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A MORPHOLOGICAL EXAMINATION OF NEARCTIC
SMINTHURUS (COLLEMBOLA: SMINTHURIDAE), WITH
REFERENCE TO SYSTEMATICS AND PHYLOGENY

By

Steven Jefferson Loring

A DISSERTATION

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ABSTRACT

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137-86/2

Nearctic members of the genus Sminthurus were examined for new characters of taxonomic and/or phylogenetic value. A system for denoting leg chaetotaxy was devised and patterns of head and antennal setae, bothriotrichium D complex, oval organ distribution, and claw morphology were clarified. Problems of synonymy were resolved and a taxonomic key to nearctic species of Sminthurus was constructed.

Taxonomic out-groups of closely related genera were used to assign polarity of characters of phylogenetic value. Possible phylogenetic relationships were analyzed using component analysis and computer generated cladograms derived from Wagner Parsimony and Dollo Parsimony algorithms.

Zoogeography of nearctic Sminthurus was analyzed using reported distributions and an area cladogram derived from a Camin-Sokal parsimony cladogram. Until all areas of North America have been sampled, only general conclusions may be drawn about the distribution of Sminthurus.

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TABLE OF CONTENTS

List of Tables	iv
List of Figures	v
Introduction	1
Materials and Methods	4
Definition of the Genus	5
Key to the Nearctic Species of <i>Sminthurus</i>	26
Morphology of Nearctic <i>Sminthurus</i>	28
Character Analysis and Phylogenetic Relationships	102
Discussion	124
Zoogeography	116
Conclusions	149
Literature Cited	150
Appendix	156

LIST OF TABLES

Table I - Autapomorphic Characters	103
Table II - Character State Matrix for Nearctic <u>Sminthurus</u>	107
Table III - Tentative Phylogenetic Characters for Nearctic <u>Sminthurus</u>	118
Table IV - Tentative Character State Matrix for Nearctic <u>Sminthurus</u>	119

LIST OF FIGURES

Figure	
1. ocellar pattern	10
2. distal segment of ANT IV	10
3. ANT III	10
4. ANT III sensory organ with accessory seta	10
5. ANT II	10
6. ANT I	10
7. cephalic setae and oval organs	10
8. procoxa	10
9. protrochanter	10
10. profemur, anterior view	10
11. protibiotarsus, anterior view	13
12. protibiotarsus, posterior view	13
13. proclaw	13
14. mesocoxa	13
15. mesotrochanter	13
16. mesofemur, anterior view	16
17. mesotibiotarsus, anterior view	16
18. mesotibiotarsus, posterior view	16
19. mesoclau	16
20. metacoxa	18
21. metatrochanter	18
22. metaclaw	18
23. corpus of collophore, anterior view	18
24. corpus of tenaculum	18

25. manubrium, dorsal view	18
26. metafemur, anterior view	20
27. metatibiotarsus, anterior view	20
28. metatibiotarsus, posterior view	20
29. left dens, anterior view	22
30. left dens, posterior view	22
31. mucro	22
32. type I bothriotrichium complex, left view	22
33. female anal papilla, lateral view	22
34. female subanal appendage, lateral view	22
35. <u>S. bivitattus</u> , profemur, anterior view	31
36. proclaw	31
37. mesofemur, anterior view	31
38. mesoclaw	31
39. metafemur, anterior view	31
40. metaclaw	33
41. mucro	33
42. <u>S. borealis</u> , profemur, anterior view	33
43. proclaw	33
44. mesofemur, anterior view	33
45. mesoclaw	33
46. metafemur, anterior view	38
47. metaclaw	38
48. mucro	38
49. <u>S. butcheri</u> , profemur, anterior view	38
50. proclaw	38
51. mesofemur, anterior view	41

52. mesoclav	40
53. metafemur, anterior view	40
54. metaclav	40
55. mucro	40
56. <u>S. carolinensis</u> , profemur, anterior view	44
57. proclaw	44
58. mesofemur, anterior view	44
59. mesoclav	44
60. mucro	44
61. metafemur, anterior view	46
62. metaclav	46
63. <u>S. eiseni</u> , profemur, anterior view	46
64. proclaw	46
65. mesofemur, anterior view	46
66. mesoclav	46
67. metafemur, anterior view	52
68. metaclav	52
69. mucro	52
70. <u>S. fischeri</u> , profemur, anterior view	52
71. proclaw	52
72. mesofemur, anterior view	52
73. metafemur, anterior view	52
74. mesoclav	56
75. metaclav	56
76. mucro	56
77. <u>S. fitchi</u> , profemur, anterior view	56
78. proclaw	56
79. mesofemur, anterior view	56

80. mucro	56
81. mesoclaw	63
82. metafemur, anterior view	63
83. metaclaw	63
84. <u>S. floridanus</u> , profemur, anterior view	63
85. proclaw	63
86. mucro	63
87. mesofemur, anterior view	67
88. mesoclaw	67
89. metafemur, anterior view	67
90. metaclaw	67
91. profile of dordum showing posterior protruberance	67
92. <u>S. incisus</u> , profemur, anterior view	71
93. proclaw	71
94. mesofemur, anterior view	71
95. mesoclaw	71
96. metafemur, anterior view	71
97. metaclaw	71
98. mucro	71
99. <u>S. incognitus</u> , profemur	75
100. proclaw	75
101. mesofemur, anterior view	75
102. mesoclaw	75
103. metafemur, anterior view	75
104. metaclaw	75
105. mucro	75
106. right dens, dorsal view	77

107.	right dens, ventral view	77
108.	<i>S. mendenbergi</i> , proclaw	77
109.	mucro	77
110.	profemur, anterior view	81
111.	mesofemur, anterior view	81
112.	mesoclau	81
113.	metafemur, anterior view	81
114.	metaclaw	81
115.	<i>S. packardii</i> , profemur, anterior view	85
116.	proclaw	85
117.	mesofemur, anterior view	85
118.	mesoclau	85
119.	metafemur, anterior view	85
120.	metaclaw	85
121.	mucro	85
122.	<i>S. purpurescens</i> , profemur, anterior view	89
123.	proclaw	89
124.	mesofemur, anterior view	89
125.	mesoclau	89
126.	metatrochanter, anterior view	89
127.	female subanal appendage, lateral view	89
128.	female subanal appendage, lateral view	89
129.	mucro	89
130.	metafemur, anterior view	91
131.	metaclaw	91
132.	<i>S. sagitta</i> , profemur, anterior view	91
133.	proclaw	91
134.	mesofemur, anterior view	91

135.	metafemur, anterior view	91
136.	mucro	91
137.	mesoclaw	93
138.	metac claw	93
139.	<u>S. sylvestris</u> , profemur, anterior view	93
140.	proclaw	93
141.	mesoclaw	93
142.	mesofemur, anterior view	98
143.	metafemur, anterior view	98
144.	metac claw	98
145.	mucro	98
146.	component analysis tree I	109
147.	componenet analysis tree II	111
148.	Wagner parsimony tree	113
149.	Dollo parsimony tree	115
150.	Camin-Sokal parsimony tree	122
151.	Area cladogram based on Camin Sokal parsimony tree	126
152.	Distribution of <u>S. bivittatus</u> (Δ) and <u>S. mencenbergi</u> (●)	128
153.	Distribution of <u>S. butcheri</u> (X = unconfirmed)	130
154.	Distribution of <u>S. carolinensis</u> (▲) and <u>S. incognitus</u> (●)	132
155.	Distribution of <u>S. eiseni</u> (X = unconfirmed)	134
156.	Distribution of <u>S. fischeri</u> (▲) and <u>S. floridanus</u> (●)	136
157.	Distribution of <u>S. fitchi</u> (X = unconfirmed)	138
158.	Distribution of <u>S. incisus</u> (O) and <u>S. viridis</u> (●) (X = unconfirmed)	140
159.	Distribution of <u>S. packardi</u> (●) and <u>S. Sagitta</u> (▲) (X = unconfirmed <u>packardi</u>)	142
160.	Distribution of <u>S. purpurescens</u> (X = unconfirmed)	144
161.	Distribution of <u>S. sylvestris</u> (X = unconfirmed)	146

INTRODUCTION

The Collembola are small, primitively apterous insect-like arthropods. They are usually considered an order of the Subclass Aperygota, Class Insecta, an arrangement followed here, although some authors (e.g. Manton, 1977) have regarded Collembola as a separate class equivalent to pterygote insects and myriapod classes such as Pauropoda and Symphyla.

Like typical insects Collembola possess one pair of segmented antennae, a three-segmented thorax with three pairs of walking appendages, and a segmented abdomen. The abdomen consists of only six segments, in contrast to pteryote insects which exhibit more abdominal segments at least during their embryonic development. The sminthurid Collembola have the fifth and sixth abdominal segments separated from the others, forming an anal papilla, with the sixth segment divided into two lateral pieces called valves. In the European literature the fifth and sixth segments are referred to as the genital and anal segments, respectively (cf. Betsch, 1980).

Unique to Collembola is the collophore, which is a cylindrical, midventral, fused abdominal appendage with paired eversible vesicles. This structure, located on the first abdominal segment, has respiratory and water regulatory functions (Chang, 1966). The majority of Collembola also have fused appendages on the second and fourth abdominal segments, the tenaculum and furcula, which are used in jumping. The furcula consists of a fused basal portion called the

manubrium, two rami known as dentes, each ending in a claw-like structure called the mucro. The tenaculum has a fused basal portion with two toothed rami, which act as hooks to hold the furcula in the springing, or resting, position.

The genus Sminthurus belongs to the family Sminthuridae, subfamily Sminthurinae, tribe Sminthurini (sensu Richards, 1968). Together with the Neelidae, the Sminthuridae constitute the suborder Symphypleona proposed by Börner (1901). These Collembola are characterized by fusion of the thoracic and first four abdominal segments, giving them a globular appearance.

Like other Collembola, sminthurid development is direct, and they molt throughout life. Juveniles differ from adults in size, body proportions, lack of a genital aperture, reduced leg chaetotaxy, and possession of a different integumental pattern during the first instar. Detailed information on the embryology, morphology and development of juvenile sminthurids may be found in Betsch (1980) and Blancquart et al (1981a & b).

Transfer of sperm is indirect. Spermatophores are deposited by males and picked up by the females (Mayer, 1957; Schliwa, 1965; Betsch-Pinot, 1974). Bretfeld (1970, 1971) described complex mating behavior in the genus Bourletiella, but such behavior has not been reported for Sminthurus. Some species of Sminthurus exhibit strong sexual dimorphism, but usually the sexes look similar.

The majority of the Sminthuridae are hemiedaphic (litter dwelling) or epigeonistic (living on plant surfaces). Consequently, relatively few sminthurid Collembola are extracted from soil samples. Most specimens of Sminthurus examined in this study were collected from grass, shrubbery, and tree bark. Field observations indicate that

species of Sminthurus are usually found on high grass in hot, relatively xeric conditions. Examination of gut contents shows a high proportion of pollen in addition to fungal spores. Knowledge of the bionomics of Sminthurus comes primarily from studies of S. viridis (Linné) 1758, which is an agricultural pest in Australia and South Africa (Holdaway, 1927; Davies 1928a & b; Davidson, 1932, 1933, 1934; Wallace, 1957, 1967, 1968; Walters, 1968).

The genus Sminthurus is taxonomically confusing. Traditional morphological characters used in the past often proved to be unreliable (e.g. body color, ratio of mucro to dens, number of subsegments of fourth antennal segments - see Mills, 1934; Maynard, 1951; Stach, 1956; Gisin, 1960), and descriptions are frequently incomplete and confusing. Even in a recently published monograph including the nearctic species of Sminthurus (Christiansen and Bellinger, 1981), several taxonomic characters have been found by this author to be highly variable (e.g. ratio of metatibiotarsal E₃ seta to outer edge of unguis, or ratio of metaunguicular filament to unguiculus). In light of this disarray, the main purpose of this study was to review the morphology of Sminthurus and establish new, unambiguous taxonomic characters and chaetotaxy systems which may serve as a basis for further study of related genera within Sminthuridae.

The present study concentrates on the nearctic members of Sminthurus because adequate numbers of palearctic species are difficult to obtain. The present treatment of nearctic Sminthurus consists of: (1) examination of morphological structures used for taxonomic purposes; (2) classification of the nearctic species, including descriptions and a dichotomous key, and (3) proposals concerning interspecific phylogenetic relationships.

MATERIALS AND METHODS

SPECIMEN PREPARATION:

Specimens were stored in 95% ethanol with 1% glycerine added to protect against drying. Wherever possible, freshly collected animals were used, since specimens preserved for several years had desiccated, become hardened, and were difficult to dissect. The head, trunk, and body appendages (prolegs, mesolegs, metalegs, collophore, tenaculum, and furcula) were dissected and mounted on individual slides to observe fine structures and chaetotaxy. Fresh specimens were left in 95% ethanol for at least two weeks to allow tissue proteins to precipitate and stabilize, then were dissected in 95% ethanol and mounted in CMCP-9 (Appendix). Cover slips (12 mm diameter, No. 0 and 00 thickness) were lightly pressed down upon the specimen to facilitate rapid penetration of the medium into tissues. Specimens were thereby prevented from collapsing in most instances. Slides were placed in a 55° C oven for 24 hours to promote clearing. CMCP-9 cleared most tissues and pigments, but shrank unless sealed. Slides were sealed with GE Glyptol enamel. The clearing action of CMCP-9 permitted easy examination of such fine structures as oval organs. Unfortunately, CMCP-9 continues to clear tissues, so that in time structures may become almost too transparent to see.

Comparison with type specimens was considered essential for characterization of each species. A list of sources and their abbreviations follows. Wherever possible the acronyms proposed by

Heppner and Lamas (1982) have been used.

INSTITUTIONAL COLLECTIONS

USNM - United States National Museum, Washington, D.C.

INHS - Illinois Natural History Survey, Champaign, Illinois

MCZ - Museum of Comparative Zoology, Cambridge, Massachusetts

PUL - Department of Entomology, Purdue University, Lafayette, Indiana

MSUE - Entomology Museum, Michigan State University, East Lansing, Michigan

UGA - Department of Entomology, University of Georgia, Athens, Georgia

ISU - Department of Zoology and Entomology, Iowa State University, Ames, Iowa

PERSONAL COLLECTIONS

PB - P. Bellinger, California State University, Northridge, California

KC - K. Christiansen, Grinnell College, Grinnell, Iowa

RJS - R.J. Snider, Michigan State University, East Lansing, Michigan

SL - S. Loring, Michigan State University, East Lansing, Michigan

DEFINITION OF THE GENUS

Genus: Sminthurus Latreille, 1804
Rhopalothrix Schött, 1926

Type species: Podura viridis Linné, 1758, by selection, Börner, 1906

Sminthurus (emendation of Smynthurus); proposed to International Commission of Zoological Nomenclature, 1954

Smynthurus; spelling invalidated by International Commission of Zoological Nomenclature, 1958

Sminthurus Latreille, 1804; placed on Official List of Generic Names, International Commission of Zoological Nomenclature, 1958

All Collembola were originally placed by Linné (1758) in the genus Podura. It became apparent that one genus was insufficient to encompass the different morphological forms of Collembola. Latreille (1804) erected the genus Smynthurus. His definition was broad enough to include most symphypleonid Collembola. The modern definition of the genus stems from the work of Börner (1906). The genus was alternately spelled Smynthurus or Sminthurus by different authors. The generic name derives from the Greek word for field mouse: Sminthus. In 1954 Gisin proposed that the name be emended to Sminthurus, because modern transliteration of the Greek letter "iota" is "i". The International Commission of Zoological Nomenclature agreed in 1958 and invalidated the spelling Smynthurus.

Classically, the genus Sminthurus, as defined by Betsch (1980), has a postantennal seta, sense organ sensillae on the third antennal segment (ANT III) enclosed in a single invagination, four macrochaetae on the basal third of ANT III, and no gland opening on the posterior dorsum of the greater abdomen. Additionally, the genus can be distinguished by leg and dental chaetotaxy, and distribution of oval organs (proprioceptors) (Snider and Loring, IN PRESS). The integument is reticulated on the head and abdomen, a condition that first appears in the second instar (Betsch, 1980).

In the following morphological descriptions of nearctic species of Sminthurus, the nomenclature used for denoting chaetotaxy of head, dens, and anal papilla is based upon Christiansen and Bellinger (1981). Designations of setae composing the bothriotrichium D complex follow Snider (1969). Unless otherwise noted, the morphology described below applies to all nearctic species of Sminthurus.

Sminthurus Latreille, 1804 s.l.

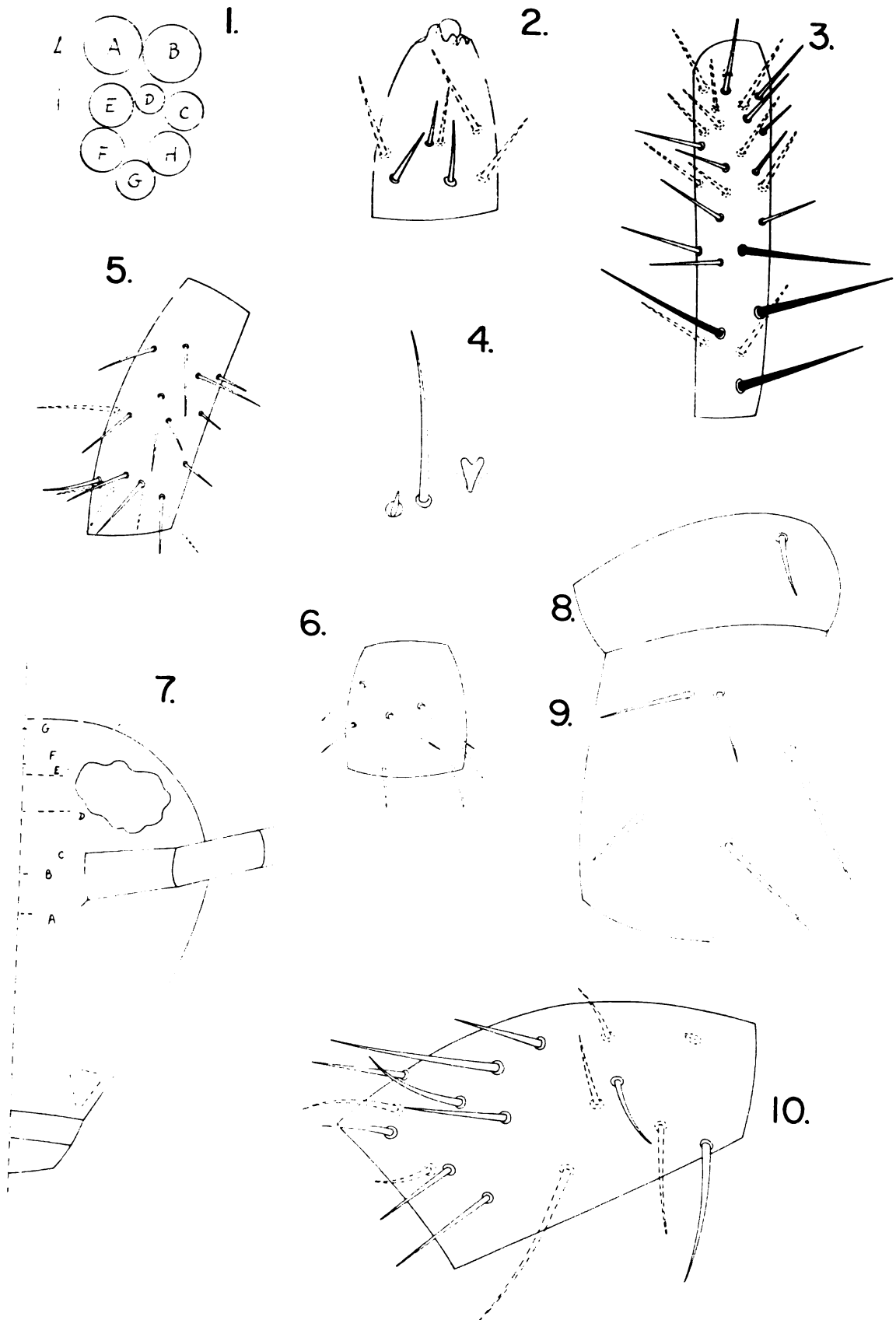
(diagnostic morphology of nearctic species)

HEAD: Eyes 8+8; ocelli A and B usually subequal, ocellus D usually half diameter of ocelli A and B (Figure 1). ANT IV with 15-22 subsegments, may have apical papilla and/or apical bulb (Figure 2); ANT III with 4 heavy outstanding setae (Figure 3), subapical sensillae in deep invagination, accessory seta may be present (Figure 3); ANT II with 4 distal ventral setulae (Figure 5); ANT I with 3 fine posterior distal setae and 4 anterior setae (Figure 6). Interocular setae A-G as in Figure 7, seta D lanceolate and ciliate; 2 unpaired frontal setae; frons with 2 oval organs near antennal bases, 1 near seta D, other in line with seta A, a 3rd located on lower frons in line between unpaired frontal setae, some species with 4th located ventro-laterad of 3rd; 3 posterior oval organs forming a right triangle on lower postgena (Figure 7).

PROLEG: coxa without oval organ; trochanter with 5 setae, without oval organ (Figure 8); femur with 15-17 setae and posterior oval organ (Figure 10); tibiotarsus with 1 anterior oval organ between AE_0 and AE_1 setae, 7 E, PE, PI file setae, 9 AE file setae, 8 AL, AI, PL file setae (PL₇ located between PL and PI files), accessory setae between AL_0 and AI_0 setae, and between PL_0 and PI_0 setae, L setae heavy with L₅ short, L₃ and L₄ missing, posterior oval organs between PE file setae (Figures 11-12); pretarsus with anterior and posterior setulae; unguis normally with inner and outer basal tooth, pseudonychia, tunica; unguiculus without corner tooth, with apical filament (Figure 13).

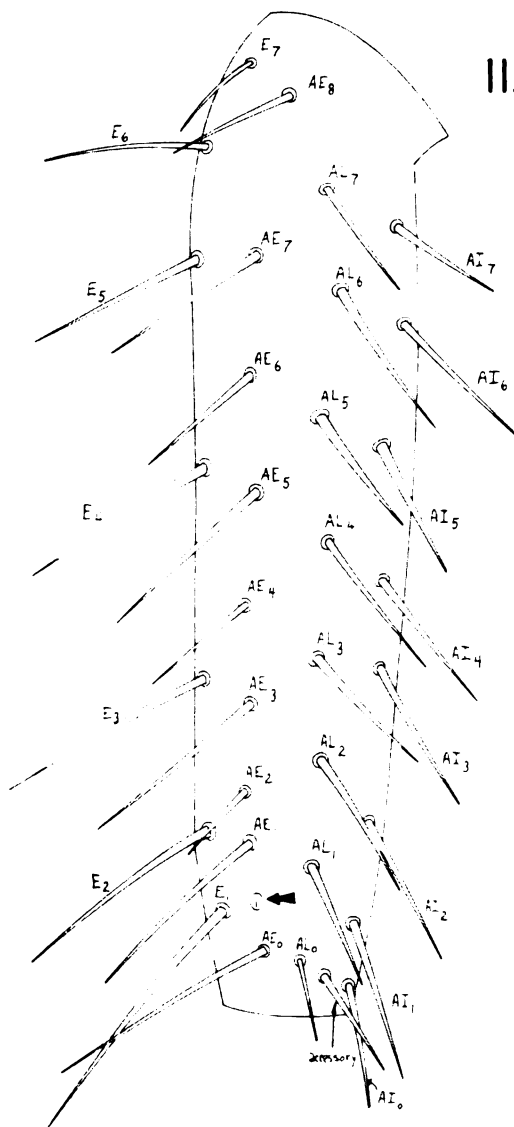
Figures 1 - 10

- 1 - ocellar pattern
- 2 - distal segment of ANT IV
- 3 - ANT III
- 4 - ANT III sensory organ with accessory seta
- 5 - ANT II
- 6 - ANT I
- 7 - cephalic setae and oval organs
- 8 - procoxa
- 9 - protrochanter
- 10 - profemur, anterior view

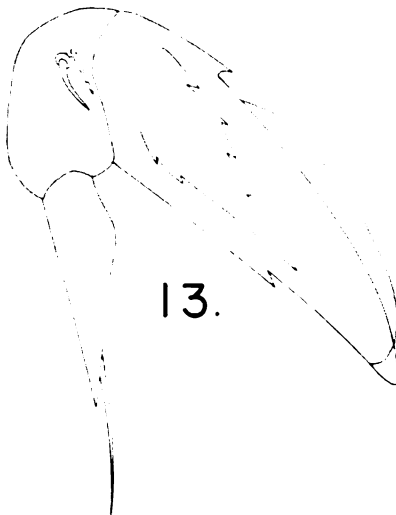
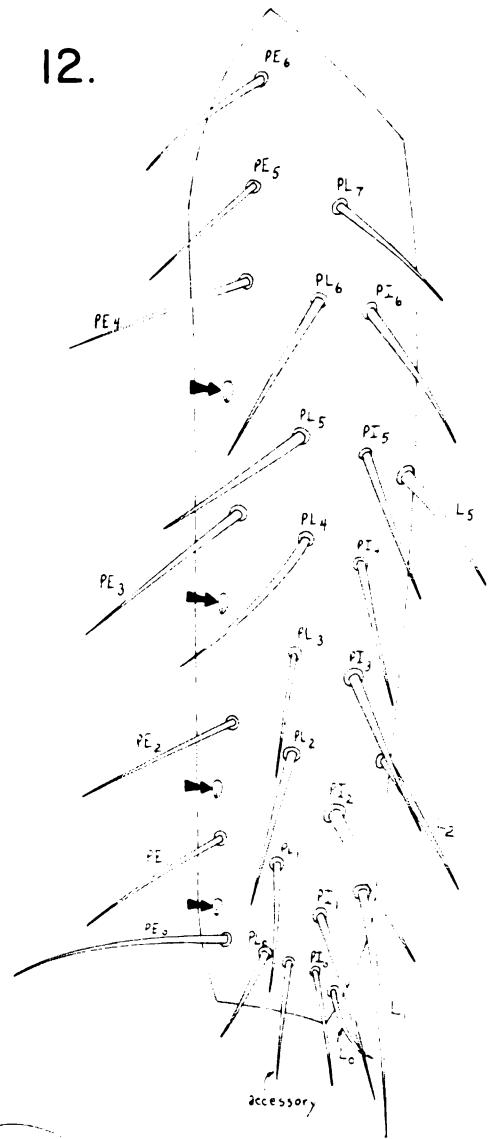


Figures 11 - 15

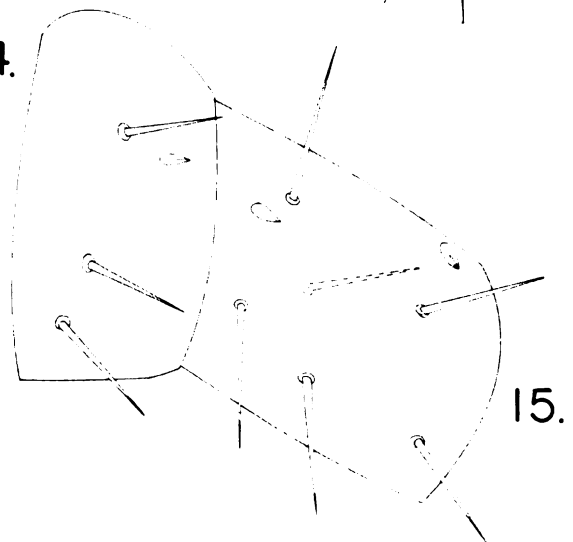
- 11 - protibiotarsus, anterior view
- 12 - protibiotarsus, posterior view
- 13 - proclaw
- 14 - mesocoxa
- 15 - mesotrochanter



12.



14.



15.

MESOLEG: coxa with oval organ and 3 setae (Figure 14); trochanter with 2 oval organs, 5 anterior and 1 posterior setae (Figure 15); femur with 1 posterior oval organ, 14-16 setae, 2 posterior setulae (Figure 16); tibiotarsus with oval organs and accessory setae located as with proleg, 7 E, PE, PL file setae, 9 AE file setae, 8 AL, AI, PI file setae, L setae heavy with L₅ short, L₄ missing (Figures 17-18); pretarsus with anterior and posterior setulae; unguis as with proleg; unguiculus with corner tooth and filament (Figure 19).

METALEG: coxa with oval organ and 4 anterior setae (Figure 20); trochanter with 2 oval organs, 4 anterior setae, 1 posterior setula (Figure 21); femur with 1 posterior oval organ, 16-17 setae, 2 posterior setulae (Figure 26); tibiotarsus with oval organs and accessory setae located as with other legs, 7 E, PE file setae, 8 PL file setae, 9 AE, AL, AI, PI file setae, L setae heavy with L₀ and L₆ short, L₅ missing (Figures 27-28); pretarsus with anterior and posterior setulae; unguis and unguiculus as with mesoleg (Figure 22).

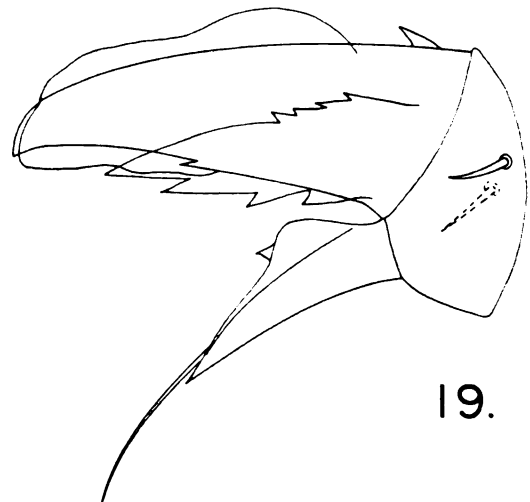
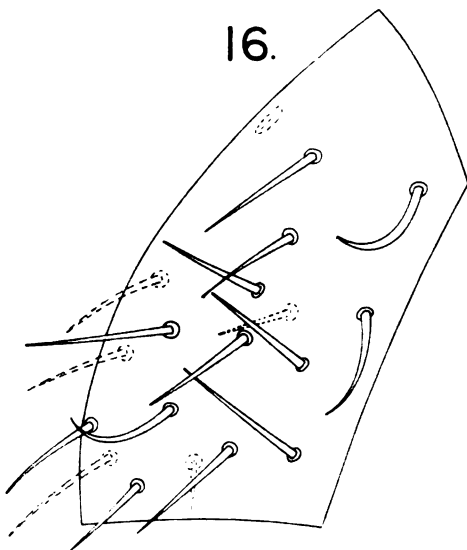
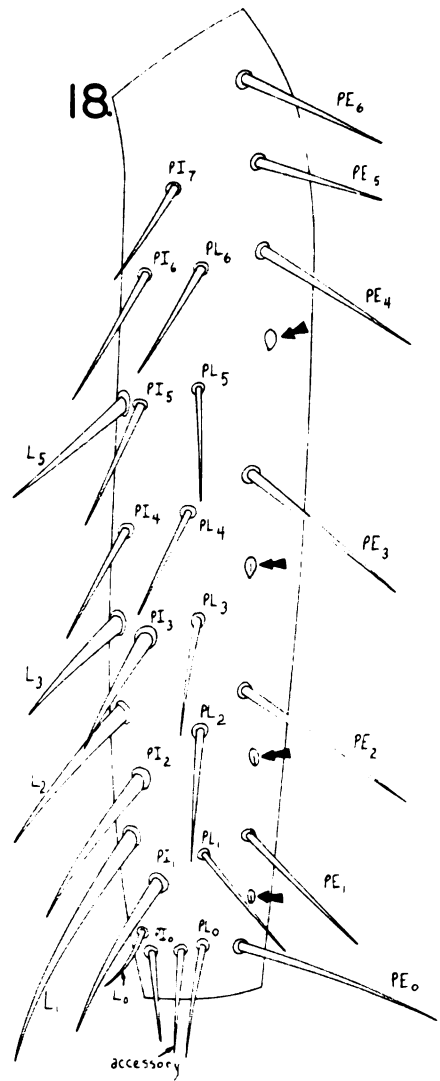
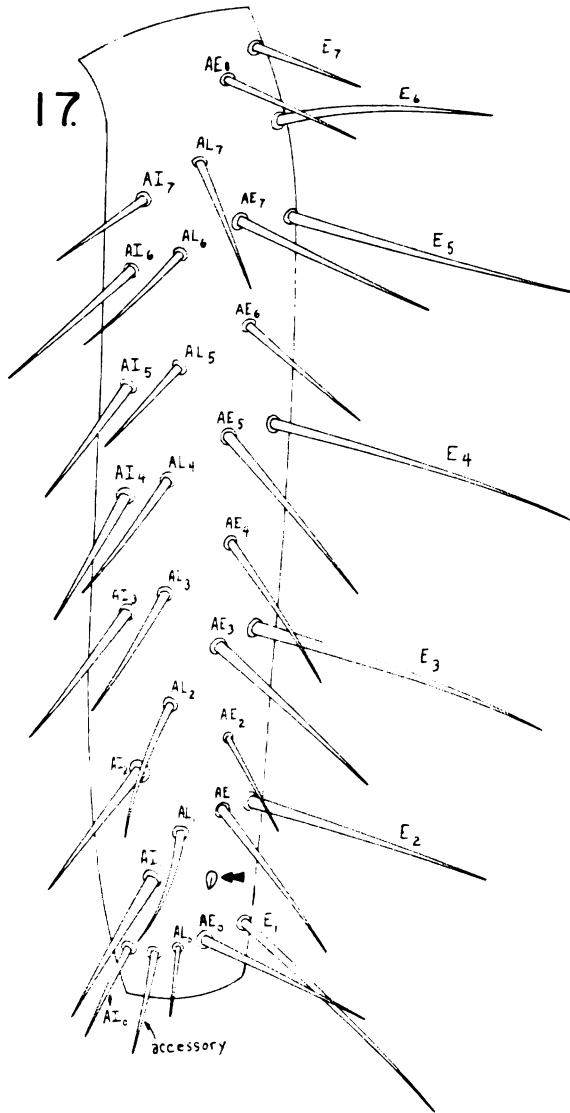
BODY: Collophore with 1+1 subapical setae, sometimes with 1+1 lateral setae, sacs warty, posterior subapical oval organs rarely present (Figure 23). Corpus of tenaculum with 4 ventral setulae, rami with 3 teeth (Figure 24). Manubrium with 8+8 dorsal and 1+1 ventral setae (Figure 25). Dens with 12 ID setae, may have ID accessory seta, with D₄ seta, 8 E file setae, 7 L file setae, Ve setal pattern 3+3+3+2+2+1+1 (Ve₁-Ve₇) (Figures 29-30). Mucro with or without teeth; basal seta usually present (Figure 31). Seta P of bothriotrichium D complex

Figures 17 - 19

17 - mesotibiotarsus, anterior view

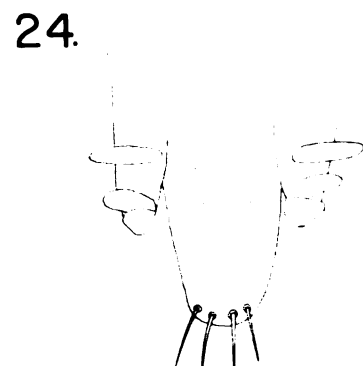
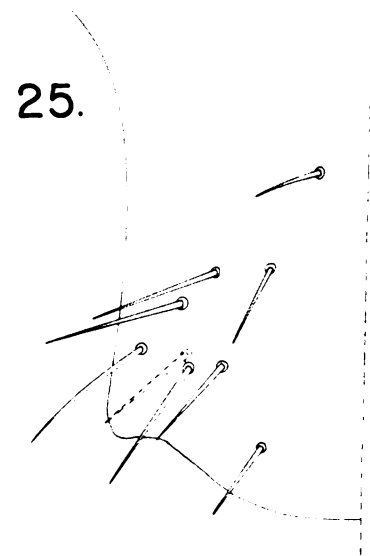
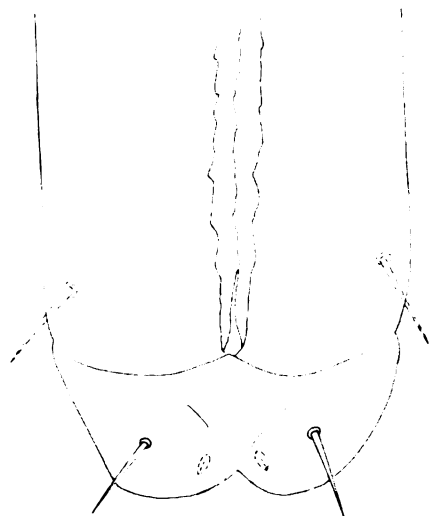
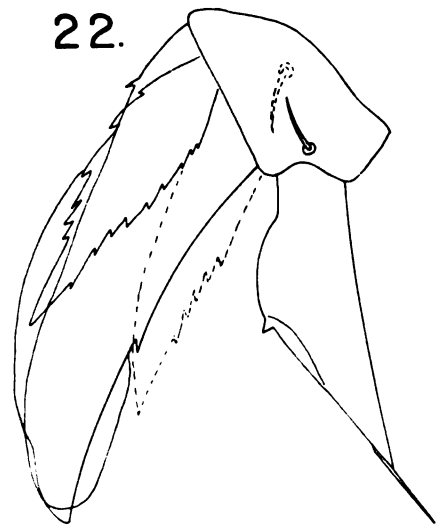
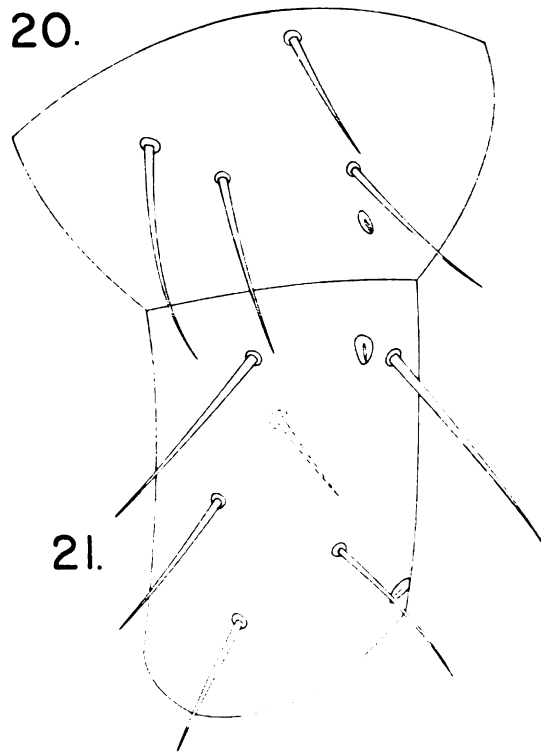
18 - mesotibiotarsus, posterior view

19 - mesoclaw



Figures 20 - 25

- 20 - metacoxa
- 21 - metatrochanter
- 22 - metaclaw
- 23 - corpus of collophore, anterior view
- 24 - corpus of tenaculum
- 25 - manubrium, dorsal view

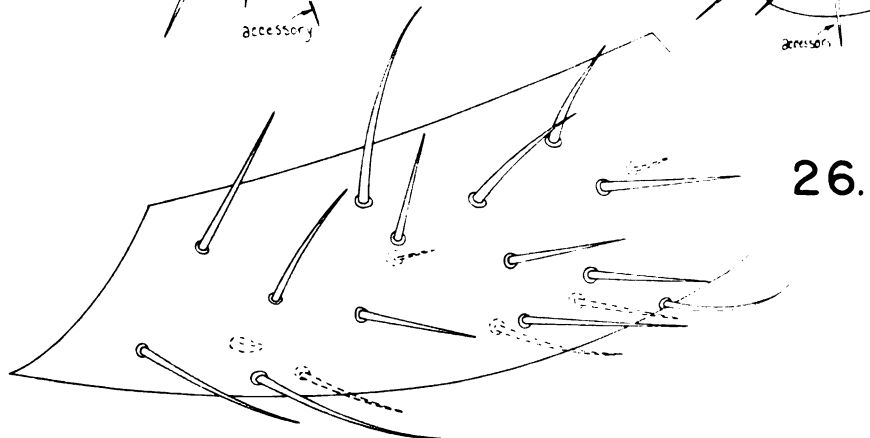
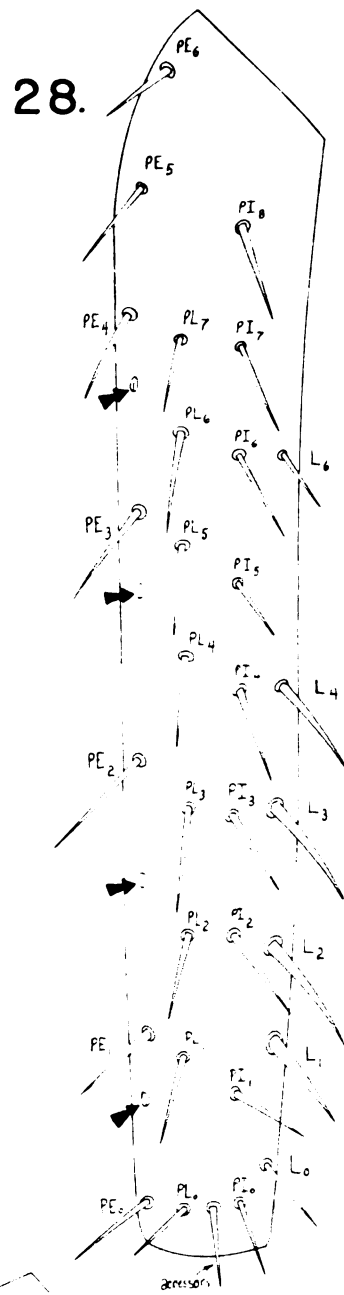
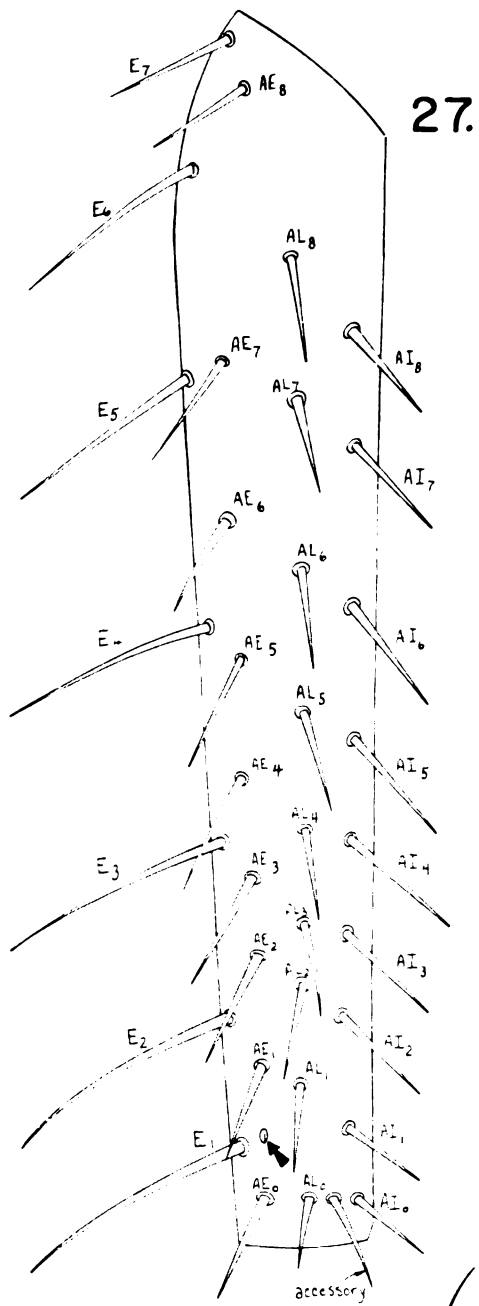


Figures 26 - 28

26 - metafemur, anterior view

27 - metatibiotarsus, anterior view

28 - metatibiotarsus, posterior view



Figures 29 - 34

- 29 - left dens, anterior view
- 30 - left dens, posterior view
- 31 - mucro
- 32 - type I bothriotrichium complex, left view
- 33 - female anal papilla, lateral view
- 34 - female subanal appendage, lateral view

ciliate (Type I) or smooth (Type II) (Figure 32). Female circumanal setae as in Figure 33, single oval organ on lower and upper valves; female subanal appendages normally acuminate, curved in lateral view (Figure 34). Length 1.5-3.0 mm.

The genus Allacma Börner, 1906 has sometimes been included with Sminthurus (Christiansen and Bellinger, 1981). Allacma is very similar to Sminthurus, and is separated by a pair of dorsal pores on the posterior abdomen, palmate female subanal appendages, and a metatrochanteral spine replacing the posterior metatrochanteral seta. The genus Allacma consists of three species with palearctic distribution, but, because the nearctic species Sminthurus purpurescens (MacGillivray) possesses the second two above character states, Christiansen and Bellinger (1981) assigned S. purpurescens to Allacma, which they then considered as a subgenus of Sminthurus. However, S. mendenbergi (Snider) has serrate female subanal appendages, and the subanal appendages of S. borealis (Snider) are finely fringed. This indicates that the condition of branched or palmate female subanal appendages may have been arrived at independently in all of these animals, or that it may be a synapomorphic character. Furthermore, dorsal abdominal pores, a synapomorphy uniting palearctic Allacma, are completely absent in Sminthurus, including purpurescens. There are other characters by which the palearctic species of Allacma differs from Sminthurus. The tunicae of Allacma claws are greatly expanded compared with those of Sminthurus; the dental ID₅ and ID₁₀ setae of Allacma are very long and clavate; cephalic seta D (postantennal seta) is roundish and finely ciliate, whereas in Sminthurus it is pointed and more strongly

fringed; the unguicular corner teeth and filaments have a different shape than in Sminthurus. Based on the above characters, it is proposed that the palearctic species of Allacma should be considered a separate genus.

Three species described from North Carolina are not included in the present study because the type specimens are unobtainable for examination. They are Sminthurus adamsi Wray (1967), Sminthurus virginidari Wray (1948), and Sminthurus yonahlossee Wray (1948).

The type specimens of Sminthurus adirondakus Maynard (1951) cannot be found. Because of the complete lack of specimens and a very inadequate species description, S. adirondakus is not considered a valid species in the present study.

A dichotomous key to the nearctic species of Sminthurus is presented here. Identification of species is accomplished largely on the basis of tibiotarsal, femoral, and dental chaetotaxy, and the number of cephalic and tibiotarsal oval organs. For these features to be seen, the specimen's appendages must be dissected and mounted on separate slides (see Materials and Methods section). Some of the structures (e.g. oval organs) are very fine and difficult to observe unless the specimens have been properly cleared and a good phase-contrast light microscope is used. Despite the difficulty involved in seeing such small structures, this key is based solely on consistent external morphology. Features exhibiting intraspecific variability, such as color patterns, are not utilized in the key.

Nearctic species of Sminthurus

A serious hinderance to identifying Sminthurus is the lack of complete and consistent species descriptions. To avoid problems, the external morphology of each of the nearctic species of Sminthurus is completely characterized for the first time in the following pages. The description format follows that of the diagnostic species (above). Only those features which are of taxonomic importance are included in the individual species descriptions; other morphological structures which are not mentioned or are said to be "normal" agree with the diagnostic species description.

The collection data, based on available information, is included for each species citation. Banks (1899) cited his collections of S. nigripes, S. fraternus, S. sylvestris, S. purpurescens, and S. argenteornatus as being from Sea Cliff, Long Island, New York. Christiansen and Bellinger (1981) placed the collection site in Queens County. In fact, Sea Cliff is located in Nassau County and is so listed in the species distributions.

Key to the nearctic species of Sminthurus

1. all leg setae acuminate-----2
- 1'. some distal leg setae clavate-----sylvestris
- 2 (1). metatibiotarsal PL7 seta absent, female subanal appendages palmate (Figures 127-128), metatrochanteral spine present (Figure 126)-----purpurescens
- 2'. metatibiotarsal PL7 seta present, female subanal appendages acuminate, no metatrochanteral spine-----3
- 3 (2'). Bothriotrichium D complex Type I (Figure 32)-----7

- 3'. Bothriotrichium D complex Type II-----4
- 4 (3'). metatibiotarsal PL seta present-----5
- 4'. metatibiotarsal PL seta absent-----incisus
- 5 (4). mucronal teeth present, dens without ID accessory seta,
collophore without lateral setae-----6
- 5'. mucronal teeth absent (Figure 48), ID accessory seta present
on dens (Figure 29), collophore with lateral setae (Figure 23)-
-----viridis
- 6 (5). mesofemur with 16 setae and 2 posterior setulae (Figure 37),
no oval organs on collophore-----bivittatus
- 6'. mesofemur with 15 setae and 2 posterior setulae, collophore with
subapical oval organs (Figure 23)-----carolinensis
- 7 (3). metatibiotarsal PL seta absent-----8
- 7'. metatibiotarsal PL seta present-----10
- 8 (7). serrate unguis lateral teeth, frons with 4 oval organs
(Figure 7)-----9
- 8'. single unguis lateral tooth (Figure 138), frons with 3 oval
organs-----sagitta
- 9 (8). mucronal seta absent (Figure 69), metafemur with 16 setae
and 2 posterior setulae-----eiseni
- 9'. mucronal seta present (Figure 31), metafemur with 17 setae and
2 posterior setulae-----packardi
- 10 (7'). dens without ID accessory seta-----11
- 10'. dens with ID accessory seta (Figure 29)-----butcheri
- 11 (10). mucro with inner teeth only (Figure 76), frons with 3 or
2 oval organs-----12
- 11'. mucro with inner and outer teeth (Figure 109), frons with 4
oval organs-----mencenbergi

- 12 (11). abdomen with dorsal protruberance (Figure 91), frons with
 2 oval organs, postgena with 1 oval organ, metatibiotarsus with
 5 posterior oval organs-----floridanus
- 12'. abdomen without dorsal protruberance, frons and postgena each
 with 3 oval organs, metatibiotarsus with 4 posterior oval organs-13
- 13 (12'). metatibiotarsus with 10 AE file setae, dens with 11-12
 L file and 13 E file setae (Figures 106-107)-----incognitus
- 13'. metatibiotarsus with 9 AE file setae (Figure 27), dens with 7 L
 file and 8 E file setae (Figures 29-30)-----14
- 14 (13'). antennal apical bulb absent, claws with 2 outer basal
 teeth (Figures 71, 74, 75)-----fischeri
- 14'. antennal apical bulb present, proclaw with 0 and meso- and
 metac claws with 1 outer basal ungual tooth (Figures 78, 81, 83)-fitchi

Sminthurus bivittatus Snider (IN PRESS)

MORPHOLOGICAL DESCRIPTION

HEAD: ANT IV with 17-18 subsegments, double apical bulb, no apical papilla. Frons with 3 oval organs.

PROLEG: Coxa and trochanter typical; femur with 17 setae, 1 posterior oval organ (Figure 35); tibiotarsus normal; unguis with tunica, pseudonychia, inner tooth, no outer basal tooth; unguiculus normal (Figure 36).

MESOLEG: Coxa and trochanter typical; femur with 13 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 37); tibiotarsus typical; unguis as with proleg, 1 small outer basal tooth; unguiculus with strong corner tooth (Figure 38).

METALEG: Coxa and trochanter typical; femur with 15 anterior and 2 posterior setae, 2 posterior setulae, posterior oval organ (Figure 39); tibiotarsus normal; unguis with pseudonychia, 1 (sometimes 2) inner tooth, no outer basal teeth; unguiculus with strong corner tooth (Figure 40).

BODY: Collophore with 1+1 subapical setae, no lateral setae.

Manubrium and dens normal, no ID accessory setae. Mucro with numerous inner and outer teeth, basal seta (Figure 41). Bothriothrichium D complex Type II. Female circumanal setae and subanal appendages normal. Length 2.0 mm.

DIAGNOSIS: Sminthurus bivittatus keys out to the S. butcheri, S. fitchi, and S. packardi complex using Christiansen and Bellinger (1981). Separation of S. bivittatus may be done on the following basis:

<u>bivittatus</u>	<u>butcheri</u>	<u>fitchi</u>	<u>packardi</u>
ANT IV apical bulb double	single	single	absent
ANT IV apical papilla absent	present	present	present
3 frontal oval organs	4	3	4
meta PL ₆ seta present	present	present	absent
collophore lateral setae absent	present	present	present
outer mucronal teeth present	absent	absent	absent
Type II Bothriotrichium D complex	Type I	Type I	Type I

DISTRIBUTION: South Carolina - Barnwell Co., Savannah River Ecology Laboratory: grass, along Road 6 near small shack at junction of road E, 10-III-1982, W. Hargrove; grass, along road A, 14-IV-1982, W. Hargrove; short grass, along road 9 by turnoff onto B-6.2 near power line cut, 14-IV-1982, W. Hargrove; grass, around concrete building foundation, junction road F and road B, 14-IV-1982, W. Hargrove; litter in low, rich, moist woods, over railing along road 7, 14-IV-1982, W. Hargrove (MSUE).

TYPE SPECIMENS: Holotype and paratypes - MSUE.

Figures 35 - 39

35 - S. bivittatus, profemur, anterior view

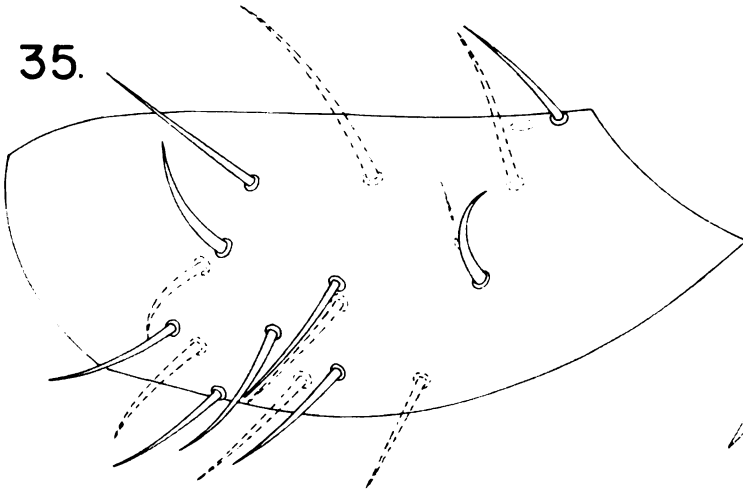
36 - proclaw

37 - mesofemur, anterior view

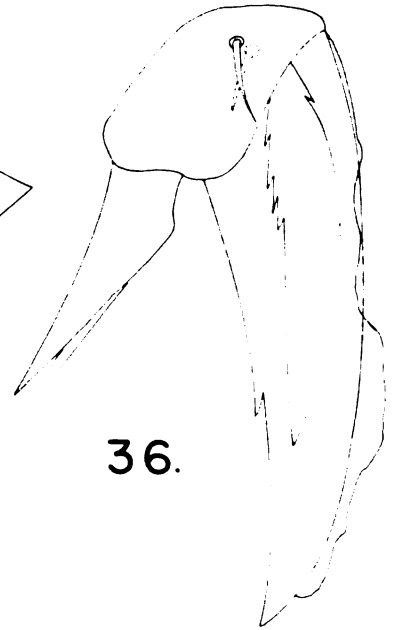
38 - mesoclau

39 - metafemur, anterior view

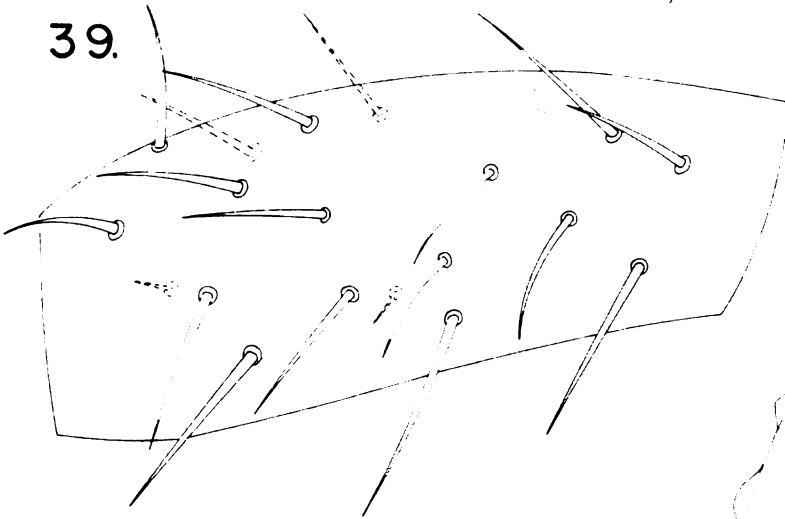
35.



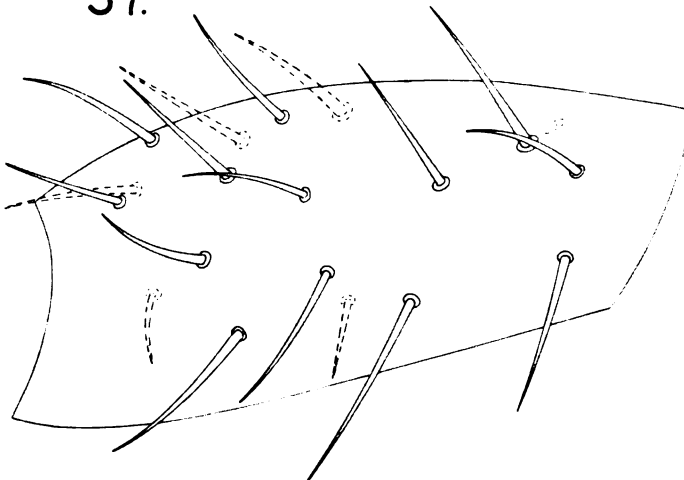
36.



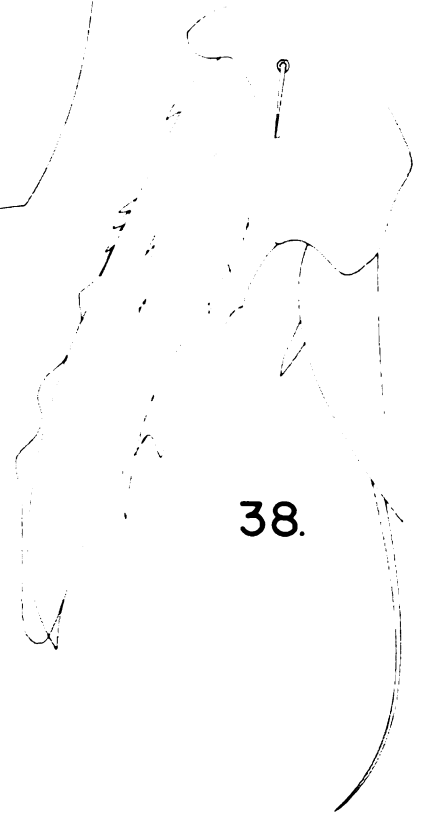
39.



37.



38.



Figures 40 - 45

40 - metaclaw

41 - mucro

42 - S. borealis, profemur, anterior view

43 - proclaw

44 - mesofemur, anterior view

45 - mesoclaw

Sminthurus butcheri Snider, 1969Smynthurus darsalis, Banks, 1899, nec Fitch, 1863Sminthurus dorsalis, Maynard, 1951Sminthurus dorsalis, Stach, 1956Sminthurus butcheri, Snider, 1969Sminthurus spinulosus, Snider, 1969Sminthurus banksi, Christiansen & Bellinger, 1981, n. syn.Sminthurus butheri, Christiansen & Bellinger, 1981

MORPHOLOGICAL DESCRIPTION

HEAD: Ocellus D 1/2 diameter of ocelli A and B; ocellus C about 3/4 diameter of ocellus A. ANT IV with 15-18 subsegments, apical bulb, apical papilla. Frons with 4 oval organs.

PROLEG: Coxa and trochanter normal; femur with 8 anterior and 9 posterior setae, posterior oval organ (Figure 49); tibiotarsus normal; claw typical, 1 outer basal tooth (Figure 50).

MESOLEG: Coxa and trochanter typical; femur with 12 anterior and 4 posterior setae, 2 posterior setulae, posterior oval organ (Figure 51); tibiotarsus normal; claw typical, 1 outer basal tooth (Figure 52).

METALEG: Coxa and trochanter typical; femur with 14 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 53); tibiotarsus normal; claw as with mesoleg (Figure 54).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens normal, with ID accessory seta. Mucro with inner teeth, basal seta (Figure 55). Bothriotrichium D complex Type I. Female subanal appendages and circumanal setae normal. Length about 2 mm.

DIAGNOSIS: Sminthurus butcheri is similar to S. packardi and S. fitchi. Sminthurus packardi differs from S. butcheri by having no ANT IV apical bulb and lacking the metatibiotarsal PL6 seta. Separation from S. fitchi may be done on the following basis:

<u>butcheri</u>	<u>fitchi</u>
4 frontal oval organs	3
1 outer basal tooth on proclaw	0
dental ID accessory seta present	absent

Color pattern ranges from white with purple mosaics to dark blue with a pale yellow dorsum, even withing the same population. Despite great variation in color and size disparity between regional populations, all specimens are morphologically uniform. No variation in the occurrence of dental ID accessory setae has been observed.

DISTRIBUTION: Florida - Glades Co., Palmdale, ex Pistia stratiotes, 9-XI-1978, E.S. DelFosse; state road 29, bridge 050031, ex Alternianthera philoxeroides (Mart.) Griseb., 27-XI-1977, E.S. DelFosse (RJS); Palm Beach Col, Jupiter Island Park, short, dry grass, 27-XII-1982, R.J. Snider and R.M. Snider (RJS); St. Johns Co., St. Augustine - Moutiere, dry grass area along road, 14-XII-1982, R.J. Snider (RJS).

Illinois - Cumberland Co.; Woodford Co., Goodfield, 27-IV-1954, no collector (RJS).

Michigan - Dickenson Co., Silver Lake, pit trap, mixed mesophytic forest, 3-VIII-1982, F. Calandrino, J.M. Nesmith, (Pinus banksiana Lamb.), pit trap, 28-VII-1965, J.H. Shaddy (holotype of butcheri) (MSUE); natural Jack Pine, pit trap, 21-28-VII-1965, J.H. Shaddy (holotype of spinulosus) (MSUE).

New York - Nassau Co., Sea Cliff, Long Island, no date, N. Banks (type of banksi) (MCZ).

North Carolina - Macon Co., Coweeta Hydrologic Laboratory headquarters, grass, 8-VII-1980, 21-VIII-1980, 21-VIII-1980, R.J. Snider; grass, 18-VII-1980, W. Hargrove (RJS).

South Carolina - Anderson Co., Pendleton, Pendleton Pines, 11-VIII-1962, R.C. Fox (RJS); Barnwell Co., Savannah River Ecology Laboratory, R.J. Snider (RJS).

Texas - Cameron Co., San Benito, on bean leaf, 24-II-1944, spec. survey 11763 (USNM); Brownsville, grass; 16-I-1981, S.R. Fishman (RJS).

Sminthurus butcheri has been reported from the following locations by Christiansen and Bellinger (1981) but could not be confirmed by this author.

Connecticut - Litchfield Co.

Indiana - Parke Co.

Louisiana - Jefferson Par., Winn Par.

Utah - Weber Co.

Similarly, Bellinger (1982) reported the occurrence of S. butcheri in Franklin Co., Vermont (Fairfax, Fort Ethan Allen, 3400-4100 feet elevation, sand pit), but this author has not seen the specimens.

TYPE SPECIMENS: Holotype and paratypes - MSUE. Paratype - MCZ.

Figures 46 - 50

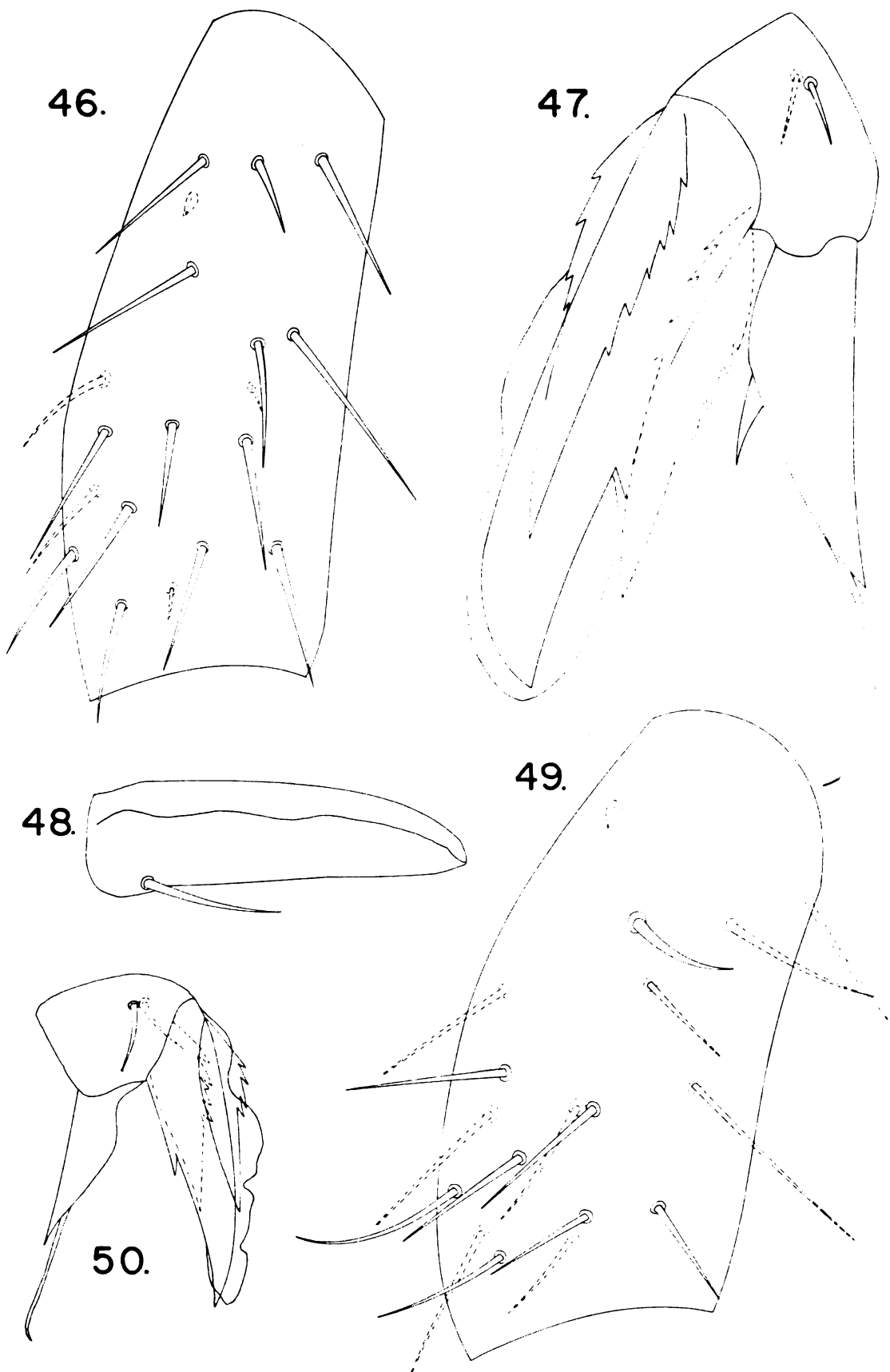
46 - metafemur, anterior view

47 - metacław

48 - mucro

49 - *S. butcheri*, profemur, anterior view

50 - proclaw



Figures 51 -55

- 51 - mesofemur, anterior view
- 52 - mesoclau
- 53 - metafemur, anterior view
- 54 - metaclaw
- 55 - mucro

Sminthurus carolinensis Snider, 1981

MORPHOLOGICAL DESCRIPTION

HEAD: Ocellus D $1/2$ diameter of B; A and B subequal, their diameters at least $1/4$ greater than other ocelli. Antennal segment ratio (female) 1:2:3:6, (male) 1:2:3:7. ANT IV with 15-16 subsegments, apical papilla, apical bulb. Frons with 3 oval organs.

PROLEG: Coxa and trochanter typical; femur with 8 anterior and 9 posterior setae, 1 posterior oval organ (Figure 56); tibiotarsus normal; unguis with tunica, pseudonychia, inner tooth, no outer basal teeth; unguiculus with weak corner tooth (Figure 57).

MESOLEG: Coxa and trochanter typical; femur with 12 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 58); tibiotarsus normal; unguis as with proleg; unguiculus with corner tooth, sometimes with 2 corner teeth (Figure 59).

METALEG: Coxa and trochanter typical; femur with 17 setae, 2 posterior setulae, oval organ (Figure 61); tibiotarsus with 5th posterior oval organ between PE_4 and PE_5 setae, otherwise normal; claw as with mesoleg (Figure 62).

BODY: Collophore with 1+1 subapical setae, no lateral setae, a pair of subapical posterior oval organs (Figure 23). Manubrium and dens normal, no ID accessory setae. Mucro with 2-3 outer and 3-5 (seldom 2) inner teeth, basal seta (Figure 60). Bothriothrichium D complex

Type II. Female circumanal setae and subanal appendages normal.
Length 2.0 mm (female), 1.3 mm (male).

DIAGNOSIS: Using Christiansen and Bellinger (1981), S. carolinensis keys out to the S. butcheri, S. fitchi, S. packardi complex.

Separation may be done based on the following characters:

<u>carolinensis</u>	<u>butcheri</u>	<u>fitchi</u>	<u>packardi</u>
3 frontal oval organs	4	3	4
15 mesofemur setae	16	16'	16
collophore lateral setae absent	present	present	present
outer mucronal teeth present	absent	absent	absent
Type II Bothriotrichium D complex	Type I	Type I	Type I
proclaw with 0 outer basal teeth	1	0	1

S. carolinensis is one of the few species to show size differences between the sexes, and is the only species so far recorded to have oval organs on the collophore.

DISTRIBUTION: Florida - St. Johns Co., St. Augustine - Moutiere, dry grass along road, 14-XII-1982, R.J. Snider (MSUE)

South Carolina - Aiken Co., Savannah River Ecological Laboratory (SREL), grass, road A 50 yards from upper 3 runs, 12-XI-1980, R.J. Snider; Allium sp., Ellenton road 3 at railroad crossing, 12-XI-1980, R.J. Snider (RJS); Barnwell Co., SREL, grass, road B 100 yards northeast of road A 18-VI-1981, R.J. Snider; pit trap, road C., 25-II-1982, W. Hargrove; grass, road 6, 10-III-1982, W. Hargrove (RJS).

TYPE SPECIMENS: Holotype (female), allotype (male), paratypes - MSUE, Paratypes - UGA.

Figures 56 - 60

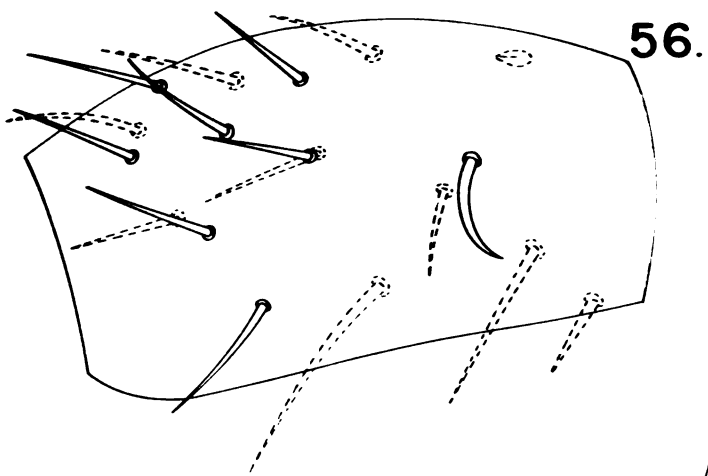
56 - *S. carolinensis*, profemur, anterior view

57 - proclaw

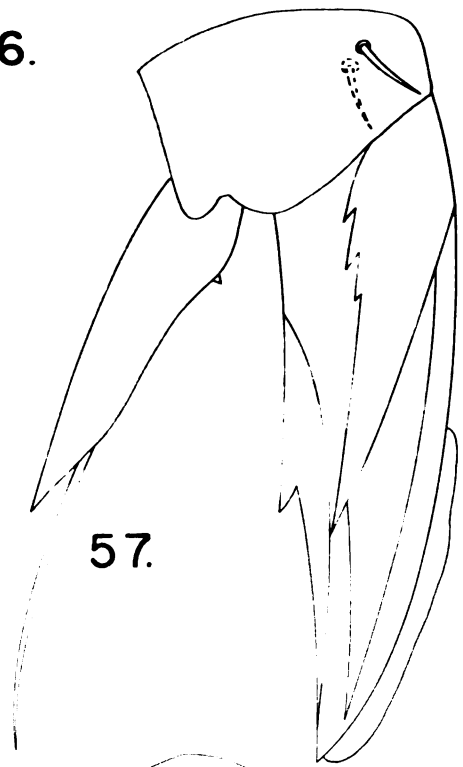
58 - mesofemur, anterior view

59 - mesoclau

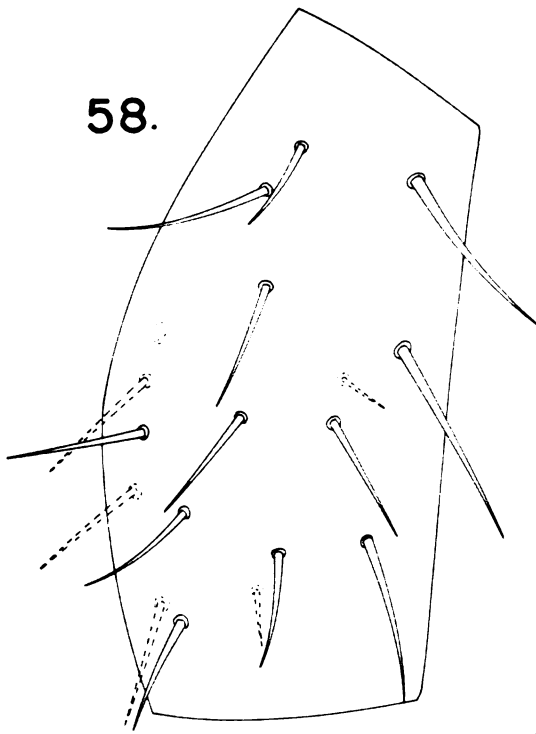
60 - mucro



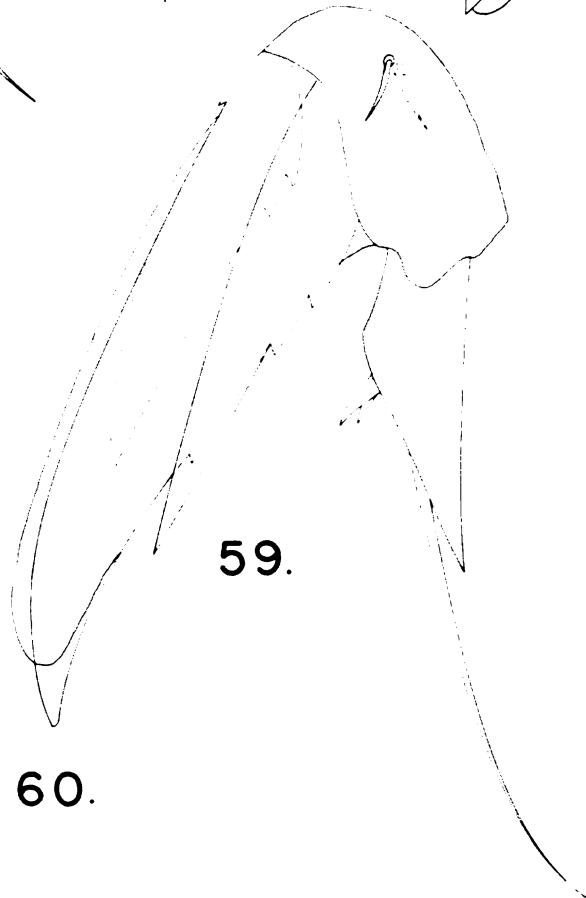
56.



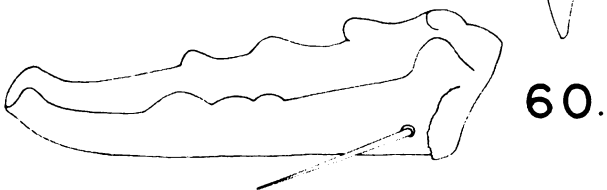
57.



58.



59.



60.

Figures 61 - 66

61 - metafemur, anterior view

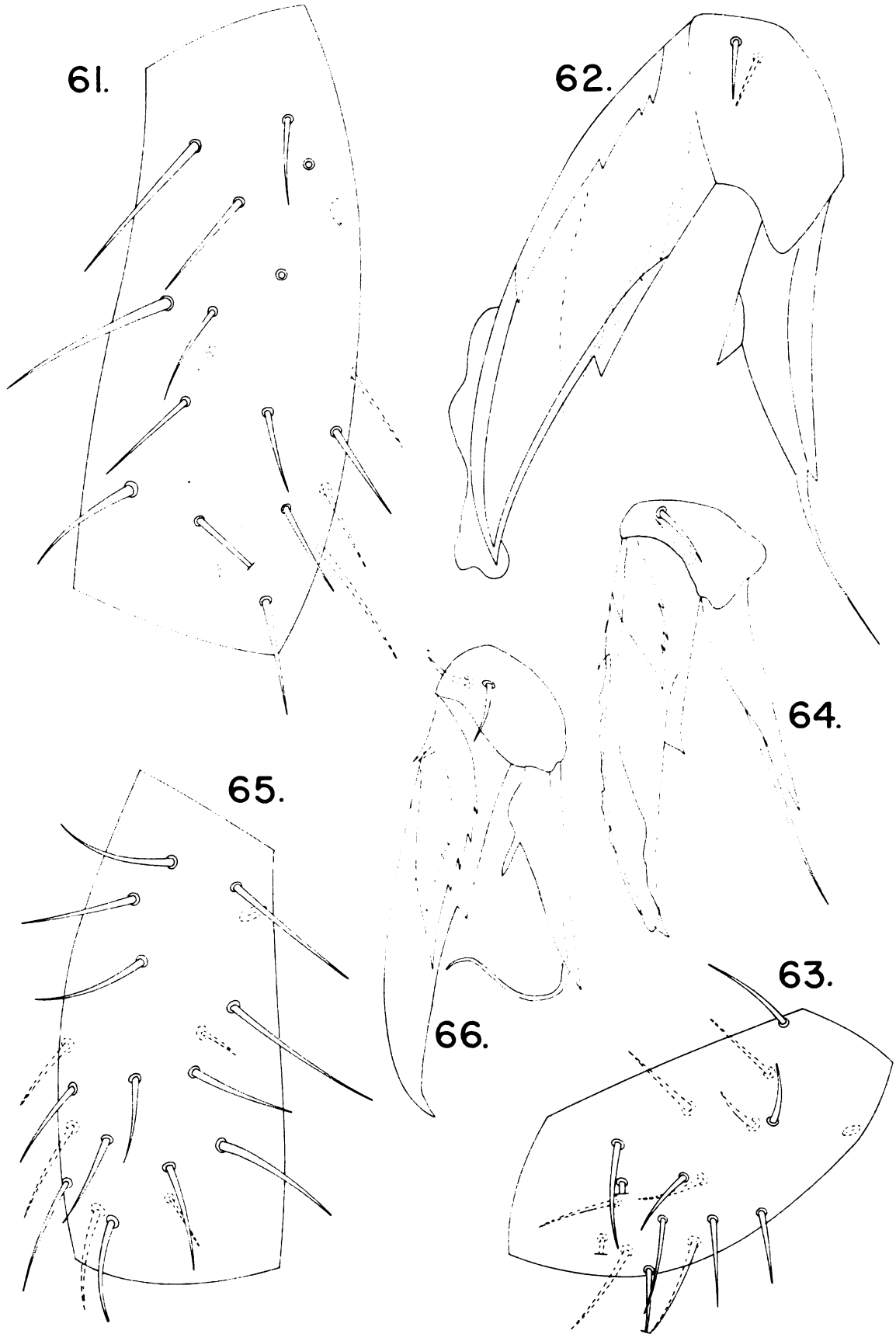
62 - metaclaw

63 - *S. eiseni*, profemur, anterior view

64 - proclaw

65 - mesofemur, anterior view

66 - mesoclaw



Sminthurus eiseni Schött, 1891

Sminthurus eiseni, Schött, 1891
Sminthurus eiseni, Edinger, 1933
Sminthurus medialis, Mills, 1934 - n. syn.
Sminthurus eiseni, Edinger, 1937
Sminthurus medialis, Perse, 1946
Sminthurus eiseni, Stach, 1956
Sminthurus medialis, Stach, 1956
Sminthurus medialis, Wilkey, 1959
Sminthurus medialis, Snider, 1967
Sminthurus medialis, Pedigo, 1970a
Sminthurus medialis, Christiansen and Bellinger, 1981
Sminthurus medialis, Christinasen and Bellinger, 1981

MORPHOLOGICAL DESCRIPTION

HEAD: Ocelli subequal, D 1/2 diameter of A and B, C slightly larger than D. Antennal segment ratio (female) 1:2:2:5:6. ANT IV with 16-17, 19 subsegments, apical bulb, weak apical papilla. Frons with 4 oval organs.

PROLEG: Coxa and trochanter typical; femur with 9 anterior and 8 posterior setae, posterior oval organ (Figure 63); tibiotarsus normal; claw typical, tunica sometimes absent (Figure 64).

MESOLEG: Coxa and trochanter typical; femur with 13 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 65); tibiotarsus normal, rarely with PL₅ or AL₃ seta missing; unguis with 2 outer basal teeth, otherwise claw normal (Figure 66).

METALEG: Coxa and trochanter typical; femur with 13 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 67); tibiotarsus lacking PL₆ seta; unguis with 2 outer basal teeth, with or without tunica; unguiculus typical (Figure 68).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens typical, no ID seta. Mucro with inner teeth, lacking basal seta (Figure 69). Bothriotrichium D complex Type I. Female circumanal setae and subanal appendages normal. Length 2.5 mm maximum.

DIAGNOSIS: This species is unique among nearctic Sminthurus in lacking a basal mucronal seta. It is also one of four nearctic species to lack the metatibiotarsal PL seta (cf. S. incisus, S. packardii, S. sagitta). Sminthurus eiseni may be further separated from these species by having 1, 2, and 2 outer basal teeth on the pro-, meso-, and metac claws respectively.

Christiansen and Bellinger (1981) distinguished between S. eiseni and S. medialis on the basis of the ratio of cephalic seta D to ocellus B, and the strongly developed claw tunicae. Cephalic seta D ratio to ocellus B has been found unreliable - many specimens had ratios intermediate to those listed for the two species. The degree of tunica development is very subjective and difficult to determine on most specimens. In other respects the specimens exhibited no morphological differences. The characters chosen by Christiansen and Bellinger appear to exhibit only normal regional variation within a species. Christiansen and Bellinger speculated that eiseni and medialis might prove to be synonyms, which has been upheld in the present study.

The species has one unconfirmed record for North Carolina; otherwise, no specimens have been recorded east of Michigan and Indiana.

DISTRIBUTION: Alberta - Banff National Park, Castle Meadows Camp, elevation 4500 feet, grass, 22-VIII-1982, L. Mendenberg (RJS).

California - Santa Barbara Co., 4-XI-1975, P.F. Bellinger (PB).

Colorado - Larimer Co., Estes Park, near National Park entrance, meadow grass, 3I-VIII-1971, R.J. Snider (RJS); Montezuma Co., Mesa Verde, grass, 4-IX-1971, R.J. Snider (RJS).

Illinois - Grundy Co., Morris, city park, grass, 27-VIII-1971, R.J. Snider (RJS); Kendall Co., alfalfa 14-VIII-1979, R.D. Lovejoy (RJS).

Iowa - Pottawattamie Co., Neola, grass, 28-VIII-1971, R.J. Snider (RJS); Story Co., Ames, grass, 6-VII-IV-1929, 7-8-9-19-20-V-1929, 4-19-IX-1929, H.B. Mills (type of medialis) (INHS).

Kansas - Riley Co., Manhattan, alfalfa, 3-VII-1939, H.B. Mills (USNM).

Michigan - Berrien Co., clover, 14-V-1963, J.C. Truchan (RJS); Kalamazoo Co., Kellogg Bird Sanctuary, grass, 3I-VII-1959, R.J. Snider (RJS); St. Joseph Co., Three Rivers, alfalfa, 25-VII-1967, R.J. Snider (RJS).

Nebraska - Lincoln Co., Maxwell, Interstate 80, Platt River, grass, 29-VII-1971, R.J. Snider (RJS); Seward Co., Goehner, Interstate 80, grass, 28-VIII-1971, R.J. Snider (RJS).

New Mexico - Los Alamos Co., Los Alamos, Mortardad Canyon, pitfall traps, 25-28-VI-1976, 30-VII-1976, 1-6-VIII-1976, VIII-IX-XI-1976/77, D.C. Lowrie (RJS).

This species has been reported from the following locations but specimens could not be obtained for confirmation by the author.

California - locality unknown (type lost), El Dorado Co., Los Angeles Co., Monterey Co., Stanislaus Co. (Christiansen and Bellinger, 1981); Alameda Co., Berkely, under stones in canyon, X-V, under Quercus sp. bark and stones in Palmer Canyon (Edinger, 1937).

Illinois - Champaign Co., Dubois Co., Kankakee Co., Lake Co., Ogle Co., Whiteside Co. (Christiansen and Bellinger, 1981).

Indiana - Tippecanoe Co., woodlands, Prudue Entomological Research Area, edge of ravine, pitfall trap, no date, L.P. Pedigo (Pedigo, 1970a).

Iowa - Dallas Co., Adel, 4-IX, H.B. Mills (Mills, 1934); Mills Co., Malvern, 9-17-IX, H.B. Mills (Mills, 1934); Woodbury Co. (Christiansen and Bellinger, 1981).

Kansas - Douglas Co. (Christiansen and Bellinger, 1981).

Minnesota - Clearwater Co. (Christiansen and Bellinger, 1981).

North Carolina - Durham Co., Duke Forest, Quercus alba L. litter on clay soil, no date (Pearse, 1946, as S. medialis).

North Dakota - Slope Co. (Christiansen and Bellinger, 1981).

Ontario - No locality, 9-V, 12-VI, H.B. Mills (Mills, 1934).

Utah - Box Elder Co., Wildcat Hills, sage litter, 8-VI-1972, no collector (Knowlton and Wray, 1975, as S. medialis).

TYPE LOCATIONS: S. eiseni - type destroyed by fire, S. medialis - co-types, INHS.

Figures 67 - 73

67 - metafemur, anterior view

68 - metacław

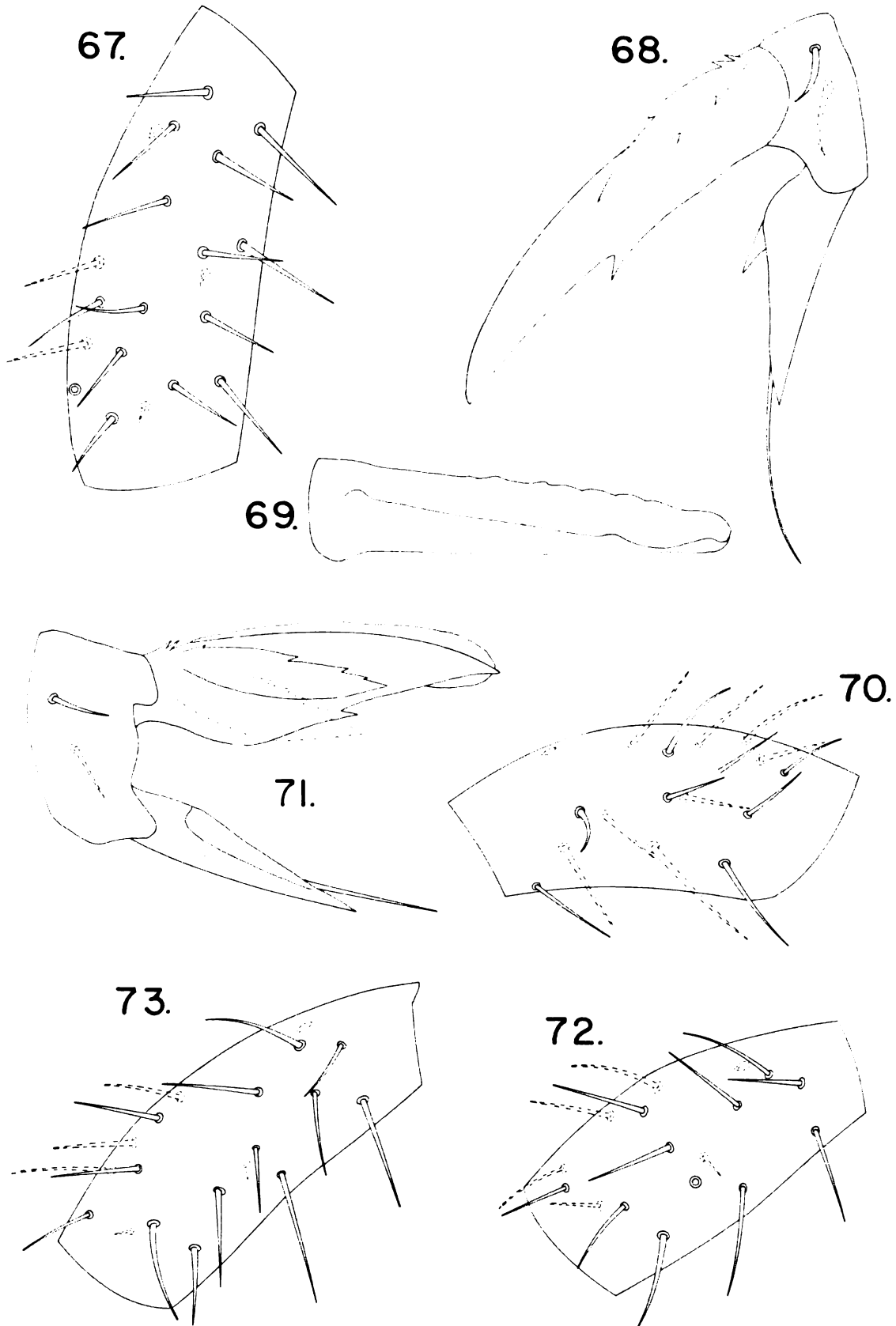
69 - mucro

70 - *S. fischeri*, profemur, anterior view

71 - proclaw

72 - mesofemur, anterior view

73 - metafemur, anterior view



Sminthurus fischeri Snider, 1982

MORPHOLOGICAL DESCRIPTION

HEAD: Ocelli C and D $1\frac{1}{2}$ diameter of A and B. Antennal segment ratio 1:2:3:8. ANT IV with 19-20 segments, apical papilla, no apical bulb. Frons with 3 oval organs.

PROLEG: Coxa and trochanter typical; femur with 9 anterior and 8 posterior setae, posterior oval organ (Figure 70); tibiotarsus normal; unguis with 2 basal teeth, otherwise typical, unguiculus normal (Figure 71).

MESOLEG: Coxa and trochanter normal; femur with 12 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 72); tibiotarsus normal; unguis as with proleg; unguiculus with 2 corner teeth (Figure 74).

METALEG: Coxa and trochanter typical; femur with 13 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 73); tibiotarsus normal; claw as with mesoleg (Figure 75).

BODY: Collophore with 1+1 subapical and lateral setae. Tenaculum rarely with 5 setulae. Manubrium and dens typical, without ID accessory seta. Mucro with inner teeth, basal seta (Figure 76). Bothriotrichium D complex Type I. Female circumanal setae and subapical appendages normal. Length 1.0-1.25 mm.

DIAGNOSIS: This species is very similar to S. fitchi. Separation of these species may be accomplished on the basis of the following features:

<u>fischeri</u>	<u>fitchi</u>
ANT IV apical bulb absent	present
2 outer basal teeth on proclaw	0
2 outer basal teeth on metaclaw	1
2 meta-unguicular corner teeth	1
filament < 0.3 length of unguiculus	<u>≥</u> 0.4

Sminthurus fischeri also resembles S. butcheri and S. packardi. Both of these species differ by the presence of 4 oval organs on the frons. Sminthurus butcheri also has ID accessory setae on the dens.

DISTRIBUTION: Georgia - Clarke Co., University of Georgia Botanical Garden, leaf litter, Riparian forest, 21-XI-1980, 10-XI-1980, R.J. Snider (MSUE, RJS); Hart Co., Hartwell Lake, leaf litter, 26-VI-1981, R.J. Snider (MSUE, RJS).

TYPE SPECIMENS: Holotype (female), allotype (male), paratypes - MSUE
Paratypes - UGA.

Figures 74 - 80

74 - mesoclaw

75 - metaclaw

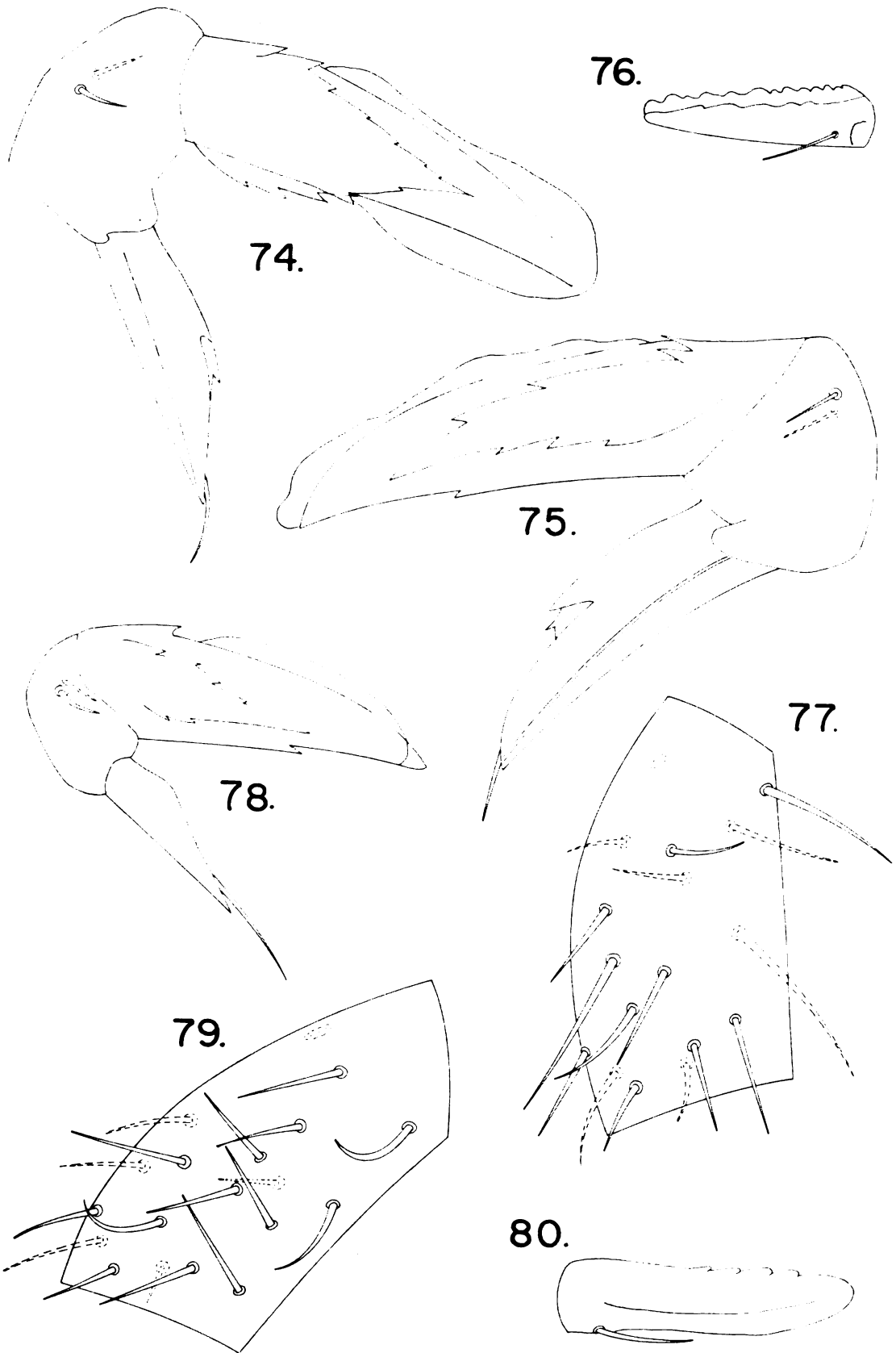
76 - mucro

77 - *S. fitchi*, profemur, anterior view

78 - proclaw

79 - mesofemur, anterior view

80 - mucro



Sminthurus fitchi Folsom, 1896

- Smynthurus fitchii, Folsom, 1896
Smynthurus argenteornatus, Banks, 1899, n. syn.
Smynthurus trilineatus, Banks, 1903
Sminthurus fitchi, Folsom, 1934
Sminthurus obscurus, Mills, 1934
Sminthurus fitchi, Brimley, 1942
Sminthurus trilineatus, Wray, 1950
Sminthurus fitchi, Maynard, 1951
Sminthurus argenteornatus, Maynard, 1951
Sminthurus fitchi, Bellinger, 1954
Sminthurus fitchi, Stach, 1956
Sminthurus obscurus, Stach, 1956
Sminthurus argenteornatus, Stach, 1956
Sminthurus fitchi, Wray & Knowlton, 1956
Sminthurus fitchi, Bickestaff & Huggans, 1962
Sminthurus fitchi, DuRant & Fox, 1966
Sminthruus fitchi, Snider, 1967
Sminthurus trilineatus, Snider, 1967
Sminthurus fitchi, Wray, 1967a
Sminthurus argenteornatus, Wray, 1967a
Sminthurus fitchi, Knowlton & Wray, 1975
Sminthurus argenteornatus, Graves, et al., 1977
Sminthurus fitchi, Graves, et al., 1977
Sminthurus argenteornatus, Christiansen & Bellinger, 1981
Sminthurus fitchi, Christiansen & Bellinger, 1981

MORPHOLOGICAL DESCRIPTION

HEAD: Ocellus D $1/2$ and ocellus C $2/3$ diameter of ocelli A and B.

ANT IV with 17-18 subsegments, apical bulb, apical papilla. Frons with 3 oval organs.

PROLEG: Coxa and trochanter typical; femur with 10 anterior and 7 posterior setae, posterior oval organ (Figure 77); tibiotarsus normal; unguis with inner tooth, smooth or finely serrate pseudonychia, no outer basal teeth; unguiculus typical (Figure 78).

MESOLEG: Coxa and trochanter typical; femur with 13 anterior and 3 posterior setae, 2 posterior setuale, posterior oval organ (Figure 79); tibiotarsus normal; unguis with inner tooth, serrate pseudonychia,

single outer basal tooth; unguiculus typical (Figure 81).

METALEG: Coxa and trochanter; femur with 15 anterior and 2 posterior setae, 2 posterior setulae, posterior oval organ (Figure 82); tibiotarsus normal; claw as with mesoleg (Figure 83).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens typical, no ID accessory setae. Mucro with inner teeth, basal seta (Figure 80). Bothriotrichium D complex Type I. Female circumanal setae and subanal appendages normal. Length 3.0 mm maximum.

DIAGNOSIS: Christiansen and Bellinger (1981) identify Sminthurus fitchi by the ratio of the metaunguicular filament and metatibiotarsal L_2 seta (=AI₂ of this system) to the length of the unguis. However, these features vary too much to be reliable taxonomic characters. Consistent characters for separating S. fitchi from S. butcheri and S. packardii are: number of oval organs on the frons, presence or absence of metatibiotarsal PL₆ seta, ANT IV apical bulb, number of outer basal teeth on the pro-unguis, and ID accessory setae on the dens (cf. butcheri and packardii).

The color pattern of this widely-distributed species is quite variable, although the external morphology is very consistent. Examination of S. argenteornatus co-types revealed no morphological differences from S. fitchi. The specific name argenteornatus is therefore synonymized with fitchi. Maynard (1951) mentioned light blue specimens of S. argenteornatus in Banks' collection. Upon examination these specimens proved to be S. fitchi.

DISTRIBUTION: District of Columbia - moss and dead leaves, V, N. Banks (holotype of trilineatus) (USNM).

Florida - Dade Co., Everglades National Park, research road, grass, 26-XII-1980, R.J. Snider (RJS); Glades Co., Bridge 050031, 28-VI-1978, E.S. Del Fosse (RJS); St. Johns Co., Augustine - Moultiere, Deltona, grass along lake shore, 14-XII-1982, R.J. Snider (RJS).

Indiana - Dubois Co., Forage Farm, pitfall traps, 26-V-1966, 9, 22, 23, 29-VI-1966, 7-VII-1966, L. Pedigo (PUL).

Massachusetts - Middlesex Co., Arlington, on dead sticks in pine woods, 19-VIII-1892, J.W. Folsom (holotype) (USNM, MCZ); Plymouth Co., East Wareham, 31-V-1931, no collector (KG).

Michigan - Keewenaw Co., Isle Royale, Daisy Farm Camp, swamp, pit trap, 12-VII-1965, D. Bixler (RJS); Monroe Co., pit trap, 10-VI-1965, 5-VII-1965, R.J. Snider (RJS); Schoolcraft Co., grass, 8-VII-1960, R.J. Snider (RJS).

New York - Nassau Co., Sea Cliff, Long Island, woods, on ground, no date, N. Banks (co-types of argenteornatus) (MCZ, USNM); Saint Lawrence Co., Oswegatchie, ground under pine tree, 29-VI-1947, E.A. Maynard (USNM).

North Carolina - Macon Co., Coweeta Hydrologic Laboratory, headquarters, tall grass, 8-VII-1980, R.J. Snider; 18-VII-1980, W. Hargrove (RJS); Swain Co., Great Smokey Mountains National Park, ex Prunus pennsylvanica, 30-VII-1942, W.F. Turner and J.R. Thomson, Jr. (USNM).

Pennsylvania - Venango Co., Pithole County Park, across from visitor's center, grass, 16-IX-1981, S.J. Loring (SL).

Texas - Cameron Co., San Benito, on bean leaf, 24-II-1944, no collector (USNM).

Virginia - Giles Co., Mountain Lake Biological Station, 3800 feet elevation, grass, 6-VIII-1981, S.J. Loring and R.M. Snider (RJS, SL).

West Virginia - Hardy Co., Lost River State Park, 1-XI-1950, O.L. Cartwright (RJS, SL)

Wyoming - Park Co., north of Powell, 18-VI-1935, M. Greenwald *USNM).

This species has been reported from the following locations, but the identity of the specimens could not be confirmed by this author.

Connecticut - Litchfield Co., Cornwell, Cathedral Pines, 800-900 feet elevation, P.F. Bellinger; Middlesex Co., Middlefield, east shore of Mt. Higby Reservoir, Pinus resinosa Ait., Pinus strobus L., mixed pine and hemlock (Tsuga canadensis L.), P.F. Bellinger (Bellinger, 1954).

Deleware - Sussex Co., Rehoboth Beach, salt marsh, 25-VII, E.A. Maynard (Maynard, 1951).

Illinois - Moultrie Co. (Christiansen and Bellinger, 1981).

Indiana - Tippecanoe Co., Wayne Co. (Christiansen and Bellinger, 1981).

Idaho - Bear Lake Co., Montpelier, grass and moss, 6-VII, G.F. Knowlton (Wray and Knowlton, 1956).

Iowa - Story Co., Ames, grass, no date, H.B. Mills (Mills, 1934).

Louisiana - East Baton Rouge Par., soil sample, no date (Hepburn and Woodring, 1963, as argenteornatus); Baton Rouge Par., Ouachita Par., Rapides Par. (Christiansen and Bellinger, 1981).

Maine - Cumberland Co. (Christiansen and Bellinger, 1981).

Maryland - Anne Co., Laurel, Patuxent Research Refuge, no date, J.L. Ostdiek (Ostdiek, 1961); Montgomery Co., Hyattstown, 27-VII, E.A. Maynard (Maynard, 1951, as argenteornatus); Prince Co., Lanham, 24-VII, E.A. Maynard; Somerset Co., Monie, 27-VII, E.A. Maynard; Wicomico Co., Quantico, Salisbury, 26-VII, E.A. Maynard (Maynard, 1951).

Massachusetts - Middlesex Co., Belmont, pine woods, 25-V, J.W. Folsom; Plymouth Co., East Wareham, vines in cranberry bog, 1-IX, H.J. Franklin (Folsom, 1934).

Mississippi - Warren Co. (Christiansen and Bellinger, 1981).

Missouri - Boone Co., soybeans, 2-VI to 1-IX, no collector (Bickestaff and Huggans, 1962).

New Jersey - Middlesex Co., Dayton, 28-VII, E.A. Maynard (Maynard, 1951); Union Co. (Christiansen and Bellinger, 1981).

New York - Nassau Co., Glen Cove, Long Island, 28-VII, E.A. Maynard; Orange Co., Highland Falls, E.A. Maynard (Maynard, 1951); Saint Lawrence Co., Star Lake, Blueberry and low argenteornatus; Westchester Co., Peekskill, 29-VII, E.A. Maynard; Ulster Co., West Hurley, 29-VII, E.A. Maynard (Maynard, 1951).

North Carolina - Macon Co., Highlands, Van Hook Campground Area, moss on log under rhododendrons, 17-VII-1962; moss on rocks near spring, 3880 feet elevation, 24-VII-1962; Cullasaja River Gorge, 3280-3400 feet elevation, ex shelf fungus (Polyporus pargmenus Fries), on Acer sp., 9-VI-1962, (Graves et al., 1977, as argenteornatus); Highlands, ex Polyporus sulphureus Bull. ex Fries, 26-VII; sphagnum-like moss on rocks under rhododendron, 4100 feet elevation, 10-VII-1962, (Graves et al., 1977, as fitchi); Transylvania Co., Pink Beds, 18 miles north-northwest of Brevard, 3280 feet elevation, ex fungus Agaricaceae on Quercus alba, 1-VII-1962 (Graves et al., 1977, as argenteornatus); Wake Co., Raleigh, X, (Wray, 1967a, as fitchi); Raleigh, leaf mould, edge of Lake Raleigh, 9-i-1948, D.L. Wray (Wray, 1967a, as trilineatus).

Pensylvania - Heidlersberg, 23-VII, E.A. Maynard (Maynard, 1951).

South Carolina - Anderson Co., Clemson, hardwood forest soil and litter, V-IX-1962, J.A. DuRant and R.C. Fox (DuRant and Fox, 1966).

Utah - Box Elder Co., Wildcat Hills, sage litter, 18-IV-1974, no collector (Knowlton and Wray, 1975).

TYPE SPECIMENS: Co-types - USNM, INHS, MCZ, ISU.

Figures 81 - 86

81 - mesoclaw

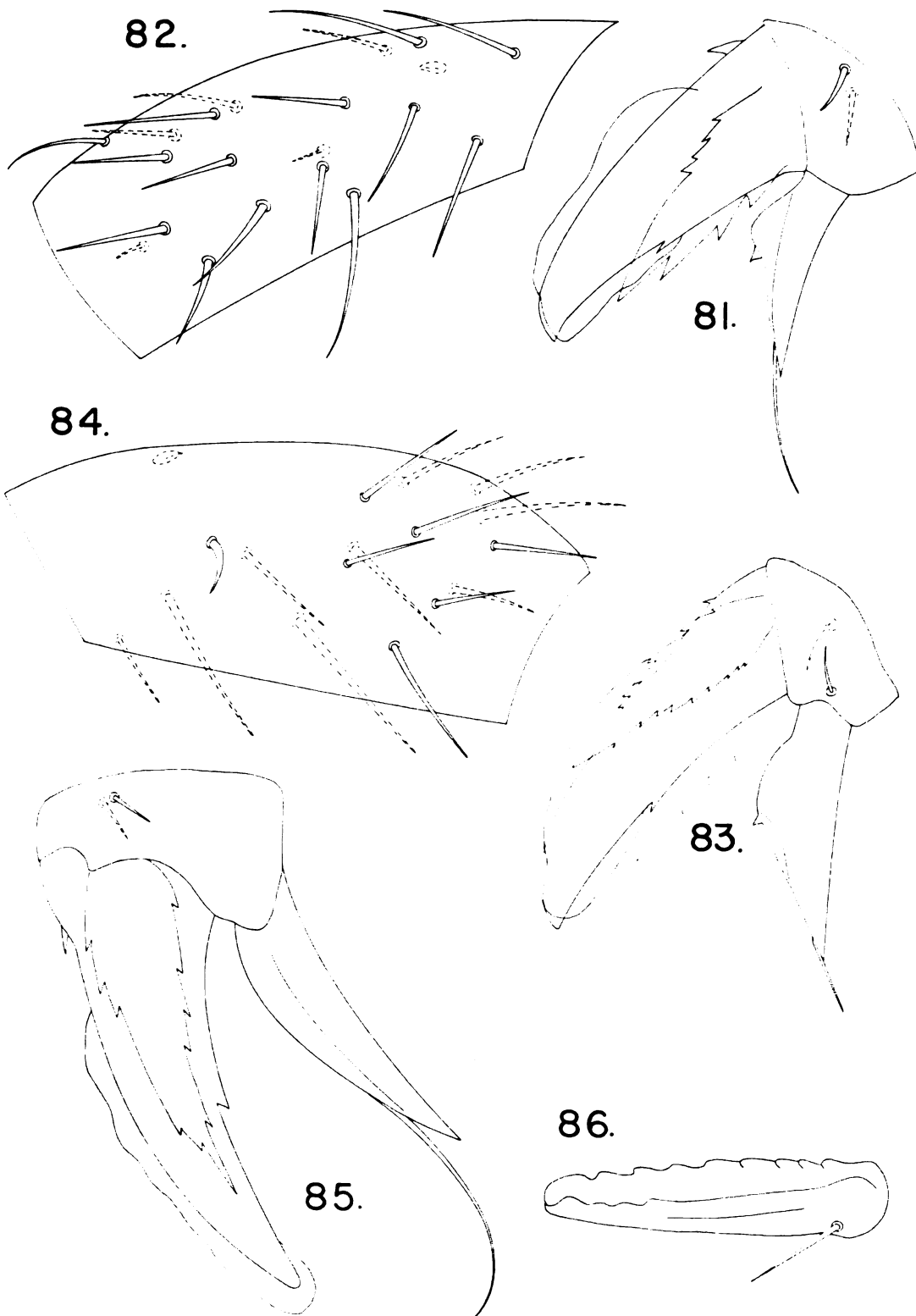
82 - metafemur, anterior view

83 - metac claw

84 - *S. floridanus*, profemur, anterior view

85 - proclaw

86 - mucro



Sminthurus floridanus MacGillivray, 1893Smynthurus floridanus, MacGillivray, 1893Smynthurus floridana, MacGillivray, 1894Sminthurus floridana, Folsom, 1934Sminthurus floridanus, Christiansen and Bellinger, 1981Sminthurus floridanus, Snider, 1982

MORPHOLOGICAL DESCRIPTION

HEAD: Ocelli C and D $1\frac{1}{2}$ diameter of ocelli A and B. Antennal segment ratio 1:1:7:2:5. ANT IV with 20 subsegments, apical papilla, without apical bulb. Only 2 frontal and 1 postgenal oval organs.

PROLEG: Coxa and trochanter normal; femur with 7 anterior and 10 posterior setae, posterior oval organ (Figure 84); tibiotarsus typical, PE₅ sometimes absent; claw normal (Figure 85).

MESOLEG: Coxa with 2 setae, oval organ; trochanter typical; femur with 1e anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 87); tibiotarsus normal; claw normal (Figure 88).

METALEG: Coxa and trochanter typical; femur with 15 anterior and 1 posterior setae, 2 posterior setulae, posterior oval organ (Figure 89); tibiotarsus with 5 posterior oval organs, otherwise typical; claw normal (Figure 90).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens normal, no ID setae; mucro with inner teeth, basal seta (Figure 86). Bothriotrichium D complex Type I. Female circumanal setae and subanal appendages typical. Posterior portion of dorsum with large protruberance (Figure 91). Length 1.75 mm.

DIAGNOSIS: This is the most distinctive species of Sminthurus. The posterior dorsal protrubance is unique within the genus. Other unique characters are: two oval organs on the frons, one postgenal oval organ, and five posterior metatibiotarsal oval organs.

For many years the only known record for this species was the battered type specimen collected in Florida. This species fhas been found recently in South Carolina (Snider, 1982) and Georgia. Further sampling of the southeastern United States may increase our knowledge of this species.

DISTRIBUTION: Florida - location unknown (holotype) (USNM).

Georgia - Putnam Co., Lake Sinclair, Oconee National Forest, grass, 25-V-1982, R.J. Snider (RJS).

South Carolina - Barnwell Co., Savannah River Ecological Laboratory, grass, road B, 100 yards northeast of road A, 12-XI-1980, R.J. Snider; roadside grass, 25-VIII-1980, R.J. Snider; grass, road B, 100 yards northeast of raod A, 18-VI-1981, R.J. Snider; grass under powerline cut along road E, 18-V-1982, W. Hargrove; grass, road G, pond 4, 26-V-1982, R.J. Snider (RJS).

TYPE SPECIMEN: Holotype - USNM.

Figures 87 - 91

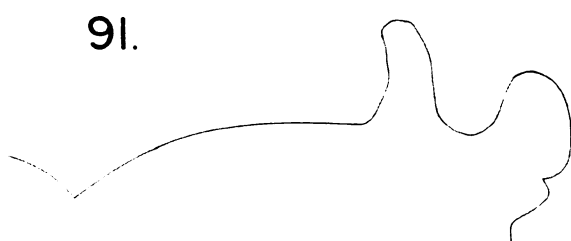
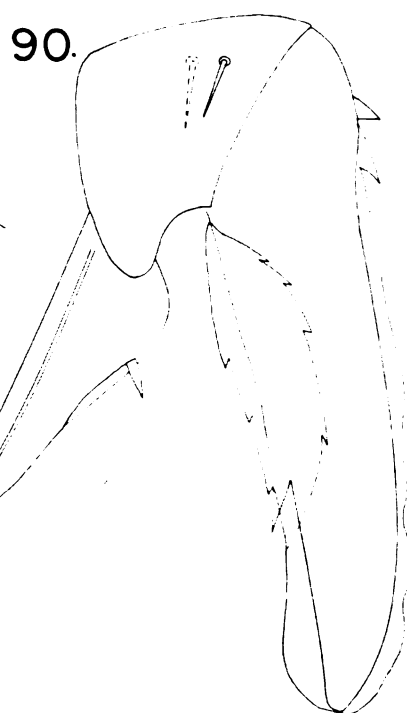
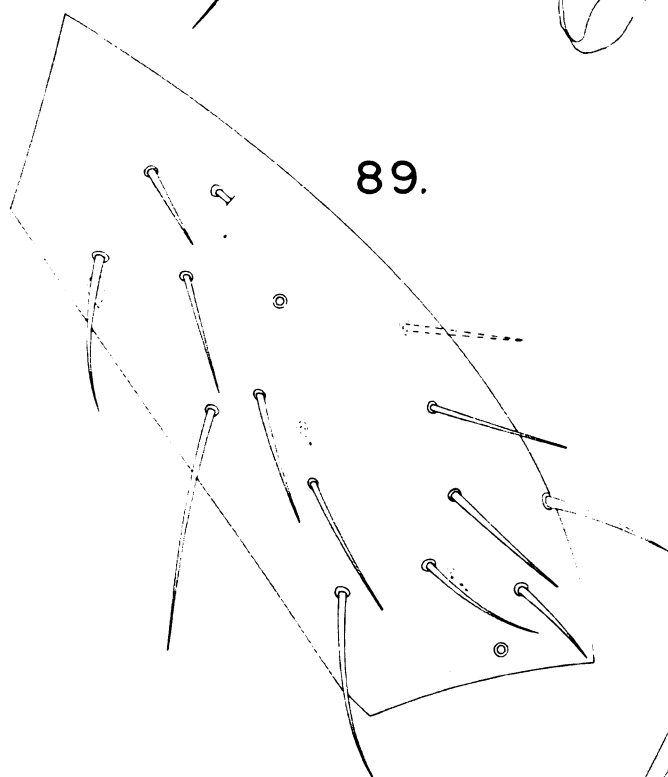
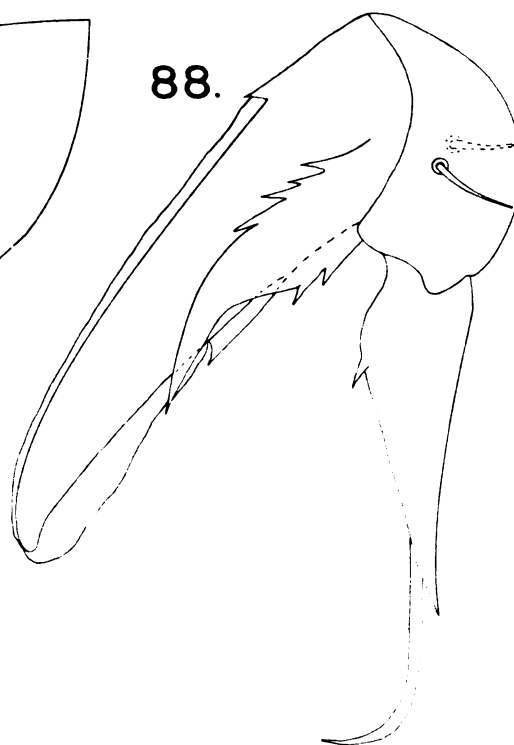
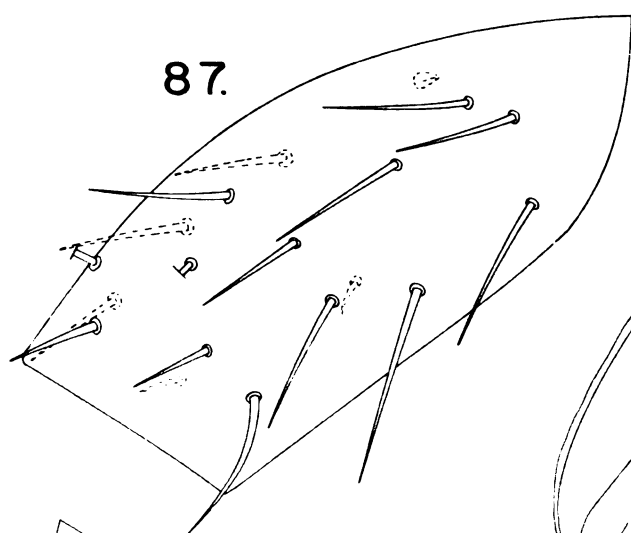
87 - mesofemur, anterior view

88 - mesoclaw

89 - metafemur, anterior view .

90 - metac claw

91 - profile of dordum showing posterior protruberance



Sminthurus incisus Snider, 1978Sminthurus incisa, Snider, 1978Sminthurus incisus, Christiansen and Bellinger, 1981

MORPHOLOGICAL DESCRIPTION

HEAD: Ocelli C and D $1/2$ diameter of ocelli A and B. Antennal segment ratio 1:2:2:5. ANT IV with 17-19 subsegments, apical bulb, and apical papilla. Frons with 3 oval organs.

PROLEG: Coxa with 1 seta; trochanter typical; femur with 8 anterior and 7 posterior setae, posterior oval organ (Figure 92); tibiotarsus normal; claw without basal tooth, otherwise typical (Figure 93).

MESOLEG: Coxa and trochanter typical; femur with 10 anterior and 4 posterior setae, 2 posterior setulae, posterior oval organ (Figure 94); tibiotarsus normal; claw without basal tooth, otherwise typical (Figure 95).

METALEG: Coxa and trochanter typical; femur with 14 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 96); tibiotarsus lacking PL₆ seta, otherwise normal; claw without basal tooth, otherwise typical (Figure 97).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens normal, with ID accessory seta. Mucro smooth, basal seta (Figure 98). Bothriotrichium D complex Type II. Female circumanal setae and subanal appendages typical. Length 2 mm maximum.

DIAGNOSIS: This species is known only from specimens collected in 1954. Unfortunately, these specimens are not in good condition; color patterns have faded and many fine structures are difficult to see. This species is distinguished by the absence of metatibiotarsal seta PL_6 and smooth edges on the mucro. The species also apparently has 15 profemur setae and 14+2 or 15+1 mesofemur setae + setulae. An ID accessory seta may be present on the dens, but is difficult to discern on the available specimens. The species is marked by strongly serrate and incised ungual pseudonychia. All known specimens were collected north of the Arctic Circle by Dr. Peter Bellinger.

DISTRIBUTION: Alaska - Barrow-Kobuk Co., Umiat, Colville River, grass, 31-VIII-1952, P.F. Bellinger; Utikok River, driftwood, 1-7-VIII-1952, P.F. Bellinger (holotype); Fairbanks-Ft. Yukon Co., Chandalar Lake, Brooks Mountains, sweeping on tundra, 21-VII-1952, P.F. Bellinger; Footprint Lake, 14-VII-1952, P.F. Bellinger (MCZ, MSUE, INHS, KC).

TYPE SPECIMENS: Holotype and paratypes - MCZ. Paratypes - MSUE, INHS, KC.

Figures 92 - 98

92 - *S. incisus*, profemur, anterior view

93 - proclaw

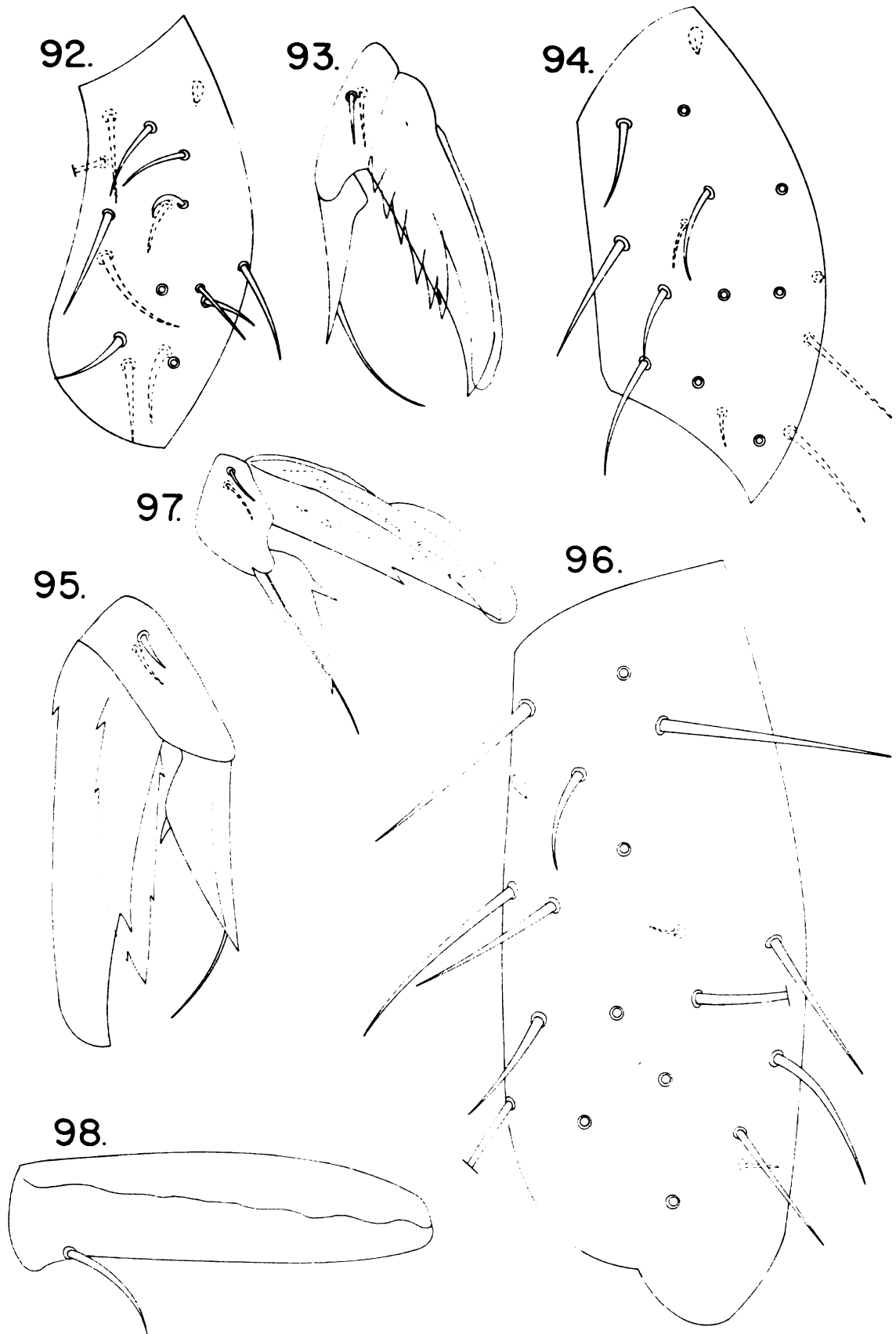
94 - mesofemur, anterior view

95 - mesoclau

96 - metafemur, anterior view

97 - metacław

98 - mucro



Sminthurus incognitus Snider and Loring, 1982

MORPHOLOGICAL DESCRIPTION

HEAD: Ocelli A and B subequal, twice diameter of C and D. Antennal segment ratio 1:1:5:2:5:6. ANT IV with 15 subsegments, apical bulb, apical papilla. Frons with 3 oval organs.

PROLEG: Coxa and trochanter typical; femur with 8 anterior and 9 posterior setae, posterior oval organ (Figure 99); tibiotarsus with seta replacing anterior oval organ, otherwise normal; claw typical (Figure 100).

MESOLEG: Coxa and trochanter typical; femur with 12 anterior and 4 posterior setae, 2 posterior setula, posterior oval organ (Figure 101); tibiotarsus with anterior oval organ replaced by seta, otherwise normal; claw typical (Figure 102).

METALEG: Coxa with 3 setae; trochanter typical; femur with 14 anterior and 1 posterior setae, 2 posterior setulae, posterior oval organ (Figure 103); tibiotarsus with anterior and distal posterior oval organs replaced by setae, with accessory seta between PE_2 seta and second oval organ, otherwise normal; claw typical (Figure 104).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium normal. Dens with 13 E file setae, 11-12 L file setae, 11-12 ID file setae, without accessory seta (Figures 106-107). Mucro with inner teeth, basal seta (Figure 105). Bothriotrichium D complex Type I. Female circumanal setae and subanal appendages normal. Length 1.5 mm.

DIAGNOSIS: Sminthurus incognitus may be separated from all other nearctic species of Sminthurus by the presence of 11-12 L file and 13 E file setae on the dens (all other nearctic species have 7 and 8 setae, respectively).

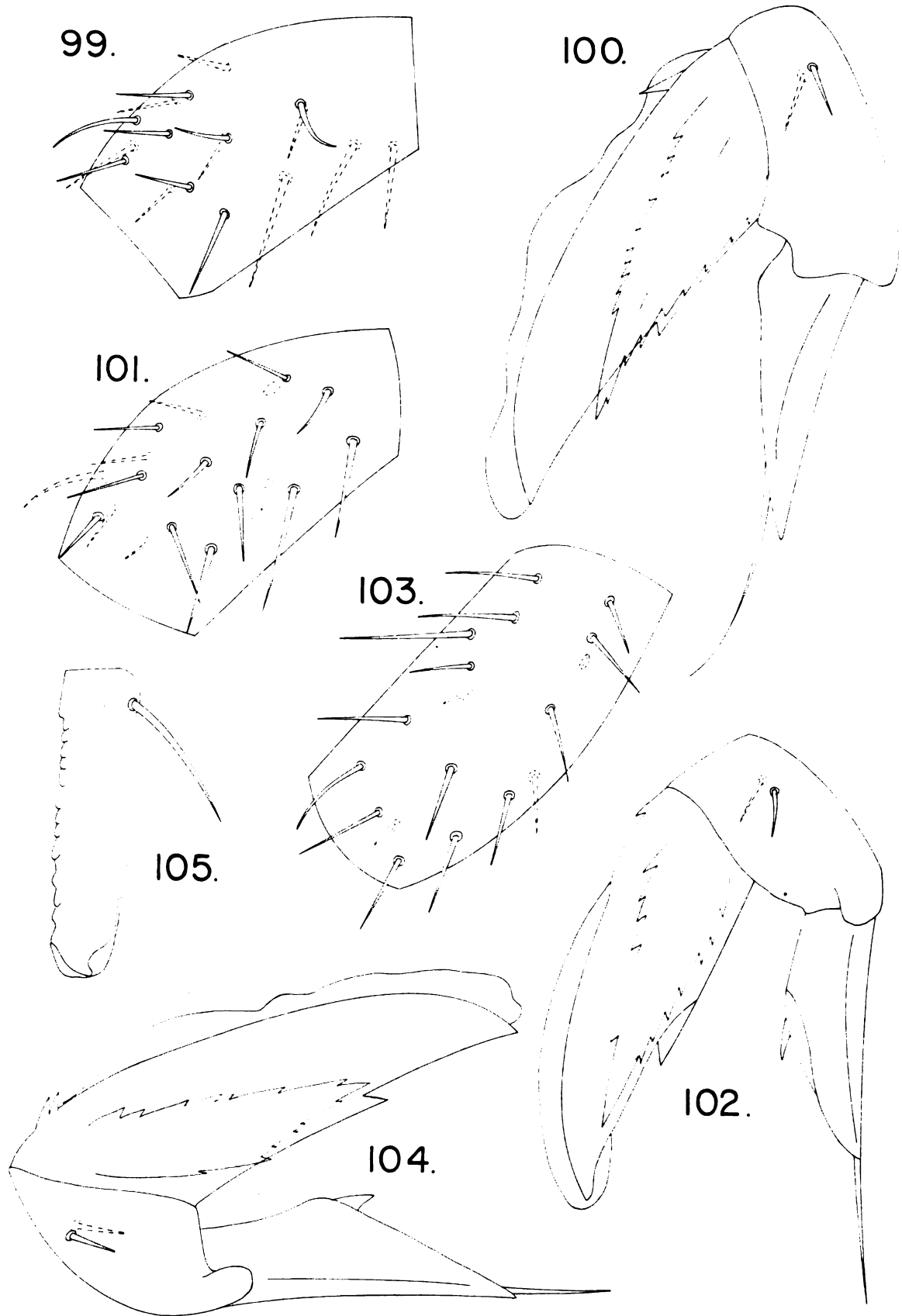
Some of the leg oval organs in this species are replaced by an apparently normal seta. Because of this, misinterpretations were made in the published description of this species (Snider and Loring, 1982) and are now corrected. The metatibiotarsal seta labeled AE₁, actually is a seta replacing the anterior oval organ. The true AE₁ seta is mislabeled AE₂ and all subsequent AE file setae are similarly mislabeled. The accessory setae give the impression of 10 AE setae and 8 PE setae. The posterior accessory₂ seta is truly an additional seta. The labeled PE₃ seta is actually the PE₂ seta, so that the PE file setae run from PE₀-PE₆. It also was incorrectly stated that there are six metatibiotarsal E file setae; in fact, there are 7.

DISTRIBUTION: Florida - Collier Co., State Road 82, bridge 120062, ex. Polygonum hydropiperoides Michaux, 2_III-1978, E.S. DelFosse (MSUE); Lee Col, bridge 120060, ex. Polygonum, 2-XI-1977, 22-XI-1977, E.S. DelFosse (MSUE).

TYPE SPECIMENS: Holotype and paratypes - MSUE.

Figures 99 - 105

- 99 - *S. incognitus*, profemur
- 100 - proclaw
- 101 - mesofemur, anterior view
- 102 - mesoclau
- 103 - metafemur, anterior view
- 104 - metacław
- 105 - mucro



Figures 106 - 109

106 - right dens, dorsal view

107 - right dens, ventral view

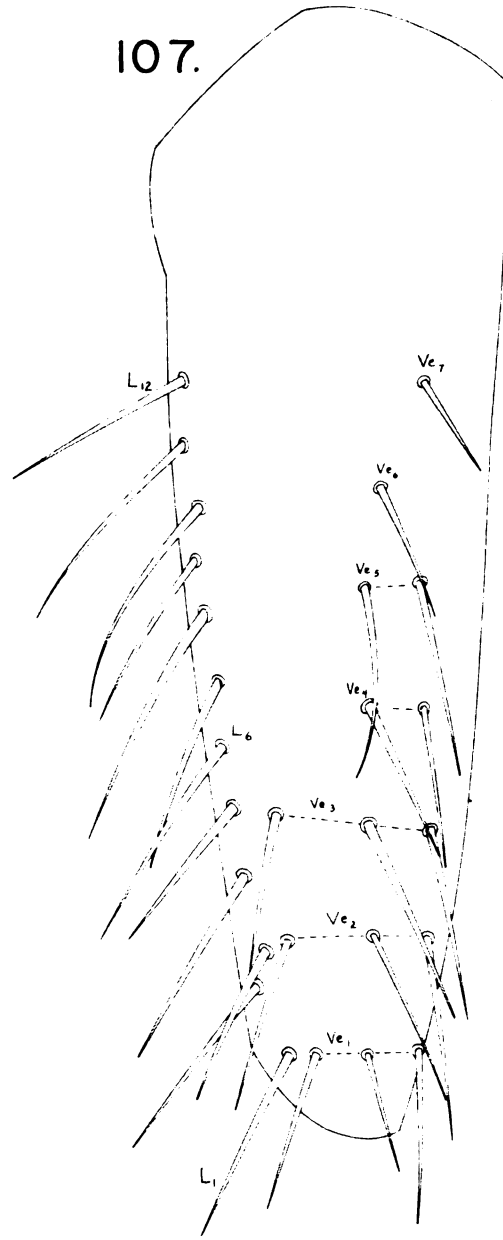
108 - *S. mendenbergi*, proclaw

109 - mucro

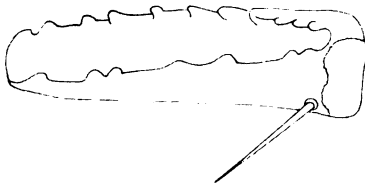
106.



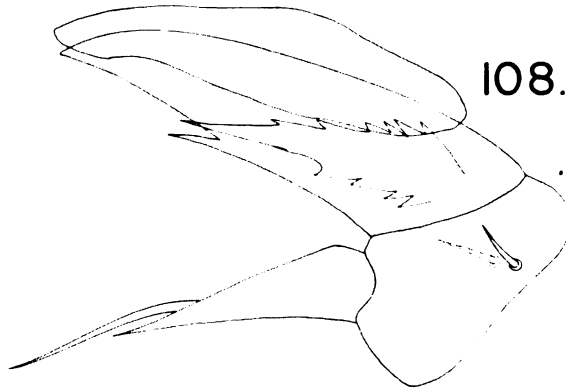
107.



109.



108.



Sminthurus mendenbergi Snider, (IN PRESS)

MORPHOLOGICAL DESCRIPTION

HEAD: ANT IV with 17-18 subsegments, apical papilla resembling apical bulb. Frons with 4 oval organs.

PROLEG: Coxa and trochanter typical; femur with 17 setae, 1 posterior oval organ (Figure 110); tibiotarsus normal; unguis with inner tooth, strongly serrate pseudonychia, expanded tunica, no outer basal teeth (Figure 108).

MESOLEG: Coxa and trochanter typical; femur with 13 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 111); tibiotarsus normal; unguis as with proleg, single outer basal tooth; unguiculus normal, sometimes with 2 corner teeth (Figure 112).

METALEG: Coxa and trochanter typical; femur with 14 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 113); tibiotarsus normal; unguis as with mesoleg, 2 outer basal teeth; unguiculus typical, sometimes with 2 corner teeth (Figure 114).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens typical, without ID accessory setae. Mucro with several teeth on inner and outer edges, basal seta (Figure 109). Bothriotrichium D complex Type I. Female circumanal setae normal. Subanal appendages stoutly serrate at end in ventral view. Length 2.0 mm.

DIAGNOSIS: On the basis of the serrate subanal appendages, Sminthurus mencenbergi will key out to S. purpurescens using Christiansen and Bellinger (1981). However, the subanal appendages of S. purpurescens are palmate and finely fringed instead of the stout serrations present on the subanal appendages of S. mencenbergi. Furthermore, S. purpurescens is distinguished by a spine on the metatrochanter and absence of the metatibiotarsal PL₇ seta.

If the female subanal appendages cannot be seen, S. mencenbergi may key out to S. butcheri, S. fitchi, or S. packardi. Separation from these species may be done on the following basis:

<u>mencenbergi</u>	<u>butcheri</u>	<u>fitchi</u>	<u>packardi</u>
ANT IV apical bulb absent	present	present	absent
4 frontal oval organs	4	3	4
meta PL seta present	present	present	absent
2 basal unguis teeth	1	1	1-2
outer mucronal teeth present	absent	absent	absent

DISTRIBUTION: Alberta - Banff National Park, Camp Two Jack, clover, elevation 2000 feet, 22-VIII-1982, L. Mencenberg (MSUE).

British Columbia - Mt. Assiniboine National Park, O'Brian Meadow, short grass, elevation 7200 feet, 1-IX-1982, L. Mencenberg (MSUE).

Michigan - S. Clair Co., Lakeport State Park, grass, 2-VIII-1960, R.J. Snider (MSUE).

TYPE SPECIMENS: Holotype and paratypes - MSUE.

Figures 110 - 114

110 - profemur, anterior view

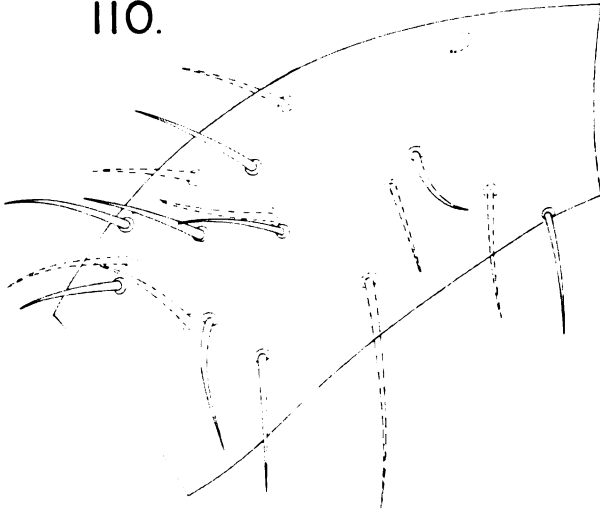
111 - mesofemur, anterior view

112 - mesoclaw

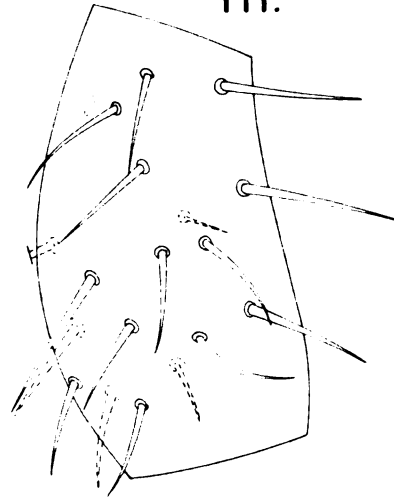
113 - metafemur, anterior view

114 - metacław

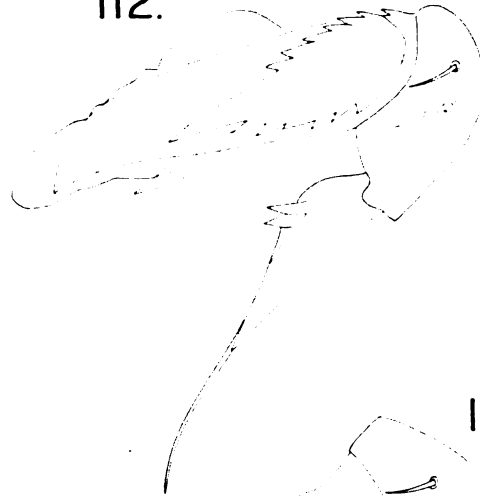
110.



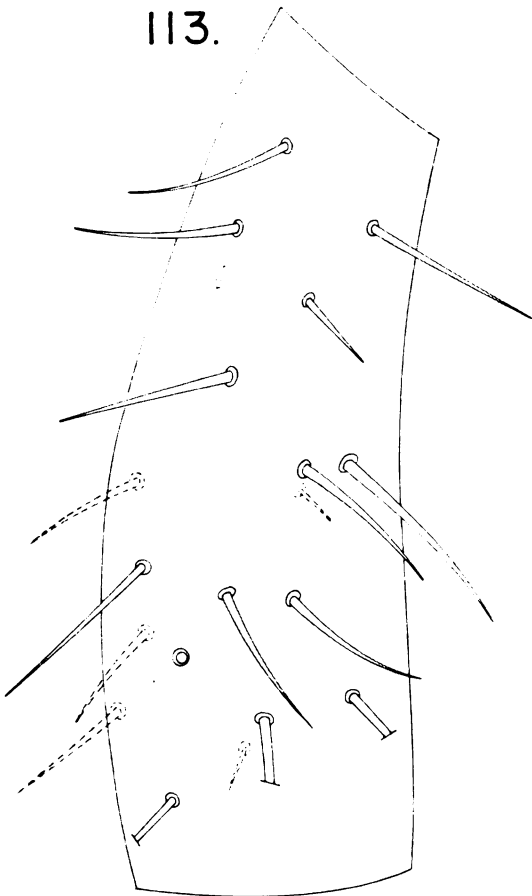
111.



112.



113.



114.



Sminthurus packardii Folsom, 1896Papyrius texensis, Packard, 1873 (in part)Smynthurus packardii, Folsom, 1896Smynthurus packardii, Folsom, 1934Sminthurus packardii, Stach, 1956Sminthurus packardii, Christiansen and Bellinger, 1981

MORPHOLOGICAL DESCRIPTION

HEAD: Ocelli subequal, ocelli C and D $2/3$ diameter of ocellus B.

Antennal segment ratio (male) 1:2:3:7, (female) 1:2:5:3:5:5:5.

ANT IV with 18 subsegments, apical papilla, no apical bulb. Frons with 4 oval organs.

PROLEG: Coxa and trochanter typical; femur with 9 anterior and 8 posterior setae, posterior oval organ (Figure 115); trochanter normal; claw without tunica, otherwise typical (Figure 116).

MESOLEG: Coxa and trochanter typical; femur with 13 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 117); trochanter normal; claw without tunica, otherwise typical (Figure 118).

METALEG: Coxa and trochanter typical; femur with 15 anterior and 2 posterior setae, posterior oval organ (Figure 119); tibiotarsus lacking PL, otherwise normal; claw as with mesoleg (Figure 120).

OBDY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens normal, with or without ID accessory setae. Mucro with inner teeth, basal seta (Figure 121). Bothriotrichium D complex Type I. Female circumanal setae and subanal appendages normal. Length 2.0 mm maximum.

DIAGNOSIS: Sminthurus packardi keys out near S. fitchi in Christiansen and Bellinger (1981) and Stach (1956), and near S. butcheri in Christiansen and Bellinger. Separation may be accomplished by the following characters:

<u>packardi</u>	<u>fitchi</u>	<u>butcheri</u>
ANT IV apical bulb absent	present	present
4 frontal oval organs	3	4
meta PL ₆ seta absent	present	present
1 outer basal tooth on proclaw	0	1

This species appears to be restricted to the southwestern United States.

DISTRIBUTION: Texas - Brazos Co., College Station, under dead leaves, 5-XI-1930, H.B. Mills (metatypes) (MCZ); Brown Co., Brownwood, on oats, 4-V-1938, L.S. Jones (USNM); McLennon Co., Waco, no date, G.W. Belfrage (cotype) (MCZ); Hidalgo Co., LaFeria, under lettuce, 16-I-1950, H.S. Mayeux (USNM, INHS).

Sminthurus packardi has been reported from the following locations:

Louisiana - Ouachita Parish (Christiansen and Bellinger, 1981).

Texas - Brazos Co., Bryan, under dead leaves, 25-III-1930, 12-IV-1930; College Station, under dead leaves, 3-III-1930, 4-IX-1930, H.B. Mills; Red River Co., Avery, damaging tomatoes, 5-IV-1930, H.B. Mills (Folsom, 1934).

TYPE SPECIMENS: Metatypes - INHS. Cotypes - MCZ, USNM.

Figures 115 - 121

115 - *S. packardi*, profemur, anterior view

116 - procalw

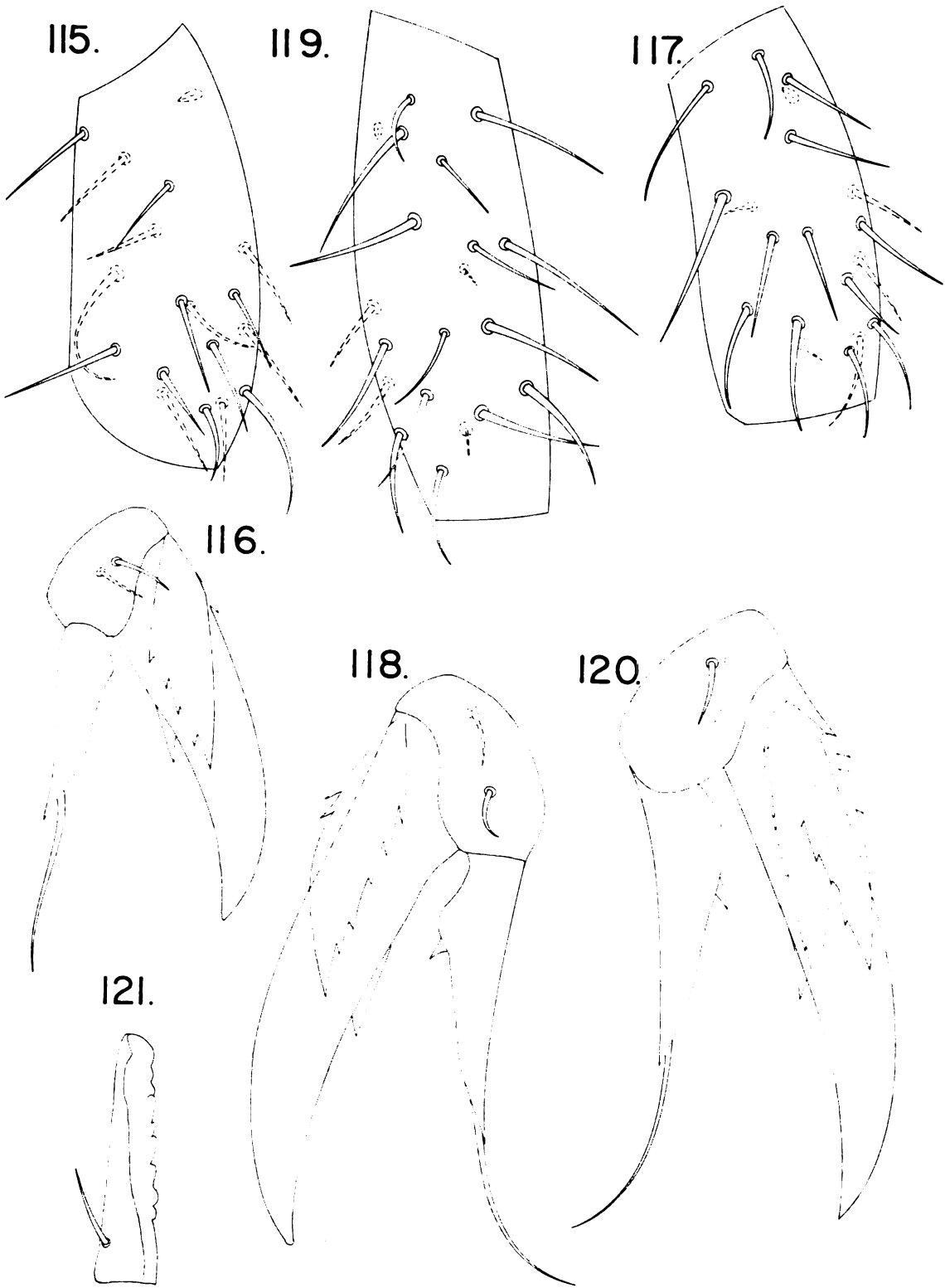
117 - mesofemur, anterior view

118 - mesoclau

119 - metafemur, anterior view

120 - metaclaw

121 - mucro



Sminthurus sagitta Loring and Snider (IN PRESS)
MORPHOLOGICAL DESCRIPTION

HEAD: Ocelli A and B subequal, twice diameter of ocelli C and D.

Antennal segment ration 1:2:3:7. ANT IV with 16 subsegments, apical papilla, without apical bulb. Frons with 3 oval organs.

PROLEG: Coxa and trochanter typical; femur with 9 anterior and 7 posterior setae, posterior oval organ (Figure 132); tibiotarsus normal; unguis with inner tooth, outer basal tooth, pseudonychia with 1 tooth, without tunica; unguiculus typical (Figure 133).

MESOLEG: Coxa with 3 setae, no oval organ; trochanter typical, 1 oval organ; femur with 11 anterior and 4 posterior setae, 2 posterior setulae, posterior oval organ (Figure 134); tibiotarsus normal; unguis as with proleg; unguiculus typical (Figure 137).

METALEG: Coxa with 3 setae; trochanter normal; femur with 14 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 135); tibiotarsus normal; claw as with mesoleg (Figure 138).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens typical, no ID accessory setae. Mucro with inner teeth, basal seta (Figure 136). Bothriotrichium D complex Type I. Female circumanal setae and subanal appendages typical. Length 1.4 mm.

DIAGNOSIS: Sminthurus sagitta most nearly resembles S. butcheri, S. fitchi, and S. packardi. The following morphological features will separate these species:

<u>sagitta</u>	<u>butcheri</u>	<u>fitchi</u>	<u>packardi</u>
ANT IV apical bulb absent	present	present	absent
3 frontal oval organs	4	3	4
16 profemur setae	17	17	17
15 mesofemur setae	16	16	17
meta PL ₆ seta absent	present	present	absent
unequal tunica absent	present	present	present/absent

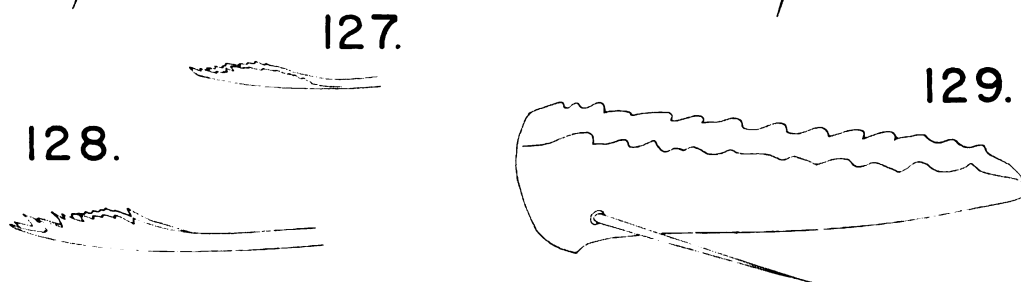
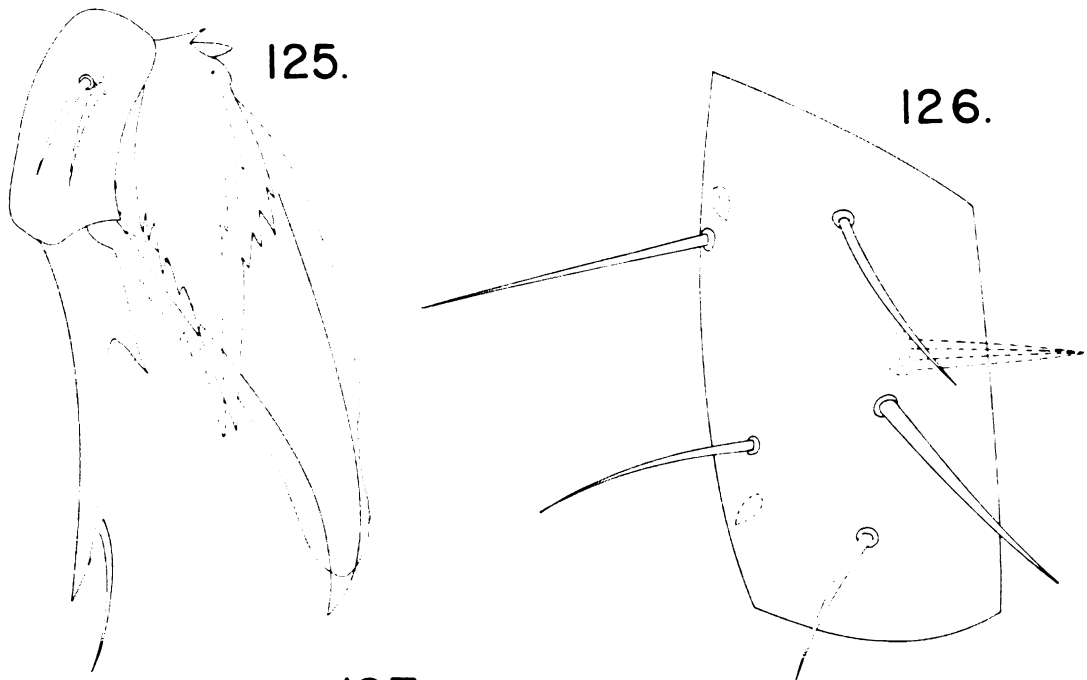
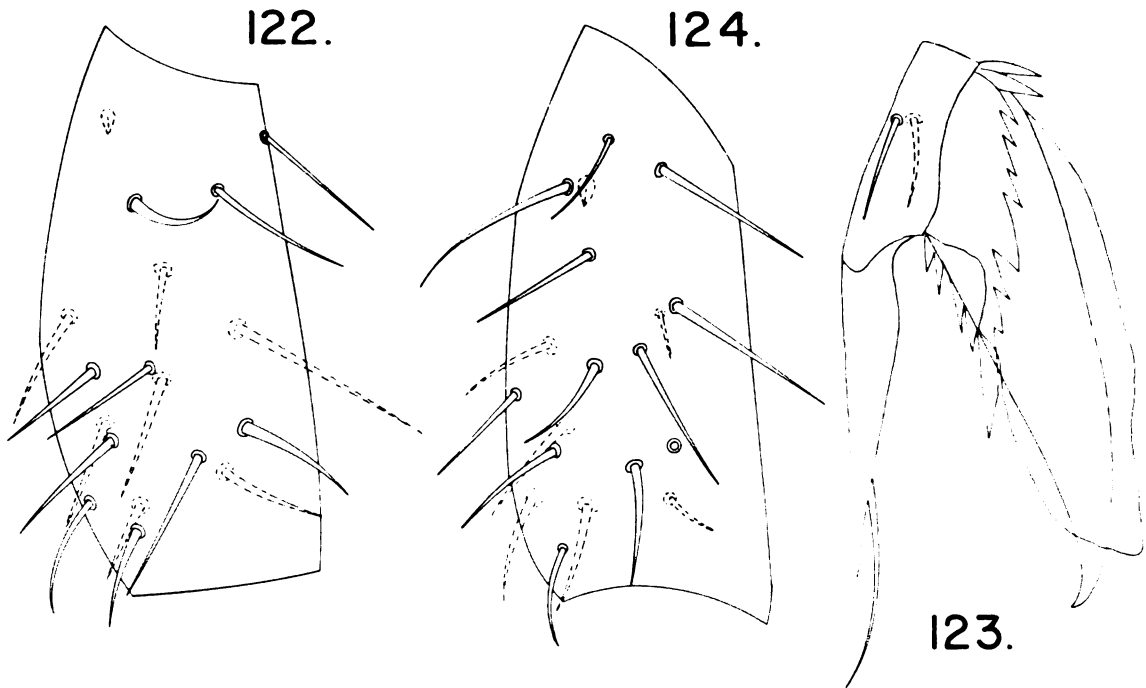
This species is known only from a collection made in 1909. During the intervening years the colors have faded beyond recognition, leaving only a pigment pattern. The condition of the specimens is so poor that some structures (e.g. antennal setal patterns) cannot be discerned. Only one specimen has an entire mucro, and an apparent basal setal socket can be observed but not with complete certainty.

DISTRIBUTION: New Mexico - Colfax Co., Springer, grass sweep at noon, 27-VIII-1909, C.N. Ainslie (USNM, MSUE).

TYPE SPECIMENS: Holotype and paratypes - USNM. Paratypes - MSUE.

Figures 122 - 129

- 122 - *S. purpurescens*, profemur
- 123 - proclaw
- 124 - mesofemur, anterior view
- 125 - mesoclau
- 126 - metatrochanter, anterior view
- 127 - female subanal appendage, lateral view
- 128 - female subanal appendage, lateral view
- 129 - mucro



Figures 130 - 136

130 - metafemur, anterior view

131 - metacław

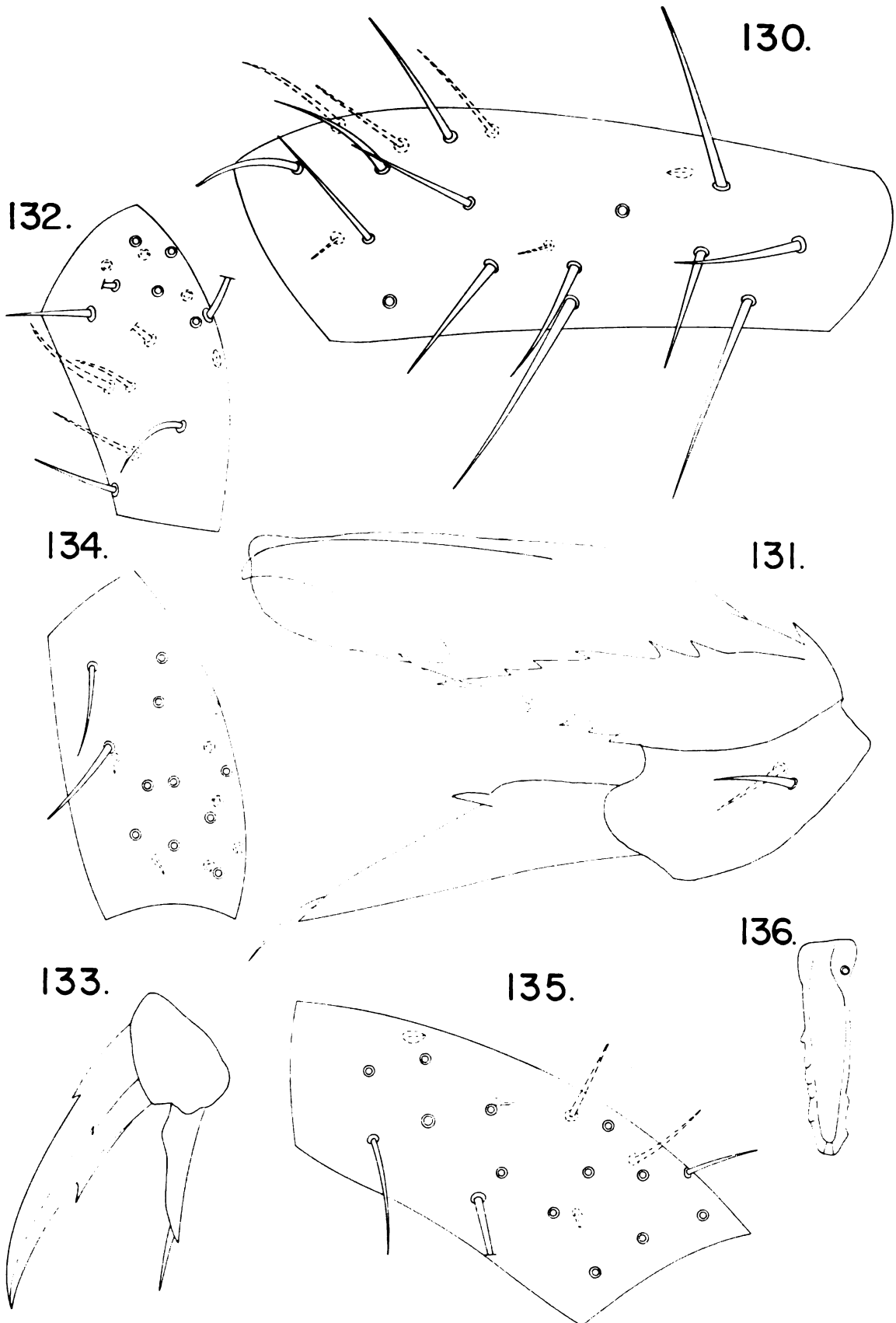
132 - S. sagitta, profemur, anterior view

133 - proclaw

134 - mesofemur, anterior view

135 - metafemur, anterior view

136 - mucro



Figures 137 - 141

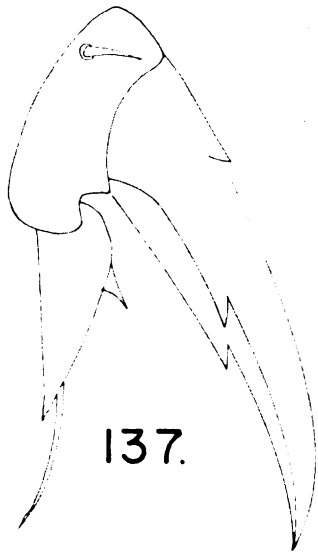
137 - mesoclaw

138 - metacław

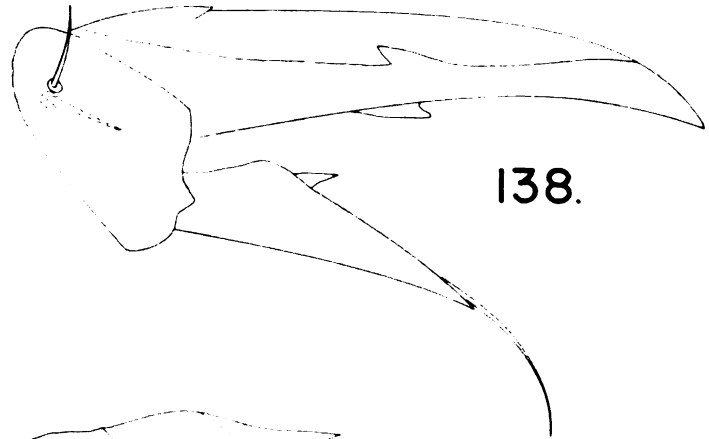
139 - *S. sylvestris*, profemur, anterior view

140 - procalw

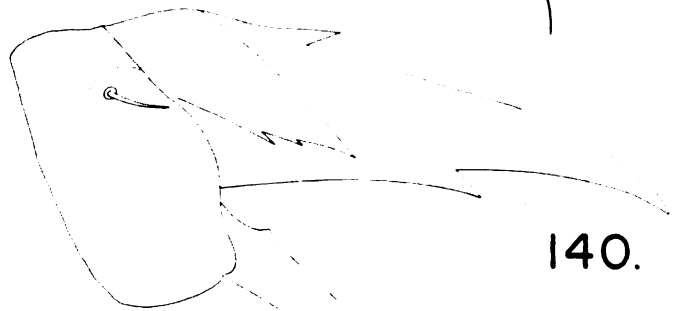
141 - mesoclaw



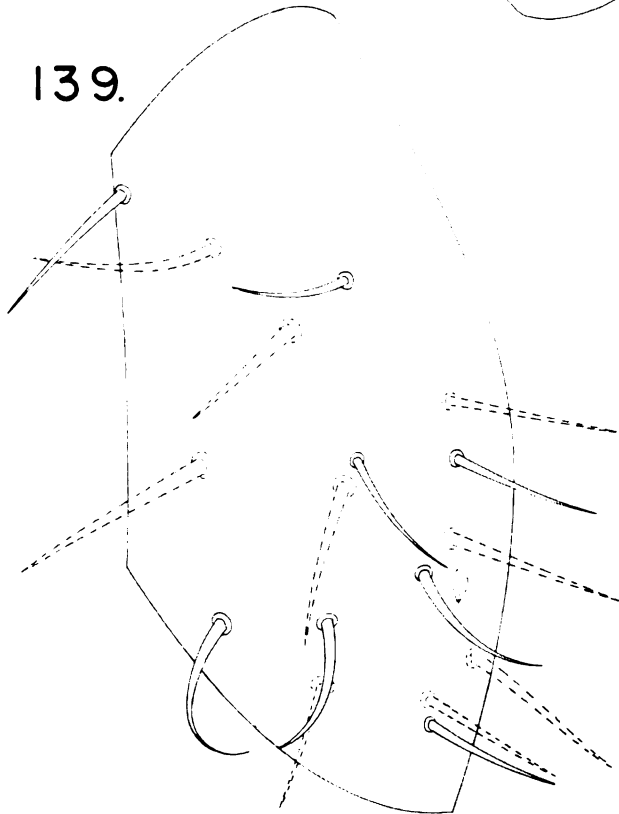
137.



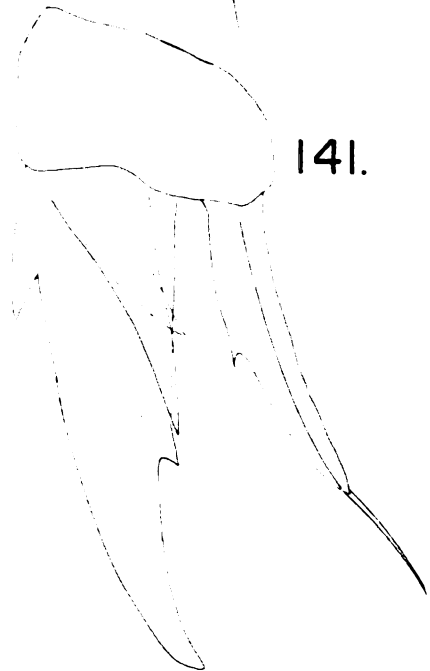
138.



140.



139.



141.

Sminthurus sylvestris Banks, 1899

Smynthurus sylvestris Banks, 1899
Smynthruus facialis Banks, 1903
Sminthurus sylvestris Folsom, 1928
Sminthurus facialis Maynard, 1951
Sminthurus sylvestris Maynard, 1951
Sminthurus sylvestris Stach, 1956
Sminthurus facialis Stach, 1956
Sminthurus sylvestris Wray, 1967a
Sminthurus facialis Pielou and Verma, 1968
Sminthurus sylvestris Hart, 1972
Sminthurus sylvestris Betsch, 1980
Sminthurus sylvestris Christiansen and Bellinger, 1981

MORPHOLOGICAL DESCRIPTION

HEAD: Ocelli A and B subequal, ocellus D $1/2-2/3$ diameter of ocellus

B. ANT IV with 18-22 subsegments, apical bulb, without apical papilla. Frons with 3 oval organs.

PROLEG: Coxa and trochanter typical; femur with 9 anterior and 8 posterior setae, posterior oval organ (Figure 139); tibiotarsus setal pattern typical for genus, but E_1 , AE_o , L_1 , PI_2 , PE_o , and posterior accessory setae clavate; unguis with inner tooth, smooth pseudonychia, outer basal tooth, without tunica; unguiculus typical (Figure 140).

MESOLEG: Coxa and trochanter typical; femur with 13 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 142); tibiotarsus typical, with E_1 , AE_o , L_1 , PI_o , PE_o , and posterior accessory setae clavate; unguis as with proleg, unguiculus with corner tooth (Figure 141).

METALEG: Coxa and trochanter typical; femur with 11 anterior and 5 posterior setae, 2 posterior setulae, posterior oval organ (Figure 143);

tibiotarsus typical, with E_1 , AE_0 , PE_0 , and posterior accessory setae clavate; claw as with mesoleg (Figure 144).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens normal, with ID accessory setae. Mucro smooth, with basal seta (Figure 145). Bothriotrichium D complex Type I. Female circumanal setae and subanal appendages normal. Length 3.0 mm maximum.

DIAGNOSIS: Sminthurus sylvestris may be distinguished from other nearctic species by the presence of clavate setae on the tibiotarsus of all legs. In addition, S. sylvestris lacks claw tunicae and inner mucronal teeth, and possesses ID accessory setae on the dens.

Five palearctic species of Sminthurus (lesnei Carl, 1899; flaviceps Tullberg, 1871; guthriei Stach, 1919; gattoi Stach, 1967; and bulgaricus Rusek, 1965) have clavate tibiotarsal setae. Betsch (personal communication) believes that they are distinct from S. sylvestris because of the spatulate shape of their tibiotarsal setae and also because they possess a Type II Bothriotrichium D complex.

DISTRIBUTION: District of Columbia - under dead leaves, January 1903, N. Banks (holotype of facialis) (MCZ).

Maryland - Worcester Co., Snow Hill, in woods, 3-V-1947, W.H. Anderson (USNM).

Michigan - Jackson Co., Lime Lake, sweeps in cherry trees (Prunus), 21-V-1967, G.V. Manley (RJS); Midland Co., 16-VI-1957, R.R. Dreisbach (RJS).

New York - Nassau Co., Sea Cliff, Long Island, no date, N. Banks (holotype of sylvestris) (MCZ).

Pennsylvania - Lackawanna Co., Spring Brook, sweeping shrubs, 23-V-1945, R.I. Sailer (USNM).

This species has been reproted from the following locations but the

specimens were not seen by this author.

Connecticut - Litchfield Co. (Christiansen and Bellinger, 1981).

Indiana - Wayne Co., no data (Hart, 1972, as facialis).

Minnesota - Crow Wing Co. (Christiansen and Bellinger, 1981).

New York - Rensselaer Co., Rensselaerville, Bristol Center, shrubs at edge of woods, 8-VI, E.A. Maynard and W.L. Downs; 16-VII, S.C. Bishop; Sphagnum sp., no date, S.C. Bishop (Maynard, 1951).

North Carolina - Wake Co., leaf mould, no date, D.L. Wray (Wray, 1967a).

Quebec - Gatineau N.C.C. Park, birch bracket fungus (Polyporus betulinus), birch around beaver dammed pools, 45 33'N, 75 58'W - 45 31'N, 75 54'W (Pielou and Verma, 1968).

TYPE LOCATION: Holotype - MCZ.

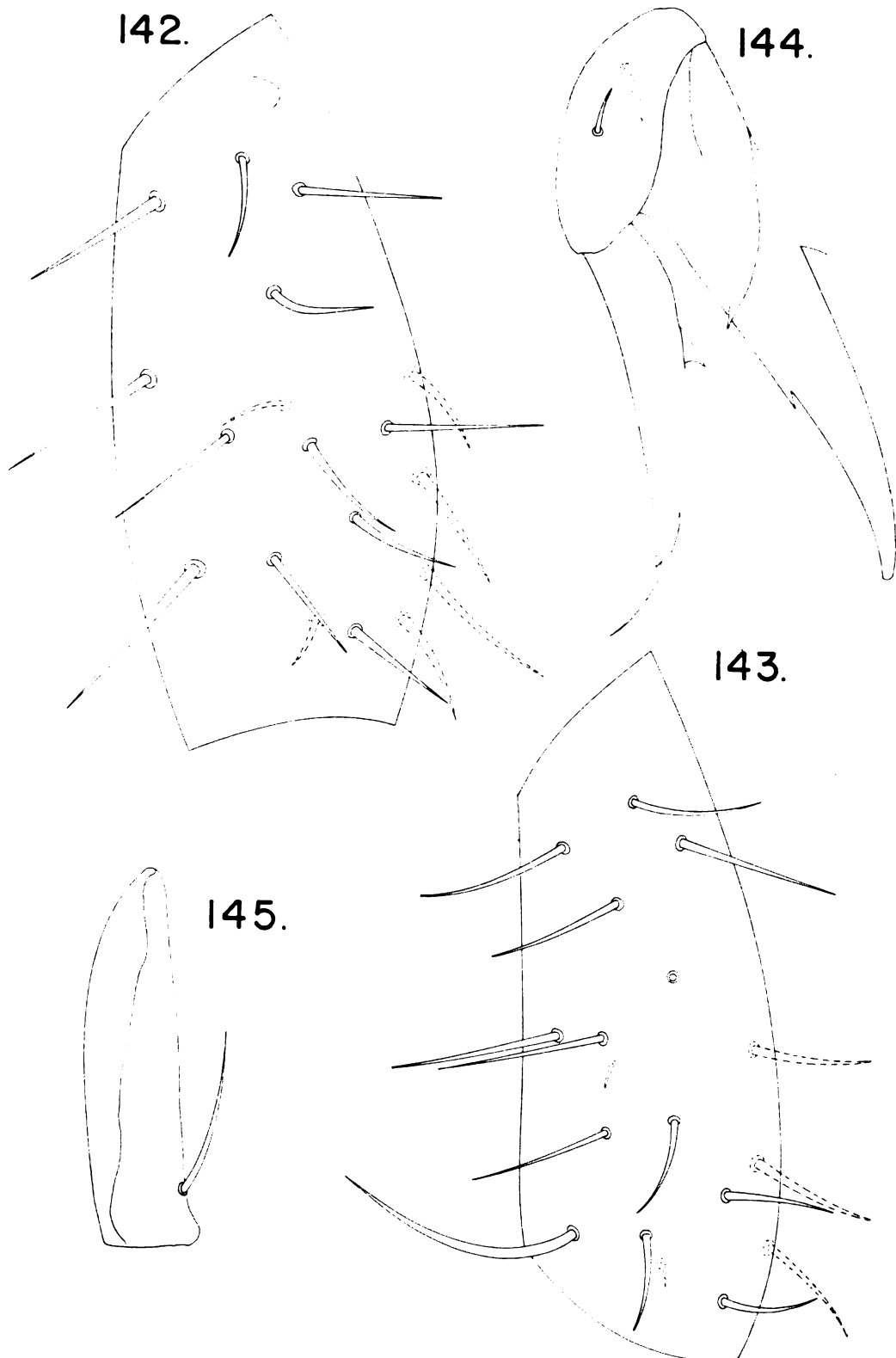
Figures 142 - 145

142 - mesofemur, anterior view

143 - metafemur, anterior view

144 - metacław

145 - mucro



Sminthurus viridis (Linné), 1758Pulex viridis plantarum, Linné, 1736Podura viridis subglobulosa, Linné, 1746Podura subglobulosa viridis, Linné, 1758Podura viridis, Linné, 1758Smynthurus viridis, Latrielle, 1804Sminthurus viridis, Bourlet, 1841Sminthurus viridis nigro-maculatus, Tullberg, 1871Sminthurus viridis nigromaculatus, Schaffer, 1897

MORPHOLOGICAL DESCRIPTION

HEAD: ANT IV with 17 subsegments, 3 apical papillae, single apical bulb. Frons with 4 oval organs.

PROLEG: Coxa and trochanter typical; femur with 10 anterior and 6 posterior setae, 1 posterior oval organ (Figure 42); tibiotarsus normal; claw typical, expanded tunica (Figure 43).

MESOLEG: Coxa and trochanter typical; femur with 13 anterior and 3 posterior setae, 2 posterior setulae, posterior oval organ (Figure 44); tibiotarsus normal; claw typical, sometimes with 2 corner teeth on unguiculus (Figure 35).

METALEG: Coxa and trochanter typical; femur with 13-14 anterior and 3 posterior setae, 2 posterior setular, posterior oval organ (Figure 46); tibiotarsus normal; claw typical (Figure 47).

BODY: Collophore with 1+1 subapical and lateral setae. Manubrium and dens normal, with ID accessory setae. Mucro without teeth, with basal seta (Figure 48). Bothriotrichium D complex without P seta. Female circumanal setae normal; subanal appendages with very

fine fringe along edges. Length 2.0 mm.

DIAGNOSIS: Using Christiansen and Bellinger (1981), Sminthurus viridis keys out to S. adirondakus and S. incisus. For the reasons mentioned above, Sminthurus adirondakus Maynar, 1951 is not considered a valid species in this treatment. Separation from S. incisus may be done on the following basis:

<u>viridis</u>	<u>incisus</u>
4 frontal oval organs	3
16 profemur setae	15
meta PL ₆ seta present	absent
ungual tunica present	absent
subanal appendages fringed	smooth

Sminthurus viridis is the only species known to lack the P seta of the bothriotrichium D complex. Nearctic specimens differ from palearctic specimens by possessing lateral colophore setae. In other respects they are identical.

The collections from the upper peninsula of Michigan represent the first conformed specimens of S. viridis from North America. Hammer (1953) reported S. viridis north of the Arctic Circle in Canada's Northwest Territory, but the identity of these specimens has yet to be confirmed. The color pattern of the Michigan specimens is identical to photographs of S. viridis nigromaculatus published by Wallace (1973). This subspecies, considered a separate species by Wallace, ranges north of the Arctic Circle in Eurasia and may be the same as the animals found in North America.

The description of S. adirondakus is very similiar to that of S. viridis. It is possible that Maynard's species would prove

synonymous with S. viridis if the specimens could be located and examined.

DISTRIBUTION: Michigan - Dickinson Co., Channing, grass sweep, 27-VII-1982, J.M. Nesmith, N. Sferra, F. Calandrino; 12-IX-1982, 13-IX-1982, R.J. Snider (MSUE).

Sminthurus viridis has been reported from the following locations but has not been confirmed by this author.

Northwest Territory - Reindeer Station, Mackenzie River delta, wet depressions at top of hill with moss, liverwort, Empetrum nigrum, Vaccinium vitis idaea; in withered grass near river bank; in thin Polytrichum; moss on tundra, 1948 (Hammer, 1953); Coppermine, west of Mackenzie River delta, willow shrub with thick damp moss and scattered Luzula nivalis and Salix reticulata, 1948 (Hammer, 1953).

TYPE SPECIMENS: Paratype - Swedish Museum of Natural History, Stockholm.

CHARACTER ANALYSIS AND PHYLOGENETIC RELATIONSHIPS

Compilation of characters is the first step in a phylogenetic analysis (cf. Richards, 1968). Embryological, genetic, and ecological data should be included, but they are seldom available. This study used external morphological features because only they were fully examined.

Evolutionary polarity (determination of apomorphic and plesiomorphic states) is assigned after characters are compiled. This often requires reference to related taxa outside of the study (out-group comparison). The uniform morphology of Sminthurus makes both taxonomic and phylogenetic analysis difficult; small differences assume great importance, and possible relationships may be obscured. The reason for this is that some character states may represent homoplasies (states arrived at independently). With few differences between species, involving minute morphology, identification of homoplasies is problematic.

METHODS

The characters used for this analysis were chosen because they represent nested sets of synapomorphies. Many taxonomic characters were discarded either because they were of doubtful phylogenetic value (polarities of evolution could not be assigned) or because they were autapomorphies and of no value for reconstructing phylogenies (Table 1).

TABLE I
AUTAPOMORPHIC CHARACTERS

posterior subapical oval organs
posterior dorsal protruberance of abdomen
5 posterior metatibiotarsal oval organs
10 metatibiotarsal AE file setae
10 metatibiotarsal PI file setae
11-12 dental L file setae
13 dental E file setae
absence of metatibiotarsal PL₇ seta
absence of mesotibiotarsal PL₆ seta
clavate leg setae

Interpreting characters involving the loss of features can be difficult. Nelson and Platnick (1981) point out that loss of a character may be treated as a character transformation and is fundamentally different from absence of a character. Loss characters believed to represent true synapomorphies, and to which evolutionary polarity could be confidently assigned, were included in this analysis. Only nearctic species of Sminthurus were used because of the complete available data, and because they are distributed within a discrete geographic unit.

Phylogenetic polarity was assigned to each character on the basis of out-group comparison (cf. Watrous and Wheeler, 1981). The genera and species used as out-groups for this analysis were Allacma fusca (Linné), 1758; Caprainea marginata (Schött), 1893; Temeritas antongilensis Betsch, 1980; and Richardsitas najtae Betsch, 1975 - all from the subfamily Sminthurinae (sensu Betsch, 1980). Whenever character states disagreed between genera, Allacma alone was used for comparison because it has always been considered the closest taxonomic relative of Sminthurus. In fact, Allacma is morphologically more similar to Sminthurus than the other genera.

CHARACTERS

1) Metatibiotarsal PL₆ seta. The normal complement of metatibiotarsal PL setae is eight (PL₀-PL₇). None of the out-groups has more than five metatibiotarsal PL file setae. The assumption made here is that Sminthurus has added both PL₆ and PL₇ metatibiotarsal seta. Loss of the same intermediate seta in four species (S. eiseni, S. incisus, S. packardi, S. sagitta) is deemed a synapomorphy.

2) Metatrochanteral spine. A normal posterior seta is typically found on the metatrochanter of Sminthurus. On S. purpurescens, however, this seta has been transformed into a spine. The same posterior metatrochanteral spine is present on all of the out-group species. Consequently, the metatrochanteral spine character state is considered plesiomorphic.

3) Bothriotrichium D complex. A Type I bothriotrichium D complex is present in all but four species of nearctic Sminthurus (S. carolinensis, S. incisus, S. viridis, S. bivittatus); S. viridis lacks the P seta entirely and it is assumed that the P seta was lost from the plesiomorphic Type II bothriotrichium D complex. According to Betsch (personal communication) all other palearctic Sminthurus have Type II bothriotrichium D complexes (normal P seta). The out-group species also have Type II bothriotrichium D complexes. The conclusion is that the Type I bothriotrichium D complex is a synapomorphy uniting the remaining nearctic Sminthurus.

4) Lateral collophore setae. All but three species of nearctic Sminthurus (S. carolinensis, S. purpurescens, S. bivittatus) possess a pair of lateral setae on the collophore. Caprainea marginata also has a lateral collophore setae, but the other three out-group species lack such setae. Absence of lateral setae is, therefore, considered plesiomorphic.

RECONSTRUCTION METHODS

The character state matrix for nearctic Sminthurus (Table 2) was analyzed by four different methods. Except for component analysis, each reconstruction was realized by using microcomputer phylogenetic

programs available from J. Felsenstein of the University of Washington. The results of each analysis are discussed below.

Component Analysis. This method of phylogenetic reconstruction relies on combining nested sets of monophyletic groups from the data. No assumptions are made regarding intermediate ancestors or evolutionary tendencies, and the method will not resolve further than the data permit. Two possible phylogenetic trees may be constructed from the character state matrix (Figures 146-147).

Wagner Parsimony method. The parsimony analysis assumes that character state gains and losses are equally likely and that both conditions are more likely than maintenance of a polymorphic state (Felsenstein, 1978). The algorithm for this method is outlined by Kluge and Farris (1969). A Wagner tree obtained from that data on nearctic *Sminthurus* is shown in Figure 148).

Dollo Parsimony Tree. Assumptions inherent in this method are: only one forward evolutionary step per character is allowed; polymorphism does not exist; and as many character state reversals as necessary are permitted to account for the pattern. A Dollo parsimony tree for *Sminthurus* is shown in Figure 149.

Camin-Sokal and Wagner Mixed Parsimony Tree. The assumptions of the Wagner parsimony method and those of the Camin-Sokal parsimony method (Camin and Sokal, 1965) are combined in this analysis. Restrictions on the Camin-Sokal method include the assumptions that the ancestral state arose only once (although derived character states may have arisen repeatedly in different branches of the taxon) and that chances of reversals in character state are much less than the chance of their arising in the first place (i.e. evolution is

TABLE II
 CHARACTER STATE MATRIX FOR NEARCTIC SMINTHURUS

Species	<u>Character state</u>			
	1	2	3	4
ancestor	0	0	0	0
<u>bivittatus</u>	0	1	0	0
<u>butcheri</u>	0	1	1	1
<u>carolinensis</u>	0	1	0	0
<u>eiseni</u>	1	1	1	1
<u>fischeri</u>	0	1	1	1
<u>fitchi</u>	0	1	1	1
<u>floridanus</u>	0	1	1	1
<u>incisus</u>	1	1	0	1
<u>incognitus</u>	0	1	1	1
<u>mencenbergi</u>	0	1	1	1
<u>packardi</u>	1	1	1	1
<u>purpurescens</u>	0	0	1	0
<u>sagitta</u>	1	1	1	1
<u>sylvestris</u>	0	1	1	1
<u>viridis</u>	0	1	1	1

Key to the character states of Sminthurus

- 1 - metatibiotarsal PL₆ seta (absence = 1)
- 2 - metatrochanteral spine (absence = 1)
- 3 - Bothrotrichium D complex (Type I = 1)
- 4 - collophore lateral setae (presence = 1)

Figure 146

component analysis tree I

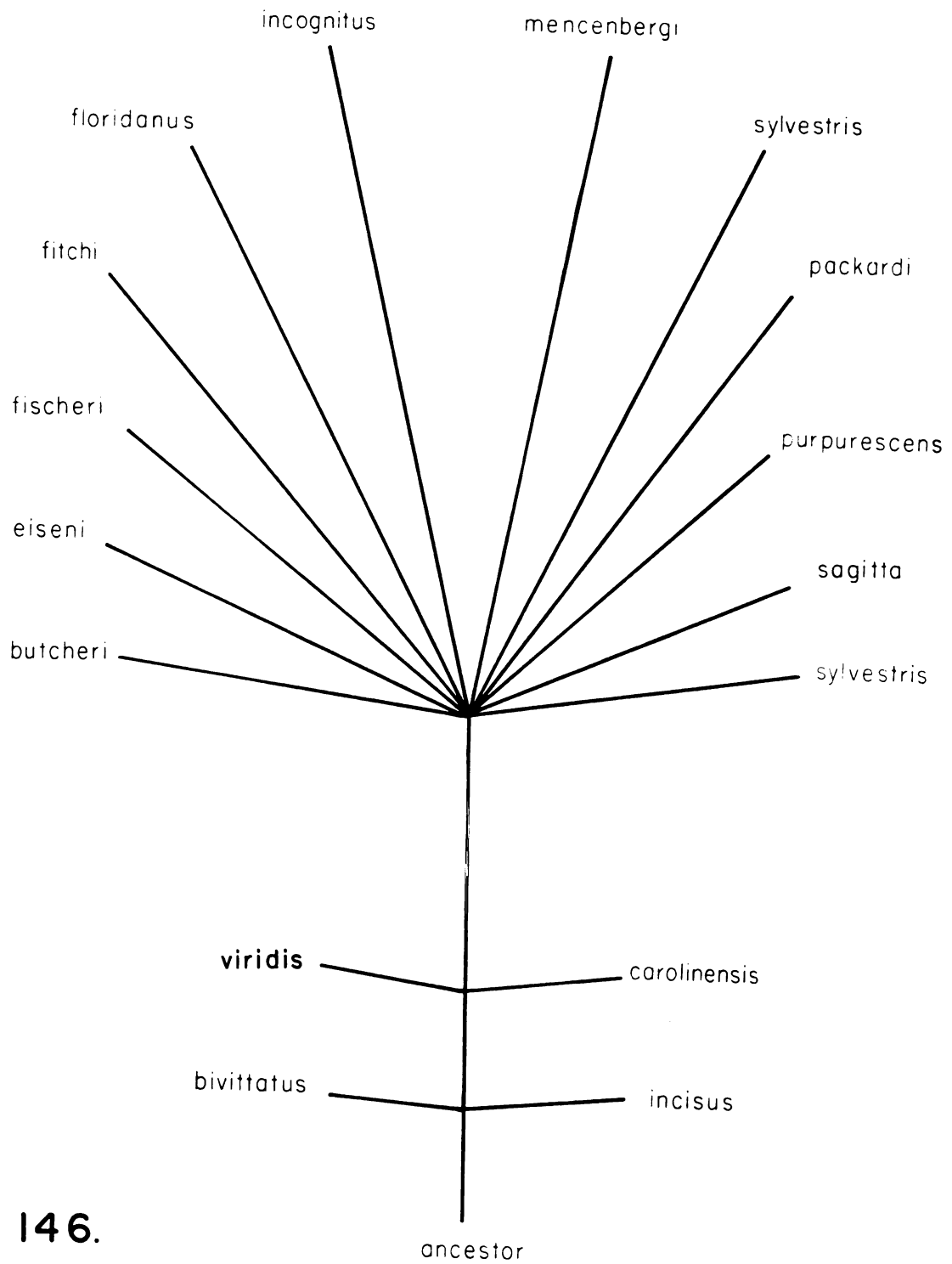


Figure 147

componenet analysis tree II

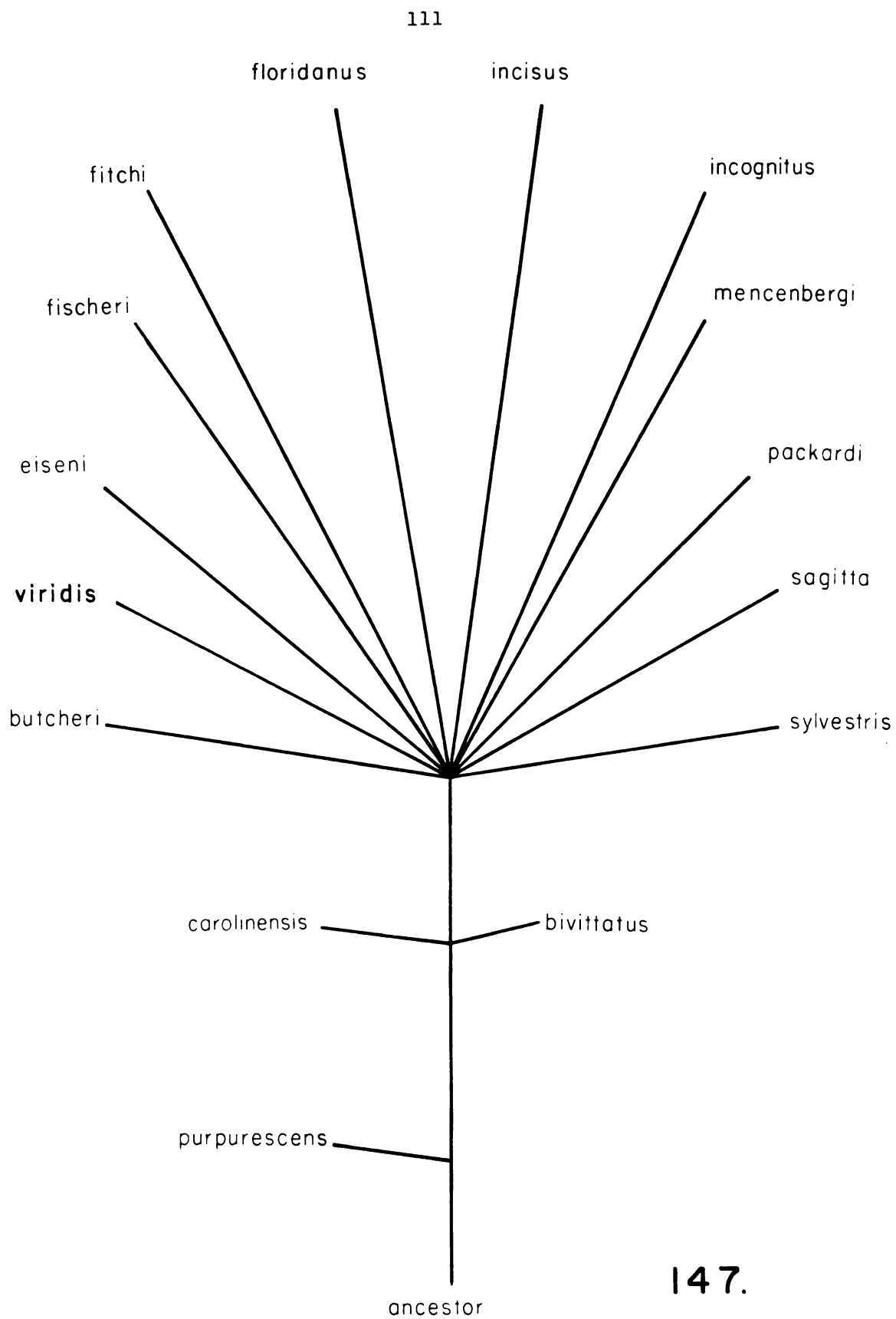


Figure 148

Wagner parsimony tree

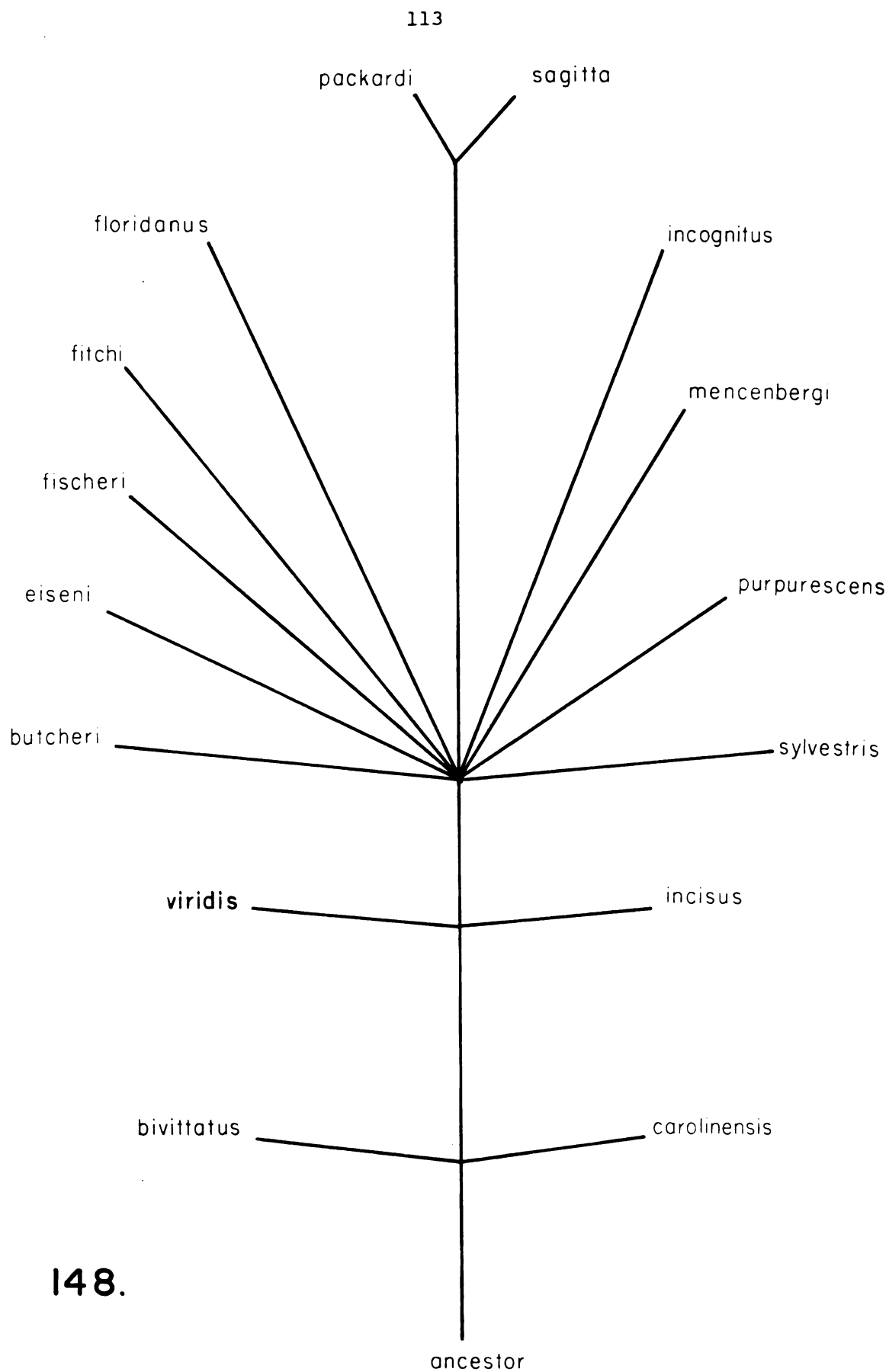
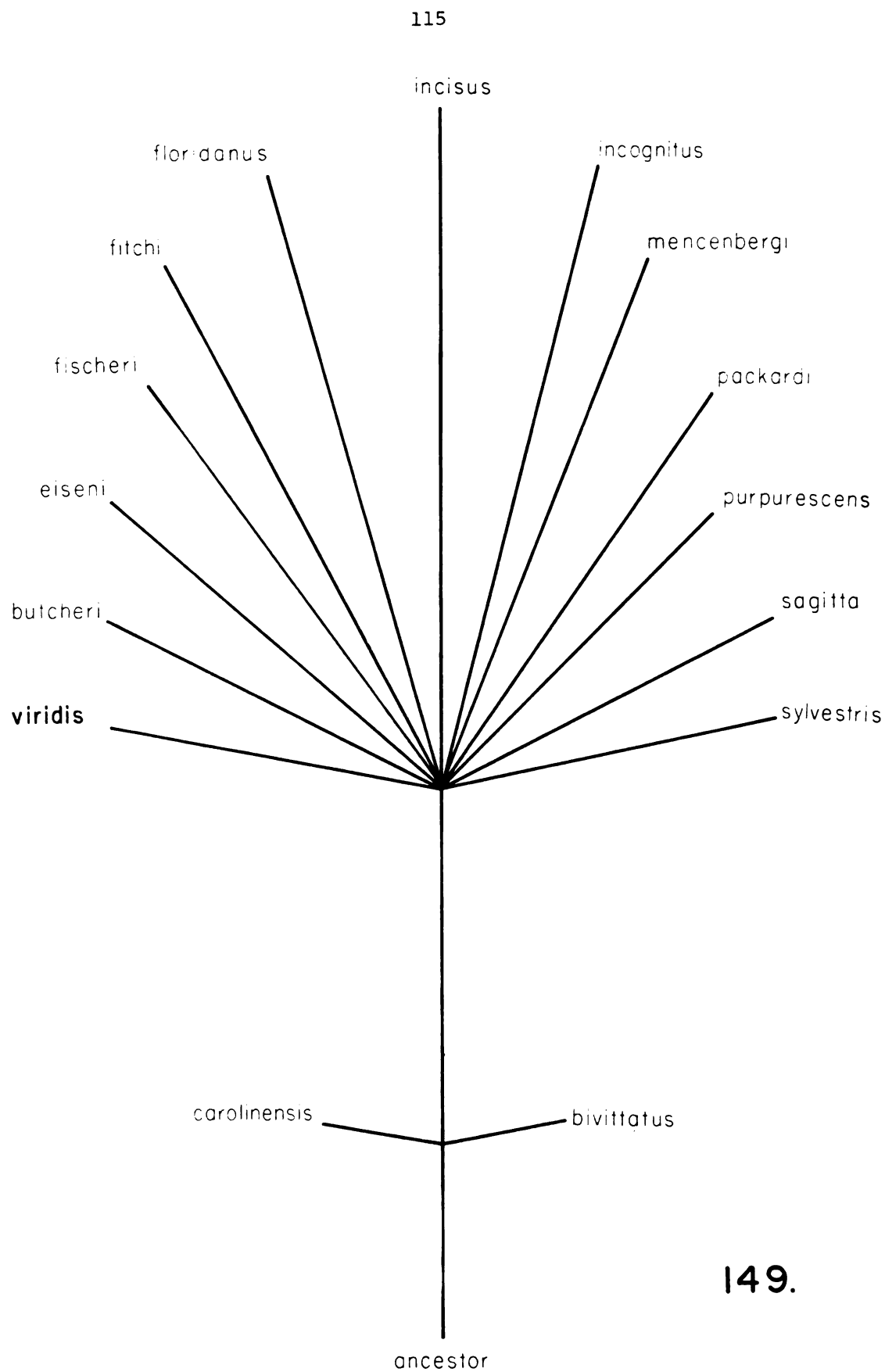


Figure 149

Dollo parsimony tree



149.

irreversible). Results of the mixed method are identical to those of the Wagner parsimony method and are not illustrated separately. With so few characters, the assumptions of the Camin-Sokal parsimony method appear not to affect the result.

DISCUSSION

Component analysis relies only upon nested sets of monophyletic subgroups and yields all possible trees permitted by the data. A parsimony tree should be rejected if it cannot be reduced to, or realized by, one of the two component analysis trees (Figures 146-147).

The trees generated from the Wagner Parsimony and Dollo Parsimony methods (rooted with a hypothetical ancestor) are compatible with component analysis tree I (Figure 146). Neither parsimony method agreed with component analysis tree II (Figure 147).

Based on the characters used here, the phylogenetic relationships among nearctic Sminthurus include one bifurcation consisting of S. packardi and S. sagitta; two trifurcations involving S. viridis, S. incisus and S. bivittatus, S. carolinensis, respectively; and a multifurcation including the remaining nearctic Sminthurus (Figure 148). The data preclude further resolution of the cladograms. However, even at the present level of detail, the parsimony trees do indicate some previously unsuspected relationships which should form the basis of further systematic and biogeographic investigations. For example, S. packardi and S. sagitta, which lack an ANT IV apical bulb and the metatibiotarsal PL seta, are both found in the southwestern United States. Similarly, two species of the southeastern United States, S. bivittatus and S. carolinensis, have a type II bothriotrichium D

complex and are part of a trifurcation in the cladogram. Little more can be said at present because great parts of the continent are undercollected and the species ranges are only partly known.

Few conclusions may be drawn on the basis of only four phylogenetic characters. Using the same assumptions about out-group analysis mentioned above, five previously discarded characters were tentatively assigned polarity (Table 3) and added to the data matrix (Table 4). The data was then reanalyzed for further resolution of phylogenetic relationships.

Neither the new Wagner parsimony or Dollo parsimony cladograms was permitted by component analysis. The new Camin-Sokal parsimony cladogram was allowed (Figure 150). This cladogram is incompatible with Figure 148, which is based on four characters. Because it has no outer mucronal teeth, Sminthurus mendenbergi appears between S. viridis and the branch consisting of S. bivittatus and S. carolinensis. Another difference is that, based on the number of frontal oval organs, S. sagitta and S. packardii are no longer paired.

Although the Camin-Sokal parsimony algorithm does yield a cladogram that can be realized by component analysis, this author has reservations about the accuracy of this cladogram. The Camin-Sokal parsimony method permits a character to independently arise several times (homoplasy). This has happened with the metatibiotarsal PL seta and the number of frontal oval organs. In this author's opinion neither of these characters truly represents homoplasies. Conversely, the subanal appendages of S. viridis, S. mendenbergi, and S. purpurens are all fringed in different fashions and may actually represent homoplasies. On the basis of out-group comparison, however, all of these subanal appendages have been treated as plesiomorphic.

TABLE III

TENTATIVE PHYLOGENETIC CHARACTERS FOR NEARCTIC SMINTHURUS

Metatibiotarsal PL₇ seta. The absence of the PL seta is considered plesiomorphic because all out-groups lack this seta.

Inner mucronal teeth. Because all out-groups have inner mucronal teeth, this condition is regarded as plesiomorphic.

Frontal oval organs. Four is considered the plesiomorphic number of oval organs on the frons of Sminthurus because Allacma possesses four frontal oval organs.

Palmate female subanal appendages. All out-group genera possess palmate (fringed) subanal appendages. Serrations or fringes on subanal appendages were treated as plesiomorphic.

Outer mucronal teeth. The out-group genus Allacma lacks outer mucronal teeth. The presence of teeth on the outer edge of the Sminthurus mucro is regarded as apomorphic.

TABLE IV

TENTATIVE CHARACTER STATE MATRIX FOR NEARCTIC SMINTHURUS

Species	<u>Character states</u>								
	1	2	3	4	5	6	7	8	9
Ancestor	0	0	0	0	0	0	0	0	0
<u>bivittatus</u>	0	1	0	0	1	1	1	1	0
<u>butcheri</u>	0	1	1	1	1	1	0	1	1
<u>carolinensis</u>	0	1	0	0	1	1	1	1	0
<u>eiseni</u>	1	1	1	1	1	1	0	1	1
<u>fischeri</u>	0	1	1	1	1	1	1	1	1
<u>fitchi</u>	0	1	1	1	1	1	1	1	1
<u>floridanus</u>	0	1	1	1	1	1	1	1	1
<u>incisus</u>	1	1	0	1	1	0	1	1	1
<u>incognitus</u>	0	1	1	1	1	1	1	1	1
<u>mencenbregi</u>	0	1	1	1	1	1	0	0	0
<u>packardi</u>	1	1	1	1	1	1	0	1	1
<u>purpurescens</u>	0	0	1	0	0	1	0	0	0
<u>sagitta</u>	1	1	1	1	1	1	1	1	1
<u>sylvestris</u>	0	1	1	1	1	0	1	1	1
<u>viridis</u>	0	1	0	1	1	0	0	0	1

Key to the character states of Sminthurus

- 1 - metatibiotarsal PL₆ seta (absence = 1)
- 2 - metatrochanteral spine (absence = 1)
- 3 - bothriotrichium D complex (Type I = 1)
- 4 - lateral collophore setae (presence = 1)
- 5 - metatibiotarsal PL₇ (presence = 1)

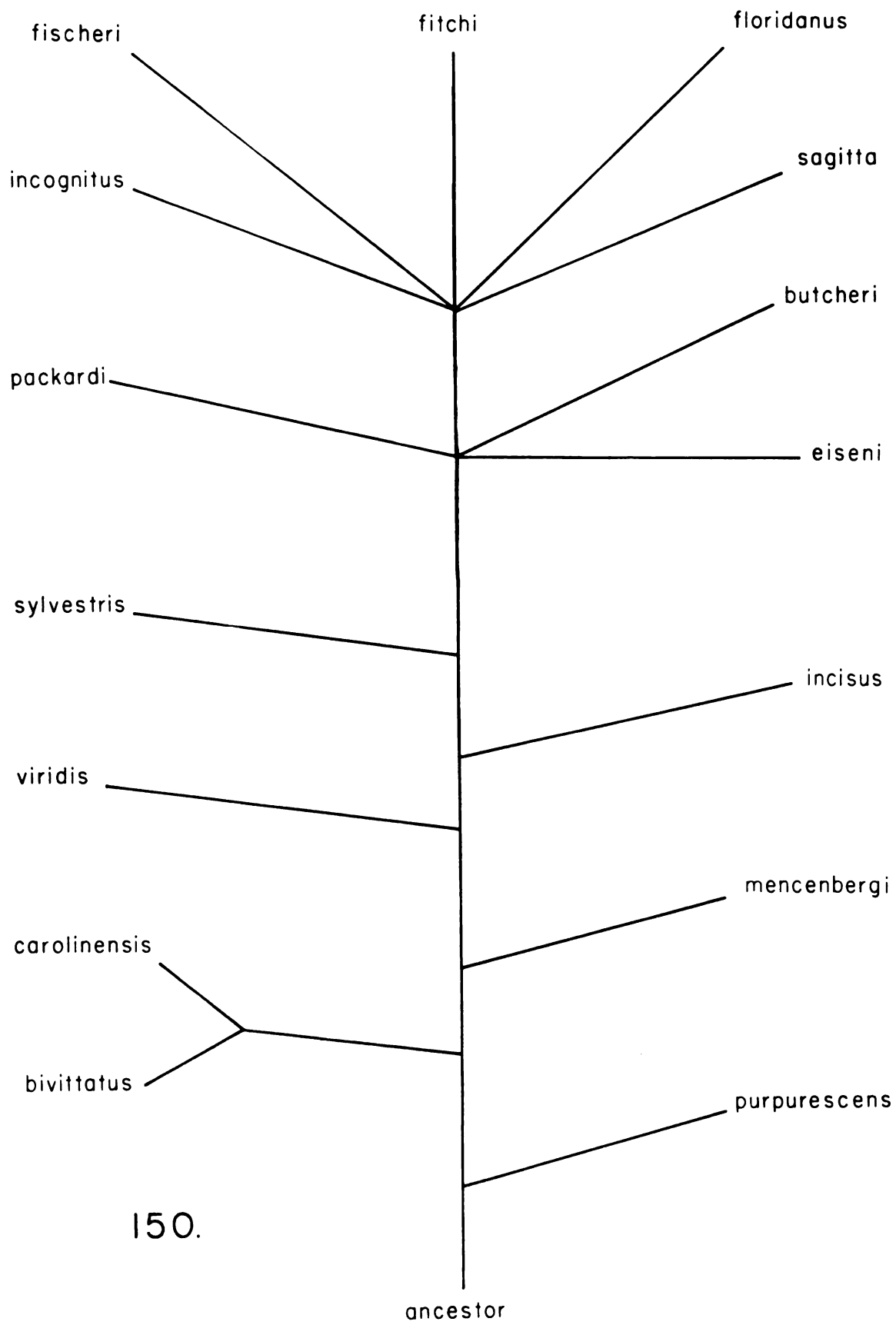
TABLE IV (continued)

- 6 - inner mucronal teeth (absence = 1)
- 7 - frontal oval organs (three or two = 1)
- 8 - female subanal appendages (smooth = 1)
- 9 - outer mucronal teeth (absence = 1)

Figure 150

Camin-Sokal parsimony tree

122



One character which traditionally has been used for species identification is color pattern (e.g. Banks, 1903; Mills, 1934); however, some populations of S. butcheri show distinct regional differences in coloration. Although all specimens are morphologically the same, only specimens from Michigan and southern Texas have the mosaic color pattern described by Snider (1969), whereas populations in South Carolina have a solid dark blue color with a yellow face. Similarly, the color pattern of S. fitchi is highly variable, ranging from solid to variegated. This variation appears to be limited to regional populations and may reflect incipient speciation. All the species described in this study are morpho-species. It is possible that some of the color variants represent sibling species. One argument against the presence of morphologically identical species with differing color patterns is the fact that several morphologically distinct species have very similar color patterns. For example, S. viridis, S. fischeri, and S. mendenbergi may each have a similar medial stripe on the dorsal abdomen. To test for sibling species the various color variants must be reared, isolated, and then crossed to check for progeny.

One of the serious drawbacks of this analysis is the small number of reliable synapomorphic characters present among the nearctic Sminthurus. Part of the problem is that taxonomically useful characters are not necessarily useful phylogenetic characters. To be phylogenetically useful a character must be able to have evolutionary polarity assigned to it and be a derived state shared with other taxa. More such phylogenetic characters are needed if the relationships are to be further resolved. Ontogenetic features may provide such characters, but developmental studies on symphyleonid Collembola are

rare. Genetic, biochemical, and behavioral studies may also yield new characters. Studies of Sminthurus viridis chromosomes were done by Tuzet and Manier (1956). The behavior of the genus Bourletiella has been investigated (Bretfeld, 1970, 1971), but no such studies have been conducted on Sminthurus. Until such information is available, phylogenetic relationships within nearctic Sminthurus cannot be further resolved.

ZOOGEOGRAPHY

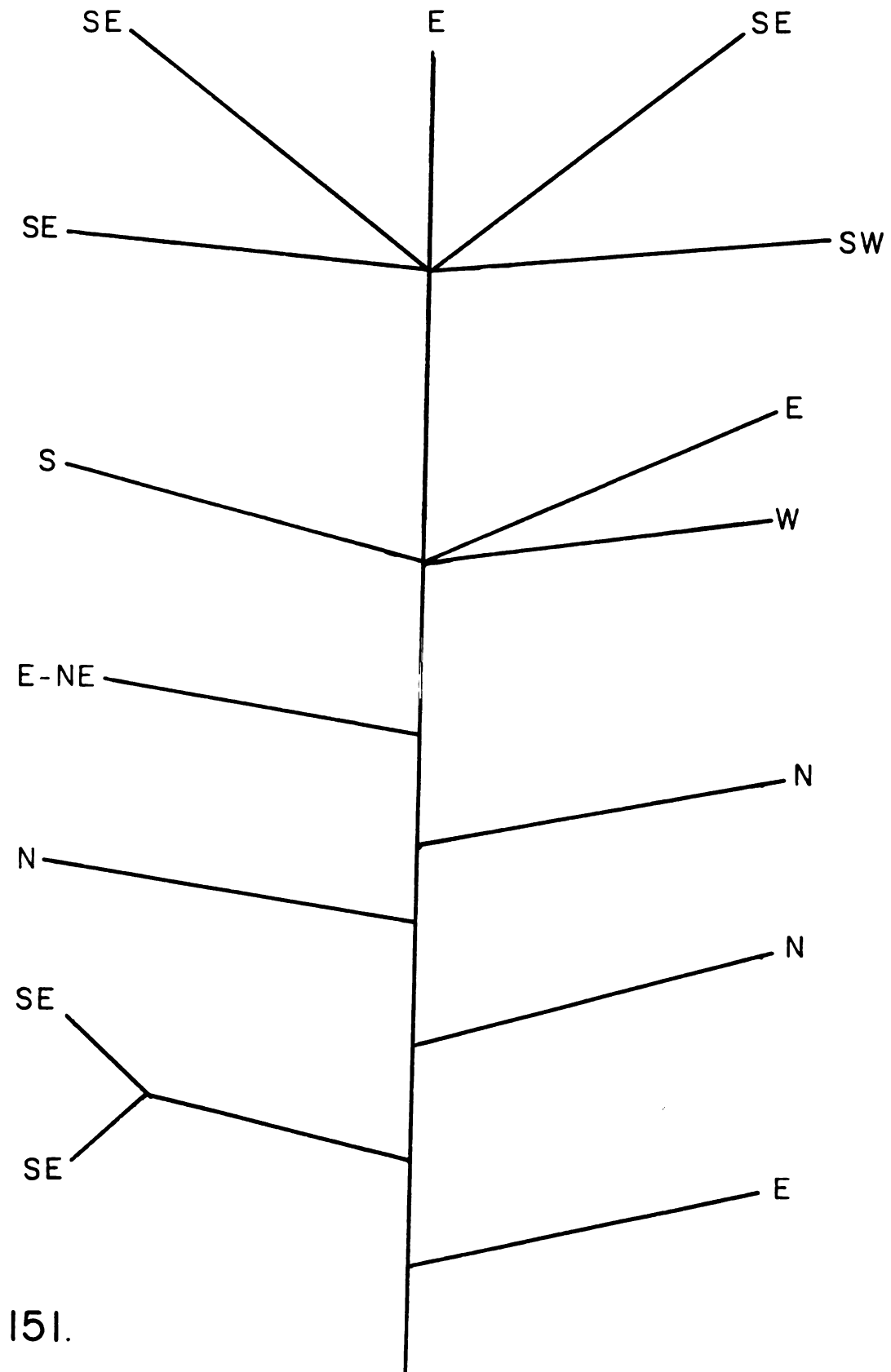
The genus Sminthurus is holarctic in distribution. Sminthurus is found throughout all of North America from northern Mexico to north of the Arctic Circle. The genus ranges in Eurasia from Greenland, Iceland, and arctic Scandinavia in the north, France and Portugal in the west, and northern Africa in the south, through the Soviet Union to Mongolia, China, and Japan. There is one holarctic species, Sminthurus viridis. Based on climatic data, Wallace (1973) expected S. viridis to occur in the western United States and southern Canada. Sminthurus viridis has now been found in the upper peninsula of Michigan, bearing out his belief. Arctic and subarctic records of S. viridis, in Wallace's opinion, probably refer to the subspecies nigromaculatus (which Wallace considered a separate species). These include records of S. viridis from the Northwest Territory of Canada (Hammer, 1953).

An area cladogram for nearctic Sminthurus based on the Camin-Sokal parsimony cladogram in Figure 150 is shown in Figure 151. Species distribution maps are illustrated in Figures 152-161. If widespread taxa (S. fitchi, S. eiseni, S. butcheri) are eliminated from consideration (cf. Platnick, 1981), it is apparent that the remaining species cluster into northern and southern distributions.

Figure 151

Area cladogram based on Camin-Sokal parsimony tree

126



151.

Figure 152

Distribution of S. bivittatus (▲) and S. mendenbergi (●)

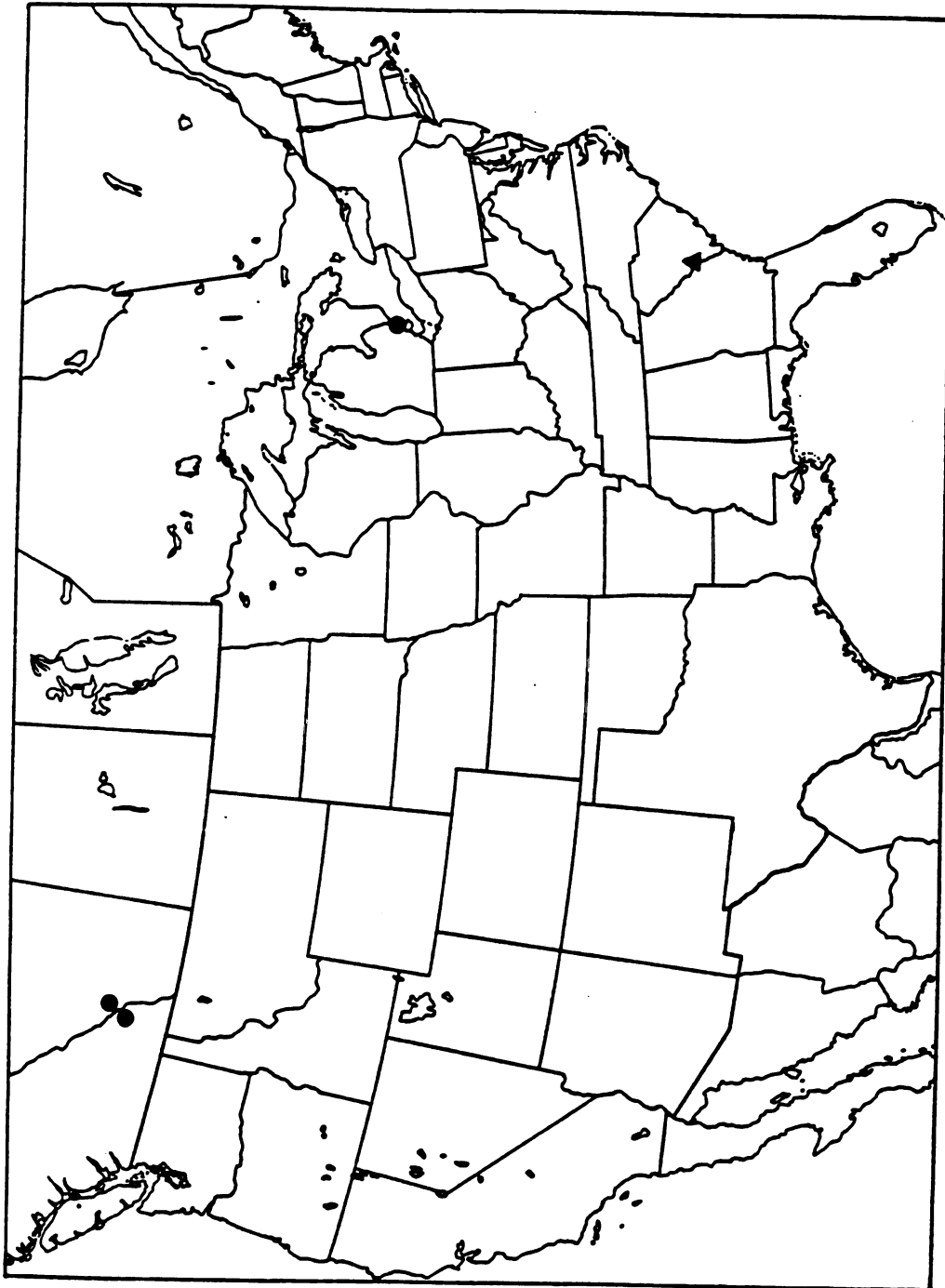


Figure 153

Distribution of S. butcheri (X=unconfirmed)

Figure 154

Distribution of S. carolinensis (▲) and S. incognitus (●)

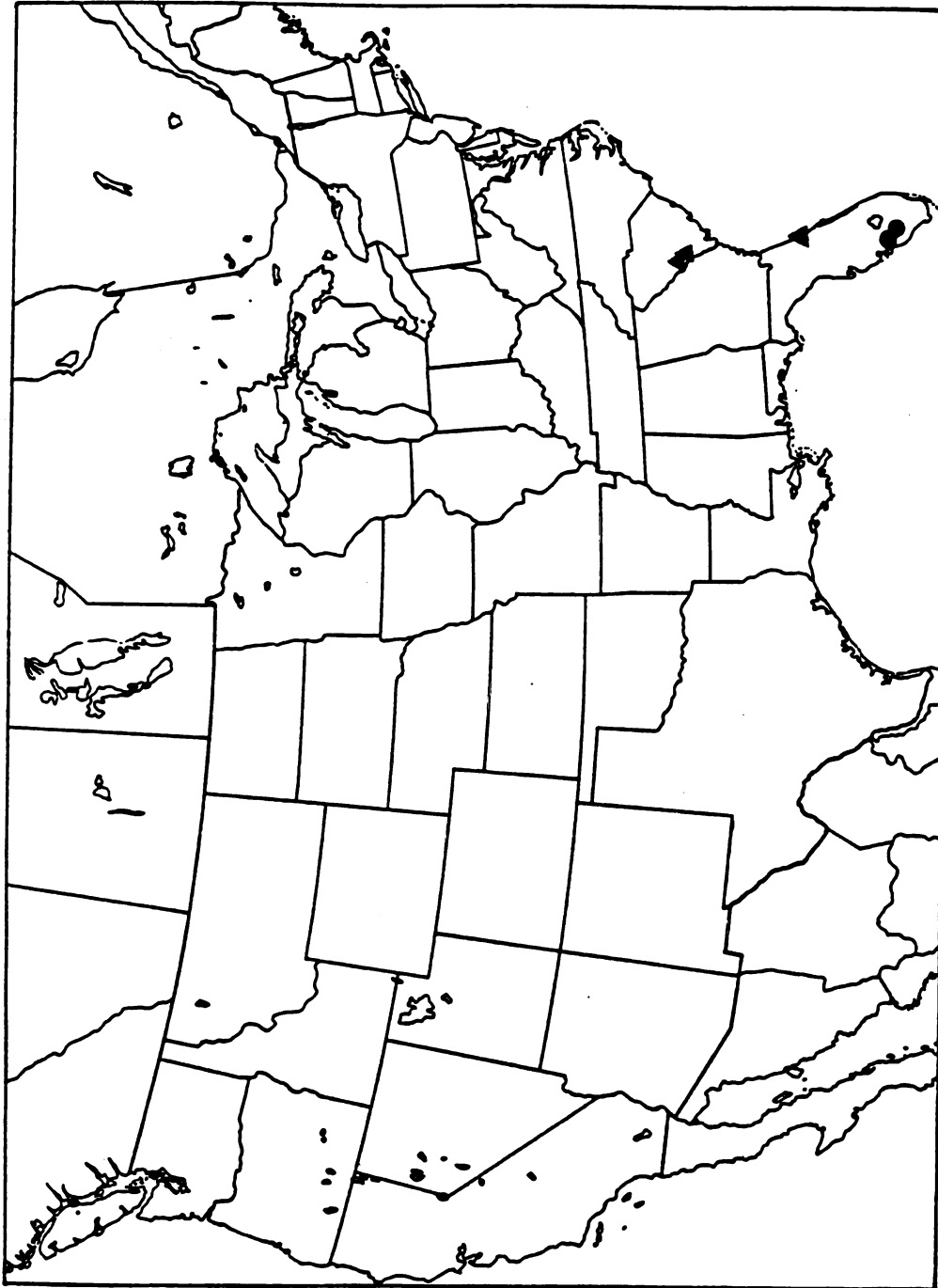


Figure 155

Distribution of S. eiseni (X = unconfirmed

Figure 156

Distribution of S. fischeri (▲) and S. floridanus (●)

Figure 157

Distribution of S. fitchi (X = unconfirmed)

Figure 158

Distribution of S. incisus (○) and S. viridis (●) (X = unconfirmed)

Figure 159

Distribution of S. packardi (●) and S. Sagitta (▲) (X = unconfirmed
packardi)

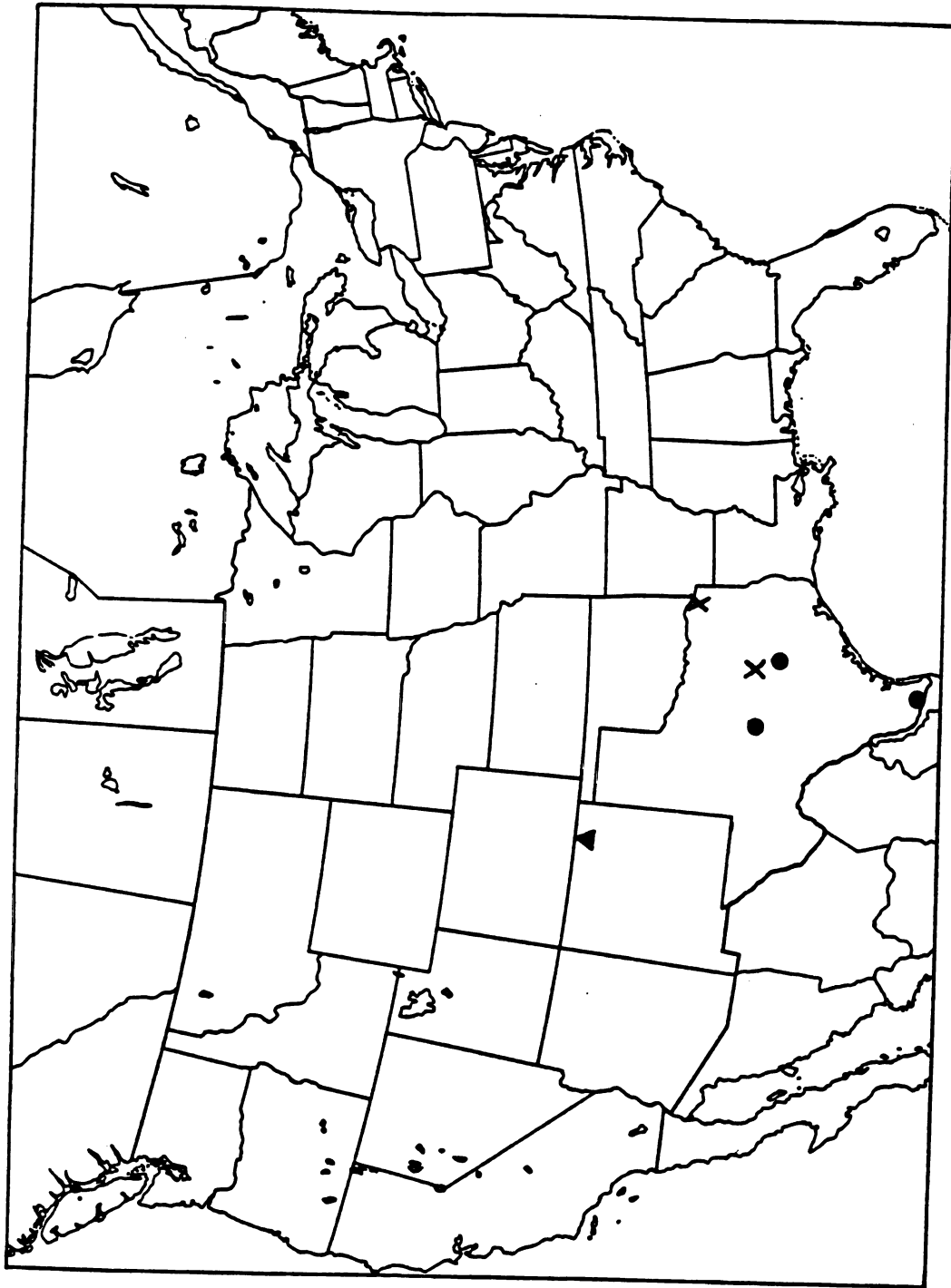
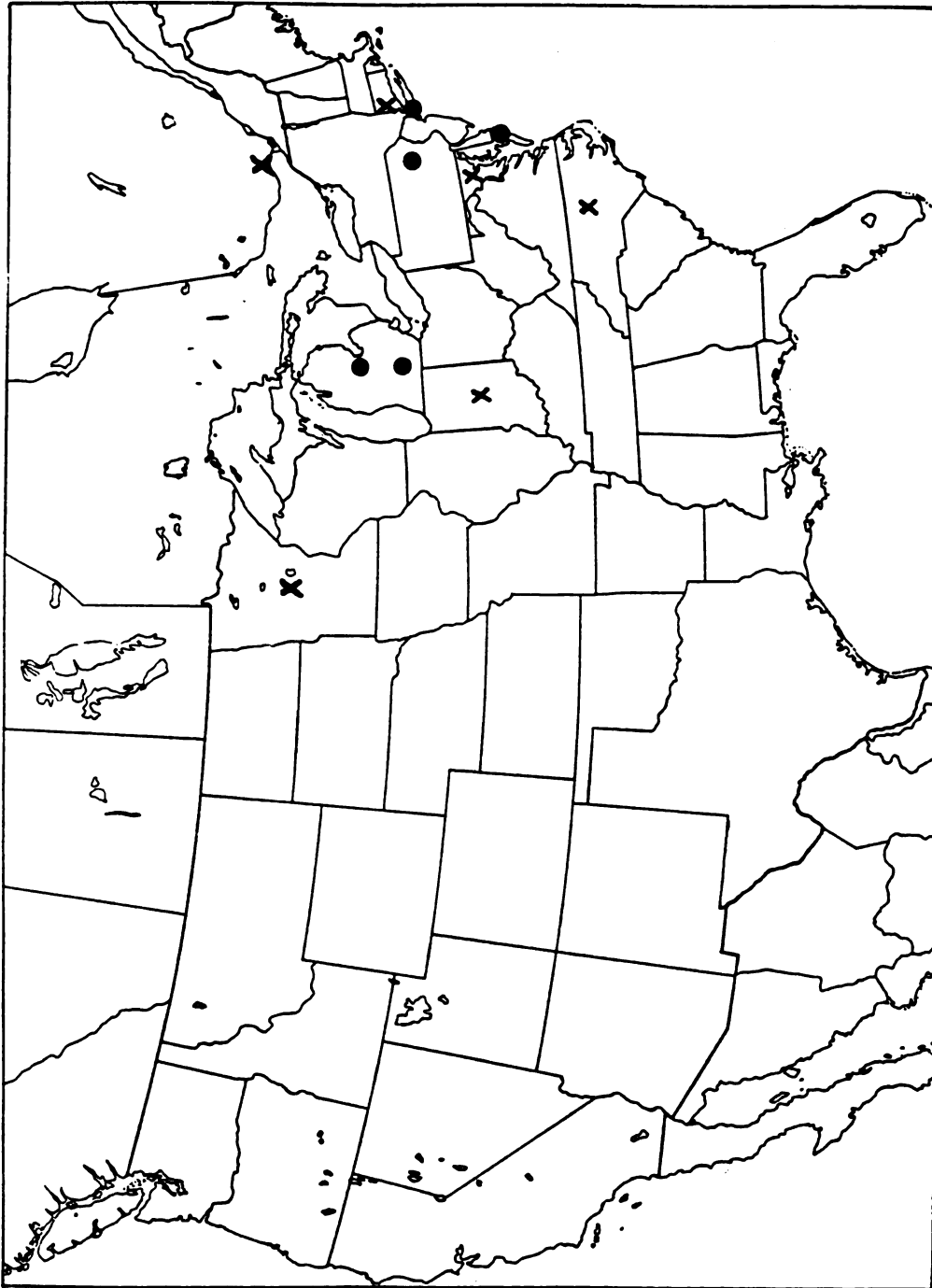


Figure 160

Distribution of S. purpurescens (X = unconfirmed)

Figure 161

Distribution of S. sylvestris (X = unconfirmed)



Seven species have been found exclusively in the southern United States and three species have only been collected north of Lake Erie. Even allowing for undercollecting, it appears that species diversity of Sminthurus is greatest east of the Mississippi River. Otherwise, there is too little information to draw biogeographic conclusions for most species.

Two widespread species, S. fitchi and S. butcheri, overlap much of their ranges and appear to live in the same types of habitats. The species are usually not collected from the same sites. Perhaps the species ranges are a mosaic pattern, with only one of these species at a given locale. Both species have been found or reported from the same disjunct region in northern Utah and surrounding area. Much more collecting needs to be done in the great plains to establish whether the above sites are truly disjunct or extensions of the eastern ranges.

There is one unconfirmed record of Sminthurus eisemi from North Carolina (Pearse, 1946), otherwise this species has been collected on grass from California to Michigan. Most of its range coincides with the prairie in the great plains, including disjunct prairie remnants in southwestern Michigan.

Richards (1968) believed that the genus was established by the late Cretaceous (c. 80 million years ago). During the mid-Jurassic to early Cretaceous (160-120 million years ago) the supercontinent of Pangaea separated into northern (Laurasian) and southern (Gondwanian) components; thus, because symphypleonid Collembola have limited dispersal ability, the antiquity of Sminthurus is attested by the fact that some of its sister-groups (e.g. Austrosminthurus, Novokatiana, and Pararrhopalites) are limited to the continents of the Southern

Hemisphere (Gondwanaland distribution).

If the genus Sminthurus is indeed so old, it seems probable that its members were present on both the North American and Eurasian landmasses before their separation by the developing Atlantic Ocean. Although some species may have migrated along the Bering Straits land bridge during the last ice age, geologically that connection was so recent and short-lived that, coupled with the apparent low vagility of Sminthurus, present distributions of most Sminthurus cannot be accounted for in this fashion. Interestingly, of the ten genera composing the Sminthurinae sensu Betsch (1980), only Sminthurus is present in North America. Four genera (Allacma, Caprainea, Gisinurus, and Disparrhopalites) are limited to Eurasia. If these genera were contemporaneous with Sminthurus, then it would be reasonable to expect them to occur in North America because they occur in similar habitats. Because the genera are also small, it seems likely that they have evolved, possibly from Sminthurus, since the separation of Eurasia and North America. For example, as mentioned above, the palearctic genus Allacma is morphologically very similar to Sminthurus, but should be considered a distinct genus.

CONCLUSIONS

During the course of this study, morphological features were completely reviewed and re-evaluated. A new system for denoting leg chaetotaxy was developed and oval organs were completely charted for the first time. On the basis of all morphological characteristics, the taxonomy of nearctic species of Sminthurus was revised and a key to species constructed.

A reconstruction of nearctic Sminthurus phylogeny was attempted. Owing to the very uniform morphology of this genus, few reliable synapomorphic characters could be established. Though useful as a first attempt which highlights areas of further systematic and biogeographic research, only a limited amount of new information surfaced through phylogenetic reconstruction. Little improvement of this situation can be expected until further fundamental ontogenetic research is conducted, and species distributions over the continent are fully documented.

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APPENDIX

APPENDIX

CMCP-9 is a non-resinous mounting medium with a refractive index of 1.4662. The formulation of CMCP-9 is as follows:

- | | |
|---|--------|
| 1. polyvinyl alcohol (DuPont Elvanol PVA 71-30) | 7.5 g |
| distilled water | 112 ml |
| 2. phenol crystalline reagent | 44 g |
| lactic acid, white USP | 44 m |

Dissolve "2" in hot water bath, then add "2" to "1" and heat in water bath. Note: Do not use 85% liquid phenol.