23/294	7.8	3/64	4.7	0/107	0.0
17-25	14/198	7.0	6/52	11.5	2/95	2.1
July total	37/492	7.5	9/116	7.7	2/202	0.9
August						
2-12	6/98	6.1	2/78	2.5	3/59	5.0
18-30	0/39	0.0	1/131	0.7	2/125	1.6
August total	6/137	4.4	3/209	1.4	5/184	2.7
Total	43/629	6.8	12/325	3.7	5/184	2.7

Table 16. Host usage by *T. auroraense* in July and August, 1990: data are given as number of hosts carrying larvae/total number of hosts examined.

Host/Date	July subtotal		August subtotal		Total	
	N	%	N	%	N	%
Tipula sp.	5/53	9.4	0/16	0.0	5/69	7.2
Protoplasa fitchii	2/46	4.3	0/22	0.0	2/68	2.9
Musca sp.	7/75	9.3	2/34	5.8	9/109	8.2
Hermetia illuceus	2/37	5.4	0/21	0.0	4/58	6.9
Chrysops univittatus	1/32	3.1	1/36	2.7	2/68	2.9
Aedes stimulaus	2/96	2.0	0/42	0.0	2/138	1.4
A. sollicitaus	1/56	1.7	0/25	0.0	1/81	1.2
Anopheles punctipennis	2/74	2.7	0/36	0.0	2/110	1.8
Sarcophaga sp.	1/35	2.8	1/13	7.6	2/48	4.1
Aphidolestes meridionalis	1/17	5.8	0/10	0.0	1/27	3.7
Chrysopa sp.	1/17	5.8	0	0.0	1/17	5.8
Poecilocapsus lineatus	2/49	4.1	1/48	2.0	3/97	3.0
Lygus lineolaris	3/55	5.4	0/20	0.0	3/75	4.0
Melanoplus differentialis	27/90	30.0	36/144	25.0	63/234	26.9
M. confusus	16/56	28.6	20/104	19.2	36/160	22.5
M. bivittatus	8/30	26.7	16/68	23.5	24/98	24.4

Table 17. Host and prey preferences of seven species of velvet mites: data are given in numbers of hosts with larvae attached/total number of hosts collected; (N) = nymphs of hosts.

Mites	Hosts	N	%
Allothrombium carusm	*Aphis sambuci*	23/427	5.3
	A. rumicis	19/409	4.6
	A. pomi	11/362	3.0
	Chaetosiphon tetrarhodum	8/176	4.5
	Rhopalosiphum ribis ?	4/119	3.3
	Macrosiphum pisi	3/112	2.6
Abrolophus welbourni	*Graphocephala coccinea*(N)	5/133	3.7
	Scaphoideus luteolus (N)	5/143	3.4
	Paraphlepsius irroratus (N)	7/147	4.7
Charletonia cunarum	*Aphis rumicis*	4/121	3.3
	A. pomi	5/100	5.0
Erythraeus michiganensis	*A. rumicis*	27/366	7.3
	Lachnus confinis	15/261	5.9
	Maerosiphum pisi	9/222	4.0
Eutrombidium locustarum	*Melanoplus differentialis*	43/79	54.0
	M. confusus	22/55	40.0
	M.bivittatus	16/40	40.0
Leptus sylvestratilis	*M. bivittatus*	8/40	20.0
	M. differentialis	10/79	12.6
	M. confusus	5/55	9.1
Podothrombium fucum	*Aphis rumicis*	7/218	3.2
	A. forbesi	4/214	1.8
	Sipha avenae	6/213	2.8

Differences in the number of larvae carried by a single host seemed to be correlated to its size. For instance, a grasshopper might have 12-25 mites attached to it, while leafhoppers often had only one mite parasite. Body size, physiological state, and behavior of hosts are probably interactive in the final outcome of parasitization rate.

In the laboratory, host preference tests were carried out using 11 types of hosts and six species of mites, larvae of which were available in relatively large numbers (Table 18).

Parasitization ratios in the laboratory were probably higher than what they might be in the field since hosts could not avoid attacks from larvae in a closed container. For instance, in two sets of 150 grasshoppers introduced to *L. sylvestratilis* and *E. locustarum*, 146 and 148 of them had larvae attached respectively.

As shown in Tables 16 and 18, *T. auroraense* used 16 host species in the field and 19 species in the laboratory, but larvae attached to dragonflies, some spiders and some leafbeetles never became engorged. This may indicate that these were occasional hosts and not real hosts in the field. Field records of hosts for *T. auroraense* differed from another report from New York state, where the same species mainly parasitized weevils (*Hypera postica* Gyll.) in alfalfa fields (V. Grandjean et al., 1977).

On the other hand, *E. locustarum* and *L. sylvestratilis* only parasitized grasshoppers both in the field and in the laboratory. Although larvae of *L. solitarius* would use grasshoppers and moths in the laboratory, field records on grasshoppers were rare. *Erythraeus michiganensis* and *P. fucum* each could use six host species in the laboratory. However, in the field, larvae of *E. michiganensis* attached to both leafhoppers

and aphids, and *P. fucum* mainly parasitized leafhoppers.

Table 18. Host acceptance by six mite species under laboratory conditions: data are given in number of hosts with mites attached (of 150 host individuals introduced), number of species in parentheses.

Host/Mite	*T. auroraense*	*L. sylvestratilis*	*L. solitarius*	*E.locustarum*	*P.fucum*	*E. michiganensis*
moths (7)	0	0	142	0	0	0
grasshoppers(3)	142	146	146	148	0	0
flies (3)	118	0	6	0	0	8
craneflies (2)	88	0	0	0	0	0
leafhoppers (3)	31	0	0	0	44	74
aphids (3)	0	0	6	0	5	31
leafbeetle (2)	41	0	0	0	0	0
groundbeetle (2)	0	0	0	0	0	0
leafmites (2)	16	0	0	0	0	2
spiders (3)	12	0	2	0	0	0
dragonflies (3)	27	0	0	0	0	0
Total host species offered	33	33	33	33	33	33
Total host species accepted	19	3	13	3	6	6

Based on all available field and laboratory observations, a list of the main hosts used by velvet mites in the study area is presented below (Table 19).

Table 19. A list of host records for velvet mites in Michigan deciduous forest.

Mite species	Host species
Allothrombium carium	*Aphis sambuci, A. rumicis, A. pomi, Chaetosiphon tetrarhodum, Rhopalosiphum ribis, Macrosiphum pisi*
Eutrombidium locustarum	*Melanoplus differentialis, M. confusus, M. bivittatus*
Podothrombium fucium	*Aphis rumicis, A. forbesi, Sipha avenae*
Trombidium auroraense	*Melanoplus differentialis, M. confusus, M. bivittatus, Musca sp., Tipula sp., Hermetia illuceus, Lygus lineolaris, Aedes stimulas, Anopheles punctipennis,*
Abrolophus welbourni	*Graphocephala coccinea, Scaphoideus luteolus, Paraphlepsius irroratus*
Charletonia cularia	*Aphis pomi, A. rumicis*
Erythraeus michiganensis	*A. rumicis, Lachnus confinis, Macrosiphum pisi.*
Leptus sylvestratilis	*Melanoplus bivittatus, M. confusus, M. differentialis.*
L. solitarius	*Crambus vitellus, Coryphista meadi altantic, Dioryctria abietella, Euphyia intermedia,*

L. solitarius — *Melanoplus differentials, M. confusus, M. bivittatus, Musca sp., Miltogramma sp.*

A possible relationship between host specificity and maturation was observed in the case of *T. auroraense*. Engorged larvae of the species were obtained from two types of host (leafbugs and grasshoppers) in 1989, reared to deutonymphs, and overwintered in the laboratory. Resulting data are given in Table 20.

Table 20. Survival of deutonymphs and size (μm) of emerging adults of *Trombidium auroraense* overwintered in the laboratory (4±1.5°C, RH=90%, Light=0).

Host of larvae	Fall 89 N deutonymphs	Spring 90 N adults (mean length x width)
leafbugs	107	12 (816 x 618)
grasshoppers	89	40 (1322 x 1144)

More deutonymphs stemming from larvae fed on grasshoppers matured to adulthood than those fed on leafbugs. The number of larvae reaching the adult stage as well as the body size of individuals were both smaller than those fed on grasshoppers, possibly due to nutritional reasons. This observation could be related to higher parasitization ratios on grasshoppers observed in the field, indicating a true "preference".

An attempt was made to explore the relationships between parasitic mites sharing the same host resource from both laboratory and field observation. Mid-June to late July, larvae of *L. sylvestratilis*, *T. auroraense* and *E. locustarum* were found mainly on grasshoppers in wooded grasslands, at roadsides and in other open areas in the forest. Attachment sites of *L. sylvestratilis* were located almost everywhere except on the wings (Table 21). Among a total of 106 *L. sylvestratilis* larvae, 66 were attached to legs, 20 were found on the antennae, six on mouthparts and nine on the host body. However, the larvae of *E. locustarum* and *T. auroraense* were found exclusively underneath the wings of the hosts.

Unlike *L. sylvestratilis*, *L. solitarius* larvae preferred moths as their major hosts, when the larval density of *Trombidium* reached a peak in early to mid-July. Although larvae were also found on grasshoppers, they were never attached to the wings. Other insects and arthropods, such as crab spiders and scorpionflies, also served as hosts. In laboratory rearing, however, *L. solitarius* accepted a wider range of host species than *L. sylvestratilis* (in addition to the moths preferred in the field).

Table 21. Attachment sites of larval *L. sylvestratilis* on grasshoppers: values represent the number of larvae found on a given anatomical area of the host.

Host	Date	6/13	6/16	6/21	6/23	7/5	7/9	7/10	7/13	7/18	7/21	7/26	Total
Melanoplus differentialis													
legs/tibia		2	1	1	-	1	-	-	-	-	-	-	5
tarsus		2	2	-	2	-	1	1	-	1	-	-	9
femur		19	5	1	1	2	1	-	-	-	1	1	31
antenna		4	1	1	1	-	1	-	1	-	1	1	10
cervex		1	1	-	-	1	-	-	-	-	-	-	3
labial pals		1	-	1	-	-	-	-	-	-	-	1	3
abdominal segments		-	1	-	2	-	-	-	-	-	-	-	3
cerci		-	1	-	-	-	-	-	-	-	-	-	1
wings		-	-	-	-	-	-	-	-	-	-	-	-
M. confusus													
legs/tibia		4	1	2	1	-	-	-	-	-	1	-	10
tarsus		1	1	-	-	-	-	-	-	-	-	-	2
femur		2	-	1	2	1	-	2	-	1	-	-	9
antenna		3	1	2	1	-	1	-	1	-	1	-	10
cervex		-	1	-	1	1	-	-	-	-	-	-	3
labial pals		2	-	1	-	-	-	-	-	-	-	-	3
abdominal segments		1	-	-	-	-	1	-	-	-	-	-	2
cerci		1	1	-	-	-	-	-	-	-	-	-	2
wings		-	-	-	-	-	-	-	-	-	-	-	-
Total		43	17	10	11	6	5	3	2	2	4	3	106

Mechanisms of co-existence for species sharing grasshopper hosts and examples are summarized below.

1. **Location of attachment on insect hosts:**
   a. *Eutrombidium locustarum* attached to grasshopper wings;
   b. *Leptus sylvestratilis* attached to grasshopper antennae, mouthparts and legs.
2. **Wider range of host species when larval densities are at a maximum:**
   a. *Trombidium auroraense* was found to use 16 host species, grasshoppers,leafhoppers, flies, craneflies and leafbeetles among them;
   b. *Leptus solitarius* was found to use seven moth species, two scorpionflies, one opilionid and one crab spider species.
3. **Different seasonal occurrence of larvae which tend to use the same host:**
   a. *E. locustarum* and *L. sylvestratilis* were active in June;
   b. *T. auroraense* larvae were active in July and August.

2. 3. RESPONSES OF THREE COMMON SPECIES TO RELATIVE HUMIDITY:

At 80% relative humidity (RH) and above, all three species (*A. welbourni, L. sylvestratilis* and *T. auroraense)* could survive quite well since the mortality rate of adults after 72 hours varied little between 80% and 100% RH. At 0% RH, survival rate of all species was low, but differences of tolerance to 0% were observed (Figs. 91-93). Among

A. welbourni, 50% were dead after 3 hours, as opposed to 5 and 14 hours for *L. sylvestratilis* and *T. auroraense* respectively. At 10, 20 and 30% RH, *A. welbourni* experienced 100% mortality after 15, 30 and 36 hours respectively. Survival over the entire 72 hour period was observed only in *L. sylvestratilis* (one individual at 30% RH) and *T. auroraense* (two and three individuals at 20% and 30% RH respectively).

Survival rates of adult velvet mites at various relative humidities showed that *Abrolophus welbourni* was very sensitive to low humidity; and that, among the three species, *T. auroraense* tolerated low humidity better than the others.

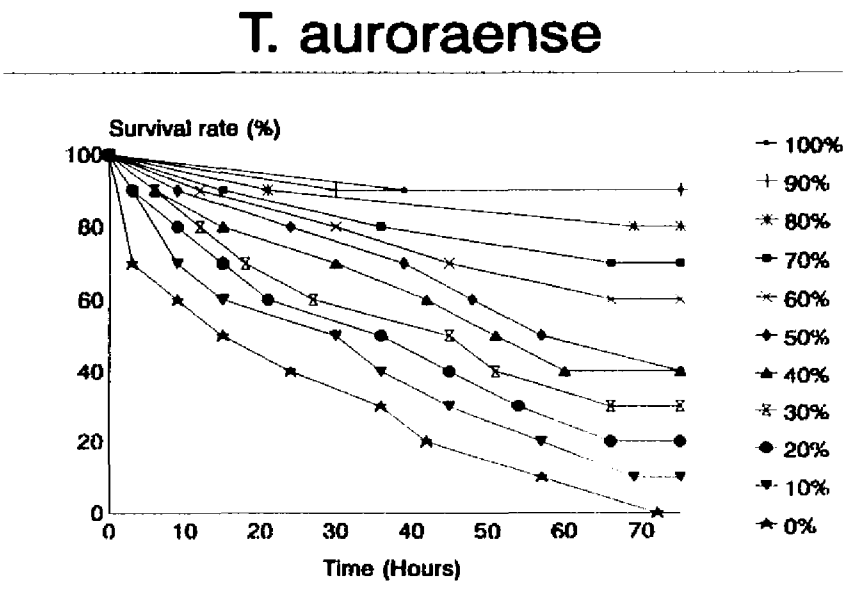


Fig. 91. Survival rate (%) of *T. auroraense* at different relative humidities.

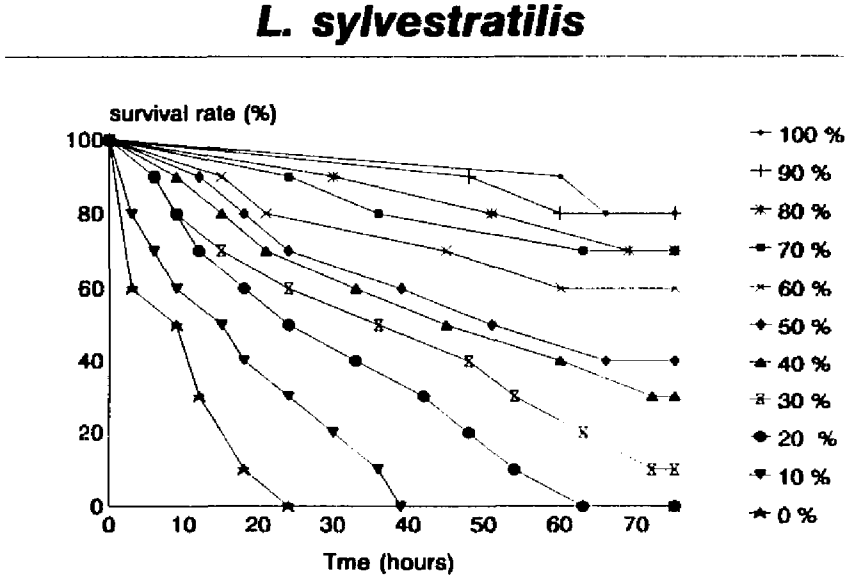


Fig. 92. Survival rate (%) of **L. sylvestratilis** at different relative humidities.

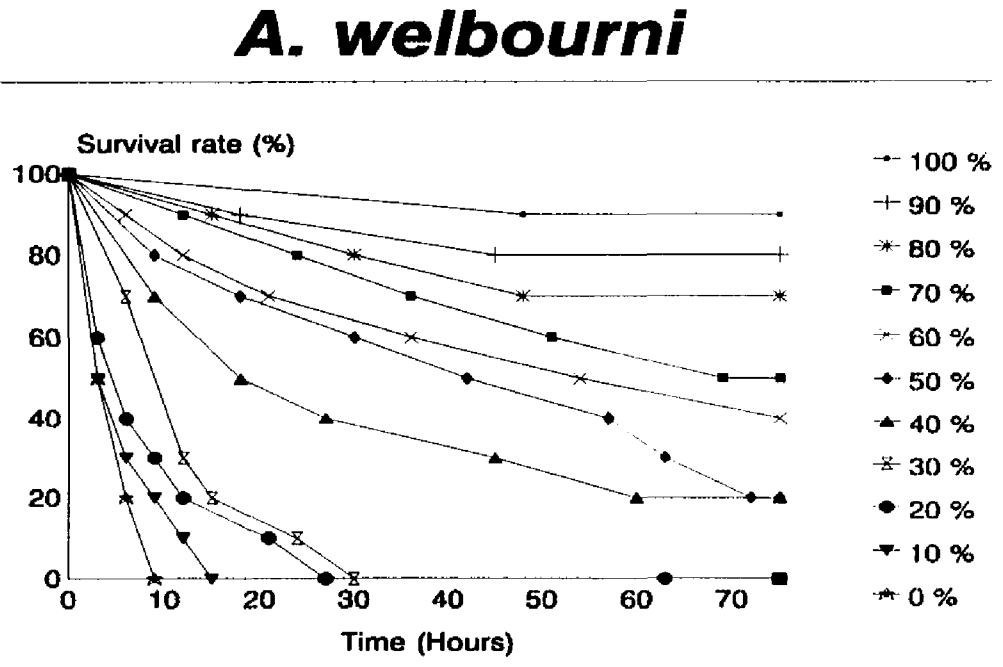


Fig. 93. Survival rate (%) of *A. welbourni* at different relative humidities.

2. 4. DIEL ACTIVITY PATTERNS OF TWO COMMON SPECIES:

Larvae of *T. auroraense* became increasingly active as temperature increased during the morning, activity peaking at 1:00 pm and then gradually declining toward 5:00 pm (Fig. 94). Among 95 individuals collected in the field, 73 were caught before 5:00 pm during the day, 22 were collected from 5:00 pm to midnight.

Larvae of *L. solitarius* were active both in mid-day and after dusk. The number of larvae captured increased gradually from 5:00 pm to 9:00 pm, when the first peak was reached. In the following four hours, the number captured dropped drastically until 1:00

am. After 5:00 am, the number of larvae caught rose and reached a second peak at 1:00 pm, dropping gradually after 1:00 pm. Among a total of 86 captured, 55 were collected before 5:00 pm and 31 were collected between 5:00 pm and 1:00 am.

Based on the above data, larvae of *T. auroraense* tended to be strongly day-active; larvae of *L. solitarius* exhibited two activity peaks during a 24-hour period, one diurnal and a second, equally pronounced, nocturnal.

Activity patterns of mite larvae may be related to species-specific tolerance of humidity levels. For instance, relatively high survival rates of *T. auroraense* at low humidity levels in the laboratory (Fig. 91) indicate that the species is capable of searching for hosts during mid-day. On the other hand, time of activity may be affected by time of hatching. Laboratory evidence strongly indicated that larvae must locate and attach to a host very soon after emergence: if unable to do so, the majority died within 2 to 5 hours.

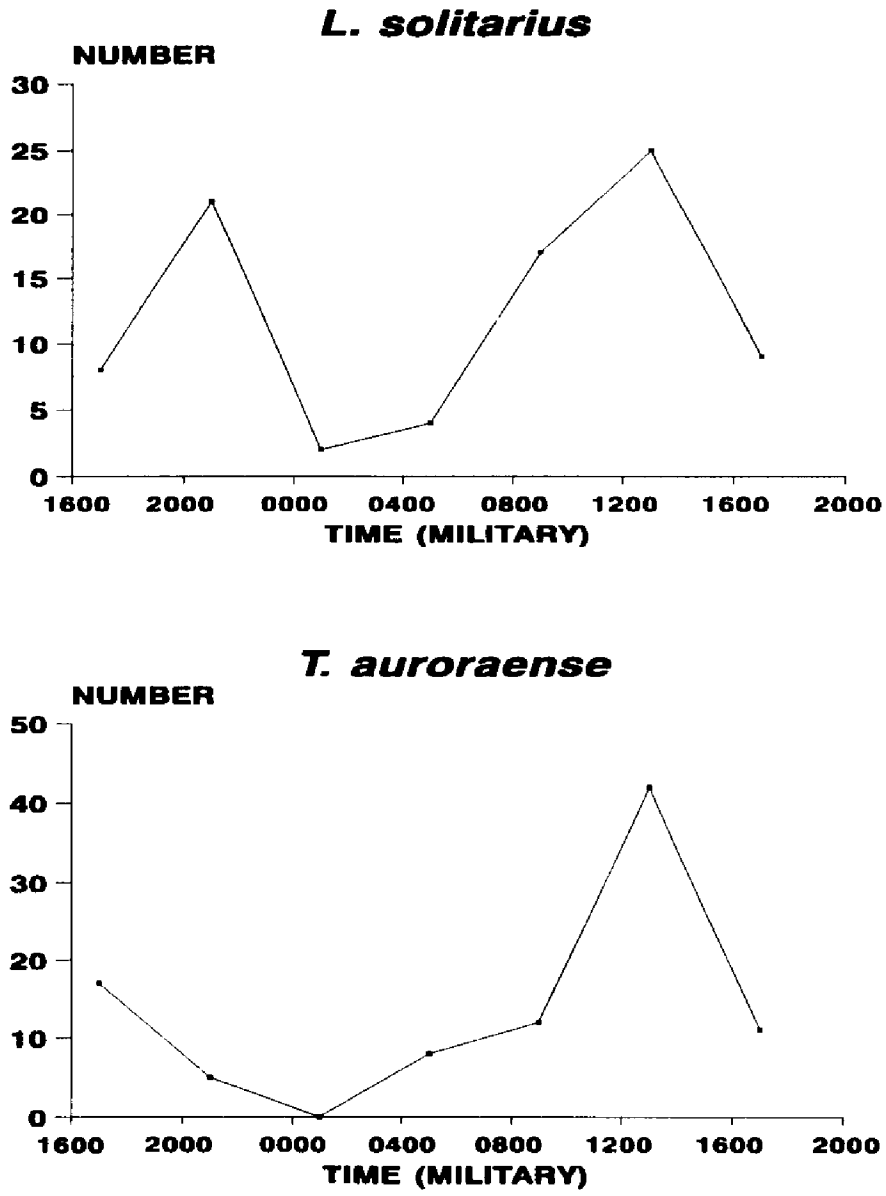


Fig. 94. Diel activity patterns of two common species in a 24-hour field survey (Mid-July, 1990). Data are given in numbers of mites collected over time.

2. 5. OVIPOSITION AND FECUNDITY OF FOUR SPECIES.

Table 22 shows the duration of oviposition periods and the number of eggs observed in four species (*E. michiganensis*, *T. auroraense*, *L. sylvestratilis* and *E. locustarum*) under laboratory conditions. One hundred females of *A. welbourni* were also incubated, but none of them could be brought to oviposit.

Table 22. Duration of oviposition period and number of eggs laid per female of four species.

Species	no. of females	Oviposition days max.	min.	$\bar{x}$ ± SD	no. eggs per female max.	min.	$\bar{x}$ ± SD
Erythraeus michiganensis (spring)	150*	58	17	25 ± 14.0	151	53	69 ± 23.0
Trombidium auroraense (laboratory)	50	78	34	45 ± 19.0	1084	238	576 ± 74.0
Leptus sylvestratilis (spring)	70*	37	14	28 ± 7.5	108	43	77 ± 18.0
Eutrombidium locustarum (spring)	50*	48	27	29 ± 5.0	70	0	38 ± 10.2

* indicates field-collected individuals.

Under laboratory conditions, the oviposition period of *T. auroraense* lasted the longest and the fecundity of the species was by far the highest (Table 22). It should be

kept in mind, however, that *T. auroraense* was the most easily reared of all species, and that these females stemmed from laboratory cultures (and had thus not yet oviposited when observations began).

Individuals of other three species were field-collected just prior to incubation. All exhibited shorter periods of oviposition and lower fecundities than *T. auroraense*. There are several possible explanations for these interspecific differences, although available evidence is not conclusive: a) nutritional or environmental requirementsof these species were not met by the rearing methods employed (e. g. *A. welbourni* never oviposited in the laboratory); b) some individuals had already begun ovipositing in the field prior to capture (e. g., 26 of 50 female *E. locustarum* did not oviposit at all), an explanation supported by the fact that all "spring-breeders" with Type I life cycles; or c) fecundities differ intrinsically between species. The last of these seems likely, but would need to be supported by extended laboratory rearing.

2. 6. DEVELOPMENTAL RATES OF THREE SPECIES UNDER LABORATORY CONDITIONS.

Table 23 shows the developmental rates of three species under constant laboratory conditions (18 $\pm$ 1.5 °C, >90% humidity, 8 hours light).

Larval development time varied little between species, lasting approximately 2 weeks. Duration of the prolarval stage (egg stage) was usually around one month for all three species. Protonymphs, from engorged larvae to deutonymph emergence, required

approximately 2 weeks for development in *T. auroraense* and *L. sylvestratilis*. In *E. locustarum*, the stage lasted from one month to the entire winter. Some engorged larvae (protonymphs) of *T. auroraense* also entered diapause and overwintered.

It is necessary to emphasize that particular environmental circumstances can be important for the development of a species; for instance, without cold temperature treatment in winter, the diapause larvae of *E. locustarum* at room temperature could not reach the deutonymph stage. However, when they were kept in a dark, cold room (-4±1.5°C), 78% of the larvae molted to deutonymphs. The same was true for tritonymphs of *T. auroraense* since among 50 TN kept at room temperature (17-26°C) over winter, only 11 reached adulthood, and the emerging adults were smaller than those kept in a cold, dark room (-4.0±1.5°C) where 87 of 100 emerged as adults the following spring. These data indicate the importance of physical factors, such as obligatory winter diapause, as well as nutritional demands (Table 20).

Life tables were compiled for the above three species. The tables showed that larvae of *T. auroraense* and tritonymphs of *E. locustarum* experienced higher mortalities of all stages under laboratory conditions, 71.5 % and 68.7 % respectively. The mortalities of larvae and tritonymphs of *L. sylvestratilis* were 42.7 % and 51.4 %. Possible reasons can be explained as nutritional requirements, that is there were not enough hosts and prey provided to the mites and larvae and deutonymphs could not meet their needs to finish development; second, maybe fluctuation of temperature played important role for the species; third, niches supplied in laboratory are not favor different stages.

Table 23. Duration in days of the developmental stages of five mite species under laboratory conditions. Win. = development over winter, $\bar{x}$ and SD calculated from the total number of individuals (in parentheses) observed in 1989, 1990, and 1991.

Stage	*T.auroraense*			*L.sylvestratilis*			*E. locustarum*		
	max.	min.	$\bar{x}$±SD	max.	min.	$\bar{x}$±SD	max.	min.	$\bar{x}$±SD
PL	36	23	28±3.2 (3478)	35	27	29±2.0 (872)	44	31	35±6.5 (1446)
Lv	17	11	14±2.0 (2911)	18	12	14±3.0 (560)	19	11	16±2.0 (721)
PN	win.	12	14±1.5 (837)	15	12	14±1.0 (321)	43	28	32±4.7 (407)
DN	25	16	17±2.0 (621)	31	15	19±3.5 (255)	87	35	42±16.0 (342)
TN	win.	20	22±2.0 (435)	win.	35	37±5.5 (177)	win.	42	46±15.0 (182)
Ad	67	23	33±7.8 (260)	25	9	22±6.7 (86)	38	27	36±7.5 (57)

Table 24. Life tables for three species under laboratory conditions. x = stage; n_x = number of individuals alive at the begining of each stage; l_x = % of original total number (eggs) surviving; d_x = number of individuals which died during each stage; q_x = % mortality during each stage.

	T. auroraense				*L. sylvestatilis*				*E. locustarum*			
x	n_x	l_x	d_x	q_x	n_x	l_x	d_x	q_x	n_x	l_x	d_x	q_x
egg	3478	100	453	13.0	872	100	139	15.9	1446	100	521	36.0
PL	3025	86.9	114	3.7	733	84.1	173	23.6	925	63.9	204	22.0
Lv	2911	83.7	2074	71.2	560	64.2	239	42.7	721	49.9	314	43.5
PN	837	24.1	216	25.8	321	36.8	66	20.6	407	28.1	65	16.0
DN	621	17.8	186	29.9	255	29.2	78	30.6	342	23.6	160	46.8
TN	435	12.5	175	40.2	177	20.3	91	51.4	182	12.6	125	68.7
Ad	260	7.5	260	100.0	86	9.8	86	100.0	57	3.9	57	100.0

2. 7. BEHAVIOR.

In laboratory and field observations, some interesting behavioral differences between species attracted my attention. The casual observations below are given in general for a group of related species qualitatively, not in quantitative terms.

Adults: *Trombidium auroraense* tended to gather during the mating season, mainly in spring. From late April to May, they often appeared in large numbers in wet, shadowed mossy areas. Peaks of adult appearance were observed during mid-May in three consecutive years, when hundreds gathered around mossy areas after a rain. Adults frequently raised their first pair of legs and made contact with others, then moved away.

The mating behavior of this species was described by Robaux (1977), with females picking up sperm which males had dropped or attached to the top of moss plants (in some degree similar to the behavior of spiders during their mating season). No body contact was observed in adults of *T. auroraense*. Whenever two adults were placed in one container, only one survived.

Unlike *T. auroraense*, individuals of *E. michiganensis* always kept a wide distance between each other. If they occasionally ran into others, they moved away as quickly as possible. Once, I saw an injured adult eaten by an uninjured adult in a few minutes. Casual field observations showed that *E. michiganensis* were able to move rapidly (the species has very long legs) and often vigorously attacked large harvestmen, small spiders and other mites. No gathering was observed among adults during mating seasons in the field. Gathering also did not occur in *L. sylvestratilis*, *L. solitarius*, *A. welbourni*, *P. fucum* and *E. locustarum*.

Adults of *L. solitarius*, *A. welbourni*, *E. michiganensis* and *P. fucum* were found in large numbers in pit-traps since they were active on the soil surface during adulthood. On the other hand, *L. sylvestratilis*, *E. locustarum*, *B. nonasum*, *A. carum* and *C. curalia* were frequently caught from bushes, trees and ferns by sweepneting. Adults of all species often laid eggs in soil and underneath bark and litter.

Larvae:

Laboratory observations suggested that larval survival may be aided by the fact that eggs hatch at different times when different numbers and species of hosts are available. The time of hatching for *T. auroraense* varied from 25 to 55 days under constant laboratory conditions. In the field, larvae of *T. auroraense* were active from early July to mid-September.

Parasitic larvae are most active immediately after hatching. If they have not found their proper hosts after 2-5 hours, most slow down and soon die. Larvae of *E. michiganensis* and *A. welbourni* were observed to transfer from one host to another in the laboratory (11 of 58 individuals of *E. michiganensis* and eight of 46 individuals of *A. welbourni* respectively). This was not observed in other species.

Deutonymphs:

The stage is free-living in all species studied. In some degree, they are more active than adults in searching for prey and shelter. They were often found in more habitats than adults, from bushes and trees to ferns. When touched, they moved away faster than adults in most species, and immediately entered litter, soil and fissures of bark.

4. DISCUSSION

In this study, host records showed that most mite species only parasitized hosts in one family and sometimes in one genus (Table 18). This appeared to agree with other current host records in many cases (Southcott, 1966, Welbourn, 1983).

However, two species, *T. auroraense* and *L. solitarius*, showed wider host acceptance than others based on field and laboratory observations. *Trombidium auroraense* used 16 host species in the field and 19 species in the laboratory (Tables 16, 18). From July to August 1990, three species of grasshoppers in the genus *Melanoplus* were the main hosts; and craneflies, flies, deerflies and plantbugs served as additional hosts (Table 16). In an old farmland in New York State, the same species was reported as parasite of a single host species, the alfalfa weevil *Hypera postica* Gyll (Curculionidae: Coleoptera)(V. Grandjean, 1977). Another nine species in the genus *Trombidium* used a total of 67 insect species and one scorpion as hosts (Southcott, 1961 a, b; Welbourn, 1983, 1987, 1989, 1991).

Leptus solitarius used 15 species in the field and 13 species in the laboratory in July (Tables 15, 18), while *L. sylvestratilis* parasitized only three grasshopper species in June (Table 17). Among 90 named species of *Leptus*, hosts are known for 31 of them, and encompass 143 species in 46 families of insects, and nine families in four orders of other arthropods (Welbourn, 1983, 1989; Fain et al., 1987; Southcott, 1988, 1989, 1991, 1992).

Seasonal appearance of mite species was closely related to host preferences and to their environmental requirements. For example, *A. welbourni* parasitized three species

of leafhoppers in the field (Table 17) and could not tolerate low humidities in laboratory tests (Fig. 93). Larvae were frequently observed in spring and entered deutonymph and adult stages in summer based on my personal collections and Project ELF data (Tables 9, 11). *Trombidium auroraense* used grasshoppers and other insect hosts in summer and fall, and the species tolerated low humidities better than others studied in the laboratory (Tables 10, 12, 15 and Figs. 91, 94).

In general, larvae of most mite species appeared in summer, but a few occurred in spring and fall and parasitized hosts available during these seasons (Table 9). If larvae of mites cannot reach full engorgement, the resulting numbers of deutonymphs and the survival rate of the species can be low (Treat, 1975). All species have to complet their parasitic larval stage when the seasonal hosts are available. In addition, the life history of *E. locustarum* and of the free-living *B. putmani* was stated to be bivoltine in North Calorina and California orchards (Severin, 1944; Putman, 1970; Childers and Rock, 1981). However, all species studied here, including *E. locustarum* and the free-living *B. nonasum*, were univoltine since their larvae were observed only once a year in the field as well as in the laboratory. This may be due to geographical divergence of the species or to effects of different climatic conditions. Generally speaking, most species of Trombidia are univoltine (Southcott, 1961a).

Because of adaptation to particular environmental variable and the dynamics of host resources, many mite species have intrinsic features for surviving under long-term unfavorable conditions. For instance, in some species, females may lay a large number of eggs during the oviposition period when larval survival rate is low. Newell (1979)

obtained 80,000 to 100,000 eggs per female in *Dinothrombium tinctorum* (L.) (Trombidiidae: Trombidia). In this study, *T. auroraense*, with the highest fecundity among the species reared in the laboratory (Table 22), may have low larval survival rate in the field during summer.

Based on current knowledge about competition among parasites of the same host resource, interspecific competition may decline after a period of time through a host shift (Colwell, 1979). In this study, *Eutrombidium locustarum* and *Leptus sylvestratilis* had different attachment sites on the same host species in the field (Table 20). Furthermore, more larvae of *L. sylvestratilis* than of *E. locustarum* were found on the grasshopper *M. bivittatus*, the latter being found more often on the grasshopper *M. differentialis*.

In two species which both attached to grasshopper wings, *T. auroraense* and *E. locustarum*, seasonal appearance were different: larvae of *T. auroraense* appeared in July and August and *E. locustarum* occurred in June (Tables 10, 12).

Based on field observations (Fig. 94) and laboratory tests (Figs. 91-93), activity patterns were closely related to survival rates at different humidities. *Trombidium auroraense*, which could tolerate low humidities better than the other two species studied (Figs. 91-94), were day-active in the field (Fig. 94). *Leptus solitarius*, which needed more humid conditions than *T. auroraense*, were active after dusk and in the morning (Fig. 94).

Factors involved in the duration of stages can be explained as nutritional variance between individuals of the same species attached to different hosts (Table 20), and different adaptations to laboratory conditions among species in the rearing tests (Tables

18, 22, 23). The duration of stages under constant laboratory conditions varied between species. For example, the maximum development time for some deutonymphs of *E. locustarum* was 87 days; in deutonymphs of *A. welbourni*, the maximum time was only 16 days (Table 22).

SUMMARY

SUMMARY

1). From personal three-year field collections and specimens obtained over 10 years by "Project ELF" in a deciduous forest in Michigan's Upper Peninsula, thirteen new species and one new genus are described. Description of seven species was based on all instars; three species were described based on larvae and adults; three species were named from larval specimens and one was described from adults. For genera (represented by six new species) are first records for North America: *Abrolophus*, *Hexathrombium*, *Calyptostoma* and *Erythraeus*.

2). Host preferences of eight species of velvet mites was documented from both laboratory rearing and field surveys. For *Leptus sylvestratilis* n. sp., *Eutrombidium locustarum* and *Trombidium auroraense*, major hosts were the grasshoppers *Melanoplus differentialis*, *M. confusus*, and *M. bivittatus*. *Trombidium auroraense* accepted 16 host species in the field and 19 in the laboratory, including leafbugs, crane flies, flies and deer flies. For *Leptus solitarius*, hosts included 13 species in the laboratory and 15 species in the field, such as moths, craneflies, crab spiders and moth larvae. *Erythraeus michiganensis*, *A. welbourni*, *A. carum* and *P. fucum* used aphids and other soft-bodied insects as their hosts.

3). Based on 11 species, three types of life histories were distinguished, and developmental stages of five species were also described based on laboratory and field data.

The Type I life history group consisted of species which spend winters in the tritonymph stage: *L. sylvestratilis*, *L. solitarius*, *E. locustarum*, *B. nonasum*, *E.*

michiganensis, *E. septemsetalis*, and *T. auroraense*. Four species which overwinter in the egg stage belonged to the Type II group: *A. carum*, *A. welbourni*, *C. cunarum* and *P. fucum*. Some *T. auroraense* which overwinter as engorged larvae were representative of the Type III group.

Under constant laboratory conditions, *T. auroraense*, *E. locustarum* and *L. sylvestratilis* were reared from larvae to adults. Deutonymphs were obtained for *A. welbourni*, but no adults of the species emerged.

In general, eggs or prelarval stages of four species lasted about 1 month. Larval development generally required approximately two weeks. Diapausing, engorged larvae or protonymphs required from two weeks to an entire winter for development, variable with species. Duration of the active deutonymph stage also varied from 20 days to 35 days. *Trombidium auroraense, L. sylvestratilis* and *E. locustarum* remained in the tritonymph stage for the entire winter at a temperature of -4 $\pm$1.5 °C.

4). Mechanisms of host-sharing were determined. For larvae of *E. locustarum* and *L. sylvestratilis*, ***species-specific locations of attachment on a given host*** allowed these two species to coexist:

a. *E. locustarum* attached to grasshopper wings;

b. *L. sylvestratilis* attached to grasshopper antennae, mouthparts and legs.

Trombidium auroraense and *L. solitarius* both parasitized grasshoppers and survived on them in the laboratory. However, they usually used other hosts instead of competing for grasshoppers when their larval densities peaked in a given location. Sixteen host species were recorded for the former in the field, including leaf bugs, flies

and crane flies. The latter was found to use seven moth species, two scorpionflies, one opilionid and one crab spider.

In species which favored the same host resource, different seasonal appearance of the larvae tended to prevent severe competition among them. Usually, *E. locustarum* and *L. sylvestratilis* larvae were active in June and used grasshoppers; *T. auroraense* larvae were active in late July and August on the same grasshopper species.

5). Responses of three dominant species to different relative humidities was determined in laboratory experiments, and diel activity of larvae of two species was observed during a 24-hour field survey. *Trombidium auroraense* tolerated low relative humidity under laboratory conditions, but *A. welbourni* was very sensitive to low humidity; responses of *L. sylvestratilis* were intermediate.

A 24-hour field survey showed that *T. auroraense* were mainly diurnal, and *L. solitarius* were both diurnal and nocturnal.

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