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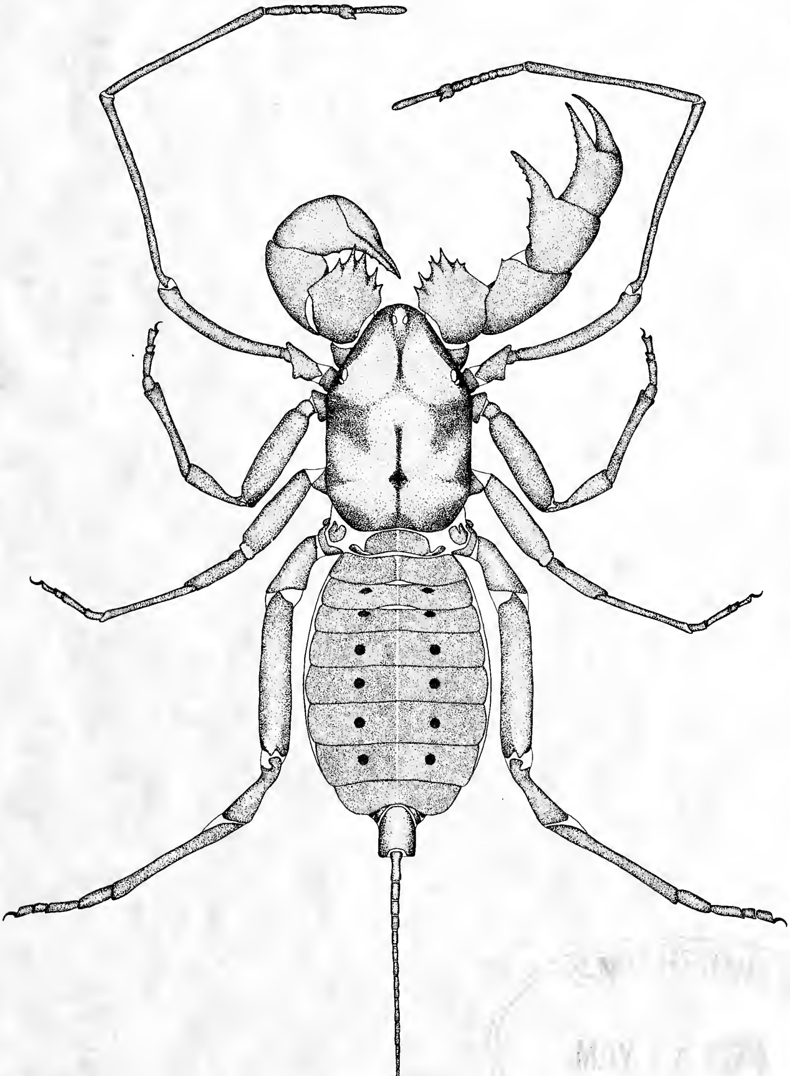

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(continued on inside back cover)

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THE RELATIONSHIP OF THE CHELICERATE ARTERIAL SYSTEM TO THE EVOLUTION OF THE ENDOSTERNITE

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ABSTRACT

Comparative anatomical studies are carried out on representatives of the Arachnida, Merostomata, and Pycnogonida with respect to (a) circulatory morphology, and (b) the morphological significance of the muscles which insert on the endosternite. A morphological relationship of the chelicerate arterial system to the endosternite is demonstrated, and evidence is brought forth that this is a primitive relationship in chelicerates. A comparative analysis of the chelicerate endosternite provides evidence that it has evolved by fusion of an arterial membrane with the connective tissue of serial, paired, transverse and dorsoventral muscles. A hypothetical model of the primitive chelicerate endosternite is reconstructed.

Specimens dissected and/or sectioned include representative genera of each arachnid order; the xiphosuran, *Limulus*; and seven genera of pycnogonids. The endosternites of merostomes and arachnids are interpreted to be homologous structures, and the transverse suspensor muscles of the endosternite are hypothesized to be homologous to the transverse muscle fibers of the pycnogonid horizontal vascular septum.

In all apulmonate arachnids which have endosternites (orders Palpigradida, Acarida, Opilionida, Ricinuleida, and Pseudoscorpionida) the endosternite is demonstrated to be continuous with a perineural vascular membrane which encloses a periganglionic arterial sinus. It is demonstrated that palpigrades possess the most primitive endosternite of all the known extant chelicerates. In the nonpalpigrade apulmonate arachnids, there has been a tendency toward reduction of the endosternite and a corresponding tendency toward development of an elaborate apodemal endoskeleton. The most extreme degree of development of an apodemal endoskeleton occurs in solpugids, and in this order the mesodermal endosternite has been reduced to absence.

Limulus (Class Merostomata) also possesses a perineural vascular membrane and an endosternite. Only in the immature *Limulus* is the endosternite continuous with the arterial system; by the adult stage the anatomical connection between the two is vestigial.

In all pulmonate arachnids (orders Scorpionida, Thelyphonida, Schizomida, Amblypygida, and Araneida) the adult arterial system includes a pair of enlarged arteries (thoracic sinuses) which lie dorsad to the subesophageal ganglionic mass. Since the larval *Limulus* possesses a similar pair of thoracic sinuses (Kingsley, 1893) which during later ontogeny hypertrophy and surround the central nervous system, giving rise to a periganglionic arterial sinus, it is hypothesized that the thoracic sinuses of adult pulmonate arachnids represent a neotenous condition. In the pulmonate arachnid orders, there is no anatomical connection between the adult arterial system and endosternite, except in the lungless spider, *Orthonops gertschi* (family Caponiidae), where an anatomical connection exists in the adult.

The existence in pycnogonids of a perivisceral arterial membrane is demonstrated, and in the light of this the circulatory blood movements in pycnogonids are reinterpreted. The perineural portion of this membrane is interpreted to be homologous to the perineural vascular membrane of merostomes and arachnids. In pycnogonids, the perivisceral arterial membrane is continuous with the double-layered horizontal vascular septum (of Dohrn, 1881) which separates dorsal and ventral portions of the trunk hemocoel. It is suggested that this septum is homologous to the hypothetical progenitor of the endosternite of merostomes and arachnids. Moreover, it is suggested that the primitive function of the chelicerate endosternite may have been vascular rather than skeletal.

It is hypothesized that neoteny has been involved in the origin of arachnids from merostomes, and in the origin of apulmonate arachnids from pulmonates. The Palpigradida is regarded as the closest apulmonate order to the ancestral apulmonate stock. The Pulmonata and Apulmonata are both regarded as natural monophyletic catagories. The Pulmonata is regarded as having emerged from the arachnid ancestors of modern scorpions. The ancestral apulmonate stock diverged to give rise both to modern palpigrades and to the nonpalpigrade apulmonates.

INTRODUCTION

The development of this research started with some observations I made of a noteworthy relationship of the arterial system to the endosternite in opilionids. The anterior aorta in these arachnids is continuous with a vascular membrane which envelops the entire central nervous system and its nerve trunks. Thus, the nervous system is enclosed within a periganglionic arterial blood sinus. The same vascular membrane is also continuous with the endosternite. A detailed observation showed that this is a histological continuity of connective tissue; the endosternite is actually a thickened portion of the perinueral vascular membrane.

Subsequently, I observed that a similar perineural arterial membrane, with the same relation to the endosternite, exists in all three suborders of the Opilionida, and I interpret this similarity to be homology. Although Kaestner (1968) mentioned the perinueral arterial membrane in opilionids, and Appelt (1900) observed that the endosternite in *Phalangium opilio* is continuous around its borders with a membrane which surrounds the brain, the actual relation of the arterial system and endosternite has never been mentioned by any author.

A perineural vascular membrane, similar to that in opilionids, has been reported for *Limulus* (Milne-Edwards, 1872; Petrunkevitch, 1922; Kaestner, 1968) and in the Acarida (Hughes, 1959; Evans, 1961), though none of these authors mentioned a relationship of this membrane to the endosternite. My own dissection of *Argas persicus*, a tick, showed that the perineural vascular membrane, is, in fact, continuous with the endosternite. I found that the same relationship exists also in an immature *Limulus*, though in the adult the endosternite has become a separate, detached structure with only a vestigial connection to the arterial system. Apparently, this relationship in the young *Limulus* was almost discovered by Snodgrass (1952), who commented:

> In a larval specimen of *Limulus* 2 cm. in length, the endosternum is a thin membrane . . . . In a specimen 5 mm. in length, the "plate" is a delicate membrane resting close upon the nerve mass beneath it . . . .

These discoveries led me to the opinion that the chelicerate endosternite is a structure of mesodermal origin, contrary to the opinions of some other arthropodologists: e.g., Bernard (1892a, b; 1894c; 1896); Comstock (1948); Chamberlin (1931); Fox and Fox (1964). In this way, I was motivated to undertake an investigation of the endosternite and its relation to the arterial system in the subphylum Chelicerata.

The endosternite is an internal skeleton composed of connective tissue. It occurs in all chelicerates, with the exception of solpugids and a few groups of mites. It is serially metamerized, though in the cephalothorax it is centralized as a common tendon for the attachments of many skeletal muscles. In the abdomen, the endosternite is uncentralized (i.e., it occurs independently in each of one or more segments). The morphological significance of the endosternite became a controversial issue after the appearance of Lankester's (1881) hypothesis that *Limulus* in an arachnid, and especially after Patten's (1889, 1899) hypothesis that *Limulus* is a prevertebrate. The most comprehensive treatments of the nature and origin of the endosternite, from the standpoint of comparative morphology, were those of Schimkewitsch (1893, 1894) and of Pocock (1902). Both of these authors supported the view that the evolution of the endosternite is most satisfactorily reconstructed by means of a theory of the hypertrophy and fusion of muscle tendons. However, neither of them recognized the role of the circulatory system in endosternite development, and accordingly they failed to reconstruct the phyletic history by which the metameric cephalothoracic elements gave rise to a centralized skeletal structure lying horizontally above the subesophageal ganglionic mass.

My own analysis of the endosternite musculature in chelicerates indicated that it is necessary to distinguish the muscles which insert upon the endosternite from those which originate from it. Muscles which insert upon the endosternite have the function of moving or tensing it when they contract; these are the suspensors of the endosternite, and there are two types: the dorsoventral suspensors and the transverse suspensors (Figs. 1, 2). Primitively, one pair of each of these took part in the development of the endosternite in each of the six appendage-bearing segments, as shown by the fact that in palpigrades the endosternite is formed by the six appendage-bearing cephalothoracic segments. The dorsoventral suspensors are bisected by the endosternite, which lies in a horizontal plane, and are thus divided into dorsal suspensors and ventral suspensors. Dorsal suspensors originate from the carapace, while ventral suspensors originate from the sternum. The transverse suspensors are bisected medially by the endosternite, and thus they are divided into right and left counterparts. They originate from the pleural region of the body wall: either from the lateral extremities of the carapace, or else from pleural sclerites (epimera) which lie between the appendicular coxae.

The suspensor muscles of the endosternite insert upon it by way of tendons which are histologically continuous with its connective tissue matrix. They cannot be separated from the endosternite without tearing either the muscle tendon or else part of the endosternite itself. Their points of origin are never on movable appendages such as coxae or endites.

Muscles which originate from the endosternite always insert upon movable structures (e.g., stomodeum, lorum, or appendages). In specimens which have been preserved in alcohol, the muscle origins can be pulled cleanly away from the endosternite, with forceps, exposing a smooth, white surface of attachment on the endosternite surface.

In all the apulmonate arachnids (i.e., those which lack book lungs) the endosternite is continuous all around its borders with a perineural vascular membrane which encloses a periganlionic arterial sinus. This sinus receives blood directly from the aorta. The perineural vascular membrane ensheathes all nerve trunks arising from the central nervous system, and it is reflected posteriorly over the entire length of the postcerebral intestine as a peri-intestinal vascular membrane which encloses a peri-intestinal arterial sinus. (I have observed the peri-intestinal vascular membrane in opilionids, in mites, and in pycnogonids. However, I have not attempted a comparative study of it, for it is not involved directly with the morphology of the endosternite, nor have I confirmed the presence of this membrane in all groups of chelicerates studied in this paper.) The peri-intestinal and perineural vascular membranes constitute collectively a perivisceral arterial membrane which is present also in pycnogonids. The perivisceral arterial membrane is composed of vascular connective tissue like that of the heart and aorta, with which it is con-

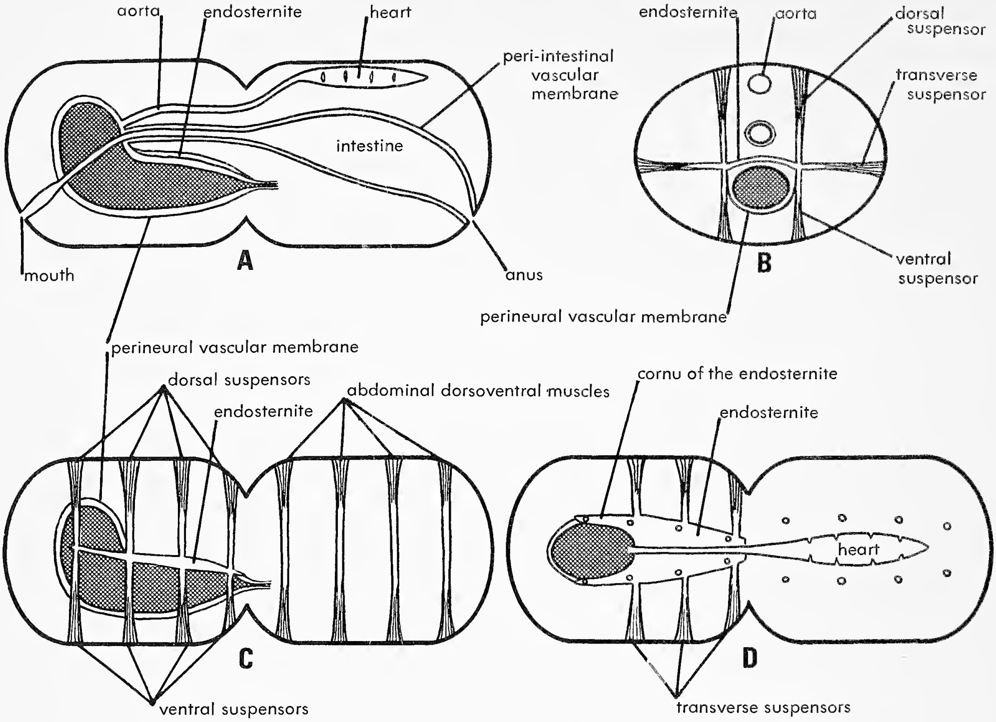


Fig. 1.–TYPICAL APULMONATE ARTERIAL SYSTEM. This condition exists in all chelicerates which lack book lungs. It exists in the arachnid orders Palpigradida, Opilionida, Acarida, Pseudoscorpionida, Ricinuleida, Solpugida, and in the lungless spiders. It exists also in the merostome, *Limulus*, and a similar, homologous condition exists in the Pycnogonida. The central nervous system is shown in dark stipple. Note that blood is pumped into a periganglionic arterial sinus which surrounds the central nervous system. A: midsagittal view; B: transverse section through the subesophageal ganglionic mass; C: lateral view of the endosternite and dorsoventral muscles, seen from the left; D: dorsal view of the endosternite and transverse suspensors; the circles represent the positions of dorsoventral muscles.

tinuous. The endosternite, in the apulmonate arachnids, is a thickened portion of the perineural vascular membrane.

In all the pulmonate arachnids (i.e., those which breathe with book lungs) the perineural arterial development stops short at the stage (as in the larval *Limulus*) in which a pair of thoracic sinuses lie on top of the subesophageal ganglionic mass (Kingsley, 1893). The endosternite of pulmonates develops independently of the arterial system, notwithstanding the primitive association of the two which persists in all other chelicerates which have endostenites. The arrested arterial development peculiar to pulmonate arachnids is an ontogenetic specialization which apparently has arisen through neoteny. The possibility that this has actually occurred will be discussed in greater detail later.

MATERIALS AND METHODS

All specimens were chosen for this study on the basis of availability. Some groups of chelicerates are rare, in which case specimens for dissection must be obtained either from specialists, or else from curators of museum collections. Dr. J. W. Hedgpeth gave me

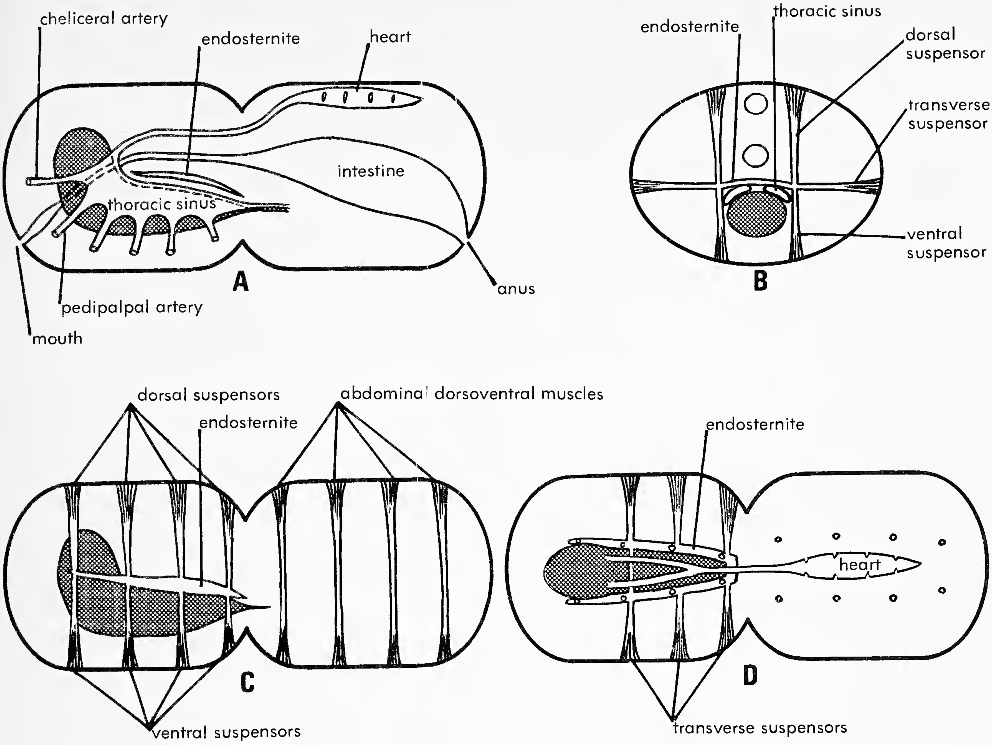


Fig. 2.–TYPICAL PULMONATE ARTERIAL SYSTEM. This condition exists in all arachnids which possess book lungs. It exists in the orders Scorpionida, Thelyphonida, Schizomida, Amblypygida, and Araneida (except lungless spiders). The central nervous system is shown in dark shading. Note that blood is pumped into a paired thoracic sinus which lies on top of the subesophageal ganglionic mass. A: sagittal view, with the left side of the arterial system superimposed, as seen from the left; B: transverse section through the subesophageal ganglionic mass; C: lateral view of the endosternite and dorsoventral muscles, seen from the left; for clarity the circulatory system is omitted; D: dorsal view of the endosternite and transverse suspensors; the circles represent the positions of dorsoventral muscles; for clarity the thoracic sinuses have been omitted, though a heart and aorta are shown. For a dorsal view of the thoracic sinus arterial system, see Figure 19B.

specimens of the following pycnogonids: *Colossendeis scotti, Pycnogonum rhinoceros, Endeis* sp., *Decolopoda australis, Nymphon charcoti, Pentanymphon antarcticum,* and *Ammothea striata.* Dr. Willis J. Gertsch gave me specimens of the following arachnids: *Prokoenenia wheeleri, Trithyreus pentapeltis, Cryptocellus boneti,* and *Orthonops gertschi.* From Dr. D. P. Abbott, I obtained *Garypus californicus*; from Dr. R. W. Mitchell, *Cryptocellus osorioi*; from Dr. L. E. Eighm, *Siro acaroides*; and from Miss M. J. Moody, a Costa Rican amblypygid, *Tarantula* sp. I purchased specimens of *Pycnogonum littorale, Argas persicus,* and *Limulus polyphemus* from General Biological, Inc. (Turtox), Chicago, Illinois.

Dr. E. T. Roche prepared serial cross sections of *Siro acaroides*; the microtome sectioning of this arachnid was made practical by the prior removal of the exoskeleton. All other specimens used in this study were dissected in 70% ethanol, using a Spencer stereoscopic dissection microscope with objectives of 1X, 4X, and 8X, and with oculars of 12X and 20X. Most specimens were cut midsagittally, with a sharp razor blade, and anchored to a Syracuse watchglass with paraffin. Other specimens were cut parasagittally, to the left of the midline, anchored in paraffin on the right side, and dissected from the left side. A few specimens were cut transversely and dissected from the anterior or posterior surface. Illumination was reflected from two sides, and in order to enchance detail, the tissues were stained, as required, with Shaeffer's washable blue Skrip ink.

OBSERVATIONS AND FINDINGS

The Apulmonate Arachnid Orders:
Palpigradida
Opilionida
Acarida
Pseudoscorpionida
Ricinuleida
Solpugida

Order Palpigradida—Most arachnologists regard palpigrades as the most generalized of the living arachnids, i.e., with the greatest number of primitive features, and with fewest specializations (Roewer, 1934). The carapace is metamerized externally, and there are five cephalothoracic sternites, the anteriormost of which belongs to the cheliceral segment. This is the only living order in which there is a distinct cheliceral sternite (Snodgrass, 1952). *Sternarthron zitteli*, stated to be a fossil palpigrade of Upper Jurassic age, possesses six cephalothoracic sternites (Petrunkevitch, 1955). Palpigrades bear close resembalance to the superorder Uropygida (schizomids and thelyphonids), and most arachnologists agree that modern palpigrades have emerged from the ancestral stock that gave rise to the non-scorpion pulmonate orders. However, palpigrades are not pulmonates, for they do not possess book lungs. Some palpigrades possess three pairs of abdominal "lung-sacs" which some investigators have interpreted as respiratory organs. Rucker (1901) believed that lung-sacs were the phyletic antecedants of both book lungs and tracheal spiracles.

The earliest published description of the internal anatomy of a palpigrade is that of Rucker (1901), who said of the circulatory system of *Prokoenenia wheeleri* only that "... the simplest condition possible exists." She said that a heart is lacking, although Börner (1904) described a heart with four pairs of ostia in *Eukoenenia mirabilis*. The endosternite of *E. mirabilis* has been described by Börner (1904), but the most detailed studies have been those of Millot (1942b, 1943, 1949b). Millot described six pairs of ventral suspensors of the endosternite; this number is regarded as primitive, since presumably there was one pair of dorsoventral muscles in each of the six appendage-bearing segments of the cephalothorax of ancestral arachnids. Only four pairs of suspensors persist on the dorsal side of the endosternite. In addition to the dorsal and ventral suspensors, Millot described five pairs of transverse suspensors (he called them "lateral suspensors") which originate from the sides of the carapace and extend horizontally to their insertions on the lateral margins of the endosternite (Fig. 4B and C).

I have examined *Prokoenenia wheeleri*, of central Texas, and I have found that the central nervous system is invested by a perineural vascular membrane which encloses a periganglionic arterial sinus (Fig. 3), as in the other apulmonate chelicerates. This membrane is continuous with the borders of the endosternite. The same membrane is continuous also with a dorsal vessal, probably an aorta, in the cephalorthorax. I did not trace this vessel into the abdomen to confirm the presence of a heart, but my diagram of a generalized palpigrade (Fig. 4) shows a heart because Börner (1904) described one in *E.*

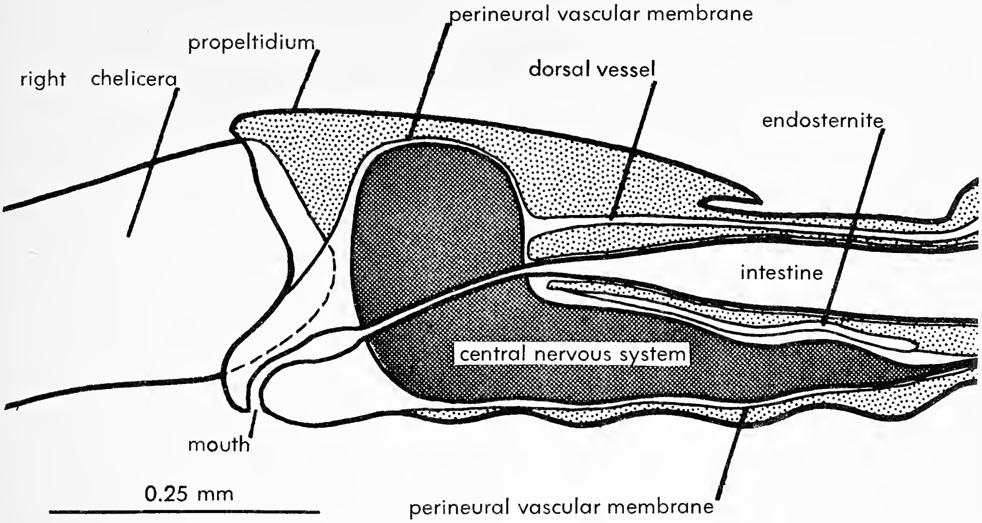


Fig. 3.—Midsagittal view of the caphalothorax of *Prokoenenia wheeleri* (order Palpigradida), seen from the left. The central nervous system is shown with dark shading.

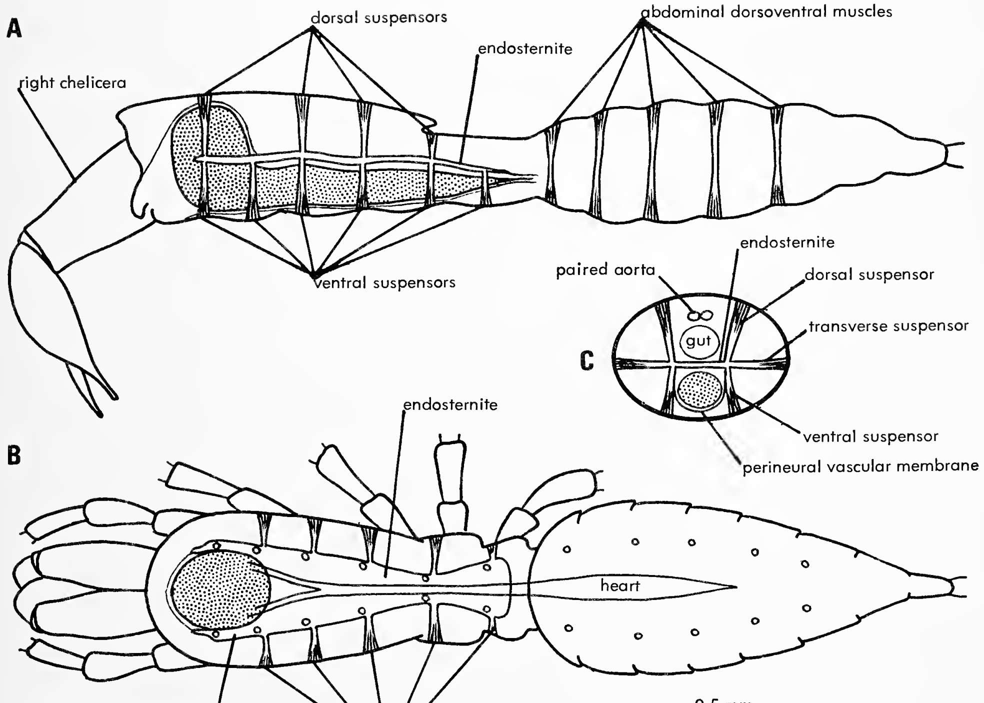
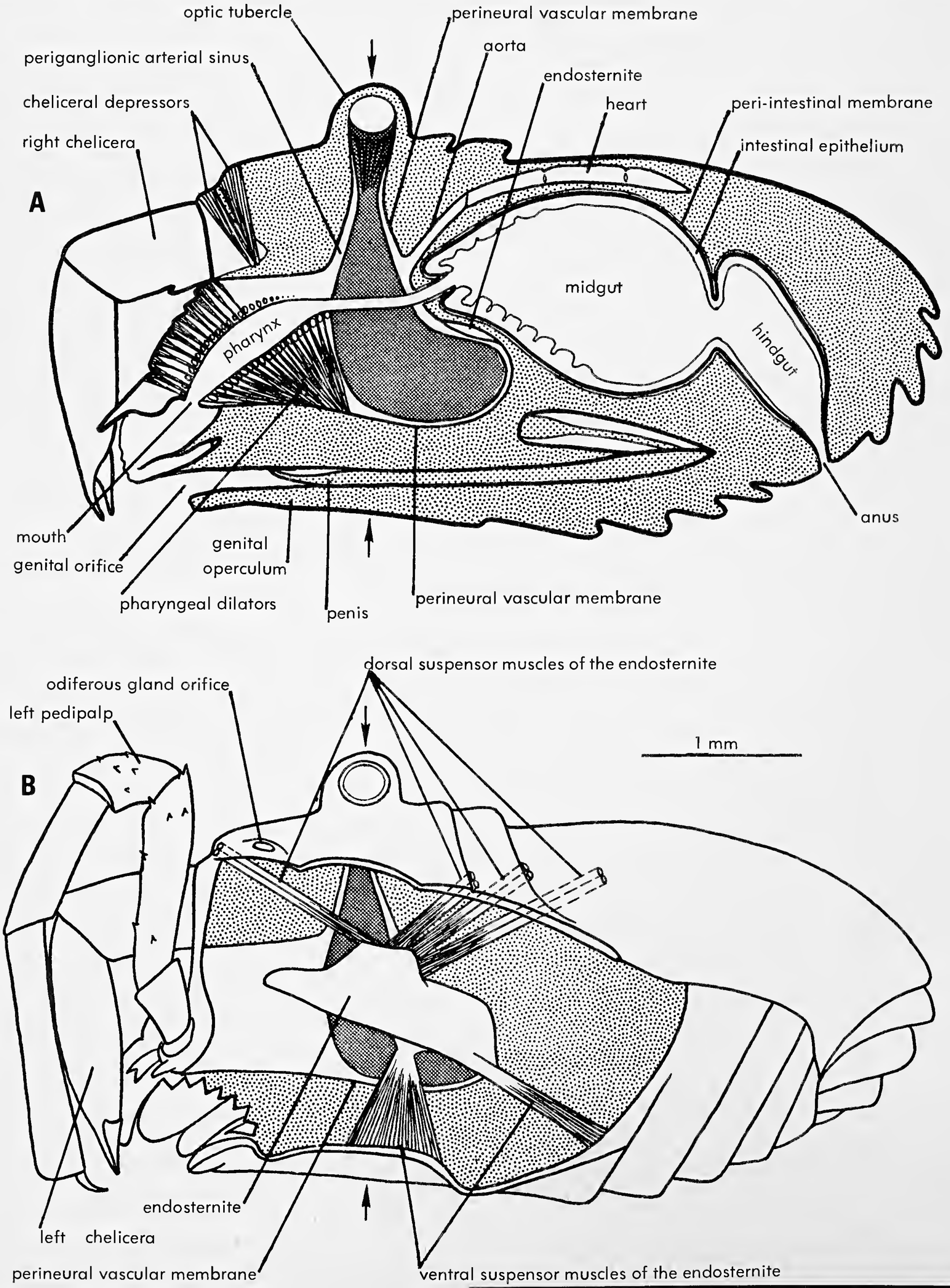


Fig. 4.—The arterial system and endosternite of a generalized palpigrade, adapted from Millot (1943), Börner (1904), Rucker (1901), and my own Fig. 3. A: lateral view, seen from the left, showing the dorsoventral muscles; B: dorsal view, showing the endosternite and its transverse suspensors; the circles represent the positions of the dorsoventral muscles; C: transverse view through the subesophageal ganglionic mass. The central nervous system is stippled.

mirabilis. The endosternite of *P. wheeleri*, and the suspensor muscles which insert upon it, correspond exactly to the condition described by Millot (1943) for *E. mirabilis*. The dorsal and ventral suspensors of the palpigrade endosternite appear to represent cephalothoracic dorsoventral muscles which are serially homologous to those of the abdomen. The palpigrade endosternite is more primitive than that of any other extant arachnid (Fig. 4), and it could almost serve as a model of the endosternite in a hypothetical ancestral arachind (Figs. 26D, 27F).

Order Opilionida—The perineural vascular membrane is most easily observed (and its relationship to the endosternite most readily discerned) in any of the common harvestment of the order Opilionida, e.g., *Leiobunum exilipes* (Figs. 5, 6). None of the morphol-



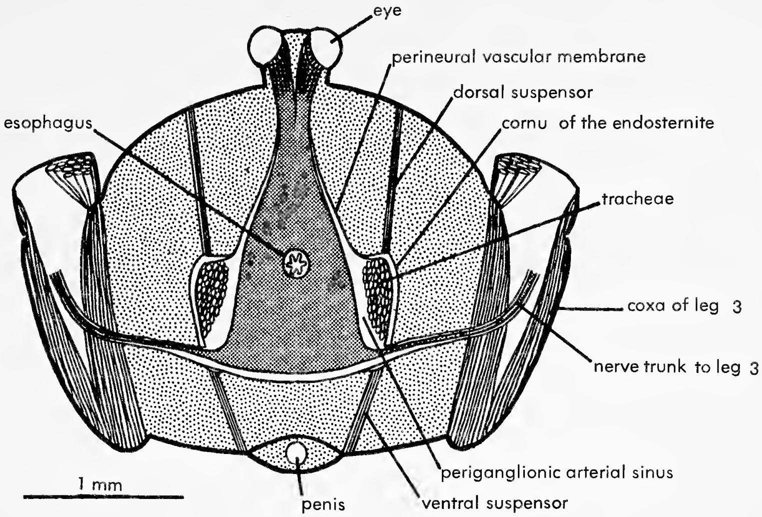


Fig. 6.–Transverse section through *Leiobunum exilipes* (order Opilionida), seen from the anterior. The plane of the section is indicated by the arrows in Fig. 5.

ogists of the last century left a published record of having observed this membrane in opilionids. The earliest students of opilionid anatomy, Treviranus (1816) and Tulk (1843), both of whom observed *Phalangium opilio*, made no mention at all of the endosternite. Apparently the first investigator to identify an endosternite in the Opilionida was Leydig (1862) who interpreted it as a chitinous derivative of the exoskeleton. In 1882, Rössler advanced the hypothesis that the opilionid endosternite is composed of a modified connective tissue, and in 1893 and 1894, Schimkewitsch adopted the same point of view in his descriptions and illustrations of the endosternite of *Opilio parietinus*. During the present century, the only published mention of the perineural membrane and endosternite of opilionids has been that of Appelt (1900) and Kaestner (1933, 1968). Appelt observed that "... the borders of the endosternite make transition into a tough membrane which embraces the whole nervous system." He did not report that he observed the continuity of this membrane with the aorta, for which reason it seems unlikely that he discerned the vascular significance of the membrane, although he stated the possibility that movements of the endosternite may facilitate the heart in the circulation of blood. Kaestner (1968) stated that the opilionid aorta "... opens as a funnel that surrounds the brain."

I have examined the arterial system and endosternite of *Leiobunum exilipes* (suborder Palpatores), a phalangid which is abundant in central California. The arterial system consists of a heart and an anterior aorta which is continuous with a perineural vascular membrane. This membrane surrounds a periganglionic arterial sinus which receives blood from the aorta. Also, the perineural vascular membrane is continuous with a peri-intestinal vascular membrane which surrounds a peri-intestinal arterial sinus (Fig. 5A). A lateral view of the endosternite of *L. exilipes* is shown in Fig. 5B. It is saddle-shaped,

Fig. 5.–A: midsagittal section through *Leiobunum exilipes* (order Opilionida), seen from the left; B: lateral view of same, with part of the body wall removed so as to show the endosternite and suspensor muscles. The central nervous system is shown with dark shading. The arrows indicate the plane of the cross section in Fig. 6.

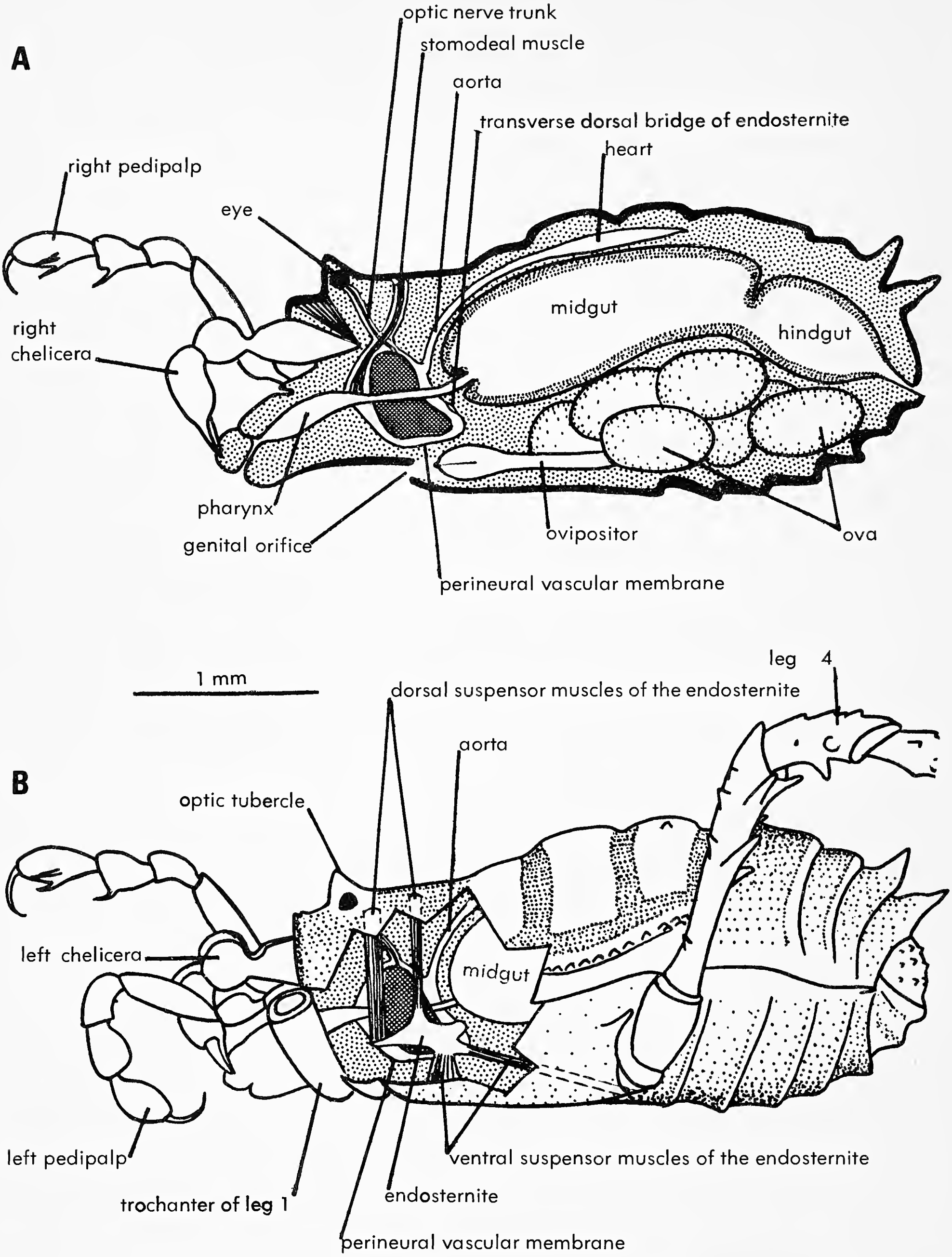


Fig. 7.—A: midsagittal section through a laniatore opilionid (family Gonyleptidae), seen from the left; B: lateral view of same, with part of the body wall removed so as to expose the endosternite and suspensor muscles on the left side. The central nervous system is shown with dark shading.

consisting of a median portion which lies above the subesophageal ganglionic mass, and a pair of cornua that extend anteriad along the sides of the supraesophageal ganglionic mass (Fig. 6). All around its border, the endosternite is continuous with the perineural vascular membrane. A close examination showed that this is a histological continuity of connective tissue; the endosternite is morphologically a thickened portion of the perineural vascular membrane. Four pairs of suspensor muscles insert onto the dorsal surface of the endosternite at its lateral margins, and two pairs insert onto the ventral surface. Transverse suspensors are lacking in all the opilionids I have examined.

The suborder Laniatores includes, among other families, the Gonyleptidae, which is confined in its distribution to Latin America (pers. comm., C. J. Goodnight). Fig. 7A and B shows that the gonyleptid possesses a perineural vascular membrane which is essentially similar to that of a palpatorid; the endosternite, however, is considerably reduced, its dorsal portion being represented by a thin, transverse band across the posterior end of the subesophageal ganglionic mass. The reduced condition of the gonyleptid endosternite closely resembles that of the other nonpalpigrade apulmonates, and is accompained by

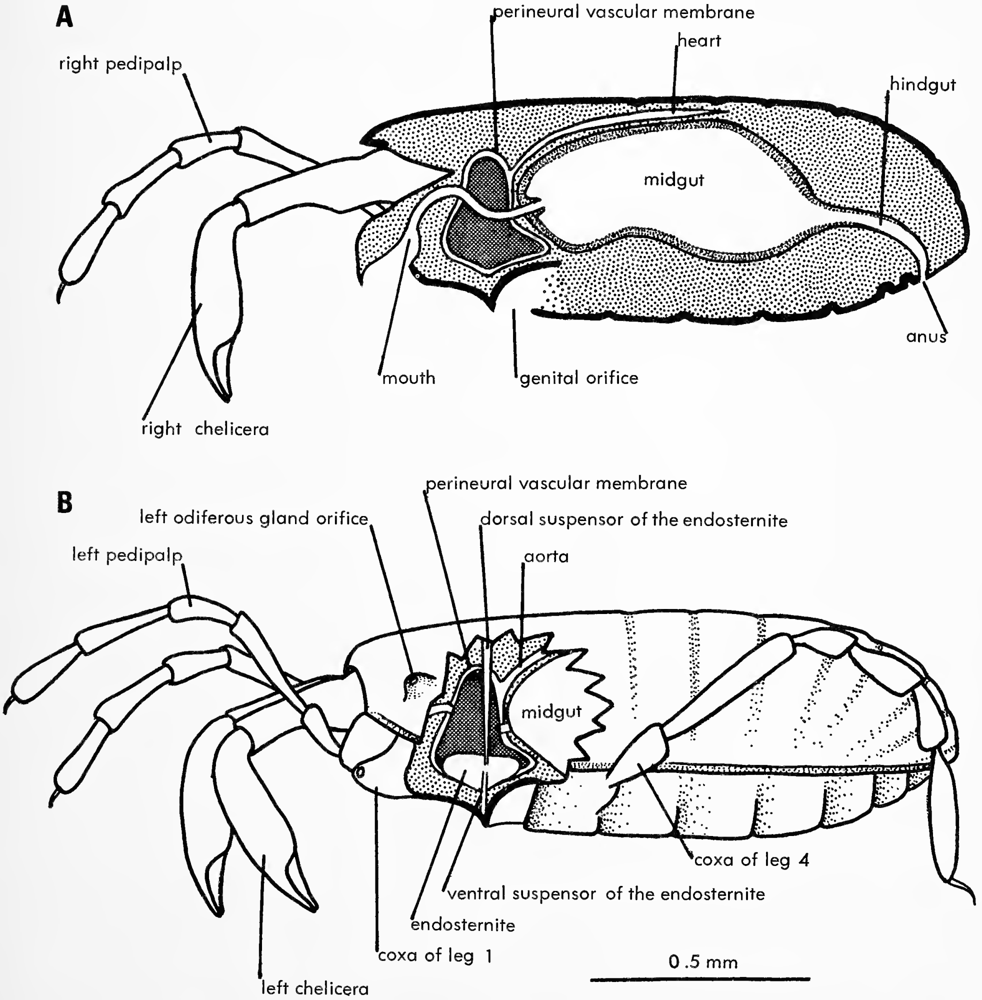


Fig. 8.–A: midsagittal view of a cyphophthalmid opilionid, *Siro acaroides*, seen from the left; B: lateral view of same, with part of the body wall removed so as to expose the endosternite and suspensor muscles on the left side. The central nervous system is shown with dark shading.

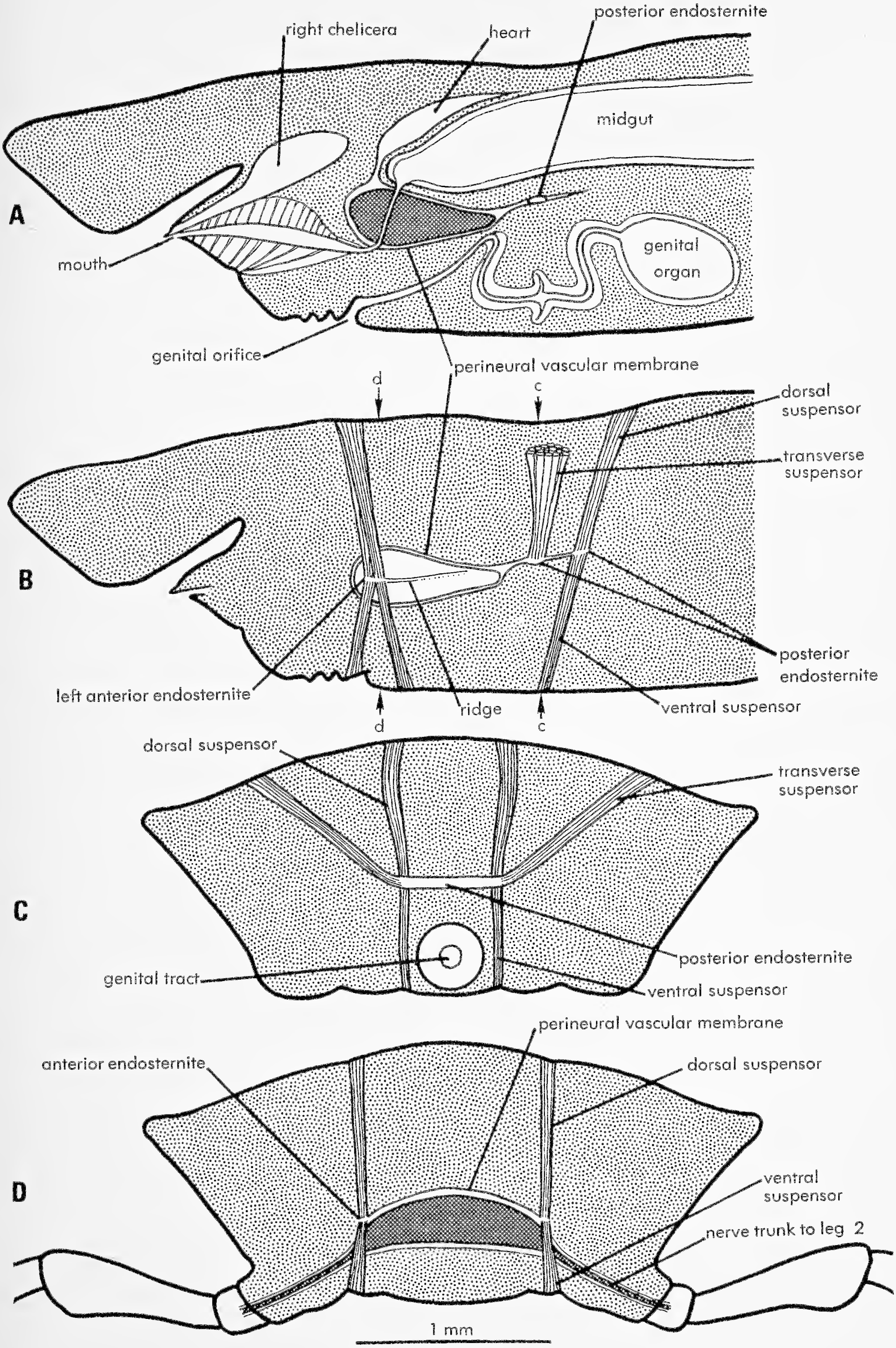
the presence of a strongly developed system of intercoxal apodemes. Only two pairs each of dorsal and ventral suspensors insert onto the gonyleptid endosternite (Fig. 7B). Sorensen (1879), in his classic treatise on the anatomy of the Gonyleptidae, made no mention of the endosternite, nor of the perineural vascular membrane.

The suborder Cyphophthalmi includes only a single family, Sironidae, of mite-sized opilionids. No previous studies of the endosternite or circulatory system have been made in this suborder. The presence of a perineural vascular membrane in *Siro acaroides* (Fig. 8) was confirmed by me, both from dissections and from serial cross sections. The endosternite of *S. acaroides* is vestigial, being represented by a pair of lateral thickenings of the perineural vascular membrane. The right and left sides are not continuous, except by way of the perineural vascular membrane; there is no dorsal, median portion connecting the right and left sides, as there is in other opilionids. The only muscles inserting onto the endosternite are a single pair of dorsoventral suspensors, though several appendicular and pharyngeal muscles originate from it.

Order Acarida—Hughes (1959) stated that in mites "... the brain is invested by a thin connective tissue sheath." This sheath is the perineural vascular membrane, and I have found it to be present in all the mites I have examined. There is general agreement among acarologists that most mites do not possess a functional heart (e.g., André, 1949); nevertheless, in all my observations I have found that a dorsal vessel or its vestige is present, and this is continuous with the perineural vascular membrane. Bonnet (1907) described a heart in the ixodid thick, *Hyaloma*, and Evans (1961) stated that the hearts of ixodids have two pairs of ostia. Winkler (1888a, b) described and illustrated a heart with a single pair of ostia in gamasid mites of the suborder Mesostigmata, and Baker and Wharton (1952) reported that a simple heart is present in the suborder Holothyroidea. Schaub (1888) in his sagittal view of *Hydrophantes dispar* (a water mite) showed a membrane which completely envelops the central nervous system, though he did not show an endosternite or a heart. However, Mitchell (1957), who described the musculature of *Hydryphantes*, mentioned a "transverse ligament" to which muscles attach, and I infer that this is an endosternite. Both Steding (1923) and Vitzthum (1940) described and illustrated an endosternite in the genus *Halarachne*; moreover, Vitzthum affirmed the existence of an endosternite in the Notostigmata, the Holothyroidea, the Gamasina, the argasid ticks, the Trombidiformes, and the Sarcoptiformes, but he stipulated that certain groups of mites lack an endosternite (e.g., the Uropodina and the Tetrapodili).

For the purposes of this research I have focused my attention upon the fowl tick, *Argas Persicus* (suborder Metastigmata). I chose this form because of its availability, and because of its large size compared to other members of the order. In the fowl tick, I found that a perineural vascular membrane is well developed; it is continuous with an endosternite and with a dorsal aorta leading from the heart (Figs. 9, 26H). This confirms the report of Borradaile, et al. (1961) that "... in the tick, *Argas*, there is a single-

Fig. 9.—A: midsagittal view through the cephalothoracic region of *Argas persicus*, the fowl tick (order Acarida), seen from the left; B: lateral view of same, showing the endosternite and its suspensor muscles, seen from the left; C: transverse section through the transverse suspensor of the posterior endosternite, as seen from the anterior, with the posteriormost pair of dorsoventral suspensor muscles behind it; the plane of the section is indicated in Fig. B by the arrows, cc. D: transverse section through the anterior endosternite, showing the attachment of the anteriormost pair of dorsoventral suspensor muscles, as seen from the anterior; the plane of the section is indicated in Fig. B by the arrows, dd.


A
right chelicera
heart
posterior endosternite
midgut
mouth
genital
organ
genital orifice
perineural vascular membrane
B
d
c
dorsal
suspensor
transverse
suspensor
posterior
endosternite
left anterior endosternite
ridge
ventral suspensor
d
c
C
dorsal suspensor
transverse
suspensor
posterior endosternite
genital tract
ventral suspensor
D
perineural vascular membrane
anterior endosternite
dorsal suspensor
ventral
suspensor
nerve trunk to leg 2
1 mm

chambered pulsating vessel with a pair of ostia and an aorta running forward to a periganglionic sinus."

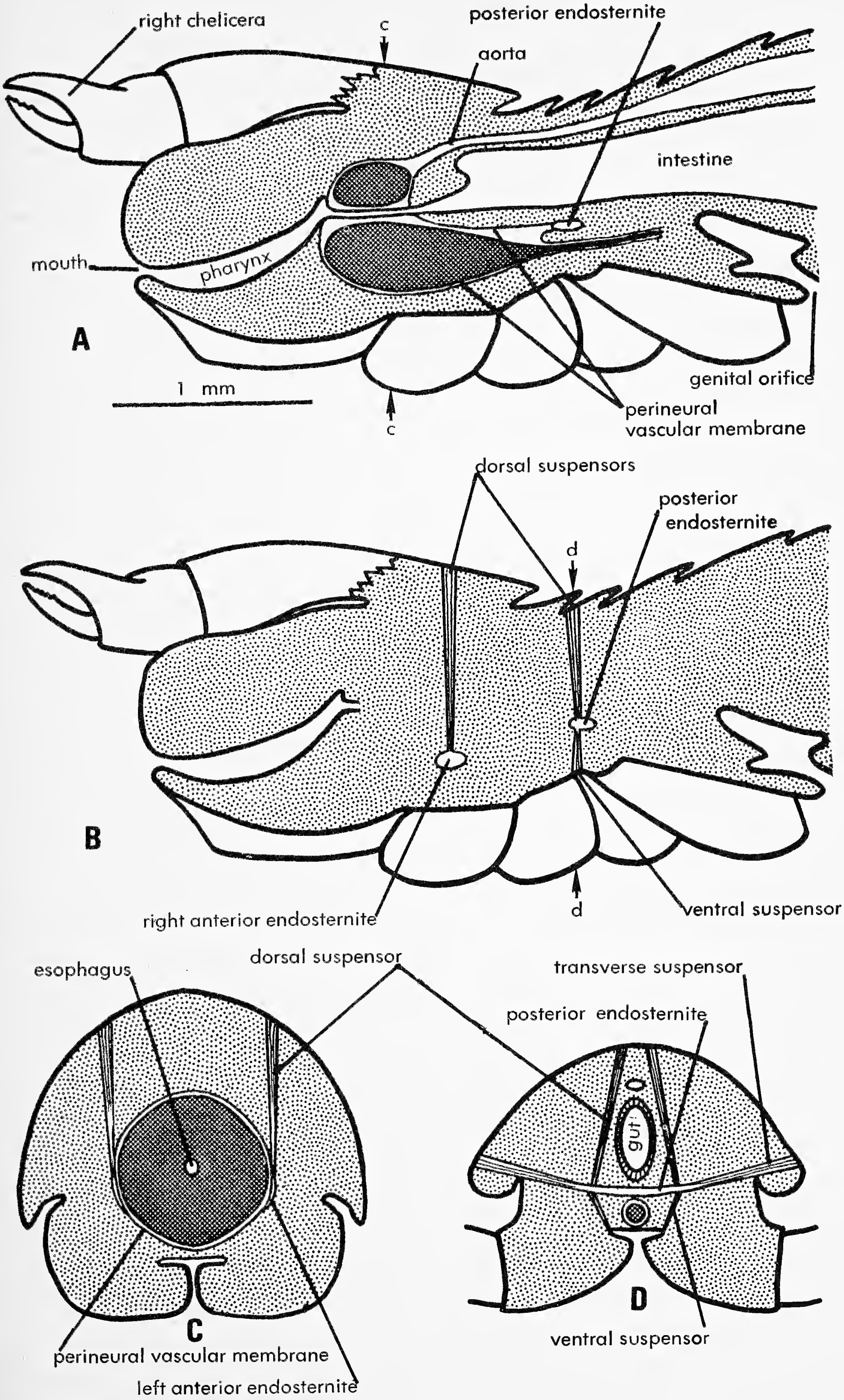
The endosternite of *A. persicus* is divided into anterior and posterior parts: the anterior endosternite consists of a pair of thickened portions of the perineural vascular membrane on the right and left sides of the brain. This condition resembles that of the cyphophthalmid endosternite (described above). Each side receives the insertions of two pairs of dorsoventral muscles (Fig. 9B and D). Extending posteriad from the anterior endosternite, on each side of the central nervous system, is a skeletal ridge of thickened perineural vascular membrane which receives the origins of many appendicular muscles, mainly coxal rotators. Morphologically, this ridge must be regarded as part of the anterior endosternite; it is labeled in Fig. 9B. The posterior endosternite is formed principally by the tendonified medial portion of a single transverse muscle (Fig. 9A, B, C). It is continuous with a posterior extension of the perineural vascular membrane. Immediately posterior to the transverse band of the posterior endosternite, a single pair of dorsoventral muscles is bisected by the perineural vascular membrane, which forms a horizontal membranous septum for a short distance behind the transverse band (Fig. 9B). Hence, the endosternite of this tick (anterior plus posterior portions) involves three pairs of dorsoventral muscles and one pair of transverse muscles. In the past, certain authors (e.g., Pagenstecher, 1862) have confused the true dorsoventral muscles with coxal elevators. The latter are powerful muscles, originating on the carapace, which extend ventrad to insert on coxal apodemes, whereas the true dorsoventral muscles originate on the carapace and sternum and insert on the endosternite.

I have studied wholemount slides (prepared by I. M. Newell) of *Caloglyphus* sp., an astigmatic mite (suborder Sarcoptiformes), which show an endosternite that is more extensively developed than in ticks. It is continuous with a perineural vascular membrane which receives a dorsal vessel, though a functional heart is said not to be present in the Sarcoptiformes. The endosternite of this mite is more similar to that of a harvestman than is the tick endosternite.

Order Pseudoscorpionida—Morphological treatments of the pseudoscorpion date back as far as the *Vermischte Schriften*, by Treviranus (1816), who examined *Chelifer* sp. The earliest investigation of the internal anatomy is that of Menge (1855), who examined various genera, though description of the circulatory structures was not attempted until 1880, by Daday, in *Chernes hahnii*. A general treatment of internal morphology was prepared in 1888, by Croneberg, who based his report upon earlier findings, and upon his own observations of *C. hahnii.*

Croneberg (1888), in describing the brain of *C. hahnii*, distinguished an "inner neurilemma" from an "outer neurilemma," and I infer that the latter is a vestige of the perineural vascular membrane. In his Fig. 17, he showed that the "outer neurilemma" is

Fig. 10.—Generalized diagram of the endosternite and perineural vascular membrane in pseudoscorpions, based upon my observations of *Microcreagris* sp. and *Garypus californicus*, and upon the descriptions of Vachon (1949) in *Chelifer cancroides*, and of Croneberg (1888) in *Chernes hahnii*. A: midsagittal view of the cephalothoracic region, seen from the left; B: lateral view of the endosternites, showing the dorsal and ventral suspensor muscles, as seen from the left; C: transverse section through the anterior endosternite, seen from the anterior; the plane of the section is indicated in Fig. A by the arrows, cc. D: transverse section through the posterior endosternite, seen from the anterior; the plane of the section is indicated in Fig. B by the arrows, dd. The central nervous system is shown with dark shading.


right chelicera
c
posterior endosternite
aorta
intestine
mouth
pharynx
A
1 mm
genital orifice
c
perineural
vascular membrane
dorsal suspensors
posterior
endosternite
d
B
d
right anterior endosternite
ventral suspensor
esophagus
dorsal suspensor
transverse suspensor
posterior endosternite
gut
C
perineural vascular membrane
left anterior endosternite
D
ventral suspensor

continuous with a dorsal vessel which I take to be the anterior aorta. Although Croneberg made no comment about this relationship, he did say that the aorta extends forward until it reaches the posterior face of the supraesophageal ganglionic mass.

The pseudoscorpion endosternite has been described by Vachon (1949), based mainly upon *Chelifer cancroides*. The endosternite of this arachnid, like that of *Argas persicus* (the fowl tick), is divided completely into separate anterior and posterior portions. The anterior endosternite is paired, lying on the right and left sides of the supraesophageal ganglionic mass (Fig. 10B, C). A single pair of dorsal suspensor muscles inserts into the anterior endosternite, and several pairs of appendicular and pharyngeal muscles originate from it. The posterior endosternite has been described by Vachon as "... a simple transverse, tendinous band." He illustrated it in both lateral and dorsal views, and Croneberg (1888) illustrated it in transverse view. A single pair of dorsoventral suspensor muscles inserts onto the posterior endosternite, and at least three pairs of appendicular muscles originate from it. According to Vachon (1949), the anterior and posterior endosternites are derived each from three segments: he said that the anterior endosternite is derived from the pedipalpal and the first and second walking-leg segments, whereas the posterior endosternite is derived from the third and fourth walking-leg and the first abdominal segments.

I have examined the arterial system and endosternite of *Microcreagris* sp. and of *Garypus californicus*. In both of these genera, I found a perineural vascular membrane (Fig. 10A, C) which is similar to that already described for other apulmonate arachnids. It is somewhat fragmentary, however, and it exists apparently as a vestige which may no longer have a vascular function. It is most plainly developed in those regions where it is continuous with the endosternites. Weygoldt (1969) in his midsagittal view of the anterior end of an embryonic *Neobisium* sp. (his Fig. 92) illustrated a membrane which is continuous with the posterior endosternite, and I believe this is the same membrane (the perineural vascular membrane) which I have observed in *Microcreagris* sp. and *G. californicus.*

The endosternites of these two pseudoscorpions correspond exactly to the earlier descriptions of Croneberg (1888) and Vachon (1949). The anterior endosternite, lying on each side of the brain, is continuous with the perineural vascular membrane; I interpret it as the morphological equivalent of the lateral horns (the anterior cornua) of the more completely developed endosternites of other arachnids. The posterior endosternite resembles the posterior portion of the tick endosternite because, morphologically, it is the tendinous, medial axis of a transverse muscle which originates, on both sides, from the carapace (Fig. 10A, D).

The pseudoscorpion endosternite, despite its morphological similarity to the argasid endosternite, is more reduced (i.e., more vestigial) than the latter: the anterior endosternite of the pseudoscorpion receives the insertion of only a single pair of dorsoventral muscles, whereas that of the argasid tick has two such insertions on each side. Moreover, the endosternal ridge, of the anterior endosternite of the tick, is not developed in the pseudoscorpion. The apodemal endoskeleton is more highly developed in pseudoscorpions than it is in argasic ticks. I believe this supports my hypothesis that there is a general correlation in all apulmonate arachnids between the extent of apodemal development and the degree of reduction of the mesodermal endosternite.

Order Ricinuleida—The first morphological treatment of the Ricinuleida was that of Hansen and Sorensen (1904), who dealt primarily with the external anatomy of various

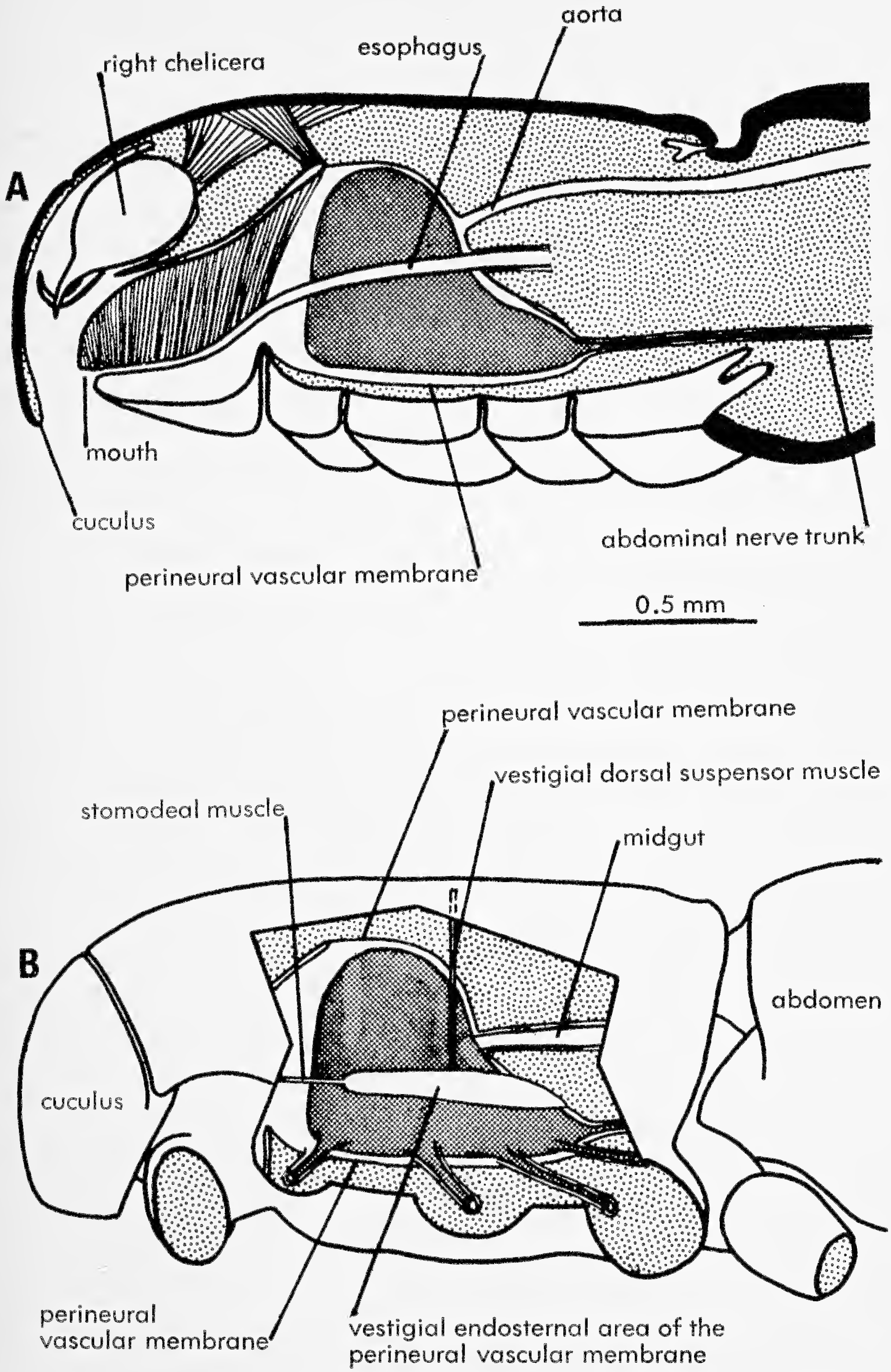


Fig. 11.–A: midsagittal view of the cephalothoracic region of *Cryptocellus boneti* (order Ricinuleida), seen from the left; B: lateral view of same, showing the vestigial endosternal area of the perineural vascular membrane; the central nervous system is shown with dark shading.

species of *Ricinoides*. The internal anatomy was not studied in detail until Millot (1945a, b, c) dissected *R. feae*. He described a reduced heart and an anterior aorta which becomes lost at the posterior surface of the supraesophageal ganglionic mass. He noted a thin "fibro-muscular sheet" associated with the brain and commented that this may represent the vestige of an endosternite.

I have examined two species of *Cryptocellus* (Fig. 11): *C. boneti*, from Morelos, México, and *C. osorioi*, from caves in San Luis Potosí, México. I find in both of these species of *Cryptcellus* the typical apulmonate condition of the arterial system: the central nervous system is invested with a perineural vascular membrane which is continuous with the aorta. Associated with this membrane, there is a certain region which I call the endosternal area (Fig. 11B). For the following two reasons, I interpret this area as a vestigial endosernite: (1) arising from the endosternal area is a pair of strands of connective tissue; these strands are probably non-contractile, but they attach to the carapace and appear to be vestiges of dorsal suspensor muscles; (2) a pair of stomedeal muscles originates from the anterior portion of the endosternal area.

The apodemal endoskeleton in ricinuleids is more strongly developed than in pseudoscorpions, but less so than in solpugids; the development of the mesodermal endosternite seems to be inversely proportional to the development of the apodemal endoskeleton, as is also the case in the other apulmonate arachnids.

Order Solpugida—In 1896, Bernard observed in *Galeodes* that ". . . the anterior end of the heart is produced into an aorta, which . . . appears to discharge the blood direct on the central nerve-mass." My own dissections of *Eremobates* sp. (Fig. 12) confirm this report; the central nervous system is enveloped by a perineural vascular membrane which encloses a periganglionic arterial sinus. The order Solpugida is unique in that all its members lack a mesodermal endosternite (Bernard, 1896; Giltay, 1925; Millot, 1949a). In its place, solpugids possess a highly developed apodemal endoskeleton. An apodemal arch arises from the floor of the tritosternal segment (Bernard, 1896; Millot and Vachon, 1949b). This arch passes over the dorsal surface of the subesophageal ganglionic mass, where it serves as a functional analogue of the mesodermal endosternite.

The solpugid endoskeleton was studied first by Kittary (1848) in *Galeodes*, and later by Dufour (1862) in *Galeodes*, Bernard (1896) in *Galeodes*, Sorensen (1914) in *Daesia, Solpuga, Galeodes, Rhagodes*, and especially by Roewer (1934) in various genera. Unfortunately, Bernard's erroneous interpretation is this structure was adopted as valid by certain influential arachnologists, such as Comstock (1948). Bernard attempted to homologize all arachnid endosternites with the apodemal endoskeleton of the solpugid, which he regarded as a primitive arachnid. Apparently, he was motivated by a determination to demonstrate unequivocally that arachnids cannot at all be closely related to *Limulus*, which he regarded as a crustacean (Bernard, 1892a, b). Bernard's interpretation of the arachnid endosternite is not in agreement with that of Pocock (1902), nor or Millot (1949a), nor of my own. Millot said that the interpretation of the solpugid tritosternal apodeme (incontestably an ectodermal structure) as a homologue of the scorpion endosternite, is an indefensible conception. Moreover, he pointed out that embryologists universally recognize the mesodermal origin of the endosternite (p. 287):

> L'apodème tritosternal des Solifuges a été parfois homologué à l'endosternite des Scorpions et, par son intermédiaire, à celui des autres Arachnides. Cette conception ne paraît pas défendable. L'apodème tritosternal, incontestablement ectodermique, ne peut être comareé à l'endosternite dont l'origine mésodermique est reconnue·par tous les embryologistes.

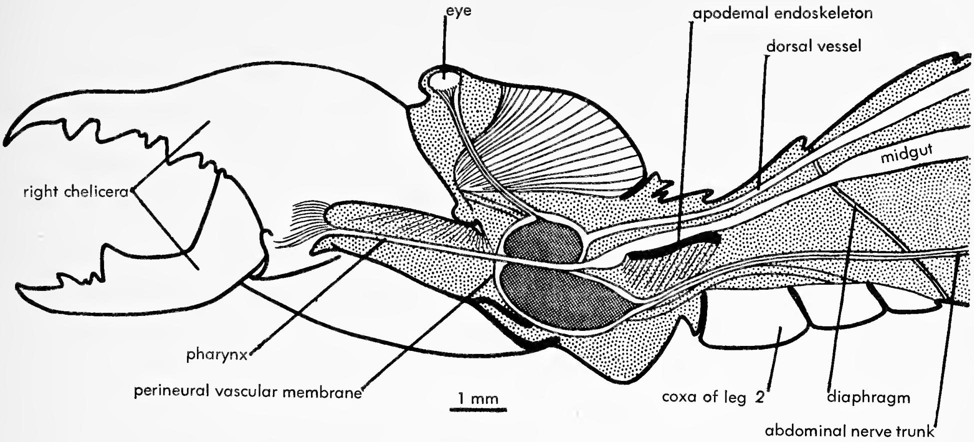


Fig. 12.–Midsagittal view of the cephalothoracic region of *Eremobates* sp., a solpugid, seen from the left. Note that a mesodermal endosternite is lacking. An apodemal invagination of the exoskeleton, derived from the tritosternum, forms a functional analogue of the endosternite. The central nervous system is shown with dark shading.

The Pulmonate Arachnid Orders:
Scorpionida
Thelyphonida
Schizomida
Amblypygida
Araneida

Order Scorpionida–The circulatory system of scorpions has been described by various investigators, including Newport (1843) in *Androctonus* and *Buthus*, Houssay (1886, 1887) in *Androctonus* and *Buthus*, Schneider (1892) in *Buthus*, Petrunkevitch (1922) in *Centrurus*, and Buisson (1925) in *Buthus*. According to these authors, the arterial system conforms to the general pattern that exists in other pulmonates (Fig. 13): a paired aorta gives rise to a paired thoracic sinus which lies on top of the subesophageal ganglionic mass. The thoracic sinuses give rise to appendicular arteries and to a series of circumneural arteries which surround the central nervous system. At their posterior ends, the thoracic sinuses give rise to a common, median, unpaired supraneural artery which carries blood posteriad into the abdomen.

The endosternite of the scorpion has been described by Beck (1885) in *Androctonus* and *Buthus*, by Bernard (1894c) in *Palamnaeus*, by Schimkewitsch (1894) in *Androctonus*, and by Pocock (1902) in *Palamnaeus, Iurus, Bothriurus*, and *Centruroides*. It consists of a pair of longitudinal rods which join each other posteriorly, where they also join a transverse muscular partition, the diaphragm, which separates the cephalothoracic and abdominal cavities. The endosternite is circumneural at its posterior end, where it joins the diaphragm; i.e., it forms a complete transverse ring around the posterior end of the subesophageal ganglionic mass (Fig. 14A; see also Fig. 26C).

The morphology of the scorpion endosternite is neither simple nor primitive; its complexity lies partly in its involvement with the diaphragm, which Bernard (1894c) regarded as the derivative of an ancient intersegmental septum. He regarded the scorpion dia-

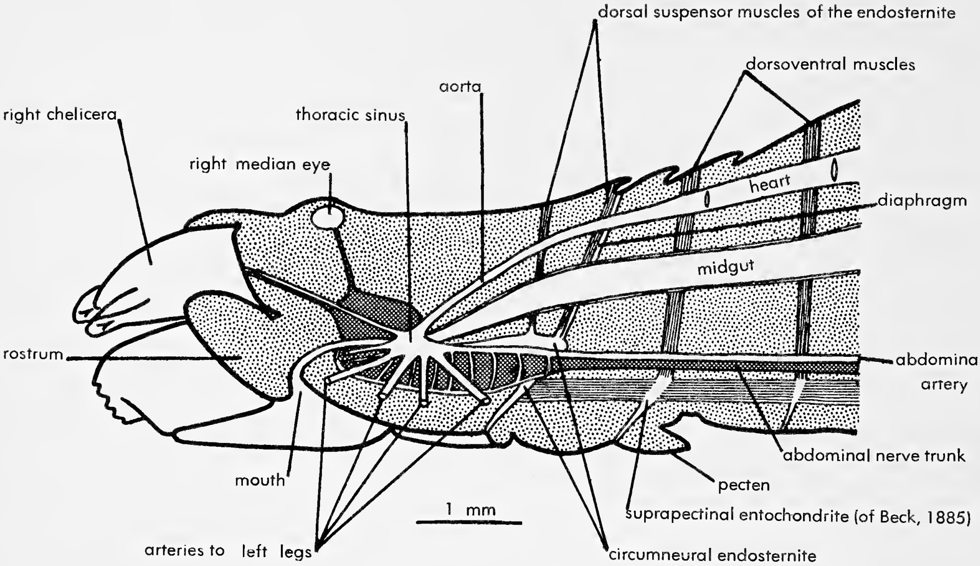


Fig. 13.—The arterial system and endosternite of a generalized scorpion, based upon my observsations of *Centruroides* sp., and upon the diagrams of Schnieder (1892), Petrunkevitch (1922), Beck (1885), Schimkewitsch (1894), and Pocock (1902).

phragm to be homologous to that of solpugids. In scorpions, the diaphragm is muscularized by a layer of dorsoventral fibers. Beck (1885) described three pairs of serial, dorsal suspensor muscles of the cephalothoracic endosternite; she named them respectively the anterior, median, and posterior dorso-plastron muscles. The posterior pair of these originates from the first mesosomatic tergite and extends ventrad for a short distance behind the diaphragm; it passes through the diaphragm and continues ventrad in front of it to an insertion on the posterior end of the circumneural endosternite. This condition apparently is homologous to that in thelyphonids and amblypygids, where the posterior end of the endosternite receives the insertions of the first pair of abdominal dorsoventral muscles (Figs. 15, 16B, 18). The median (penultimate) dorsal suspensor of the scorpion is adherent to the anterior surface of the diaphragm; this muscle is actually part of (derived from) the diaphragm musculature. I believe this fact gives a clue to the evolutionary origin of the chelicerate dorsoventral muscles: they are derived from the muscle fibers on primitive intersegmental transverse septa which internally separated the trunk segments of prechelicerate ancestors.

Beck also described three pairs of transverse suspensors (her epimero-plastron muscles) which insert onto the cephalothoracic endosternite (Fig. 14A; see also Fig. 26C).

In addition to the cephalothoracic endosternite, scorpions possess also an abdominal endosternite (Beck's suprapectinal chondrite) at the anterior end of the mesosoma (Beck, 1885) (Fig. 14B). Morphologically, this is a transverse muscle, for on either end it is contractile, with origins on the body wall. It differs from the cephalothoracic endosternite, however, in that it lies under the nervous system rather than over it. It is fused with the connective tissue of a single pair of dorsoventral muscles, and Lankester (1885) believed it to be homologous to one of the mesosomatic entochondrites of *Limulus.*

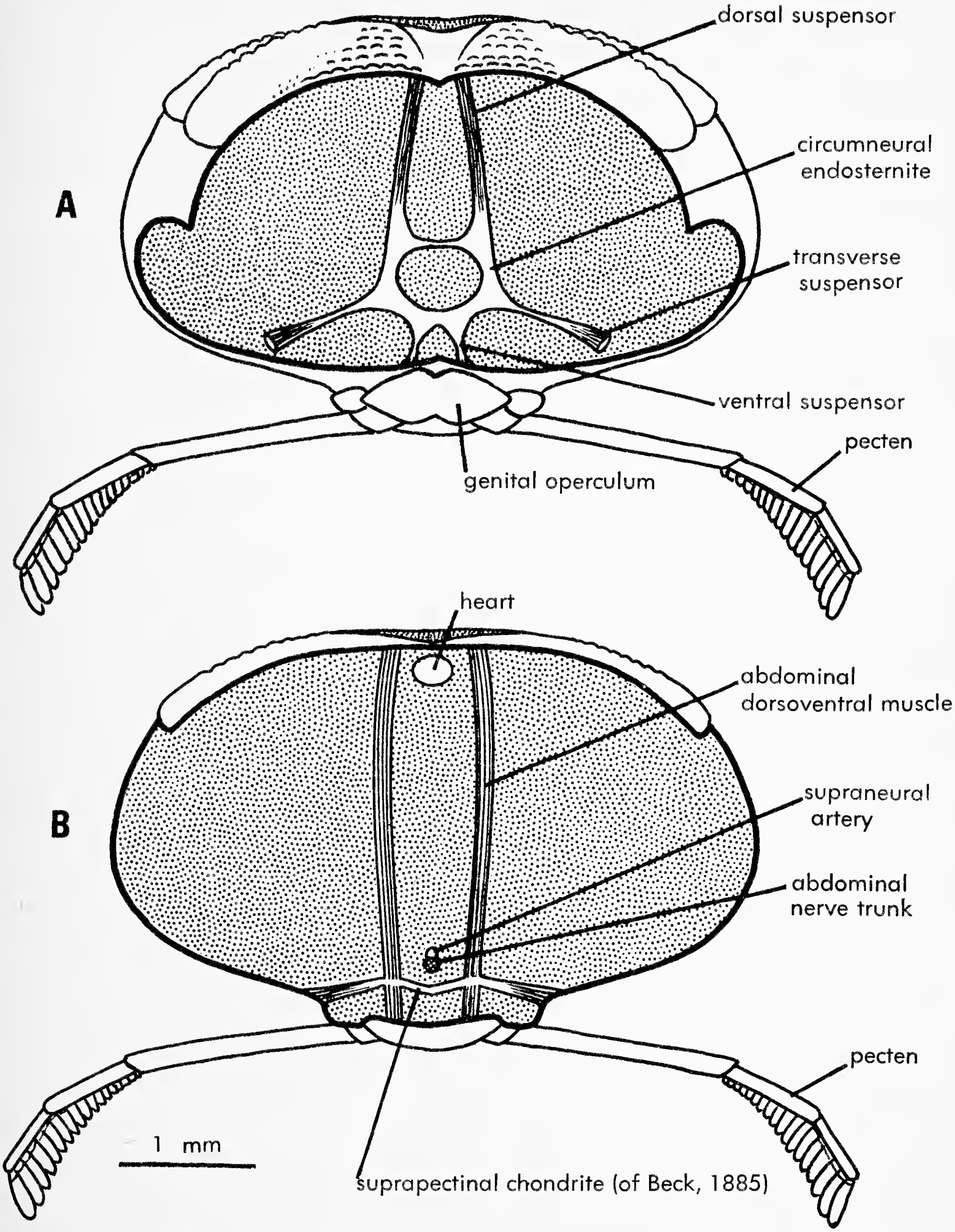


Fig. 14.–A: transverse section through the circumneural portion of the endosternite of *Centruroides* sp. (order Scorpionida), showing the muscles which insert upon it, as seen from the anterior; B: transverse section through the suprapectinal endosternite of same.

I have examined the arterial system and endosternite of *Centruroides* sp., and my observations correspond exactly to the descriptions of the authors cited above.

Order Thelyphonida—I have examined the endosternite and arterial system of *Mastigoproctus giganteus.* I find that the arterial system conforms to the basic pattern for pulmonate arachnids. The endosternite corresponds to the earlier descriptions of Tarnani (1890) in *Thelyphonus asperatus*, Pocock (1902) in *Mastigoproctus giganteus,* Börner (1904) in *T. caudatus*, and Millot (1949c) in *M. giganteus.* However, the published drawings do not distinguish dorsoventral suspensors from transverse suspensors, and they compound confusion by showing the two kinds as though they were serial homologs. The thelyphonid endosternite consists of a pair of longitudinal rods which join

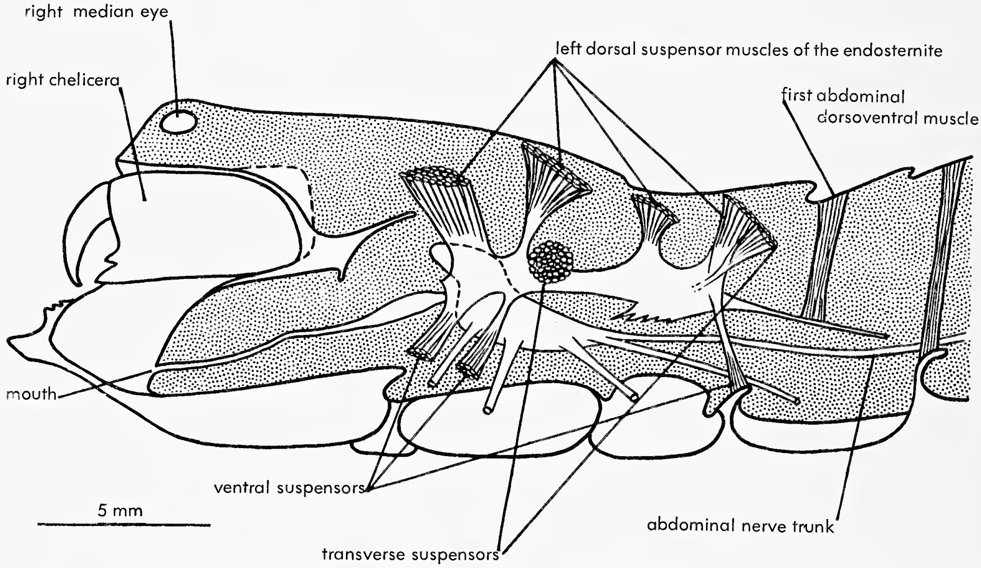


Fig. 15.—Sagittal view of the cephalothoracic region of *Mastigoproctus giganteus*, a whip scorpion (order Thelphonida), showing a superimposed lateral view of the left side of the endosternite and central nervous system.

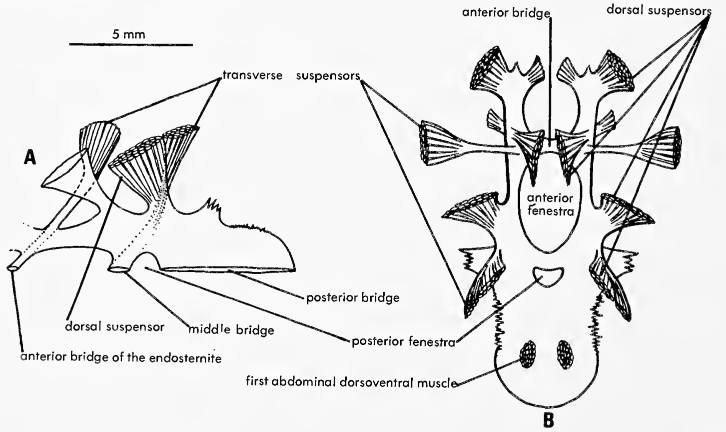


Fig. 16.—A: Dorsomedial view of the right half of the posterior end of the endosternite (cut midsagittally) of *Mastigoproctus giganteus*, showing the dorsal and transverse suspensor muscles, as seen from the left. Note that the anterior and middle cross-bridges are morphologically part of the transverse suspensors. Also note that the posterior transverse suspensor is anatomically integrated with the posterior dorsal suspensor. B: dorsal view of the endosternite.

each other at their posterior ends by a bridge which extends horizontally posteriad to the second abdominal segment. The endosternite receives the insertions of four pairs of dorsal suspensors, three pairs of ventral suspensors, and two pairs of transverse suspensors. The positions of the anterior and posterior transverse suspensors are marked respectively by anterior and middle bridges which join the right and left sides of the endosternite (Fig.16). The space enclosed by these two bridges forms the anterior fenestra, and behind the middle bridge there is a smaller posterior fenestra which separates it from the posterior bridge. The right and left extremities of the anterior transverse suspensor originate from the lateral margins of the cephalothorax, but the posterior transverse suspensor is deflected dorsomedially so as to become anatomically and functionally indistinguishable from the posteriormost pair of dorsal suspensors (Fig. 16A). A close examination of the transverse suspensors shows that the connective tissue fibers which strengthen them run across the respective bridges; hence, the anterior and middle bridges may be interpreted as morphological components of (as derived from) the transverse muscles.

Order Schizomida—Except for their small size, schizomids are very similar to thelyphonids, externally and internally. Millot (1942a) split the heterogeneous order Pedipalpi, and put schizomids, thelyphonids and amblypygids into respective orders of their own. Later, however, Millot (1949c) and Kaestner (1968) reunited the schizomids and thelyphonids as families of the order Uropygida. Nothwithstanding this, there is a current trend to separate schizomids and thelyphonids (Petrunkevitch, 1955; Savory, 1964), and to recognize both as separate orders.

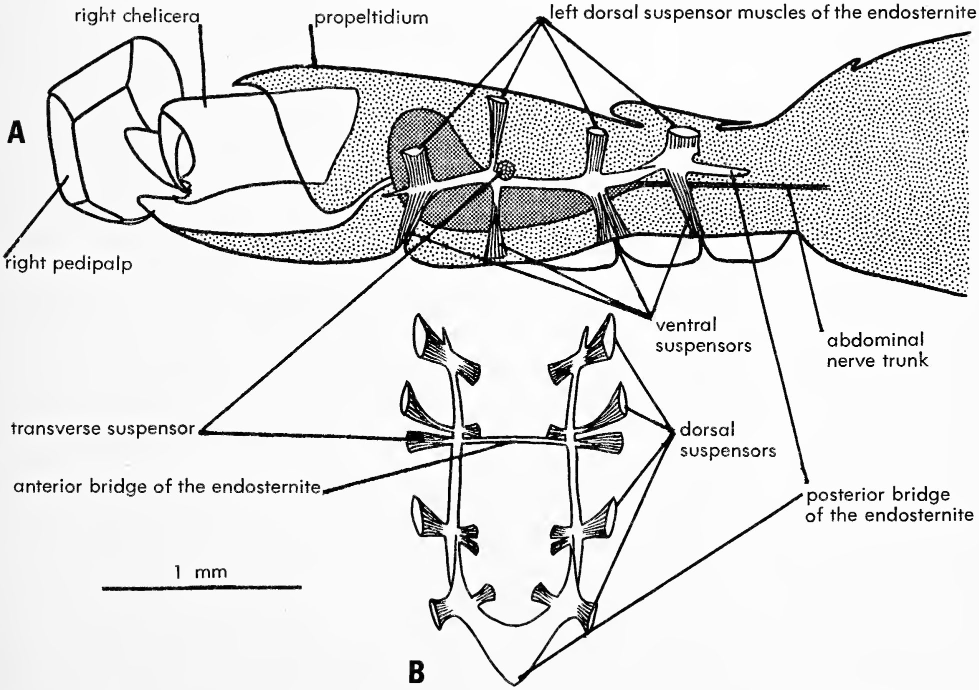


Fig. 17.—A: midsagittal view of the cephalothoracic region of *Trithyreus pentapeltis* (order Schizomida), showing a superimposed lateral view of the left side of the endosternite; B: dorsal view of the endosternite.

The earliest study of the schizomid arterial system is that of Börner (1904) who described a heart with five pairs of ostia in *Trithyreus cambridgei.* I have examined *T. pentapeltis*, and I find that the arterial system conforms to the basic pattern which is typical of other pulmonate arachnids.

A description of the endosternite of *T. cambridgei* was given by Börner (1904). My own observations of *T. pentapeltis* confirm Börner's findings. The schizomid endosternite is morphologically very similar to that of a thelyphonid, except that it lacks the middle bridge and accordingly has only one central fenestra. There are four pairs of dorsal suspensors which are matched below by four pairs of ventral suspensors (Fig. 17). The histological continuity of these dorsoventral muscles through the endosternite is readily apparent, even by gross observation: it can be seen clearly that the dorsal and ventral suspensors are continuous with each other by a tendinous tract of connective tissue fibers which passes vertically through the endosternite. A transverse muscle passes horizontally through the endosternite immediately behind the second dorsoventral suspensors, and at right angles to them (Fig. 17B). The right and left extremities of this muscle, which originate from the lateral margins of the carapace, are continuous with each other by a tendinous bar which constitutes the anterior cross-bridge (Börner's "verdere Querbrücke") of the endosternite of *Trithyreus.*

Order Amblypygida—The circulatory system of amblypygids has been described by Blanchard (1852) in *Tarantula palmata*. The arterial system conforms to the basic pattern for pulmonate arachnids. The endosternite has been described by Börner (1904) in *T. palmata*, and by Millot (1949d) in *Damon medius*. I have examined the endosternite of *Tarantula* sp, from Costa Rica. Its endosternite (Fig. 18), while bearing certain resemblances to that of thelyphonids, is shaped more like that of an orthognath spider. It has four pairs of dorsal suspensors and three pairs of transverse suspensors. On the ventral side, there are two pairs of non-contractile tendinous processes which represent the first and fourth ventral suspensors (i.e., they match the first and fourth dorsal suspensors). According to Millot (1949d, Fig. 325) in the endosternite of *Damon medius* the first pair of ventral suspensors are contractile. As in thelyphonids, the endosternite extends posteriad to the second abdominal segment. However, it lacks the anterior and middle bridges, and accordingly it has no fenestrations; in this way, it resembles the cephlothoracic endosternite of spiders.

Order Araneida—Except for lungless spiders, the circulatory system of spiders corresponds to the basic pattern depicted in Fig. 19: a paired anterior aorta gives rise to a paired thoracic sinus which lies on top of the subesophageal ganglionic mass. Appendicular arteries arise from the sinus on each side, and a series of circumneural arteries surrounds the central nervous system. An unpaired abdominal artery extends posteriad from the thoracic sinus. All of this has been described and illustrated by Schneider (1892) in *Tegenaria*, and in various other genera by Causard (1896). As in all nonscorpion pulmonate arachnids, there is no apparent morphological continuity of the arterial system with the endosternite.

An endosternite is universally present in spiders (Comstock, 1948), although there is variety in its shape and relative size throughout the order. I have studied the endosternites of various spiders: among those of the suborder Orthognatha, I have examined the brown tarantula, *Eurypelma californicum* (cf. Firstman, 1954), and the trapdoor

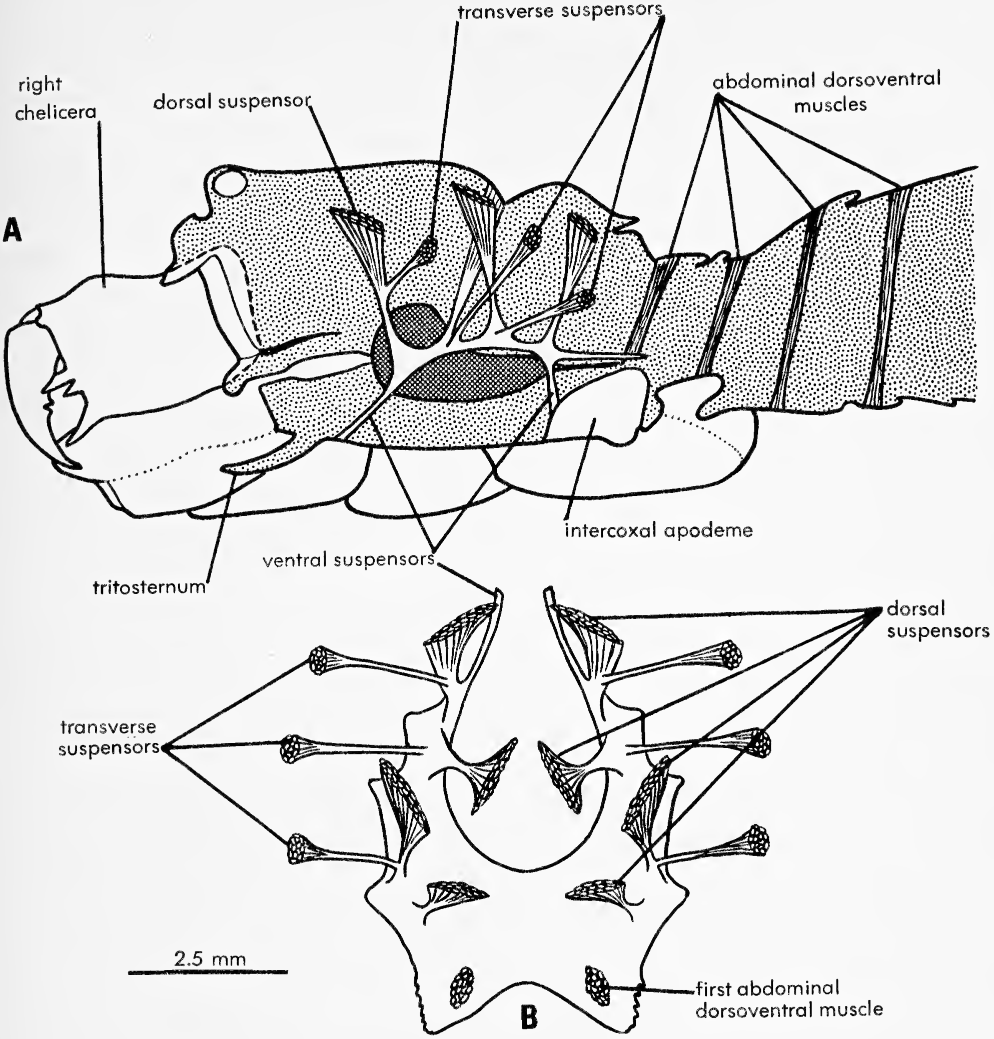


Fig. 18.–A: midsagittal view of the cephalothoracic region of *Tarantula* sp. (order Amblypygida), showing a superimposed lateral view of the left side of the endosternite; B: dorsal view of the endosternite.

spider, *Bothriocyrtum californicum*. Among the spiders of the suborder Labidognatha, I have examined representatives of the following genera: *Latrodectus* (family Theridiidae), *Argiope* (family Araneidae), *Gnaphosa* (family Gnaphosidae), *Ctenus* (family Ctenidae), *Phiddipus* (family Salticidae) and *Orthonops* (family Caponiidae). On the basis of my observations, I make the following generalizations with regard to the endosternite: the cephalothoracic endosternite of spiders is centralized into a single, metamerized, unfenestrated structure which receives the origins of rostral, stomodeal, gastric, coxal and pedicellar muscles. On its dorsolateral margins it receives the insertions of four pairs of dorsal suspensor muscles, and one to three pairs of transverse suspensors.

In the true spiders (suborder Labidognatha), there are no ventral suspensors (Fig. 20A); however, in the tarantulas and their allies (suborder Orthognatha), each dorsal suspensor is continuous through the endosternite with a noncontractile tendon that ex-

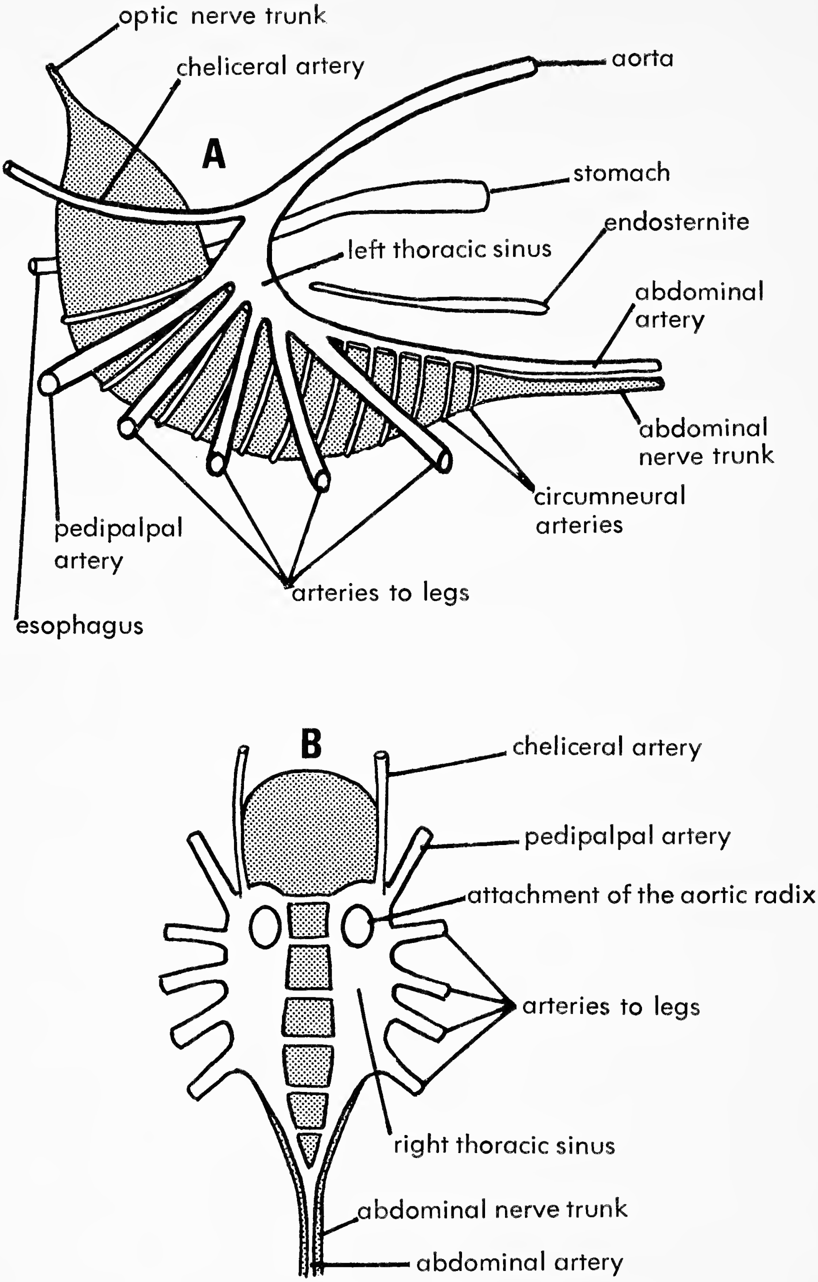


Fig. 19.–Generalized diagram of the arterial system of a spider, based on Schneider (1892) and Causard (1896); A: lateral view of the central nervous system, showing the left thoracic sinus, as seen from the left, with the endosternite shown in midsagittal section; B: dorsal view of same, with the endosternite omitted.

tends from the ventral surface of the endosternite to an attachment on the sternum (Fig. 20B). When Pocock (1902) saw this in the tarantula, he realized that each ventral tendon, plus its dorsal counterpart, represents a cephalothoracic dorsoventral muscle. Thus, he became convinced that the connective tissue of the dorsoventral muscles has become an integral part of the endosternite, and that the bisected dorsoventral muscles have given rise to both conditions in spiders: (1) as in the orthognath spiders, where each ventral suspensor is a non-contractile tendinous process, and (2) as in the true spiders, where ventral suspensors have disappeared altogether. Schimkewitsch (1893, 1894) had already suggested that the endosternite (he called it an aponeurotic membrane) is formed by the coalescence of muscle tendons, based on his observations of spiders, thelyphonids, opilionids, scorpions and *Limulus*.

The suspensor muscles which originate from the cervical apodeme of spiders I interpret as transverse suspensors, for these bear the same morphological relation to the endosternite as the transverse suspensors of other nonscorpion pulmonate arachnids (Figs. 26F, 27I). Hence, according to this view, the transverse suspensors of spiders are peculiar,

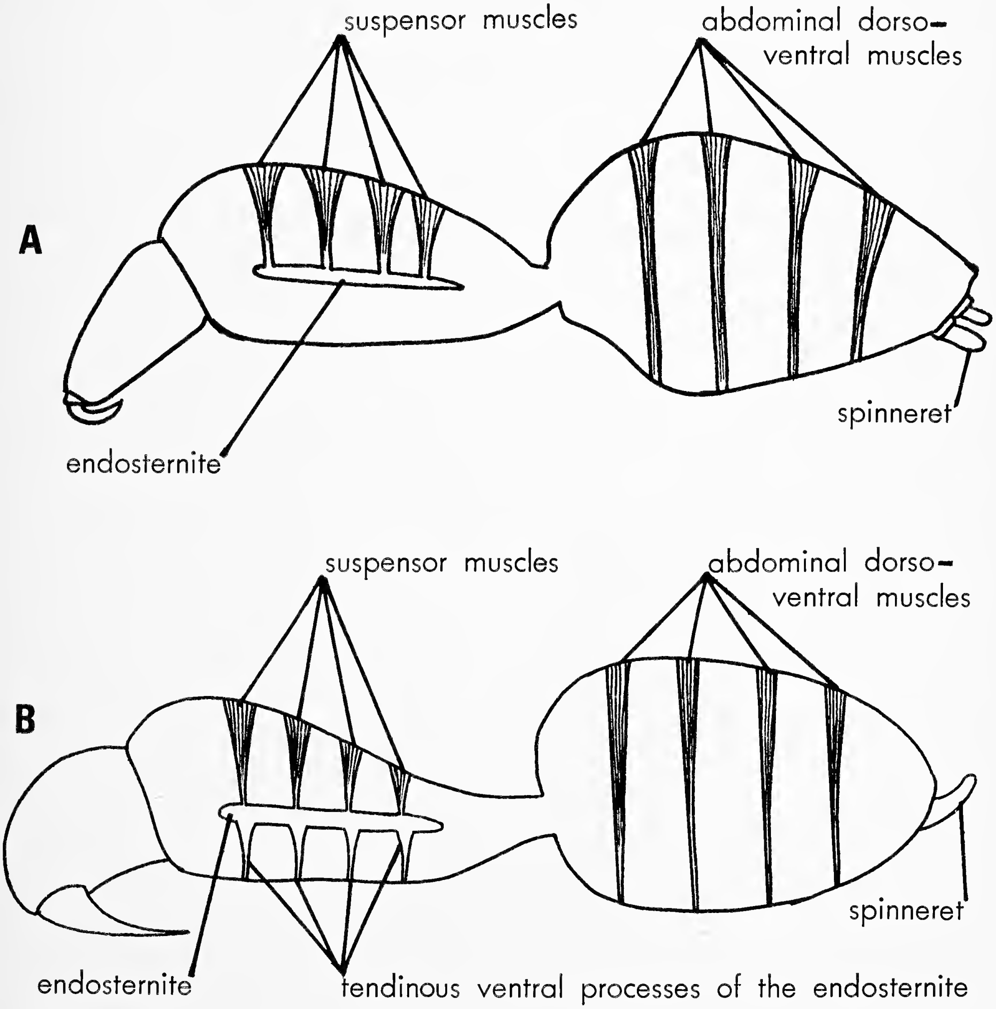


Fig. 20.–Schematic depictions of the serial homology of the dorsoventral muscles of spiders. A: a true spider (suborder Labidognatha); note that the dorsal suspensors of the endosternite are incomplete dorsoventral muscles. B: a mygalomorph spider (suborder Orthognatha); note that the dorsoventral suspensors of the endosternite are morphologically complete, but ventral to the endosternite they are non-contractile.

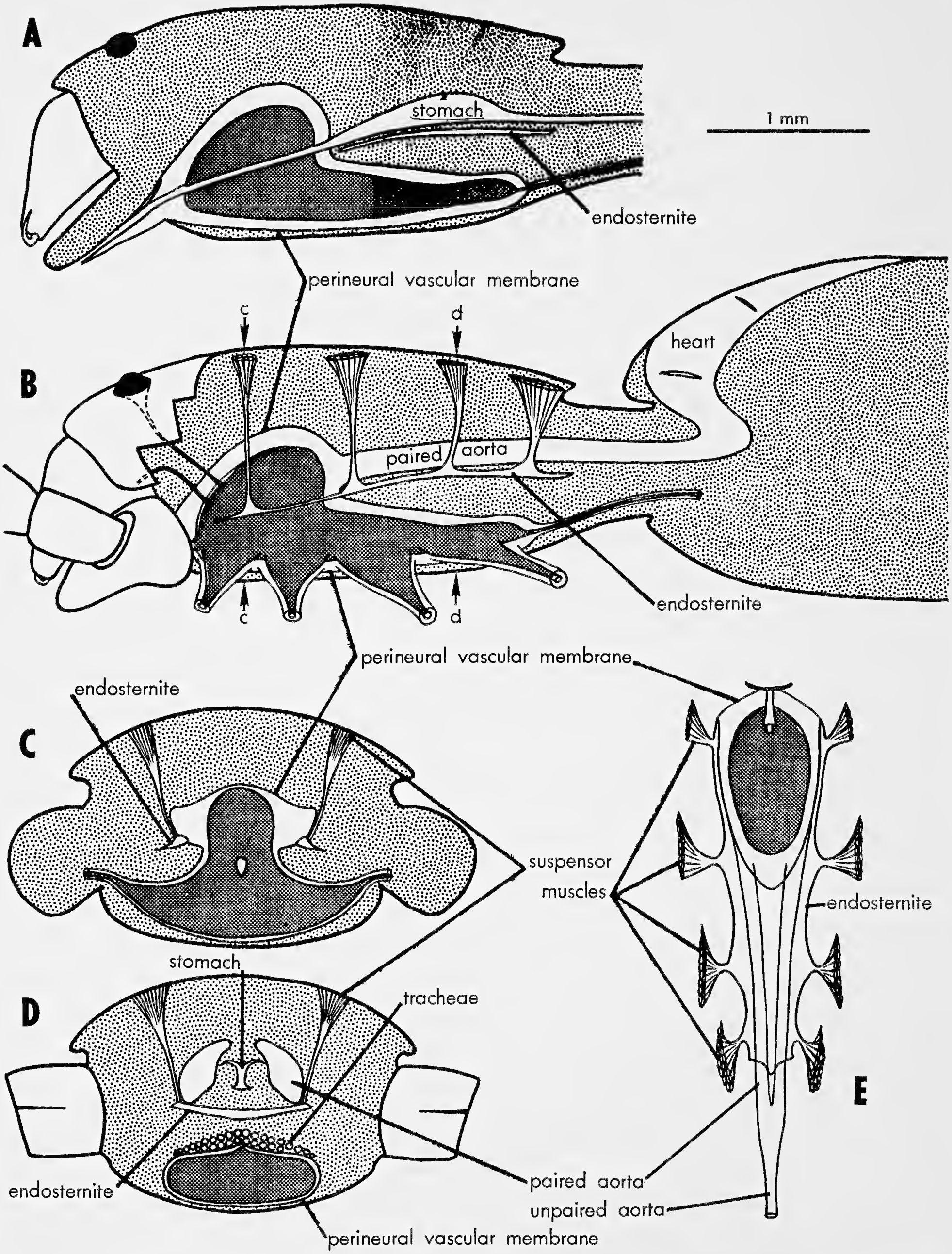


Fig. 21.–A lungless spider, *Orthonops gertschi* (order Araneida, family Caponiidae). A: midsagittal view of the cephalothorax, seen from the left. B: lateral view on the left side of the endosternite, showing the arterial system and the central nervous system. C: transverse section through the anteriormost pair of dorsal suspensor muscles, showing that the anterior cornua of the endosternite are continuous with the perineural vascular membrane; the plane of the section is indicated in Fig. B by the arrows, cc. D: transverse section through the suspensor muscles of the third walking-leg segment; the plane of the section is indicated in Fig. B by the arrows, dd. E: dorsal view of the endosternite. The central nervous system is shown with dark shading.

compared to those of other arachnids, because they are deflected dorsomedially, so as to originate from the cervical apodeme rather than from the lateral extremities of the carapace. In most of the spiders I have examined, there is only one apparent pair of transverse suspensors, located in the segement of the second walking leg. However, in the genus *Ctenus*, I find two pairs of transverse suspensors; the posteriormost of these has merged with the posterior pair of dorsal suspensors, as in thelyphonids. In the jumping spider, *Phiddipus*, I find three distinct pairs of transverse suspensors. In the lungless spiders of the family Caponiidae, where a cervical apodeme is lacking, transverse suspensors are absent altogether.

I have examined the arterial system and endosternite of the lungless *Orthonops gertschi* (family Caponiidae). This spider possesses an arterial system which is periganglionic, as in apulmonate arachnids. The central nervous system is invested by a perineural vascular membrane which is continuous with a paired aorta (Fig. 21). The anterior cornua of the endosternite are anatomically continuous with the perineural vascular membrane; this is the only spider species in which the endosternite is known to be continuous with an arterial membrane. The same circumstances probably exist also in the other lungless families (Telemidae, Symphytognathidae) but I have not examined these.

Class Merostomata, Subclass Xiphosura

Borradaile, et al. (1961) pointed out that "... a unique feature of *Limulus* is the complete investment of the ventral nervous system by an arterial vessel which corresponds to the supraneural vessel of the scorpion." It has been known since the last century that the central nervous system of the horseshoe crab is ensheathed completely by a perineural vascular membrane which is continuous with the left and right radices of the paired anterior aorta (Fig. 22). The complex circulatory system of *Limulus* has been described by Alphonse Miln-Edwards (1872), Owen (1873), Patten and Redenbaugh (1899), Petrunkevitch (1922), Lameere (1933), and Fage (1949a). It is noteworthy that the larval *Limulus* passes through a thoracic sinus stage of arterial development which corresponds to that of the adult scorpion (Kingsley, 1893) (Fig. 34). The implication which follows this is that in the pulmonate arachnids a selection pressure has foreshortened the development of the arterial system (I interpret this as neotenous developmental retardation), probably related to some physiological contingency of breathing atmospheric air with book lungs. Levi (1967) has compared circulatory development in spiders, with regard to their respiratory adaptations.

I have examined the arterial system and endosternite of *Limulus polyphemus*. All of my observations verify the descriptions of the authors cited above. The arterial system of *Limulus* includes a perineural vascular membrane which surrounds a periganglionic arterial sinus (Fig. 22). This sinus receives the radices of the paired dorsal aorta.

The endosternite of the horseshoe crab was first described by Straus-Dürckheim (1829), to whom the arachnid similarities seemed immediately obvious. Later, it was described in greater detail by various investigators, principally Lankester (1881a; 1884; 1885) and his student, Benham (1885), and by Patten and Redenbaugh (1899). My own observations of the endosternite of *L. polyphemus* confirm the observations of these authors. The cephalothoracic endosternite of *Limulus* is roughly rectangular, located horizontally above the central nervous system (Figs. 22, 23). It receives the insertions of three pairs of dorsal suspensors and one pair of ventral suspensors. In addition, there are two pairs of transverse suspensors (the lateral tergo-proplastral muscles, of Benham,

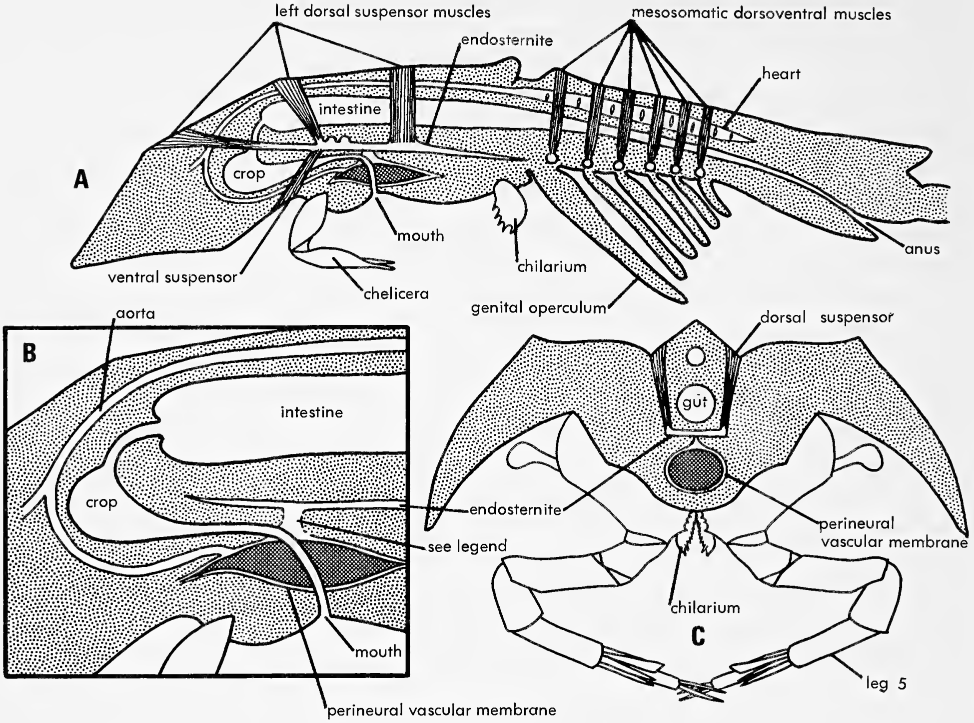


Fig. 22.–A: midsagittal view of *Limulus polyphemus* (class Merostomata), showing the endosternites and the muscles which insert upon them, seen from the left. The muscles of the left side have been superimposed. The white circles in the mesosoma represent the locations of the mesosomatic endosternites. The two bumps on the dorsal surface of the cephalothoracic endosternite represent the positions of the transverse suspensors. B: an enlarged detail, midsagittal, with musculature omitted; the region indicated by "see legend" contains strands of connective tissue, in the adult, representing the vestigial connection of the perineural vascular membrane to the endosternite. C: transverse section through the subesophageal ganglionic mass, showing the cephalothoracic endosternite and one pair of dorsal suspensors, seen from the anterior.

1885); these I interpret as homologous to the transverse suspensors of arachnid endosternites.

Six abdominal endosternites are also present in *Limulus* (the mesosomatic entochondrites of Benham, 1885). Morphologically, each of these is a tendonified transverse muscle which is contractile at its lateral extremities (Fig. 23). Each one receives the insertion of a single pair of dorsal suspensors. The anatomical configuration of these abdominal endosternites, in relation to the muscles which insert on them, gives the impression that they are serially homologous to the metameric elements of the cephalothoracic endosternite, and that they represent a primitive stage of endosternite evolution, for this is the way that Lankester (1885) interpreted them. I do not doubt that the mesosomatic dorsoventral muscles are serially homologous to those of the cephalothorax, but the transverse muscles differ from those of the cephalothorax in that: (1) they lie under the nervous system instead of over it, and (2) they attach distally to movable structures (the book gills) instead of the body wall. Lankester resolved the first problem, to his own satisfaction, by hypothesizing that the nerve cords (which he presumed were primitively in a lateral position) moved medially to their present position on the midline during a time when the endosternite was in a formative stage of evolutionary development. He assumed that the endosternites were derived from subepidermal connective tissue of the ventral floor, and that the cephalothoracic endosternite (which presumably is older) had arisen far enough from the ventral floor that it came to lie over the relocated nervous system, while the younger abdominal endosternites were still under it.

Although Snodgrass (1952) feels that Lankester's hypothesis is overly contrived, I do not feel that the question of the morphological significance of the mesosomatic endosternites of *Limulus* has been resolved one way or another. However, I am inclined to the opinion that the mesosomatic transverse muscles of *Limulus*, because they attach distally to movable appendages, are not serially homologous to those which have been instru-

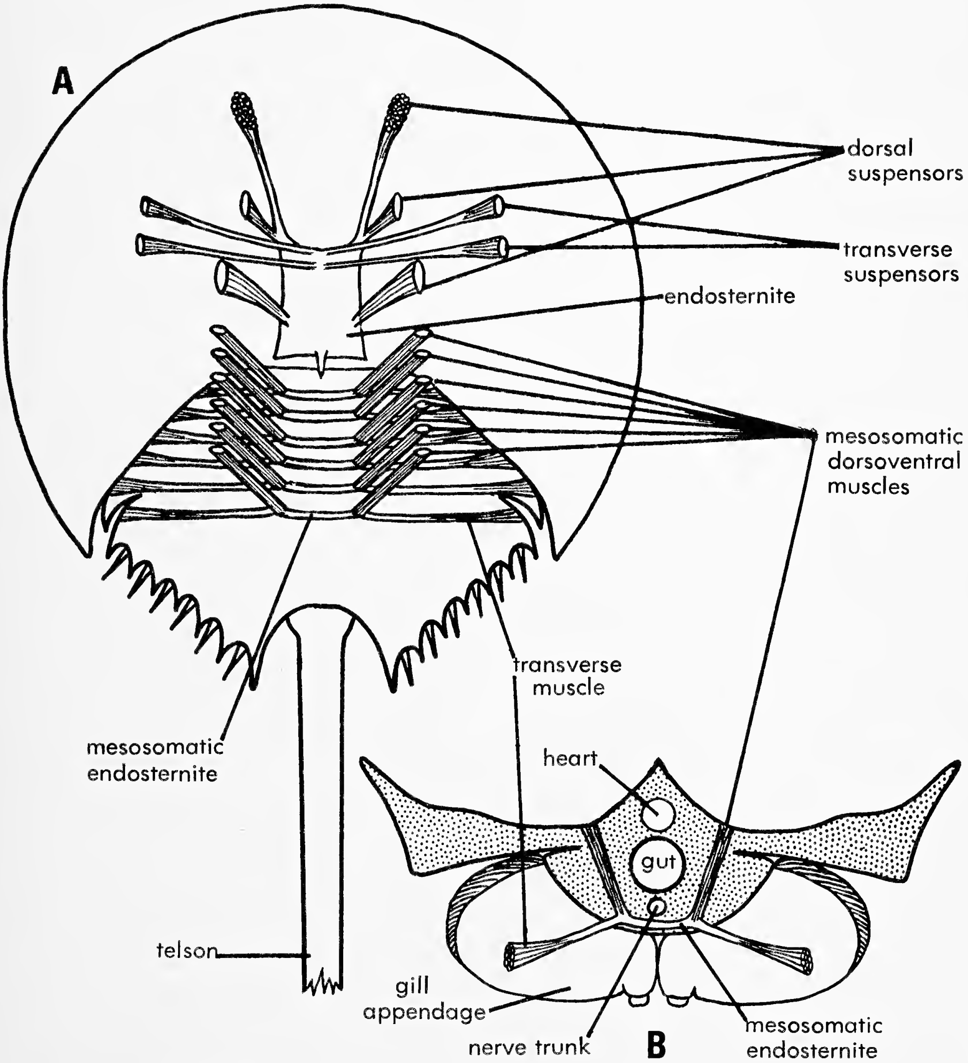


Fig. 23.–A: dorsal view of *Limulus polyphemus*, showing the endosternites and the muscles which insert upon them. B: transverse section through the mesosoma, showing one of the mesosomatic endosternites, seen from the anterior.

mental in the formation of the cephalothoracic endosternite. In accordance to the comparative evidence put forth in this paper, I believe the transverse suspensors of the cephalothoracic endosternite are derivatives of serial transverse muscles which lay primitively over the nervous system. In this connection, Snodgrass (1935, 1952) pointed out that in insects there are serial transverse muscles which lie over the nervous system (Fig. 28).

Class Pycnogonida

The Pycnogonid Arterial System—Early observations of circulation in pycnogonids were made Johnston (1837), Henri Milne-Edwards (1840), Quatrefages (1845), and Van Beneden (1846). None of these authors described a heart, although Van Beneden saw some of the movements of blood beneath the dorsal integument of a living specimen of *Nymphon*. Cole (1910) similarly described circulatory movements which he observed in living specimens of *Endeis*. A heart was described in *Nymphon* by Zenker (1852), in *Endeis* by Krohn (1885), and in *Colossendeis* and certain other genera by Hoek (1881). A detailed description of the pycnogonid circulatory apparatus, based principally upon *Endeis* and *Nymphon*, was given by Dohrn in 1881. He agreed with Hoek in describing the heart as a tube which attaches dorsally to the integument and ventrally to the gut. It was Dohrn who first pointed out that the pycnogonid hemocoel is divided longitudinally by a double-walled, horizontal, vascular septum which separates dorsal and ventral blood cavities; blood in the dorsal cavity is directed anteriad, whereas blood in the ventral cavity flows posteriad. The ventral surface of the heart is continuous with this septum along its midline; rhythmic undulations of the septum coincide with the cardiac systole and diastole, and these undulatory movements create the pressures which aspirate blood in and out of the paired appendages. The concept of Dohrn's horizontal vascular septum has been reviewed and diagrammed by Cole (1910).

My own dissections of pycnogonids include the following species: *Pycnogonum littorale, P. rhinoceros, Endeis* sp., *Colossendeis scotti, Decolopoda australis, Nymphon charcoti, Pentanymphon antarcticum*, and *Ammothea striata*. These dissections show the presence of a perivisceral arterial membrane, continuous with the aorta, which envelops the intestine and the central nervous system (Figs. 24, 25). As in *Limulus* and the arachnids, this membrane encloses a perivisceral arterial blood sinus. The membrane is continuous with the double-walled horizontal septum (described above) that extends laterad to the body wall, separating the venous hemocoel into dorsal and ventral cavities. The horizontal septum is partially muscularized by means of transverse muscle fiber bands that originate on the exoskeleton; it extends horizontally through the coxae into the walking legs (the legs protrude laterally from the trunk), separating their lumina into dorsal and ventral venous channels.

The horizontal vascular septum (of Dohrn) is present in all the pycnogonids I have examined, although the exact vertical position of its horizontal plane, with respect to the gut, differs from family to family. Whereas in *Colossendeis* it is situated immediately beneath the heart, in *Endeis* it extends laterad from the sides of the gut, and in *Pycnogonum* it extends from the base of the gut; in all casses it is a continuation of the perivisceral arterial membrane (Fig. 27A, B, C). Between the two layers of the horizontal septum there lies a thin arterial blood sinus which is continuous with the rest of the perivisceral blood sinus.

Loman (1917) studied the blood circulation in *Nymphon*. He described the aorta as bifurcating to go around the optic nerve ("läuft ringförmig um den Augennerv") and

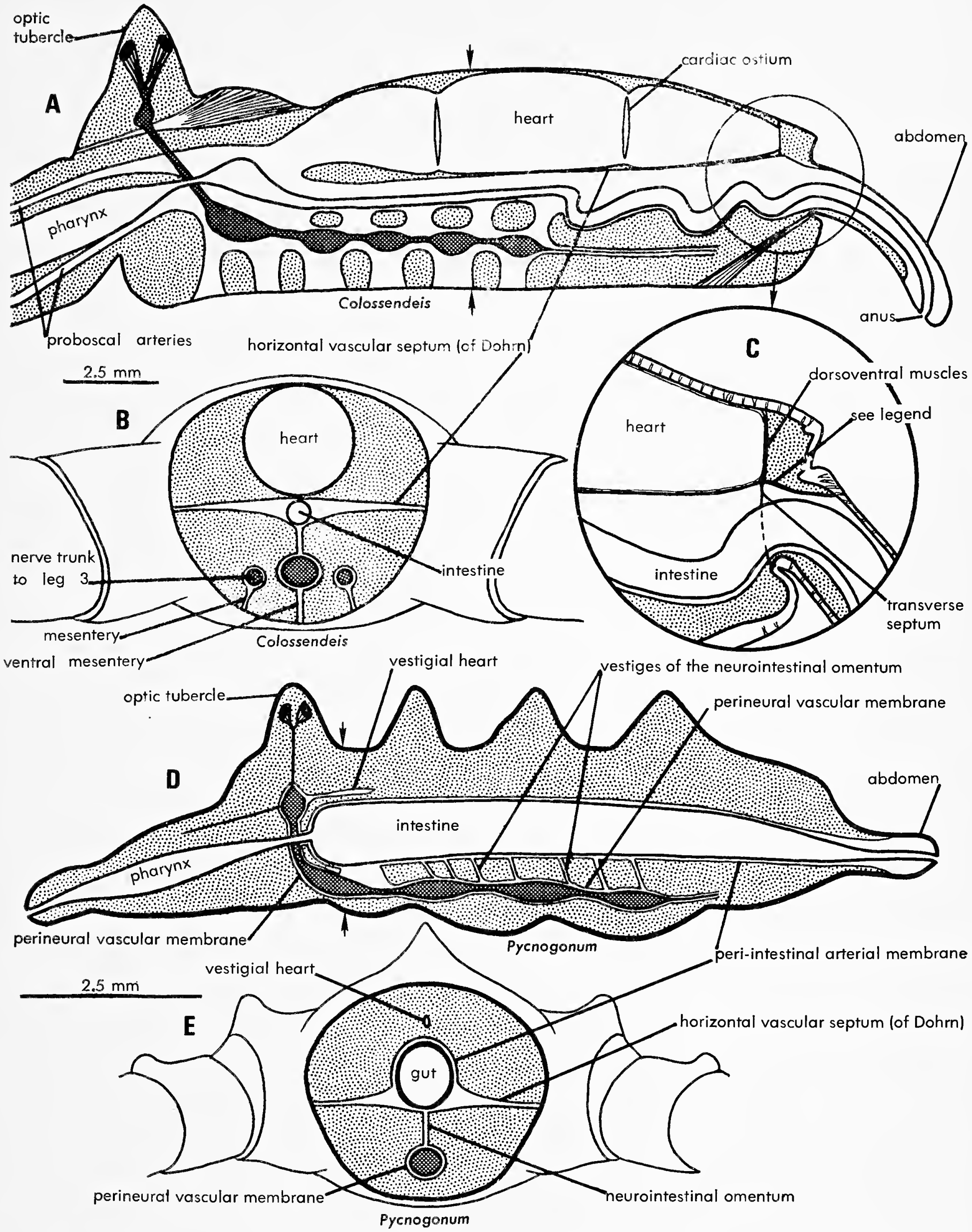
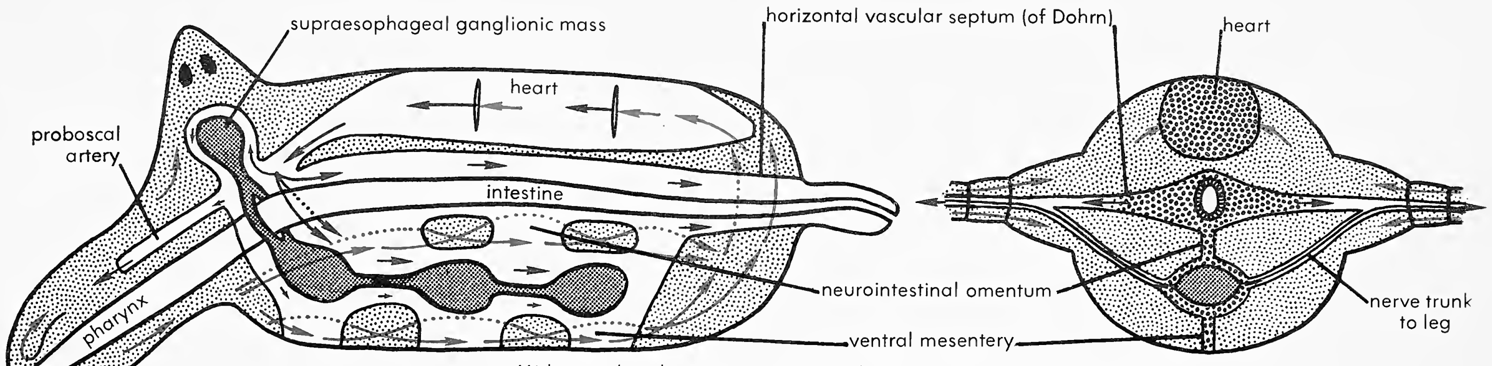
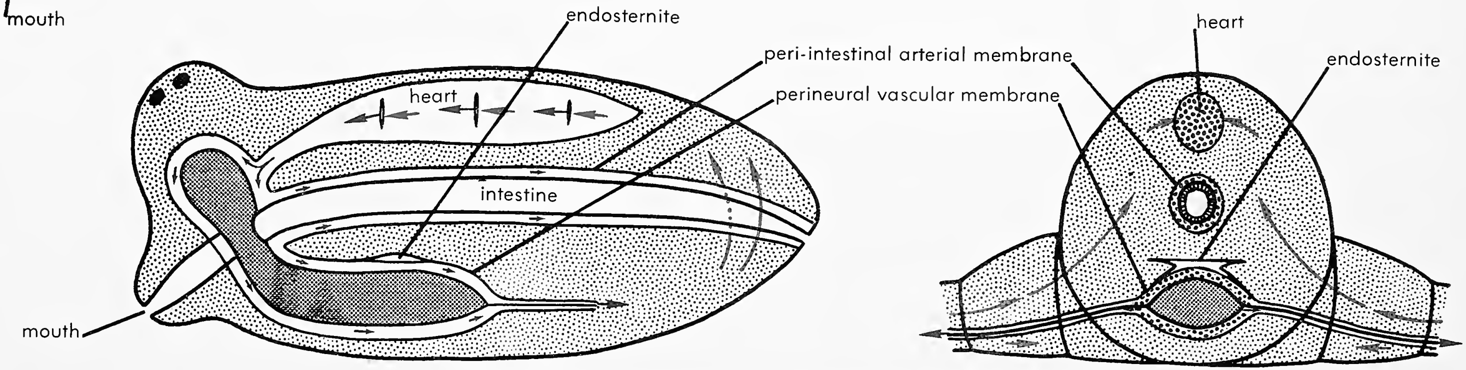


Fig. 24.—A: midsagittal view of *Colossendeis scotti* (class Pycnogonida), seen from the left. The full length of the proboscis is not shown. The oval windows above the nerve cord are perforations in the neurointestinal omentum; the ovate windows below the nerve cord are perforations in the ventral mesentery. B: transverse section through the plane indicated by the arrows in Fig. A. C: an enlarged detail of Fig. A. The structure indicated by "see legend" is the uppermost membrane (the top) of Dohrn's horizontal vascular septum; it is thickened at this point and it receives the insertions of cardiac muscles which extend dorsoventrally from the dorsal integument. D: midsagittal view of *Pycnogonum littorale*. E: transverse section through the plane indicated by the arrows in Fig. D. The central nervous system is shown with dark shading. The venous hemocoel is stippled; the heart, arterial system and gut are unshaded.



Midsagittal and transverse sections through a generalized pycnogonid



Midsagittal and transverse sections through a generalized merostome-arachnid

Fig. 25.—Blood flow diagrams comparing the basic circulation of a generalized pycnogonid with that a a generalized merostome-arachnid. The central nervous system is shown with dark shading. The venous hemocoel is shown with black stipples; the heart, arterial system and gut are unshaded. Red arrows represent the direction of arterial flow (the arterial system is restricted to the perivisceral arterial sinus), and blue arrows represent venous flow. Red stipples represent arterial flow which is perpendicular to the plane of the page. Oval windows above the pycnogonid nerve cord represent perforations in the neurointestinal omentum; ovate windows beneath the pycnogonid nerve cord represent perforations in the ventral mesentery.

extending anteriad as an artery into the proboscis. On the contrary, my own observations convince me that, in fact, the aorta envelops the entire central nervous system and gut as a perivisceral membrane which encloses a perivisceral arterial blood sinus (Figs. 24, 25, 27). The peri-intestinal and perineural portions of this sinus are continuous with each other by a double-walled neuro-intestinal omentum, and the perineural portion extends ventrad to the trunk floor as a double-walled ventral mesentery. Also, each nerve trunk to the legs is anchored to the ventral floor by a mesentery. Sanchez (1959) described and illustrated all of this in *Endeis spinosa*. She said that the perivisceral membrane continues also beneath the hypodermis of the integument so as to enclose a hemocoel cavity with parietal and splanchnic lining, in the manner of a true coelom. However, Sanchez dismissed all notions that this cavity may, in fact, be a true coelom.

According to my observations of the circulatory anatomy of pycnogonids, I describe blood movements differently from any previous descriptions (Fig. 25). There are two hemocoelic spaces:

(1) a *perivisceral arterial sinus* fed by the aorta, supplies blood to the viscera and to the proboscis and appendages; at the distal extremities of this sinus, blood passes into

(2) a *venous hemocoel*, which is subdivided by the horizontal septum into two compartments:

  (a) beneath the horizontal septum, the right and left *ventral venous hemocoels* communicate with each other by large foramina in the neuro-intestinal omentum and in the ventral mesentery. The ventral venous hemocoels are continuous, through openings at the extremities of the horizontal septum with

  (b) the *pericardial cavity*, which lies above the horizontal septum. Blood contained within the pericardial cavity bathes the heart and enters its lumen through paired ostia in the cardiac wall.

Since there are no respiratory organs in pycnogonids, it follows that external respiratory gas exchanges occur across the integument between the sea and the blood contained within the venous hemocoels; once inside the heart, freshly aerated blood is pumped into the perivisceral arterial sinus to supply the nervous system and gut. This understanding of pycnogonid circulation provides, I believe, a historical basis for understanding the morphology of the perineural and peri-intestinal arterial membranes in the other chelicerate classes. I hypothesize that remote common ancestors of the Merostomata and Arachnida possessed a perivisceral arterial system homologous to that of modern pycnogonids (Fig. 27).

A heart is lacking in all species of the genus *Pycnogonum*. In the large *P. rhinoceros*, and even in *P. littorale*, I find just behind the brain some loosely organized connective tissue, associated with the perineural vascular membrane, which I take to be a functionless vestige of the heart (Fig. 14D). A perivisceral arterial membrane is present in *Pycnogonum*, but the ventral mesentery is lacking and the neuro-intestinal omentum is reduced to fine strands, faintly visible (Fig. 14D); these persist only as sheaths surrounding the fine autonomic nerve trunks which pass dorsad on the midsagittal plane from the central nervous system to the alimentary canal. How does an animal of the size of *Pycnogonum* survive without a heart? Probably the peristaltic contractions of the extensive digestive caeca (these movements can be observed through the integument of a living specimen) are of sufficient force to effect blood movements.

The Pycnogonid Endosternite—In *Colossendeis*, the posteriormost portion of Dohrn's horizontal septum is chondrified (thickened slightly) as a tough membrane to which cardiac muscles attach (Fig. 24C). I believe this condition supports the idea that Dohrn's horizontal septum is potentially skeletogenous. It is a major thesis of this paper that a homolog of Dohrn's septum in ancient merostomes and arachnids (or in the common ancestor of both) has established the horizontal plane of the endosternite; this plane lay between the intestine and the central nervous system. According to this interpretation, the transverse muscle bundles of the pycnogonid horizontal septum are homologous to the transverse muscles of the endosternites of merostomes and arachnids (Fig. 27).

DISCUSSION

Origin of Dorsoventral Muscles

According to my general observations (and general inference from the literature I have seen), serial dorsoventral muscles occur in all chelicerates except pycnogonids. By definition, a dorsoventral muscle is one which attaches dorsally to a tergite or carapace and ventrally to a sternite or sternum in the same segment. They are always paired muscles (except in ticks, where there are median, unpaired dorsoventral muscles, as well as paired ones), serially arranged along the length of the trunk of the body. The abdominal dorsoventral muscles function as compressors, where they doubtless serve a vascular function in regulating abdominal blood pressures. In mites without hearts, it is known that dorsoventral muscles function to maintain circulation of blood (Mitchell, 1957; Evans, 1961). The cephalothoracic dorsoventral muscles of *Limulus* and all arachnids are interrupted (bisected) by the endosternite, so as to form its dorsal and ventral suspensors. Only in ticks have I seen cephalothoracic dorsoventral muscles which are not integrated with the endosternite.

The scorpion diaphragm helps, I believe, to throw light on the original condition of dorsoventral muscles in arachnids, for it is muscularized dorsoventrally along its entire width, and the median (penultimate) pair of dorsoventral suspensors of the cephalothoracic endosternite are a part of this diaphragm musculature. If Bernard's hypothesis, that the diaphragm is a persistent intersegmental septum held over from prechelicerate ancestors, be true, then it is reasonable to hypothesize that all dorsoventral muscles have originated in this way (i.e., as a specialization of septal musculature).

The exact manner in which cephalothoracic dorsoventral muscles became involved with the chelicerate endosternite is a problem which cannot be resolved until the nature of the trunk musculature in the immediate ancestors of arthropods is better known. Since dorsoventral muscles are very common in many groups of polychaete worms (pers. comm., Donald P. Abbott), it seems to me reasonable to hypothesize that dorsoventral musculature is a primitive arthropodan feature, derived from polychaete ancestors. Serial dorsoventral muscles are lacking in pycnogonids and in the onychophoran, *Peripatus* (personal observation). While I do not gainsay the possibility that this is a primary absence in both of these, and that dorsoventral muscles may have arisen independently and convergently in the other arthropod groups, it seems to me more conservative a hypothesis that ancestral arthropods had dorsoventral muscles, and that the absence of these muscles in pycnogonids and in *Peripatus* are cases of secondary loss. In pycnogonids, I suggest that such loss has been correlated with heavy sclerotization of the integument, and with the development of a rigid, inflexible trunk.

Origin of Transverse Muscles

The transverse suspensor muscles appear to be a more primitive feature of the chelicerate endosternite than the dorsoventral suspensors, for their occurence in living merostomes and arachnids is more archaic (i.e., in a more vestigial state). If *loss of muscles* be regarded as a specialized evolutionary development, then chelicerates in general can be said to be less specialized in the direction of loss of dorsoventral suspensors than they are in the loss of transverse suspensors. Only palpigrades, among living arach-

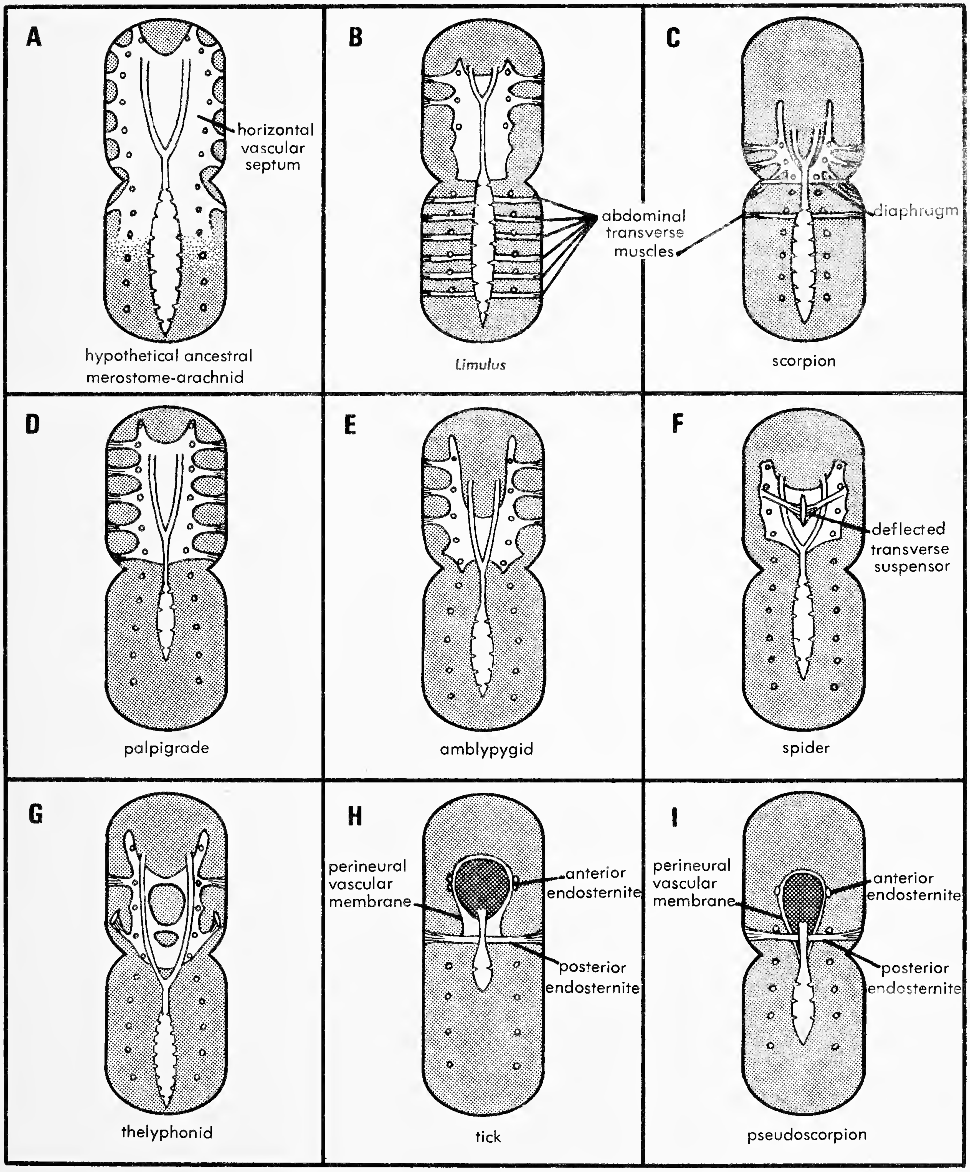


Fig. 26.—Sterograms depicting adaptive radiation of the transverse musculature of the cephalothoracic endosternite in chelicerates. All views are dorsal, with the heart and aorta shown in position over the endosternite. Circles represent the locations of the dorsoventral muscles. The abdominal transverse muscles of *Limulus* and the scorpion are shown. The central nervous system (shown only for the tick and pseudoscorpion) is shaded darkly.

nids, possess as many as five pairs of transverse suspensors of the endosternite. Scorpions possess three pairs, and the nonscorpion pulmonates have from one to three pairs. In the nonpalpigrade apulmonates, where the endosternite has tended toward reduction, the number of persistent transverse muscles never exceeds one pair, if they are present at all (Fig. 26).

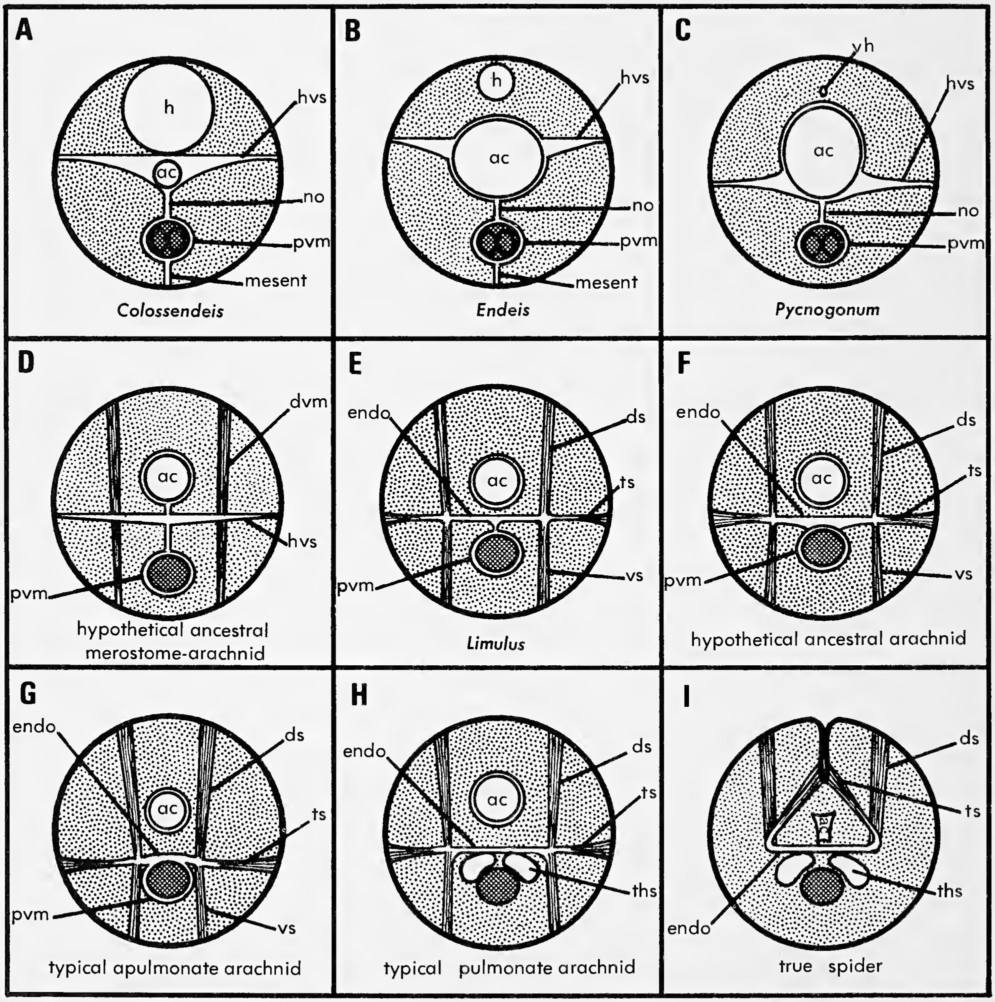


Fig. 27.—Schematic cross-sections of actual and hypothetical chelicerates. A, B, and C are three representative pycnogonids, showing that the horizontal plane of Dohrn's septum can occupy different positions with respect to the gut. D: hypothetical common ancestor of the Merostomata and Arachnida, showing a transversely muscularized horizontal septum (the precursor of the endosternite) lying in a plane between the gut and nervous system. E: the merostome, *Limulus*. F: hypothetical ancestral arachnid, with an endosternite similar to that of modern palpigrades. G: a typical apulmonate. H: a typical pulmonate. I: a typical true spider, with ventral suspensor muscles lacking, and with the transverse suspensors deflected dorsomediad so as to originate from the cervical apodeme. Sections D through I are in a plane through the subesophageal ganglionic mass. The central nervous system is shown with dark shading. Symbols are as follows: ac, alimentary canal; ds, dorsal suspensor muscle; dvm, dorsoventral muscle; endo, endosternite; h, heart; hvs, horizontal vascular septum; mesent, mesentery; no, neurointestinal omentum; pvm, perineural vascular membrane; ths, thoracic sinus; ts, transverse suspensor muscle; vh, vestigial heart; vs, ventral suspensor muscle.

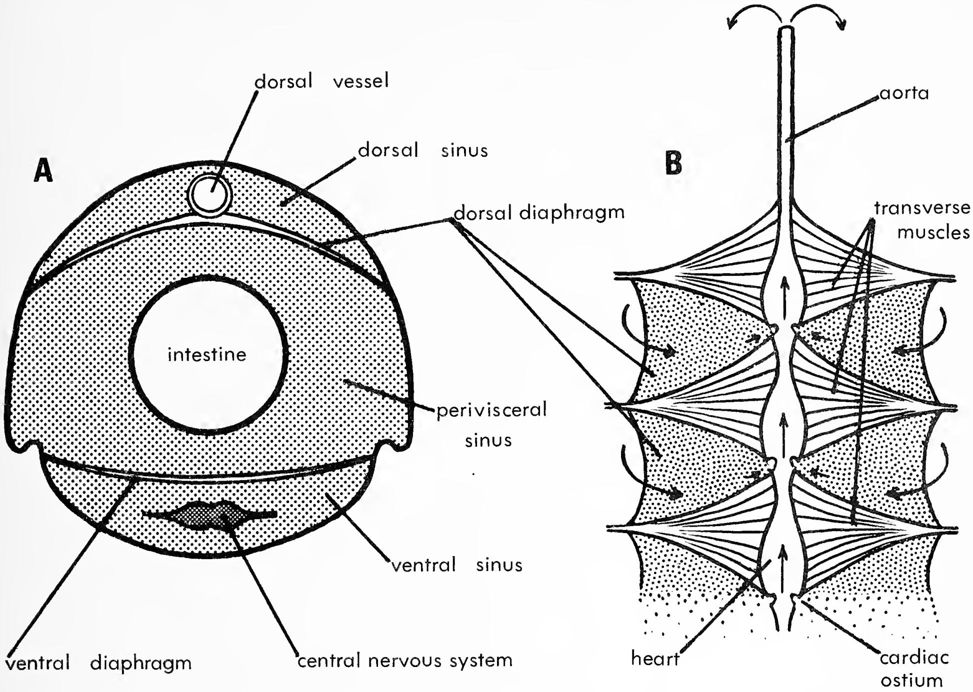


Fig. 28.—A: diagramatic transverse section through an insect, showing the circulatory membranes and sinuses. B: dorsal view of the heart and dorsal diaphragm of an insect, showing the dorsal transverse muscles. Arrows indicate the direction of blood flow. Redrawn from Snodgrass (1935).

There is comparative evidence that the transverse muscles of chelicerates have arisen from primitive septal musculature. The pycnogonid horizontal vascular septum could be homologous to a similar septum of hypothetical prechelicerate ancestors; its transverse muscle fibers could be the progenitors of the transverse suspensors of the endosternite (Fig. 27). This hypothesis is supported by the following facts:

1. The pycnogonid horizontal vascular septum is muscularized transversely, a condition which allows its undulatory movements. The septum extends along the entire length of the trunk (cephalothorax), and thus its musculature is predisposed toward serial metamerization.
2. The plane of the pycnogonid horizontal septum can be variably located (Fig. 27A, B, C) with regard to the position of the gut: in *Colossendeis*, it lies essentially over the gut; in *Endeis*, it straddles the sides of the gut; in *Pycnogonum*, it lies at the base of the gut. In a hypothetical merostome-arachnid ancestor, it would have needed to lie under the gut (Fig. 27D) and over the central nervous system.
3. In *Colossendeis*, the skeletogenous nature of the horizontal vascular septum suggests that it is an incipient endosternite. At its posterior end, the horizontal septum (which is already muscularized transversely) traverses a transverse septum which is muscularized dorsoventrally (Fig. 24C). This situation suggests a prototype of the endosternite musculature.

Snodgrass (1935) has described horizontal diaphragms in insects (Fig. 28) and these have a vascular function, for they separate blood sinuses. There are two principal horizontal septa in insects: (1) a dorsal diaphragm, separating the pericardial and perivisceral hemocoels, and (2) a ventral diaphragm, separating the perivisceral and perineural hemocoels. Both of these diaphragms are muscularized by transverse fibers. The ventral diaphragm holds a particular interest because it lies in a plane which separates the intestine from the central nervous system, and thus it suggests the hypothetical chelicerate condition depicted in Fig. 27D. Although I do not intend here to suggest homologies between the Insecta and the Chelicerata, I think that the mere presence in insects of a

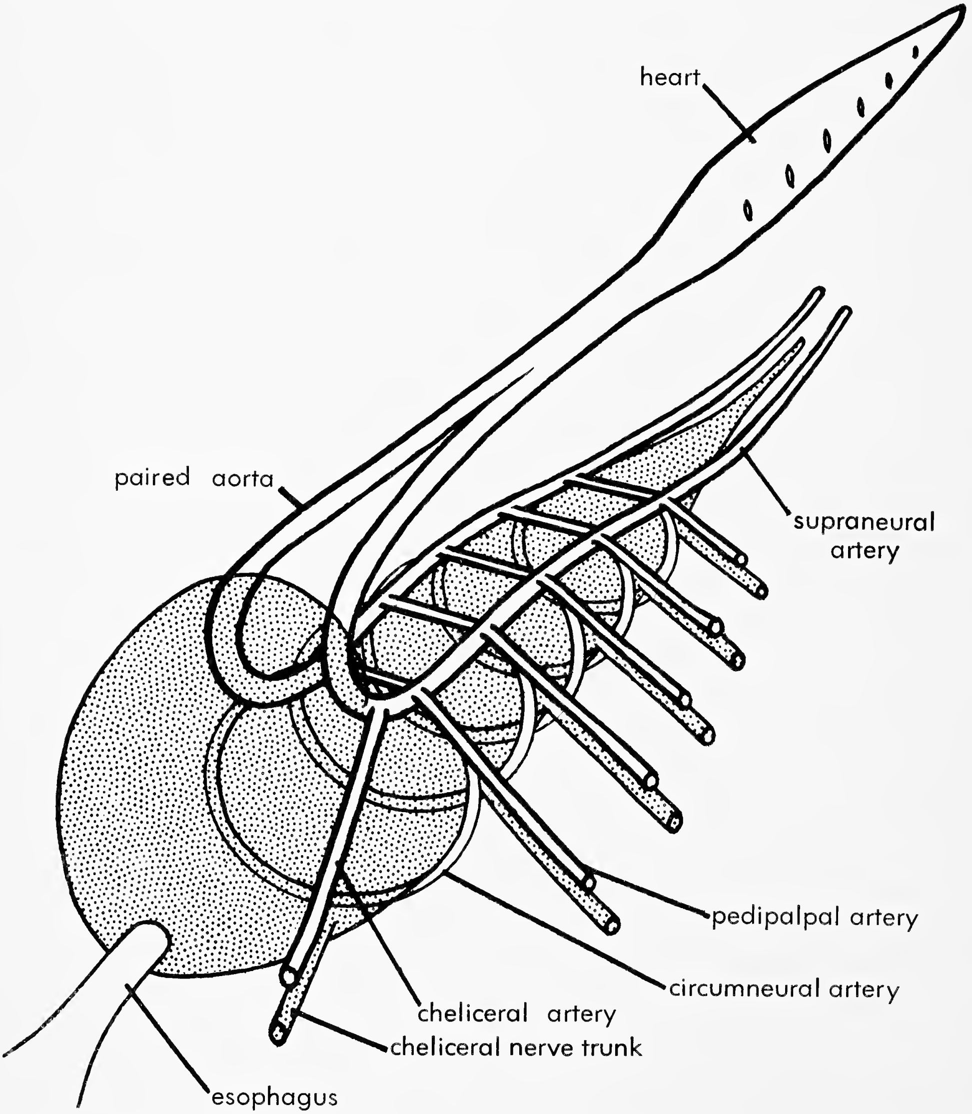


Fig. 29.—Hypothetical arterial system of a prechelicerate, showing a paired supraneural artery. The view is anterodorsolateral. A ghost of the central nervous system (stippled) is shown in position. See Fig. 34A.

transversely muscularized horizontal septum, lying in a plane between the gut and the nervous system, supports my hypothesis that a similar condition could have existed in primitive chelicerates.

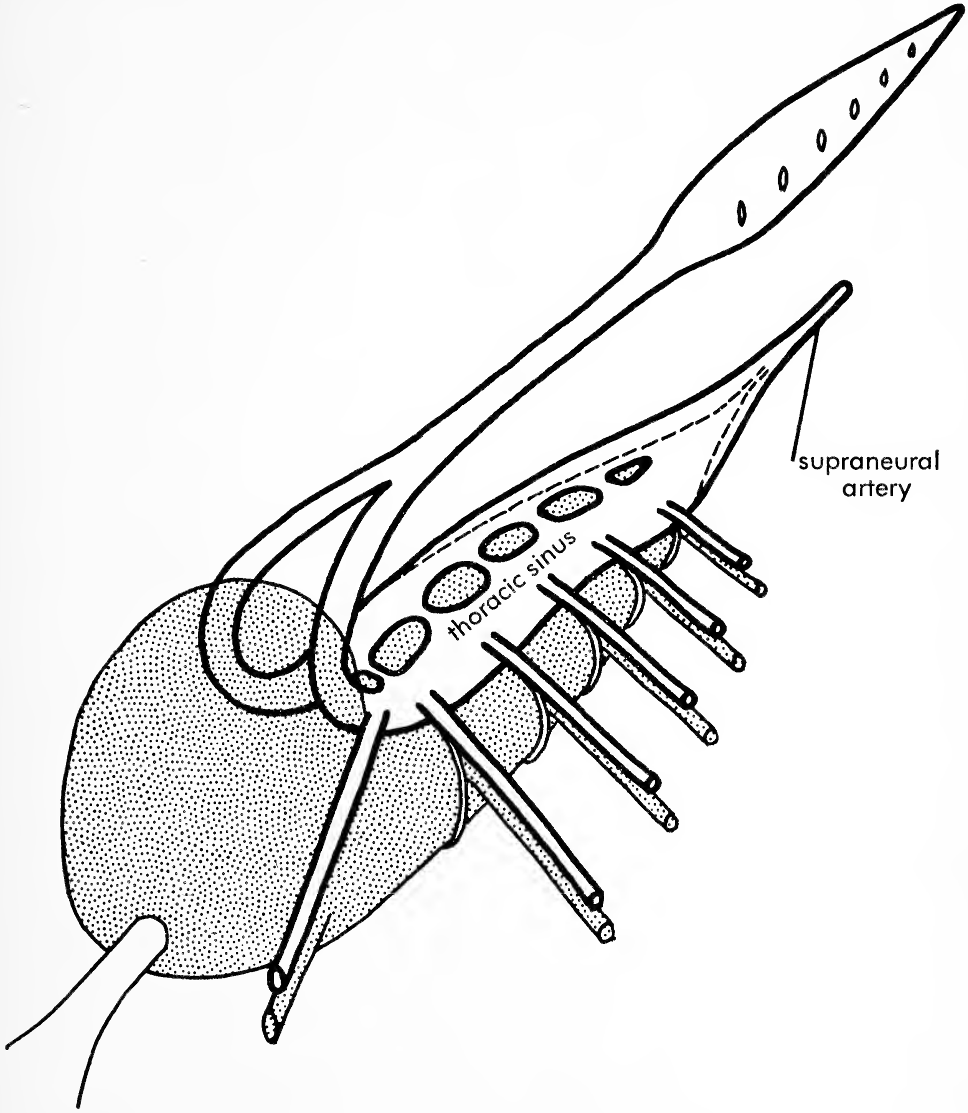


Fig. 30.—The thoracic sinus stage of arterial development. This stage persists in the adults of all pulmonate arachnids. See Fig. 34B.

The Evolution of Arterial Membranes

In pycnogonids, in *Limulus*, and in apulmonate arachnids, the arterial system is perivisceral. From this evidence, it seems likely that the same state of being existed also in ancestral chelicerates. In the light of the ontogeny of *Limulus*, discussed earlier, the

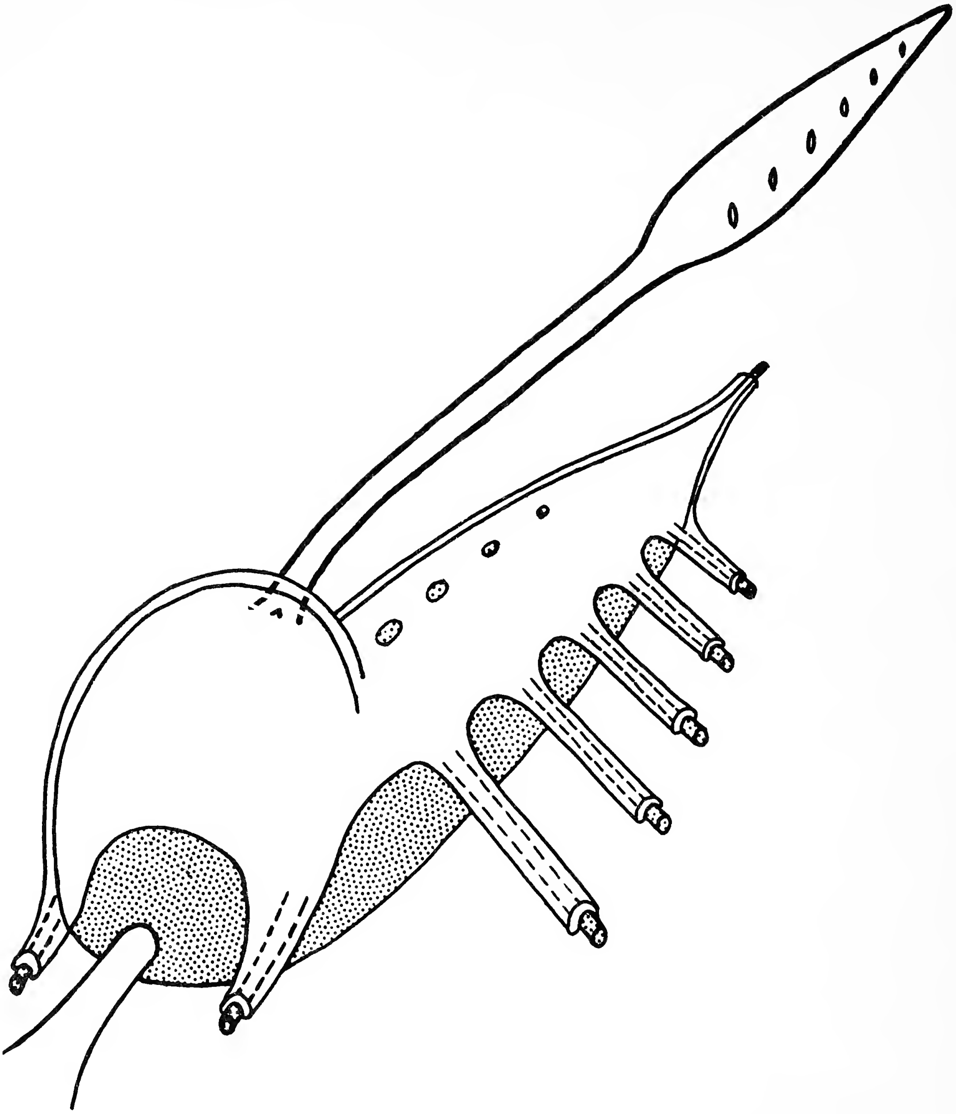


Fig. 31.—A stage of arterial development intermediate between the thoracic sinus and the periganglionic sinus. See Fig. 34C.

periganglionic arterial sinus probably emerged through a series of stages of arterial evolution, as depicted in Figs. 29 to 34:

1. A paired supraneural artery (Figs. 29, 34A) probably existed in prechelicerate ancestors. This type of condition is presaged by the neural circulation in certain polychaetes; e.g., *Nereis cultrifera* (Karandikar and Thakur, 1946).
2. Hypertrophy of the supraneural arteries, and expansion of their lumina, as depicted in Figs. 30, 34B, produced a thoracic sinus condition, such as occurs in all pulmonate arachnids. However, the thoracic sinuses of pulmonate arachnids are here regarded as a neotenous retardation of the developmental process because *Limulus*

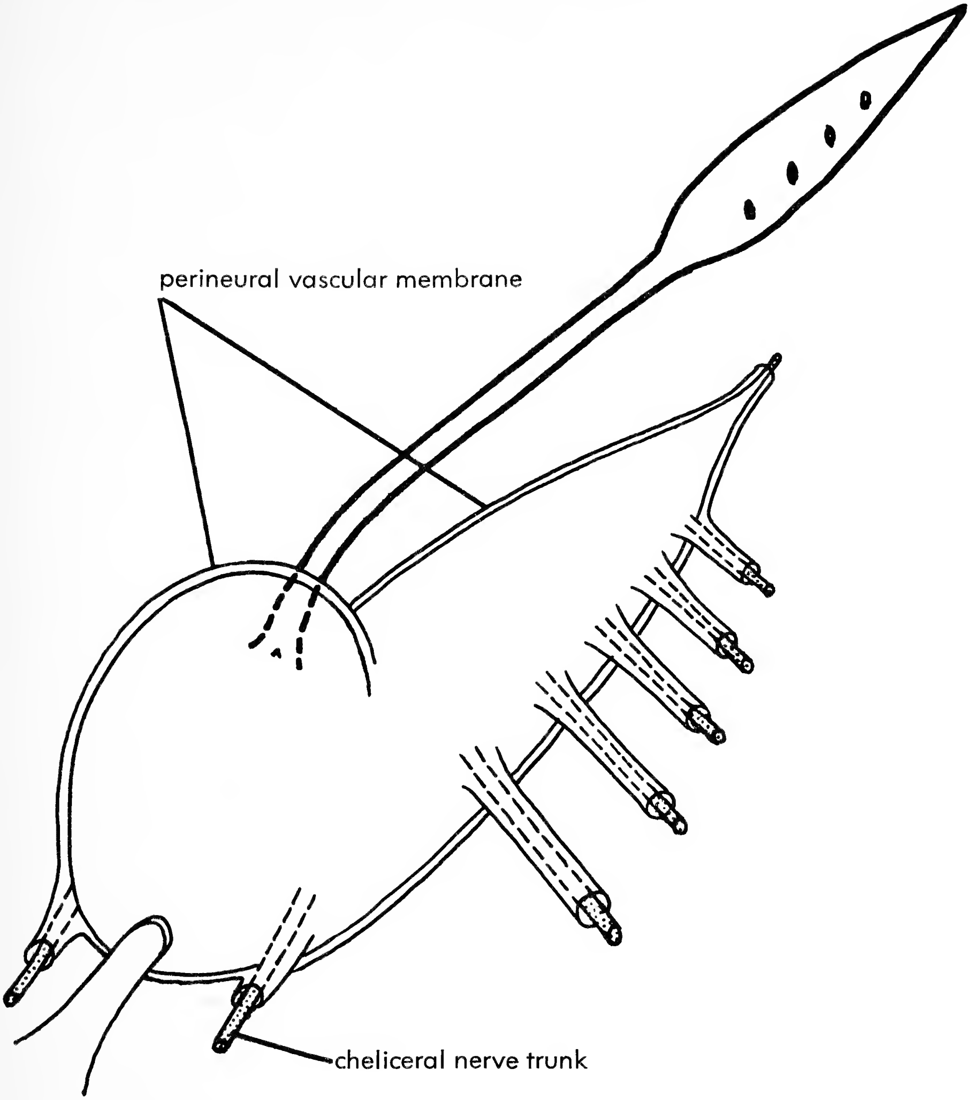


Fig. 32.–The definitive periganglionic stage of arterial development. This condition exists in all adult chelicerates which lack book lungs. See Fig. 34D.

passes through a larval stage in which it has a paired thoracic sinus, and because lungless spiders still possess the genetic machinery to carry their development on (in the absence of book lungs) to the full periganglionic sinus condition.

3. Figs. 31 and 34C depict an intermediate condition between the paired thoracic sinus and the full periganglionic sinus. This stage does not exist in any adult chelicerate, but it occurs in the larva of *Limulus* (Kingsley, 1893).
4. The definitive periganglionic arterial sinus (Figs. 32, 34D) is enclosed by a perineural vascular membrane which ensheathes all the nerve trunks arising from the central nervous system. This membrane, which consists of connective tissue, is the substratum for the phylogenetic development of the endosternite.

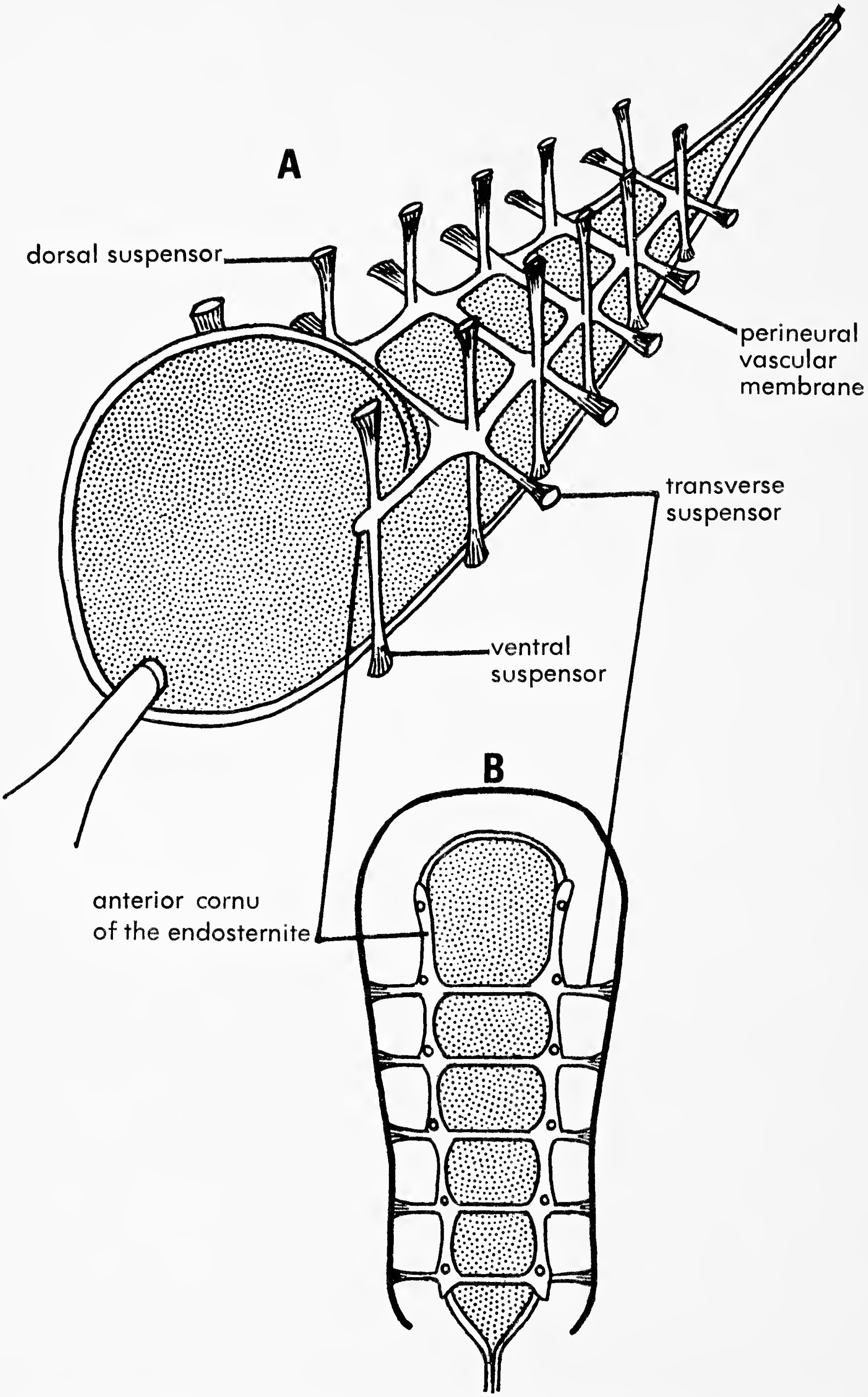


Fig. 33.–A: hypothetical model of the primitive chelicerate endosternite, as formed by fusion of the perineural vascular membrane with the connective tissue of dorsoventral and transverse muscles. The view is anterodorsolateral. B: dorsal view of same. The circles represent the positions of dorsoventral muscles.

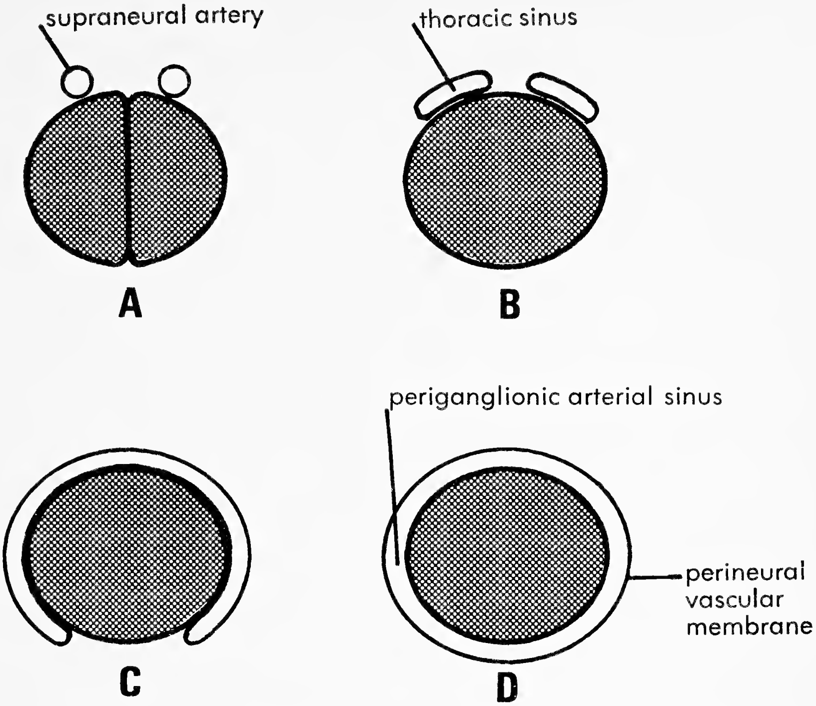


Fig. 34.—Hypothetical origin of the perineural vascular membrane. All diagrams represent transverse sections through the subesophageal ganglionic mass, shown with dark shading. A: prechelicerate condition, with paired supraneural artery. See Fig. 29. B: paired thoracic sinus, found in all adult pulmonates, and in the larval *Limulus*. See Fig. 30. C: intermediate stage. See Fig. 31. D: periganglionic arterial sinus, found in all apulmonate chelicerates. See Fig. 32.

Origin of the Chelicerate Endosternite

Primitively, according to my hypothesis, the endosternite formed as a result of the fusion of the perineural vascular membrane with the connective tissue of transverse muscles, serially arranged above the neuromeres of the central nervous system. At their points of contact with the membrane, these muscles became tendonified (non-contractile) cross-bars, and their lateral contractile extremities, which presisted as transverse suspensors, were the first muscles to insert on the endosternite. Originally, the transverse muscles may have been associated with a horizontal vascular septum lying in a plane beneath the gut and over the nervous system (Fig. 27D, E, F). Eventually, the cross-bars became involved with dorsoventral muscles through fusion of connective tissue. The upper and lower extremities of the dorsoventral muscles became became respecitvely the dorsal and ventral suspensors of the endosternite.

Originally, the dorsoventral muscles may have had a vascular function, for up and down movements of the endosternite may have had a role to play in maintaining arterial blood pressures. Mitchell (1957) pointed out that in the Hydryphantidae (Acarida) dorsoventral muscles are important in regulating local changes in blood pressure, and Parry and Brown (1959a and b) have shown that in some arachnids leg extension depends upon the maintenance of a cephalothoracic blood pressure higher than that of the abdomen. Hence, the original function of the endosternite may have been vascular rather than skeletal.

In my hypothesis, the primitive endosternite had the form of a lattice (Fig. 33), with transverse and dorsoventral muscles crossing perpendicularly above the subesophageal ganglionic mass, and with fenestrations filled in with perineural vascular membrane. The thickening of this membrane produced a nonfenestrated endosternite such as that which occurs in adult palpigrades. In a young palpigrade, such as that described by Börner (1904), rough handling can puncture the thin membrane and cause the endosternite to appear fenestrated (Börner illustrated it that way in this text figure 17). In the thelyphonid endosternite there are two persistent fenestrae, and in schizomids there is one persistent fenestra.

The "cephalothoracic" endosternites of thelyphonids and amblypygids extend into the abdomen through its first segment, so it is probable that the primitive endosternite did the same. Abdominal endosternites occur in *Limulus*, in scorpions, and in spiders, but these always exist independently in separate segments and are never fused into a centralized mass as they are in the cephalothorax. The abdominal endosternites of *Limulus* have been discussed; they are structurally similar to the cephalothoracic endosternite, but are probably not serially homologous to it because their transverse muscles insert upon movable appendages and lie beneath the nervous system. In scorpions, the circumneural ring appears to be the result of an overlapping of cephalothoracic and abdominal elements in one segment. The suprapectinal endosternite, which lies in the segment immediately posterior to the circumneural ring, is serially homologous to the inferior portion of the circumneural ring.

In pulmonate arachnids, were arterial development stops short at the thoracic sinus stage, the genes responsible for the development of the endosternite are still operative, and accordingly the endosternite develops as though it were morphologically independent of the arterial membranes. However, in the lungless spiders, where arterial development proceeds to the periganglionic stage, the endosternite is continuous with the perineural vascular membrane, as it is in the apulmonates. From these facts, one may infer that the neotenous retardation of the arterial development is a pulmonate specialization, and that the endosternite already existed (in prepulmonate ancestors) before the specialization occurred.

The palpigrade has the most primitive endosternite of all apulmonates, and it could well serve as a model of the prototype from which the nonpalpigrade apulmonates have evolved through specialization. In nonpalpigrade apulmonates, there has been a tendency toward reduction in the size and extent of the endosternite. This has been correlated with a corresponding tendency toward a general increase in the development of an apodemal endoskeleton. This trend is perhaps a result of terrestrialization, in which a selective premium has been placed on a specialized musculature requiring elaborate apodemes.

Opilionids of the suborder Palpatores have the most fully developed cephalothoracic endostermite of all the nonpalpigrade apulmonates, although transverse suspensor muscles are lacking in the entire order. Laniatore opilionids have an endosternite somewhat more reduced, and accordingly the coxal apodemes are more strongly developed in this suborder. The cyphophthalmids, which I regard as specialized opilionids, and by no means primitive, have an extremely reduced endosternite which could have been derived from either of the other two opilionid suborders.

The tick endosternite, which has a single pair of persistent transverse suspensors and three pairs of dorsoventral suspensors, has a paradoxical primitiveness which strangely belies the otherwise specialized morphology of ticks. Among nonpalpigrade apulmonates, the Acarida are second only to opilionids in endosternite development. The tick and the opilionid are similar in that both have a conspicuously developed perineural vascular membrane, although the tick endosternite is more vestigial. In some of the Acarida, the arterial system and the endosternite are reduced to the point of absence, but this is due probably to their small size, and to the fact that apodemes for muscle attachment have functionally superseded the mesodermal endosternite.

The pseudoscorpion endosternite is even more reduced than that of the tick, and the perineural vascular membrane is so vestigial that its presence can be detected only because portions of it are still adherent to the endosternites. The ricinuleid endosternite is virtually absent, but the perineural vascular membrane is well enough developed that vestiges of the endosternite can be identified.

In solpugids, the tendency toward reduction of the mesodermal endosternite has reached its most extreme degree, for in the entire order there is none at all (Millot and Vachon, 1949b), though the perineural vascular membrane is still present and functional. Solpugids have the most elaborately developed system of apodemes to be found in the entire Arachnida, and this fact misled Bernard (1896) to the conclusion that the endosternites of all arachnids are morphological apodemes, and hence, of ectodermal origin. Bernard was convinced that *Limulus* is a crustacean, based on its convergent similarity to the notostracan branchiopod, *Apus* (Bernard, 1892a, b). In reply to Lankester's (1881) *Limulus an Arachnid*, Bernard was intent upon proving that the endosternite of *Limulus* can in no way be homologous to that of arachnids, so he capitalized on the solpugid apodemal endoskeleton to force this point. Unfortunately, Comstock (1948) in writing his popular spider book, was influenced by Bernard's point of view, so that some American arachnologists have since been persuaded that the endosternite is an apodemal derivative in all arachnid orders. In his chapter on the internal anatomy of spiders, Comstock speaks disparagingly of the "... school of writers who believe that the endosternite is formed by the coalescence of the tendons of muscles." Apparently, these aspersions were directed toward Schimkewitsch (1893, 1894), and toward Pocock (1902), both of whom took the viewpont which this research confirms.

Lankester (1884), made a chemical analysis of the endosternite of *Limulus*, and he found that its constituents were "nearly equal quantities of chitin and of mucin." This fact posed a problem, for mesoderm is not thought of generally as giving rise to chitinous structures. In Lankester's address to this problem, he acknowledged that

> ... the presence of chitin in a tissue belonging to the skeletotrophic group, and derived from the mesoblast is a novelty. It appears to have been too readily assumed that the connective tissue of Invertebrata correspond in their chemical nature with those of the Vertebrata, and the notion that chitin is a product confined to the activity of the tissues of the epiblast has been hitherto adopted without sufficient basis in fact. The skeletal product of the protoplasmic cells which build up the endosternite of Limulus is chiefly chitin, and I am led, from the behaviour of the fibers and the trabeculae of the connective tissue in other regions of the body of Limulus, and in other Arthropoda, to suspect that this substance takes the place of collagen and chondrin in the skeletal tissues of the Arthropoda.

General Remarks Regarding the Phylogeny of the Arachnid Orders

The fossil record is very suggestive of the theory that scorpions arose either from a eurypterid ancestry (Beklemischev, 1958), or else from the immediate merostome ancestors of eurypterids (Stormer, 1944, 1969). The earliest scorpions may have been aquatic (Stormer, 1933), though there is an alternative possibility that the transition from water to land was made by the eurypterids themselves, so that scorpions may have arisen from terrestrial eurypterids (Barnes, 1967). There is an enigma which arises from the fact that

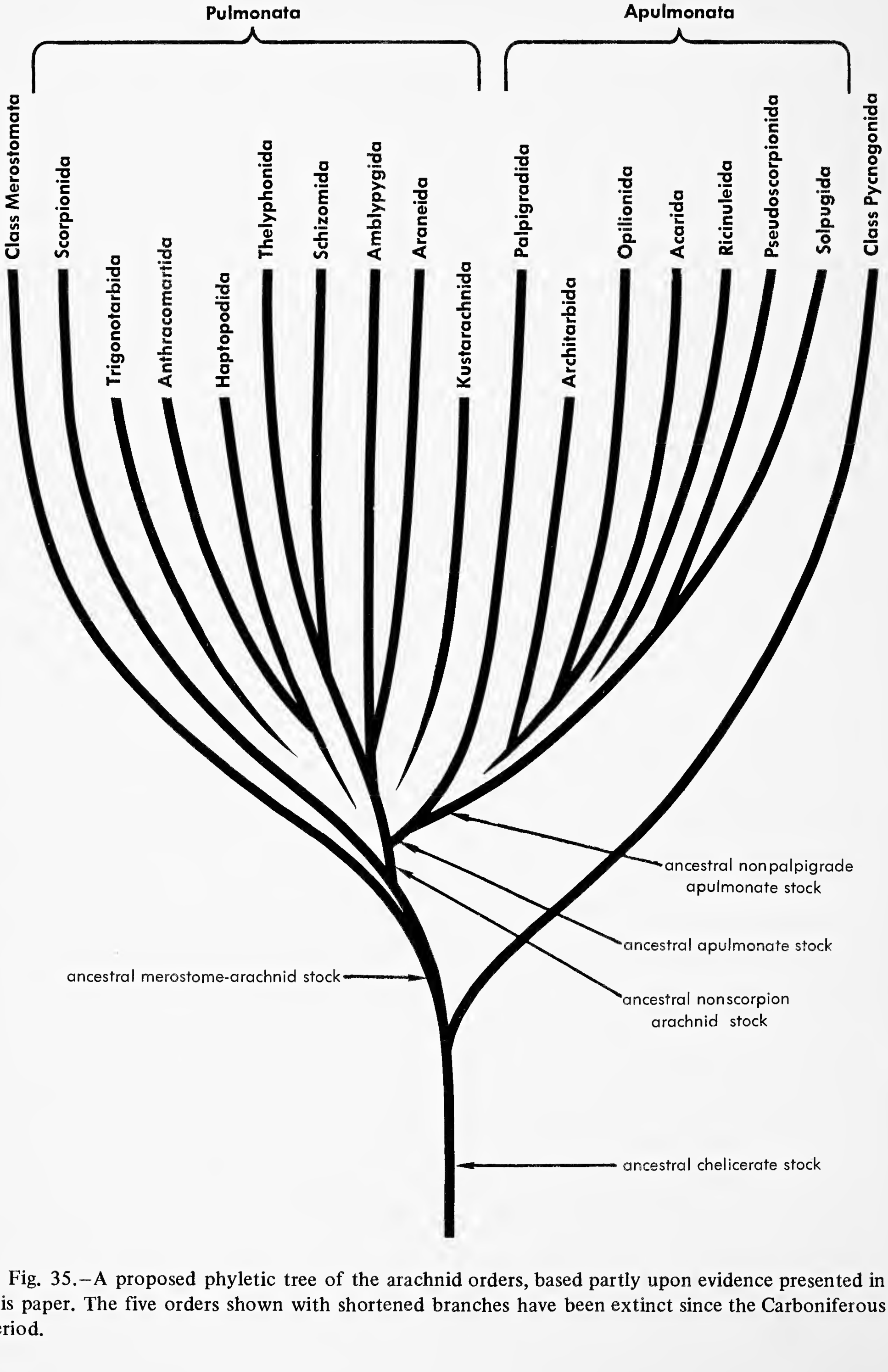


Fig. 35.—A proposed phyletic tree of the arachnid orders, based partly upon evidence presented in this paper. The five orders shown with shortened branches have been extinct since the Carboniferous Period.

neither modern scorpions nor their fossil forebears can be regarded as primitive arachnids, for scorpion morphology does not lend itself easily to a model of the hypothetical ancestral arachnid (Snodgrass, 1952). If the persuasion of the fossil evidence, that the first arachnids were scorpions, be accepted at face value, it becomes necessary either to derive all other arachnid orders from a scorpion ancestry, or else to contrive a diphyletic theory of arachnid origins. The latter possibility seems unnecessary to me in view of the similarities between scorpions and thelyphonids. Moreover, thelyphonids are so similar to schizomids that many authorities put these two together as a single order, the Uropygida, and there are no modern arachnologists who doubt the affinities of the Thelyphonida-Schizomida (Uropygida) to the Palpigradida. However, the enigma of which I speak lies precisely in the fact that, in certain respects, palpigrades are the most generalized of all known arachnids: (1) the cephalothoracic venter has five sternites, including a cheliceral sternite; (2) the endosternite has six pairs of ventral suspensor muscles (hypothetically, this is the primitive number); (3) the endosternite has five pairs of transverse suspensor muscles; (4) rudimentary respiratory organs (lung-sacs) are present, in some palpigrades in place of book lungs or tracheal spiracles. In these respects, palpigrades are more primitive chelicerates even than *Limulus*.

How is it possible to account for the primitiveness of palpigrades if a scorpion (or scorpion-like) stock was ancestral to the entire class Arachnida? Sharov (1966) offers a resolution to this problem by suggesting that the Arachnida is diphyletic: that scorpions and nonscorpion arachnids have each descended independently from a eurypterid ancestry. In order to do this, he invokes a great deal of parallel evolution in explaining the similarities of scorpions and nonscorpion arachnids, including independent emergence of these two terrestrial groups from marine ancestors. My own preference is for a monophyletic model of arachnid phylogeny, for this eliminates the improbabilities of convergent evolution which a diphyletic model requires.

I propose the hypothesis that arachnid evolution has involved neoteny and subsequent adaptive radiation from neotenous ancestors (Fig. 35). According to this view, the ancestral scorpion was a neotenous eurypterid (i.e., neotenous with respect to the development of the book lungs, the appendages, the lateral eyes, the endosternite, and the arterial system) which, through adaptive radiation, gave rise both to modern scorpions and the nonscorpion pulmonate arachnids. According to the same view, the original apulmonate arachnids were neotenous scorpions (i.e., neotenous with respect to the development of the cephalothoracic sternites and peltidia, the appendages, the respiratory organs, the endosternite, and the abdominal tagma) which gave rise both to modern palpigrades and the nonpalpigrade apulmonates. The foregoing part of this paragraph is intended here only as a suggestion; an intensive defense of this idea would exceed the scope of this study.

CONCLUSIONS

1. The chelicerate endosternite is embryonically of mesodermal origin.
2. The cephalothoracic endosternite has evolved from a vascular membrane which has incorporated the connective tissue of dorsoventral and transverse muscles.
3. The abdominal endosternites, when present, have evolved from the connective tissue of dorsoventral and transverse muscles, without the involvement of a vascular membrane.

4. In all chelicerates which lack book lungs there exists a perivisceral arterial sinus. This sinus persists in its most primitive state in pycnogonids. In *Limulus* and the apulmonate arachnids, it persists principally in the form of a periganglionic arterial sinus.
5. The thoracic sinus arterial system of pulmonate arachnids in an arrested stage of arterial development and is interpreted here as neoteny. This stage occurs in the larval *Limulus*, and presumably it occurs also during the embryogeny of other chelicerates.
6. In the apulmonate arachnids, the development of the mesodermal endosternite is inversely proportional to the development of the apodemal endoskeleton. Hence, the more highly developed the apodemal endoskeleton, the more vestigial is the endosternite.
7. The pycnogonid horizontal vascular septum is probably homologous to the ancestral progenitor of the endosternite in merostomes and arachnids.
8. The primitive function of the endosternite may have been vascular. Movements of the endosternite may have augmented cardiac contractions in effecting blood circulation through the perivisceral arterial sinus and into the appendicular arteries.
9. Probably, neoteny has been involved in the origin of arachnids from merostomes, and in the origin of apulmonate arachnids from pulmonates.
10. The Pulmonata is a natural monophyletic category. It includes the Scorpionida, Thelyphonida, Schizomida, Amblypygida and Araneida.
11. The Apulmonata is a natural monophyletic category. It includes the Palpigradida, Acarida, Opilionida, Ricinuleida, Pseudoscorpionida and Solpugida. The ancestral apulmonate stock diverged to give rise both to modern palpigrades and to the nonpalpigrade apulmonates.

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SYSTEMATICS OF THE ARACHNID ORDER UROPYGIDA (=THELYPHONIDA)[1]

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ABSTRACT

This paper presents a review of the genera of extant whipscorpions (Arachnida: Uropygida, or Thelyphonida), and of the characters used in their systematics. Family group and generic taxa are keyed and diagnosed, and a synoptic list of the species and their distribution is given. The family Mastigoproctidae is relegated to synonymy, the subfamily Hypoctoninae is elevated to family status, and the subfamilies Uroproctinae and Typopeltinae are created.

INTRODUCTION

The whipscorpions, although conspicuous and sometimes locally abundant, have attracted little attention from systematists and remain a poorly known order. The principal monographs of the group (Pocock, 1894; Kraepelin, 1897, 1899; Mello-Leitao, 1931; Werner, 1935) are now considerably out of date, particularly since additional genera and species have been described.

The main purpose of this paper is to provide a readily available way of identifying the family group and generic taxa of Uropygida by means of a key and diagnoses. The diagnoses are brief, but bring together for the first time all those characters thought useful in recognizing the various taxa. In most cases we have treated each of at least five characters, but some genera are based on a single specimen, thus making mention of certain sexual characters impossible. Also provided is a badly needed synopsis of the species, and their general distribution. In addition to general revisionary works, references are given to some important papers which have escaped attention until now.

This paper forms the first stage in a thorough revision of the whipscorpions of the world, and summarizes the present state of our knowledge.

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SYSTEMATICS

In older works the whipscorpions and schizomids were usually considered as the suborders Holopeltidia and Schizopeltidia, respectively, within the order Uropygida. This system is followed by those authors (Millot, 1949; Kaestner, 1968) who wish to emphasize their numerous morphological similarities. There is, however, a growing tendency to treat these groups as separate orders (Petrunkevitch, 1945a, 1945b, 1955; Savory 1964; Levi and Levi, 1968), but a discussion of the merits of these higher classifications is beyond the scope of this paper.

A cursory examination suggests that the obvious external characters traditionally used to distinguish uropygid genera are both sound and clear-cut. It has become apparent, however, that the existing classification is inadequate, especially in one assemblage of genera. Some of the characters at present used to distinguish these genera are of doubtful phylogenetic significance, show considerable variation, and may even intergrade. Nevertheless, we feel that the classification presented here is sufficiently sound to provide a workable basis for further studies.

At the present time the 85 known species of whipscorpions are divided among 16 genera, and up until now were usually all placed in the single family Thelyphonidae. Speijer (1933) erected the family Mastigoproctidae for the New World genus *Mastigoproctus*, but has not been followed in this by other workers. The four genera added by Speijer (1933, 1936) have gone virtually unnoticed, which is fortunate, for his inadequate understanding of the Uropygida adds only confusion to an already questionable classification.

The following will clarify some of the terms used herein, and will serve to emphasize a few of the deficiences of the existing classification.

In earlier systematic literature (Pocock, 1894, 1900; Kraepelin, 1897, 1899; Gravely, 1916; Mello-Leitao, 1931; Werner, 1935) confusion existed over the correct terminology for the parts of the pedipalp, and this has been perpetuated by Millot (1949) in his authoritative account of uropygid morphology. Snodgrass (1948) demonstrated that the moveable finger of the pedipalp is a fusion of both basitarsus and tarsus, and that the fixed finger arises as an apophysis of the tibia rather than of the basitarsus. Thus, what hitherto has been regarded as the tibia is in reality the patella. Arising from the patella is a large apophysis (Figs. 14-17) that opposes the inner surface of the tibia and in effect forms a second pincer. The patellar apophysis has thus previously been called the tibial apophysis. In several genera the patellar apophysis is basically similar in both sexes, although the male's is frequently longer and more slender (Figs. 16, 17). In *Hypoctonus*, *Labochirus*, and *Typopeltis* the patellar apophysis of the male is much enlarged and elaborated (Figs. 14, 15), providing valuable characters for distinguishing species. In *Uroproctus* the male's apophysis has a very slight anterior elaboration of spines. This could be the first step toward the condition occurring the the previous three genera. Whether or not the modification of the apophysis has arisen independently in any of these genera, which otherwise represent three very distinct groups, is a matter of considerable interest. Further study toward elucidation of this problem will require, however, examination of far more material than is presently available to us.

Females of the genera *Tetrabalius*, *Thelyphonus*, *Abaliella*, *Typopeltis*, and *Ginosigma* have one or more of the distal tarsal segments of the first leg distinctively modified (Fig. 13). This condition can range from a few minor incrassations on the pentultimate segment, to deep sculpturing and production of long apophyses on the four or five most distal segments. In the above genera, frequently most or all of the female's tarsal segments are more nearly moniliform than in the male's. Females of *Abaliella rohdei* from New

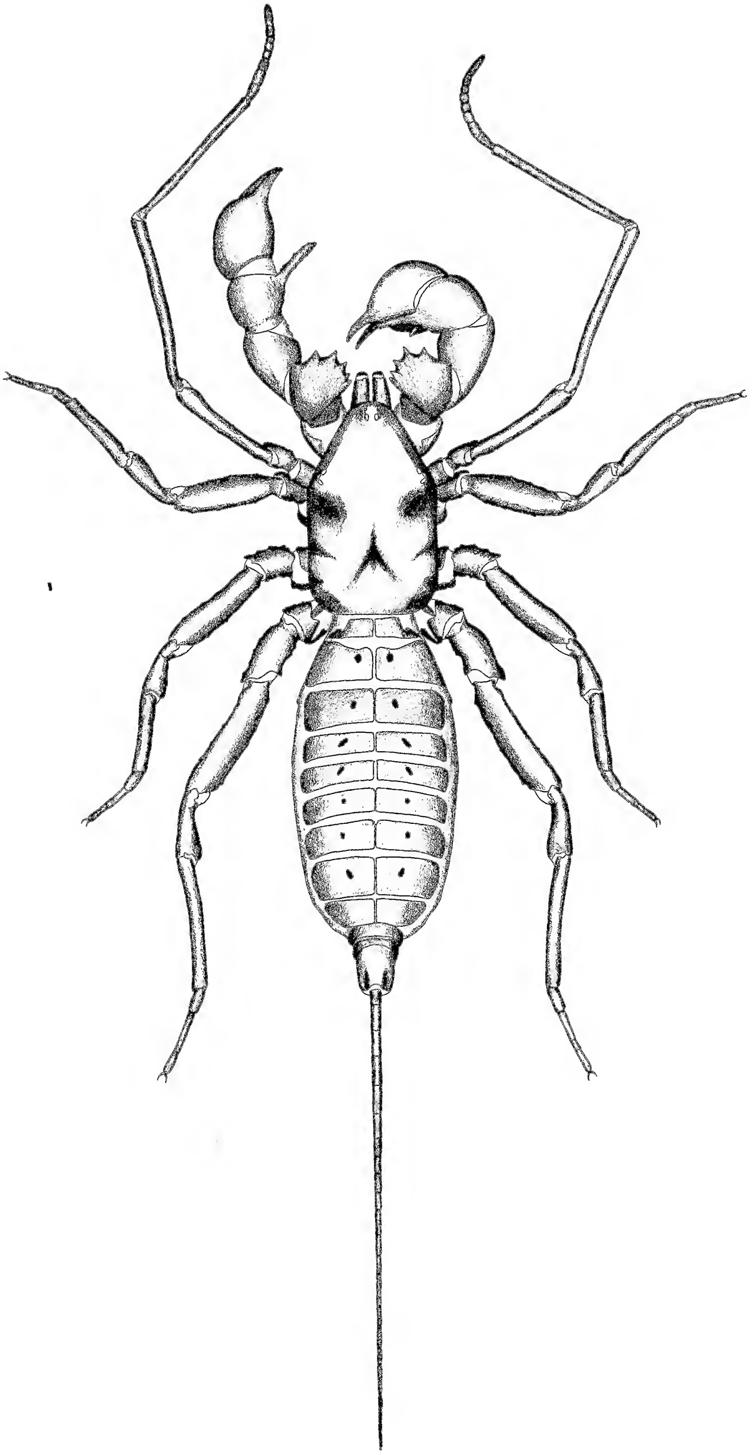


Fig. 1.–Dorsal view of *Glyptogluteus augustus.*

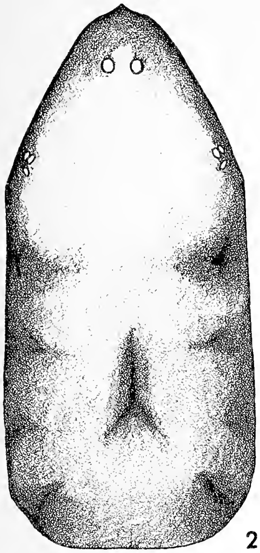
Guinea, however, differ from other members of the genus in having all the tarsal segments of the first leg uniformly similar. This problematic species, the type of *Abaliella*, may necessitate a redefinition of the genus and the consequent reassignment of the remaining species.

The anal segment is the last true body segment, and with the two preceding segments forms the pygidium from which the flagellum arises. On the dorsolateral surface of the anal segment of most genera are paired, pale patches of undetermined function, known as ommatidia or ommatoids. Since they are not proven to be light sensitive, though Laurie (1894) showed them to have a thin, specialized cuticle, the more noncommital term ommatoids is to be preferred. The work of Patten (1917) would indicate that these structures are not at all light sensitive. Considerable variation exists in the size and shape of the ommatoids and in some species they are extremely reduced (Figs. 4-7). The orifices of the anal glands, the structure and defensive function of which were well described by Eisner, et al. (1961), lie in the arthrodial membrane on either side of the anus, ventrolateral of the insertion of the flagellum. These orifices should not be confused with the ommatoids.

Tetrabalius, *Abaliella*, and *Chajnus* apparently differ significantly from *Thelyphonus* only in the number or configuration of the ommatoids. The size of the ommatoids in species of the latter genus varies from those that are easily visible with the unaided eye, to those which are scarcely distinguishable from large setal pits from which the setae are missing. Two large ommatoids are present on each side of the anal segment in *Tetrabalius*, the lower pair being somewhat smaller than the upper pair. *Chajnus* has a sclerotized inclusion in each ommatoid. The margin of the ommatoids can be circular, or can be very irregular, as in the African species of *Hypoctonus*. Having examined specimens of several diverse species, we are of the opinion that the presence, absence, or slight modification of the ommatoids is generally of questionable value in the separation of genera. Rowland (1973a) found a great similarity among several species from New Guinea and the Solomon Islands which, by definition, belong to different genera. The species were considered to be poorly separated into two genera solely on the basis of presence or absence of ommatoids.

The modification of abdominal sternites II (genital sternite) and III indicated for various genera is manifested in several forms. Modification in the males is usually in the form of a median, longitudinal furrow, or sulcus, on sternite II, and a posteromedian projection on sternite III (Fig. 8). The genital sternite in *Mimoscorpius pugnator* was reported to be uniquely modified (Pocock, 1894). It is in actuality, elaborated medially and its posterior border is mesally convex which closely approaches the condition found in males of *Uroproctus* and *Mastigoproctus*. Modifications in female uropygids take on a variety of forms. The posterior margin of this segment can be gently rounded, or can be acutely produced. Several further specializations may also occur in the structure of the surface of sternite II. Modification of sternite III in the females consists of a pronounced anterior emargination, usually accommodating the modified posterior margin of sternite II.

The division of abdominal tergites by a median suture was mentioned by Pocock (1894) and Kraepelin (1897). This character has not until now been used to distinguish supraspecific taxa. The variation in this character runs from no division in any tergite, to a wide division in all non-pygidial tergites (Fig. 1). In some the division occurs only in tergite I, II, or III, while in others it occurs in all non-pygidial tergites other than IV, V, or VI. The latter condition occurs in species which are otherwise considered to be closest related to those with all non-pygidial tergites divided.



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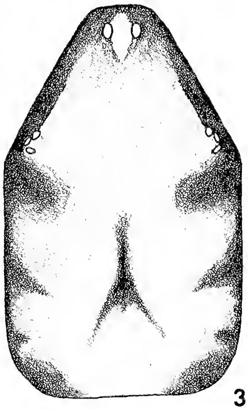

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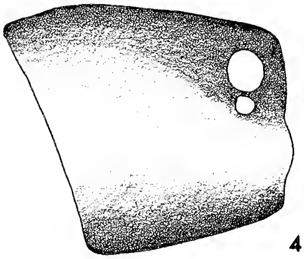

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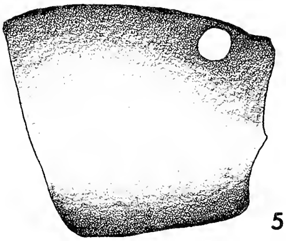

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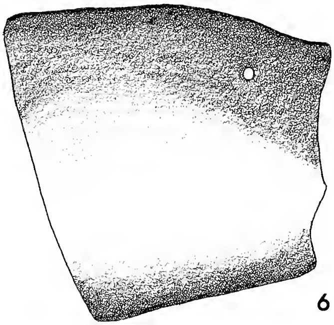

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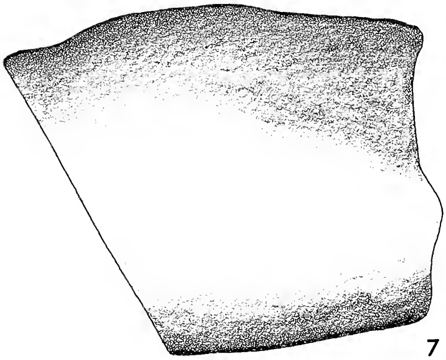

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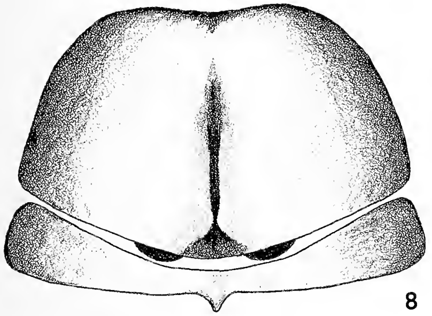

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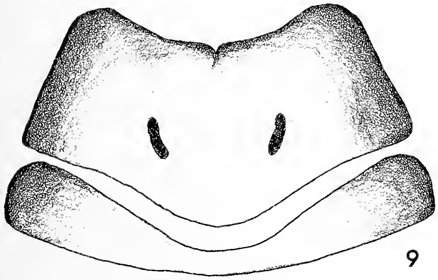

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Figs. 2-3.–Dorsal view of prosoma: 2, *Hypoctonus* sp., typical for hypoctonid genera; 3, *Thelyphonus* sp., typical for thelyphonid genera.

Figs. 4-7.–Lateral view of anal segment: 4, *Tetrabalius* sp., typical for genus; 5, *Thelyphonus* sp., typical also for *Mastigoproctus*, *Uroproctus*, *Typopeltis*, *Labochirus* and *Hypoctonus*; 6, *Thelyphonus lawrencei*; 7, *Abaliella* sp., typical also for *Glyptogluteus*, *Amauromastigon* and *Thelyphonellus*.

Figs. 8-9.–Ventral view of sternites II and III: 8, male *Thelyphonus* sp., typical for most Thelyphoninae males; 9, female *Thelyphonus* sp., typical for most Thelyphoninae females.

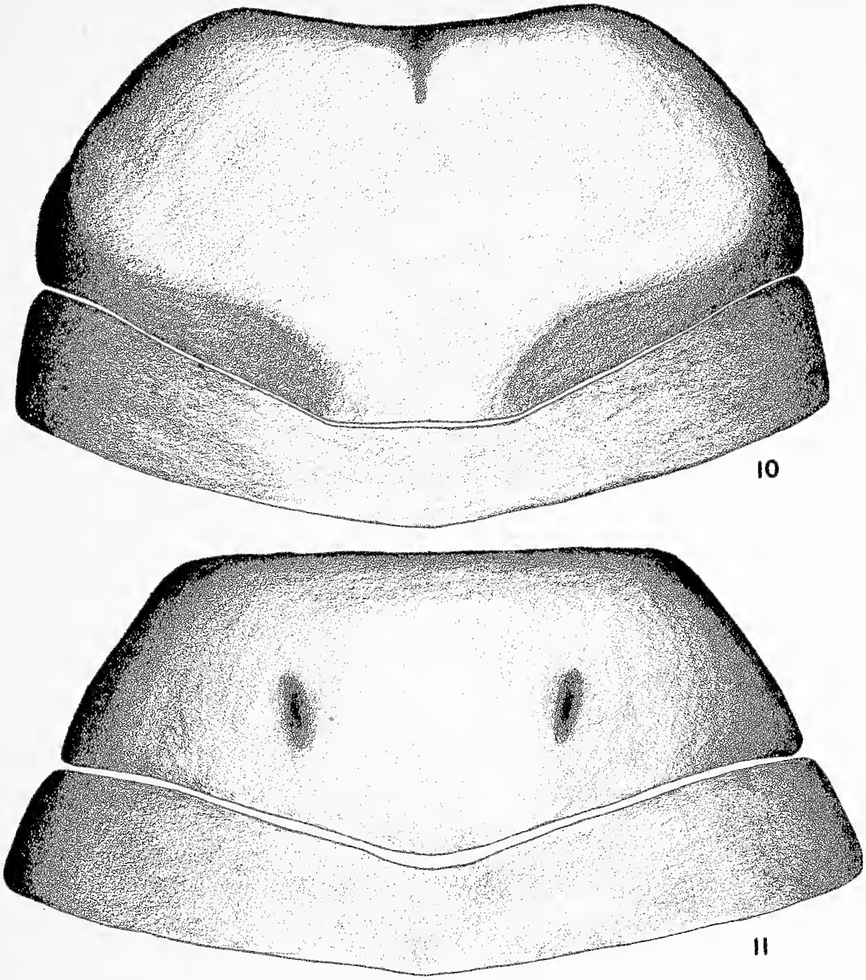
Speijer (1933), in ignorance of generic relationships within the order, erected the family Mastigoproctidae. The two genera placed in this family are supposed to possess one less tarsal segment on the first leg than other whipscorpions. We have not seen specimens of *Teltus vanoorti*, but no species of *Mastigoproctus* known to us show any reduction in the number of tarsal segments. Mastigoproctidae must, therefore, be relegated to synonymy under Thelyphonidae.

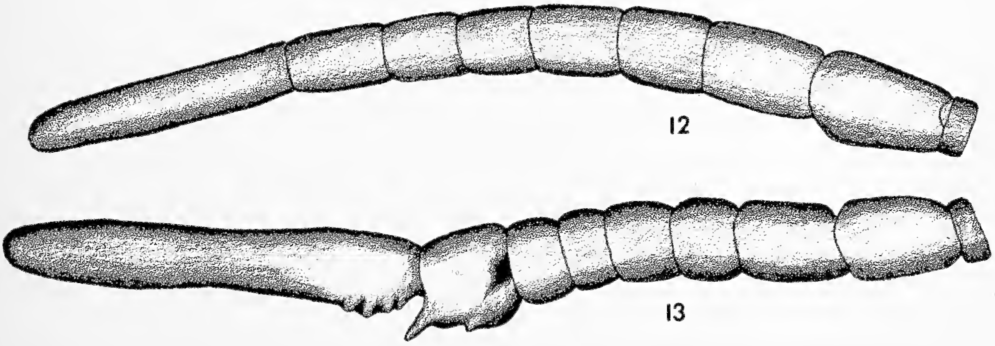
We concur, however, with Pocock (1899) who separated into subfamilies those genera possessing a ridge or keel running between the lateral and median eyes from those without this keel (Figs. 2, 3); the subfamilies Thelyphoninae and Hypoctoninae, respectively. From our knowledge of the groups, and in keeping with the systematics of other related orders, we find it necessary to elevate these subfamilies to family rank, and to further elaborate on the subordinate taxa within these groups. Within the Thelyphonidae (*sens. str.*) we erect herein the new subfamily Uroproctinae for *Uroproctus, Mastigoproctus, Amauromastigon*, *Mimoscorpius* and, tentatively, *Teltus*, and the new subfamily Typopeltinae for *Typopeltis*. This scheme much more adequately reflects the relationships of the genera.

The hypoctonid genera, besides lacking a keel, also lack any specialization of the tarsal segments of the first pair of legs. They appear to be closely related, although *Thelyphonellus* males do not display the elaboration of the patellar apophysis as found in the other two genera. There may be just cause to put *Thelyphonellus* in its own subfamily, separate from *Hypoctonus* and *Labochirus*. We feel, however at this point, that it would be unadvisable solely on the basis of the unmodified nature of the patellar apophysis in the males.

Gravely (1916) split the keeled genera (Thelyphonidae, *sens. str.*) into three groups. The first is characterized by a strongly modified patellar apophysis in the males (Fig. 14) and is represented by *Typopeltis*. The second group, characterized by a strongly modified hand and finger of the pedipalp, is represented by *Mimoscorpius*. In the third group, consisting of *Mastigoproctus*, *Uroproctus*, *Thelyphonus*, *Abaliella*, and *Tetrabalius*, both the hand and the patellar apophysis of the males are unmodified (Fig. 16). *Teltus*, *Chajnus*, *Minbosius*, *Ginosigma* and *Amauromastigon*, although poorly defined (Mello-Leitao, 1931; Speijer, 1933, 1936), and *Glyptogluteus* would have undoubtedly been considered as members of his latter group.

Gravely's third group contains a heterogenous assemblage of genera, and probably wrongfully divorces *Mimoscorpius. Mastigoproctus* and *Uroproctus* are apparently closer related to *Mimoscorpius* than to *Thelyphonus*, *Abaliella*, and *Tetrabalius*. A marked morphological dichotomy exists within the above group of genera. We see fit to place *Uroproctus*, *Mimoscorpius*, *Mastigoproctus*, *Amauromastigon* and *Teltus* into the new subfamily Uroproctinae, apart from the other genera, and likewise, Gravely's first group (*Typopeltis*) into the new subfamily Typopeltinae. The Uroproctinae display little (Figs. 10,11) or no modification of the genital sternite in either sex, and have at most only the anterior abdominal tergites divided by a median suture. The tarsal segments of the first leg in females, and the patellar apophysis of the pedipalp in males are never strongly modified. There exists in all species of Thelyphoninae a modification of the genital sternites and at least the anterior and posterior non-pygidial abdominal tergites are divided by a median suture (Fig. 1). Only in two species of the Thelyphoninae, *Minbosius manilanus* and *Abaliella rohdei*, are the tarsal segments of the female's first leg known to be unmodified, althouth this sex is unknown in *Chajnus* and *Glyptogluteus.*





Figs. 10-11.–Ventral view of sternites II and III: 10, male *Mastigoproctus* sp., typical also for *Amauromastigon*, *Uroproctus*, *Mimoscorpius* and hypoctonid males; 11, female *Mastigoproctus* sp., typical also for *Amauromastigon*, *Uroproctus* and hypoctonid females.

Figs. 12-13.–Mesal view of tarsus-basitarsus of first leg: 12, male *Thelyphonus* sp., typical for Thelyphoninae and Typopeltinae males, for both sexes of Uroproctinae and Hypoctoninae, and for *Minbosius* and *Abaliella rohdei* females; 13, female *Thelyphonus* sp., typical for most Thelyphoninae females and all Typopeltinae females.

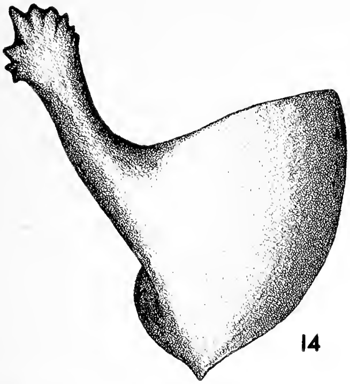
Typopeltis is represented by several widespread species, and appears to be the most specialized genus of the order, and is placed in its own new subfamily, Typopeltinae. It differs from the other thelyphonids most significantly in having the patellar apophysis of the male's pedipalp greatly modified (Fig. 14). Also considered to be of importance is the lack of a posterior projection on abdominal sternite III of males, the great modification of abdominal sternite II in females, which is strongly raised and unevenly produced distally, and the possession of entire, undivided, posterior non-pygidial abdominal tergites.

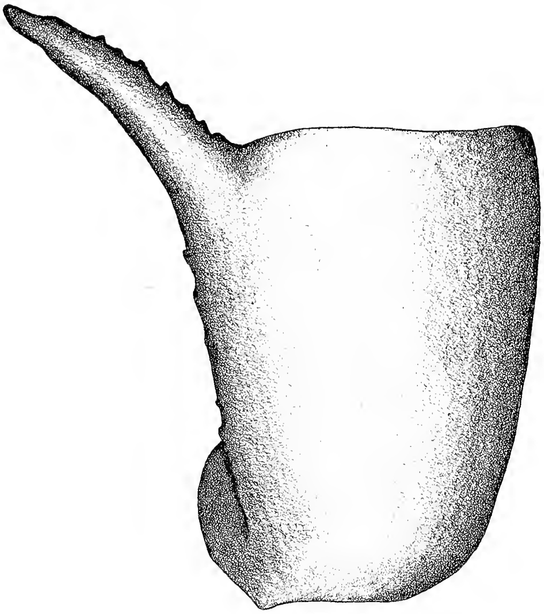
NOTES ON THE GENERA

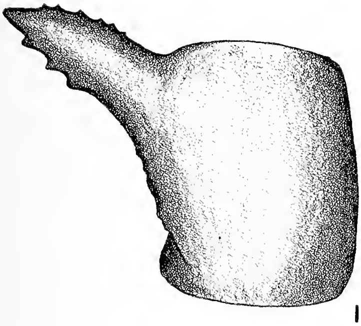
Mastigoproctus shows little specialization and has been assumed by Gravely (1916) to be the most primitive genus. The characters most often used to separate species within the genus are color and the dorsal armature of the pedipalpal tronchanter. Both of these characters, unfortunately, vary geographically, and with age within a single species. Considerable study will be necessary in order to clarify the specific limits within the genus and to establish the relationships of the species. *Amauromastigon*, also from the New World, differs from *Mastigoproctus* apparently only in the absence of ommatoids, a characteristic of doubtful significance as already indicated. The other New World genus, *Thelyphonellus*, is represented by a single enigmatic species. It bears more resemblance to *Labochirus* and *Hypoctonus* than other genera in being keel-less, but unlike the latter two genera the patellar apophysis of the male's pedipalp is not modified. It is possible that *Thelyphonellus* may have been introduced from the Far East where the other hypoctonid genera occur, in the same way that species of *Hypoctonus* may have been introduced into West Africa (Cooke and Shadab, 1973).

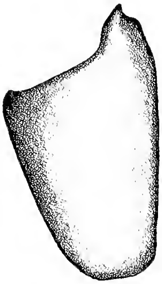
Of the Old World genera, *Uroproctus* has been suggested by Gravely (1916) to be the most similar to *Mastigoproctus*, as is reflected in our classification. This monotypic genus appears to be the most primitive of the Old World genera, and may represent an ancient relict. We are not able to confirm the relationship of the other Old World uroproctine genus, *Teltus*, to *Mastigoproctus*, but Speijer (1936) united them as the only representatives of his family, Mastigoproctidae.

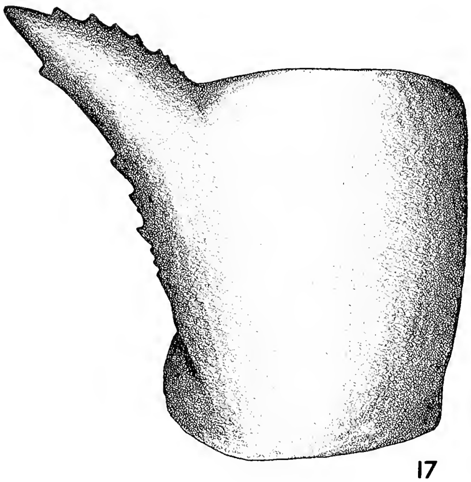
Labochirus and *Hypoctonus* have obvious mutual afffinities and represent the most advanced non-keeled genera. A dichotomy of opinion exists concerning the definition of these genera. Kraepelin (1897, 1899) and Pocock (1894, 1900) defined *Labochirus* as possessing a conspicuous accessory tooth on the inner margin of the anterior process (apophysis) of the pedipalpal coxa (Fig. 18), *Hypoctonus* being distinguished by the absence of such a tooth (Fig. 19). Gravely (1916) discounted this character and rearranged the species on the basis of whether or not the tibia of the third leg possesses an apical spine. Although Mello-Leitao (1931) follows Gravely's arrangement, Werner (1935) does not, and we, too, disagree with Gravely's classification and follow the earlier arrangement. Not only does this present a better zoogeographical picture, with *Hypoctonus* confined essentially to Burma and *Labochirus* to South India and Ceylon, but the accessory tooth on the coxal apophysis of the pedipalp appears to be a more dependable character than the tibial spines, which are known to vary. An African *Hypoctonus* specimen, for example, was found to possess this apical, tibial spine on one side only, while it was entirely absent in other specimens of the same species. Moreover, tibial spines are also present in several species of other genera.











Figs. 14-17.–Dorsal view of patella of right pedipalp: 14, male *Typopeltis* sp., typical also for *Hypoctonus* and *Labochirus* males; 15, female *Typopeltis* sp., typical for all uropygid females; 16, male *Mastigoproctus* sp., typical for all uropygid males other than *Typopeltis*, *Labochirus* and *Hypoctonus*; 17, female *Mastigoproctus* sp., typical for all uropygid females.

Figs. 18-19.–Ventral view of coxa of right pedipalp: 18, *Labochirus* sp., typical also for *Uroproctus*; 19, *Hypoctonus* sp., typical also for *Mastigoproctus*.

Thelyphonus is the most widespread and diversified genus. There is some doubt, however, that all the species attributed to it are discrete. Unfortunately, many of the names are based on missing or inadequate material. The close relationship between *Abaliella* and certain species of *Thelyphonus* was emphasized by Rowland (1973a). A significant dichotomy may indeed exist somewhere within the *Abaliella-Thelyphonus* complex, however, the only characteristic currently separating these genera is the lack of ommatoids in *Abaliella* (Fig. 7). *Tetrabalius* also conforms well with the latter group, differing only in the possession of two pairs of ommatoids (Fig. 4).

Mimoscorpius and *Glyptogluteus* are represented by two very singular species (Rowland, 1973b). These species, unlike any other whipscorpions, display remarkable, but dissimilar, modifications of the hand and finger of the pedipalps, and, in the latter genus, a unique configuration of abdominal sternites VIII and IX. Their relationships to other Thelyphonidae are obscure, however, due to the absence of females for study. *Mimoscorpius pugnator* is perhaps the most difficult to place of all the aberrant species. Pocock (1894) reported that while this species has a well developed keel, the median eyes are not separated by a median ridge. The ridge is apparently present in all other keeled genera. Further study of this species shows, however, that on the basis of the unmodified genital sternite and the entire posterior abdominal tergites, it fits well in the subfamily Uroproctinae. Gravely (1916) set *Mimoscorpius* in a group separate from the other keeled genera on the basis of its pedipalpal modification alone, but we cannot agree with this separation.

The genera created by Speijer (1933, 1936), *Teltus*, *Minbosius*, *Chajnus* and *Ginosigma*, are poorly diagnosed and must await further study to determine their exact placement. *Minbosius* and *Ginosigma* are separated from *Thelyphonus* on the basis of tarsal modifications of the female's first leg. They are apparently similar to *Thelyphonus* in all other features. *Minbosius* is distinguished by having no modification of the tarsus at all, which may be significant. *Ginosigma*, however, is based on a seemingly common modification of the ultimate segment, which is of doubtful generic importance.

The generic name *Abalius* Kraepelin (1897) was found to be a junior homonym and replaced by *Abaliella* Strand (1928). *Gipopeltis* was created by Speijer (1934) for *Typopeltis harmandi* Kraepelin (1901), but was later again synonymized by Speijer (1936) under *Typopeltis*.

Two of the genera created by Speijer, *Minbosius* and *Ginosigma*, were first mentioned as new taxa in 1933. Speijer failed, however, to mention any species in connection with either of these genera, although he purported to distinguish them from related groups. In 1936 he finally satisfied the conditions for availability by attributing the appropriate species to their respective genera. We have accordingly assigned the date of 1936 as the date at which time these generic names became available. The type species of *Minbosius* is established by monotypy, however the type species of *Ginosigma* must be arrived at by other criteria. We have decided that *G. schimkewitschi* (Tarnani, 1894) should become the type since it was the only described species capable of being attributed to *Ginosigma* when, in 1933, Speijer first proposed the genus. At the same time that *Ginosigma* became available Speijer also described *G. lombokensis*, the only other species attributed to the genus.

DIAGNOSES OF THE FAMILY GROUP AND GENERIC TAXA AND SYNOPSIS OF THE SPECIES OF UROPYGIDA

Family Hypoctonidae Pocock, 1899.
[*nom. transl.* Rowland and Cooke, herein (*ex* Hypoctonini Pocock, 1899)]

Diagnosis–Tarsal segments of first leg of female unmodified, similar to male; patellar apophysis of pedipalp of male modified or unmodified; abdominal sternites II and III modified or unmodified; two or no ommatoids present; keel absent.

Genus *Hypoctonus* Thorell, 1889. (Type)

Diagnosis–Tarsal segments of first leg of female unmodified, similar to male; patellar apophysis of pedipalp of male modified; abdominal sternites II and III modified or unmodified; two ommatoids present; keel absent.

1. *H. africanus* Hentschel, 1899. Africa.
2. *H. andersoni* (Oates), 1890. Burma.
3. *H. binghami* (Oates), 1890. Burma.
4. *H. birmanicus* Hirst, 1911. Burma.
5. *H. browni* Gravely, 1912. Burma.
6. *H. carmichaeli* Gravely, 1916. South China.
7. *H. clarki* Cooke and Shadab, 1973. Africa.
8. *H. dawnae* Gravely, 1912. Burma.
9. *H. ellisii* Gravely, 1912. Burma.
10. *H. formosus* (Butler), 1872. Burma. (Type)
11. *H. gastrostictus* Kraepelin, 1897. Borneo.
12. *H. granosus* Pocock, 1900. South China.
13. *H. kraepelini* Simon, 1901. Malaysia.
14. *H. oatesi* Pocock, 1900. Burma.
15. *H. rangunensis* (Oates), 1890. Burma.
16. *H. saxatilis* (Oates), 1890. Burma.
17. *H. silvaticus* (Oates), 1890. Burma.
18. *H. stoliczkae* Gravely, 1912. Burma.
19. *H. woodmasoni* (Oates), 1890. Burma.

Genus *Labochirus* Pocock, 1894.

Diagnosis–Tarsal segments of first leg of female unmodified, similar to male; patellar apophysis of pedipalp or male modified; abdominal sternites II and III modified; two ommatoids present; keel absent; accessory tooth on inner margin or anterior process of pedipalpal coxae.

20. *L. cervinus* Pocock, 1900. India.
21. *L. proboscideus* (Butler), 1872. Ceylon. (Type)
22. *L. tauricornis* Pocock, 1900. India.

Genus *Thelyphonellus* Pocock, 1894.

Diagnosis–Tarsal segments of first leg of female unmodified, similar to male; patellar apophysis of pedipalp of male unmodified, similar to female; abdominal sternites II and III unmodified; ommatoids absent; keel absent.

23. *T. amazonicus* (Butler), 1872. Guyana, Brasil. (Type)

Family Thelyphonidae Lucas, 1835.

Diagnosis—Tarsal segments of first leg of female modified or unmodified; patellar apophysis of pedipalp of male unmodified in all but *Typopeltis*; abdominal sternites II and III modified or unmodified; two, four or no ommatoids present; keel present.

Subfamily Thelyphoninae Lucas, 1835. (Type)

[*nom. correct.* Rowland and Cooke, herein (*pro* Thelyphonini Lucas, Pocock, 1899)]

Diagnosis—Tarsal segments of first leg of female modified in all but *Minbosius manilanus* and *Abaliella rohdei*; patellar apophysis of pedipalp of male unmodified, but in some species longer than in female; abdominal sternites II and III modified; two, four or no ommatoids present; keel present; posterior abdominal tergites divided.

Genus *Thelyphonus* Latreille, 1802. (Type)

Diagnosis—Tarsal segments of first leg of female modified; patellar apophysis of pedipalp of male unmodified, but in some species longer than in female; abdominal sternites II and III modified; two ommatoids present; keel present; posterior abdominal tergites divided.

24. *T. anthracinus* Pocock, 1894. Borneo.
25. *T. asperatus* Thorell, 1888. Java; Ambon.
26. *T. billitonensis* Speijer, 1931. Belitung.
27. *T. borneensis* Kraepelin, 1897. Borneo.
28. *T. burchardi* Kraepelin, 1912. Sumatra.
29. *T. caudatus* (Linne), 1758. Java. (Type)
30. *T. celebensis* Kraepelin, 1897. Celebes.
31. *T. doriae* Thorell, 1888. Borneo; Belitung; Singapore.
32. *T. grandis* Speijer, 1931. Borneo.
33. *T. hanseni* Kraepelin, 1897. Philippines.
34. *T. insulanus* Keyserling, 1884. New Hebrides.
35. *T. kinabaluensis* Speijer, 1933. Malaysia.
36. *T. klugi* Kraepelin, 1897. Sumatra; Celebes.
37. *T. lawrencei* Rowland, 1973. Solomon Islands.
38. *T. leucurus* Pocock, 1898. Solomon Islands.
39. *T. linganus* Koch, 1843. Lingga; Sumatra.
40. *T. pococki* Tarnani, 1901. Celebes.
41. *T. schnehageni* Kraepelin, 1897. Burma.
42. *T. semperi* Kraepelin, 1897. Philippines.
43. *T. sepiaris* Butler, 1873. Ceylon, India.
44. *T. sumatranus* Kraepelin, 1897. Sumatra.
45. *T. sucki* Kraepelin, 1897. Borneo.
46. *T. vanoorti* Speijer, 1936. Philippines.
47. *T. wayi* Pocock, 1900. Thailand.

Genus *Abaliella* Strand, 1928.

Diagnosis—Tarsal segments of first leg of female modified, except in *A. rohdei*; patellar apophysis of pedipalp of male unmodified, similar to female; abdominal sternites II and III modified; ommatoids absent; keel present; posterior abdominal tergites divided.

48. *A. dicranotarsalis* Rowland, 1973. New Guinea.
49. *A. gertschi* Rowland, 1973. New Guinea.

50. *A. manilana* (Kraepelin), 1901. Philippines.
51. *A. rohdei* (Kraepelin), 1897. New Guinea. (Type)
52. *A. samoana* (Kraepelin), 1879. Samoa.
53. *A. willeyi* (Pocock), 1898. New Britain.

Genus *Tetrabalius* Thorell, 1889.

Diagnosis–Tarsal segments of first leg of female modified; patellar apophysis or pedipalp of male unmodified, similar to female; abdominal sternites II and III modified; four ommatoids present; keel present; posterior abdominal tergites divided.

54. *T. nasutus* Thorell, 1889. Borneo.
55. *T. seticauda* (Doleschall), 1857. Moluccas. (Type)

Genus *Minbosius* Speijer, 1936.

Diagnosis–Tarsal segments of first leg of female unmodified, similar to male; patellar apophysis of pedipalp of male unmodified, similar to female; abdominal sternites II and III modified; two ommatoids present; keel present; posterior abdominal tergites divided.

56. *M. manilanus* (Koch), 1843. Philippines; Moluccas; New Guinea. (Type)

Genus *Ginosigma* Speijer, 1936.

Diagnosis–Tarsal segments of first leg of female modified, bayonet shaped; patellar apophysis of pedipalp of male unmodified, similar to female; abdominal sternites II and III modified; two ommatoids present; keel present.

57. *G. lombokensis* Speijer, 1936. Sunda Islands.
58. *G. schimkewitschi* (Tarnani), 1894. Thailand. (Type)

Genus *Chajnus* Speijer, 1936.

Diagnosis–Tarsal segments of first leg of female unknown; patellar apophysis of pedipalp of male unknown; abdominal sternites II and III modified; two ommatoids present, with sclerotized inclusion; keel present.

59. *C. renschi* Speijer, 1936. Sunda Islands. (Type)

Genus *Glyptogluteus* Rowland, 1973.

Diagnosis–Tarsal segments of first leg of female unknown; patellar apophysis of pedipalp of male unmodified, hand orbital and stout, fixed and movable fingers short and stout; abdominal sternites II, III, VIII, and IX modified in male; ommatoids absent; keel present; posterior abdominal tergites divided.

60. *G. augustus* Rowland, 1973. Philippines. (Type)

Subfamily **Uroproctinae** Rowland and Cooke, NEW SUBFAMILY

Diagnosis–Tarsal segments of first leg of female unmodified, similar to male; patellar apophysis of pedipalp of male unmodified, slightly longer than in female, or very slightly elaborated anteriorly; abdominal sternites II and III unmodified; two or no ommatoids present; keel present; posterior abdominal tergites undivided.

Genus *Uroproctus* Pocock, 1894. (Type)

Diagnosis–Tarsal segments of first leg of female unmodified, similar to male; patellar apophysis of pedipalp of male slightly elaborated anteriorly; abdominal sternites II and III unmodified; two ommatoids present; keel present; posterior abdominal tergites undivided.

61. *U. assamensis* (Stoliczka), 1869. Assam. (Type)

Genus *Mimoscorpius* Pocock, 1894.

Diagnosis—Tarsal segments of first leg of female unknown; patellar apophysis of pedipalp unmodified, presumably similar to female; abdominal sternites II and III unmodified; two ommatoids present; keel present; pedipalpal hand in male extremely flat, twice as wide as femur; posterior abdominal tergites undivided.

62. *M. pugnator* (Butler), 1872. Philippines. (Type)

Genus *Amauromastigon* Mello-Leitao, 1931.

Diagnosis—Tarsal segments of first leg of female unmodified, similar to male; patellar apophysis of pedipalp of male unmodified, similar to female; abdominal sternites II and III unmodified; ommatodis absent; keel present; posterior abdominal tergites undivided.

63. *A. annectens* (Werner), 1916. Brasil. (Type)

Genus *Teltus* Speijer, 1936.

Diagnosis—Tarsal segments of first leg of female unknown; patellar apophysis of pedipalp of male unmodified, similar to female; abdominal sternites II and III unmodified; ommatoids absent; keel present; posterior abdominal tergites undivided.

64. *T. vanoorti* Speijer, 1936. Hainan. (Type)

Genus *Mastigoproctus* Pocock, 1894.

Diagnosis—Tarsal segments of first leg of female unmodified, similar to male; patellar apophysis of pedipalp of male unmodified, similar to female; abdominal sternites II and III unmodified; two ommatoids present; keel present; posterior abdominal tergites undivided.

65. *M. baracoensis* Franganillo, 1931. Cuba.
66. *M. brasilianus* (Koch), 1843. Brasil.
67. *M. butleri* Pocock, 1894. Brasil.
68. *M. colombianus* Mello-Leitao, 1940. Colombia.
69. *M. formidabilis* Hirst, 1912. Venezuela.
70. *M. giganteus* (Lucas), 1835. North America. (Type)
71. *M. liochirus* Pocock, 1902. Mexico; Guatemala.
72. *M. maximus* (Tarnani), 1889. Brasil.
73. *M. minensis* Mello-Leitao, 1931. Brasil.
74. *M. perditus* Mello-Leitao, 1931. Brasil.
75. *M. proscorpio* (Latreille), 1806. Antilles.
76. *M. tantalus* Roewer, 1954. El Salvador.

Subfamily **Typopeltinae** Rowland and Cooke, NEW SUBFAMILY

Diagnosis—Tarsal segments of first leg of female modified; patellar apophysis of pedipalp of male modified; abdominal sternites II and III modified; two ommatoids present; keel present; posterior abdominal tergites undivided.

Genus *Typopeltis* Pocock, 1894. (Type)

Diagnosis—Tarsal segments of first leg of female modified; patellar apophysis of pedipalp of male modified; abdominal sternites II and III modified; two ommatoids present; keel present; posterior abdominal tergites undivided.

77. *T. amurensis* (Tarnani), 1889. China.
78. *T. cantonensis* Speijer, 1936. China.

79. *T. crucifer* Pocock, 1900. Thailand. (Type)
80. *T. dalyi* Pocock, 1900. Thailand.
81. *T. harmandi* Kraepelin, 1901. South Vietnam.
82. *T. kamahouii* Tarnani, 1900. Siberia.
83. *T. niger* (Tarnani), 1894. China.
84. *T. stimpsoni* (Wood), 1862. China; Japan.
85. *T. tarnanii* Pocock, 1902. Thailand.

KEY TO THE FAMILIES, SUBFAMILIES, AND GENERA OF UROPYGIDA

1a. Distinct keel or ridge present between median and lateral eyes (Fig. 3); elevated ridge usually present between median eyes .... **Thelyphonidae** 2

1b. Keel between median and lateral eyes absent, or very indistinct (Fig. 2); elevated ridge never present between median eyes ...... **Hypoctonidae** 14

2a(1a). Genital sternite unmodified, or at most with vague lateral swelling in males (Figs. 10, 11); tarsal segments of female's first leg unmodified (Fig. 12); posterior abdominal tergites without median suture .... **Uroproctinae** NEW SUBFAMILY 3

2b. Genital sternite modified, usually with a median furrow in males (Fig. 8) and deep lateral pits or median elaboration in females (Fig. 9); tarsal segments of female first leg modified (Fig. 13), except in *Minbosius manilanus* and *Abaliella rohdei*; posterior abdominal tergites usually with median suture (Fig. 1).. 7

3a(2a). Coxa of pedipalp with a conspicuous accessory tooth on inner margin of apophysis (Fig. 18). .... *Uroproctus*

3b. Coxa of pedipalp without an accessory tooth on inner margin of apophysis (Fig. 19). 4

4a(3b). Anal segment with two ommatoids (Figs. 5, 6). 5

4b. Anal segment without ommatoids (Fig. 7) .... *Amauromastigon*

5a(4a). Patellar apophysis of male pedipalp with front edge truncate ...... *Teltus*

5b. Patellar apophysis of male pedipalp with front edge not truncate (Fig. 16)...6

6a(5b). Pedipalpal hand of male extremely elongate and flat .... *Mimoscorpius*

6b. Pedipalpal hand of male not elongate or flat .... *Mastigoproctus*

7a(2b). Patellar apophysis of male pedipalp enlarged and elaborated (Fig. 14); abdominal sternite III of male without median projection; abdominal sternite II of female greatly modified, median portion elaborated, raised, and unevenly produced distally; posterior abdominal tergites entire .... **Typopeltinae**, NEW SUBFAMILY; ***Typopeltis***

7b. Patellar apophysis of male pedipalp not enlarged or elaborated (Fig. 16), although it may be somewhat longer and more slender than in the female (Fig. 17); abdominal sternite III of male usually with a median projection (Fig. 8); abdominal sternites of female not modified as above, usually with a pair of lateral depressions, and produced distally, sternite III anteriorly emarginate (Fig. 9); posterior abdominal tergites with a median suture (Fig. 1) .... ***Thelyphoninae*** 8

8a(7b). Anal segment with two or four ommatoids (Fig. 4-6). 9
8b. Anal segment without ommatoids (Fig. 7). 13

9a(8a). Anal segment with two ommatoids (Figs. 5, 6). 10
9b. Anal segment with four ommatoids (Fig. 4) . . . . ***Tetrabalius***

10a(9a). Tarsal segments of female first leg modified (Fig. 13). 11
10b. Tarsal segments of female first leg unmodified, similar to male's (Fig. 12). . . . . ***Minbosius***

11a(10a). Terminal tarsal segment of female first leg bayonet shaped . . . . . ***Ginosigma***
11b. Terminal tarsal segment of female first leg not bayonet shaped. 12

12a(11b). Ommatoids with a dark, sclerotized spot near center . . . . ***Chajnus***
12b. Ommatoids without a dark, sclerotized spot near center . . . . .***Thelyphonus***

13a(8b). Abdominal sternites VIII and IX of male intricately modified . ***Glyptogluteus***
13b. Abdominal sternites VIII and IX of male not modified, similar to VI and VII. . . . . ***Abaliella***

14a(1b). Anal segment with two ommatoids (Fig. 5, 6); patellar apophysis of male pedipalp enlarged and elaborated (Fig. 15). 15
14b. Anal segment without ommatoids (Fig. 7); patellar apophysis of male pedipalp not enlarged or elaborated (Fig. 16) . . . . ***Thelyphonellus***

15a(14a). Coxa of pedipalp with an accessory tooth on inner margin of apophysis (Fig. 18). . . . . ***Labochirus***
15b. Coxa of pedipalp without an accessory tooth on inner margin of apophysis (Fig. 19) . . . . ***Hypoctonus***

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(continued from inside front cover)

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CONTENTS

THE JOURNAL OF ARACHNOLOGY

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Feature Articles

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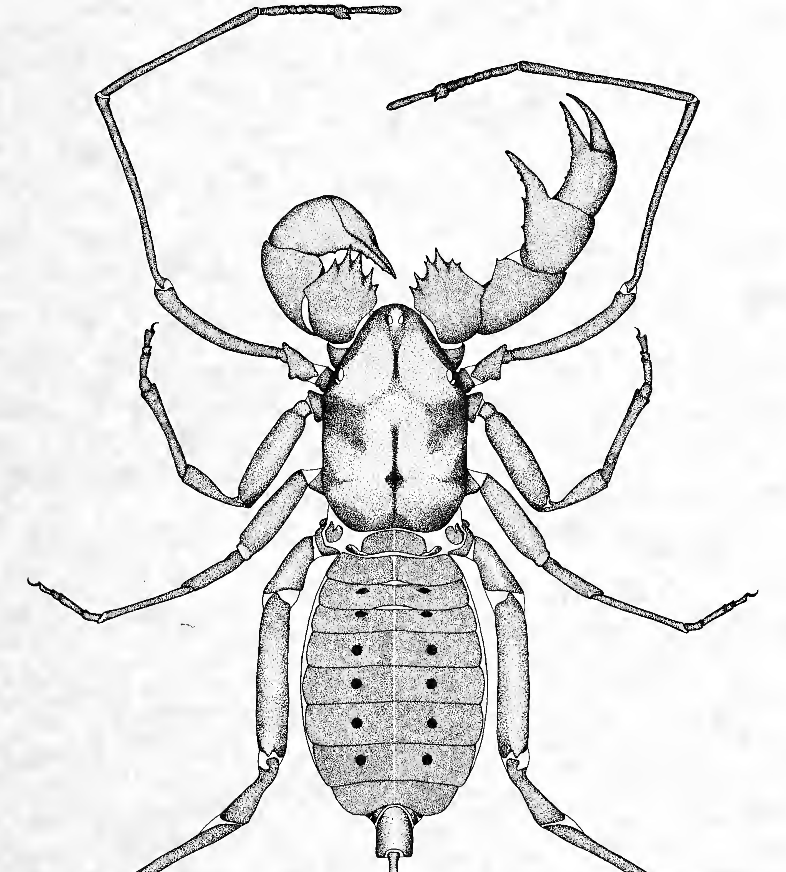

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THE JOURNAL OF ARACHNOLOGY

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Márquez Mayaudon, C., y J. Ramos Elorduy de Conconi. 1974. Un nuevo ricinulideo del género *Cryptocellus* Westwood para la fauna de México (Arthropoda, Arachnida). J. Arachnol. 1:73-84.

UN NUEVO RICINULIDEO DEL GENERO *CRYPTOCELLUS* WESTWOOD PARA LA FAUNA DE MEXICO (ARTHROPODA, ARACHNIDA)

Carlos Márquez Mayaudon
y
Julieta Ramos Elorduy de Conconi

Laboratorio de Entomología
Instituto de Biología
Universidad Nacional Autónoma de México

RESUMEN

Este trabajo comprende la descripción de un nuevo arácnido para la ciencia, aumentando a 22 las especies descritas del único género americano *Cryptocellus*, siendo para México un total de nueve especies, de las cuales siete de ellas se colectaron en cuevas de Tamaulipas, San Luis Potosí, Durango y Chiapas y dos de ellas incluyendo la especie colectada por nosotros en medio epigeo, esto es *C. spinotibialis*, debajo de troncos podridos en campos cafetaleros del volcán Tacaná, Tapachula, Chiapas y *C. gertschi* sp. nov. colectada debajo de troncos podridos en la selva de Playa Escondida, Catemaco, Veracruz. Se anexa una clave para las especies americanas tomando en cuenta principalmente los caracteres distintivos forma, tamaño y ornamentación del cuculus y cefalotórax de cada una de ellas y un mapa de distribución.

ABSTRACT

One species, new to science, of the arachnid genus *Cryptocellus* is described herewith. The American genus *Cryptocellus* includes 22 species, nine of which occur in México. Seven of the Mexican species have been recorded from caves in the states of Tamaulipas, San Luis Potosí, Durango and Chiapas, one species was collected from underneath rotten logs in coffee plantations (Tacaná Volcano, Tapachula, Chiapas), and *C. gertschi* n. sp. was collected underneath rotten logs in Playa Escondida, Catemaco, Veracruz. A key to the American species of *Cryptocellus* is included based on morphological characters of cuculus and cephalothorax. A map of distribution is also provided.

INTRODUCCION

La historia de este grupo por demás interesante ya ha sido abordado por otros autores (Ewing, 1929; Bolívar y Pieltain, 1941). Una parte de su biología, en especial lo referente a la cópula por Cooke, (1967). En lo que se refiere a estructuras de valor en la taxonomía del género en base a diez ejemplares de *C. foedus*, por Beck y Schubert, (1968) y muy reciente un excelente estudio morfológico comparativo de la especie *C. pelaezi* por Pittard y Mitchell (1972). Algunas descripciones de ciertas especies fueron muy breves como es el caso de *C. foedus*, en el trabajo de Westwood, (1874) y de *C. pearsi* y *C. relictus* de Chamberlin y Ivie, (1938).

Cryptocellus gertschi, sp. nov.

Caracteres de holotipo macho—Longitud del cuerpo 4.3 mm (Fig. 5). De color café-rojizo. Todo su cuerpo ornamentado con tubérculos y pelos. El segundo par de patas muy desarrollado, como es característico de este grupo de Arácnidos y en el tercero el órgano copulador de compleja estructuración. El primero y cuarto pares de patas presentan los fémures muy hinchados, ligeramente mas en el primero, que es distintivo en esta especie.

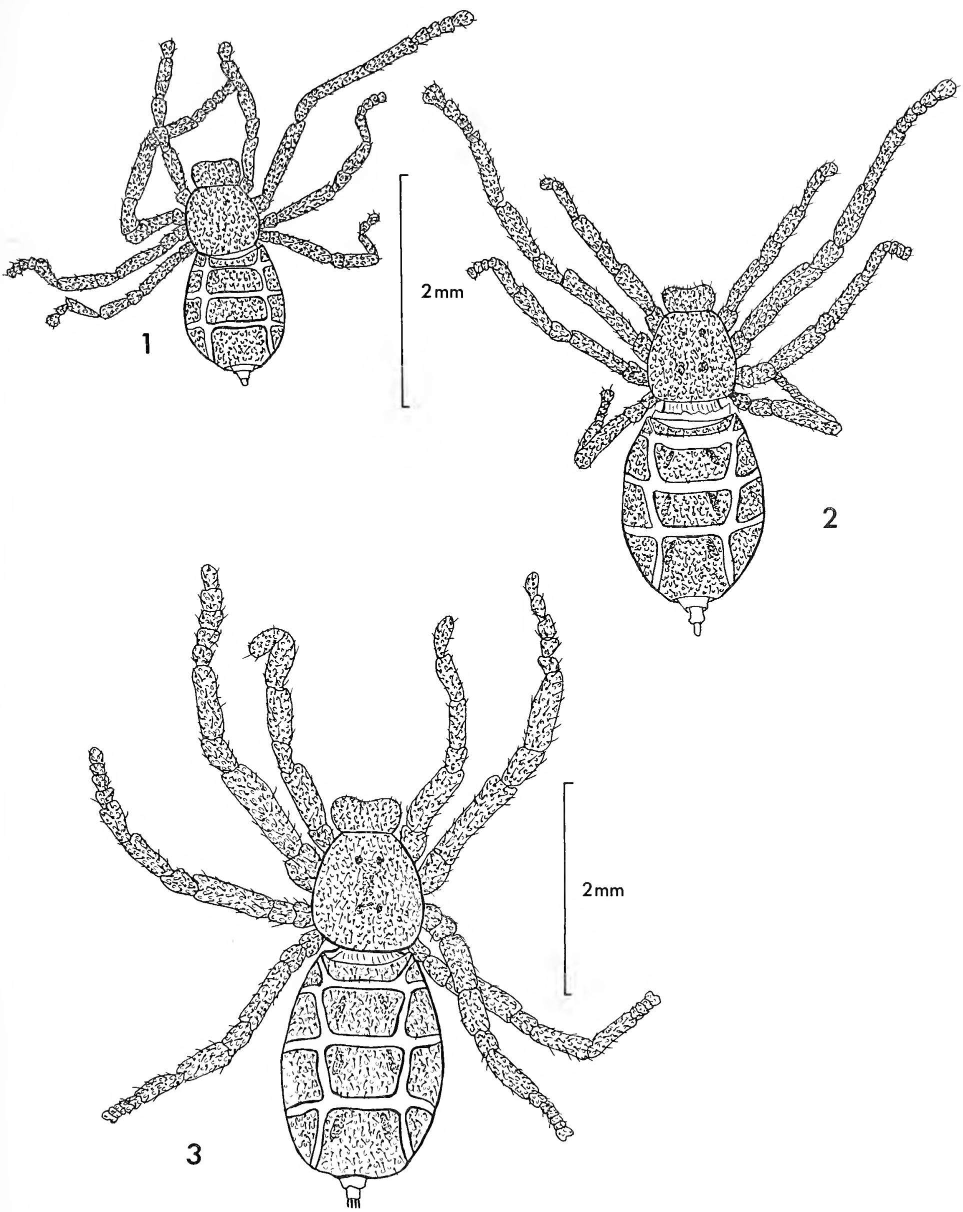
Etimología—Esta especie está dedicada al Dr. Willis J. Gertsch estudioso de este grupo de arácnidos, a sugerencia del Dr. Robert W. Mitchell.

Cuculus—Mas ancho que largo (Fig. 16); el borde posterior es el más angosto, ampliándose y terminando convexamente hacia los lados. El borde anterior en una vista dorsal se observa bilobulado, es decir con una leve escotadura en su parte media. Está ornamentado con tubérculos romos y pelos distribuídos uniformemente en toda su superficie.

Cefalotórax—De forma subtrapezoidal, muy convexo, más angosto en su porción anterior. Angulos lateroposteriores ampliándose aún más, pero observándose siempre el conjunto del cefalotórax muy convexo. En la parte central y dorsal del cefalotórax, se nota un leve surco que no alcanza los márgenes anterior y posterior. Este surco está limitado hacia adelante y hacia atrás por dos pequeñas fosetas laterales, además lateralmente se aprecian tres depresiones circulares poco profundas, de las que la central es la mas grande. Toda la superficie se presenta ornamentada con tubérculos, más numerosos en las partes laterales. Los bordes laterales no son rectos, sino que presentan sinuosidades. La parte ventral del cefalotórax se presenta ornamentada con tubérculos distribuídos de la siguiente manera (Fig. 18), en la coxa I se encuentra una sola hilera en el borde posterior, la mitad posterior del borde lateral externo tiene aspecto serrado. La coxa III, que es la mas angosta tiene forma subrectangular e igualmente con tubérculos a lo largo de todo el perímetro, constituyéndose una doble hilera en el borde lateral. La coxa IV se encuentra totalmente ornamentada con tubérculos uniformemente distribuídos en toda su superficie pero en mayor número hacia los márgenes. Con respecto a los grupos formados por Beck y Schubert (1968), de la distancia existente entre el tritosterno y la coxa I, esta especie estaría dentro del segundo grupo, es decir que la coxa I toca al tritosterno con la punta proximal, y las coxas II y III, son diferentes en tamaño como en *C. pseudocellatus* Roewer.

Quelíceros—Grandes y fuertes (Fig. 13). El dedo fijo ligeramente curvo, terminando en una punta fina. El borde interno armado de seis dientes, los cuales son de diferente tamaño siendo el basal el más pequeño, aumentando gradualmente y siendo los tres distales los de mayor tamaño. El tercer diente es bífido. El dedo móvil es más grande y más curvado que el dedo fijo, aguzado y mas encorvado en su terminación; su borde interno está armado con 10 dientes de los que el cuarto y el distal son los más grandes. El segmento basal de los quelíceros está provisto en su cara interna de numerosas sedas largas y finas que alcanzan la parte distal del dedo móvil y algunas otras lo sobrepasan.

Pedipalpos—Largos y delgados (Fig. 14), semejantes a los de otras especies de ricinúlidos. Su porción más distal, al igual que las pinzas se ven de un color café oscuro. Ornamentados únicamente con pelos, sin los tubérculos que se observan en el resto de su cuerpo. El dedo móvil es casi una y media veces más grande que el inmóvil.



Figs. 1-3.–*Cryptocellus gertschi*: 1, Ninfa del primero estadio; 2, Ninfa del segundo estadio; 3, Ninfa del tercero estadio.

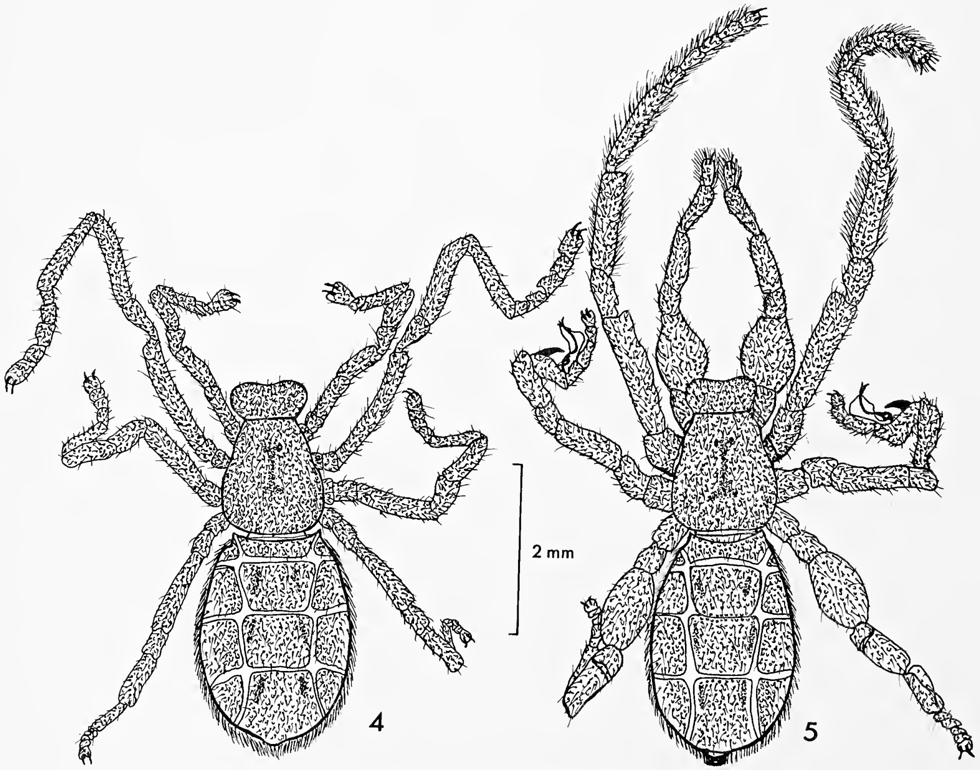
Patas–La relación de la longitud de las patas es II, III, IV, I. Todas se presentan ligeramente acanaladas en la parte ventral, pero está más marcado en las tibias, en las patas IV casi no se nota. Ornamentadas en la parte coxal con escasos tubérculos, el resto de la superficie de las patas ornamentadas con el mismo tipo de tubérculos que se ven sobre el cuerpo excepto en la parte acanalada, además están cubiertos de cerdas gruesas y pelos dirigidos hacia la parte distal de la pata.

Las patas I son las más cortas y presentan los fémurs muy hinchados; las patelas y tibias en su parte latero-ventral están provistas de dos hileras de tubérculos romos, que le dan un aspecto crenado, con la superficie ventral acanalada. Los metatarsos se observan en forma de prismas rectangulares, las cuatro aristas están ornamentadas con tubérculos un poco más grandes que los del resto de la pata, además también la superficie dorsal, distalmente se ve algo acanalada. El tarso está formado por un solo segmento, está cubierto de numerosos pelos cortos y finos. Las patas II son las más largas de todas, observándose lateralmente en las tibias, una hilera de tubérculos aguzados que se presentan como pequeños procesos dentiformes, al igual que en el metatarso en donde están distribuídos regularmente en la parte ventrolateral, en los tarsos los tubérculos tienen aspecto normal.

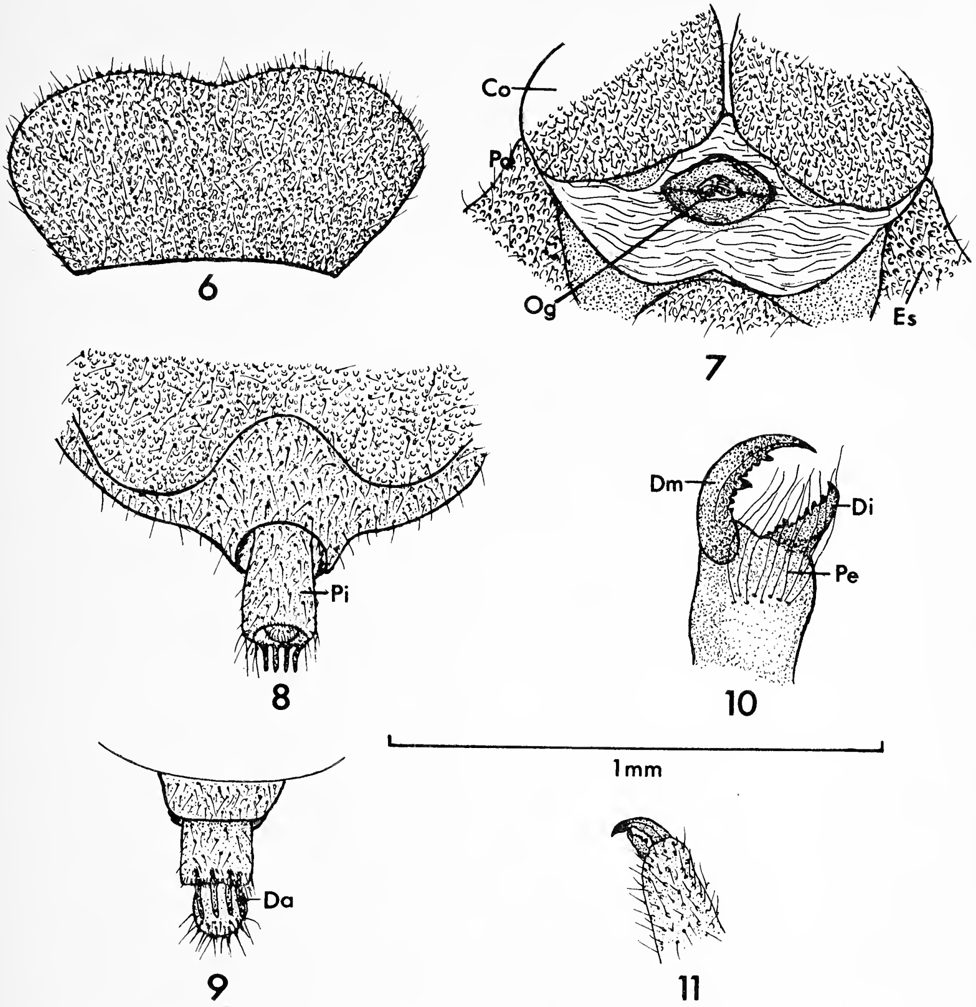
Tarso y metatarsos provistos en su cara ventral de pelos largos y finos y con otros más finos y cortos en su parte distal, dando un aspecto aterciopelado a esta porción. El metatarso es casi de la misma longitud que los segmentos tarsales.

Las patas III son más cortas que las II y llevan al órgano copulador, el cual se repliega sobre las tibias, que en su cara ventral lo alojan. Toda la superficie de estas patas está ornamentada con tubérculos semejantes a los que se observan sobre el cuerpo aunque son más numerosos.

En las patas IV los fémures también están muy engrosados, pero se ven menos globosos que los de las patas I. Tibias ligeramente engrosadas, las patelas son muy pequeñas, los metatarsos son de menor longitud que la de los cinco segmentos tarsales juntos. Los



Figs. 4-5.–*Cryptocellus gertschi*: 4, Adulto macho; 5, Adulto hembra.

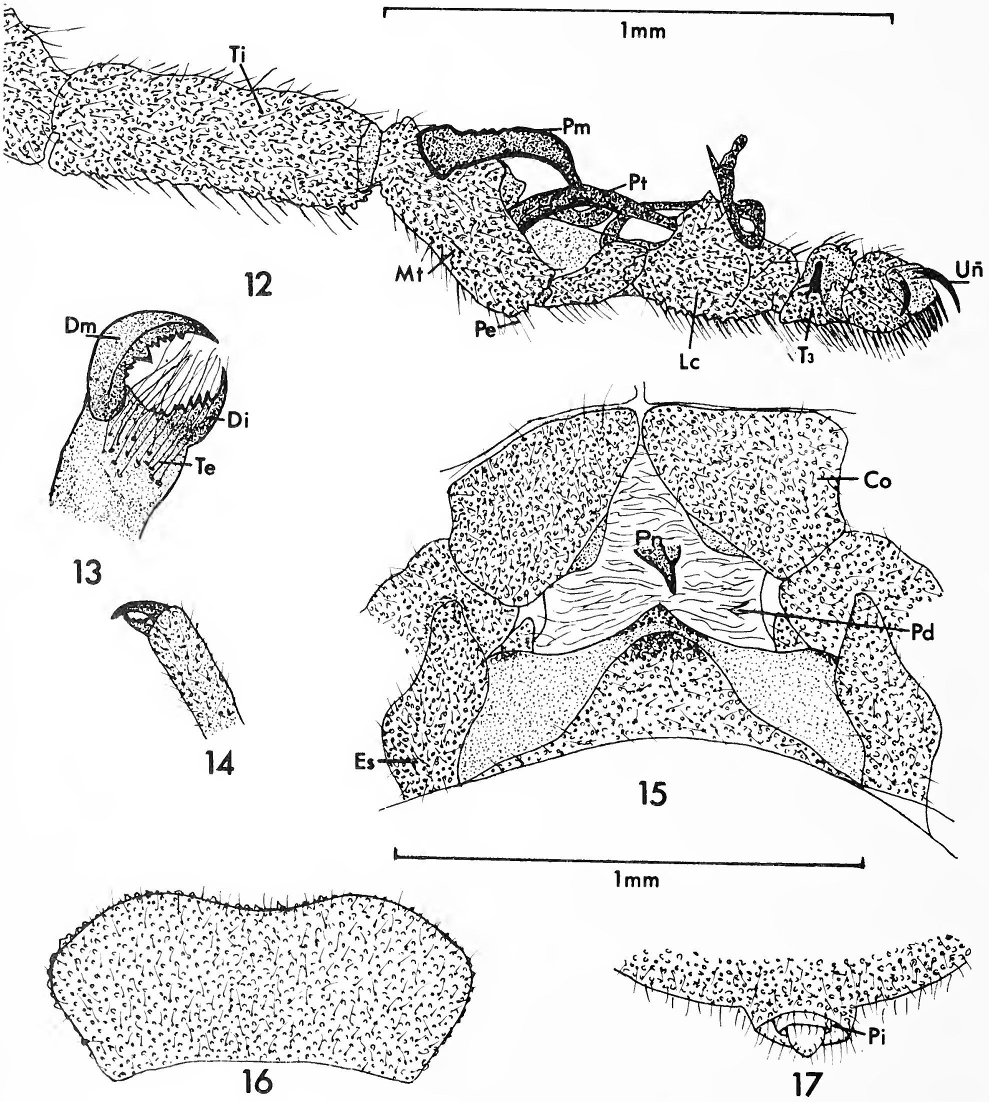


Figs. 6-11.–*Cryptocellus gertschi*: 6, Vista dorsal del cuculus de la hembra; 7, Vista ventral del área membranosa que une el cefalotórax y el opistosoma, mostrando en la parte central el orificio genital de la hembra: Pd, pedicelo; Og, orificio genital; Co, coxa IV; Es, esternito primero del opistosoma; 8, Vista dorsal de la parte distal del opistosoma de la ninfa del tercero estadío mostrando el pigidio; 9, Vista ventral de la parte distal del opistosoma de la ninfa del tercero estadío mostrando los dientes preanales: Da, dientes preanales. 10, Vista del quelícero izquierdo de la hembra: Dm, dedo móvil; Di, dedo fijo. 11, Vista del pedipalpo derecho de la hembra.

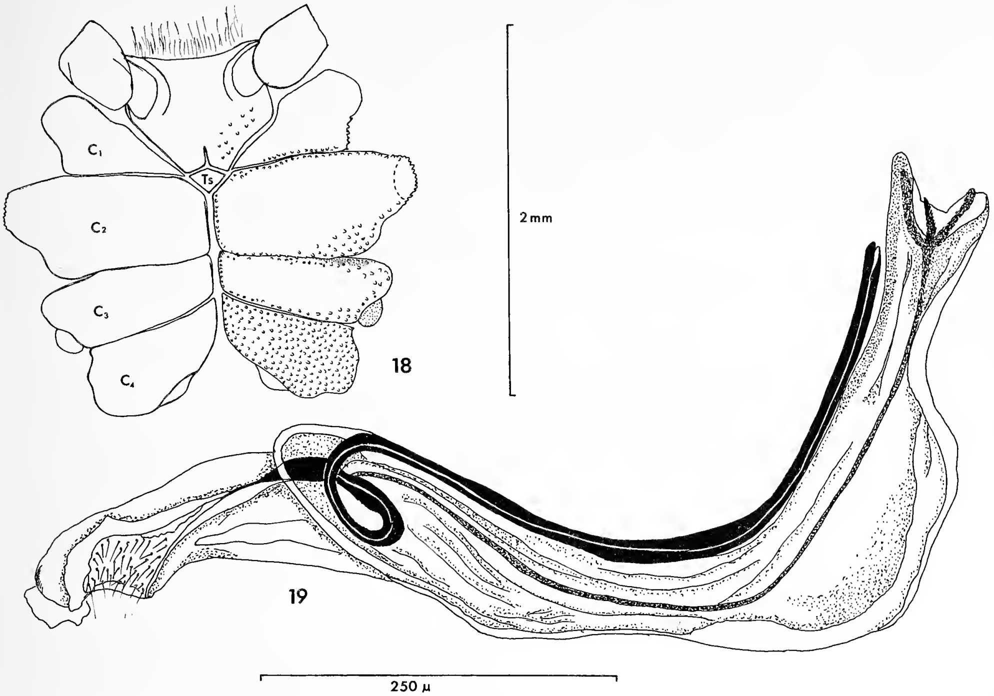
tubérculos que se observan en estas patas son más gruesos que los del cuerpo, de más o menos el mismo tamaño que los de la parte ventral del cefalotórax. Todas las patas terminan en un par de uñas. En la unión del cefalotórax y el opistosoma, dentro del área membranosa de la superficie ventral y en posición central está el pene de consistencia un poco más dura.

Opistosoma–Comprende cuatro segmentos, cada uno de los cuales está subdividido en tres partes siendo la central y las partes más laterales sobresalientes, encontrándose el nivel más bajo en el sitio de unión con las membranas articulares.

La distribución de los tubérculos en los escleritos centrales no es uniforme ya que en el primer segmento son mucho más abundantes hacia el borde anterior sin un arreglo particular. En el segundo segmento son abundantes tanto en el borde anterior como en el posterior disponiéndose en líneas horizontales y siendo también abundantes en las dos fosetas medio laterales. En el tercer segmento son abundantes en el márgen anterior y las fosetas. En el cuarto segmento son un poco abundantes en el borde anterior y las fosetas y más escasos hacia su márgen posterior.



Figs. 12-17.–*Cryptocellus gertschi*: 12, Vista lateral del órgano copulador del macho: Ti, tibia; Mt, metatarso; Pm, proceso metatarsal; Ta, tarso, primero artejo; Lc, lámina ciatiformis del tarsómero; Uñ, uñas; Pe, pelo; Pt, proceso tarsal; T_3, segmento tarsal III; 13, Vista dorsal del quelícero izquierdo del macho: Dm, dedo móvil; Di, dedo fijo; Pe, pelos; 14, Vista del pedipalpo derecho del macho; 15, Vista ventral de la unión del cefalotórax con el opistosoma, mostrando el área membranosa donde se localiza el pene: Co, coxa IV; Pd, pedicelo; Pn, pene; Es, esternito primero del opistosoma; 16, Vista dorsal del cuculus del macho; 17, Vista dorsal del pigidio del macho: Pi, pigidio.



Figs. 18-19.–*Cryptocellus gertschi*: 18, Vista ventral del cefalotórax del macho: Cl, coxa I; C2, coxa II; C3, coxa III; C4, coxa IV; Es, tritosterno; 19, Vista lateral del órgano copulador del macho.

En los escleritos laterales los tubérculos se concentran más hacia la parte media interna, siendo muy escasos en el resto del esclerito. Los tubérculos del borde son más gruesos que los demás y están provistos con numerosos pelos que al microscopio se ven como verdaderos flecos.

La región pleural es bastante ancha y membranosa, conteniendo cuatro escleritos de diferente tamaño. El primero es el más pequeño, el segundo y tercero de talla semejante y el cuatro que es el mayor, se observa subdividido en cuatro o cinco más pequeños. En la región ventral el primer segmento visible está formado de tres partes esclerosadas de forma, piramidal, tubérculados uniformemente, con excepción de la cúspide del esclerito central que se nota con más tubérculos. Estas partes esclerosadas están separadas entre si por áreas menos endurecidas. En el resto del opistosoma, no se nota la división en segmentos, ni en escleritos, sin embargo, una hilera de tubérculos más gruesos delinean cada uno de los segmentos, todo está ornamentado con tubérculos y cerdas distribuidos uniformemente, que se vuelven un poco más pequeños todavía a la altura que correspondería a las fosetas dorsales marcándose como partes más oscurecidas.

El pigidio está formado por tres segmentos ornamentados únicamente con pelos, y el último de ellos termina en una punta roma (Fig. 17).

Hembra–Es un poco más pequeña mide 4 mm, presenta el cuerpo ornamentado con los mismos tubérculos que en el macho pero más uniformemente distribuídos (Fig. 4). No presenta los fémures de las patas primeras y cuartas hinchados como en el macho, en la primera pata se distingue al femur ligeramente engrosado, los tubérculos aguzados de la patela, tibia y tarso de la primera pata están mucho menos marcados, al igual que los pelos distales de la segunda pata. En los quelíceros el dedo móvil tienen siete dientes de diferentes tamaños siendo el tercero basal mucho más grande que el resto y con una pequeña gibosidad en la parte proximal. Su punta es aguzada. El dedo inmovil tiene cuatro dientes casi iguales entre sí. El pedipalpo es semejante al del macho, el dedo móvil es 1/3 más grande que la longitud del dedo fijo. Los tubérculos de la parte ventral del cefalotórax están igual, pero menos marcados. El orificio genital se encuentra en la parte central del área membranosa que une el cefalotórax y el opistosoma circundándolo unos labios más gruesos.

Ninfas—Las ninfas son de consistencia suave y muy semejantes entre sí y únicamente se va notando un aumento de tamaño y un ligero mayor grado de esclerosamiento según el estadio de que se trate.

La ninfa del tercer estadio (Fig. 3) mide 3.8 mm es de color amarillo claro y todo el cuerpo está ornamentado con pelos y tubérculos siendo éstos más obscuros que el color del cuerpo en general, así como también las fosetas del cefalotórax y del abdomen. Los quelíceros y los pedipalpos en su parte final se encuentran fuertemente esclerosados, notándose de color café rojizo. Las segundas patas son las más largas, la tercera y cuarta son más o menos de la misma longitud y la primera es la más corta como en el adulto.

La ninfa del segundo estadio (Fig. 2) mide 3 mm, el cefalotórax ya se ve trapezoidal como en el adulto, los tubérculos que la ornamentan presenta distribución uniforme.

El opistosoma se ve más hinchado que en el adulto pero es mucho más suave, dorsalmente su superficie no es uniforme presentando ya los mismos desniveles que en el adulto, pero notándose aún más la depresión a nivel de las membranas articulares.

La ninfa del primer estadio (Fig. 1) es más pequeña mide 2 a 2.3 mm, pero presenta las mismas características de las anteriores solo que es mucho muy delicada debido al poco esclerosamiento de su cuerpo.

Localidad del tipo—Holotipo macho colectado en Playa Escondida, Catemaco, Veracruz, 12, de enero de 1971, en tronco podrido al igual que ocho ninfas; paratipo hembra colectado el 19 de julio de 1972 debajo de una piedra; dos paratipos machos, 19 de julio de 1972; y tres ninfas. Todos los ejemplares fueron colectados por el Dr. Carlos Márquez Mayaudon haciendo un total de cuatro individuos adultos y 11 ninfas.

Disposición de los tipos—Los ejemplares quedan depositados en la colección del Instituto de Biología de la U.N.A.M.

RELACIONES DE *C. GERTSCHI* CON OTRAS ESPECIES

De acuerdo con nuestras observaciones las especies más cercanas a la que se describe en este trabajo serían *C. spinotibialis* y *C. pearsi*, pero se diferencia de éstas por no presentar una espina o proceso cónico grande sobre la tibia del segundo par de patas, pues solo presenta pequeños procesos dentiformes en la tibia de las patas II, distinguiéndose el que está en la parte central ligeramente mayor que el resto, presentando también algunos de ellos en el metatarso de la misma pata. Además, como otro carácter diferente de nuestra especie con *C. spinotibialis* es el de tener el tarso distal de las patas II de longitud semejante a cualquiera de los tarsos terceros y cuartos y no una longitud igual a la de los tarsos terceros y cuartos que es característico de *C. spinotibialis*, De *C. pearsi*, el cúculus que no es bilobulado, en *C. gertschi,* sp. nov., es claramente bilobulado. Un carácter muy marcado en el macho de*C. gertschi,* sp. nov.,es el de presentar los femures de las patas I y IV muy hinchados especialmente los anteriores, carácter que no presentan ninguna de las especies mencionadas y además en muchas de las especies del género, solo se consigna que el fémur de las patas II son los que se observan más gruesos, por lo que éste se puede distinguir con facilidad de los del resto del grupo.

CLAVE PARA LAS ESPECIES DEL GENERO *CRYPTOCELLUS*

1a. Cuculus más ancho que su longitud 5
1b. Cuculus casi igual de ancho que su longitud 2

2a(1b). Cuculus sin tubérculos 3
2b. Cuculus con tubérculos 4

3a(2a). Cuculus provisto con pelos escamosos blancos; sin áreas pálidas sobre los márgenes laterales del carapacho sin apariencia de ojos . . . *C. albosquamatus*
3b. Cuculus desprovisto de pelos escamosos blancos; con áreas pálidas sobre los márgenes laterales del carapacho con apariencia de ojos . . . . *C. lampeli*

4a(2b). Cuculus no agostándose hacia su base y no tuberculado en sus márgenes laterales . . . . *C. blesti*
4b. Cuculus angostándose hacia su base y con tubérculos en sus márgenes laterales . . . . *C. centralis*

5a(1a). Tibia del segundo par de patas con uno o varios procesos cónicos 6
5b. Tibia del segundo par sin uno o varios procesos cónicos 9

6a(5a). Con un proceso cónico grande en la tibia de la pata II . . . . *C. pearsi*

6b. Con varios procesos pequeños y dentiformes en la tibia de las patas II 7

7a(6b). Con el fémur de tamaño normal . . . . *C. reddelli*

7b. Con el fémur de alguna o algunas de las patas engrosado 8

8a(7b). Con el fémur de las patas I y IV del macho engrosados . . *C. gertschi*, sp. nov.

8b. Con el fémur de las patas II del macho engrosado . . . . *C. mitchelli*

9a(5b). Tibia del segundo par de patas con una espina a cada lado . . . *C. spinotibialis*
9b. Tibia del segundo par de patas sin una espina a cada lado 10

10a(9b). Cuculus claramente bilobulado 11
10b. Cuculus no claramente bilobulado 14

11a(10a). Cuculus con pocos tubérculos 12
11b. Cuculus con numerosos tubérculos 13

12a(11a) Pata II mucho más gruesa que las otras . . . . *C. relictus*
12b Pata II no más gruesa que las otras . . . . *C. simonis*

13a(11b). La mitad basal del cuculus adornado con tubérculos aplanados, agrupados lateralmente y a lo largo de la línea media . . . . *C. manni*
13b. Cuculus tachonado con tubérculos no dispuestos como en el caso anterior . . . . *C. foedus*

14a(10b). De cuerpo grande, cuculus de forma trapezoidal 15
14b. De cuerpo pequeño, cuculus de forma subrectangular 19

15a(14a). Integumento no tuberculado de cuerpo muy grande . . . . *C. magnus*
15b. Integumento tuberculado de cuerpo moderadamente grande 16

16a(15b). Carapacho con cuatro "ocelos" laterales, simulando un pequeño domo . . . . *C. pseudocellatus*
16b. Carapacho sin cuatro "ocelos" laterales simulando un pequeño domo 17

17a(16b). Escasos tuberculitos aislados en su integumento que dan apariencia denticulada a las dos quintas partes basales del cefalotórax . . . . . . *C. osorioi*
17b. Numerosos tuberculitos en su integumento 18

18a(17b). Fémures de las patas II de tamaño normal, uñas de los tarsos II espatuladas . . . . *C. bolivari*
18b. Fémures de las patas II más gruesos y casi del doble de las patas III, uñas de los tarsos II normales . . . . *C. boneti*

19a(14b). Cuculus un poco menos de una y media veces más ancho que largo de cuerpo delgado . . . . *C. dorotheae*
19b. Cuculus un poco más de una y media veces más ancho que largo, de cuerpo oval 20

20a(19b). El último segmento del tarso III inflado y en forma de diamante . . . . *C. emarginatus*
20b. El último segmento del tarso III, no inflado ni en forma de diamante 21

21a(20b). Cuculus provisto sobre cada lado en su base de un racimo de tubérculos, carapacho más largo que su anchura mayor . . . . *C. barberi*
21b. Cuculus no provisto sobre cada lado en su base de un racimo de tubérculos, carapacho casi igual de largo que su anchura mayor . . . . *C. pelaezi*

Cuadro I.–El tamaño de los ejemplares y la distribución de las especies del género *Cryptocellus* Westwood, 1874. Las más de las cifras se tomaron de la descripción original (Bolívar y Pieltain, 1946; Chamberlin y Ivie, 1938; Cooke, 1967; Ewing, 1929; Fage 1921, 1938; Gertsch y Mulaik, 1939; Gertsch, 1971; Goodnight y Goodnight, 1952; Coronado, 1970; Merrett, 1960; Roewer, 1952; Westwood, 1874; Whittick, 1938) y del trabajo de Beck y Schubert, 1968 (*). El tamaño del macho y hembra conocidos es semejante, según se puede apreciar en las columnas respectivas. [1] incluso cuculus, [2] según Pittard y Mitchell, [3] según Whittick (1938), [4] incluso postabdomen, [5] ninfa, [6] excluida la "torrecilla anal."

ESPECIE	MACHO	HEMBRA	DISTRIBUCION
C. magnus	–	7.8	Cincinati, COLOMBIA
C. osorioi	7.0	7.3	San Luis Potosí, MEXICO
C. reddelli	7	–	Mapimi, Durango, MEXICO
C. bolivari	6.5	5.4	Comitán y Zapaluta, Chiapas, MEXICO
C. spinotibialis	–	6.3, 6.7*	Tapachula, Chiapas, MEXICO
C. pelaezi	6.2[2], 5	–	Tamaulipas, MEXICO
C. foedus	6.2, 4.9	4.7-5.5*	Amazonas, BRASIL
C. boneti	6.0	–	Cacahuamilpa, Guerrero, MEXICO
C. pseudocellatus	6.0	5.7*	Santa Rosa, Chinchipe, PERU
C. simonis	5.3, 6.3[3]	–	Amazonas, BRASIL; GUAYANA BRITANICA
C. mitchelli	5	5.5	Torreón, Durango, MEXICO
C. centralis	5.0	5.0*	La Caja, COSTA RICA
C. manni	–	4.9, 5.0*	Cincinati, COLOMBIA
C. albosquamatus	–	4.6[6]	Amazonas, BRASIL
C. pearsi	4.6[4]	5.6	Yucatán, MEXICO
C. barberi	–	4.5	Livingston, La Ceiba, GUATEMALA
C. lampeli	4.3	4.6*	GUAYANA BRITANICA
C. emarginatus	–	3.8	Granjas Navarro, COSTA RICA
C. gertschi	3.8	–	Catemaco, Veracruz, MEXICO
C. relictus	–	3.6	Barro Colorado, PANAMA
C. dorotheae	3.1	2.9	Edinburg, Texas, U.S.A.
C. blesti	3.1[5]	4.5	Barro Colorado, PANAMA

⇦Fig. 20.–Mapa de distribución del género *Cryptocellus*; 1, *C. foedus* Westwood, 1874; 2, *C. simonis* Hansen y Sorensen, 1904; 3, *C. centralis* Fage, 1921; 4, *C. magnus* Ewing, 1929; 5, *C. manni* Ewing, 1929; 6, *C. emarginatus* Ewing, 1929; 7, *C. barberi* Ewing, 1929; 8, *C. pearsi* Chamberlin y Ivie, 1938; 9, *C. relictus* Chamberlin y Ivie, 1938; 10, *C. dorotheae* Gertsch y Mulaik, 1939; 11, *C. boneti* Bolívar y Pieltain, 1941; 12, *C. osorioi* Bolívar y Pieltain, 1946; 13, *C. pseudocellatus* Roewer, 1952; 14, *C. spinotibialis* Goodnight, 1952; 15, *C. blesti*, 1960; 16, *C. lampeli* Cooke, 1967; 17, *C. albosquamatus* Cooke, 1967; 18, *C. pelaezi* Coronado, 1970; 19, *C. reddelli* Gertsch, 1971; 20, *C. mitchelli* Gertsch, 1971; 21, *C. bolivari* Gertsch, 1971; 22, *C. gertschi* sp. nov.

En la elaboración de la clave, para las 22 especies de *Cryptocellus* se tomaron en cuenta algunos carácteres consignados en la descripción original comprendiendo sobretodo, aquellos que se consideran como distintivos para cada una de las especies. Se puede apreciar también que en muchos de los pasos de esta clave, se utilizan diferentes particularidades del cuculus y cefalotórax, puesto que en la mayoría de las descripciones es precisamente a estas estructuras a las que se hace alusión, destacando algunas como son las denticulaciones de los quelíceros que pueden variar aún en la misma especie. Pensamos nosotros que las diferencias típicas en las especies de *Cryptocellus*, puedan definirse en forma más precisa mediante la observación microscópica en detalle de los órganos copuladores que presentan los machos en su parte distal del tercer par de patas.

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THE AFRICAN GENUS *RICINOIDES* (ARACHNIDA, RICINULEI)

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ABSTRACT

Seven species of the genus *Ricinoides* (originally *Cryptostemma*) are known. On the basis of some new material of *Ricinoides afzelii* Thor. and type material of all species, new descriptions of the seven species are given. Especially stressed is the taxonomic value of the tubercles and scales on the pedipalps and the detailed structure of the male copulatory apparatus.

INTRODUCTION

The first member ever mentioned of the arachnid order Ricinulei was a specimen described by Guérin-Méneville at the very beginning of his new journal "*Revue Zoologique*" in January 1838, p. 11. He gave it the name *Cryptostemma westermanni*, since it was "envoyée par M. Westermann, comme provenant de la Guinée." The description was repeated and the figures promised in his paper were given by H. L(ucas) in Guérin-Méneville's *Dict. Pitt. d'Hist. Nat.* VII 1838, (according to Thorell 1892; I have not seen this book), and finally both were copied by Gervais in Walckenaër's *Hist. Nat. d'ins. Apteres* III 1844 p. 131 and P1.47 Fig. 4 and 4a. Unfortunately the specimen does not exist any more to my knowledge, at least not in the Copenhagen or Paris Museum, but from the figure we can see that it must have been a male, and we can say a little more on its origin.

B. W. Westermann was a Danish tradesman. Born in 1781 he went to India and Java and retired in 1817 to Copenhagen with a fortune and a collection of insects from Java and, collected on the way home, from the Cape of Good Hope. From then on, until his death in 1868, he lived mostly for his collection, which at that time was one of the greatest and most beautiful private collections in Europe, comprising about 45,000 species. He was in correspondence and exchanged insects with all known entomologists of his time; this correspondence is now kept together with the collection in the Zoological Museun of Copenhagen. Curiously enough, however, the ricinuleid is not mentioned in the letters from Guérin-Méneville.

After 1820 Westermann did not collect himself, but he had specimens sent from all over the world. When Guérin in his description wrote "provenant de Guinée," that part of West Africa was meant which was then known as Danish Guinea, later Gold Coast, and now Ghana. This country was then a Danish colony, and the colonial officials often sent specimens to the Danish collections. In 1830-1835 J. R. Chenon worked in "Guinea" and sent home to Westermann two cabinets with 26 boxes each, filled with "insects." Among those must have been the specimen of *Cryptostemma westermanni*, but why Westermann happened to send it to Guérin we cannot say. But we can thus state the type locality to be Ghana. Chenon was born in 1806; he travelled around in "Guinea" during the years 1830-1835, but came home ill and died in 1838.

Curiously enough, the next African ricinuleid to be described was collected even earlier. It was sent home to the Stockholm Museum by the naturalist A. Afzelius who was born in 1750, went to England and from there to Sierra Leone in 1789, and returned to Sweden in 1799. He sent collections to London and to Riksmuseet in Stockholm, and among the latter material Thorell found a ricinuleid which, in 1892, he described as *Cryptostemma afzelii.*

In 1904 Hansen and Søresen described four new species and redescribed *C. westermanni* on the basis of new material and *C. afzelii* on the original and new material.

Finally, H. J. Hansen, in 1921, redescribed a species from 1904 and described a new one, *C. feae*. Millot (1945) gave a detailed and beautiful anatomical description on the basis of new material of this species.

This is what is known at present on the genus *Cryptostemma*, which name, since it was preoccupied by a bug (*Cryptostemma* H.–S. 1833), was changed to *Ricinoides* by Ewing (1929). *Ricinoides* was probably shaped in connection "somehow" with Ricinulei, but means actually "something like *Ricinus*" which is *Ixodes*. As all words ending with -oides, however, it is neuter. Thorell (1876) gives no reason for establishing the name Ricinulei (p. 454: "il quale potrà esser chiamato Ricinulei"), but he probably also had *Ixodes* in mind.

In 1957 a large ricinuleid was sent to the Zoological Museum of Copenhagen by Mr. Sv. Herold Olsen, a Danish collector who has lived since World War II in what was once French Guinea. The specimen was found near manure in an open wood near N'Zérékoré between 10-25 April 1957. It was a male, and I immediately asked for more specimens, but it was not until four years later that another specimen was found, 15 April 1961, at the same place. It was a female, and no other specimen has been sent by him since then.

In an attempt to identify these two specimens which seemed to be very close to both *R. afzelii* and *R. feae*, I realized that I had to see the whole material which Hansen and Sørensen had before them of the genus "*Cryptostemma*." The other genus, *Cryptocellus*, was revised in 1968 by Beck and Schubart. On the basis of material consisting of only 5 males and 5 females of *C. foedus* Westwood they attempted to determine which characters were suitable for distinguishing the species and which were too variable. Unfortunately the material of *Ricinoides* is too small for such a determination. I, therefore, have profited by their results and examined in *Ricinoides* the characters which they found valid for *Cryptocellus*, but I have also added a study of the male copulatory apparatus. The characters examined are the following:

1. The shape of opisthosoma.
2. The ventral side of prosoma.
3. The presence or absence of scales.
4. The shape of cucullus and the size of its tubercles.
5. The chelicerae.
6. The pedipalpi which proved especially valuable with several important characters.
7. The presence or absence of dorsal furrows on the femora of the legs.
8. The shape of the male copulatory apparatus.

The two new specimens are so closely related to, or so similar to, the species *R. afzelii*, of which only the type specimen and a specimen in the British Museum (Natural History), both females, were known to me that I do not see any reason to describe them as new.

THE CHARACTERS

1. The shape of the opisthosoma may be expressed as a ratio of dorsal length to greatest width. It is in most species oval (length to width ratio, 1.1–1.2), but in *R. feae* and *R. sjostedti* paralled-sided and narrower (length to width ratio, 1.5). This holds true also for the immatures, where they are known.

2. Coxal shape and sternal shape are alike among all species though there may be small differences between male and female as shown in Fig. 2. Coxae I never reach the sternum.

3. The species of *Ricinoides*, to a much higher degree than *Cryptocellus*, are covered by tubercles and in some cases also scales. The tubercles are of several different kinds of shape and size and differently sculptured. Kennaugh (1968) figured some types of tubercles in *R. afzelii* and *R. sjostedti*. Since their distribution on the pedipalpi is of systematic value I shall mention and draw the types. The tubercles of *C. pelaezi* have been described and illustrated by Pittard and Mitchell (1972).

The tibia of the pedipalp carries at the distal fourth, or third, or even half, some tubercles which may be short or long and densely set or scattered. They are shaped as shields raised on a higher or low tapering socle or pedestal, but with the distal apex free. Since they are only found here and are typical of the species, the apex of tibia will be described and drawn for each species.

At the base of tibia and on the proximal segments, as well as on the whole body, several types of tubercles are found, different and differently distributed in the several species. The base of the tibia and apex of the femur will, therefore, be drawn in each species. The types of tubercles are as follows:

a. The corrugated type (Fig. 1, A) mentioned by Kennaugh (1968) is conical, but with furrows in a characteristic pattern, concave posteriorly, and is found in all the species.

b. The saucer-shaped type (Fig. 1, B) mentioned by Kennaugh (1908) is circular, almost level with the surface and built-up of more or less concentric rings which are quite dark or quite light according to the focusing of the microscope, and only found in *R. sjostedti* and *R. karschi*.

c. The mushroom-shaped type (Fig. 1, C) is a fairly high tubercle on a narrower pedestal and found only in *R. karschi*.

d. Big broadly conical spines are present especially in trochanter II of pedipalp, but also on many other limbs and body.

The setae are of different kinds, short and pointed, and long and pointed, in several cases spatulate, in *R. westermanni* and *R. crassipalpe* (Figs. 35, 41), where they may form the transition to the scales, characteristic to these two species. The scales are of two types, very broad with a row of "papillae" all along a hollow trough (*R. crassipalpe*, Fig. 1, E) or narrow with a row of broad papillae or more like a veil on each side of the hollow trough (*R. westermanni*, Fig. 1, D). In *R. crassipalpe* the scales are narrower near the tip of the limbs.

4. The shape of cucullus is given specific value by Hansen and Sørensen (1904) as well as by Beck and Schubart (1968) who further mention the different shape in the two

sexes, which, however, according to Pittard and Mitchell (1972) is not consistent. I have drawn this difference in the case of *R. afzelii* (Fig. 3) but restrain from using it in the descriptions.

The size of the big tubercles may be judged by their numbers in a row over the anterior edge of cucullus. They seem to fall into two groups: 25-30 in the row (*R. feae*, *R. sjostedti*, *R. westermanni*) or 40-45 (*R. afzelii*, *R. karschi*, *R. crassipalpe*) as seen in the drawings of the chelicerae *in situ.*

5. About the chelicerae, Beck and Schubart (1968) state the number of teeth in both fingers to be variable, though the presence or absence of a big tooth distally on the fixed finger or basally on the movable one may be of specific value.

In all species of *Ricinoides* the distal tooth on the fixed finger is perhaps a little larger than numbers 2 and 3, and the one or two proximal teeth are still smaller. The movable finger carries five to seven smaller or larger teeth. Thus no valuable diagnostic characters seem to be found in the number or shape of the teeth of the chelicerae in *Ricinoides*. Still, I have drawn them *in situ* together with cucullus for all species. Of course, the accessory tooth at the base of the fixed finger which distinguishes *Ricinoides* from *Cryptocellus* is always present. This "ricinoides-tooth" is marked with "r" in the figures.

Beck and Schubart (1968) mention as a possible specific character the number of setae located ventrally at the base of the movable finger. In all species of *Ricinoides* there are two setae on this place.

6. The pedipalps consist of a coxa, two trochanters, femur, and tibia with a free finger, the tarsus. This is movable against another finger which is regarded as a tibial process though it is distinguished well from it by a weakly sclerotized line. The segments are covered by scales in some species and tubercles, and their shape and distribution on the tibia, especially, is different among the six species and may be used for identification. The tibia is dark brown in all species as is the whole animal when mature, but the immature specimens are bright yellow, and on these the proximal half of the tibia is yellow, the distal half brown.

Beck and Schubart (1968) have discovered some sensory slits ("Sinnesspalten") in the segments of the pedipalps and state them to be intraspecifically constant. This may be correct, though their material (ten specimens) is fairly small. They depict them on the frontal side, but the slits are also present on the opposite side and not distributed in the same way, as Pittard and Mitchell (1972) have shown for *Cryptocellus*. In the specimen I have examined of *R. afzelii* they are even present in different numbers on the right and left pedipalp. I am, therefore, a little in doubt as to their specific constancy, but my material is far too small for a decision. I have drawn them for all six species. I have also indicated the presence of some small pits appearing as round or oval patches in the sculpture which consist of an immense number of regular grains. In some few cases I have been able to see a small sensory (?) hair in these pits, but more intimate exploration is needed to decide whether they are sensorial. They seem to be distributed at random. The distribution of the sensory slits and the pits is stated for each species; Beck and Schubart (1968) especially stress the number of slits on the femur and the presence of slits on tibia. As to the sensory slits Pittard and Mitchell (1972) have demonstrated their presence on all postcheliceral appendages. I have not checked this in *Ricinoides*. In Fig. 1, F one of the tibial slits is drawn in great magnification.

Fig. 1, G shows an organ which is called by Beck and Schubart (1968) a sensory groove ("Sinnesgrube"), by Pittard and Mitchell (1972) simply a "pit." It is present dorsally on the prolateral side of tibia near the movable finger and is of a long, tubular form with a round opening on the surface. It contains what in *Cryptocellus* (Pittard and Mitchell, 1972) is a spearlike seta, but in *Ricinoides* it resembles a sensory hair which at its base shows signs of a nerve fiber. This sensory pit is depicted on the schematical drawings of the pedipalps showing the slits; it is present in *R. afzelii*, *R. feae*, *R. sjostedti*, and *R. crassipalpe*, but missing in *R. karschi* and *R. westermanni.*

The fixed finger is crenulated or with teeth. In *Cryptocellus* the movable finger is said (Pittard and Mitchell, 1972) to carry similar teeth, but this is an optical illusion. The "teeth" in *Ricinoides* are clear areas (with some fluid ?) representing canals going from the interior of the tarsus (movable finger) through its integument (Fig. 4) resembling

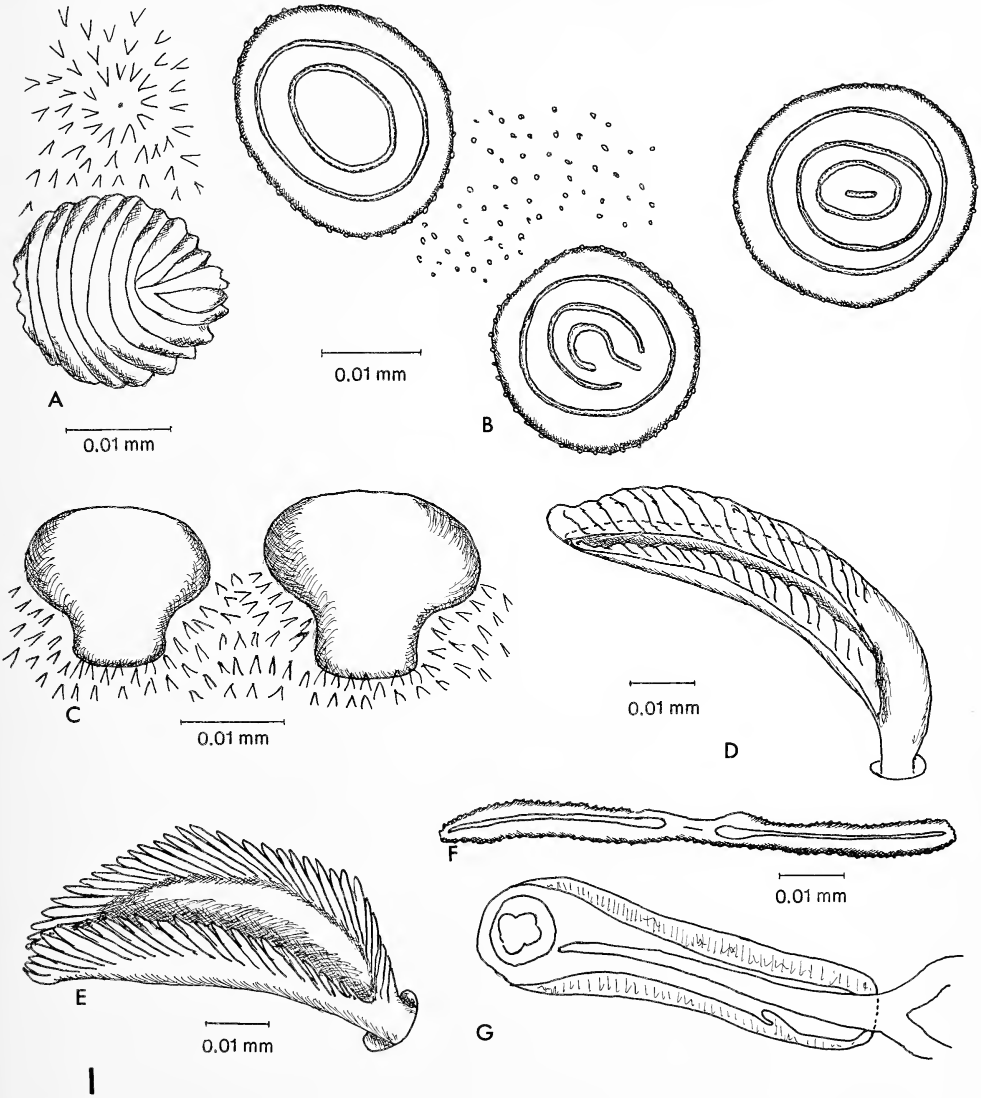
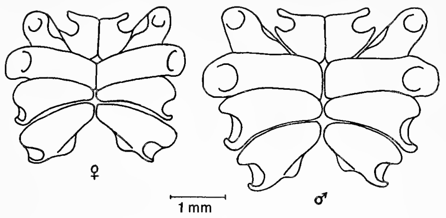


Fig. 1.–Tubercles, scales, and sense organs: A, corrugated tubercle of *R. afzelii*, above one of the very small sensory (?) pits; B, three saucer-shaped tubercles of *R. sjostedti*, sculpturing between partially indicated; C, mushroom-shaped tubercles of *R. karschi;* D, scale of *R. westermanni*, E, scale of *R. crassipalpe*, both in half profile; F, sensory slit; G, sensory pit ("Sinnesgrube") of *R. sjostedti.*



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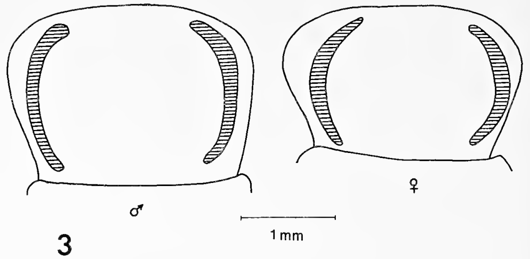

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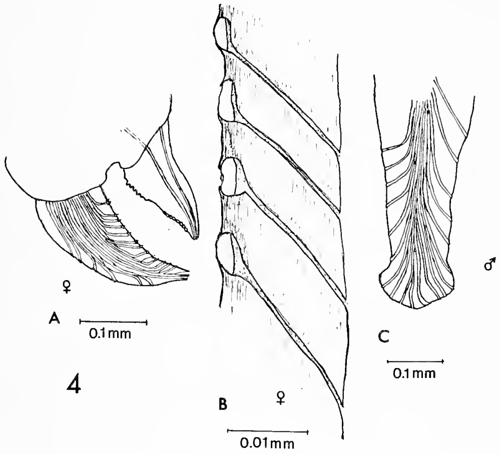

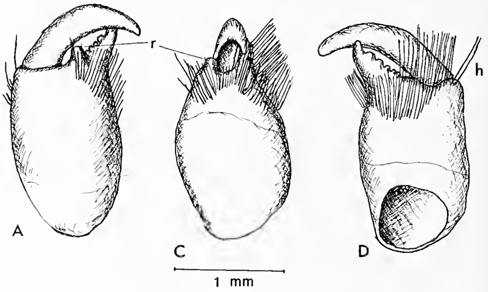

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Figs. 2-4.–*R. afzelii,* Zoological Museum, Copenhagen; 2, tritosternum and coxae of female and male; 3, outline of cucullus of male and female with furrows indicated; 4A, fixed and movable finger of pedipalp showing canals; 4B, some of the canals in higher magnification; 4C, apex of metatarsal process of male copulatory organ showing canals and their opening.

Fig. 5.–*R. afzelii*, chelicera of type specimen, Stockholm Museum: A, dorsal view; B, medial view; C, ventral view; r, the ricinoides tooth; h, the setae at base of movable finger.

somewhat the canals I have described in the chelicera of Solifugae (Tuxen, 1956), but without the sense-papillae. Whether they are connected into longer canals inside the tarsus, as I have schematized in Fig. 4, A, or whether they just enter the "hollow" interior I cannot say from direct inspection. At least these canals are not confined to the "tooth-carrying" edge of the finger in *Ricinoides*, but are found scattered over the surface as shown in the figures of the apices of the pedipalps of the different species. I have examined the question also in *Cryptocellus pelaezi* and found that these "cups" actually appear as flat or conical teeth, but they are all of them connected with a canal to the interior.

7. Furrows may be present on the dorsal and/or ventral side of some of the leg segments. Hansen and Sørensen (1904) used the presence or absence of a dorsal femoral furrow as a distinguishing character.

8. The male copulatory apparatus, as is well known, is formed of modifications of the metatarsus and proximal two or three tarsal segments of the third pair of legs. The metatarsus is greatly enlarged and carries a dorsal furrow. To its anterior side is attached a process, which is movably adjoined in a separate pit independent of the dorsal furrow. This metatarsal process is differently shaped and more or less hooked at the apex. The hook is flattened and contains canals opening the same way as mentioned previously for the tarsus of the pedipalp (Fig. 4, C).

The second tarsal segment is dilated retrolaterally forming the *lamina cyathiformis*, the cup- or spoon-shaped blade which protects the tarsal process. It is said to be differently shaped in the species ("which varies not a little in shape" Hansen and Sørensen, 1904, p. 134; "the shape of the lamina cyathiformis varies to accommodate the different types of tarsal process in different species," Cooke, 1967, p. 36). This may be the case within *Cryptocellus* in which the *lamina* is very different from that of *Ricinoides*, but in the latter genus the interspecific difference is negligible. Also, the first tarsal segment may bear an extension similar to the *lamina cyathiformis* (*R. afzelii*, *R. feae*, *R. karschi*), but even where it is missing there is a cavity in the first segment which together with the protected one of the second segment conceals the movable tarsal process originating from the first segment.

The tarsal process is very complicated in construction, but may be said to consist of two portions (Hansen and Sørensen, 1904, p. 135) which are not movably connected. They are called by Pittard and Mitchell (1972) base and body. On the prolateral side of the body there is a broad, leaf-shaped extension, the lateral lobe, and at the distal end several lobes which are differently shaped in the different species. We may in general speak of three apical lobes, a broader lobe flanked by two narrower ones.

These apical lobes may be quite soft or more or less sclerotized. The retrolateral lobe which I shall call lobe "a" is generally well sclerotized and light brown; the middle one, "b," may be sclerotized, light brown, or quite soft, but with indentations; the prolateral one, "c," is generally soft, and may be long and narrow. See the figures under the separate species.

The most interesting feature at this process is, however, a system of stronger sclerotizations in its wall. In the proximal portion (base) a stronger sclerotization runs helically from base to apex on the retrolateral side, whereas two straight sclerotizations support it on the prolateral side (against the first tarsal segment). The helix gives the impression of a tightened spring carrying the distal portion (body). And also in this portion the sclerotizations form a sort of a tightened spring. From the point where the posterior "spring" reaches this portion, another bowed sclerotization departs along the margin and, distal to the base of this, a sclerotization is "rolled up," as it would appear. The most curious thing about this sclerotization which is called by Pittard and Mitchell (1972) the accessory piece, is that it is free of the rest of the process and may be bent out ("released") after which it immediately snaps into the process again. I have drawn this accessory piece in released position (s′) as well as in normal position (s). This rod, which thus has the shape of a watch spring, adds immensely to the whole impression of an apparatus meant for being suddenly released and thrown against or into something else, but how is still unknown, even after the meticulous (unpublished) observations by Jerry W. Cooke on the copulation in *Cryptocellus pelaezi*.

The copulatory organ is depicted in detail for each species.

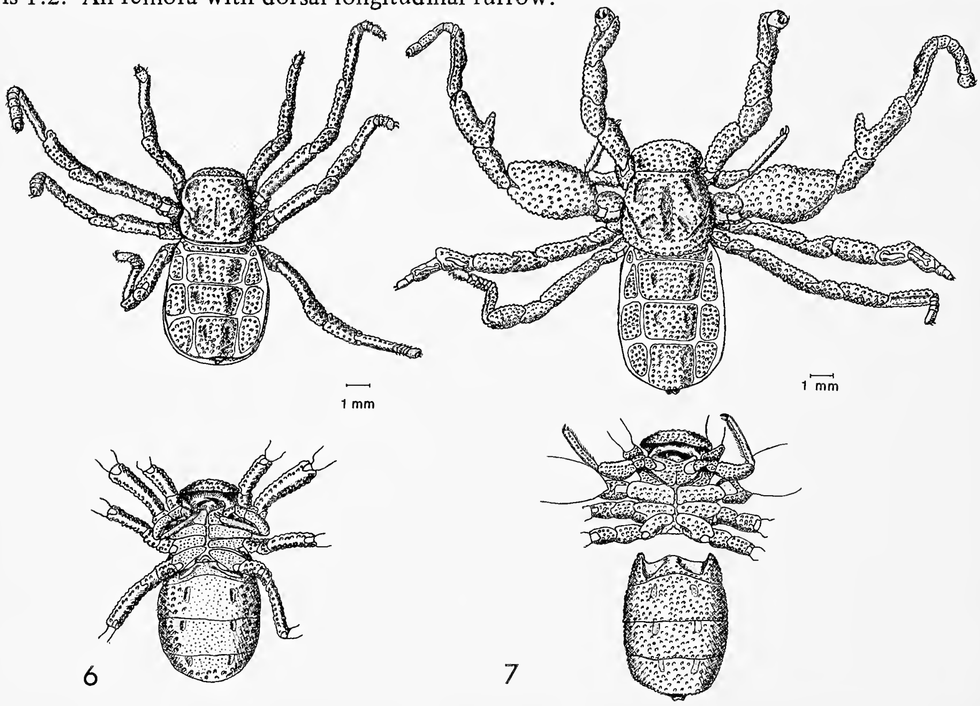
1. *Ricinoides afzelii* (Thorell, 1892)

The type specimen found in Sierra Leone in the 1790's is kept in Naturhistoriska Riksmuseet, Stockholm. It was described in 1892 with some fairly rough drawings, but at present both pedipalps are missing as well as cucullus and most tarsi, so that a new description cannot be given on the basis of this specimen. The left chelicera is free, however, and I have drawn it from three sides as typical of a *Ricinoides* chelicera with the big dorsal "ricinoides tooth" (Fig. 5, r). The fixed finger carries five teeth, the distal one hardly larger than the others. The movable finger is weakly crenulated. There are two strong setae ventrally on the proximal joint at the base of the movable finger (h). The length to width ratio of the opisthosoma is 1.15. It is a female.

It is evident that Hansen and Sørensen (1904) based most of their description not on this specimen, but on another female from the British Museum, also from Sierra Leone but without date, collected by E. E. Austen. The chelicera (plate VIII, 2, d), however, must have been drawn from the type specimen, because the specimen from the British Museum has six to seven distinct teeth on the movable finger, and the distal tooth on the fixed finger is larger than the others and coniform, not flattened (Fig. 8). I have examined and also drawn the pedipalp; it exhibits the same characters as my new material.

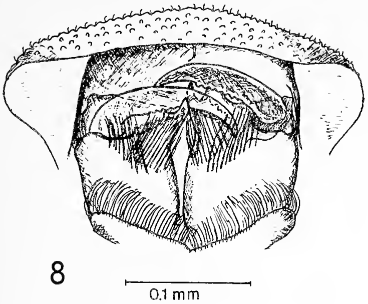
The Copenhagen material of *Ricinoides afzelii* consists of a male and a female from N'Zérékoré, Guinea, collected by S. Herold Olsen in 1957 and 1961, respectively (see the introduction).

Female—Length of animal without cucullus and pygidium, 8.0 mm, i.e., a little shorter than the female from the British Museum. Fig. 6 shows the animal from the dorsal and, with only the base of the legs, the ventral side. The length to width ratio of opisthosoma is 1.2. All femora with dorsal longitudinal furrow.



Figs. 6-7.—*R. afzelii*, Zoological Museum, Copenhagen: 6, female, dorsal and ventral views; 7, male, dorsal and ventral views.

The chelicera (Fig. 9) has five distinct teeth on the movable finger and four, plus a very small basal one, on the fixed finger. The distal one is not larger than the others. This is important, since it is distinctly larger in the female from the British Museum, and since Beck and Schubart (1968) state this character to be the only reliable one in the dentition of the chelicera. Pittard and Mitchell (1972) follow them in their study of a large sample of *C. pelaezi*. I would be tempted to consider not even this character reliable.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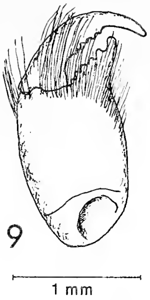

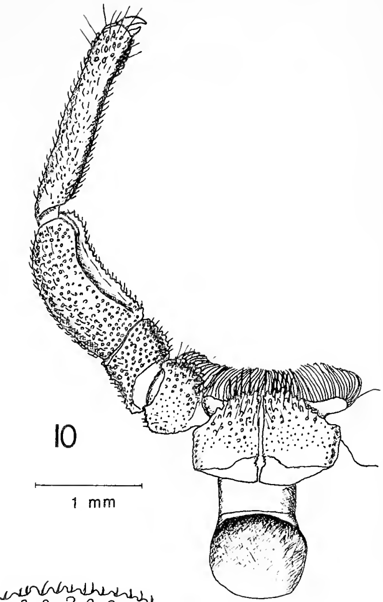

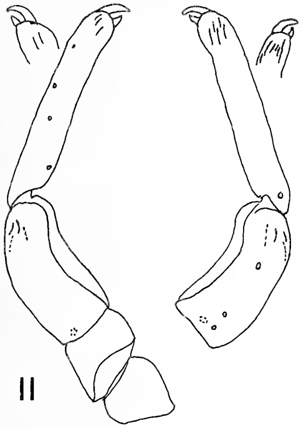

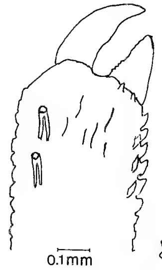

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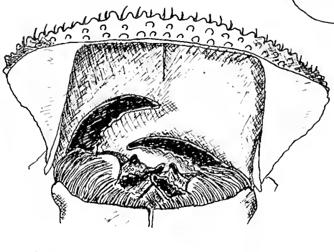
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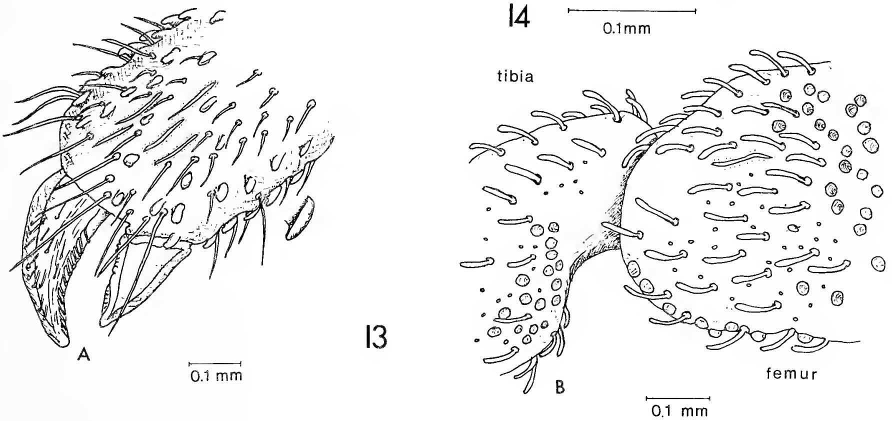


Fig. 8.–*R. afzelii*, British Museum, female, chelicerae and cucullus *in situ*.

Figs. 9-14.–*R. afzelii*, Zoological Museum, Copenhagen: 9, female, right chelicera, ventral view; 10, female, right pedipalp, retrolateral view; 11, female, position of sensory slits and bare patches on pedipalp; 12, female, position of sensory pits ("Sinnesgrube")(exceptionally two) and slits on left pedipalp, prolateral view. 13, female, pedipalp: A, apex of tibia; B, base of tibia and apex of femur; 14, male chelicerae and cucullus *in situ*.

In the pedipalp the tibia and tarsus show the features of greatest interest and probably of the greatest value to taxonomy. The pedipalp is drawn in retrolateral aspect in Fig. 10 to show the relative length of the segments, coxa, the two trochanters, femur, tibia and tarsus (movable finger). Fig. 11 shows the position of the sensory slits on both sides and in both retrolateral and prolateral view. Beck and Schubart (1968), who first observed these slits, figure them only from the prolateral side and as shown in Fig. 11 their position may be, and most often is, different on the prolateral and the retrolateral sides. They do not, however, attach importance to the number of the slits on tibia, just to whether they are there or not. But to the number of slits on the femur, they attach taxonomic importance.

In the present case, five and six slits occur on the retrolateral and prolateral side, respectively, of the left tibia, and three and two, respectively, on the right one (Fig. 11). On the distal part of femur two slits are present on each side of each pedipalp. Some small, rounded bare patches, which also may be sensory pits, are marked on the figure. Finally, two sensory pits ("Sinnesgruben") are found prolaterally on the left pedipalp (Fig. 12). On the right pedipalp there is only one such pit.

The fixed finger (Fig. 11) carries a row of many small acute teeth.

The pedipalp is covered by hairs and tubercles and the shape, size, and distribution of these seem to be of taxonomical value. In Fig. 13, A is shown the tarsus and distal part of the tibia in retrolateral view. The setae are slender and pointed, and the tubercles fairly small and scattered. They all have the shape of a disc raised on a socle or pedestal with the distal apex free; a schematical profile of one is seen on the side of Fig. 13. These tubercles are confined to the distalmost part of tibia where on the dorsal and ventral side they may take the form of larger spines (Fig. 10).

The proximal part of tibia and femur is covered by tubercles of the corrugated type. Only this type of tubercle is present on the pedipalp. The setae here are spatulate, not pointed as at the apex of tibia.

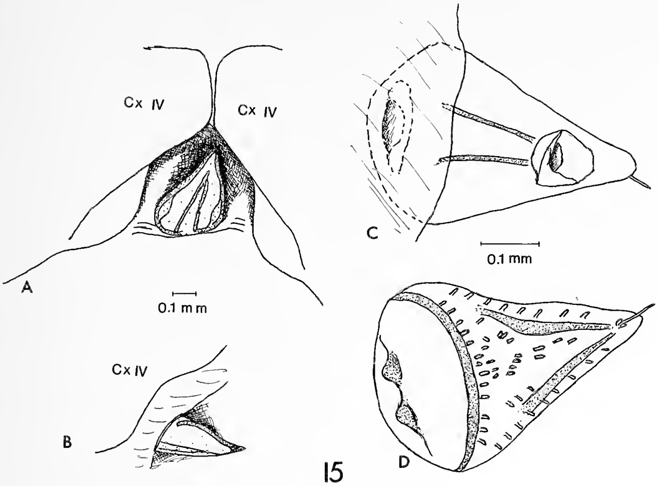
In Fig. 13 is shown still another structure found on both tibia and femur, namely extremely small pits, hardly visible on the surface, devoid of the minute conical "teeth" which cover the whole integument as a rasp. In the center of these pits the tip of "something" is sometimes seen which may be a sensory seta. The size and position relative to a corrugated tubercle is correctly drawn in Fig. 1, A.

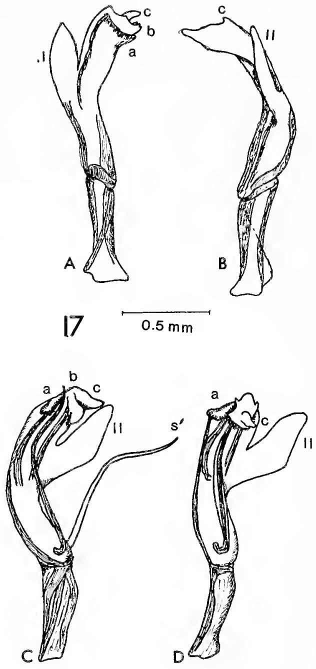
Male—Length of the animal without cucullus and pygidium, 9.3 mm. Fig. 7 shows the animal from the dorsal side and, with only the base of the legs, the ventral side. The length to width ratio of opisthosoma is 1.2. The male of *R. afzelii* has not been described before.

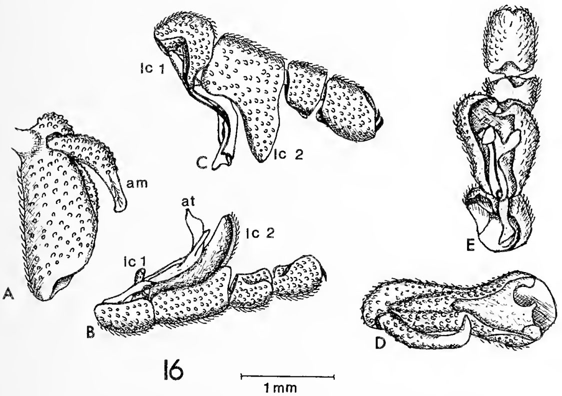
There is a great sexual difference in this species in the shape of the first and second legs (compare Figs. 6 and 7). In the first leg the femur, patella, tibia, and metatarsus are much broader and stouter in the male. In the second leg the femur is enormous, the tibia is provided with a long basal process and the metatarsus with a small prominence. This was not known for any of the species described by Hansen and Sørensen in 1904, but in 1921 Hansen described this feature for the new species *R. feae* in exactly the same way as I have drawn it for *R. afzelii*. Beck and Schubart (1968) mention some apophyses in the males of some species of *Cryptocellus* (p. 73), but they are partly on other parts of the legs.

A small sexual difference is seen on the ventral side (Fig. 2), the third coxae being relatively shorter than in the female; and then, on the whole, the male is stouter than the female. Another difference is found in the shape of cucullus (Fig. 3), but Pittard and Mitchell (1972) emphasize the variability of the shape of cucullus also within the sexes.

The chelicerae (Fig. 14) show a just crenulated or finely toothed movable finger and four teeth on the fixed finger, the distal not being larger than the others. In this figure is also shown the tubercles at the border of cucullus; they are fairly large in *R. afzelii*, and







Figs. 15-17.–*R. afzelii*, Zoological Museum, Copenhagen, male: 15, penis: A-B, tip turned anteriorly; C, posteroventral view; D, anterodorsal view. 16, left copulatory organ: A, metatarsus prolateral view; B, tarsus, dorsal view. lc 1 and lc 2, *laminae cyathiformes* of first and second segment; am, metatarsal process; at, tarsal process. 17, left tarsal process: A, retrolateral-ventral views; B, prolateral view; C-D, two dorsal views. a,b,c, the apical lobes; ll, lateral lobe; s, accessory piece; s', accessory piece released.

their number (here about 45) may indicate their size and be a valuable character in taxonomy.

The pedipalps are like those of the female.

The male genital aperture is described by Hansen (1921) in *R. feae* and *R. crassipalpe* as "much smaller than in the female"; "the sternite of first segment is produced downwards as a freely protruding, triangular plate about as long as broad and with the end subacute"; "the sternite of second segment is . . . semicircular . . . ." He gives, however, no drawings. In 1972, Pittard and Mitchell gave drawings of the structure, calling it penis, in *C. pelaezi*, where it is a "tubelike piece formed by the fusion of extended sternite 8 and slightly shorter sternite 9." In the drawings it is a long conical, apparently weak structure.

In *R. afzelii* (Fig. 15), the penis is a cone, very broad at its base, weak, but with two stiffenings in the wall almost to the tip on the anterodorsal side and two shorter and narrower ones on the posteroventral side. This side is flat, the anterodorsal concave. On the posteroventral side, a little from the tip, is found the genital opening surrounded by some loose flaps (lips ?). On the anterodorsal side a seta in a small groove is present almost at the tip, and some scattered teeth on the surface. The whole penis, though weakly sclerotized, apart from the stiffenings, is more sclerotized than the surrounding pedicel.

The copulatory organ on leg III is drawn in Fig. 16. The metatarsal process (am) is very broad at the apex (Fig. 16, A), which is bent posteriorly as seen in dorsal view (Fig. 16, D). The broad apex is filled by canals in the same way as mentioned for the movable finger of the pedipalp (Fig. 4, C). The first tarsal segment carries a long process, as a spur, retrolaterally, protecting the inner part of the tarsal process, the *lamina cyathiformis* 1 (1c,1). The second segment carries the *lamina cyathiformis* 2 (1c 2) retrolaterally, and a lower blade prolaterally, thus protecting the distal part of the tarsal process on both sides (Fig. 16, B,C,E). The *lamina cyathiformis* 2 is extremely high. The third and fourth segments are but little changed.

Inside the "cup" of tarsal segments 1 and 2 lies the tarsal process (Fig. 16 B, at). Its apparent shape is very different, dependent on the way it is viewed. I have therefore drawn it in four different aspects in Fig. 17. The leaf-like lateral lobe (ll) is broad. Of the apical lobes, "a" is more sclerotized than "b" and "c," "b" is broad and "c" long, but broad in the other dimension. The shape of these three apical lobes is most clearly seen in retrolateral and prolateral views.

Along the distal part of the tarsal process the accessory piece (s) is seen which actually is fixed to it only at its base. In Fig. 17, C is shown how it is possible to loosen it for almost its whole length from the rest of the distal part (s'). Its tip even exceeds the soft lobes.

After these descriptions were finished I have seen a paper by Pollock (1967) in which he mentions having found over a hundred specimens of *R. afzelii* and an undescribed species. The latter has not been described to my knowledge.

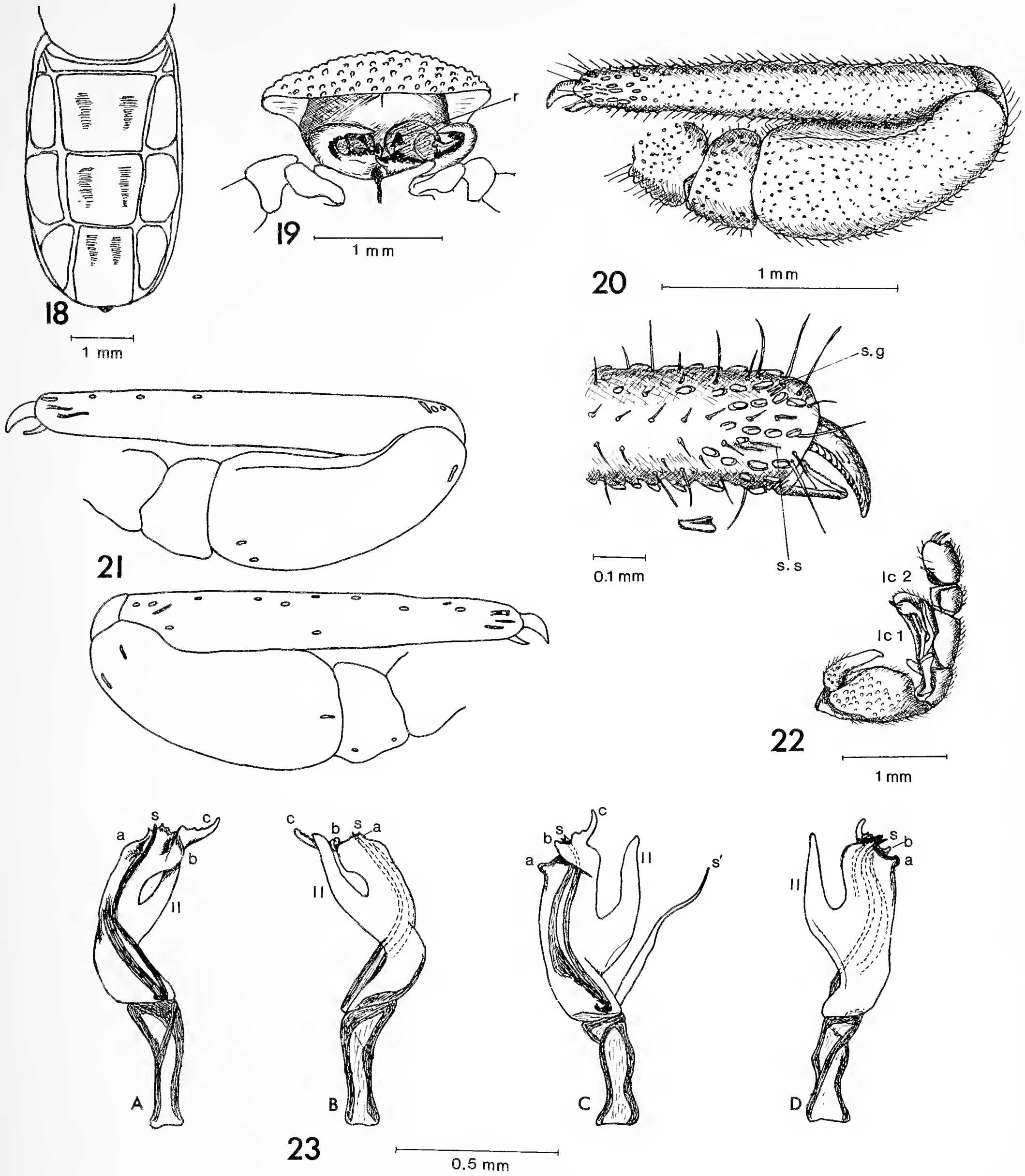
2. *Ricinoides feae* (Hansen, 1921)

Described on the basis of material from Portuguese Guinea (near lat. 12 degrees N) at Bolama June-December, 1899, "many specimens," and at Rio Cassine January-April, 1900, "numerous specimens." Hansen did not select a holotype. The whole material was handed over to him for study by the Museo Civico di Storia Naturale in Genova. Some of the material was given to the Zoological Museum of Copenhagen and my descriptions are based on this, but a lectotype must be selected from the Genova material, and this I have not seen.

Millot (1945) made his admirable study on the internal anatomy of Ricinulei on specimens of *R. feae*.

This species is very closely related to *R. afzelii*, but it is smaller; length without cucullus and pygidium is about 6.5 mm. The shape of opisthosoma is very different from that of *R. afzelii,* almost parallel-sided; length to width ratio is 1.5 (Fig. 18). The tubercles on cucullus are larger and more dispersely set, only about 25 in a row behind its anterior margin (Fig. 19). All femora are with a dorsal longitudinal furrow.

The chelicerae are with about six teeth on the movable finger, five on the fixed one, of which the two basal ones are quite small, but the distal one not remarkably larger than the other. Two setae are situated ventrally at the base of the movable finger.



Figs. 18-23.–*R. feae*, Zoological Museum, Copenhagen, male: 18, opisthosoma; 19, chelicerae and cucullus *in situ*, left chelicera fully opened. r, the ricinoides tooth; 20, right pedipalp, prolateral, and apex of left pedipalp, prolateral view. sg, sensory pit ("Sinnesgrube"), below a tubercle in higher magnification; 21, pedipalp showing position of sensory pit ("Sinnesgrube"), sensory slits and sensory (?) patches in retrolateral (above) and prolateral view; 22, left metatarsus and tarsal segments of leg III, prolateral view. lc 1 and lc 2, *laminae cyathiformes* of first and second tarsal segment; 23, left tarsal process: A, retrolateral view; B, prolateral view; C, dorsal view; D, ventral view. a,b,c, the apical lobes; ll, lateral lobe; s, accessory piece; s', accessory piece released.

In the pedipalps there are small differences from that of *R. afzelii*. It is comparatively broader, not tapering towards the middle, and the tubercles are comparatively larger in size and fewer in number (Fig. 20). On the ventral and dorsal side they have even the character of spines in one or two rows along the whole length of tibia. Two prolateral and three retrolateral sensory slits on the distal part of tibia and one prolateral sensory pit

("Sinnesgrube"). At the base of tibia and on femur and trochanters, the setae are spatulate and the tubercles all corrugated as in *R. afzelii*. The distribution of sensory slits and small rounded sensory (?) patches is seen in Fig. 21.

The male has the same extreme enlargement of femur and tibia of the second pair of legs as *R. afzelii* and exactly in the same shape (Fig. 7, and Hansen 1921, plate III, Fig. 1, b). This is not known from any other species of *Ricinoides*.

The copulatory organ, too, resembles that of *R. afzelii* in the shape of metatarsus and its process as well as in the first and second tarsal segments with *laminae cyathiformes* (Fig. 22). But there are distinct differences in the tarsal process (Fig. 23). The lateral lobe (ll) is narrower and pointed (seen in dorsal view), the apical lobe "c" is long and narrow and with small soft teeth at the upper margin. Lobe "a" is more firmly sclerotized than the other two, as in *R. afzelii*. The accessory piece is not so heavily curled at the basis.

3. *Ricinoides sjostedti* (Hansen and Sorensen, 1904)

Material for the original description: Male and immature female from N'dian, Cameroun, June 1891, collected by Y. Sjöstedt (Stockholm Museum). Hansen has noted on the label that they are "types for the drawings." "Pullus" from Bibundi, Cameroun, August, 1891, collected by Y. Sjöstedt (Zoological Museum, Copenhagen). Male and female and immature female (?) from Joh. Albrechts-Höhe, 21 July-31 August 1897, collected by L. Conradt (Naturhistorisches Museum, Berlin). I have only seen the immature female.

According to these data, I select the male in the Stockholm Museum as the lectotype. On it were based the drawings in the original description, and on it are based my drawings in the present paper. Some few other specimens have been found since the days of the description (Kennaugh, 1968).

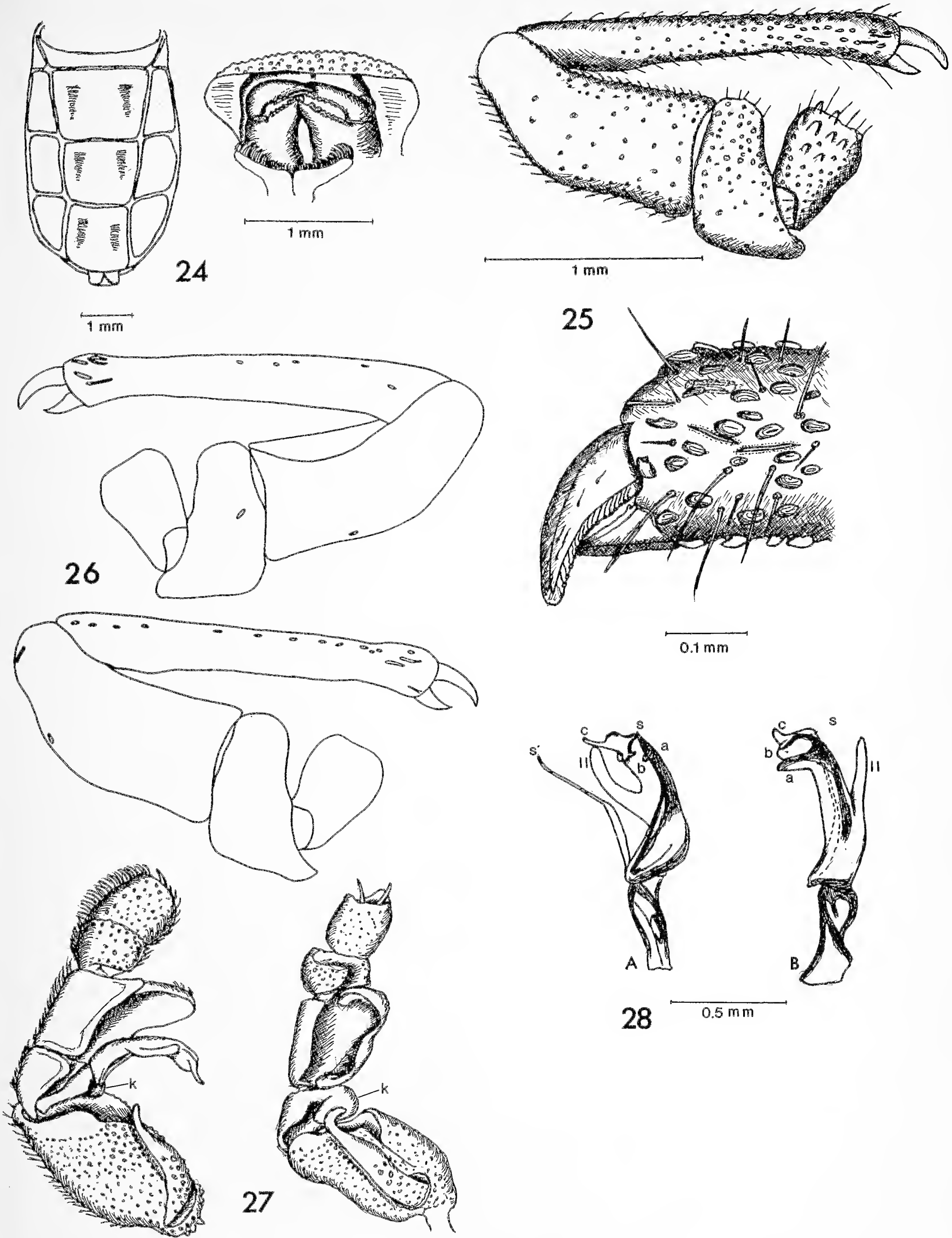
Length without cucullus and pygidium is 7.0 mm. Opisthosoma rather narrow, length to width ratio is 1.45, but a little more rounded than in *R. feae* (Fig. 24). The tubercles in cucullus are smaller than those of *R. feae*, about 30 in a row behind its anterior margin (Fig. 24).

Femora are without dorsal longitudinal furrows. The male is with a process on the first tibia in the Stockholm material, but not in the Berlin material (only those two males known).

The chelicerae are with five teeth on the fixed finger, the apical hardly longer than the others. The movable finger is with five to six conspicuous teeth (Fig. 24).

The pedipalps are very different from those of the two preceding species. The tibia is more slender, narrowed somewhat in the middle, and the tubercles are dispersed in another way (Fig. 25). At the apex there are many fairly long tubercles which look like fishes' otoliths (Fig. 25). At the dorsal and especially ventral sides are strong spines like those in *R. feae*. The "otoliths" continue, dispersing, mostly on the dorsal side, until the narrowed middle of the tibia where they are replaced by saucer-shaped tubercles. The tubercles thin out towards the base of tibia, where some of the corrugated type occur. On femur both saucer-shaped and corrugated tubercles are found, intermingled. On the first trochanter are several strong spines.

The distribution of the sensory slits and the sensory pit ("Sinnesgrube") is seen in Fig. 26.



Figs. 24-28.–*R. sjostedti*, Stockholm Museum, male: 24, lectotype, opisthosoma and chelicerae with cucullus *in situ*; 25, lectotype, right pedipalp, retrolateral and apex of tibia, prolateral view; 26, lectotype, pedipalp showing position of sensory pit ("Sinnesgrube"), sensory slits and sensory (?) patches in prolateral (above) and retrolateral view; 27, lectotype, metatarsus and tarsal segments of right leg III, prolateral with tarsal process and dorsal with tarsal process removed. lc 2, *lamina cyathiformis* 2. *k* a knob replacing *lamina cyathiformis* 1; 28, right tarsal process: A, dorsal view; B, retrolateral view. a,b,c, the apical lobes; ll, lateral lobe; s, accessory piece; s', accessory piece released.

The copulatory organ (Fig. 27) is different from that of the two preceding species. There is no *lamina cyathiformis* on the first tarsal segment, only a rounded knob (k) to protect the tarsal process. The metatarsal process is more pointed at the curved apex. Metatarsus with some large spines at base. The tarsal process (Fig. 28) differs especially in the shape of the apical lobe "b" which is bipartite and smaller than in *R. feae*, as well as in the shape of lobe "a" which is narrower and darker than the other lobes. Lobe "c" is shorter than in *R. feae* and without dorsal teeth. In Fig. 28, A I have figured the accessory piece *in situ*, and as if withdrawn from the body. It is broader in its basal half. The lateral lobe is narrower and not pointed.

4. *Ricinoides karschi* (Hansen and Sørensen, 1904)

Cryptostemma westermanni, Karsch 1892, p. 25, ff.

Material for the original description: Male and female from Kribi, Cameroun, October, 1888 (Naturhistorisches Museum, Berlin). Male and two females from Benita River, Congo, collected by G. L. Bates (British Museum).

The material in the Berlin museum was identified by Karsch as *R. westermanni* Guérin. This is the reason why Hansen and Sørensen (1904) gave the species its name, so actually the lectotype might be selected here. But the tarsal process is missing on both sides in the male, and since I think the most important specific character is found in this process I have selected the male in the British Museum as the lectotype and base my description on it.

Length without cucullus and pygidium about 6.0 mm. Opisthosoma oval, rounded, length to width ratio is 1.10 (Fig. 29). Tubercles on cucullus are small, about 30 in a row behind its anterior margin (Fig. 29).

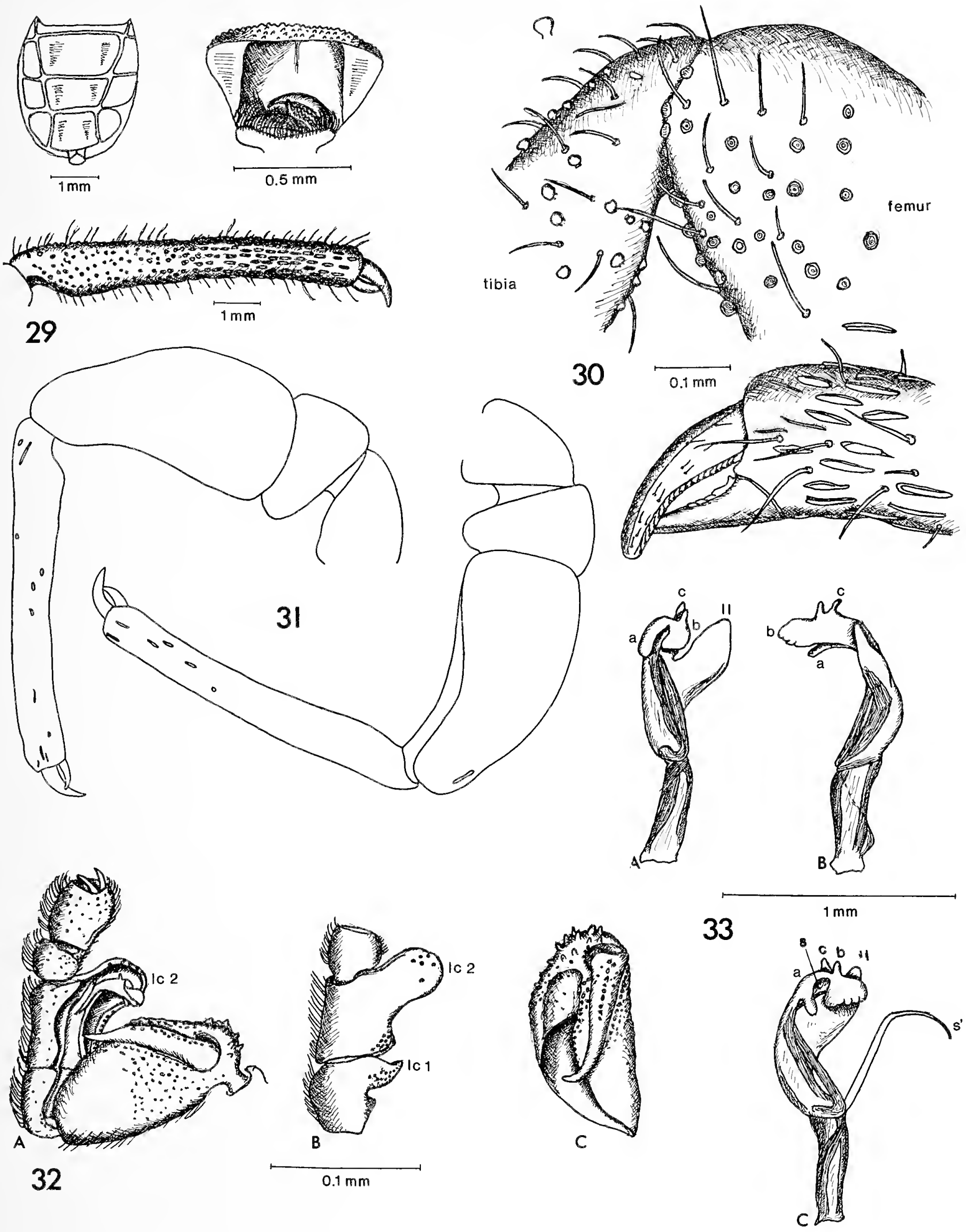
Femora are without dorsal longitudinal furrows. Tibia of first leg in the male are with an enlargement in the middle and femur of second leg much broadened, as shown in Hansen and Sørensen (1904, plate VIII, 4a, cf. IX 1a).

Chelicerae are with five teeth on the fixed finger, the two basal ones small, and the apical one not longer than the next two. The movable finger is with six to seven fairly small teeth (Fig. 29).

The pedipalp is very different from that of the preceding species. It is only sparsely provided with hairs, some very long and curved and some short in between. The tubercles on the apex of tibia are very long, narrow, and low, not very densely set and cover about the distal two-fifths or half. At the base of tibia there are some mushroom-shaped tubercles. At the distal part of femur almost all tubercles are saucer-shaped except ventrally where some of the corrugated type are found. At the base of femur corrugated and saucer-shaped tubercles are mingled among each other (Fig. 30).

The distribution of the sensorial slits is seen in Fig. 31. There is only one slit at apex of femur, prolateral, and no sensory pit ("Sinnesgrube").

In the copulatory organ (Fig. 32) the metatarsal process is bent towards the middle line, but more pointed than in *R. afzelii*. Metatarsus is with several very strong teeth or spines near base. Both first and second tarsal segments carry *laminae cyathiformes*; in the first segment it is a little twined towards the middle line. In the tarsal process the accessory piece is not S-shaped but U-shaped, ending behind the apical lobe "b." This lobe is very broad and "fleshy," with indentations. Lobe "a" is soft and lobe "c" fairly small. The accessory piece is drawn also in released position in Fig. 33, C.

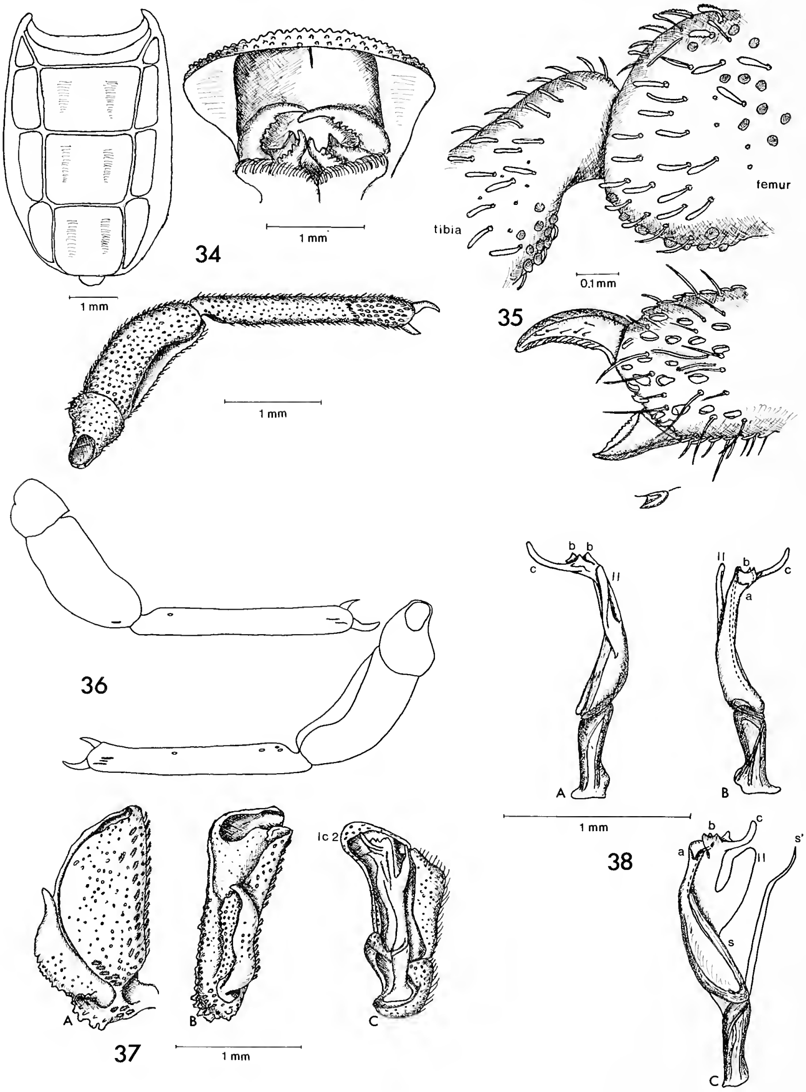


Figs. 29-33.–*R. karschi*, British Museum: 29, female, opisthosoma, chelicerae and cucullus *in situ*, and left pedipalp, prolateral view; 30, female, left pedipalp, apex of tibia and base of same plus apex of femur, retrolateral view; 31, female, pedipalp showing distribution of sensory slits and sensory (?) patches, prolateral (left) and retrolateral view; 32, male, lectotype, right copulatory organ: A, prolateral view; B, tarsal segments 1-3, retrolateral view; C, metatarsus, dorsal view. lc 1 and lc 2, *laminae cyathiformes* of tarsus 1 and 2; 33, male, lectotype, tarsal process of right leg III: A, dorsal view; B, prolateral view; C, dorsal-retrolateral view. a,b,c, the apical lobes; ll, lateral lobe; s, accessory piece; s', accessory piece released.

5. *Ricinoides westermanni* (Guérin-Méneville, 1838)

The type specimen, a male, is lost, but Hansen and Sørensen (1904) described a specimen, also a male, in Naturhistorisches Museum, Berlin, and this must therefore be regarded as a neotype. It was collected in Bismarcksburg, Togo, by R. Büttner on 16 January 1893. Another specimen, immature, is mentioned by Hansen and Sørensen (1904) and seen by me; collected in the same locality by the same collector July 1891.

Length without cucullus and pygidium is 8.5 mm. Opisthosoma is fairly narrow, but



Figs. 34-38.–*R. westermanni*, Naturhistorisches Museum, Berlin, neotype: 34, opisthosoma, chelicerae and cucullus *in situ*, and right pedipalp, retrolateral view; 35, apex of right pedipalp and base of same plus apex of femur, prolateral view; 36, pedipalp, retrolateral (above) and prolateral view, to show distribution of sensory slits and patches; 37, left copulatory organ: A, prolateral view; B, dorsal view; C, tarsal segments 1 and 2, dorsal view. lc 2, *lamina cyathiformis* of tarsus 2; 38, tarsal process of left leg III: A, prolateral view; B, dorsal view; C, retrolateral view. a,b,c, the apical lobes, ll, lateral lobe, s, accessory piece; s', accessory piece released.

very shrunk, length to width ratio is 1.3, fairly parallel sided (Fig. 34). The tubercles on the cucullus are big and fairly closely set, about 30 in a row behind its anterior margin (Fig. 34).

Femora are with narrow dorsal longitudinal furrows. Since the female is not known, nothing can be said as to sexual differences.

The whole body is covered with scales, which are narrow and have the shape of a hollow trough with two patches of hairs or papillae along the sides (Fig. 1, D).

The chelicerae (Fig. 34) are with five to six rather big teeth on the movable finger and four on the fixed, the distal only slightly larger than the others.

In the pedipalp (Figs. 34, 35) the tibia is slender and with a slight narrowing in its distal third. The distal third is covered with rather short tubercles and mostly short, pointed setae. On the base of tibia the setae are broad, spatulate; ventrally some corrugated tubercles. At the femur all tubercles are corrugated, no saucer-shaped ones are present. The setae are spatulate and some scales are intermingled. Sensory slits as shown in Fig. 36, one slit prolaterally on femur. No sensory pit ("Sinnesgrube") present.

The copulatory organ (Fig. 37). The metatarsal process is very broad in lateral view, a little twined when seen from above, apex tapering and not bent as much against the middle as in the other species. *Lamina cyathiformis* of second tarsal segment of the common size, but that of first segment almost missing (Fig. 37). The tarsal process is very characteristic, with a long and narrow apical lobe "c" and stronger sclerotized lobe "b". Lobe "a" is sclerotized, short, and pointed. The accessory piece is free and drawn released (s') in Fig. 38, C.

6. *Ricinoides crassipalpe* (Hansen and Sørensen, 1904)

Described from an immature and quite young ("pullus") specimen from Cameroun, collected by Y. Sjöstedt, but in 1921 Hansen described it again on five adult specimens and two immatures collected by L. Fea on the Island of Fernando Póo in 1901-1902 and kept in Museo Civico di Storia Naturale, Genova. A male and a female from Musola, Fernando Póo, was presented to the Zoological Museum, Copenhagen, and I have based my description below on the male.

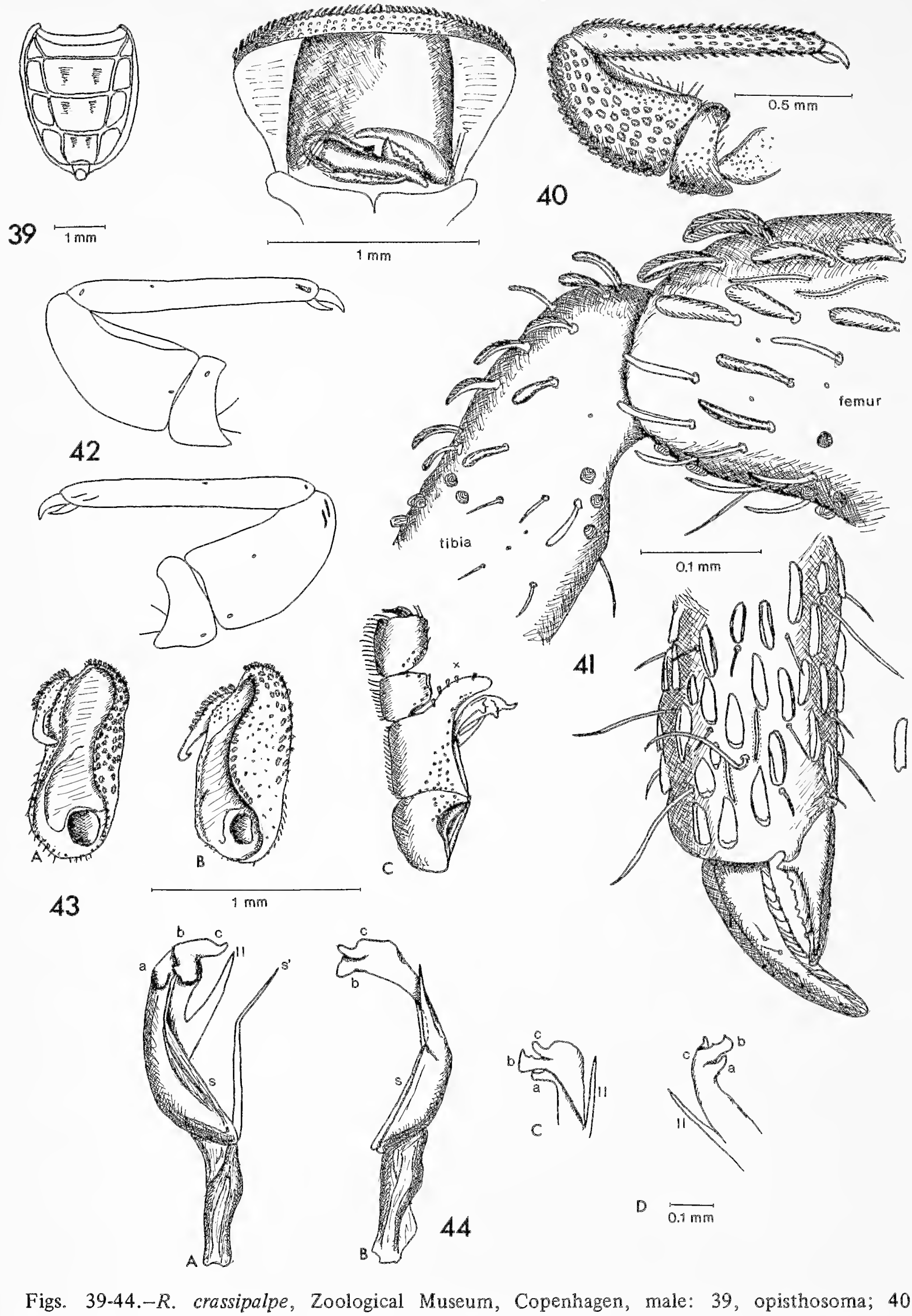
Length without cucullus and pygidium is 4.5 mm. Opisthosoma more ovoid than in the other species, length to width ratio is 1.1 (Fig. 39). The tubercles on cucullus are closely set, about 40 in a row behind its anterior margin (Fig. 40); and cucullus densely covered by scales.

Femora are without dorsal furrows. Only small sexual differences occur in the thickness of the segments of leg I.

The whole body is densely covered with very broad scales (Fig. 1, E) with long hairs or papillae at the sides and at the end. The scales are narrow at tibia and part of femur, but very broad on the rest of the limbs and body.

Chelicerae (Fig. 40) with five to six small teeth on the movable finger and five almost equal, fairly big teeth on the fixed one.

The pedipalps are figured in Figs. 40-42. Tibia is narrow and with a slight narrowing almost at the middle. It is covered with fairly long tubercles for more than the distal half. At its base there are some few corrugated tubercles and some few slender scales. Femur is very broad (thence the name *crassipalpe*) and densely covered with scales, narrow ones at its apex, broader ones towards bases. All the tubercles on the



Figs. 39-44.–*R. crassipalpe*, Zoological Museum, Copenhagen, male: 39, opisthosoma; 40, chelicerae and cucullus *in situ*, and left pedipalp, prolateral view; 41, left pedipalp, apex of tibia and base of same plus apex of femur, retrolateral view; 42, pedipalp prolateral view (above) and retrolateral view, to show distribution of sensory slits and pit ("Sinnesgrube"); 43, left copulatory organ: A, metatarsus, dorsal view; B, retrolateral view; C, tarsus, retrolateral view. x, small, blunt hairs on *lamina cyathiformis* 2; 44, left tarsal process: A, dorsal view; B, prolateral view; C, apical lobes, dorsal-prolateral view; D, ventrolateral view. a,b,c, apical lobes; ll, lateral lobe; s, accessory piece; s', accessory piece released.

pedipalp are of the corrugated type. A sensory pit ("Sinnesgrube") is present at the apex of tibia on the prolateral side of which, however, no sensorial slits are found. Two sensorial slits occur retrolaterally and two prolaterally on the femur (Fig. 42).

Metatarsus of the copulatory organ is densely covered by scales, and the metatarsal process is short and slender, with the tip bent sharply against the middle line. No *lamina cyathiformis* occurs on first tarsal segment; that of the second segment carries distally a few curious short blunt hairs or papillae (Fig. 43). The tarsal process (Fig. 44) is with a very narrow and pointed lateral lobe. The three apical lobes are soft, "b" almost fleshy, but with some characteristic "teeth"; I have therefore drawn it in different positions; "c" has the curious shape of a snub nose.

7. *Ricinoides plebejum* (Hansen and Sørensen, 1904)

This species was described on a single immature specimen from Togo, Misalishe, 24 June, 1894, collected by E. Bauman, and kept in Naturhistorisches Museum, Berlin. Since it is a young stage and the changes from one stage to another is not known for the *Ricinoides* species, except partly for *R. feae*, I restrain from giving a new description, which, I think, should await more material. It is important, however, to notice, that it is covered by scales.

ACKNOWLEDGEMENTS

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I also want to thank Dr. Robert W. Mitchell, Texas Tech University, Lubbock, who sent me living *Cryptocellus pelaezi* as well as the then unpublished drawings (without the text, however) by Kay Pittard, which are each a piece of art and wonderfully instructive. At the time my study was almost finished, I received Pittard and Mitchell's (1972) extremely valuable paper on *C. palaezi* which caused many changes in my manuscript especially in anatomical name-giving. Dr. Mitchell has also perused my paper and sent me the still unpublished paper by Jerry W. Cooke on copulation in ricinuleids. I owe him my most heartfelt thanks.

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REVISION AND KEYS TO THE HIGHER CATEGORIES OF VEJOVIDAE (SCORPIONIDA)

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ABSTRACT

The higher categories of the Vejovidae have been revised and keys to these categories are presented. As part of the revision a new subfamily, the Hadrurinae, has been recognized. In the subfamily Syntropinae a new genus, *Vejovoidus*, has been introduced. In the subfamily Vejovinae new genera recognized are *Serradigitus* and *Pseudouroctonus*. Thirteen species previously placed in the genus *Uroctonus* have been shown to belong to the genus *Vejovis*. An extensive study of the value of trichobothria in scorpion systematics is presented. The systematic status of *Uroctonus fractus* is doubtful. It has been eliminated from the Vejovidae and apparently should be placed in the Chactidae where it will undoubtedly be synonymized.

INTRODUCTION

A revision of the Vejovidae is long overdue. With the introduction of ultraviolet detection (Stahnke, 1972) many new species are being discovered and placed into the literature with little regard to the more precise recognition of higher categories and in most instances without the characterization of the genera in which the new species are placed. This paper is a beginning toward a more precise recognition of the apparent higher categories through a careful study of the type-species as a point of departure.

The spelling "*Vejovis*" is used rather than the original "*Vaejovis*" as previously seemed correct (Stahnke, 1972). The decision is based on Art 23b of the International Code. The emendation *Vejovis* is a junior synonym (Art 33a) and has been in use since 1876 (Thorell, 1876). Therefore, on the basis of usage the spelling "*Vejovis*" appears to be correct according to the ICZN and is also etymologically correct (Stahnke, 1972).

The basic nomenclature used in this paper is that proposed by Snodgrass (1952) for the arthropods and adopted with additions, based on common usage, for the Scorpionida by Stahnke (1970). It is unfortunate that any group of specialists should seek to introduce and/or perpetuate a jargon that does not relate to the entire phylum. Zoology as a whole and scorpiology in particular are the losers by such practice.

It is hoped that this paper can render the service for the Vejovidae—especially the genus *Vejovis*—that Vachon's various studies did for what used to be the "catch-all" genus *Buthus* of the Buthidae.

PART I. THE FAMILY AND A KEY TO ITS SUBFAMILIES

VEJOVIDAE THORELL, 1876.

Vejovoidae Thorell, 1876, Ann. Mag. Nat. Hist. 17:10(part); Thorell, 1876, Atti. Soc. Italia Sci. 19:83,183(part); Karsch, 1879, Mitt. Muchen Entomol. Ver. 3(1):7,8,10,21 (part); Karsch, 1879, *op. cit.* 3(2)97-99,101,102(part). **Vejovidae** Kraepelin, 1899, Das Tierreich, Scorp., Pedip. 8:5,176-189; Pocock, 1900, Fauna British India, Arachnida p. 64-75; Kraepelin, 1901, Bull. Mus. Paris 7:273; Kraepelin, 1905, Zool. Jahrb. Syst. 22:330-333,340,341,345; Kraepelin, 1913, Mitt. Nat. Mus. Hamburg 30:153-162; Birula, 1917, Fauna of Russia, Arach., Scorp. 1(1):57,58,88,108; Birula, 1917, Ann. Caucasian Mus., Ser. A, 5:15,151,162,163,168,170,184,190,191,195,199; Ewing, 1928, Proc. U.S. Natl. Mus. 73:7; Hoffmann, 1931, An. Inst. Biol. México 2:333; Mello-Leitão, 1932, Arq. Mus. Nac. 34:33, Mello-Leitão, 1934, An. Acad. Brasil Sci. 6(2):75,78-81; Mello-Leitão, 1934, Reun. Soc. Arg. Patol. Reg. Norte 8(51):5; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip. Band 5, Abt. 4, Buch 8:280; Stahnke, 1939, *Scorpions of Arizona*, Iowa State Univ. p. 67-111; Mello-Leitão, 1945, Arq. Mus. Nac. 40:118-133; Takashima, 1945, Acta Arachnol. 9(3/4):71; Gertsch, 1958, Amer. Mus. Novitates 1903:5-7; Bucherl, 1959, Mem. Inst. Butantan 29:270-272; Stahnke, 1961, Entomol. News 2:206-212; Gertsch and Allred, 1965, Brigham Young Univ. Sci. Bull., Biol. Ser., 6(4):3-14; Williams, 1966, Proc. California Acad. Sci. 34(8):419-428; Gertsch and Soleglad, 1966, Amer. Mus. Novitates 2278:1-54; Stahnke, 1967, Turtox News 45(9):223; Williams, 1968, Pan-Pac. Entomol. 44:313-321; Stahnke, 1969, Entomol. News 80:57-65; Williams, 1970, Proc. California Acad. Sci. 37(8):275-332; Williams, 1970, Occ. Papers California Acad. Sci. 87:1-26; Williams, 1970, Pan-Pac. Entomol. 46:1-11; Williams, 1970, *op. cit.*, 46:238-241; Williams, 1970, Proc. California Acad. Sci. 37(12)395-418; Bucherl, 1971, *Venomous Animals and Their Venoms* 3:328-329; Stahnke, 1971, *op. cit.*, 82:121-131; Gertsch and Soleglad, 1972, Bull. Amer. Mus. Nat. Hist. 148:553-607. **Vaejovidae**, Pocock, 1902, Biologia Centrali Americana, Scorp., Pedip., Solif. p. 4-19(part); Gertsch, 1938, Baylor Univ. Mus. Contrib. p. 18; Williams, 1971, Wasmann J. Biol. 29:37-63; Williams, 1972, Occ. Papers California Acad. Sci. 94:1-16; Hjelle, 1972, Occ. Papers California Acad. Sci. 92:7-29. **Scorpionidae (Vejovini)** Kraepelin, 1894, Mitt. Mus. Hamburg 11(1):7,181. Iuridae Pocock, 1893, Ann. Mag. Nat. Hist. 12:308(part); Laurie, 1896, Ann. Mag. Nat. Hist. 18:129(part).

Characters—All Vejovidae possess a subpentagonal sternum which is usually broader than long. Both coxal endite I's are narrowed, not truncate, along the anterior border. External and internal pedal spurs are present but never tibial spurs. Stigmata are generally slit-like but frequently subellipitical but not circular. Most vejovids have three pair of lateral eyes. This, however, is not a safe criterion for separation. Recently some forms have been taken from the same habitat and obviously belonging to the same specific taxon but some of the specimens had two pair of lateral eyes, others had three, while some had two on one side and three on the other. Then there is the genus *Parascorpiops* Banks which possesses only two pair of lateral eyes but possesses more vejovid characteristics than chactid. The size and position of these eyes vary within a species so that their systematic use at this level can be very misleading.

Considerable variation exists structurally in the Vejovidae. Pectines, for example, range in structure from a simple fused lamella with teeth bearing sensilla (Fig. 1A,B) (Scorpiopsinae) to the large forms (*Hadrurus*, *Paruroctonus*) made up of the marginal lamellae, numerous spherical to elongate vaulted middle lamallae, well developed fulcra and numerous large teeth, bearing large areas of sensilla. (For detailed discussion see Carthy, 1968.) The entire pectine may bear only four teeth or over forty and be quite devoid of setae or densely hirsute.

The chaetotaxy of trichobothria is of considerable systematic importance. These are innervated, slender setae set in an alveolar depression with raised lips (Fig. 1D) and found on the femur, patella, and tibia of the pedipalps. They can be confused readily with what we will temporarily dub here as "pseudotrichobothria" (Fig. 1C) found on *Hadrurus* and other vejovids as well as on some Scorpionidae. True trichobothria have the peripheral

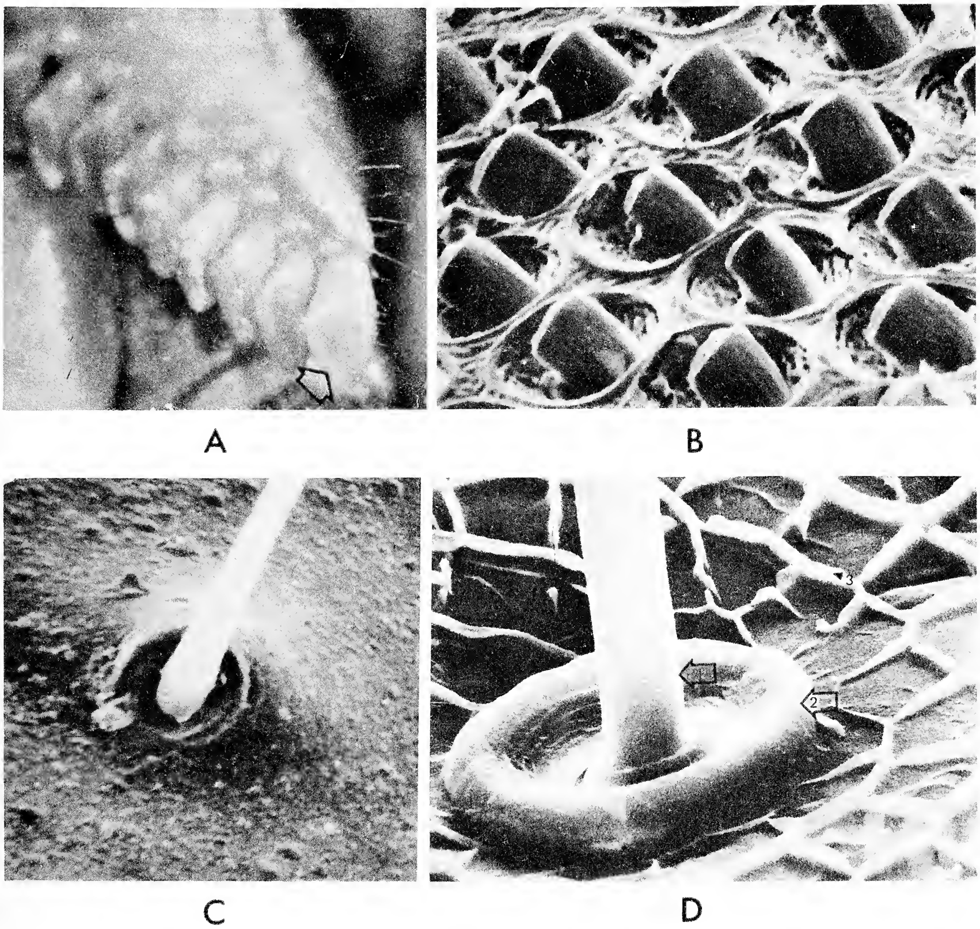

Fig. 1.–A, Pectinal teeth showing areas of sensilla; B, Micrograph of sensilla; C, Micrograph of basal portion of macrochaeta ("pseudotrichobothrium"); D, Micrograph of basal portion of trichobothrium showing (1) uniform shaft of setae and (2) raised lip of alveolus; (Micrographs from the unpublished work of J. Swafford, Electronmicroscope Laboratory, Department of Botany and Microbiology, Arizona State University).

ABBREVIATIONS USED IN FIGURES

ExS, Exterior Surface; InS, Interior Surface; InfS, Inferior Surface; SuS, Superior Surface; 72, Superior-interior keel; 75, Superior-exterior keel; 76, Exterior median keel; 77, Inferior-exterior keel; 87, Exterior marginal keel; 88, Secondary accessory keel; 89, Exterior secondary keel; 90, Digital keel; 91, Subdigital keel; 92, Inner secondary keel; 93, Subinner keel; 94, Interior marginal keel; Broken line, Vestigial keels; •, Macrochaetes; ○ Trichobothria (variance in diameter indicates relative variance in size of cup).

lips (frequently these are of a whitish color) elevated somewhat higher than the pseudo-forms and their setae are considerably more slender with a taper that is much more gradual. The shaft of the pseudo-forms more nearly fills the setal cup. The true forms also have a sort of ball and socket structure at their base. The size of trichobothria may vary on a given animal. Thus when setae are lost from preserved specimens differentiation between true and pseudotrichobothria in some species is extremely difficult. Sometimes the setae of pseudo-forms remain while those of the true forms are lost. Then comparing the base of the seta with the cup diameter may not always lead to satisfying conclusions. True trichobothria wave back and forth in response to very slight currents; pseudotrichobothria or other setae do not move even under relatively strong air currents.

Trichobothria seem to be genetically transmitted by clusters. Certain clusters are rather constant in the Vejovidae and among several other families. These apparently genetic clusters and the spatial relations between the trichobothria of the clusters, as well as between the clusters, seem to have systematic value. In this paper we attempt to show the evolutionary migration of the intra-cluster trichobothria and the clusters themselves. In order to accomplish this we have used the trichobothrial systems on the patella and tibia; those on the femur of vejovids are three in number and show very little migration, hence of little systematic importance.

As a base of comparison the trichobothrial system of the genus *Diplocentrus* (Diplocentridae) has been used (Fig. 2A,B). In this taxon the clusters are clearly defined and the trichobothria readily recognizable. In order to more clearly portray the patterns, stereograms of the patella and tibia are used. Since the proportions of the patella are unimportant to the distribution, a common pattern has been used in most cases. The tibia stereograms are more representative of the particular taxon involved. The keels of these structures are used to delimit their areas, e.g. the region between the superior and inferior marginal keels of the tibial manus is the "exterior surface" (Kraepelin's "hinterhand"), the digital extension of the interior marginal keel limits the superior surface of the tibial finger, etc.

Since Vachon's (1972) coding did not prove suitable for this study, a simple identification code for each cluster and the trichobothria within the cluster was formulated (Fig. 2A,B). A capital letter identifies the area in which the cluster is found on *Diplocentrus*; this is followed by a number to identify the individual trichobothrium. Thus the evolutionary migration of the individual trichobotrium is indicated very readily. No coding is needed at this stage that in itself would indicate the spatial relationship; when needed, this accomplished quantitatively by ratios. The anatomical cardinal directions (dorsal, etc.) are proving unsuitable and misleading on an appendage such as the pedipalp and thus avoided. There are no duplications of letters between the patellar and tibial systems. The code letters for the tibia are: **D**, tibial digit superior surface; **I**, inferior surface of tibial finger; **M**, distal area of superior tibial manus; **B**, basal area of superior tibial manus; **C**, central area of superior tibial manus; **E**, exterior surface of manus. The code letters for the patella are: **A**, interior ("anterior") surface; **P**, exterior ("posterior") surface; **V**, inferior ("ventral") surface. Additional coding is introduced as needed for trichobothria not serviced by the basic (diplocentrid) system.

The chelicerae are also of systematic importance. The denticle coding of Vachon (1963) will be used. Since the movable finger is generally forked, the tines will be referred to as superior and inferior tines. Only those structures that are distinctly developed as small teeth will be referred to as "denticles," other projections will be referred to as "dentoid" structures. The fixed finger is not forked. On its superior margin are two teeth plus the sharp terminus (Vachon's **d**): the basal tooth is bicuspid (**mb**). This dentition is found also in other families of the order and is not of great systematic significance. In some taxa the inferior border bears denticles which are of systematic value. Proximal to the superior tine of the movable finger are three or four teeth. Again, this condition is quite common throughout the order. The length and position of the superior tine is of greater significance as are also the presence of denticles, tubercles and serrula on the inferior margin.

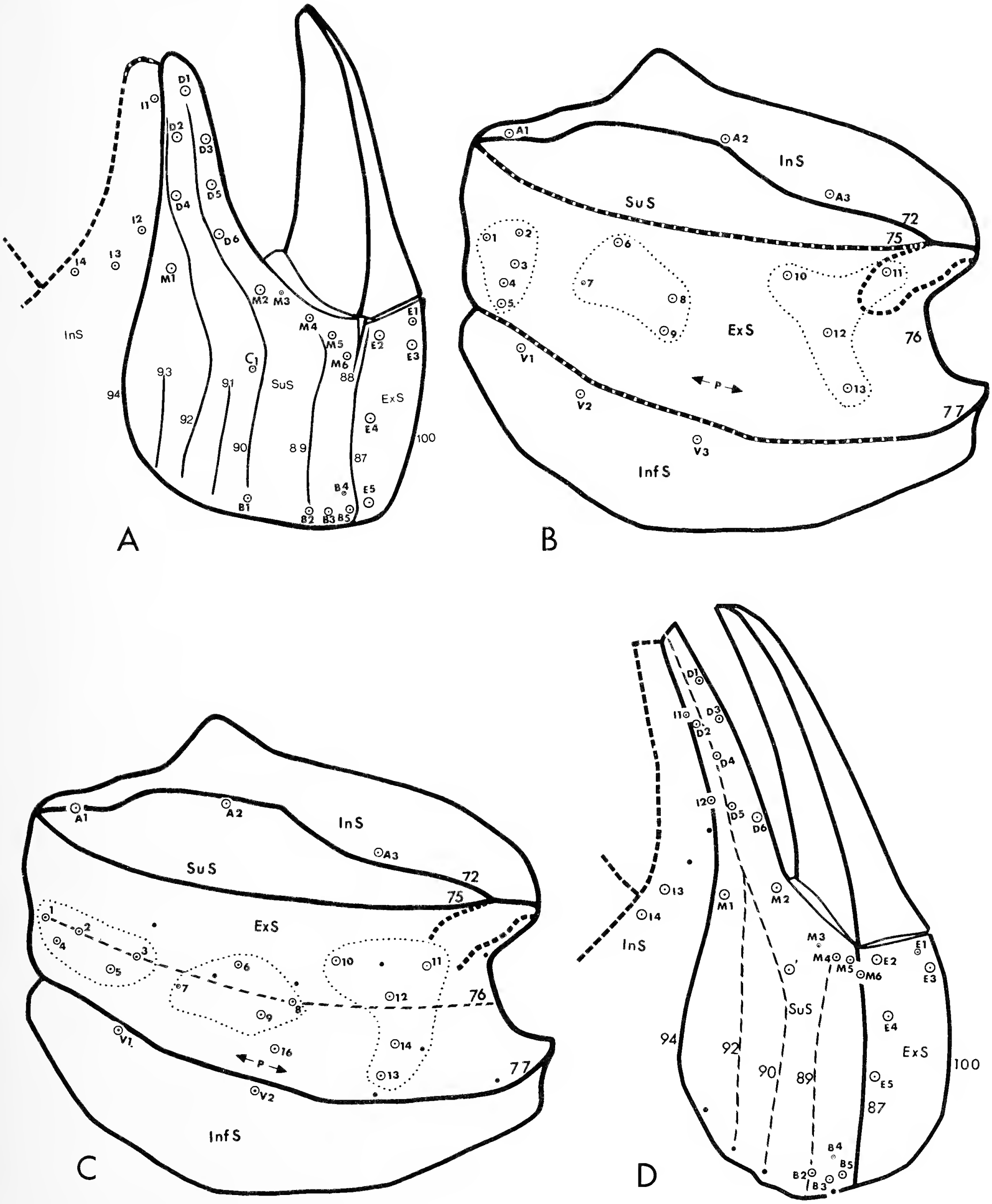

Fig. 2.–Trichobothrial systems: A, *Diplocentrus*, right chela with C_1 added; B, *Diplocentrus*, right patella; C, *Caraboctonus* right patella; D, *Caraboctonus*, right chela. (Right pedipalp used in all figures.)

In size the adults of the Vejovidae range from 130 mm (5 inches) to those only 20 mm (3/4 inches) in length. Although the pedipalp chela may be very slender to moderately broad, none of them are the powerful structures found in the *Heterometrus* of the Scorpionidae.

All the Vejovidae appear to be active burrowers (Stahnke, 1966). Many of them are psammophilous and equipped with macrochaete combs found principally on the tibia of the legs. Taxa that seem to be incapable of burrowing, such as the *Centruroides* of the Buthidae, do not seem to exist.

As far as is known, there are no vejovids that produce a venom sufficiently toxic to be lethal to man through natural sting. It is interesting to note, however, that in massive doses the venom of such forms as *Vejovis spinigerus* and *Hadrurus arizonensis* produce symptoms, such as excessive drooling, convulsions and fornication, which are parts of the syndrome produced by the venom of lethal buthid species.

Distribution—The Vejovidae are principally neartic and neotropical forms. They range from southwestern Canada to northern South America. The greatest number of species and the heaviest populations are found in southwestern United States and northern México. In the United States the greatest number of species seem to exist in California and Arizona and decreasing eastward and northward. Only one species (*Vejovis carolinianus* Beauvois, 1805) is known east of Louisiana; this has been taken as far north as Kentucky and Virginia. Only a relatively few species are known from South America. These are found in three monotypic genera: *Caraboctonus* of Peru and Chile; *Hadruroides* of Equador, Peru, Bolivia and Galapagos, and *Physoctonus* in Brazil. One subfamily, Iurinae, (one genus *Iurus* and two species) is found in Meridional Europe and Asia Minor. The subfamily Scorpiopsinae (two genera: *Scorpiops* and *Parascorpiops*) is found in India and the East Indies.

KEY TO THE SUBFAMILIES OF THE VEJOVIDAE

1a Caudal segments I-IV with single inferior median keel .... **Syntropinae** Kraepelin, 1905 (p. 113)

1b Caudal segments I-IV with paired inferior median keels or remnants of such. 2

2a(1b) Without well developed median claw (unguicular spine) on pretarsus. Ventral surface of tarsomere I with a row of papilla-like pads or setaceous tufts which fork distad in a Y-like manner and cover area of median claw .... **Caraboctoninae** Kraepelin, 1905 (p. 113)

2b Distinct median claw (unguicular spine) on pretarsus 3

3a(2b) Inner edge of pedipalp tarsus with many imbricated oblique rows of denticles. Very large, curved tooth on inferior margin of cheliceral movable finger ....**Iurinae** Thorell, 1876 (Jurinae Kraepelin, 1905) (p. 114)

3b Inner edge of pedipalp tarsus without imbricated rows of denticles 4

4a(3b) Median rows of small granules or denticles of inner edge of pedipalp tarsus flanked by large interior and exterior lateral granules or denticles which sometimes extend over only part of tarsal length. Movable finger of chelicera forked with both tines sub-equal in length .... **Scorpiopsinae** Kraepelin, 1905 (p. 116)

4b Inner edge of pedipalp tarsus with only large interior lateral denticles or granules. Movable finger of chelicera forked but superior tine always distinctly shorter than inferior tine 5

5a(4b) Trichobothria exceed 12 on inferior surface and 30 on exterior surface of pedipalp patella and exceed 16 on external surface of pedipalp manus (Figs. 5A,B, 6A) .... **Hadrurinae** NEW SUBFAMILY (p. 116)

5b Trichobothria do not exceed 3 on inferior surface and 16 on exterior surface of pedipalp patella, nor do they exceed 5 on external surface of pedipalp manus (Figs. 6C,D, 9) .... **Vejovinae** Thorell, 1876 (p. 118)

PART. II. THE SUBFAMILIES AND KEYS TO THEIR GENERA

1. SYNTROPINAE KRAEPELIN, 1905.

Syntropinae Kraepelin, 1905, Zool. Jahrb. Syst. Band 22, Heft 3:323; Birula, 1917, Ann. Caucasian Mus., Ser. A, 5:163,184,191; Birula, 1917, Fauna of Russia, Arach., Scorp. 1(1):57; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip., Band 5, Abt. 4, Buch 8:281; Stahnke, 1939, *Scorpions of Arizona*, Iowa State Univ., p. 15-18,68; Mello-Leitão, 1945, Arq. Mus. Nac. 40:118; Gertsch, 1958, Amer. Mus. Novitates 1903:14-15.

Characters—Caudal segments I-IV with a single, inferior median keel. This cristate condition is also found in the following: Urodacinae (Scorpionidae), an exclusive Australian taxon; Hemiscorpioninae (Scorpionidae), exclusive to Arabia; Megacorminae (Chactidae), apparently confined to the State of Veracruz, México. In other respects these taxa may vary greatly, e.g. *Megacormus granosus* Gervais has small pectines consisting of four to six pectinal teeth and lacking fulcra. Its cauda (male) is about 1.2 times as long as the trunk. *Syntropis macrura* Kraepelin, on the other hand, has complex pectines consisting of about 29 teeth, fulcra and numerous middle lamellae while the cauda (male) is about 2.2 times the trunk length.

Distinctly serrate denticles are found on the inner edge of the pedipalp tibial finger and tarsus, similar to those found in *Serradigitus* (Vejovinae), and eight to nine interior lateral granules. The legs have well developed lateral claws on the pretarsus, two simple pedal spurs but no tibial spur. The inferior border of cheliceral movable finger devoid of denticles or dentoid structures. The pectines, whose length is greater than coxa IV, contain numerous subcircular middle lamellae and fulcra.

Three lateral eyes are present, the first one larger than the second and third. Sternum almost as long as wide. Stigmata elongate, slit-like. Sternite VII bears two lateral keels.

Two species are at present recognized: *Syntropis macrura* Kraepelin and *S. longiunguis* Williams. These two species differ greatly. The correlation between them, based on 34 variables, is only 0.65 and between *S. longiunguis* and *Vejovis mexicanus* (C. L. Koch) is 0.71. Obviously another genus should be recognized in this subfamily.

KEY TO THE GENERA OF SYNTROPINAE

1a. Dorsal caudal keels without large distal spine. Caudal segments I-IV length to width ratios range from about 2 to 7............ *Syntropis* Kraepelin, 1900

1b. Dorsal caudal keels with large distal spine-like denticle. Caudal segments I-IV length to width ratios from about 1 to 3 .... *Vejovoidus*, NEW GENUS

2. CARABOCTONINAE KRAEPELIN, 1905.

Caraboctoninae Kraepelin, 1905, Zool. Jahrb. Syst. Band 22, Heft 3:323; Birula, 1917, Fauna of Russia, Arach., Scorp. 1(1):57; Birula, 1917, Ann. Caucasian Mus., Scorp., Ser.

A, 5:163,183,191; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip., Band 5, Abt. 4, Buch 8:281; Stahnke, 1939, *Scorpions of Arizona.* Iowa State Univ. p. 15-18,69; Roewer, 1943, Senckenbergianna 26:236. **Hadruroidinae** Mello-Leitão, 1934, Ann. Acad. Brasil Sci. 6(2):81; Mello-Leitão, 1945, Arq. Mus. Nac. 40:119.

Characters—Caudal segments I-IV with paired interior median keels. Without well developed median claw (unguicular spine) on pretarsus. Ventral surface of tarsomere II with a row of papilla-like pads or setaceous tufts which fork distad in a Y-like manner and cover area of median claw. Middle lamellae of pectines few in number. Pedipalp tarsus inner edge with an irregular median row of granules. Two trichobothria on inferior surface of pedipalp patella and six on exterior surface of manus (Fig. 2C,D) (Fig. 3A,B). Chelicera movable finger forked with superior tine much shorter than inferior one and approaching a position at right angles to it. Bearing four denticles on superior surface with second one (**m**) very much larger than other three; inferior, basal surface with a large denticle. Fixed finger superior surface with two denticles, the basal one larger and bicuspid (**mb**), with both cusps strongly developed.

KEY TO THE GENERA OF THE CARABOCTONINAE

1a. Sternum about as wide as long with a deep longitudinal furrow. Caudal segment V with granulated lateral and median ventral keels; other segments with ventral surface bearing agranular vestigial keels. Supernumerary granules interspersed between large, interior lateral granules of pedipalp tarsus. Sternite VII without two pair granular lateral keels .... *Hadruroides* Pocock, 1893

1b. Sternum much wider than long and at most with deep basal pit but without furrow. Caudal segment V ventral surface almost entirely agranular and without keels but segment I and II with granular lateral and median keels. Supernumerary granules lacking on interior surface of pedipalp tarsus; exterior lateral granules lacking. Sternite VII with two pair granular lateral keels .... *Caraboctonus* Pocock, 1893

3. IURINAE THORELL, 1876.

Iurini Thorell, 1876, Ann. Mag. Nat. Hist. 17:11(part); Pocock, 1893, Ann. Mag. Nat. Hist. 12:309(part); Laurie, 1896, Ann. Mag. Nat. Hist. 18:129. **Iurinae** Kraepelin, 1905, Zool. Jahrb. Syst. 22:341,345,351,352; Mello-Leitão, 1934, Ann. Acad. Brasil Sci. 6(2):80; Mello-Leitão, 1945, Arq. Mus. Nac. 40:118; Vachon, 1948, Ann. Nat. Hist. Mus. Wein 56:62,63. **Jurini** Karsch, 1879, Mitt. Munchen Entomol. Ver. 3(1):19(part); Karsch, 1879, Mitt. Munchen Entomol. Ver. 3(2):101. **Jurinae** Kraepelin, 1905, Zool. Jahrb. Syst. 22:331; Birula, 1917, Fauna of Russia, Arach., Scorp. 1(1):57; Birula, 1917, Ann. Caucasian Mus., Ser. A, 5:163,185,191; Werner, 1934, Bronns Klassen und Ordnungen des Tierreich, Scorp., Pedip. Band 5, Abt. 4, Buch 8:282; Stahnke, 1939, *Scorpions of Arizona*, Iowa State Univ. p. 15-18,69.

Characters—Sternum about as broad as long with slit-like longitudinal furrow throughout two-thirds of its length. Inner edge of pedipalp tarsus with about 12 imbricated oblique rows of denticles, each with a large denticle at its proximal end and flanked by 11 large interior lateral denticles; exterior lateral denticles and supernumerary granules lacking. Movable finger of chelicera forked with superior tine subparallel to inferior and about two-thirds its length; superior margin with three, large subequal denticles; inferior margin with very large, curved teeth. Two teeth of fixed finger subequal to length; basal bicuspid tooth with cusps of moderate size. Pedipalp manus (Fig. 3C,D) exterior surface bearing five trichobothria, four of which are grouped at distal end; only four **B**'s, with **B**1 missing, but seven **M**'s and no **C**'s; four **I**'s and six **D**'s. Patella with two trichobothria on superior surface, one on interior surface, one on inferior surface (Vachon, 1948, reports two on this surface). The female specimen at my disposal has clearly only one on both pedipalps and 11 pectinal teeth and 15 on exterior surface (eight above exterior median keel and seven below); **P**7 has migrated into basal division of **P** cluster. Pretarsus with

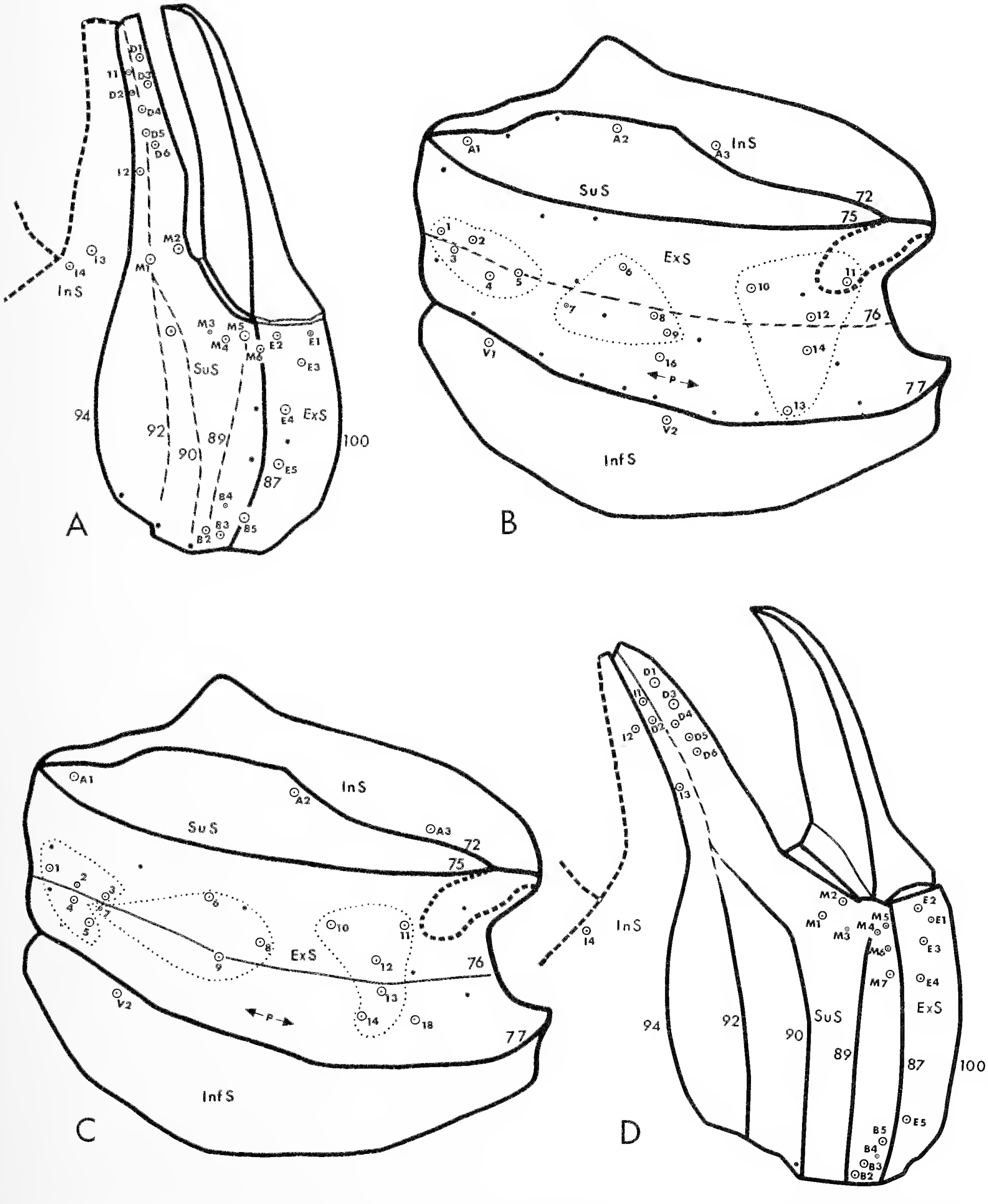

Fig. 3.–Trichobothrial systems: A-B, *Hadruroides*, chela and patella; C-D, *Iurus*, chela and patella.

well developed lateral and median claws. Pedal spurs strongly developed. Tarsomere II soles with median row of setaceous tufts (superficially appear as spines) that terminate distad in Y-like manner. The arms of the Y consist of flat, closely compact setaceous clusters.

All keels of pedipalp manus well developed, with the external keel very strongly so; external median keel of patella strongly developed. All caudal keels moderately to strongly developed with most of them bearing large, serrate denticles.

4. SCORPIOPSINAE KRAEPELIN, 1905.

Scorpiopsinae Kraepelin, 1905, Zool. Jahrb. Syst. 23:331,333,345; Birula, 1917, Fauna of Russia, Arach., Scorp. 1(1):57; Birula, 1917, Ann. Caucasian Mus., Scorp. Ser. A, 5:163,174,186,193; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip. Band 5, Abt. 4, Buch 8:282; Mello-Leitão, 1934, Ann. Acad. Brasil Sci. 6(4):193,195; Stahnke, 1939, *Scorpions of Arizona,* Iowa State Univ. p. 69; Mello-Leitão, 1945, Arq. Mus. Nac. 40:119; Takashima, 1945, Acta Arachnol. 9(3/4):71; Bucherl, 1971, *Venomous Animals and Their Venoms.* The Academic Press. Vol. 3:328.

Characters—Deep carapacial median notch. Two or three pairs of lateral eyes. Caudal segments I-IV with paired inferior median keels. Inner edge of pedipalp tarsus with large lateral denticles, or granules, interior and exterior to median rows of small denticles, or granules; sometimes lateral granules extend only over distal half of tarsus. Movable finger of chelicera with both tines subequal in length; superior margin bearing four denticles with second about twice the size of other three; inferior margin with four to six distinct denticles. Patella with strongly developed median exterior keel; manus strongly developed digital keel and moderately to strongly developed exterior marginal keel. On the exterior inferior margin of pedipalp patella (Fig. 4A-D) (Fig. C,D) are seven to 19 **V** trichobothria and on the exterior surface of the manus are five **E** trichobothria, four of which are inferior to the exterior marginal keel. The exterior and interior pedal spurs and the pretarsus lateral and median claws well developed. Pectines simple: Marginal lamella absent to distinct, middle lamellae not present or indistinct, fulcra absent or very minute, pectinal teeth five to 11. Stigmata elliptical.

KEY TO THE GENERA OF SCORPIOPSINAE

1a.	Three pair lateral eyes	*Scorpiops* Peters, 1861
1b.	Two pair lateral eyes	*Parascorpiops* Bank, 1928

HADRURINAE NEW SUBFAMILY.

Characters—This subfamily is primarily characterized by its large number of trichobothria (86 to 145) as compared with all the other subfamilies (45 to 63) (Table 1) (Figs. 5A,B, 6 A,B). When compared with the Vejovinae trichobothrial system (Figs. 6C,D, 9A-D) one notices that the great difference is due mainly to the increase in number and variation of pattern of the patella exterior surface (**P** cluster), the exterior margin of the inferior surface (**V** cluster) and the exterior surface of the manus (**E** cluster). Both genera (*Hadrurus* and *Anuroctonus*) have the **V** cluster extend onto the exterior surface (**VP** cluster) and the inferior-exterior keel turns onto the exterior surface but is vestigial on the margin from that point distad. (In contrast to this the 18 **V**'s of *Scorpiops* *montanus* continues linearly on the inferior surface.) The exterior surface of the pedipalp manus has an **E** cluster of 17-19, instead of the customary five of Vejovinae. The **A, D, M, C**, and **B** clusters are typical vejovid in their composition.

The sternum is as long as or longer than wide; the median eyes are located approximately midway between the anterior and posterior margin and the carapace is as long or longer than the posterior width. The dorsal caudal keels are without a large terminal denticle; the ratio of caudal segment V length to width is over 2.65. The cheliceral movable finger is forked with the superior tine much shorter and placed nearly at right angles to the inferior tine. The inferior border of the movable finger bears a **bi** denticle.

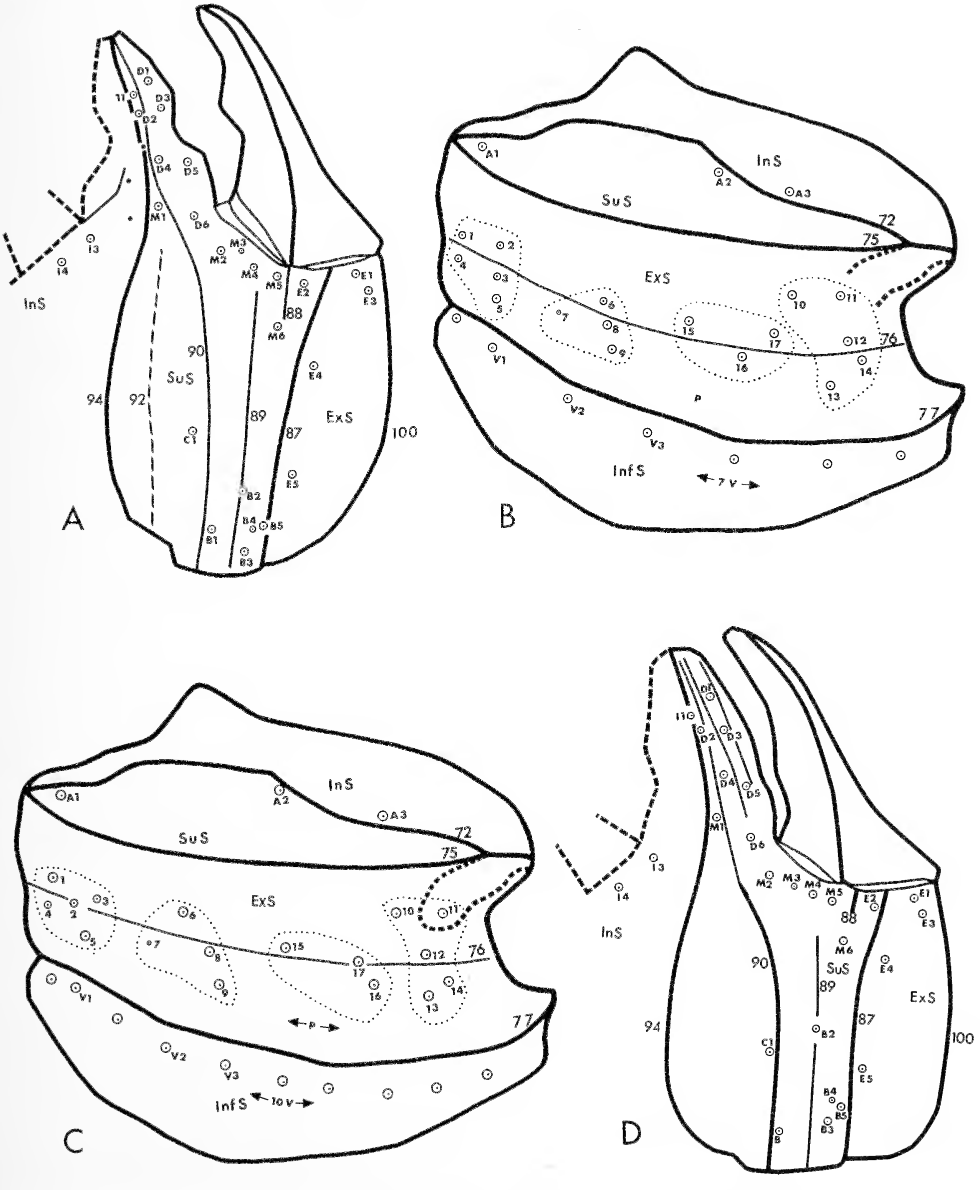

Fig. 4.–Trichobothrial systems: A-B, *Scorpiops petersi,* chela and patella; C-D, *S. longimanus*, patella and chela.

Members of this subfamily, when disturbed, do not flick their telson and run, but rather strike a defensive pose, with the cauda in a subvertical position and strut in a threatening manner. They are all active burrowers in either loose or hard soil. The venom is of low toxicity but a severe sting may cause local edema and ecchymosis.

The importance of the numerous trichobothria of this taxon was mentioned by Stahnke (1969) and Gertsch and Soleglad (1972) illustrated the patterns. Although the two genera assigned to this subfamily vary widely in some respects, the trichobothria indicate a closer affinity between them than to the genera herein assigned to the Vejovinae.

KEY TO THE GENERA OF THE HADRURINAE

1a. More than 25 trichobothria on inferior exterior margin of patella. Pectines with numerous middle lamellae, and 25 to 40 plus teeth. Inferior border of movable cheliceral finger bearing a single, large, sharp darkly pigmented **bi** tooth. Pedal spurs branched . . . . *Hadrurus* Thorell, 1876.

1b. Less than 14 trichobothria on inferior exterior margin of pedipalp patella. Pectines with few (generally indistinct) lamellae and not over 13 teeth. Inferior border of movable cheliceral finger with small **bi** denticle. Pedal spurs simple spines. Aculeus of adult male with bulbous base . . *Anuroctonus* Pocock, 1893

5. VEJOVINAE THORELL, 1876.

Iurini Thorell, 1876, Ann. Mag. Nat. Hist. 17:11(part); Pocock, 1893, Ann. Mag. Nat. Hist. 12:306-309(part); Laurie, 1896, Ann. Mag. Nat. Hist. 18:129(part). **Jurinae** Karsch, 1879, Mitt. Munchen Entomol. Ver. 3:101(part). **Uroctoninae** Mello-Leitão, 1934, Ann. Acad. Brasil Sci. 6(2):81(part); Mello-Leitão, 1945, Arq. Mus. Nac. 40:119,128(part); Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Band 5, Abt. 4, Buch 8:283(part). **Vejovinae** Birula, 1917, Fauna of Russia, Arach., Scorp. 1(1):57(part); Birula, 1917, Ann. Caucasian Mus., Ser. A, 5:163,184,191(part); Hoffmann, 1931, Ann. Inst. Biol. México 2:333(part); Werner, 1934, *op. cit.* p. 282(part); Mello-Leitão, 1934, *op. cit.* p.79,80(part); Stahnke, 1939, *Scorpions of Arizona*, Iowa State Univ. p. 69(part); Mello-Leitão, 1945, *op. cit.* p. 118(part); Gertsch and Soleglad, 1972, Bull. Amer. Mus. Nat. Hist. 148:583. **Vejovini** Kraepelin, 1894, Mitt. Mus. Hamburg 11:7,181(part); Laurie, 1896, *op. cit.* p. 130(part).

Characters—Members of this subfamily have paired inferior median keels, or their vestiges, on the first four caudal segments. Normally three pairs of lateral eyes are present with the third pair usually distinctly the smallest; the median ocular tubercle is located anterior to the middle of the carapace; a distinct median claw (unguicular spine) is present on the pretarsus; the inner edge of the pedipalp tarsus bears a straight row of granules (denticles) which may be divided into a series of short, non-oblique rows, flanked by large interior lateral granules. Exterior lateral granules are absent as are also supernumerary granules. Tarsomere II with a row of short bristles or spinules. The cheliceral structures are characteristic of the family. Of importance in the vejovines are the size and position of the superior tine of the movable finger; the number, location and size of the teeth on its superior inner margin and the dentoid structures, the denticles, tubercles and serrula on the inferior margins of both fingers.

Trichobothria are distributed as follows: 3 on femur; patella with 3 A's, 2-3 V's, 13-14 P's, chela 3 I's, 6 D's, 6 M's, 1 C, 5 B's, and 5 E's. (See Table 1.)

All known members of this subfamily are efficient burrowers–many are psammophilic–, are positively geotropic and have a venom of low toxicity.

KEY TO THE GENERA OF THE VEJOVINAE

1a. Inferior surface of pedipalp patella with three trichobothria 2

1b. Inferior surface of pedipalp patella with two trichobothria 3

2a(1a). Caudal segment IV and V greatly dilated and telson vesicle narrower than segment I .... *Physoctonus* Mello-Leitão, 1934

2b. Caudal segment IV and V not dilated excessively but subequal in width to other segments. Telson vesicle subequal in width to caudal segment I .... *Uroctonus* Thorell, 1876

3a(1b). Inner edge of pedipalp tarsus with a continuous row of conspicuously serrate, subequal denticles, uninterrupted, or indefinitely so, by larger denticles. Terminal denticle extra-large, claw-like. Interior lateral, large flanking denticles vary in position and number. Female pectines with teeth 1 to 3 more paddle-like and somewhat larger than the others ...... *Serradigitus* NEW GENUS

3b. Inner edge of pedipalp tarsus with a series of non-oblique rows of small denticles, each row proximally terminating in a larger granule. Terminal denticle not excessively large or claw-like. Female pectines with teeth 1 to 3 not larger or more paddle-like than others 4

4a(3b). Inner inferior surface of movable cheliceral finger with 4 to 7 well developed denticles and 2 to 3 well developed denticles on inferior surface of fixed finger. Stigmata elongate ovoid .... *Pseudouroctonus* NEW GENUS

4b. Inner inferior surface of movable cheliceral finger may be smooth, repand, or with 3 to 6 dentoid structures, often in form of angular scallops. Inferior surface of fixed finger may or may not have one or two broad tubercles or tubercular denticles 5

5a(4b). Inferior surface of both cheliceral finger smooth or slightly repand but not with angular scallops. Dorsal caudal furrow generally well developed. Dorsal keels (Fig. 7 D & F) of segments II to IV with distal granule more denticulate and larger than preceding ones; superior lateral keels with such condition only on segments II and III but the distal terminus of IV flat, subtriangular and projecting somewhat laterad. Ratio of caudal segment V length to width generally under 2.30 .... *Vejovis* C. L. Koch, 1836

5b Inner inferior surface of movable cheliceral finger not smooth but may have a deeply repand edge or angular scallops; the fixed finger may bear 1 to 3 tubercles. Dorsal caudal furrow weakly developed. Distal granules of dorsal and superior lateral keels not noticeably larger or more denticulate than the preceding ones; terminus of dorsal keel on segment V not flat and triangular. Ratio of segment V length to width usually over 2.45 .... *Paruroctonus* Werner, 1934

Remarks—The status of *Uroctonoides fractus* Chamberlin is doubtful and accordingly has been omitted from the Vejovidae. This taxon is based on only one male specimen whose caudal segment III and vesicle are missing. The type locality given is Quito, Ecuador, a region whose fauna is rich in chactids. This specimen possesses the following characteristics: Color, dark reddish brown, almost black, the legs paler. Anterior margin of carapace with very slight median notch, the bottom of which is an obtuse angle. Anterior and posterior median furrow well developed. Surface of carapace coarsely granular posteriad and laterad; tergites granular; sternite VII smooth and keelless; stigmata circular. Inferior surface of pedipalp patella with five trichobothria. Digital keel obsolete. Tarsus and tibial finger with conspicuous lobe, that of the tarsus obtuse, the other acute. Pectinal teeth seven; fulcra small and inconspicuous. Three pair of lateral eyes but the third pair are very minute. Median claw of pretarsus strongly developed; two pedal spurs; tarsal soles with five thick, thorn-like bristles. Specimen about the same size as an adult *Uroctonus mordax.*

All of the above characteristics are found on chactids in our collection from Quito. Careful examination of the region of the lateral eyes reveals a small, clear granule that could be mistaken for a minute third eye on some specimens. At this state of our investigation it seems highly probable that *U. fractus* is a chactid.

PART III. CHARACTERIZATION OF THE GENERA OF THE VEJOVIDAE

A. SYNTROPINAE

1. Genus *Syntropis* Kraepelin, 1900

Syntropis Kraepelin, 1900, Abhandl. Gebiete Naturwiss. 16:16,17; Birula, 1917, Ann. Caucasian Mus. Ser. A, 5:163; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip. Band 5, Abt. 4, Buch 8:281; Mello-Leitão, 1945, Arq. Mus. Nac. 40:118; Stahnke, 1975, Proc. California Acad. Sci. 30(13):257-258.

Dorsal caudal keels without large distal spine-like denticle; similar to *Paruroctonus* (Vejovinae). Caudal segments elongate and slender, more so than the typical *Paruroctonus*, especially segments IV and V. Inner edge of pedipalp tarsus with a continuous row of sharply serrate denticles subdivided into short rows by six larger denticles. Eight large interior lateral cone-shaped granules, counting the two distal ones, are present. The tibial finger and tarsus terminate in a large claw-like denticle which bears on its terminus an elongate, whitish cap. Inferior median keel well developed on all segments; agranular on first three, fourth and part of fifth with confluent granules but distal half of fifth bearing serrate granules.

Type-species—Only known species, *S. macrura* Kraepelin, 1900.

Distribution—Central Baja California, México near Comondu.

2. **Vejovoidus** New Genus

Characters—Dorsal caudal keels with large terminal spine-like denticle and caudal segments not especially elongate. In both these respects similar to the typical *Vejovis* (Vejovinae). Inner edge of pedipalp tarsus with a continuous row of sharply serrate denticles subdivided into short rows by eight to nine large denticles. Eight to nine interior lateral granules present. Both tibial finger and tarsus terminate in a relatively small, cone-shaped denticle. Inferior median keel absent on segments I and II, vestigial and

Table 1. Trichobothrial systems.

	CHELA							PATELLA				
	I	D	M	B	C	E	Total	A	P	V	Total	Sum Total
Diplocentrus (model)	4	6	6	5	0	5	26	3	13	3	19	45
VEJOVIDAE												
Caraboctoninae												
Caraboctonus	4	6	6	4	1	5	26	3	15	2	20	46
Hadruroides	4	6	6	4	1	5	26	3	15	2	20	46
Iurinae												
Iurus	4	6	7	4	0	5	26	3	15	1	19	45
Vejovinae												
Uroctonus	3	6	6	5	1	5	26	3	13	3	19	45
Serradigitus	3	6	6	5	1	5	26	3	14	2	19	45
Pseudouroctonus	3	6	6	5	1	5	26	3	14	2	19	45
Vejovis spinigerus	3	6	6	5	1	5	26	3	14	2	19	45
Vejovis montereus	3	6	6	5	1	5	26	3	14	2	19	45
Paruroctonus gracilior	3	6	6	5	1	5	26	3	14	2	19	45
Paruroctonus boreus	3	6	6	5	1	5	26	3	14	2	19	45
Scorpiopsinae												
Scorpiops petersi	3	6	6	5	1	5	26	3	17	7	27	53
Scorpiops longimanus	3	6	6	5	1	5	26	3	17	10	30	56
Scorpiops montanus	3	6	6	5	1	5	26	3	17	18	38	64
Hadrurinae												
Anuroctonus	3	6	6	5	1	19	40	3	30	13	46	86
Hadrurus	10	6	6	5	1	17	45	3	62	35	100	145

agranular on III, smooth and confluent granules on IV and irregularly serrate on V.

Type-species—Only known species, *V. longiunguis* (Williams), 1969.

Distribution—West coast of central Baja California, México.

B. CARABOCTONINAE

3. Genus *Caraboctonus* Pocock, 1893

Caraboctonus Pocock, 1893, Ann. Mag. Nat. Hist. 12:92(part); Pocock, 1893, Ann. Mag. Nat. Hist. 12:329,330; Kraepelin, 1894, Mitt. Mus. Hamburg 11:209; Kraepelin, 1899, Das Tierreich, Scorp., Pedip. 8:189; Birula, 1917, Fauna of Russia, Arach., Pedip. 8:189; Birula, 1917, Ann. Caucasian Mus., Ser. A, 5:163,191; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip. Band 5, Abt. 4, Buch 8:284; Mello-Leitão, 1945, Arq. Mus. Nac. 40:119,120.

Characters—Besides the key characteristics this genus has on the inner margin of the pedipalp tarsus a series of about six longitudinal, oblique rows of denticles, the proximal denticle of each enlarged; also a large interior lateral denticle at the distal extremities of each row. Median ocular furrow lacking. Telson vesicle as wide as, or less than the width of segment V. Movable cheliceral finger with moderately large basal tooth on inferior margin. Sternum considerably wider than long but without deep median furrow. Sternite VII with two pair, granular lateral keels. Trichobothrial system as shown in Figs. 2 C-D.

Type-species—*C. keyserlingi* Pocock, 1893.

Other species—Apparently monotypic. See remarks under *Hadruroides.*

Distribution—Peru, Chile.

4. Genus *Hadruroides* Pocock, 1893

Caraboctonus Pocock, 1893, Ann. Mag. Nat. Hist. 12:92(part). ***Hadruroides***, Pocock, 1893, Ann. Mag. Nat. Hist. 12:329,330; Kraepelin, 1894, Mitt. Mus. Hamburg 11:206; Kraepelin, 1899, Das Tierreich, Scorp., Pedip. 8:188,189; Pocock, 1900, Ann. Mag. Nat. Hist. 5:474, Birula, 1917, Fauna of Russia, Arach., Scorp. 1(1):57; Birula, 1917, Ann. Caucasian Mus., Ser. A, 5:163,191; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Band 5, Abt. 4, Buch 8:284; Roewer, 1943, Senckenbergianna, 26:236; Mello-Leitão, 1945, Arq. Mus. Nac. 40:119,120. ***Telegonus*** Koch, 1867, Verh. Zool. Bot. Ges. Wien, 17:237(part).

Characters—Besides the key characteristics this genus does not have the large interior lateral denticles of the pedipalp tarsus placed on the distal extremity of each oblique row. Median ocular furrow well developed. Telson vesicle as wide as, or wider, than caudal segment V. Movable cheliceral finger with a very strongly developed brown tooth (**bi**) on inferior surface (similar to *Hadrurus*). Sternum about as wide as long with deep median furrow. Sternite VII without lateral keel. Trichobothrial pattern as shown in Fig. 3 A,B; cluster **D** located more distad than in *Caraboctonus.* **E**1, 2, 3 nearly form isosceles triangle.

Type-species—*H. lunatus* (L. Koch), 1867.

Other species—Mello-Leitão (1945) recognized only one species; early writers (Pocock 1900) recognized more. With better sampling techniques and quantitative studies undoubtedly more species will be recognized.

Distribution—Equador, Peru, Bolivia into Chile, Galapagos.

C. IURINAE

5. Genus *Iurus* Thorell, 1876

See characteristics of subfamily.

Type-species–*I. dufoureius* (Brulle), 1832.

Other species–*I. kraepelini* Ubich, 1922 (doubtful).

Distribution–Greece, Crete, Samoa, Asia Minor.

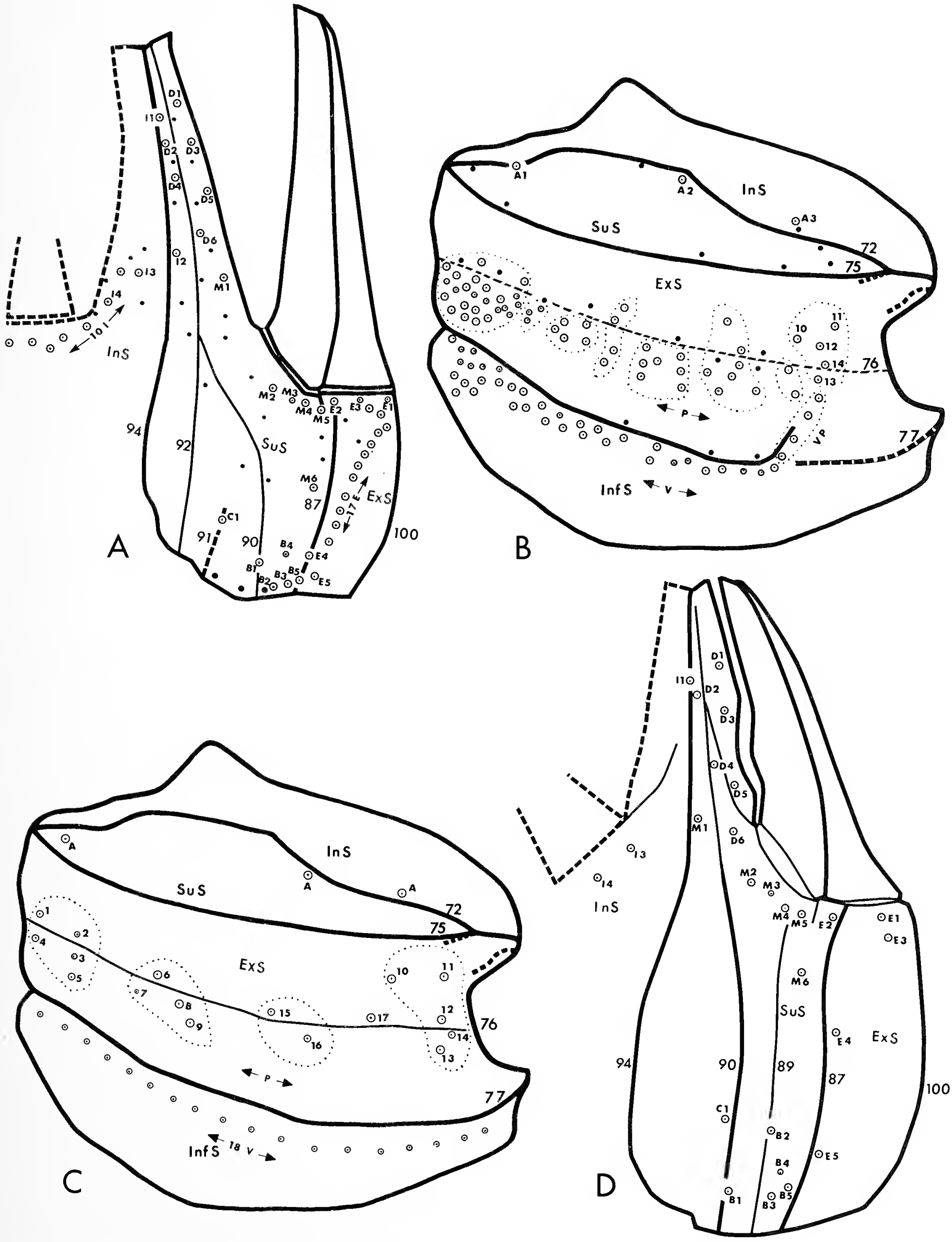

Fig. 5.–Trichobothrial systems: A-B, *Hadrurus* chela and patella; C-D, *Scorpiops montanus* patella and chela.

D. SCORPIOPSINAE

6. Genus *Scorpiops* Peters, 1861

Scorpiops Peters, 1861, Mon. Akad. Berlin 16:510; Thorell, 1876, Ann. Mag. Nat. Hist. 17:14; Karsch, 1879, Mitt. Munchen Entomol. Ver. 3:19; Thorell, 1889, Ann. Mus. Genova 27:573; Kraepelin, 1894, Mitt. Mus. Hamburg 11:185-188; Kraepelin, 1899, Das Tierreich, Scorp., Pedip. 8:179; Pocock, 1900, Fauna of British India, Arach. p. 64; Kraepelin, 1913, Mitt. Mus. Hamburg 30:153; Birula, 1917, Fauna of Russia, Arach., Scorp. 1(1):57; Birula, 1917, Ann. Caucasian Mus., Ser. A, 5:163,191; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip. Band 5, Abt. 4, Buch 8:283; Stahnke, 1939, *Scorpions of Arizona*, Iowa State Univ. p. 14-16,18,69; Takashima, 1945, Acta Arachnol. 9(3/4):71.

Characters—Carapace with three pair lateral eyes and with deep median anterior notch. Seven to 19 trichobothria along exterior margin of inferior surface of pedipalp patella (Figs. 4 A-D; 5 C,D). Dorsal keels of cauda with terminal denticle larger than preceding ones; ventral keels indistinct. Pectines simple; pectinal teeth five to 11.

Type-species—*S. hardwicki* (Gervais), 1884.

Other species—At present about thirteen species and subspecies are recognized. The variation is so great among these that two or three genera should be recognized. Sufficient material was not available to make such a study at this time.

Distribution—The Deccan, South slope of the Himalayans from Punjab to Assam, then through Burma to Tenasserim (Lower Burma).

7. Genus *Parascorpiops* Banks, 1928

Parascorpiops Banks, 1928, J. Sarawak Mus. 3(11):505,506; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip. Band 5, Abt. 4, Buch 8:283; Takashima, 1945, Acta Arachnol. 9(3/4):71.

Characters—Carapace with two pair lateral eyes and with deep median anterior notch. Ten trichobothria along exterior margin of inferior surface of pedipalp patella. Cauda with very low and lightly granulated keels; dorsal keels most strongly developed but without large terminal denticle. Ventral keels distinct. Female genital operculum undivided. Pectines simple. No distinct middle lamella or fulcra; pectinal teeth, male and female, six, with those of male much larger than female's.

Type-species—*P. montana* Banks, 1928.

Other species—Apparently monotypic.

Distribution—Mt. Poi, 4350-5450 feet; Mt. Dulit, 4000 feet, Sarawak, Borneo.

E. HADRURINAE

8. Genus *Hadrurus* Thorell, 1876

Hadrurus Thorell, 1876, Ann. Mag. Nat. Hist. 17:11 (Original citation, only part of key dichotomy); Thorell, 1876, Atti Della Soc. Italia Sci. Nat. 19:83 (Part of key); Karsch, 1879, Mitt. Munchen Entomol. Ver. 3:21 (No description); Pocock, 1894, J. Linn. Soc. Zool. 24:375,401; Pocock, 1894, Nat. Sci. 4:359,360; Kraepelin, 1894, Jahrb. Hamburg Wiss. Anst. 11:204,205; Kraepelin, 1899, Das Tierreich, Scorp., Pedip. 8:187; Pocock, 1902, Biologia Centrali Americana, Scorp., Pedip., Solif., p. 5; Ewing, 1928, Proc. U.S. Natl. Mus. 73:7, Hoffmann, 1931, An. Inst. Biol. México, 2:334; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs Band 5, Abt. 4, Buch 8:282; Stahnke, 1939, *Scorpions of Arizona.* Iowa State Univ. p. 103; Stahnke, 1945, Amer. Mus. Novitates, 1298:1-4; Diaz Najera, 1964, Rev. Inst. Salubr. Enferm. Trop. (México) 24:19,26,27,29; Gertsch and Allred, 1965, Brigham Young Univ. Sci. Bull., Biol. Ser., 6(4):12; Stahnke, 1969, Entomol. News 80:57,58; Williams, 1970,Occ.Papers California Acad. Sci. 87:3,4; Gertsch and Soleglad, 1972, Bull. Amer. Mus. Nat. Hist. 148:564,566; ***Buthus*** Wood, 1863a, Proc. Acad. Nat. Sci. Philadelphia, p. 108(part); Wood, 1863b, J. Acad. Nat. Sci. Philadelphia, Ser. 2, 5:367-368(Part).

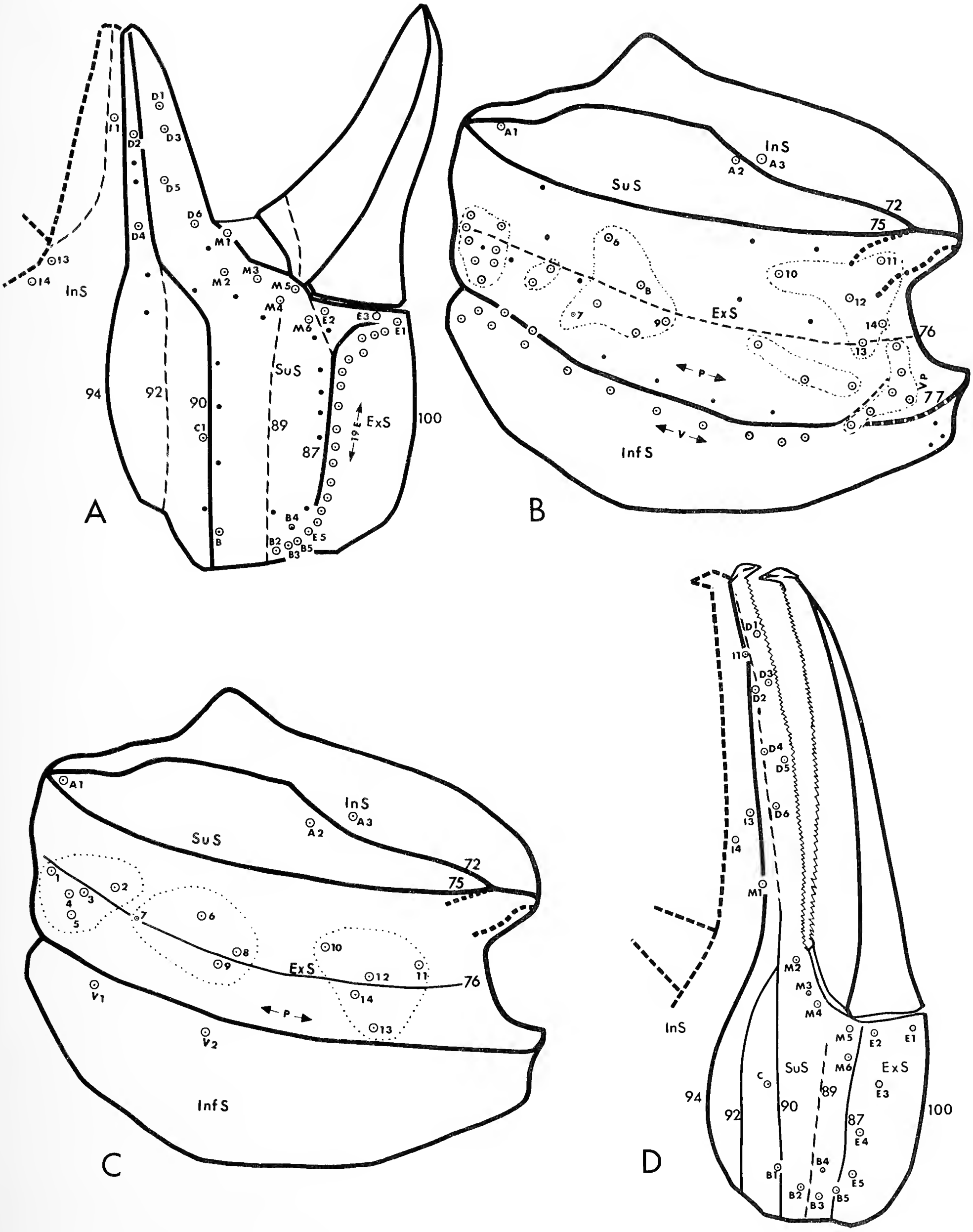

Fig. 6.–Trichobothrial systems: A-B, *Anuroctonus*, chela and patella; C-D, *Serradigitus*, patella and chela.

Characters–Numerous trichobothria (over 140; see Table 1) as compared to the relatively low count of 45 in the Vejovinae. This contrast is augmented when comparing the count of over 35 on the inferior surface of the patella with the count of two to three on that of the Vejovinae; a count of over 60 on the exterior patella surface with a count of 14 on the Vejovinae; and a count of over 15 on the exterior surface of the pedipalp manus in the **E** cluster compared to 5 on the Vejovinae. The genus *Hadrurus* is also very hirsute. Numerous macrochaetes (longer than the trichobothrial setae) are found on the pedipalps with a dense concentration on the walking legs, caudal segments, and especially the telson. On the inferior border of the cheliceral movable finger denticel **bi** is extremely large. Interior and exterior pedal spurs are present and these bear denticulate projections, the interior spurs with three to four denticles and the exterior with five to six. This condition is not encountered in any other taxa of the Vejovidae. The carapace length approximates the posterior width (L/W= 0.92-104). The median eyes situated slightly forward of the middle (ratio of distance from anterior margin to anterior edge of median eyes to carapace length 0.46-0.50). Third marginal lamella of pectines longer than second. In its defensive behavior it resembles the paruroctonids (Stahnke, 1966).

Type-species–*Hadrurus hirsutus* (Wood), 1863 (*nec* Williams, 1970).

Other species–*H. aztecus* Pocock, 1902; *H. arizonensis* Ewing, 1928; *H. pinteri* Stahnke, 1969; *H. spadix* Stahnke, 1940; *H. thayeri* Stahnke, 1969. Doubtful species not listed.

In his recent study of this genus, Williams (1970) somewhat arbitrarily changed the taxon representing the type-species. It is unfortunate that all the facts should not have been considered before introducing such confusion into the literature. He correctly reported that John Xantus de Vesey collected the original material that Wood (1863a and b) described. However, he failed to point out that de Vesey must have traveled the length of the Baja peninsula into Southern California from the nature of the material that he collected. From this material Wood described two species which he called *Buthus hirsutus* and *Buthus emarginaticeps*. As indicated above, his descriptions were published twice. In one the locality is given as Lower California and in the other only California. In both descriptions the type specimen size is reported as: length of body, 1 5/8 inches; of tail 2 5/8 inches or a total of approximately 4 1/4 inches. The specimen in the U.S. National Museum is only 3.3 inches (82.1 mm) long, with a trunk length of 1.4 inches (34.3 mm) and caudal length of 1.9 inches (47.8 mm).

In 1876 Thorell erected a new genus for the taxon, i.e. *Hadrurus,* and continued to recognize only two species, *Hadrurus hirsutus* and *H. emarginaticeps*. The latter is now considered as an anomalous specimen but Wood's description of it, together with that of *H. hirsutus*, reveals the true status of the material in his possession.

For *H. hirsutus* he states: "The common tint of the dorsum is a very dark reddish-brown, but varies greatly, in some specimens being as light as the legs, in others even olive. In the typical pattern, whilst the penultimate caudal segment is of the same reddish-brown as the body, the terminal is very light." In the description of *H. emarginaticeps* he states: "The color of our single specimen is an olive yellow tint, with a very dark crescentic blotch at the position of the median eyes. But this pattern does not differ from some individuals of the preceding species."

From this color description and other remarks, Wood had before him a conglomerate of specimens representing a number of species as now recognized. Color, and other characteristics, e.g. pedal spurs, thickness of metasoma, and 'the opposing edges of fingers are armed with obliquely longitudinal imbricated rows of small teeth' were of no signifi-

Table 2. A comparison of the type-species of *Uroctonus*, *Vejovis*, and *Pseudouroctonus*.

	P. reddelli	*U. mordax*	*V. mexicanus*
1. Length (mm)	♀ 56; ♂ 52	♀ 52; ♂ 51	♀ 49; ♂ 45
2. Stigmata	Elongate oval	Oval	Elongate ellip. to slit-like
3. No. pect. teeth	♀ 16-17; ♂ 18-19	♀ 8-9; ♂ 10-12	♀ 16-17; ♂ 18-19
4. No. mid. lamel.	♀ 10; ♂ 12	♀ 7; ♂ 11	♀ and ♂ 11-12
5. No. V trich.;	2	3	2
P	14	13	14
6. Dent. on inner inf. marg. chel. mov. finger	4-7 well developed	3-6 moderately developed	None
7. Dent. on inner inf. marg. chel. fixed finger	2-4 well formed	None	None
8. Carapace anter.	♀ 0.37; ♂ 0.39	♀ 0.48; ♂ 0.49	♀ 0.50; ♂ 0.38
9. Correlations	♀ : ♂ = 0.82	♀ : ♂ = 0.74	♀ : ♂ = 0.96
	♂ *P. r.* : ♂ *U. m.* = 0.62		
	♀ *P. r.* : ♀ *U. m.* = 0.71		
	♂ *P. r.* : ♀ *V. m.* = 0.76		
	♀ P. r. : ♀ *V. m.* = 0.82		
	♂ *V. m.* : ♂ *U. m.* = 0.51		
	♀ *V. m.* : ♀ *U. m.* = 0.61		
10. Ratios:			
a. Metasoma L./ Manus W.	♀ 7.73; ♂ 8.03	♀ 5.35; ♂ 6.14	♀ 9.0; ♂ 8.68
b. Femur L/D	♀ 5.58; ♂ 7.11	♀ 3.22; ♂ 3.38	♀ 4.5; ♂ 5.00
c. Seg. IV/VW	♀ 1.21; ♂ 1.19	♀ 1.39; ♂ 1.40	♀ 1.0; ♂ 0.94
d. Seg. IV L/W	♀ 1.70; ♂ 1.89	♀ 1.75; ♂ 1.77	♀ 1.26; ♂ 1.41
e. Carapace ant. L/median notch depth	♀ 9.63; ♂ 11.00	♀ 5.40; ♂ 6.00	♀ 10.00; ♂ 8.50

cance to him. He was impressed with the large macrochaetes and other setae, hence the name *hirsutus*. It is unfortunate that Thorell was also similarly impressed and failed to see that more than "two species" were represented.

Hoffman (1931) was the first to recognize the error and designated the "crescentic" form as *Hadrurus hirsutus* (Fig. 7 B,C) and Stahnke (1939, 1945, 1969), likewise, recognized this taxon as representing the type-species. Thus on the basis of priority and use, designating intent, the "crescentic" form fully described and illustrated by Hoffmann (1931) is the valid taxon to represent *Hadrurus hirsutus* (Wood), the type-species of *Hadrurus* Thorell, and *Hadrurus thayeri* Stahnke must be recognized as the species endemic to the southern portion of the Baja peninsula.

Distribution–Arizona, Northern Utah and Nevada, Southern California and Mexico.

9. Genus *Anuroctonus* Pocock, 1893

Anuroctonus Pocock, 1893, Ann. Mag. Nat. Hist. 12:328; Kraepelin, 1899, Das Tierreich, Scorp., Pedip. 8:183; Kraepelin, 1901, Bull. Mus. Paris 7:274; Pocock, 1902, Biologia Centrali Americana, Scorp., Pedip., Solif. p. 13; Banks, 1910, Pomona Coll. J. Entomol. 2:186; Penther, 1913, Ann. K. K. Nat. Hist. Hof. Mus. p. 247; Ewing, 1928, Proc. U.S.

Nat. Mus. 73:14; Hoffmann, 1931, An. Inst. Biol. México 2(4):403-405; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip. Band 5, Abt. 4, Buch 8:284; Gertsch, 1958, Amer. Mus. Novitates 1903:14; Gertsch, 1965, Brigham Young Univ. Sci. Bull., Biol. Ser., 6(4):11; Williams, 1966, Proc. California Acad. Sci. 34(8):419-428; McDaniel, 1968, Entomol. News 79:278; Hjelle, 1972, Occ. Papers California Acad, Aci. 92:7,8; Gertsch, 1972, Bull. Amer. Mus. Nat. Hist. 148:564,565. ***Centrurus*** Wood, 1863, J. Acad. Natl. Sci. Philadelphia Apr. p. 111; Wood, 1863, J. Acad. Natl. Sci. Philadelphia 5:360,372. ***Oncocentrus*** Thorell, 1894, Bull. Soc. Entomol. Italia 25:375. ***Uroctonus*** Karsch, 1879, Mitt. Munchen Entomol. Ver. 3:103(part); Kraepelin, 1894, Mitt. Mus. Hamburg 11:196(part).

Characters—The trichobothrial patterns (Figs. 6 A,B) of *Anuroctonus* differs less than other Vejovidae than do the *Hadrurus* patterns (Table 1). The latter differs in clusters **V**, **P**, **I**, and **E**, whereas *Anuroctonus* differs in **V**, **P**, **D**, and **E** with the striking differences in clusters **V**, **P**, and **E**. *Anuroctonus* has a total trichobothrial count of 98 against only 48 on the Vejovinae.

The sternum is longer than broad. Pectines with one to four indistinct to moderately distinct middle lamellae. Pectine teeth: five to nine in the female, 6 to 11 in the male. Chelicera movable finger with very short superior tine, set at right angles to inferior tine; superior margin bears four denticles with one and two subequal, three and four very small and equal in size; inferior margin usually with a **bi** denticle which may be very small and difficult to locate because of the heavy hirsute condition. Usually this denticle is of moderate size and occasionally flanked by one to two dentoid structures. Genital papillae more triangular than cylindrical in form. Adult male aculeus with bulb near base but it is lacking in immature males. Caudal segment V wider than deep. Carapace with three pair distinct lateral eyes with one and two generally larger than number three. A fourth small eye appears to be present on some specimens but is missing on others.

Type-species—*A. phaiodactylus* (Wood), 1863.

Other species—Apparently monotypic but there are some extreme color variations.

Distribution—In our collection are specimens from Arizona, Central and Southern California, Nevada, and Utah. Other accounts on distribution are: Utah Territory (Wood, 1863b), Virginia (Pocock, 1893), Guatemala (Thorell, 1894), Texas (Kraepelin, 1901), Denver, Colorado (Pocock, 1902), Ciudad, Mexico (one Male) (Penther, 1913). Hoffman (1931) states "the species exists in the Mexican Republic apparently only in Baja California." He very likely was not aware of Penther's report.

The localities of Virginia and Guatemala are doubtful. However, Thorell's account credits Dr. G. Eisen as collector and places the specimen in the Guatemala collection of the Florentine Museum. Pocock received his Virginia specimen from the collection of Owens College, Manchester. His remarks are of interest: "I have seen a single specimen (female, with normal aculeus) from Virginia . . . Karsch . . . referred it to *Uroctonus*, and characterizes *Uroctonus* as having a series of teeth on the lower border of the digit of the chelicera. Dr. Marx also referred it to *Uroctonus*. But I cannot see any series of teeth at all comparable to the series presented by *Uroctonus*. On the contrary, there is only one tooth, not so large it is true as the one on *Hadrurus*, but occupying the same position, and the edge in front of this may be fairly roughened; but there is no structure presented that I should call a series of teeth."

This writer concurs with the observations of Pocock after examining a large series from the localities indicated above. The trichobothria, however, are now the positive differentiating characteristics for *Anuroctonus*. The bulb on the aculeus is not reliable since it is not present on large juveniles and the cheliceral teeth are also unreliable in adult specimens since these are frequently worn off very seriously from digging in hard, compact soil.

F. VEJOVINAE

10. Genus *Physoctonus* Mello-Leitão, 1934

Physoconus Mello-Leitão, 1934, An. Acad Bras. Sci. Río. 6(2):75-6; Mello-Leitão, 1945, Arq. Mus. Nac. 40:129.

The following is taken from the original description: Carapace with anterior median notch and three pair of lateral eyes; median ocular furrow present. Inferior edge of movable cheliceral finger with two blunt, well separated denticles and that of the fixed finger has a small hypophysis. Sternum pentagonal; length and width about equal. Well developed median claw on pretarsus. Last two caudal segments greatly dilated; ratio of widths of segment IV to I = 1.35; that of segment V to I = 1.47. Segment V width 2.5 times that of telson vesicle which is narrower than segment I. Stigmata linear. Tergite I-VI with median keel; VII with lateral keels. Pedipalp tarsus with an inner continuous row of granules flanked by 25 interior lateral granules; exterior lateral granules and supernumerary granules lacking. Patella with three V inferior trichobothria.

Type-species–*P. physurus* M.L., 1934.

Other species–Apparently monotypic.

Distribution–Northeast Brazil.

11. Genus *Uroctonus* Thorell, 1876

Uroctonus Thorell, 1876, Ann. Mag. Nat. Hist. 17:11; Thorell, 1876, Att. Soc. Italia Sci. 19:196; Karsch, 1879, Mitt. Munchen Entomol. Ver. 3(1):19; Karsch, 1879, Mitt. Munchen Entomol. Ver. 3(2):101-103; Pocock, 1893, Ann. Mag. Nat. Hist. 12:328; Thorell, 1894, Bull. Soc. Entomol. Italia 25:374; Kraepelin, 1894, Mitt. Mus. Hamburg 11:193(part); Kraepelin, 1899, Das Tierreichs, Scorp., Pedip. 8:182; Pocock, 1902, Biologia Centrali Americana, Scorp., Pedip., Solif. p. 14; Borelli, 1909, Portici Boll. Lab. Zool. 3:324; Comstock, 1912, *The Spider Book*, New York, p. 30; Ewing, 1928, Proc. U.S. Natl. Mus. 73:15; Hoffmann, 1931, An. Inst. Biol. México 2(4):402; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip. Band 5, Abt. 4, Buch 8:283,284; Stahnke, 1939, *Scorpions of Arizona*, Iowa State Univ. p. 70; Hjelle, 1972, Occ. Papers California Acad. Sci. 92:9(part); Gertsch and Soleglad, 1972, Bull. Amer. Mus. Nat. Hist. 148:553-564(part).

Characters–The carapace has a pronounced anterior median notch; the ratio of the anterior carapace length to the median notch depth is about 5.4 female, 6.00 male. The total taper of the carapace is about 0.48 mm/mm length (male and female); the anterior taper is about 0.65 (female), 0.79 (male) mm/mm length and the posterior taper is about 0.37 (female), 0.32 (male) mm/mm of posterior length. The median ocular furrow is lacking. Three pair of lateral eyes are present with the first two well developed but the third much smaller and placed at about 45° to the other two. The median eyes are of moderate size and placed near the front: The ratio of the anterior length to the total length is about 0.38; the ratio of the carapace length to the diameter of the eyes is about 16.25 to 17.25; the ratio of the median ocular tubercle width to the diameter of the eyes is about 2.5 female, 2.38 male; the median eyes are about 1.54 times the width of the first lateral eye; the distance between the median eyes is about 1.33 times their diameter.

The inferior surface of the cheliceral movable finger bears from three to six denticles; occasionally some may be serrate and some truncate, but more often they are all more elongate tubercular. The inferior surface of the fixed finger is devoid of denticles or tubercles. The inferior tine of the movable finger is more than twice the length of the superior tine; the superior margin bears four denticles with the second at least twice the size of the other three which are subequal.

The pedipalp tarsus inner edge has a continuous row of granules divided into six short rows by five large granules; flanking this row are seven to eight large interior lateral granules; the tibial finger bears seven large interior lateral granules; no exterior lateral granules or supernumerary granules are present.

The dorsal caudal furrow is weakly to moderately developed. The distal terminal granule of the caudal dorsal and superior lateral keels are not denticulate or spinous (Fig. 7A) and not distinctly larger than the other granules. The distal terminus of the superior lateral keel of segment IV does not bear an enlarged, subtriangular projection (Fig. 7A). The ratio of caudal segment V length to width ranges from 2.52-3.22 (females); 2.42-3.18 (male); the ratio of telson vesicle width to segment V width ranges from 1.00-1.41 (female); 1.04-1.20 (male).

For trichobothrial patterns of *Uroctonus* see Fig. 8 A,B and Table 1. Some ratios between trichobothrial distances are: Distance between D1-D6 to D1-M1 = 1.09; between E1-E4 to E1-E5 = 0.45; between E2-E4 to E2-E5 = 0.45.

The sternum is broader than long; ratio of breadth to length about 1.56 to 1.65 (female); 1.80 (male). Stigmata elongate elliptical but not circular as in Chactidae. Sternite VII lateral keels from obsolete to slight vestiges; never well developed.

Type-species—*U. mordax* Thorell, 1876.

Other species—Using the type-species of the genus *Vejovis*, *V. mexicanus*, as a basis for judgement the following species placed in *Uroctonus* by Gertsch and Soleglad (1972) must be considered as belonging to the genus *Vejovis* (which see): *U. montereus*, *U. rufulus*, *U. sequoia*, *U. bogerti*, *U. williamsi*, *U. andreas*, *U. angelenus*, *U. lindsayi*, *U. chicano*, *U. apacheanus*, *U. cazieri*, *U. huachuca* is doubtful. *U. grahami* appears to be *Uroctonus. U. glimmei* Hjelle, 1972, also belongs to the genus *Vejovis. U. yosemitensis* (Ewing), 1928 (=*V. yosemitensis*); based on a quantitative study of the type.

Distribution—In our collection we have *Uroctonus*, as herein characterized, from Arizona, Utah, Oregon and the length of California. Thorell (1894) recorded *Urocontus* from Guatemala and Hoffmann (1931) reported it from Baja. Thus far these last two localities have not been confirmed.

12. **Serradigitus**, new genus

Characters—The inner edge of the pedipalp tarsus has a continuous row of conspicuously serrate, subequal denticles, uninterrupted, or indefinitely so, by larger denticles. The terminal denticle is abnormally large and claw-like and bears on its terminus an elongated whitish cap. Interior lateral, large flanking denticles vary in position and number from six on the type-species up to 16 on other species.

Female pectines with teeth number one to three more paddle-like and somewhat larger than the others. Stigmata elongate elliptical.

For trichobothrial patterns of type-species see Fig. 6 C,D and Table 1. Ratio of distances on pedipalp patella of P7-P6 and P6-P9 = 1.24. On *V. spinigerus*, a typical vejovid, this ratio equals about 0.69. On this type-species pedipalp tibia the ratio of the distance between **D**1-**D**6 and **D**1-**M**1 equals 0.73. For *V. spinigerus* this ratio is about 0.81 and for *V. mexicanus* about 0.91. The ratio of the distance between **D**1-**D**2 and **D**2-**D**3 for the type-species is 2.85; for *V. spinigerus* 1.67 and *V. mexicanus* is 1.46.

The total trichobothria on the femur is three, the patella 19 and tibia 27 or a sum total of 49. It differs from *Uroctonus* in having two V's instead of three, 14 **P**'s instead of 13, and four **I**'s instead of three. It differs from *Vejovis* in having four **I**'s instead of three.

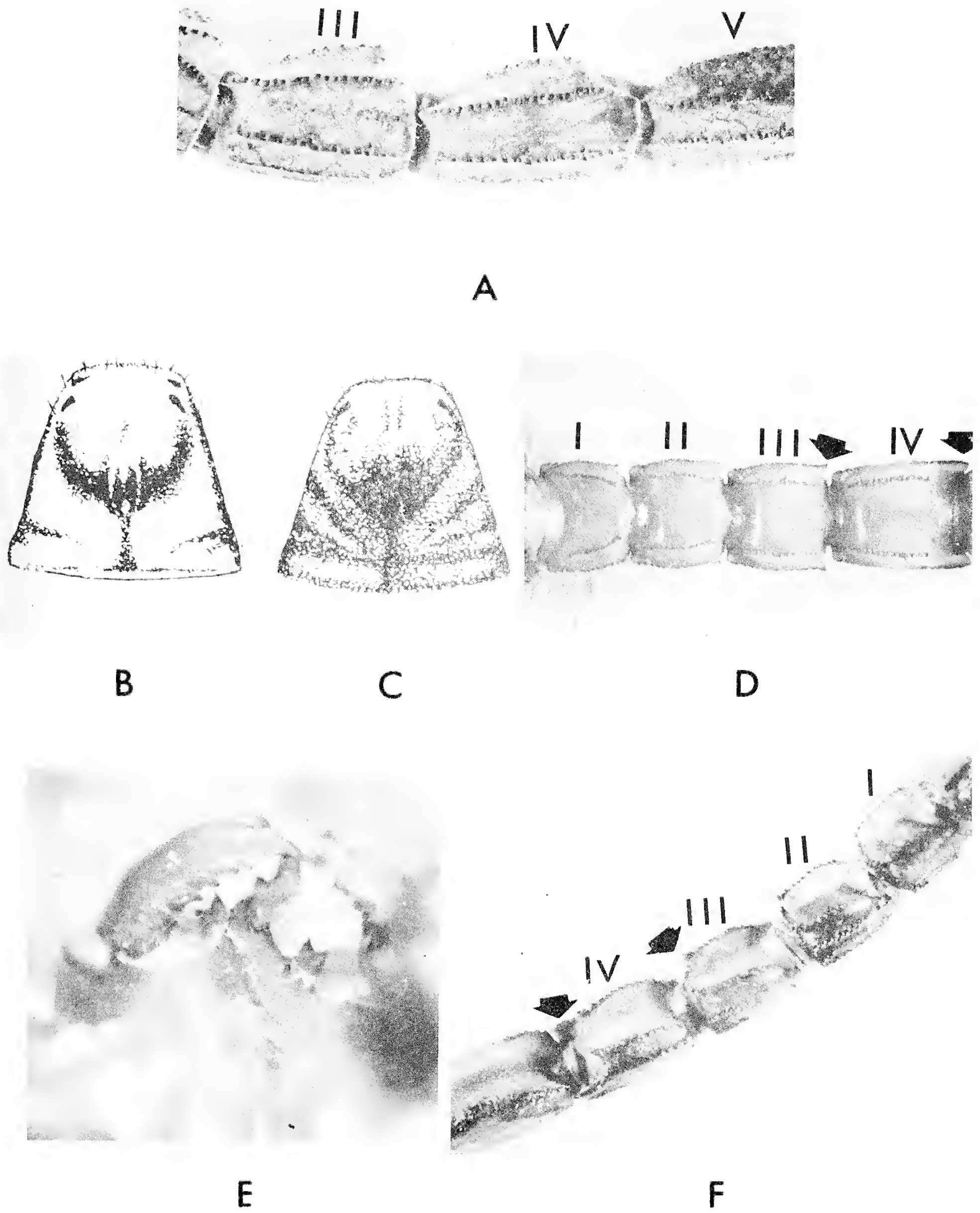

Fig. 7.–A, *Uroctonus* caudal segments (B-C from Hoffmann, 1931); B, *H. hirsutus* carapace; C, *H. aztecus*; D, *Vejovis spinigerus*, caudal segments; E, inferior cheliceral denticles of *Pseudouroctonus*; F, *Vejovis mexicanus*, caudal segments.

Type-species–*Serradigitus wupatkiensis* (Stahnke), 1940 (=*Vejovis wupatkiensis*).

Other species–*S. gertschi* (Williams), 1970 (=*V. gertschi*); *S. harbisoni* (Williams), 1970 (=*V. harbisoni*); *S. minutis* (Williams), 1970 (=*V. minutis*); *S. gramenestris* (Williams), 1970 (=*V. gramenestris*); *S. deserticola* (Williams), 1970 (=*V. deserticola*); et al.

Distribution–From southern Wyoming, western Colorado and New Mexico, Utah, Nevada, central and southern California, Arizona; Baja California and Sonora, Mexico.

13. **Pseudouroctonus**, new genus

Characters–This taxon has been mistaken for *Uroctonus* and *Vejovis mexicanus* by the lay scorpiologist. Its only known representative is a dark, reddish brown species. The stigmata are elongate ovoid. The female pectine has 10 subcircular, vaulted middle lamellae and the male 12. The genital operculum is completely divided on the male but only the posterior one-third is divided on the female. The superior interior margin of the cheliceral movable finger bears four denticles of which the second is very much larger than the other subequal three; the inferior inner margin bears from four to seven well developed denticles. The inferior margin of the fixed finger bears two or three relatively large denticles (Fig. 7E). The inner edge of the pedipalp tarsus bears a continuous row of small denticulate granules broken into shorter rows by four large denticulate granules and is flanked by five large interior granules plus two large ones on the distal terminus; terminal tooth not claw-like. Supernumerary teeth lacking. See Fig. 9 A,B and Table 1 for trichobothrial systems.

Type-species–*Pseudouroctonus reddelli* (Gertsch and Soleglad), 1972 (=*V. reddelli*).

Other species–Possibly one more species as yet undescribed.

Distribution–See excellent list in Gertsch and Soleglad. Our specimens come mainly from Brehmer Cave, New Braunfels and San Marcos, Texas. Several were taken under boards and one under a door mat.

For a comparison of the type-species of *Uroctonus*, *Vejovis*, and *Pseudouroctonus* see Table 2.

14. Genus *Vejovis* Koch, 1836

Vaejovis Koch, 1836, Arach., 3:51; Koch, 1837, Uber Arachnidensystems, Nürmberg 1:38; Gervais, 1844, Scorpions, 3:50, in Walckenaer, Ins. Apt.; Peters, 1861, Monbr. Ak. Bert. 16:510; Pocock, 1898, Ann. Mag. Nat. Hist. 1:394; Pocock, 1902, Biología Centrali Americana, Scorp., Pedip., Solif. p. 8; Borelli, 1909, Bo. Lab. Zool. Gen. Agraria 3:234; Herrera, 1917, Bol. Dir. Estr. Biol. México 2:271; Ewing, 1928, Proc. U.S. Natl. Mus. 2730:7; Roewer, 1943, Senckenbergianna 26:235; Hjelle, 1972, Occas. Papers California Acad. Sci. 92:20. ***Vejovis*** Thorell, 1876, Ann. Mag. Nat. Hist. 17:10 (emend.); Kraepelin, 1894, Mitt. Mus. Hamburg 11:198; Laurie, 1896, Ann. Mag. Nat. Hist. 18:130; Kraepelin, 1899, Das Tierreich, Scorp., Pedip. 8:133; Comstock, 1912, *The Spider Book*, New York, p. 31; Penther, 1913, Ann. K. K. Nat. Hist. Hof. Mus. p. 247; Birula, 1917, Fauna of Russia, Arach., Scorp. 1(1)57; Birula, 1917, Ann. Caucasian Mus., Ser. A, 5:163,191; Hoffmann, 1931, Ann. Inst. Biol. México 2(4)346; Mello-Leitão, 1934, Ann. Acad. Brasil Sci. 6(2):77; Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Scorp., Pedip. Band 5, Abt. 4, Buch 8:282; Stahnke, 1939, *Scorpions of Arizona*, Iowa State Univ., pp. 70-72; Mello-Leitão, 1945, Arq. Mus. Nac. 40:118; Gertsch and Allred, 1965, Brigham Young Univ. Sci. Bull., Biol. Ser., 6(4)3(part); Gertsch and Soleglad, 1966, Amer. Mus. Novitates 2278:3(part); Williams, 1970, Pan-Pac. Entomol., 46:1; Gertsch and Soleglad

1972, Bull. Amer. Mus. Nat. Hist. 148:593. ***Buthus***, Wood, 1863, J. Acad. Nat. Sci. Philadelphia 5:368-371; Wood, 1864, Proc. Acad. Nat. Sci. Philadelphia p. 109.

Characters—From a study of the syntypes of *Vejovis mexicanus* Koch, the type-species and closely related taxa, the following appear to be significant generic characteristics:

Carapace approximately as long as broad (male may be slightly longer than broad) with an anterior-posterior taper of 0.48-0.53 male and 0.38-0.47 female mm/mm length. Three pair lateral eyes; the first two well developed but the third may be small or

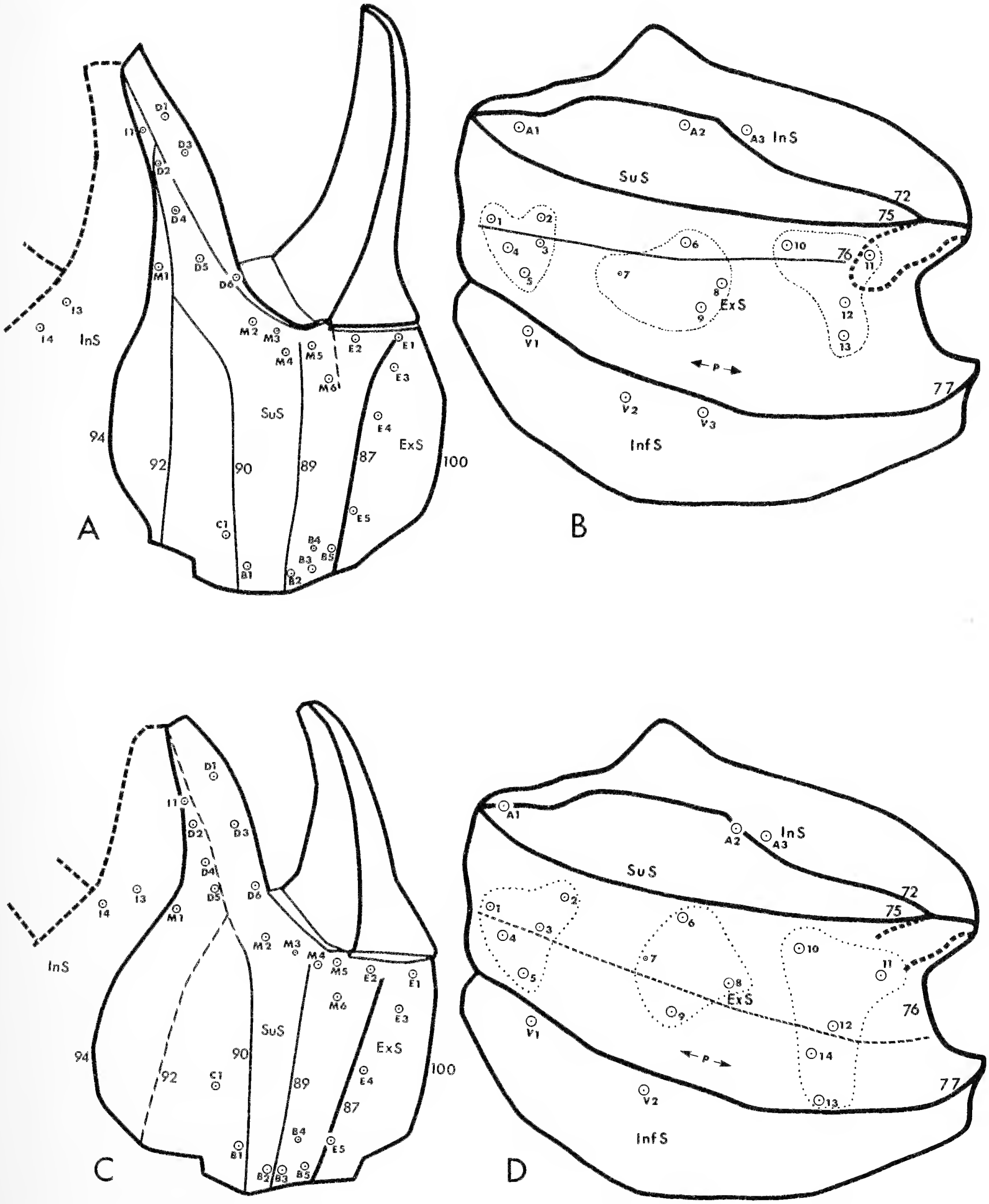

Fig. 8.—Trichobothrial systems: A-B, *Uroctonus* chela and patella; C-D, *Vejovis montereus* chela and patella.

obsolete. Median eyes weakly to moderately developed and located about 0.30-0.35 of carapace length from anterior margin which may be straight to moderately notched. The sternum is about as broad as long or broader than long with a deep median groove.

Inferior surfaces of cheliceral fingers without denticles or tubercles; the inner inferior edge of movable finger may be repand. Pedipalp tarsus inner edge bears a straight row of small granules divided into a series of six smaller rows, including a short distal row, by five large denticles, or possibly seven rows due to a large granule sometimes present midway in the basal granular row. Seven interior lateral denticles are present. Exterior lateral denticles and supernumerary granules are lacking. For trichobothrial patterns see Fig. 9 C,D, and Table 1.

Tarsomere II with a median row of short bristles or spinlets on soles. Legs without macrochaete combs.

Dorsal and superior lateral keels of cauda with distal granule more denticulate (or spinous) and larger than preceding ones; the distal terminus of superior lateral keels of segment IV flat, subtriangular and projecting somewhat laterad (Fig. 7 D,F). Ratio of caudal segment V length to width generally under 2.30.

Genital operculum of male divided entire length, female undivided or divided approximately two-thirds the length. Pectines with fewer than 16 middle lamellae organized in a single row. Stigmata elongate elliptical to slit-like.

The genus *Vejovis* differs from *Uroctonus* as shown in Table 3.

Type-species–*V. mexicanus* Koch, 1836.

Table 3. Inter-generic differences between *Vejovis* and *Uroctonus.*

	V. mexicanus	*U. mordax*
1. Ratio metasoma L : manus L	♀ 9.00 ♂ 8.68	♀ 5.35 ♂ 6.14
2. R. carapace anterior L : notch depth	11:00 to infin.	5.00 to 6.00
3. Ratio of carapace L:W	♀ 1.00 ♂ 1.13	♀ 0.93 ♂ 0.97
4. R. caudal segment V L:W	♀ 2.00 ♂ 2.06	♀ 2.52-3.22 ♂ 2.42-3.18
5. Ratio of carapace med. W.: med. ocular W	♀ 5.00 ♂ 4.88	♀ 5.90 ♂ 5.68
6. Trichobothria V	2	3
7. Denticles on inferior surface chel. M.F.	0	3 to 6

Table 4. Correlations showing inter-generic relationships between *Vejovis* and *Uroctonus.*

	V. mexicanus		*U. mordax*	
	male	female	male	female
P. gracilior	0.35	0.40	0.33	0.53
P. vachoni	0.55	0.58	0.29	0.26
P. boreus	0.50	0.63	0.35	0.57
U. mordax	0.51	0.61	–	–

Other species–*V. carolinianus* Beauvois, 1905 (=*V. carolinus* Koch, 1843); *V. nitidulus* Koch, 1843; *V. punctipalpi* (Wood), 1863; *V. eusthenura* (Wood), 1863; *V. spinigerus* (Wood), 1863; *V. punctatus* Karsch, 1879; *V. crassimanus* Pocock, 1898; *V. pusillus* Pocock, 1898; *V. granulatus* Pocock, 1898; *V. bilineatus* Pocock, 1898; *V. flavus* Banks, 1900; *V. minimus* Kraepelin, 1911; *V. hirsuticauda* Banks, 1928; *V. confusus* Stahnke, 1940; *V. jonesi* Stahnke, 1940; *V. lapidicola* Stahnke, 1940; *V. vorhiesi* Stahnke, 1940; *V. coahuilae* Williams, 1966; *V. gilvus* Williams, 1968; *V. diazi* Williams, 1970; *V. hoffmanni* Williams, 1970; *V. gravicaudus* Williams, 1970; *V. waeringi* Williams, 1970; *V.*

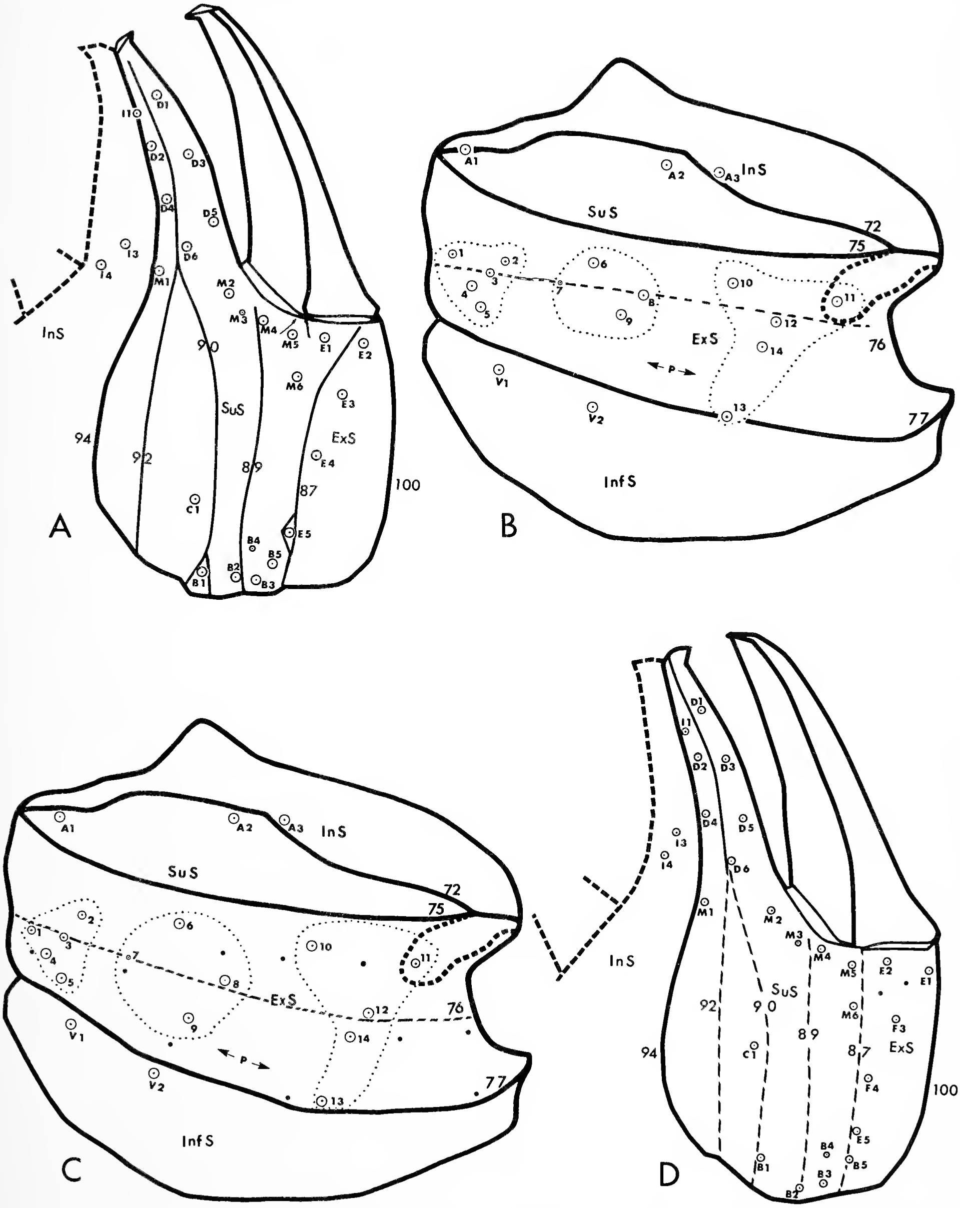

Fig. 9.–Trichobothrial systems: A-B, *Pseudouroctonus* chela and patella; C-D, *Vejovis*, patella and chela.

coloradensis Williams, 1970; *V. galbus* Williams, 1970; *V. ivei* Gertsch and Soledad, 1972; *V. vaquero* G & S, 1972; *V. waueri*G & S, 1972; *V. andreas*(G & S), 1972; *V. bogerti* (G & S), 1972; *V. montereus* (G & S), 1972; *V. sequoia* (G & S), 1972; *V. williamsi* (G & S), 1972; *V. angelenus* (G & S), 1972; *V. lindsayi* (G & S), 1972; *V. chicano* (G & S), 1972; *V. apacheanus* (G & S), 1972; *V. cazieri* (G & S), 1972; *V. glimmei* (Hjelle), 1972.

Species that appear to be of doubtful status have been omitted.

Distribution—*Vejovis* have been taken as far south as Veracruz, Mexico and as far north as northern California. Apparently only one species extends to our eastern seaboard. Westward the number of species begin to increase in eastern Texas with the greatest number of species known from Arizona, California; Baja California, Mexico, and mainland Mexico. The center of distribution seems to be in Mexico. Undoubtedly many more new species will be uncovered in this area. With the increased use of U.V. light detection many more species will not only be found in Mexico, but also in New Mexico, Colorado, and Texas.

15. Genus *Paruroctonus* Werner, 1934

Uroctonoides Hoffmann, 1931, Ann. Inst. Biol. México 2(4)405 (*nec.* Chamberlin, 1920, Mus. Sci. Bull. Brooklyn 3:35-44). *Paruroctonus* Werner, 1934, Bronns Klassen und Ordnungen des Tierreichs, Band 5, Abt. 4, Buch 8:283; Stahnke, 1957, Entomol. News 68:253-259; Williams, 1972, Occ. Papers California Acad. Sci. 94:1-16. *Hoffmanniellus* Mello-Leitão, 1934, An. Acad. Brasil Sci. 6(2)75-82. *Vejovis*, Gertsch and Allred, 1965, Brigham Young Univ. Sci. Bull., Biol. Ser., 6(4)3,4(part); Gertsch and Soleglad, 1966, Amer. Mus. Novitates 2278:3-52(part).

Characters—This rather distinctive taxon, first introduced into the literature by Hoffmann (1931) as *Uroctonoides* has given subsequent taxonomists difficulty, because they like Hoffmann have tried to characterize it with a few subjective characteristics. As his name for the taxon suggests, he considered it closely related to *Uroctonus*. According to his description this conclusion seems to be based primarily upon the presence of dentoid structures on the inferior inner margin of the cheliceral movable finger. *Uroctonus* has definite denticles, some of which are often distinctly serrate while those of *Paruroctonus gracilior* are at best angular scallops. Werner (1934) discovered that the name *Uroctonoides* was occupied (see synonymy) but in renaming it apparently made the same error when he introduced the name *Paruroctonus*. He then placed the genus in the Uroctoninae. However, in his key to the subfamilies the dichotomy leading to this taxon reads "pectines with indefinite, or not over 6 middle lamellae." In his description of *Paruroctonus* he states that it has 18 middle lamellae. Gertsch and Allred (1965) likewise emphasized the cheliceral structures. Since they considered the chelicera similar in structure in *Uroctonus*, *Vejovis*, and *Paruroctonus* they gave the latter only subgeneric status. Williams (1972) correctly tries to remove the focus from cheliceral denticles or dentoid structures but errs by his inadequate characterization of the genus. For example, his statement that the genital operculum of vejovid females is completely fused is incorrect. On *V. mexicanus* and other species the genital operculum is only partially fused along the median, longitudinal furrow. Also, distinct denticles, he states, are always present on the inferior border of the movable cheliceral fingers of *Paruroctonus*. Sometimes only a strongly repand condition prevails and never are distinct denticles found, as in *Uroctonus* and *Pseudouroctonus*, but at most only angular scallops. Furthermore, his statement that the pedipalp palms of *Paruroctonus* are "somewhat less swollen"

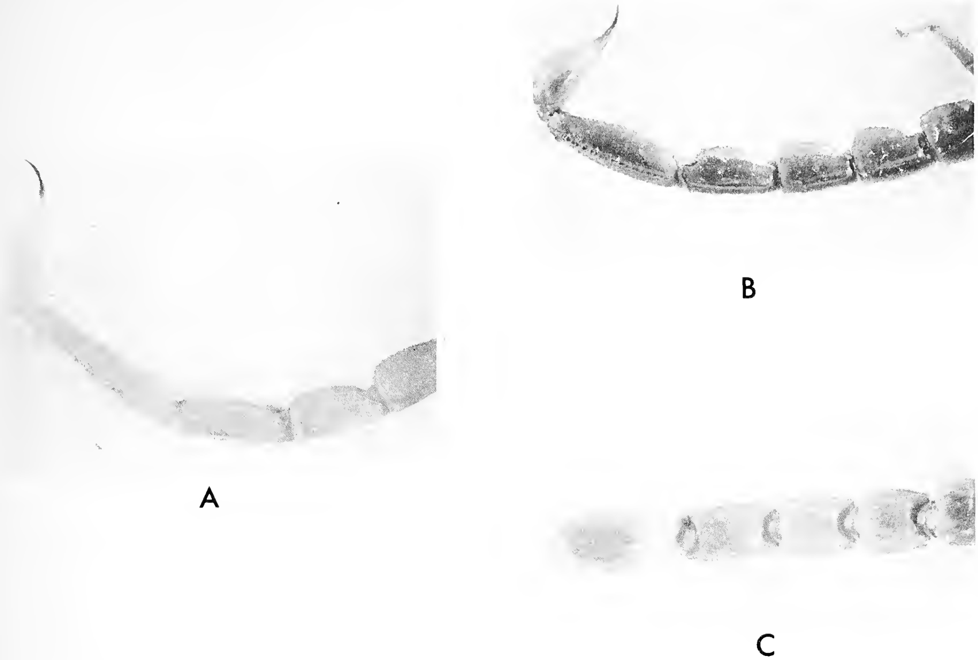

Fig. 10.–Cauda: A, *P. gracilior;* B-C, *P. boreus.*

than *Uroctonus* certainly does not clearly differentiate these taxa. This may be a visual impression but actually the opposite seems to be true. The ratio of manus length to width for the male *U. mordax* is about 1.45, that of *P. vachoni* 1.39, and of *P. gracilor* 1.35. Even the ratio of total tibial length to manus width shows *U. mordax* as 2.37 and *P. gracilior* 2.30. The ratio of manus length to thickness gives similar results, i.e. *Uroctonus* manus actually is not more swollen than that of *Paruroctonus.*

Paruroctonus boreus (Girard) appears more closely related to *Vejovis mexicanus* than the more typical *Paruroctonus*. In fact a more analytical study of the entire genus may indicate that "*boreus*" is representative of a subgenus or perhaps another genus.

Hoffmann's "*gracilior*" designation of the type-species seems more descriptive of the genus than his *Uroctonoides*. This over-all impression is primarily due to the long, slender cauda. The ratio of the length/width of segment V in the typical form ranges from 3.79 to 4.10 and the atypical forms, such as *P. boreus* and *P. aquilionalis* range from 2.45 to 3.04. In contrast, these ratios for *Vejovis*, except for a few unusual forms, do not go above 2.30 and very frequently below 2.00.

In *Paruroctonus* the dorsal and superior lateral keels do not have the distal granule noticeably larger or more denticulate, nor is the distal terminus of the dorsal keel on segment V flat and subtriangular (Fig. 10). The dorsal caudal furrow is also weakly developed. In this respect it resembles *Uroctonus* (Fig. 7A) but is in sharp contrast to *Vejovis* (Fig. 7 D,F).

Paruroctonus has three pair of well developed lateral eyes with the third pair of smaller diameter but always distinct. The median eyes are often relatively large on the typical forms and may be from 2.3 to 3.0 times the diameter of the first pair of lateral eyes; on *P. boreus* this may reduce to 1.65 in females and 2.00 in males. On *Uroctonus* this ratio lowers to 1.54 in females and in males and on *V. mexicanus* to 1.00 in females and 1.15

in males. In *Paruroctonus* the ratio of the carapace length to the diameter of the median eyes ranges from approximately 9.50 to 14.19; this ratio in *Uroctonus* ranges from 16.25 to 17.25 and in *V. mexicanus* from 17.10 to 18.79. The anterior margin of the carapace on *Paruroctonus* is either straight or projects slightly. The total anterior-posterior taper of *Paruroctonus* ranges from 0.31-0.38 mm/mm of length, whereas the *Uroctonus* taper is about 0.48 mm/mm of length. The anterior taper of the *Paruroctonus* ranges from 0.33-0.50 mm/mm of length but this ratio for both *Uroctonus* and *V. mexicanus* ranges from 0.67-0.79 mm/mm of length.

The cheliceral fixed finger of *Paruroctonus* has the usual vejovid denticulate structure. On the movable finger the superior tine is distinctly shorter than the inferior one and may be subparallel, or almost at right angles, to the inferior tine. Of the four denticles on the superior margin of the movable finger one, three, and four are subequal but two is about twice the size of either of the other three. The inferior edge of the movable finger is not smooth but may be deeply repand or bear angular scallops. The inferior surface of the fixed finger may bear one to three tubercles or tubercular denticles.

A general concept of the inter-generic relationships may be obtained from Table 4 which shows correlations derived from forty-one variables.

The typical trichobothrial systems for the genus are shown in Fig. 11 A,D and in Table 1.

Type-species—*P. gracilior* (Hoffmann), 1931.

Other species—*P. boreus* (Girard), 1853; *P. aquilionalis* (Stahnke), 1940; *P. mesaensis* Stahnke, 1957; *P. vachoni* Stahnke, 1961; *P. bantai* (Gertsch and Soleglad), 1966; *P. stahnkei* (G & S), 1966; *P. xanthus* (G & S), 1966; *P. luteolus* (G & S), 1966; *P. auratus* (G & S), 1966; *P. becki* (Gertsch and Allred), 1965; *P. utahensis* (Williams), 1968; *P. pallidus* (Williams), 1968; *P. shulovi* (Williams), 1970; *P. minckleyi* (Williams), 1968; *P. grandis* (Williams), 1970; *P. pumilis* (Williams), 1970; *P. pseudopumilus* (Williams), 1970; *P. viscainensis* (Williams), 1970.

Species that seem to be of doubtful status have been omitted.

Distribution—In our collection we have specimens from Osoyoso, B.C., Canada; Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, Texas, Utah, Washington, Wyoming; throughout the Baja peninsula and the states of Sonora, Chihuahua, and Coahuila.

Ewing (1928) reports species of this genus from South Dakota and Nebraska. Hoffmann (1931) gives the type locality of *P. gracilior* as Aguascalientes, Mexico.

Its center of distribution appears to be Arizona, California, Nevada and into northern Mexico and the Baja peninsula.

DISCUSSION

The trichobothria appear to be excellent indicators of systematic affinity. Table 1 shows that C1 is not found on *Diplocentrus* but is present on all Vejovidae except *Iurus*. The five trichobothria of the **E** cluster are present in all taxa except the Hadrurinae; this subfamily is sharply different from all the others. However, on the chela are found the characteristic family patterns in the **D**, **M**, and **B** clusters.

From the consistency displayed in other subfamilies it seems obvious that the Scorpiopsinae should be divided into more genera. Such a decision should be supported, however, by quantitative data taken from an ample sampling.

The Vejovinae show a fairly consistent pattern so that generic status is determined mainly from other characteristics and quantitative comparisons. However, the migration of trichobothria within the clusters seem to be significant. In *Uroctonus* V3 is present but in *Pseudouroctonus*, with only V1 and V2 present, P13 has migrated onto the inferior-exterior keel in such a manner as to suggest that V3 is a migrant P13. The significance of migration at the species level will have to be determined through careful quantitative studies. For example, in the **D** and **P** clusters, are such differences as the formation by certain trichobothria of isoceles, scalene, equilateral, etc. triangles of systematic significance? If so very excellent key characteristics will be available regardless of the scorpion's age. Even now the recognition of the vast differences in the number and

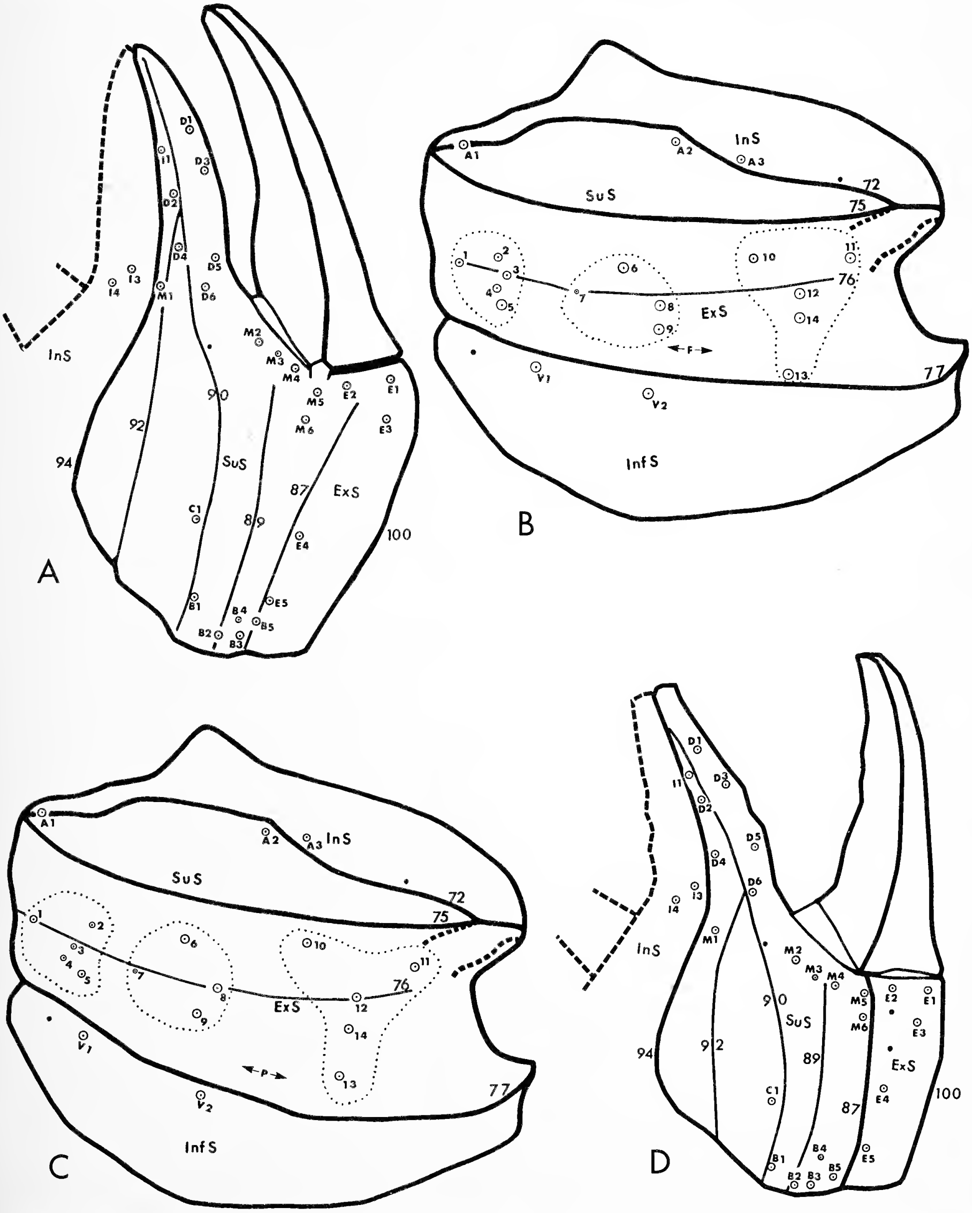

Fig. 11.–Trichobothrial systems: A-B, *Paruroctonus gracilior*, chela and patella; C-D, *Paruroctonus boreus*, patella and chela.

arrangement of these setae on the Hadrurinae make for quick and positive identification of taxon status of juveniles of these taxa.

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Sincere appreciation is expressed to Sherman Minton, Jr., for vejovid specimens from West Pakistan, to C. L. Kau for specimens from Landour, India and to the following for the loan of material for study and the courtesies extended while visiting their various institutions: M. S. U. Siddiqi, Zoological Survey of Pakistan; P. L. Sina, Bengal Veterinary College, Calcutta; A. P. Kapur, Zoological Survey of India; K. H. Hyatt, and the late D. J. Clark, British Museum (Natural History); B. Hubendick, Goteborgs Museum of Natural History; M. Mortiz, Zoologisches Museum für Naturkunde Humboldt-Universitat, E. Berlin; E. Tortonese, Museo Civico di Storia Naturale (Genoa); M. Vachon, Museum National d' Histoire Naturelle (Paris); I. Likharev, Zoological Institute Academy of Sciences (Leningrad); V. Baldasseroni, Zoological Museum, Univ. Florence (Italy); L. Pardi, Instituto e Museo di Zoologia (Torino); W. Gertsch (Emeritus), American Museum of Natural History; H. Levi, Museum of Comparative Zoology, Harvard University; R. E. Crabill, and K. V. Krombein, U.S. National Museum of Natural History, Smithsonian Institution; California Academy of Sciences. Technical assistance is also credited to R. L. Johns.

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Received for publication 18 April 1973

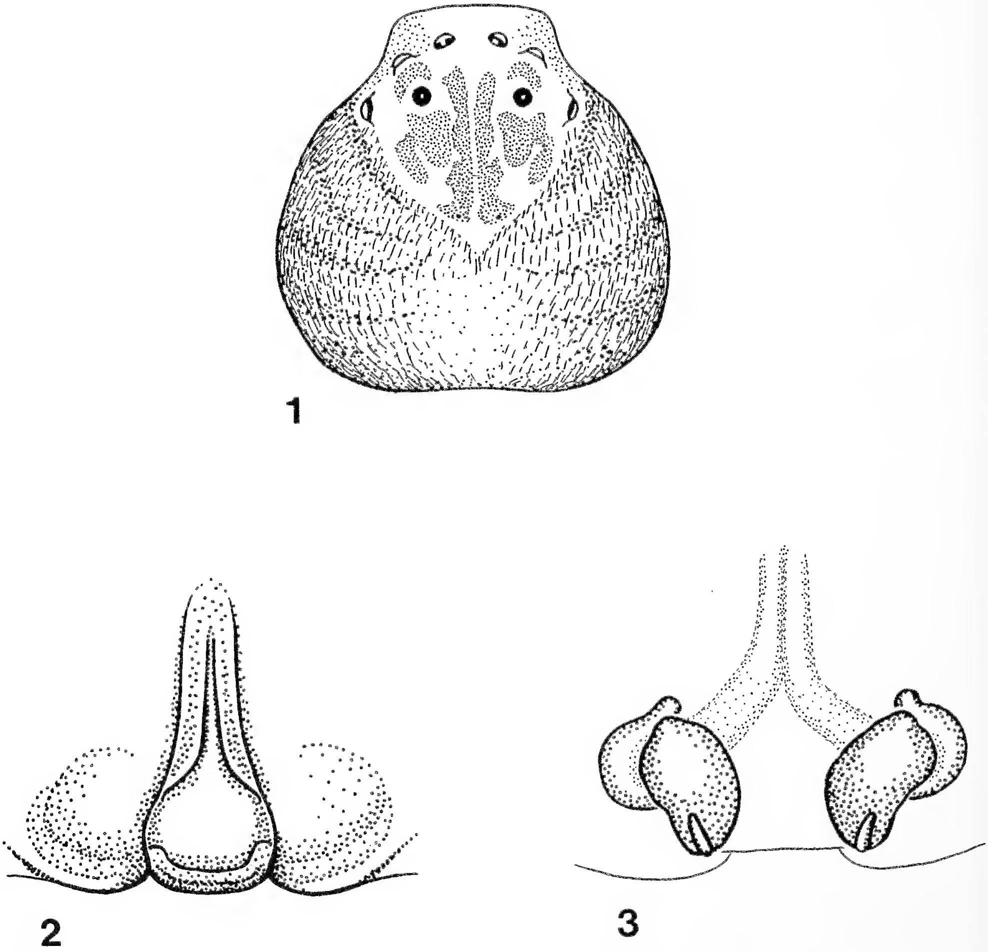
RESEARCH NOTES

A NEW *PHILODROMUS* (ARANEAE: THOMISIDAE) FROM ARIZONA

Philodromus eremus, new species

Male.—Unknown.

Female.—Total length 5.4 mm; cephalothorax 2.05 mm long and 2.03 mm wide. Femur I 2.35 mm long; femur II 2.68 mm long. Carapace orange-brown, darker laterally; meta- and prodiscal areas patterned with pale creamy orange (Fig. 1). Eyes, except anterior medians, on low tubercles; with inconspicuous narrow light marginal rings; posterior medians closer to anterior laterals than to posterior laterals. Legs with relatively dense scopulae; orange-brown, irregularly speckled and blotched with darker brown; darker at segment ends; with incompletely developed dark dorsal stripe on patella, tibia



Figs. 1-3.—Structures of *Philodromus eremus*, new species: 1, Female carapace; 2, Epigynum; 3, Female genitalia, dorsal view.

and metatarsus. Femur I with 3 dorsal macrosetae and 3 prolaterals; tibia I with 2 dorsal macrosetae, 3 prolaterals, 3 retrolaterals and 3 pairs of ventrals. Abdomen cleft in front, evenly rounded laterally, widest at middle, its form reminiscent of the genus *Rhysodromus*. Dorsum of abdomen with dark heart mark followed by median dark area which narrows posteriorly; covered with feathery golden-brown scales. Sides with mottled pattern of brown and pale scales. Venter pale.

Epigynum with median septum narrow anteriorly and expanding posteriorly into a broad plate (Fig. 2). Spermathecae as shown (Fig. 3).

Type.—Holotype female from the Chiricahua Mountains, Cochise County, Arizona (1 July 1965. V. Roth), deposited in the American Museum of Natural History.

Range.—Known only from the type locality.

Comments and diagnosis.—The female of *Philodromus eremus* is distinguished from other members of the genus *Philodromus* by its genitalia. The form of the spermathecae and that of the epigynum, especially its median septum, is distinctive. In general appearance *P. eremus* is closest to certain species of the *aureolus* group (*P. keyserlingi* Marx, *P. spectabilis* Keyserling) but its placement with certainty awaits the discovery of the male.

Dr. C. D. Dondale made the specimen available for study and provided helpful comments. My wife Judith did the drawings. **Donald J. Buckle** GBS 1-7, R.R. 1, Preeceville, Saskatchewan.

EGG COCOON OF THE FILMY DOME SPIDER, *LINYPHIA MARGINATA* C. L. KOCH (ARANEAE: LINYPHIIDAE)

Neither McCook (Acad. Nat. Sci. Philadelphia 2:119, 1890) nor Kaston (Bull. Connecticut Geol. Nat. Hist. Surv. 70:123, 1948) could find the eggs of the very common filmy dome spider, *Linyphia marginata* C. L. Koch, but both referred to Blackwall (*A History of the Spiders of Great Britain and Ireland,* Ray Society, London, 1941), who reported that the female of this species attaches her cocoon "to withered leaves, or other objects situated near the snare." However, Blackwall's *L. marginata* is not *L. marginata* C. L. Koch, but instead is synonomous with *L. montana* Sundevall and *L. resupina* Wider. [According to Bristowe (*The Comity of Spiders,* Ray Society, London. 1941) *L. marginata* Blackwall is also synonomous with *L. resupina domestica* (Linnaeus).] Blackwall uses the name *L. triangularis* for *L. marginata* C. L. Koch and does not mention the egg cocoon. Eliminating Kaston's and McCook's incorrect references thus leaves no record of the filmy dome spider's egg cocoon.

In 1972 a study was made of *L. marginata* inhabiting ground junipers (*Juniperus communis*) in oak woods on the E. S. George Reserve, Pinckney, Michigan. During May and June I observed many females mate, become gravid, and later disappear, but failed to find any egg cocoons. During the next two months eight apparently gravid spiders were placed in separate isolators made of aluminum insect screening, 30 cm high and 20 cm in diameter, covered top and bottom with fiberglass screening. Each isolator contained dirt covered with oak leaves and was placed in the woods. The spiders built webs in the isolators, and six spiders had deposited single egg cocoons within six days of being introduced into the isolators. Two spiders died without laying eggs. Four cocoons were deposited under the leaves, on the dirt, and two were placed in the curl of a leaf. The cocoons were loosely woven masses of white silk, approximately 7 mm in diameter and 4 mm high, surrounding nonagglutinated yellow eggs. Each egg was approximately 0.6 mm in diameter and weighed about 0.12 mg. The number per cocoon ranged from 63 to 93 (mean of 78) for five cocoons; eggs in the sixth cocoon were desiccated and could not be counted accurately. Eggs comprised about 95% of the cocoon's total weight and represented about 50% of the gravid female's weight.

These observations do not indicate how far from the web the female normally places her egg cocoon. It is clear that she leaves the eggs and either returns to her web or constructs a new one. Five spiders were marked and returned to juniper bushes; four remained and built webs but disappeared before becoming gravid again. The sixth female was fed fruit flies (*Drosophila melanogaster*) in an outdoor cage and appeared to be developing a second clutch of eggs, but she died without laying them.

L. marginata may not usually deposit its egg cocoon on the dirt; the exact location may depend upon the litter's depth and relative humidity. Inability to locate egg cocoons in nature and the location of eggs in the isolators lead to the conclusion, though, that *L. marginata* deposits its eggs deep in the litter, not on an exposed surface. Several other species of *Linyphia* place their eggs closer to the web or in more exposed locations (Nielsen, *The Biology of Spiders, with Especial Reference to the Danish Fauna.* Levin and Munksgaard, Copenhagen. 1931; Turnbull, Can. J. Zool. 38:859-873, 1960).

This work was supported in part by a National Science Foundation Graduate Fellowship; a grant from the National Science Foundation, GB-25986, to N. G. Hairston, the University of Michigan, for research in Systematic and Evolutionary Biology; and a Graduate Student Dissertation Research Grant, the University of Michigan. **David H. Wise**, Museum of Zoology, University of Michigan, Ann Arbor, Michigan 48104.

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CONTENTS

THE JOURNAL OF ARACHNOLOGY

Volume 1 May 1973 Number 2

Feature Articles

Research Notes

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7/26

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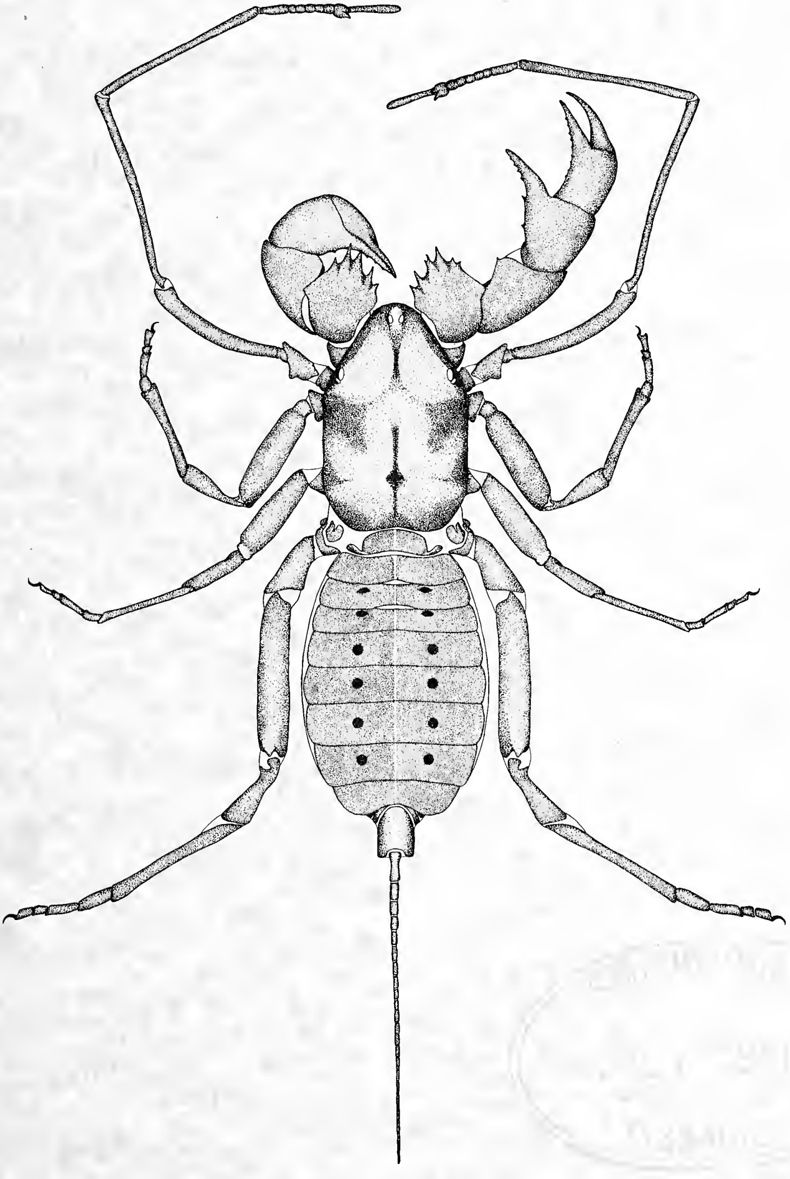

OLUME 1 SEPTEMBER 1973 NUMBER 3

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THE JOURNAL OF ARACHNOLOGY

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(continued on inside back cover)

Gertsch, W. J. 1974. The spider family Leptonetidae in North America. J. Arachnol. 1:145-203.

THE SPIDER FAMILY LEPTONETIDAE IN NORTH AMERICA

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ABSTRACT

A systematic review of spiders of the family Leptonetidae in North America is presented with analyses of their characters and relationships. Reasons are given for using only two generic names for the 44 taxa of this fauna, most of which are described as new. The subfamily Leptonetinae includes all representatives of the world fauna in which the posterior median eyes are situated far back of the posterior lateral eyes. The genus *Leptoneta*, which is the basic standard of the family and occurs widely in Palearctica, is considered to include all but three of the American species. Its disjunct distribution in North America makes possible treatment of different faunas of four quite discrete centers of distribution. The largest fauna of 15 species occurs in the southern Appalachian Mountains, includes six epigean species and nine cavernicoles; of the latter one from Georgia is an eyeless troglobite and others have eyes in various stages of reduction. A dozen species from the Edwards Plateau Region of middle Texas and some outlying districts are related to those of Appalachia; one of the nine cavernicoles is eyeless and others have rudimentary eyes. Nine species from eastern Mexico show more morphological variability but differ little in basic features from those from the southeastern United States; two of them are blind troglobites. The five Californian representatives of *Leptoneta* are all big-eyed epigean types notable for remarkable, derivative modifications of the male palpi of some. A new genus *Archoleptoneta* is given subfamily status for various unusual features. The posterior median eyes form a transverse row with the posterior lateral eyes in an eye formula probably reminescent of the ancestral stock of the family. The male palpus presents generalized features of the bulb and especially of the tarsus which lacks a transverse groove present in various degrees of development in the Leptonetinae. *Archoleptoneta* is an exclusively American group so far known from three species in California, Texas and Chiapas, México.

INTRODUCTION

This family of minute spiders is identified with cave habitats more than any other and most of the species have been described from caves. The typical cave leptonetid is white or yellowish with scarcely any dark pattern, a sedentary aerial spider that hangs from a small tangle or sheet web on long thin legs. Its eyes are normally of small size, may be reduced to vestiges or may be completely obsolete. The eyeless ones are obligative cavernicoles but it is also likely that others with reduced or rudimentary eyes may deserve such a classification. Several species of Europe, where few are completely blind, are regarded as being troglobites. The eyeless species so far noted from the Americas are the following: *Leptoneta isolata* Gertsch and *L. capilla* Gertsch from México and *Leptoneta*

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anopica Gertsch and *L. georgia* Gertsch described in this paper from Texas and Georgia in the United States. Other suggested species with reduced eyes noted in the descriptions may eventually prove to be troglobites. Leptonetids from epigean situations are lucifugous types with shorter legs and evidence of dusky pattern of carapace and abdomen. They live deep in ground detritus and under imbedded rocks in mesic situations of forests and mountains. Some of these differ very little from their cave relatives.

The present revision, based on much recently collected material in the American Museum of Natural History in New York, represents a preliminary report on the family Leptonetidae in North America. To a considerable extent it has been prompted by need for specific names by colleagues doing geographical studies of caves and faunas. Several more species have been added to the Mexican fauna considered by me (Gertsch, 1971) on the basis of various cave representatives. Up to the present time only six leptonetids have been reported from the United States where the family has been considered to be a rare one. One of these species came from a Texas cave, three were taken in the Appalachian Mountains, and two came from California and Oregon. The American fauna is herein very substantially enlarged to 44 species, and it is obvious that eventually this fauna will be found far richer even than shown by the presently available material. Of outstanding interest is discovery of a new genus, *Archoleptoneta*, which presents what may well have been the original eye pattern of the family.

North American leptonetids have so far been taken only in four, quite discretely separated centers as follows: the southern Appalachian Mountains of our southeast; the Edwards Plateau and adjacent areas of Texas; the mountains of eastern México; and the Californian region of our northwest. Most material has come from students of cave faunas who have emphasized cavernicolous habitats, thus accounting for 26 of the known species. The epigean species number 18 from the four centers and include the six so far known from the Californian region. The Mexican fauna is less well known than the others and its taxa likely will be found to have wider ranges. The distribution pattern for the leptonetids is found repeated in other groups of generalized spiders, notably the Nesticidae, which for the most part presents nuclei of species groups in each of the mentioned centers. The following systematic considerations of the American Leptonetidae treats the taxa of each center as a separate entity.

FAMILY LEPTONETIDAE

Simon, 1893, pp. 279-285 (Part). Fage, 1913, pp. 481-577. Bonnet, 1957, p. 2395.

Small haplogyne spiders of suborder Araneomorphae. Respiratory system consisting of pair of book lungs at base of abdomen and double system of tracheal tubes within abdomen opening through single spiracle in front of spinnerets. Spinnerets six; colulus small, flat lobe bearing few setae. Eyes nocturnal; anterior median eyes obsolete; anterior lateral eyes contiguous in front as first row; four posterior eyes in transverse row (*Archoleptoneta)* or in strongly procurved row, with median eyes placed far back from recurved row of four in front (*Leptoneta*, etc.). Chelicerae without lateral condyle, elongated, free at base, with long thin fang; promargin armed with row of small teeth and thin carina in basal half; retromargin with few trivial denticles. Labium immobile, little wider than long, with transverse groove. Endite longer than broad, narrowly to broadly rounded at apex, moderately convergent, with apical scopula and thin serrula on outer corner. Legs long, thin, with weak spines or none; three tarsal claws usually on onychium; trichobothrial pattern: one on metatarsi and single row of one to four on tibiae. Female palpus with long claw. Epigynum internal, with atriobursal orifices below lip of genital groove leading to voluminous pouch and single tube on each side. Male palpus generalized; tarsus leg-like segment, little modified, with weakly developed alveolus to hold bulb.

Discussion—The family Leptonetidae was characterized by Fage (1913) in an excellent paper describing the European fauna. The stem genus *Leptoneta* was represented by a series of closely allied species in which the transversely grooved tarsus of the male palpus was produced in front into a prominent retrolateral lobe bearing a conspicuous modified seta. Two species lacking such modifications on the tarsi and having slightly different dentition on the chelicerae were given generic rank as *Paraleptoneta*. The several genera established since that time for Paleartic leptonetids were based on such features as shape of the endites, presence or absence of an apical serrula on the endites, shape of the sternum, on the number and arrangement of teeth on the promargin of the chelicerae, and especially on the interesting specializations of the palpi of males. Most of these characters are integradient and fragment the basic pattern of *Leptoneta* in directions even within what are obviously closely allied series. Only after a world revision of these difficult spiders, certain to be far more numerous than so far known, becomes available can the generic limits be adequately defined. To my mind the genera so far proposed mostly represent species groups so it is a matter of taste whether one or many generic names be used. The American species differ in insignificant features from those of Europe so I have decided to use only the generic name *Leptoneta* for the many species of the United States and México. This keeps *Leptoneta* in line with similar generalized genera, such as *Nesticus*, with clusters of species groups in various world centers all retained within a single generic unit.

SUBFAMILY LEPTONETINAE

Diagnosis—Diad of posterior median eyes remote from posterior lateral eyes. Tarsus of male palpus with transverse groove.

Genus *Leptoneta* Simon

Leptoneta Simon, 1872, p. 477; 1893, p. 283. Fage, 1913, p. 132. Gertsch, 1971, p. 50. *Paraleptoneta* Fage, 1913, p. 551. *Neoleptoneta* Brignoli, 1972, p. 134.

Types of genera—Of *Leptoneta, L. convexa* Simon of Europe; of *Paraleptoneta, L. spinimana* Simon of Algeria; of *Neoleptoneta, L. capilla* Gertsch of México.

Diagnosis—Characters of family as given above or as modified below shared by all or most American species, making repetition of them in descriptions unnecessary.

Small spiders, 1 to 3 mm long, typically whitish without darker pattern, more rarely with dusky shadings of spots or bands on carapace and abdomen. Carapace longer than broad, suboval to moderately elongated, convex, rounded in front and on sides, subtruncated behind, highest behind eyes at midpoint of carapace, smooth and shiny with short bristles in row from cervical area to eyes and one of few on clypeus, all usually rubbed off. Pars cephalica subtriangular, with cephalic grooves scarcely evident and median groove trivial linear depression. Clypeus prominent, declining forward, usually as high as eye group. Eyes typically six; in epigean forms larger and subequal in size, in cavernicoles variable and sometimes completely obsolete; front four eyes usually subequal in size and contiguous, in strongly recurved row on quite prominently elevated tubercles; posterior pair of eyes on very low tubercles well removed behind front eyes and often smaller in size. Chelicerae robust, evenly narrowed to apex; promargin with row of seven to 13 closely spaced or separated teeth; retromargin with two to six minute denticles. Labium transversely suboval sclerite closely joined to sternum; anterior margin with four barbed hairs or spines and several simple hairs. Endites subparallel, about twice as long as broad, narrowed and convergent apically; apical serrula distinct, continuous, minutely toothed band on outer side at apex. Sternum subcordate, narrowed between and separating posterior coxae by width of coxa. Abdomen suboval, as high as broad, clothed with simple hairs. In mature females area in front of genital groove convex, sometimes protruding to show internal features; atriobursal orifices voluminous pouches funnelling embolus and bulb of palpus to tubular seminal receptacle on each side. Male palpus generalized; tarsus leg-like segment little modified, with weakly developed alveolus to hold bulb; tarsus with transverse groove near middle, sometimes armed with retrolateral lobes and modified setae of various kinds; other segments variously provided or not with spurs and modified setae; bulb suboval, attached to tarsus near middle; embolus typically little sclerotized, indistinct projection at apex.

THE APPALACHIAN FAUNA

This fauna, seemingly the richest of our country, ranges from West Virginia and Tennessee south into Georgia and Alabama mainly in mountainous or deeply wooded situations. The first species, *silvicultrix*, an epigean type well befitting its name, years ago was sifted from rich ground litter in mesic woods of North Carolina. Five additional epigean species are reported here from woodland stations in the southern Appalachians. These are mostly small, averaging about 1.5 mm, dusky species with legs of medium length. Their fairly large eyes are well pigmented. Nine cavernicolous species are described in this paper for the first time; one from Arkansas is arbitrarily included in this fauna, to which it is closely related, as a practical expedient. The cave species feature small size and pale coloration and their legs are considerably longer. Their small eyes vary from medium size to obsolescence. Only one species, *georgia*, is completely eyeless.

Males of only seven of the 15 species of the *silvicultrix* group are presently known. Such species as *silvicultrix, coma* and *gertschi* appear to be close relatives of the cave species of Europe with which they share similar features of body morphology and genitalia. The male palpi have exactly the same basic elements: deeply grooved tarsi with prominent subapical retrolateral lobes set with distinctive setae; suboval bulbs with bluntly rounded, variously spined embolar parts; similar binding junctures of bulbs with weakly developed cymbia and prolateral paracymbial lobes. Along with these quite standard species are some with more weakly grooved tarsi and usual lack of retrolateral lobes, as exemplified by *sandra, alabama* and others. Some of these have retrolateral apophyses on the tibiae set with distinctive setae but in others this segment is unmodified. This group corresponds in a general way with the genus *Paraleptoneta* of Fage, but in this paper such species are considered merely to represent taxa of a wider genus *Leptoneta*. The chelicerae of the group exhibit modest variability and differ little from those of European representatives. The seven to 11 teeth on the promargin may be closely or more loosely spaced but they differ little in size. The epigyna of the females are of quite stereotyped design with lightly sclerotized atrial chambers and a coiled tube on each side. The artificial keys offered below are based on various morphological features but mostly on those of the genitalia.

KEY TO THE FEMALES

1a. Eyeless species (Fig. 5) from Byers Cave, Dade County, Georgia . . . . . *georgia*, new species

1b. Eyes present 2

2a(1a). Epigynum with tightly coiled tubular receptacles 3

2b. Epigynum with heavier S, C, or otherwise shaped receptacles 10

3a(2a). Legs short, first leg at most 4.5 times, first femur at most 1.2 times as long as carapace; epigean species 4

3b. Legs longer, first leg at least 5.6, first femur at least 1.5 times as long as carapace; cavernicolous species 6

4a(3a). Promargin of chelicera with eight teeth; epigynum (Fig. 43) . . . . . *silvicultrix* Crosby & Bishop

4b. Promargin with seven teeth 5

5a(4a). Epigynum (Fig. 44) . . . . . *coma* Barrows

5b. Epigynum (Fig. 45) . . . . . *gertschi* Barrows

6a(3b). Epigynum with shallow, semilunar bursae 7

6b. Epigynum of different pattern 8

7a(6a). Promargin of chelicera with 10 teeth; epigynum (Fig. 46); Bangor Cave, Blount County, Alabama . . . . . *barrowsi*, new species

7b. Promargin with eight to 11 teeth; epigynum (Fig. 39); Crystal Caverns, Jefferson County, Alabama . . . . . *jonesi*, new species

8a(6b). Legs shorter, first femur 1.2 times as long as carapace; Bat Cave, Lauderdale County, Alabama . . . . . *credula*, new species

8b. Legs longer, first femur at least 1.5 times as long as carapace 9

9a(8b). Posterior eyes small, widely separated from lateral eyes (Fig. 8); epigynum (Figs. 37-38); Ingram Cave, Blount County, Alabama . . . . . *blanda*, new species

9b. Eyes larger, epigynum (Fig. 40); caves of northern Georgia . . . . . *fiskei*, new species

10a(2b). Epigean species 13

10b. Cavernicolous species 11

11a(10b). S shaped receptacles of epigynum widely separated (Fig. 36); all eyes separated (Fig. 7); Blanchard Springs Caverns, Stone County, Arkansas . . . . . *arkansa*, new species

11b. S shaped receptacles closer together; eyes subcontiguous 12

12a(11b). Promargin with eight to 11 teeth; epigynum (Fig. 33); caves of Marshall and deKalb Counties, Alabama . . . . . *alabama*, new species

12b. Promargin with seven teeth; epigynum (Fig. 35); Collier Cave, Lauderdale County, Alabama . . . . . *serena*, new species

13a(10a). Legs shorter, first femur 1.2 times as long as carapace; epigynum (Fig. 41); Georgia . . . . . *iviei*, new species

13b. Legs longer, first femur 1.6 times as long as carapace; epigynum (Fig. 47); West Virginia, Virginia . . . . . *sandra*, new species

KEY TO THE MALES

1a.	Tarsus of male palpus with retrolateral lobe	2
1b.	Tarsus without such lobe	5
2a(1a).	Bulb of palpus bifid at apex	3
2b.	Bulb not bifid at apex	4
3a(2a).	Base of tarsus with modified setae on retrolateral margin (Fig. 32)	*gertschi* Barrows
3b.	Base of tarsus without such setae (Fig. 24	*silvicultrix* Crosby & Bishop
4a(2b).	Femur of palpus with series of heavy spines at apex on retrolateral side (Fig. 28); bulb with long wisp of fused setae (Fig. 29)	*coma* Barrows
4b.	Femur without such spines (Fig. 93)	*jonesi*, new species
5a(1b).	Tibia of palpus with trivial apophysis (Fig. 220) and femur with subventral row of heavy spines	*sandra*, new species
5b.	Tibia of palpus without retrolateral apophysis; femur without heavy spines	6
6a(5b).	Palpal segments short (Fig. 19)	*archeri*, new species
6b.	Palpal segments elongate (Fig. 16)	*alabama*, new species

Leptoneta silvicultrix Crosby & Bishop

Leptoneta silvicultrix Crosby & Bishop, 1925, p. 142, Fig. 1. Bishop & Crosby, 1926, p. 174. Roewer, 1942, p. 313. Bonnet, 1957, p. 2394.

Diagnosis—Small, dark, short-legged epigean species with eyes of medium size, first leg of female 3.8 times, first leg of male 4.5 times as long as carapace; male palpus short, stocky, with prominent rounded lobe on tarsus armed with short spine; epigynum (Fig. 43).

Etymology—Specific name from Latin *silvicultrix*, inhabiting woods.

Female—Total length 1.4 mm. Carapace 0.64 mm long, 0.51 mm wide. Abdomen 0.86 mm long, 0.63 mm wide.

Carapace brown with dusky radiating shadings and lateral dark seam on pars thoracica and dark linear median groove; front eyes enclosing black field and posterior eyes narrowly ringed with black; sternum flecked with brown and margined by narrow brown band; labium, endites and chelicerae dull brown; legs dull yellowish brown. Abdomen brown to purplish in base color; dorsum paler at center but sides and venter more purplish, broken with numerous pale spots.

Carapace (Fig. 1) broadly oval; clypeus 0.13 mm high, longer than width of front eyes and about equal to length of eye group. Eyes of medium size (Fig. 2); front eyes subequal in size and subcontinguous; posterior eyes slightly smaller, separated from front lateral eyes by less than diameter of former. Sternum 0.42 mm long, 0.39 mm wide. Chelicera (Fig. 15) prominent; promargin with eight teeth, basal one forming part of keel; retromargin with two small denticles.

Leg formula 4123. First leg 3.8 times, first femur 1.1 times as long as carapace.

Epigynum as shown in Fig. 43.

	I	II	III	IV	Palpus
Femur	0.70	0.61	0.52	0.71	0.27
Patella	0.18	0.17	0.16	0.18	0.27
Tibia	0.68	0.54	0.44	0.71	0.20
Metatarsus	0.52	0.45	0.41	0.56	–
Tarsus	0.42	0.38	0.35	0.42	0.27
Total	2.50	2.15	1.88	2.58	0.84

Male holotype—Total length 1.2 mm. Carapace 0.6 mm long, 0.52 mm wide. Abdomen 0.6 mm long, 0.4 mm wide.

Clypeus 0.14 mm long, longer than width of front eye row, about as long as eye group. Sternum 0.35 mm long and wide.

Leg formula 1423. First leg 4.5 times, first femur 1.2 times as long as carapace.

Male palpus (Figs. 24-26) with short segments and oval bulb; femur with cluster of short spines in distal half on prolateral side; tarsus deeply grooved beyond middle, with rounded lobe armed with short spine; bulb bifid at apex.

	I	II	III	IV	Palpus
Femur	0.72	0.62	0.50	0.70	0.21
Patella	0.20	0.19	0.15	0.15	0.10
Tibia	0.70	0.55	0.47	0.72	0.12
Metatarsus	0.66	0.47	0.44	0.60	–
Tarsus	0.43	0.35	0.30	0.42	0.21
Total	2.71	2.18	1.86	2.59	0.64

Type Data—Male holotype, male and three females from Oteen, North Carolina, 15 October 1923 (C. Crosby, S. Bishop), in Cornell University collection.

Distribution—Virginia to North Carolina.

Records— *Virginia*: Lee County: Cumberland Gap National Park, trail to Skylight Cave, 10 June 1971 (W. A. Shear), three males, females from dry and wet litter. *North Carolina*: Blowing Rock, 10 October 1923, two males, female. Montreat, 16 Ocotber 1923, male. Minehole Gap, Buncombe County, 17 October 1923, female. Four miles N Oteen, 16 October 1965 (J. & W. Ivie), two males, five females. North of Ashville, 7 July 1933 (W. Ivie), penultimate male probably this species. Junction Rt. 441, Tuskee Gap Trail, Swain County, 24 October 1969 (W. A. Shear, F. Coyle), two females.

Leptoneta coma Barrows

Leptoneta coma Barrows, 1940, p. 131, Fig. 3. Vogel, 1967, p. 88. Brignoli, 1972, p. 135.

Diagnosis—Dusky, stocky, short-legged epigean species with eyes of medium size; first leg of female 4.5 times, first leg of male 4.8 times as long as carapace; male palpus of medium length, with prominent rounded lobe on tarsus armed with long, thin spine; epigynum (Fig. 44).

Etymology—Specific name of Latin *coma*, in reference to wisp of long hairs on bulb of male palpus.

Female paratype—Total length 1.7 mm. Carapace 0.7 mm long, 0.57 mm wide. Abdomen 1 mm long, 0.8 mm wide.

Coloration and structure like those of *silvicultrix* unless otherwise noted. Clypeus 0.16 mm high, much broader than width of front eyes, about equal to length of eye group. Eyes of medium size (Fig. 10); front eyes subequal; posterior eyes suboval, slightly smaller than front eyes and separated by full diameter. Sternum 0.42 mm long, 0.4 mm wide. Promargin of chelicera with seven subequal teeth but apical three more widely spaced.

Leg formula 4123. First leg 4.5 times, first femur 1.2 times as long as carapace.

Epigynum as shown in Fig. 44.

	I	II	III	IV	Palpus
Femur	0.87	0.76	0.60	0.87	0.35
Patella	o.21	0.20	0.20	0.21	0.15
Tibia	0.93	0.74	0.60	0.93	0.23
Metatarsus	0.65	0.60	0.52	0.76	–
Tarsus	0.50	–	0.42	0.50	0.40
Total	3.16	–	2.34	3.27	1.13

Male paratype–Total length 1.5 mm. Carapace 0.73 mm long, 0.61 mm wide. Abdomen 0.72 mm long, 0.56 mm wide.

Coloration and structure like those of female except as noted; front edge of pars cephalica more narrowed; clypeus 0.17 mm high. Sternum 0.45 mm long, 0.38 mm wide at front, abnormal, triangular. Fang of chelicera strongly bent at middle.

First leg 4.8 times, first femur 1.3 times as long as carapace.

Male palpus (Figs. 27-29) of medium length; femur with cluster of short spines in apical half on retrolateral side; tarsus deeply grooved at middle, with prominent rounded lobe armed with principal long, thin spine; bulb with wisp of long setae below.

	I	II	III	IV	Palpus
Femur	0.95	0.80	0.60	0.90	0.35
Patella	0.22	0.21	0.20	0.21	0.15
Tibia	0.98	0.77	–	–	0.13
Metatarsus	0.82	0.64	–	–	–
Tarsus	0.52	0.47	–	–	0.25
Total	3.49	2.89	–	–	0.88

Type Data–Male holotype, and male and five female paratypes, from Gatlinburg, Tennessee, 21 June 1936 (W. M. Barrows), by sifting leaves near river, in Ohio State University. Male and two females of above (labelled cotypes) in American Museum of Natural History.

Leptoneta gertschi Barrows

Leptoneta gertschi Barrows, 1940, p. 131, Fig. 2. Vogel, 1967, p. 88. Brignoli, 1972, p. 135.

Diagnosis–Small, dark, short-legged epigean species with eyes of medium size; first leg of female 4.1 times as long as carapace; male palpus massive, with rounded lobe on tarsus armed with curved spine; epigynum (Fig. 45).

Female–Total length 1.35 mm. Carapace 0.64 mm long, 0.38 mm wide. Abdomen 0.8 mm long, 0.57 mm wide.

Coloration and structure like those of *silvicultrix*. Clypeus 0.14 mm high, longer than width of front eyes, about as long as ocular group. Eyes of medium size (Fig. 11); front eyes subequal, contiguous; posterior eyes smaller than and separated from front lateral eye by diameter of latter. Sternum 0.4 mm long, 0.36 mm wide, subtriangular, slightly deformed. Chelicera like that of *silvicultrix*, with seven teeth on promargin of which apical three larger and slightly separated.

Leg formula 1423, first and third legs subequal. First leg 4.1 times, first femur 1.2 times as long as carapace.

Epigynum as shown in Fig. 45.

	I	II	III	IV	Palpus
Femur	0.80	0.70	0.60	0.80	0.34
Patella	0.20	0.19	0.18	0.18	0.11
Tibia	0.80	0.65	0.54	0.80	0.22
Metatarsus	0.65	0.55	0.53	0.70	–
Tarsus	0.48	0.42	0.35	0.43	0.32
Total	2.93	2.51	2.20	2.91	0.99

Male paratype—Carapace 0.7 mm long, 0.57 mm wide.

Coloration and structure like those of female except as noted. Clypeus 0.16 mm high. Sternum 0.4 mm long, 0.38 mm side. Fang of chelicera strongly bent at middle.

First femur 1.3 times as long as carapace.

Male palpus (Figs. 30-32) of medium length; tarsus deeply grooved beyond middle, rounded on side and armed with curved spine; basal half of tarsus armed with four curved setae; massive bulb deeply incised in apical part.

	I	II	III	IV	Palpus
Femur	0.90	0.72	0.65	0.90	0.37
Patella	–	0.22	0.17	0.21	0.15
Tibia	–	0.73	0.58	0.91	0.20
Metatarsus	–	0.80	0.58	0.80	–
Tarsus	–	–	0.37	0.52	0.28
Total	–	–	2.35	3.34	1.00

Type Data—Male type and paratype from Greenbrier section of Great Smoky Mountains National Park, Tennessee, 14 June 1939 (W. M. Barrows), taken by sifting leaves, in Ohio State University collection; paratype in American Museum of Natural History.

Distribution—Tennessee to South Carolina.

Records—*Tennessee*: Kingston, 12 July 1933 (W. Ivie), female. *South Carolina:* Greenville, 11 March 1954 (W. Ivie), male, two females, two immature.

Leptoneta sandra, new species

Diagnosis—Dusky epigean species with fairly long legs; first leg of female 6.7 times, first leg of male 7.3 times as long as carapace; tarsus of male palpus without lateral lobe and femur armed with eight stout spines on retrolateral side (Fig. 20); epigynum (Fig. 47).

Etymology—Named for Mrs. Sandra Bird Porterfield, who worked on the bionomics of this interesting spider.

Female—Total length 1.8 mm. Carapace 0.63 mm long, 0.57 mm wide. Abdomen 1.1 mm long, 0.7 mm wide.

Cephalothorax and appendages light dusky brown; carapace with dark shadings and faint marginal seam; front eyes enclosing black field and posterior eyes ringed with black; sternum with indistinct dark marginal seam. Abdomen purplish brown, with paler spotting on sides and venter.

Structure like that of *silvicultrix* except as noted. Clypeus 0.14 mm high, equal to length of eye group. Eyes large, subequal in size; subround posterior eyes separated by their radius from front lateral eyes. Sternum 0.44 mm long and wide. Chelicera: promargin with eight teeth, those at apex more widely separated; retromargin with three denticles.

Leg formula 1423. First leg 6.7 times, first femur 1.6 times as long as carapace.

Epigynum as shown in Fig. 47.

	I	II	III	IV	Palpus
Femur	1.15	0.92	0.76	1.10	0.40
Patella	0.24	0.21	0.20	0.21	0.12
Tibia	1.27	0.90	0.70	1.15	0.30
Metatarsus	0.96	0.70	0.62	0.90	–
Tarsus	0.64	0.55	0.47	0.55	0.37
Total	4.26	3.28	2.75	3.91	1.19

Male—Total length 1.9 mm. Carapace 0.75 mm long, 0.64 mm wide. Abdomen 1 mm long, 0.78 mm wide.

Leg formula 1423. First leg 7.3 times, first femur 1.8 times as long as carapace.

Male palpus (Figs. 20-21) with elongate segments; femur with subventral series of eight stout spines along retrolateral side; tarsus elongate, moderately grooved at middle, lacking accessory lobes or modified spines; tibia rounded at apex and with two long spines on retrolateral side.

	I	II	III	IV	Palpus
Femur	1.40	1.10	0.85	1.27	0.53
Patella	0.26	0.24	0.20	0.20	0.21
Tibia	1.70	1.13	0.85	1.32	0.26
Metatarsus	1.33	0.90	0.76	1.04	–
Tarsus	0.77	0.65	0.55	0.63	0.26
Total	5.46	4.02	3.21	4.46	1.26

Type Data—Male holotype, male, female and immature from Camp Creek State Forest, Mercer County, West Virginia, 9 May 1967 (W. A. Shear), from rhododendron litter.

Distribution— West Virginia and adjacent Virginia.

Records—*West Virginia*: Mercer County: NW side of East River Mountain, 5 mi SE Bluefield, 3 June 1971 (W. A. Shear), berlese from mixed deciduous litter, two immature females. *Virginia*: Tazewell County: East River Mt., Bluefield-Cove Creek Road, 4 April 1971 (W. A. Shear), male, two females, immature from summit bog at about 3800 feet.

Leptoneta iviei, new species

Diagnosis—Pale epigean species with small eyes and short legs; first leg 4.8 times as long as carapace; epigynum (Fig. 41).

Etymology—Named for the late Wilton Ivie.

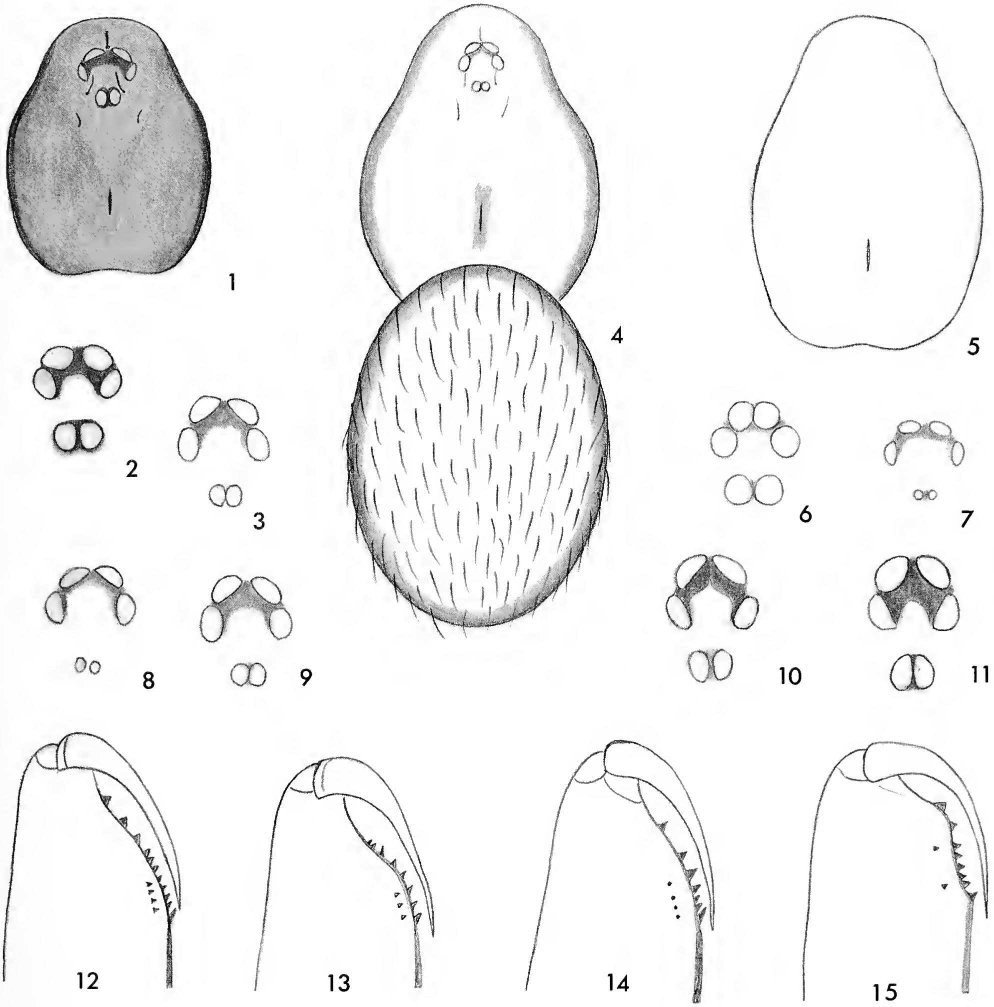
Female—Total length 1.5 mm. Carapace 0.58 mm long, 0.57 mm wide. Abdomen 1 mm long, 0.7 mm wide.

Cephalothorax and appendages pale yellow; front eyes enclosing black field; posterior eyes narrowly ringed with black; abdomen whitish.

Clypeus 0.1 mm high, equal in length to width of front eye group, shorter than length of eye group. Eyes small, subequal in size; oval posterior eyes separated from lateral front eyes by short diameter of first. Sternum 0.42 mm long and wide. Chelicera: promargin with eight teeth, apical two more widely spaced.

Leg formula 1423. First leg 4.8 times, first femur 1.2 times as long as carapace.

Epigynum (Fig. 41) with coiled tube on each side curved toward midline.



Figs. 1-15.—Species of *Leptoneta*: 1, *L. silvicultrix*, carapace of female, dorsal view; 2, *L. silvicultrix*, eyes of female; 3, *L. alabama*, eyes of female; 4, *L. alabama*, carapace and abdomen of female; 5, *L. georgia*, carapace of female; 6, *L. archeri*, eyes of male; 7, *L. arkansa*, eyes of female; 8, *L. blanda*, eyes of female; 9, *L. jonesi*, eyes of female; 10, *L. coma*, eyes of female; 11, *L. gertschi*, eyes of female; 12, *L. alabama*, chelicerae of female from Painted Bluff Cave, ventral view; 13, *L. alabama*, chelicerae of female from Weaver Cave, ventral view; 14, *L. credula*, chelicera of female, ventral view; 15, *L. silvicultrix*, chelicera of female, ventral view.

	I	II	III	IV	Palpus
Femur	0.70	0.61	0.53	0.72	0.25
Patella	0.19	0.17	0.16	0.17	0.10
Tibia	0.72	0.60	0.45	0.75	0.20
Metatarsus	0.80	0.47	0.44	0.60	–
Tarsus	0.45	0.40	0.32	0.45	0.30
Total	2.76	2.25	1.90	2.69	0.85

Type Data—Female holotype from NW of Clayton, Georgia, 28 April 1943 (W. Ivie).

Distribution—Georgia.

Record—*Georgia*: SE of Toccoa 29 April 1943 (W. Ivie), immature probably this species.

Leptoneta archeri, new species

Diagnosis—Small, yellowish epigean species with legs of medium length and distincitive male palpus; eyes evanescent, of medium size; first leg 5.5 times as long as carapace; tibia of male palpus with retrolateral lobe bearing short spine.

Etymology—Named for Dr. Allan F. Archer of Tift College, Forsyth, Georgia.

Male—Total length 1.12 mm. Carapace 0.5 mm long, 0.44 mm wide. Abdomen 0.62 mm long, 0.45 mm wide.

Cephalothorax and appendages yellow; front eyes enclosing tiny dusky smudge; abdomen dull yellow.

Clypeus 0.1 mm high, as long as width of front eyes, little shorter than length of eye group. Eyes of front row of medium size (Fig. 6), evanescent, subequal and subcontiguous; oval posterior eyes little smaller, separated from front lateral eyes by narrow diameter. Sternum 0.4 mm long, 0.3 mm wide, abnormal.

Leg formula 1423. First leg 5.5 times, first femur 1.4 times as long as carapace.

Male palpus (Figs. 18-19) with short segments; tarsus with trivial transverse groove, without special modification or enlarged setae; tibia with lateral lobe bearing short seta.

	I	II	III	IV	Palpus
Femur	0.76	0.60	0.55	0.77	0.26
Patella	0.20	0.18	0.16	0.18	0.10
Tibia	0.77	0.54	0.44	0.60	0.12
Metatarsus	0.60	0.43	0.45	0.58	–
Tarsus	0.42	0.38	0.32	0.40	0.18
Total	2.75	2.13	1.92	2.53	0.66

Type Data—Male holotype from ravine in Partlow Hospital grounds, Alberta City, Tuscaloosa County, Alabama, 8 March 1940 (A. F. Archer).

Leptoneta fiskei, new species

Diagnosis—Dusky yellow, long-legged troglophile with spotted abdomen; posterior eyes about one-fourth diameter of anterior lateral eyes; first leg 6.4 times as long as carapace; epigynum (Fig. 40).

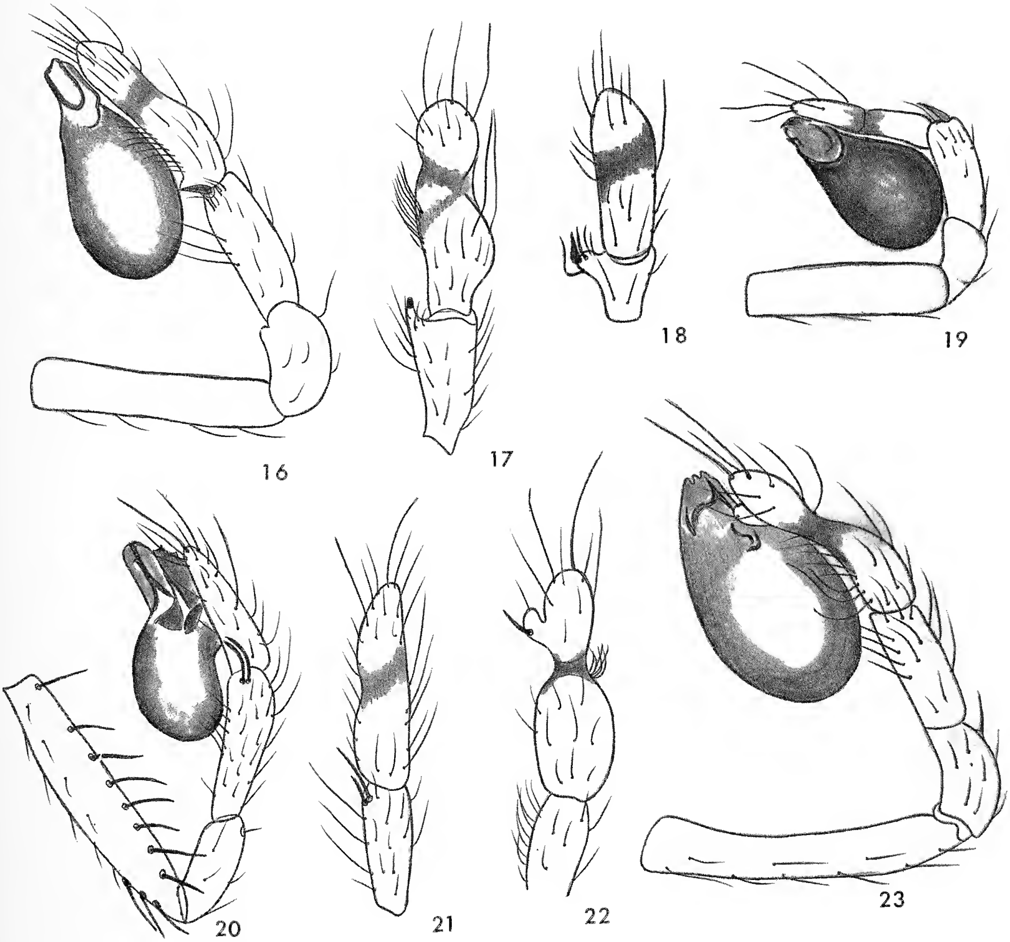
Etymology—Named for Mr. A. Fiske.

Female—Total length 1.45 mm. Carapace 0.65 mm long, 0.55 mm wide. Abdomen 0.8 mm long, 0.55 mm wide.

Carapace yellow with lateral duskiness; front eyes enclosing black field, posterior eyes with faint dusky margins; legs dull yellow with duskiness on coxae, patellae and segment junctures; labium, endites, chelicerae dusky yellow. Abdomen dull white with pattern of small subintegumental flecks.

Clypeus 0.15 mm high, longer than width of front eye group, as long as ocular group. Eyes small; front eyes subequal, contiguous; posterior eyes small, about fourth diameter of and separated from lateral front eye by its full diameter. Sternum 0.45 mm long, 0.4 mm wide. Checlicera: promargin with seven teeth, with apical three slightly larger and more widely spaced; retromargin with three denticles.

	I	II	III	IV	Palpus
Femur	1.17	1.00	0.84	1.11	0.40
Patella	0.22	0.22	0.19	0.21	0.12
Tibia	1.15	0.94	0.71	1.00	0.23
Metatarsus	0.96	0.78	0.70	0.84	–
Tarsus	0.70	0.60	0.51	0.62	0.40
Total	4.20	3.54	2.95	3.78	1.15



Figs. 16-23.–Left male palpi of species of *Leptoneta*: 16, *L. alabama*, whole palpus, retrolateral view; 17, *L. alabama*, tibia and tarsus, dorsal view; 18, *L. archeri*, tibia and tarsus, dorsal view; 19, *L. archeri*, whole palpus, retrolateral view; 20, *L. sandra*, whole palpus, retrolateral view; 21, *L. sandra*, tibia and tarsus, dorsal view; 22, *L. jonesi*, tibia and tarsus, dorsal view; 23, *L. jonesi*, whole palpus, retrolateral view.

Leg formula 1423. First leg 6.4 times, first femur 1.5 times as long as carapace.

Epigynum (Fig. 40) subtriangular, presenting lateral pouches surmounted by small, twisted tube on each side.

Type Data—Female holotype from Harrisburg Cave, four mi W Center Post, Walker County, Georgia, 12 July 1967 (S. Peck, A Fiske).

Distribution—Caves of northwestern Georgia.

Record—*Georgia*: Walker County: Pettijohn Cave, SW LaFayette, 10 June 1969 (J. Holsinger, S. Peck, A. Fiske, R. Baroody), penultimate male probably this species.

Leptoneta georgia, new species

Diagnosis—Pale, eyeless, long-legged troglobite; first leg 7.4 times as long as carapace; epigynum with S-shaped tube on each side (Fig. 34).

Etymology—Named for State of Georgia.

Female—Total length 1.75 mm. Carapace 0.8 mm long, 0.6 mm wide. Abdomen 1.05 mm long, 0.8 mm wide.

Celphalthorax and legs clear yellow; sternum with narrow dusky seam; abdomen dirty white.

Structure typical; carapace (Fig. 5) rather short, gently rounded in front, with median line of bristles from trivial linear groove forward to clypeus, smooth on ocular region and without trace of eyes. Sternum 0.52 mm long, 0.46 mm wide. Chelicera: promargin with eight teeth, apical ones larger and more widely spaced like those of *alabama* (Fig. 13).

Leg formula 1423; legs long and thin, first femora weakly enlarged. First leg 7.4 times, first femur 2.1 times as long as carapace.

Epigynum as shown in Fig. 34.

	I	II	III	IV	Palpus
Femur	1.68	1.40	1.15	1.53	0.43
Patella	0.27	0.26	0.21	0.24	0.14
Tibia	1.76	1.43	1.10	1.46	0.31
Metatarsus	1.40	1.10	1.03	1.32	–
Tarsus	0.84	0.70	0.82	0.82	0.44
Total	5.95	4.89	4.11	5.37	1.32

Type Data—Female holotype from Byers Cave, 1.5 mi SW Rising Fawn, Dade County, Georgia (J. Holsinger, S. Peck, A Fiske, R. Baroody).

Leptoneta arkansa, new species

Diagnosis—Yellowish troglophile with small, separated eyes; first leg 5.5 times as long as carapace; epigynum (Fig. 36) with S-shaped tubes on each side widely separated.

Etymology—Named for State of Arkansas.

Female—Total length 1.5 mm. Carapace 0.58 mm long, 0.48 mm wide. Abdomen 0.9 mm long, 0.6 mm wide.

Carapace yellow; eyes narrowly bordered with black; appendages dusky yellow; abdomen whitish.

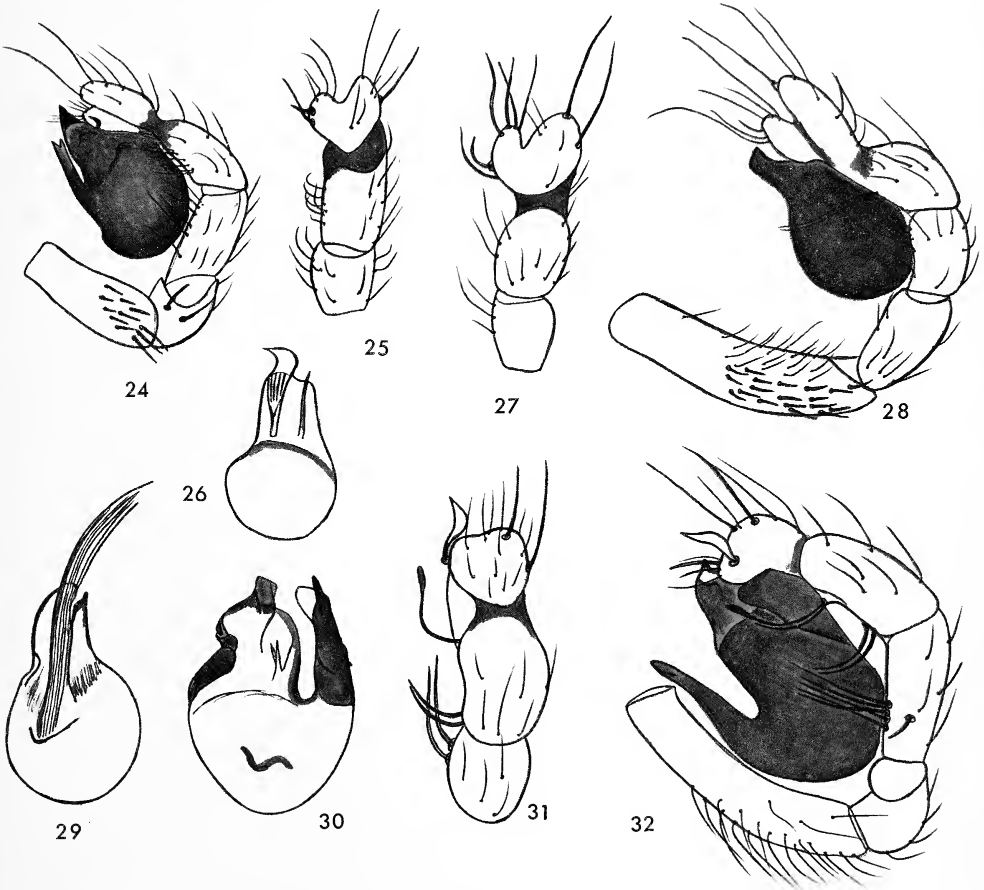
Structure typical with obvious relationship to *alabama* and relatives; clypeus 0.1 mm high, sloping, about as high as eye group. Eyes (Fig. 7) small, on weakly developed tubercles; anterior eyes in rather widely recurved row, subequal in size; posterior eyes small, separated from anterior lateral by full diameter of latter. Sternum 0.4 mm long, 0.36 mm wide. Chelicera typical: promargin with seven teeth; retromargin with three denticles.

Leg formula 1423. First leg 5.5 times, first femur 1.4 times as long as carapace.

Epigynum as shown in Fig. 36.

	I	II	III	IV	Palpus
Femur	0.86	0.70	0.63	0.86	0.30
Patella	0.20	0.20	0.19	0.20	0.10
Tibia	0.88	0.68	0.56	0.94	0.18
Metatarsus	0.73	0.55	0.55	0.74	–
Tarsus	0.55	0.46	0.40	0.52	0.26
Total	3.22	2.59	2.33	3.26	0.84

Type Data–Female holotype, female and immature from Blanchard Springs Caverns, Stone County, Arkansas, 27 September 1967 (T. Barr, T. Marsh).



Figs. 24-32.–Left male palpi of species of *Leptoneta*: 24, *L. silvicultrix*, whole palpus, retrolateral view; 25, *L. silvicultrix*, tibia and tarsus, dorsal view; 26, *L. silvicultrix*, bulb, subventral view; 27, *L. coma*, tibia and tarsus, dorsal view; 28, *L. coma*, whole palpus, retrolateral view; 29, *L. coma*, bulb, subventral view; 30, *L. gertschi*, bulb, subventral view; 31, *L. gertschi*, tibia and tarsus, dorsal view; 32, *L. gertschi*, whole palpus, retrolateral view.

Leptoneta alabama, new species

Diagnosis—Yellowish, long-legged troglophile with rather small, evanescent eyes (Fig. 3); first leg of female 6.4 times, of male 6.7 times as long as carapace; male palpus with elongated segments, tarsus without lobe and tibia with retrolateral spur bearing short spine; epigynum (Fig. 31) with S-shaped tube on each side.

Etymology—Named for State of Alabama.

Female—Total length 1.9 mm. Carapace 0.7 mm long, 0.56 mm wide. Abdomen 1.3 mm long, 0.8 mm wide.

Cephalothorax and legs dull yellow to orange; carapace with dusky shadings on pars thoracica; sternum with narrow dusky seam on margins; abdomen dull white.

Structure typical; outline of carapace and abdomen as shown in Fig. 4; clypeus 0.13 mm high, fully as high as length of eye group. Eyes (Fig. 3) of medium size, with little pigment; anterior row of eyes recurved, eyes subequal and subcontiguous; posterior eyes smaller, separated from anterior lateral eyes by their diameter. Chelicerae somewhat variable (Figs. 12-13).

Leg formula 1423, legs long and thin. First leg 6.4 times, first femur 1.7 times as long as carapace.

Epigynum as shown in Fig. 33.

	I	II	III	IV	Palpus
Femur	1.20	1.03	0.86	1.23	0.35
Patella	0.24	0.22	0.22	0.23	0.15
Tibia	1.35	0.95	0.87	1.20	0.25
Metatarsus	1.00	0.80	0.71	0.95	–
Tarsus	0.72	0.59	0.53	0.65	0.39
Total	4.51	3.59	3.19	4.26	1.14

Male—Total length 1.6 mm. Carapace 0.7 mm long, 0.57 mm wide. Abdomen 0.85 mm long, 0.6 mm wide.

Leg formula 1423; legs long and thin. First leg 6.7 times, first femur 1.8 times as long as carapace.

Male palpus (Figs. 16-17); tarsus with moderate transverse groove beyond middle, broadly rounded but lacking lobe and spine; tibia with blunt retrolateral process armed with short spine; bulb of medium size, suboval, tipped with blunt embolus.

	I	II	III	IV	Palpus
Femur	1.26	1.03	0.82	1.15	0.35
Patella	0.26	0.23	0.20	0.22	0.12
Tibia	1.42	1.05	0.83	1.25	0.18
Metatarsus	1.10	0.82	0.72	1.05	–
Tarsus	0.76	0.64	0.57	0.70	0.26
Total	4.80	3.77	3.14	4.37	0.91

Type Data—Male holotype and four females from Painted Bluff Cave, Marshall County, Alabama, 16 March 1966 (S. Peck).

Distribution—Caves of Alabama

Records—*Alabama*: Marshall County: Painted Bluff Cave, 16, June 1967 (S. Peck, A. Fiske), three females. Calhoun County: Kilgore Cave, near Weaver Station, 15 March 1962 (W. B. Jones), two males, two females, two immature. Weaver Cave, 5 June 1940 (W. B. Jones, A. Archer), female. Lady Cave, 5 June 1940 (W. B. Jones, A. Archer), three males, 12 females, immature. DeKalb County: Cemetery Cave No. 444, six mi W Fort Payne, 28 August 1965 (S. Peck), two females.

Leptoneta jonesi, new species

Diagnosis–Yellowish troglophile with eyes of medium size and fairly long legs; first leg of female 5.5 times, of male 6.1 times as long as carapace; male palpus with elongated segments, narrow tarsus bearing small retrolateral lobe bearing thin spine; epigynum (Fig. 39) with transverse, semilunar bursa and long, tightly coiled tube on each side.

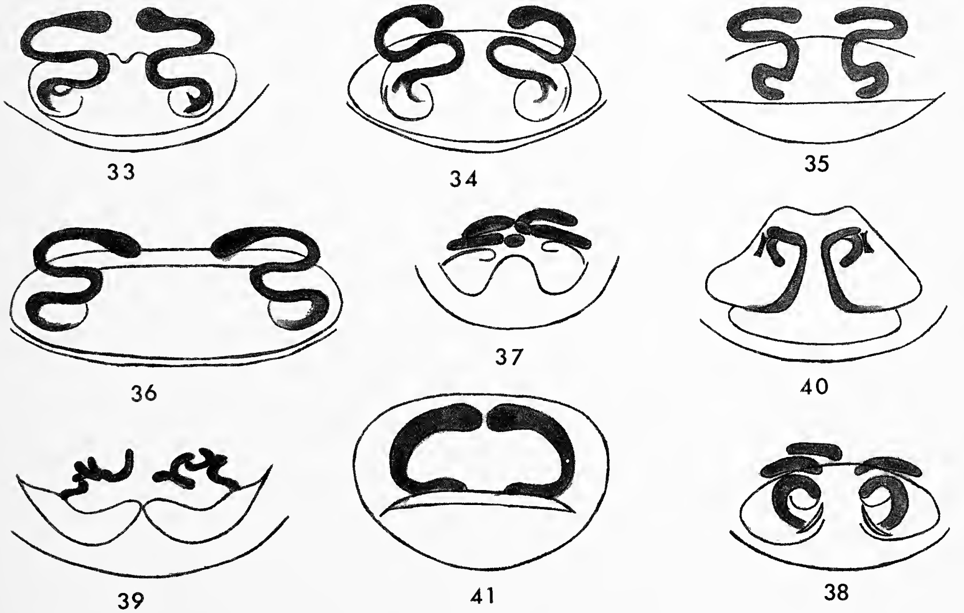
Etymology–Named for Dr. W. B. Jones of the Alabama Museum of Natural History.

Female–Total length 1.7 mm. Carapace 0.8 mm long, 0.55 mm wide. Abdomen 1 mm long, 0.8 mm wide.

Cephalothorax and appendages dull yellow to orange; front eyes enclosing dusky field; sternum with narrow dusky seam. Abdomen whitish, with dusky markings on sides and venter.

Structure like that of *alabama*; clypeus 0.14 mm high, strongly declining, shorter than height of eye group. Eyes of medium size (Fig. 9); posterior eyes smaller than anterior lateral and separated from them by full diameter of latter. Sternum 0.4 mm long and wide. Chelicerae variable like those of *alabama*.

	I	II	III	IV	Palpus
Femur	1.00	0.86	0.75	1.00	0.37
Patella	0.24	0.21	0.19	0.22	0.14
Tibia	1.04	0.83	0.65	0.95	0.26
Metatarsus	0.85	0.72	0.65	0.86	–
Tarsus	0.63	0.55	0.46	0.60	0.37
Total	3.76	3.17	2.70	3.63	1.14



Figs. 33-41.–Epigyna of species of *Leptoneta*: 33, *L. alabama*, dorsal view; 34, *L. georgia*, dorsal view; 35, *L serena*, dorsal view; 36, *L. arkansa*, dorsal view; 37, *L. blanda*, dorsal view; 38, *L. blanda*, ventral view; 39, *L. jonesi*, dorsal view; 40, *L. fiskei*, ventral view; 41, *L. iviei*, dorsal view.

Leg formula 1423. First leg 5.5 times, first femur 1.5 times as long as carapace.

Epigynum as shown in Fig. 39.

Male—Total length 1.55 mm. Carapace 0.7 mm long, 0.55 mm wide. Abdomen 0.8 mm long, 0.55 mm wide.

Leg formula 1423. First leg 6.1 times, first femur 1.6 times as long as carapace; first tibia without ventral spines but with few prolateral and retrolateral spines.

Male palpus (Fig. 22-23) with all segments elongated; tibia without enlargements or special setae; tarsus deeply grooved beyond middle, with small retrolateral lobe near apex armed with thin spine; bulb large, suboval, with embolar part bluntly rounded.

	I	II	III	IV
Femur	1.12	0.96	0.80	1.08
Patella	0.24	0.22	0.21	0.23
Tibia	1.24	0.94	0.73	1.07
Metatarsus	1.02	0.80	0.72	1.04
Tarsus	0.70	0.60	0.52	0.63
Total	4.32	3.52	2.98	4.05

Type Data—Male holotype, male and female from Crystal Caverns, Jefferson County, Alabama, 18 March 1966 (S. Peck).

Distribution—Known only from Crystal Caverns.

Record—*Alabama:* Jefferson County: Crystal Caverns, 29 July 1958 (W. B. Jones, T. Semnes, T. W. Daniel, Jr.), two females.

Leptoneta serena, new species

Diagnosis—Dusky brown, long-legged species with reduced eyes; first leg 6.8 times as long as carapace; epigynum (Fig. 35) with S-shaped tube on each side.

Etymology—Specific name from Latin *serenus*, serene.

Female—Total length 2 mm. Carapace 0.8 mm long, 0.65 mm wide. Abdomen 1.2 mm long, 0.8 mm wide.

Cephalothorax and appendages dull yellowish brown; front eyes enclosing black smudge; sternum dusky brown with narrow marginal brown seam; abdomen dirty white.

Clypeus 0.15 mm high, much wider than width of front eye row, about as long as eye group. Eyes small; front eyes subequal and subcontiguous; posterior eyes smaller, separated from each other by their radius and from front lateral eyes by two full diameters of latter. Chelicera: promargin with seven evenly spaced teeth, apical four larger.

Leg formula 1423. First leg 6.8 times, first femur 1.8 times as long as carapace.

Epigynum as shown in Fig. 35.

	I	II	III	IV	Palpus
Femur	1.48	1.10	1.02	1.34	0.43
Patella	0.29	0.25	0.22	0.22	0.14
Tibia	1.58	0.95	0.90	1.40	0.32
Metatarsus	1.25	0.83	0.86	1.22	–
Tarsus	0.84	0.60	0.60	0.83	0.44
Total	5.44	3.73	3.60	5.01	1.33

Type Data—Female holotype and two females from Collier Cave, fives miles W Florence, Lauderdale County, Alabama, 20 August 1965 (S. Peck).

Leptoneta credula, new species

Diagnosis–Yellowish troglophile with legs of medium length and small eyes; first femur about 1.2 times as long as carapace; epigynum (Fig. 42) of distinctive form.

Etymology–Specific names from Latin *credulus*, credulous.

Female–Total length 1.6 mm. Carapace 0.72 mm long, 0.58 mm wide. Abdomen 0.9 mm long, 0.65 mm wide.

Cephalothorax and appendages dusky yellow; front eyes enclosing black field; sternum with dusky shadings.

Clypeus 0.17 mm high, nearly twice as long as width of front eye row and longer than eye group. Eyes small, forming tight semicircle with lateral eyes separated by diameter; posterior eyes half diameter of front lateral eye and separated by more than full diameter of latter. Sternum 0.42 mm long and wide. Chelicera: promargin (Fig. 14) with seven teeth, basal three widely spaced; retromargin with four denticles.

Legs mostly missing; femur I 0.95 mm long, about 1.2 times as long as carapace.

Epigynum as shown in Fig. 42.

Type Data–Female holotype and immature from Bat Cave, Shoal Creek, Lauderdale County, Alabama 1 May 1942 (W. B. Jones).

Leptoneta blanda, new species

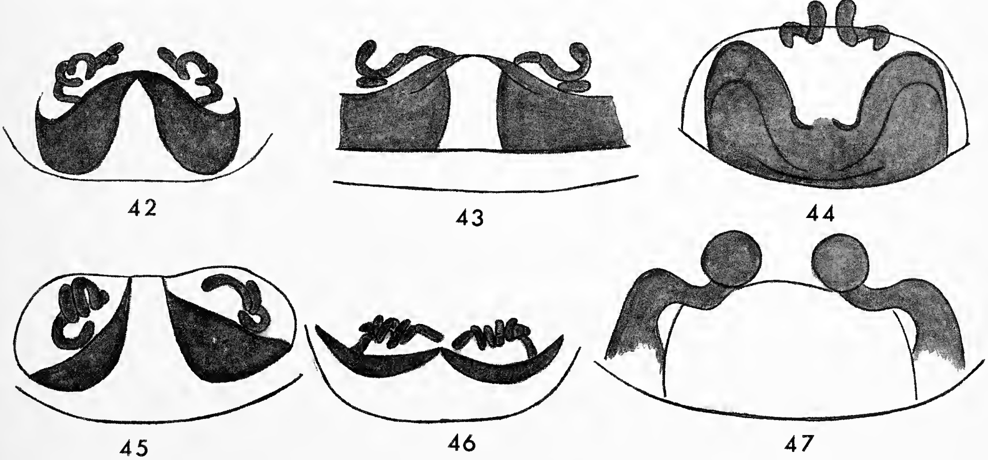
Diagnosis–Yellowish, long-legged troglophile with evanescent eyes of medium size; first leg seven times as long as carapace; epigynum (Figs. 37-38) of distinctive design with tightly coiled tubes close together on midline.

Entymology–Specific name from Latin *blandus*, flattering.

Female–Total length 1.55 mm. Carapace 0.75 mm long, 0.61 mm wide. Abdomen 0.7 mm long, 0.5 mm wide.

Cephalothorax and appendages dull yellow; eyes evanescent, with dusky smudge enclosed by front row; abdomen whitish.

Clypeus 0.15 mm high, longer than eye group. Eyes small (Fig. 8); anterior front eyes smaller than front lateral eyes; posterior eyes small, about half diameter of front lateral and separated from it by full long diameter of latter. Sternum 0.45 mm long and wide.



Figs. 42-47.–Dorsal view of epigyna of species of *Leptoneta*: 42, *L. credula*; 43, *L. silvicultrix*; 44, *L. coma*; 45, *L. gertschi*; 46, *L. barrowsi*; 47, *L. sandra*.

	I	II	III	IV	Palpus
Femur	1.45	1.23	1.00	1.35	0.43
Patella	0.25	0.25	–	0.24	0.15
Tibia	1.55	1.20	–	1.40	0.30
Metatarsus	1.20	0.96	–	1.10	–
Tarsus	0.82	0.70	–	–	0.48
Total	5.27	4.34	–	–	1.36

Epigynum as shown in Figs. 37-38.

Type Data—Female holotype, two females and immature from Ingram Cave, near Allgood, Blount County, Alabama, 8 March 1940 (W. B. Jones).

Leptoneta barrowsi, new species

Diagnosis—Yellowish troglophile with evanescent eyes of medium size and fairly long legs; first leg about 5.6 times as long as carapace; epigynum (Fig. 46).

Etymology—Named for the late Professor William A. Barrows of Ohio State University.

Female—Total length 1.65 mm. Carapace 0.65 mm long, 0.56 mm wide. Abdomen 1 mm long, 0.73 mm wide.

Cephalothorax and appendages dusky yellow; eyes faintly ringed with dusky, abdomen whitish.

Clypeus 0.15 mm high, longer than width of front eye row and slightly longer than length of eye group. Eyes evanescent; front median eyes slightly larger than laterals; posterior eyes slightly smaller and separated from front lateral eye by little more than full diameter of latter. Sternum 0.42 mm long and wide. Chelicera: promargin with 10 teeth, apical three widely separated; retromargin with four denticles.

Leg formula 1423. First leg about 5.6 times, first femur about 1.5 times as long as carapace.

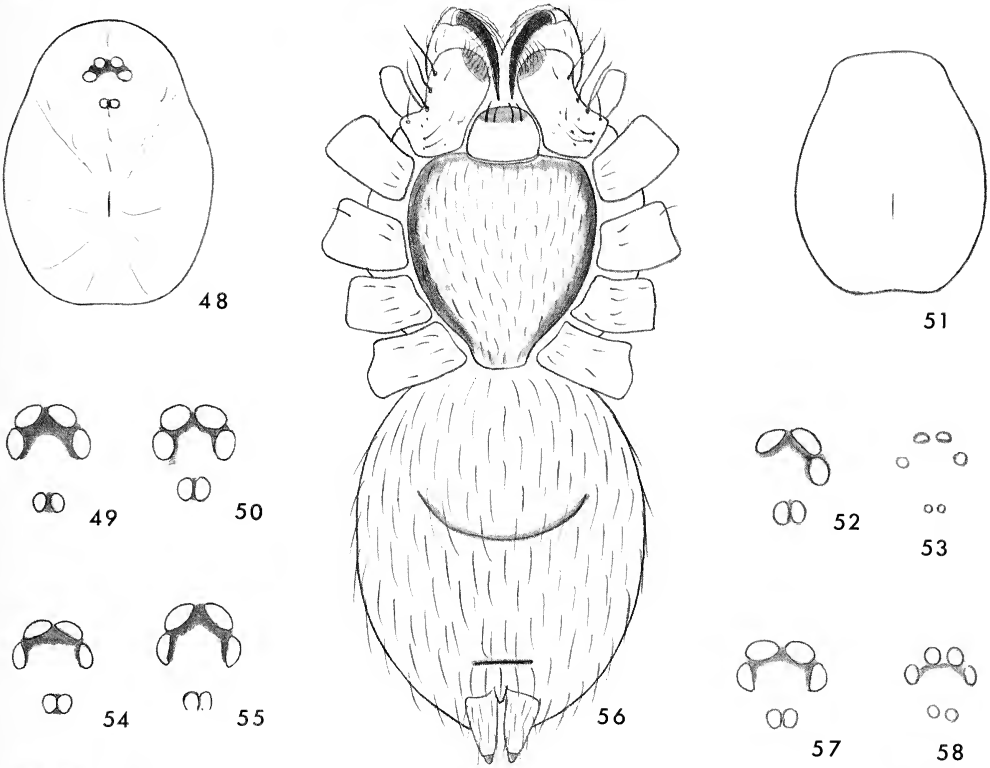
	I	II	III	IV	Palpus
Femur	0.95	0.87	0.73	0.96	0.40
Patella	0.22	0.21	0.19	0.19	0.12
Tibia	1.00	0.80	0.64	0.95	0.27
Metatarsus	0.84	0.70	0.62	0.82	–
Tarsus	0.62	0.56	0.46	0.55	0.41
Total	3.63	3.14	2.64	3.47	1.20

Type Data—Female holotype from Bangor Cave, one mi N Bangor, Blount County, Alabama, 28 June 1967 (S. Peck, A. Fiske).

THE TEXAS FAUNA

The dozen species assigned to this group come mostly from caves of the Edwards Plateau Region of middle Texas and some outlying districts. One closely allied species from Durango, México, is assigned here and a more variant species from the Chiricahua Mountains of Arizona is placed here as a matter of convenience. The group can appropriately be dubbed the *coeca* group in deference to the first described species and also to the fact that most species are cavernicoles. The three epigean species come from ground detritus in moist areas but they differ little from those from caves. The cave species comprise a closely allied series showing the same kind of variation as those from caves in the Appalachian region. They are all small with pale coloration and fairly long legs. Their small eyes vary from medium size to complete obsoletism. One species, *anopica*, is eyeless but several others with rudimentary eyes are probably troglobites, restricted to single caves or cave systems in a generally drier area than Appalachia.

Males of only five of the dozen species of the *coeca* group are presently known. The palpal tarsi of these are similar to those of *alabama, sandra* and others with shallow transverse grooves bearing on the retrolateral margins no especially notable setae or spines. Only one, *valverdae,* has developed a retrolateral lobe on the tarsus and this lacks a modified seta. All five males have well developed retrolateral apophyses on the tibiae



Figs. 48-64.–Species of *Leptoneta*: 48, *L. myopica*, carapace of female, dorsal view; 49, *L. myopica*, eyes of female; 50, *L. coeca*, eyes female; 51, *L. anopica*, carapace, dorsal view; 52, *L. concinna*, eyes of female; 53, *L. microps*, eyes of female; 54, *L. devia*, eyes of female; 55, *L. uvaldea*, eyes of female; 56, *L. myopica*, cephalothorax and abdomen, ventral view; 57, *L. valverdae*, eyes of female; 58, *L. valverdae*, eyes of male; 59, *L. chisosea*, eyes of female; 60, *L. limpida*, eyes of female; 61, *L. myopica*, right chelicera of female, dorsal view; 62, *L. myopica*, right chelicera of female, ventral view; 63, *L. apachea*, eyes of male; 64, *L. furtiva*, eyes of female.

similar to those of the *alabama* series to which they in most respects seem closely related. The chelicerae of the *coeca* series are mostly armed with seven or eight small, subcontiguous teeth on the promargin. The epigyna are all of quite similar design and present on each side a heavy tubular receptacle and a broad shallow atrium between. The presumed course of the embolus of the male is pictured by arrows in Fig. 73.

KEY TO THE FEMALES

1a. Eyeless species (Fig. 51) from Cobb Cave, Williamson County, Texas . . . . . . *anopica*, new species
1b. Eyes present 2
2a(1b). Eyes small, reduced to trivial vestiges (Fig. 53); Government Canyon Bat Cave, Bexar County, Texas . . . . . . *microps*, new species
2b. Eyes larger 3

3a(2b). Posterior eyes separated from front lateral eyes by two or more diameters . . 4
3b. Posterior eyes separated by less than two diameters 5

4a(3a). Bulb of seminal receptacle of medium size (Fig. 74); Story Cave, Uvalde County, Texas . . . . . . *uvaldea*, new species
4b. Bulb larger (Fig. 81); Schulze Cave, Travis County, Texas . . *devia*, new species

5a(3b). Legs longer, first at least 6.1 times as long as carapace, femur at least 1.8 times as long as carapace 6
5b. Legs shorter, first not more than 4.3 times, first femur 1.2 times as long as carapace 8

6a(5a). Eyes of front row subcontiguous 7
6b. Eyes of front row well separated (Fig. 60); Cueva de los Riscos, Durango, México . . . . . . *limpida*, new species

7a(6a). Promargin of chelicera with eight teeth; bulb of seminal receptacles separated at midline (Fig. 73); Tooth Cave, Travis County, Texas . . . . . . *myopica*, new species

7b. Promargin of chelicera with seven teeth; bulb of seminal receptacle larger, subcontiguous, pointed posteriorly; caves of Val Verde County, Texas . . . . . . *valverdae*, new species

8a(5b). Cavernicolous species 9
8b. Epigean species 10

9a(8a). Bulb of seminal receptacle of medium size (Fig. 76); caves of Travis County, Texas . . . . . . *concinna*, new species
9b. Bulb larger, directed posteriorly; caves of Comal County, Texas . . . . . . *coeca* Chamberlin & Ivie

10a(8b). Epigynum (Fig. 121) with heavy tubular receptacles; Chisos Mountains, Brewster County, Texas . . . . . . *chisosea*, new species
10b. Epigynum (Fig. 122) with small, tightly coiled, tubular receptacles; Blackwell, Nolan County, Texas . . . . . . *furtiva*, new species

KEY TO THE MALES

1a. Tarsus of palpus with small retrolateral lobe (Fig. 70); eyes small, separated (Fig. 58) . . . . *valverdae*, new species

1b. Tarsus of palpus without retrolateral lobe 2

2a(1b). Tibial apophysis of palpus conspicuous, retrolaterally directed spur 3

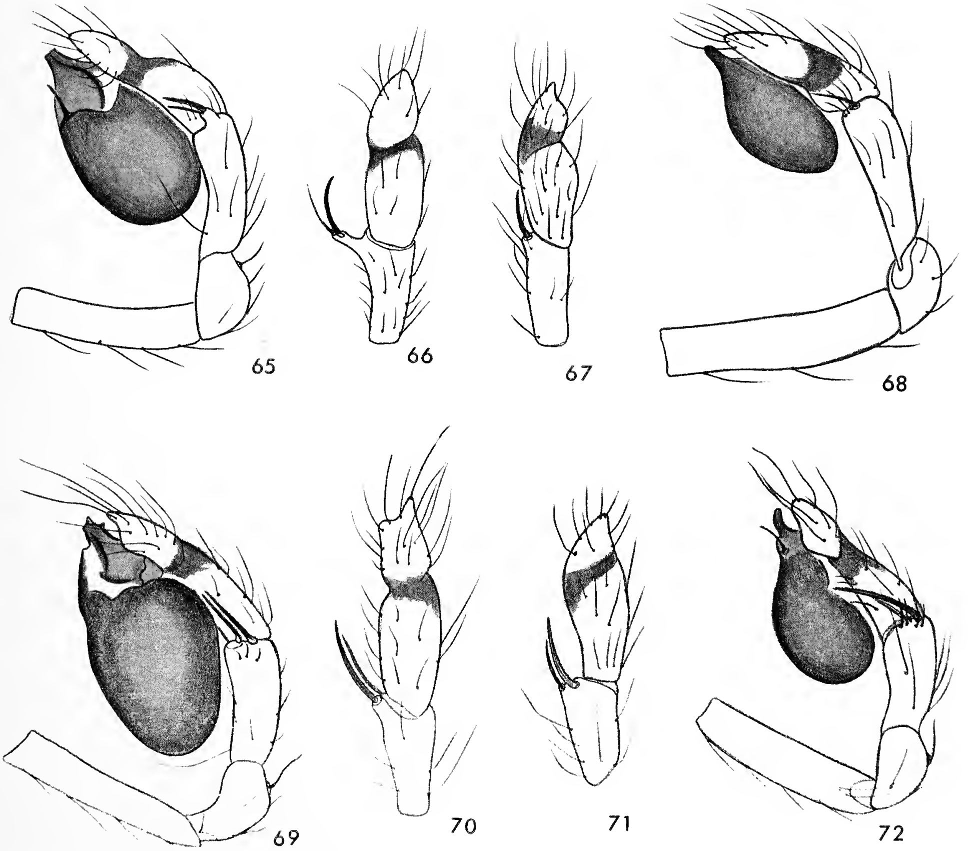
2b. Tibial apophysis small apical enlargement 4

3a(2a). Tibial apophysis heavy spur (Fig. 96); short-legged epigean species of Arizona. . . . . *apachea*, new species

3b. Tibial apophysis thin spur (Fig. 66); long-legged cavernicole from Travis County, Texas . . . . *myopica*, new species

4a(2b). Male palpus (Fig. 71-72) with shorter segments and fairly large bulb; shorter-legged species from caves of Travis County, Texas . . . *concinna*, new species

4b. Male palpus (Figs. 67-68) with longer segments and small pointed bulb; longer-legged species from caves of Comal County, Texas . . . . *coeca* Chamberlin & Ivie



Figs. 65-72.–Left male palpi of species of *Leptoneta*: 65, *L. myopica*, whole palpus, retrolateral view; 66, *L. myopica*, tibia and tarsus, dorsal view; 67, *L. coeca*, tibia and tarsus, dorsal view; 68, *L. coeca*, whole palpus, retrolateral view; 69, *L. valverdae*, whole palpus, retrolateral view; 70, *L. valverdae*, tibia and tarsus, dorsal view; 71, *L. concinna*, tibia and tarsus, dorsal view; 72, *L. concinna*, whole palpus, retrolateral view.

Leptoneta myopica, new species

Diagnosis—Small, whitish, long-legged cavernicole with obsolescent eyes, probable troglobite; first leg in both sexes 6.1 times as long as carapace; tibia of male palpus with thin retrolateral process set with curved spine; epigynum (Fig. 73).

Etymology—Specific name from Greek *myopia*, nearsighted.

Female—Total length 1.6 mm. Carapace 0.7 mm long, 0.5 mm wide. Abdomen 0.9 mm long, 0.6 mm wide.

Base color of cephalothorax and appendages whitish to dull yellow; sternum with very faint marginal dusky seam; legs faintly dusky at junctures of segments; abdomen whitish to gray.

Structure typical (Figs. 48, 56); clypeus 0.12 mm long, gradually sloping, about as long as eye group. Eyes (Fig. 49) of medium size, without dark pigment; front eye row moderately recurved, eyes subcontiguous and subequal in size; posterior eyes subcontiguous, set back from anterior lateral eyes by width of both. Sternum 0.45 mm long, 0.37 mm wide. Labium 0.12 mm long and wide. Endite 0.25 mm long, 0.18 mm wide at base; serrula on outer corner at apex. Chelicera narrowed moderately to apex; promargin with eight small, subcontiguous teeth; retromargin with three denticles; see Figs. 61-62.

Leg formula 1423. First leg 6.1 times, first femur 1.8 times as long as carapace; femora with slight thickening in basal half. Clothing of legs fine hairs and few weak spines; first tibia with 2-2-0 ventral spines; all patellae with single apical spine above. Female palpus with thin claw.

Abdomen suboval, as high as broad, sparsely clothed on all surfaces with suberect dusky hairs (Fig. 56).

Epigynum as shown in Fig. 73.

	I	II	III	IV	Palpus
Femur	1.25	1.05	0.86	1.14	0.33
Patella	0.23	0.23	0.23	0.23	0.11
Tibia	1.28	0.96	0.75	1.23	0.25
Metatarsus	0.98	0.80	0.70	0.88	–
Tarsus	0.57	0.46	0.46	0.57	0.33
Total	4.31	3.50	3.00	4.05	1.02

Male—Total length 1.6 mm. Carapace 0.7 mm long, 0.5 mm wide. Abdomen 0.9 mm long, 0.5 mm wide.

Coloration and structure like those of female; femora of legs more dusky.

Leg formula 1423; legs long and thin. First leg 6.1 times, first femur 1.7 times as long as carapace; femora slightly thickened. Legs with few more spines than female; first femur with two ventral pairs and two single spines.

Male palpus (Figs. 65-66) with segments moderately elongated; tarsus with moderately deep transverse groove in apical part, without lobe or special setal armature; tibia with thin retrolateral spur set with principal curved spine; bulb suboval, or medium size.

	I	II	III	IV	Palpus
Femur	1.23	1.15	0.83	1.10	0.37
Patella	0.22	0.20	0.20	0.21	0.13
Tibia	1.24	0.87	0.75	1.18	0.22
Metatarsus	1.00	0.80	0.67	1.00	–
Tarsus	0.66	0.49	0.43	0.57	0.22
Total	4.35	3.39	2.88	4.06	0.94

Type Data–Male holotype from Tooth Cave, 15 mi NW of Austin, Travis County, Texas, 30 March 1965 (J. Reddell).

Distribution–Known only from Tooth Cave.

Records–*Texas*: Travis County: Tooth Cave, 25 February 1963 (D. McKenzie, J. Reddell), male, three females; 9 June 1967, four males, seven females; 19 August 1970, three females; 5 March 1964 (J. Reddell, D. McKenzie, T. Phillips), female; 14 May 1966 (W. Russell), female; 30 March 1965 (J. Reddell), male; 8 March 1968 (J. Reddell, W. Russell, S. Fowler), female; 19 August 1970, male.

Leptoneta concinna, new species

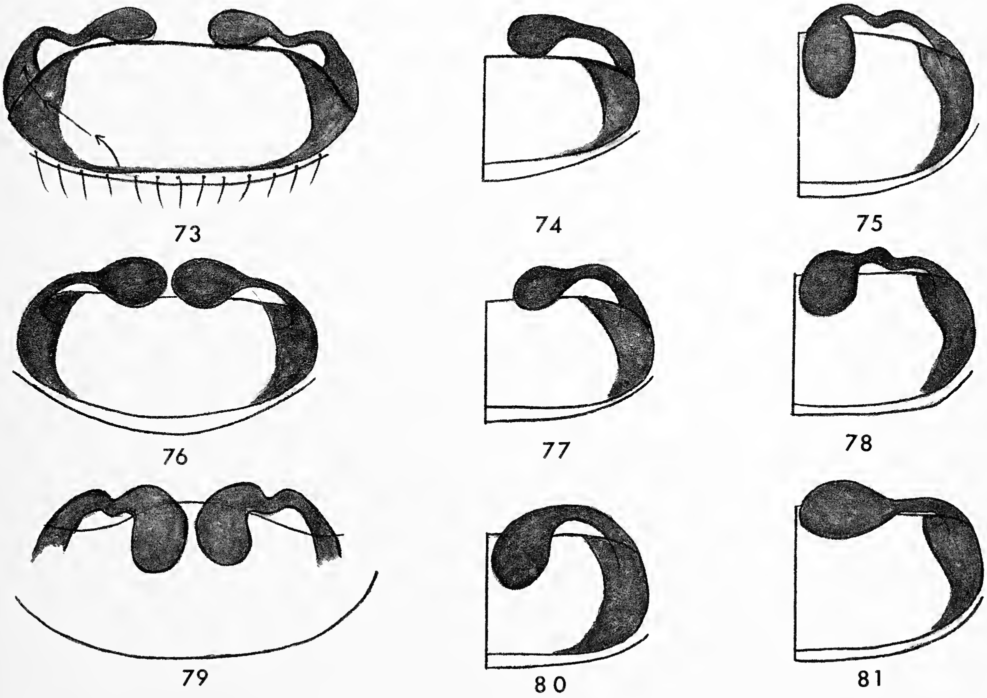
Diagnosis–Small, whitish, short-legged cavernicole, probably troglobite; first leg of female 2.7 times, of male four times as long as carapace; tibia of male palpus with trivial lateral spur armed with long spine; epigynum (Fig. 76).

Etymology–Specific name from Latin *concinnus*, pleasing.

Female–Total length 1.5 mm. Carapace 0.59 mm long, 0.44 mm wide. Abdomen 0.9 mm long, 0.65 mm wide.

Cephalothorax and appendages dusky yellow; eyes narrowly ringed with black; abdomen white.

Structure like that of *myopica* unless otherwise noted. Carapace suboval, short, quite high, narrowly rounded in front; clypeus 0.07 mm high, equal to half length of eye group. Eyes (Fig. 52) of medium size; anterior eye row strongly recurved, eyes subequal and contiguous (left lateral eye missing); posterior eyes contiguous, separated from anterior



Figs. 73-81.–Dorsal and right half dorsal view of epigyna of species of *Leptoneta*: 73, *L. myopica*; 74, *L. uvaldea*; 75, *L. valverdae*; 76, *L. concinna*; 77, *L. microps*; 78, *L. anopica*; 79, *L. limpida*; 80, *L. coeca*; 81, *L. devia*.

lateral by full diameter. Sternum 0.4 mm long, 0.36 mm wide. Chelicera: promargin with seven teeth; retromargin with two denticles.

Leg formula 4123; legs short, moderately stout. First leg 3.7 times, first femur about as long as carapace.

Epigynum as shown in Fig. 76.

	I	II	III	IV	Palpus
Femur	0.62	0.53	0.46	0.64	0.24
Patella	0.18	0.16	0.15	0.17	0.10
Tibia	0.61	0.46	0.38	0.65	0.15
Metatarsus	0.46	0.39	0.37	0.52	–
Tarsus	0.31	0.29	0.27	0.33	0.22
Total	2.18	1.83	1.63	2.31	0.71

Male–Total length 1.45 mm. Carapace 0.61 mm long, 0.47 mm wide. Abdomen 0.8 mm long, 0.5 mm wide.

Coloration and structure like those of female. Eyes narrowly ringed with black. Carapace proportionately broader and subtruncate in front. Clypeus 0.08 mm, narrower than length of eye group.

Leg formula 4123. First leg four times, first femur 1.1 times as long as carapace.

Male palpus (Figs. 71-72) with segments fairly short; tarsus with moderately developed transverse groove beyond middle; tibia with trivial retrolateral spur bearing long spine and four subsidiary, overlapping spines.

	I	II	III	IV	Palpus
Femur	0.68	0.55	0.45	0.69	0.23
Patella	0.18	0.18	0.17	0.15	0.11
Tibia	0.63	0.53	0.44	0.68	0.15
Metatarsus	0.53	0.43	0.40	0.55	–
Tarsus	0.40	0.33	0.30	0.40	0.20
Total	2.42	2.02	1.76	2.57	0.69

Type Data–Male holotype from Lost Gold Cave, 5 mi W Austin, Travis County, Texas 27 May 1963 (J. Reddell, B. Frank), found in second room in darkness.

Distribution–Travis County caves.

Record–*Texas:* Travis County: Stark's North Mine, 9 mi NNE Austin, 20 August 1963 (W. Russell), female described above.

Leptoneta coeca Chamberlin & Ivie

Leptoneta coeca Chamberlin & Ivie, 1942, p. 10, Fig. 9. Vogel, 1967, p. 87. Brignoli, 1972, p. 135.

Diagnosis–Small, whitish, short-legged cavernicole, probable troglobite; first leg of female 4.3 times, of male 5.2 times as long as carapace; male palpus with elongated segments, tarsus without accessory lobe, tibia with trivial lateral spur set with fairly long spine; epigynum (Fig. 80).

Etymology–Specific name from Latin *caecus*, blind, hidden.

Female–Total length 1.35 mm. Carapace 0.53 mm long, 0.45 mm wide. Abdomen 0.8 mm long, 0.5 mm wide.

Cephalothorax and appendages yellow; eyes narrowly margined with black; abdomen whitish.

Structure typical; clypeus 0.07 mm high, subvertical, much shorter than length of eye group. Eyes (Fig. 50) small; anterior eyes subequal, contiguous; posterior eyes smaller, separated from front lateral by more than diameter of latter. Sternum 0.36 mm long, 0.33 mm wide.

	I	II	III	IV	Palpus
Femur	0.66	0.56	0.45	0.63	0.35
Patella	0.18	0.16	0.16	0.15	0.10
Tibia	0.64	0.50	0.38	0.65	0.23
Metatarsus	0.50	0.42	0.37	0.57	–
Tarsus	0.33	0.30	0.30	0.35	0.19
Total	2.31	1.95	1.66	2.35	0.87

Leg formula 4123. First leg 4.3 times, first femur 1.2 times as long as carapace.

Epigynum as shown in Fig. 80.

Male–Total length 1.45 mm. Carapace 0.62 mm long, 0.5 mm wide. Abdomen 0.77 mm long, 0.55 mm wide.

Coloration and structure like those of female. Carapace suboval, with front gently rounded. Clypeus 0.14 mm high, equal to length of eye group.

Leg formula 1423. First leg 5.2 times, first femur 1.4 times as long as carapace.

Male palpus (Figs. 67-68) with long, thin segments; tarsus with deep transverse groove beyond middle, without lobes or other modifications, tibia with weak retrolateral spur bearing quite long spine; bulb small, suboval, with pointed embolus.

	I	II	III	IV	Palpus
Femur	0.89	0.72	0.60	0.86	0.35
Patella	0.20	0.17	0.16	0.18	0.10
Tibia	0.95	0.66	0.56	0.93	0.23
Metatarsus	0.72	0.56	0.55	0.73	–
Tarsus	0.44	0.38	0.32	0.40	0.19
Total	3.20	2.49	2.19	3.10	0.87

Type Data–Male holotype from Brehmmer Cave (=Heidrich's Cave), 5 mi W New Braunfels, Comal County, Texas, 20 June 1938, in American Museum of Natural History (University of Utah Collection).

Distribution–Caves of Comal County, Texas.

Records–*Texas*: Comal County: Brehmmer (=Heidrich's) Cave 19 March 1960 (W. J. Gertsch), male, female. Natural Bridge Cave, 13 mi W New Braunfels, 13 July 1963 (J. Reddell), two females, 3 juvenile; 23 February 1963 (J. Reddell, D. McKenzie), female in pit 50 feet from entrance.

Leptoneta devia, new species

Diagnosis–Small, whitish, short-legged cavernicole, probable troglobite; first leg 4.4 times as long as carapace; epigynum (Fig. 81) with large receptacles nearly touching at midline.

Etymology–Specific name from Latin *devius*, out of the way.

Female–Total length 1.3 mm. Carapace 0.57 mm long, 0.43 mm wide. Abdomen 0.7 mm long, 0.45 mm wide.

Cephalothorax and appendages dull yellow; eyes enclosing dusky field; abdomen whitish.

Structure like that of *myopica*; clypeus 0.09 mm high, equal in height to nearly length of eye group. Eyes (Fig. 54) small, on low tubercles; posterior eyes small, separated from anterior lateral eye by nearly two diameters. Sternum 0.4 mm long, 0.33 mm wide. Chelicera: promargin with seven small teeth; retromargin with three separated denticles.

	I	II	III	IV	Palpus
Femur	0.70	0.53	0.49	0.73	0.21
Patella	0.19	0.18	0.17	0.19	0.07
Tibia	0.70	0.54	0.40	0.72	0.15
Metatarsus	0.54	0.43	0.39	0.56	–
Tarsus	0.40	0.34	0.31	0.40	0.23
Total	2.53	2.02	1.76	2.60	0.66

Leg formula 4123. First leg 4.4 times, first femur 1.2 times as long as carapace.

Epigynum as shown in Fig. 81.

Type Data—Female holotype and three females from Schulze Cave, 13 mi NNW Austin, Travis County, Texas, 21 August 1963 (W. Russell).

Leptoneta anopica, new species

Diagnosis—Small, whitish, long-legged troglobite without trace of eyes; first femur 2.7 times as long as carapace; epigynum (Fig. 78).

Etymology—Specific name from Greek *a*, without, *nops*, eyes, without eyes.

Female—Total length 1.4 mm. Carapace 0.6 mm long, 0.4 mm wide. Abdomen 0.82 mm long 0.54 mm wide.

Cephalothorax and appendages dull yellow; abdomen whitish.

Structure like that of *myopica*; carapace suboval, nearly truncated in front (Fig. 51); eyes completely obsolete. Sternum 0.45 mm long, 0.36 mm wide. Chelicera: promargin with seven small teeth; retromargin with three denticles.

Legs fragmented; first femur 1.35 mm, second femur 1.13 mm, third femur 0.95 mm, fourth femur 1.26 mm. Palpus: femur 0.35 mm, patella 0.09 mm, tibia 0.21 mm, tarsus 0.35 mm, total 1 mm.

Epigynum as shown in Fig. 78.

Type Data—Female holotype from Cobb Cavern, 10 mi NNW Georgetown, Williamson County, Texas, 31 March 1963 (J. Reddell, D. McKenzie).

Leptoneta microps, new species

Diagnosis—Small, yellowish, short-legged, essentially eyeless cavernicole, probable troglobite; first leg 4.4 times as long as carapace; epigynum (Fig. 77).

Etymology—Specific name from Greek *mikros*, small, and *ops*, eyes, small eyed.

Female—Total length 1.7 mm. Carapace 0.6 mm long, 0.45 mm wide. Abdomen 1.1 mm long, 0.7 mm wide.

Carapace dull yellow to orange; appendages dusky orange; abdomen dull yellowish.

Structure typical; clypeus 0.07 mm high, narrower than length of eye group. Eyes (Fig. 53) small, nearly obsolete, represented by trivial corneal spots; anterior row moderately recurved, eyes subequal in size and separated by more than radius; posterior eyes very small round spots placed far back from anterior lateral by nearly three diameters of anterior lateral eye. Sternum 0.4 mm long, 0.35 mm wide.

First leg 4.4 times, first femur 1.3 times as long as carapace.

Epigynum as shown in Fig. 77.

	I	II	III	IV	Palpus
Femur	0.78	0.65	0.57	0.77	0.27
Patella	0.18	0.17	0.17	0.16	0.10
Tibia	0.70	0.55	0.48	–	0.19
Metatarsus	0.60	0.50	0.46	–	–
Tarsus	0.40	0.34	0.31	–	0.24
Total	2.66	2.21	1.99	–	0.80

Type Data–Female holotype from Government Canyon Bat Cave, 5 mi SW Helotes, Bexar County, Texas 11 August 1965 (J. Reddell, J. Fish).

Leptoneta uvaldea, new species

Diagnosis–Small, yellowish, short-legged cavernicole; first leg 4.7 times as long as carapace; epigynum (Fig. 74).

Etymology–Named for Uvalde County, Texas.

Female–Total length 1.4 mm. Carapace 0.65 mm long, 0.5 mm wide. Abdomen 0.8 mm long, 0.6 mm wide.

Cephalothorax and abdomen bright yellow; eyes enclosing reduced black field; abdomen white.

Structure typical; clypeus 0.09 mm high, shorter than length of eye group. Eyes (Fig. 55) of average size; anterior median eyes distinctly separated by fourth of diameter; posterior eyes slightly smaller than anterior lateral and separated from them by about diameter of latter. Sternum 0.4 mm long, 0.3 mm wide. Chelicera: promargin with seven teeth; retromargin with three denticles.

Leg formula 4123; first and fourth pairs subequal. First leg 4.7 times, first femur 1.4 times as long as carapace.

Epigynum as shown in Fig. 74.

	I	II	III	IV	Palpus
Femur	0.92	0.72	0.62	0.88	0.30
Patella	0.20	0.18	0.16	0.17	0.10
Tibia	0.90	0.66	0.54	0.88	0.19
Metatarsus	0.70	0.58	0.47	0.70	–
Tarsus	0.36	0.36	0.32	0.44	0.26
Total	2.08	2.50	2.11	3.07	0.85

Type Data–Female holotype from Story Cave, 22 mi NE Uvalde, Uvalde County, Texas, 18 October 1964 (J. Reddell, D. McKenzie).

Leptoneta valverdae, new species

Diagnosis–Small, whitish, long-legged cavernicole with small, evanescent eyes, probable troglobite; first leg of female 6.3 times, first leg of male seven times as long as carapace; male palpus with very large bulb, tarsus bearing small retrolateral process and tibia with long retrolateral spine; epigynum (Fig. 75).

Etymology–Named for Val Verde County, Texas.

Female—Total length 1.5 mm. Carapace 0.65 mm long, 0.53 mm wide. Abdomen 0.8 mm long, 0.65 mm wide.

Cephalothorax and appendages pale, dull yellow; eyes very narrowly margined with black; abdomen whitish.

Structure like that of *myopica* unless otherwise noted. Carapace oval, gently rounded in front; clypeus 0.1 mm high, equal in length to that of eye group. Eyes (Fig. 57) small, evanescent; anterior eyes subequal and subcontiguous; posterior eyes smaller, separated from anterior lateral by diameter of these eyes. Sternum 0.46 mm long, 0.38 mm wide. Chelicera: promargin with seven teeth; retromargin with three denticles.

Leg formula 1423. First leg 6.3 times, first femur 1.8 times as long as carapace.

Epigynum as shown in Fig. 75.

	I	II	III	IV	Palpus
Femur	1.12	1.05	0.86	1.14	0.34
Patella	0.23	0.23	0.20	0.20	0.10
Tibia	1.16	0.93	0.77	1.15	0.20
Metatarsus	0.95	0.77	0.72	0.90	–
Tarsus	0.67	0.60	0.50	0.60	0.30
Total	4.13	3.61	3.05	3.99	0.94

Male—Total length 1.55 mm. Carapace 0.69 mm long, 0.55 mm wide. Abdomen 0.8 mm long, 0.55 mm wide.

Coloration and structure like those of female. Eyes (Fig. 58) smaller, evanescent, with anterior lateral indistinctly apparent; posterior eyes small, separated by radius and from anterior lateral by two diameters of these eyes. Clypeus 0.12 mm high, more widely rounded, higher than length of eye group. Sternum 0.45 mm long, 0.4 mm wide.

Leg formula 1423. First leg seven times, first femur about twice as long as carapace; first tibia with 2-2-2-0 spines, first pair close to base of segment.

Male palpus (Figs. 69-70) with elongated segments; tarsus moderately grooved in apical third, pointed at apex and bearing small rounded lobe on retrolateral side lacking prominent seta; tibia with moderately developed retrolateral apophysis at apex bearing long spine.

	I	II	III	IV	Palpus
Femur	1.35	1.18	1.00	1.30	0.40
Patella	0.25	0.23	0.21	0.23	0.11
Tibia	1.44	1.20	0.96	1.43	0.16
Metatarsus	1.16	0.92	0.84	1.08	–
Tarsus	0.80	0.68	0.58	0.70	0.27
Total	5.00	4.21	3.59	4.74	0.94

Type Data—Male holotype from Oriente Milestone Molasses Bat Cave, about 8 mi NE Del Rio, Val Verde County, Texas, 25 January 1964 (J. Reddell, D. McKenzie, J. Porter), from under rocks beyond the bat room.

Distribution—Caves of Val Verde County, Texas.

Records—*Texas*: Val Verde County: Fawcett's Cave, 36 mi NE Del Rio, 10 April 1968 (J. Reddell), two females, immature; 25 March 1961 (M. Tandy), two juvenile.

Leptoneta limpida, new species

Diagnosis—Pale, long-legged cavernicole with reduced eyes, probable troglobite, related to species of Texas; first leg 6.7 times as long as carapace; epigynum (Fig. 79).

Etymology–Specific name from Latin *limpidus*, clear, limpid.

Female–Total length 1.4 mm. Carapace 0.63 mm long, 0.58 mm wide. Abdomen 0.72 mm long, 0.6 mm wide.

Cephalothorax and appendages pale yellow; front eyes enclosing black field; abdomen whitish.

Clypeus 0.12 mm high, wider than width of front eyes, about equal to length of eye group. Eyes (Fig. 60) reduced in size; front eyes small, oval, well separated; posterior pair smaller, separated from anterior lateral by more than long diameter of latter.

First leg 6.7 times, first femur 1.8 times as long as carapace.

Epigynum (Fig. 79) presenting enlarged receptable on each side nearly touching at midline.

	I	II	III	IV	Palpus
Femur	1.13	1.04	0.85	1.16	0.34
Patella	0.24	0.20	0.20	0.20	0.11
Tibia	1.21	–	0.76	–	0.22
Metatarsus	0.98	–	0.70	–	–
Tarsus	0.70	–	0.47	–	0.36
Total	4.26	–	2.98	–	1.03

Type Data–Female holotype and one immature from Cueva de los Riscos, 4 km S Mapimí, Durango, México, 15 June 1972 (J. Reddell, E. Alexander, W. Elliott, C. Kunath).

Leptoneta chisosea, new species

Diagnosis–Small, yellowish, short-legged epigean species with features differing little from cavernicolous representatives; first leg four times as long as carapace; epigynum (Fig. 121) with receptacles widely separated on midline.

Etymology–Named for Chisos Mountains of Texas.

Female–Total length 1.55 mm. Carapace 0.65 mm long, 0.55 mm wide. Abdomen 0.9 mm long, 0.7 mm wide.

Cephalothorax and abdomen dull yellow; front eyes enclosing dusky field and posterior eyes narrowly ringed with black; sternum with dusky line around margins; abdomen whitish, with faint brown shadings on sides of venter.

Clypeus 0.12 mm high, as long as width of front eyes, narrower than length of eye group. Eyes (Fig. 59) of medium size; eyes of front row subequal and subcontiguous; posterior eyes about equal with front eyes and separated by full diameter of latter. Sternum 0.4 mm long, 0.36 mm wide. Chelicera: promargin with single row of seven teeth; retromargin with two denticles.

Leg formula 4123. First leg four times, first femur 1.1 times as long as carapace.

Epigynum as shown in Fig. 121.

	I	II	III	IV	Palpus
Femur	0.75	0.68	0.55	0.81	0.28
Patella	0.20	0.18	0.18	0.20	0.10
Tibia	0.80	0.60	–	0.82	0.18
Metatarsus	0.58	0.47	–	0.62	–
Tarsus	0.43	0.36	–	0.43	0.30
Total	2.76	2.29	–	2.88	0.86

Type Data—Female holotype and female from The Basin, Chisos Mountains, Big Bend National Park, Texas, 28 September 1950 (W. J. Gertsch), from ground detritus in ravine.

Leptoneta furtiva, new species

Leptoneta californica: Gertsch, 1935, p. 21 (not Banks). Bonnet, 1957, p. 2392 (part: Texas record).

Diagnosis—Small, yellowish epigean species with distinctive epigynum (Fig. 122).

Etymology—Specific name from Latin *furtivus*, furtive.

Female—Total length 1.43 mm. Carapace 0.58 mm long, 0.43 mm wide. Abdomen 0.85 mm long, 0.7 mm wide.

Cephalothorax and appendages yellowish to dusky orange; front eyes enclosing narrow dusky field; sternum with narrow dusky line along margins; abdomen dull yellow.

Clypeus 0.12 mm high, longer than width of front eyes, about as long as length of eye group. Eyes (Fig. 64) of medium size; median eyes of front row larger than lateral, all subcontiguous; posterior eyes about equal to front lateral eyes and separated by full diameter. Sternum 0.38 mm long, 0.3 mm wide. Chelicera like that of *silvicultrix*, with six small teeth and two enlarged, separated ones at apex of row.

Legs mostly missing; leg IV, femur 0.7 mm, patella 0.18 mm, tibia 0.7 mm. Palpus: femur 0.29 mm, patella 0.11 mm, tibia 0.21 mm, tarsus 0.28 mm, total 0.89 mm.

Epigynum as shown in Fig. 122.

Type Data—Female holotype from Blackwell, SW Abilene, Nolan County, Texas, 15 August 1927.

Leptoneta apachea, new species

Diagnosis—Small, yellowish epigean species readily recognized by distinctive features of male palpus (Figs. 96-97).

Etymology—Named for the Apache Indians.

Male—Total length 1.55 mm. Carapace 0.68 mm long, 0.57 mm wide. Abdomen 0.8 mm long, 0.55 mm wide.

Cephalothorax and appendages mostly yellow; sternum with narrow dark seam; front eyes enclosing black field and posterior eyes narrowly ringed with black; femora of legs somewhat dusky; abdomen whitish.

Clypeus 0.12 mm high, about as long as width of front eye row, not as long as eye group. Eyes (Fig. 63) of medium size; posterior eyes oval, separated from front lateral eye by nearly their diameter. Sternum 0.42 mm long, 0.39 mm wide. Chelicera: promargin with seven, close-set teeth.

Leg formula probably 1423. First femur 1.1 times as long as carapace.

Palpus (Figs. 96-97) with short segments; tarsus shallowly grooved beyond middle, without lobe or modifications; tibia with heavy retrolateral process bearing fairly long spine.

	I	II	III	IV	Palpus
Femur	0.98	0.80	0.70	0.90	0.31
Patella	0.20	0.20	0.19	0.19	0.12
Tibia	–	0.81	0.66	–	0.15
Metatarsus	–	0.65	0.63	–	–
Tarsus	–	0.45	0.43	–	0.27
Total	–	2.91	2.61	–	0.85

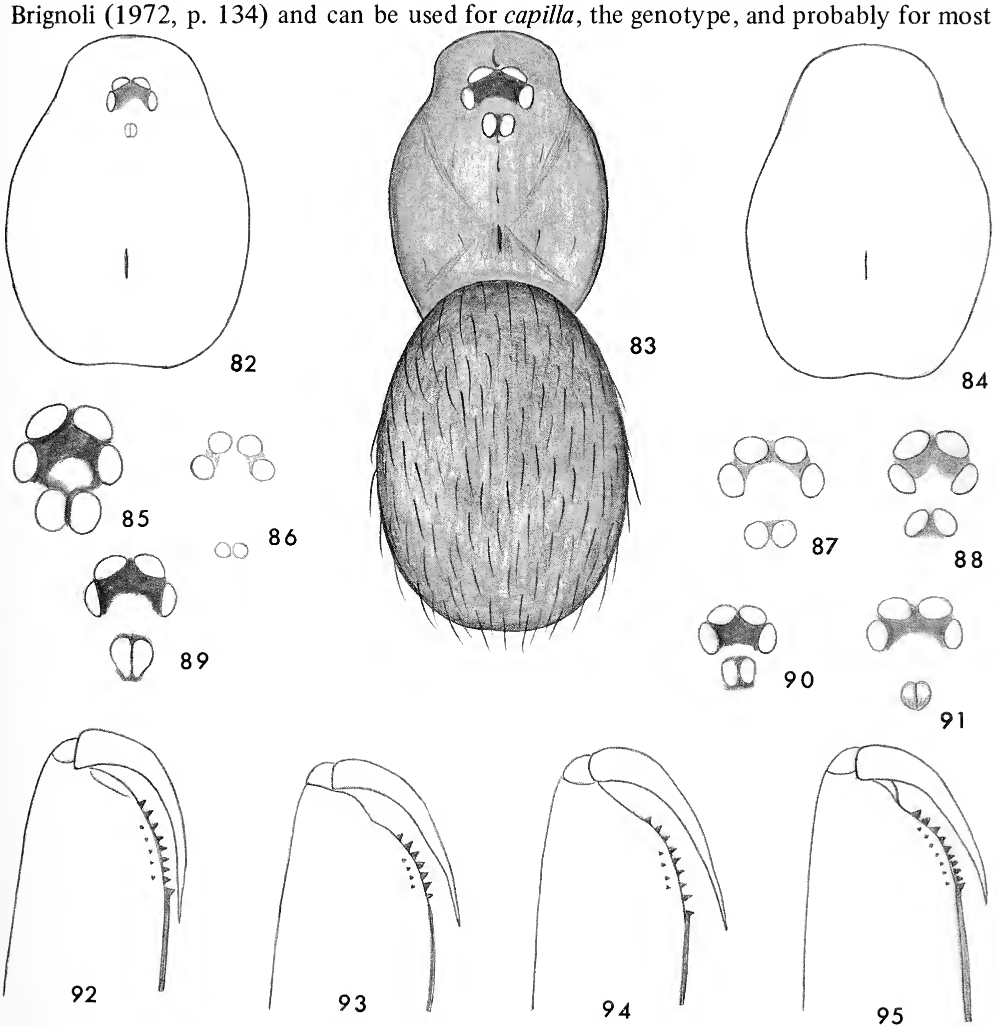
Type Data–Male holotype from Southwestern Research Station, 5 mi SW Portal, Cochise County, Arizona, August 1956 (A. F. Archer).

Distribution–Chiricahua Mountains of Arizona.

Record–Arizona: Cochise County: above Southwestern Research Station, 5400 feet, 5 mi SW Portal, 15 April 1967 (V. Roth), penultimate male from oak leafmold.

THE MEXICAN FAUNA

The typical *Leptoneta* so far known from eastern México present only small differences from those of Texas and Appalachia and are here maintained in the same genus. In an earlier paper (Gertsch, 1971) I described six species and three others are added here. The new generic name *Neoleptoneta* was applied to the Mexican series by Brignoli (1972, p. 134) and can be used for *capilla*, the genotype, and probably for most



Figs. 82-95,–Species of *Leptoneta*: 82, *L. capilla*, carapace and eyes of male from Cueva Mina; 83, *L. brunnea*, carapace and eyes of female, dorsal view; 84, *L. capilla*, carapace of male; 85, *L. brunnea*, eyes of female; 86, *L. reclusa*, eyes of female; 87, *L. pecki*, eyes of female; 88, *L. modica*, eyes of female; 89, *L. rainesi*, eyes of female; 90, *L. bonita*, eyes of male; 91, *L. delicata*, eyes of female; 92, *L. capilla*, right chelicera of female, ventral view; 93, *L. brunnea*, right chelicera of female, ventral view; 94, *L. isolata*, right chelicera of female, ventral view; 95, *L. reclusa*, right chelicera of male, ventral view.

of the other American species. For this paper I have decided to follow the conservative course and regard all our American taxa as comprising a single generic group with a number of intergradient species groups. The basic differences between epigean and cave species hold for the Mexican series. The cavernicoles are usually paler with longer legs. The essentially eyeless species, *capilla* and *isolata*, are claimed to be troglobites and others with reduced eyes may also qualify. A male of *capilla* with eyes is discussed in the formal description of that species.

Males of all nine species from eastern México are known and their palpi are of special interest since they clearly show relationship to Texas and Alabama species. The tarsi are provided with transverse grooves of various development but this segment bears few modified setae and only in species, *pecki* and *isolata*, are retrolateral lobes developed and these without enlarged setae. *Leptoneta modica* is unique in having a prominent prolateral lobe on the tarsus. Most of the Mexican species have well developed tibial apophyses armed with heavy spines. *Leptoneta brunnea* has heavy spines below the femur borne on elevated, peglike alveolae. The chelicerae of the Mexican series are notable mainly in having more numerous teeth on the promargin but these are typically closely spaced and of similar size. The epigyna are diagnostic for each species and feature the typical tubular receptacle on each side and variously developed transverse bursae.

KEY TO THE MALES

1a. Eyes obsolete or nearly so 2
1b. Eyes present 3

2a(1a). Tarsus of male palpus with retrolateral lobe (Fig. 108); Grutas de García, Nuevo León . . . . *isolata* Gertsch
2b. Tarsus of palpus without retrolateral lobe (Fig. 115); caves of Tamaulipas . . . . *capilla* Gertsch

3a(1b). Femur of palpus with subventral row of six heavy spines; epigean species of Hidalgo . . . . *brunnea*, new species
3b. Femur of palpus without heavy spines 4

4a(3b). Tarsus of palpus with prolateral lobe (Fig. 99); epigean species of Nuevo León . . . . *modica*, new species
4b. Tarsus of palpus without prolateral lobe 5

5a(4b). Tarsus of palpus with retrolateral lobe (Fig. 105); Grutas de San Bartolo, Nuevo León . . . . *pecki* Gertsch
5b. Tarsus of palpus without retrolateral lobe 6

6a(5b). Tibia of palpus with trivial retrolateral apophysis set with long seta (Fig. 109); Cueva Bonita, Tamaulipas . . . . *bonita*, new species
6b. Tibia of palpus with well marked retrolateral apophysis 7

7a(6b). Tibial apophysis directed apically, armed with long flat spine (Fig. 104); caves of Tamaulipas . . . . *rainesi* Gertsch
7b. Tibial apophysis directed retrolaterally 8

8a(7b). Tibial apophysis long sharp spur (Fig. 113); Iron Mine of Querétaro . . . . *delicata* Gertsch
8b. Tibial apophysis shorter (Fig. 11); Cueva de Chorros de Agua, Nuevo León . . . . *reclusa* Gertsch

KEY TO THE FEMALES

1a. Eyes obsolete or nearly so 2
1b. Eyes present 3

2a(1b). Legs longer, first femur 2.8 times as long as carapace; epigynum (Fig. 119) with broad bursa and pair of thin tubular receptacles; caves of Tamaulipas . . . . *capilla* Gertsch
2b. Legs shorter, first femur 2.2 times as long as carapace; epigynum (Fig. 123) broad with heavier tubular receptacles; Grutas de García, Nuevo León . . . . *isolata* Gertsch

3a(1b). Dark epigean species of Hidalgo with large eyes (Figs. 83, 84); legs short, first femur 1.4 times as long as carapace . . . . *brunnea*, new species
3b. Pale cavernicolous species with smaller eyes and longer legs 4

4a(3b). Promargin of chelicera with seven teeth 5
4b. Promargin with eight or nine teeth 6

5a(4a). Legs longer, first femur twice as long as carapace; epigynum (Fig. 120); Grutas de San Bartolo, Nuevo León . . . . *pecki* Gertsch
5b Legs shorter, first femur 1.5 times as long as carapace; epigynum (Fig. 117); caves of Tamaulipas . . . . *rainesi* Gertsch

6a(4b). Promargin of chelicera with eight teeth; epigynum (Fig. 124); Iron Mine of Querétaro . . . . *delicata* Gertsch
6b. Promargin of chelicera with nine teeth; epigynum (Fig. 118); Cueva de Chorros de Agua, Nuevo León . . . . *reclusa* Gertsch

Leptoneta capilla Gertsch

Leptoneta capilla Gertsch, 1971, p. 52, Figs. 1-2. *Neoleptoneta capilla* Brignoli, 1972, p. 135, Figs. 6-10.

Diagnosis–Pale, long-legged, eyeless troglobite; first leg of female and male 10 times as long as carapace; tarsus of male palpus with simple, apically rounded principal branch without accessory lobe; epigynum (Fig. 119).

Discussion–The discovery of a male with eyes from Cueva de la Mina, in Tamaulipas, is most interesting and shows that the eyeless condition is not completely erased from the genes. The male agrees completely with typical *capilla* except for somewhat shorter appendages, the disparity probably falling well within the range of the species. In the same collection were two eyeless juvenile specimens, these maintaining the presumed normal condition of the species.

Female–Total length 2 mm. Carapace 0.85 mm long, 0.75 mm wide. Abdomen 1.2 mm long, 0.8 mm wide.

	I	II	III	IV	Palpus
Femur	2.40	2.00	1.65	2.20	0.50
Patella	0.30	0.26	0.25	0.30	0.20
Tibia	2.60	1.85	1.45	2.20	0.36
Metatarsus	2.00	1.60	1.35	1.75	–
Tarsus	1.30	1.10	0.85	1.15	0.26
Total	8.60	6.80	5.55	7.60	1.32

Right chelicera as shown in Fig. 92.

Leg formula 1423. First leg 10 times, first femur 2.8 times as long as carapace.

Epigynum as shown in Fig. 119.

Male holotype—Total length 1.85 mm. Carapace 0.85 mm long, 0.7 mm wide. Abdomen 1 mm long, 0.7 mm wide.

Carapace of normal eyeless male (Fig. 84) and eyed male from Cueva de la Mina (Fig. 82).

Leg formula 1423. First leg about 10 times, first femur about three times as long as carapace.

Male palpus (Figs. 115-116) with greatly elongated segments; tarsus deeply grooved at middle, lacking lobe or special setal development; tibia with thin retrolateral spur bearing long spine.

	I	II	III	IV	Palpus
Femur	2.65	2.15	1.80	2.20	0.80
Patella	0.30	0.30	0.28	0.25	0.40
Tibia	2.60	2.10	1.70	2.30	0.40
Metatarsus	2.10	1.65	1.50	1.85	–
Tarsus	1.30	1.15	0.95	1.15	0.40
Total	8.95	7.35	6.23	7.75	2.00

Type Data—Male holotype from Cueva de la Capilla, 13.5 km NNW Gómez Farías, Tamaulipas, México, in the American Museum of Natural History.

Distribution—Caves of Tamaulipas, México.

Record—México: *Tamaulipas*: Cueva de la Mina, 8 km NW Gómez Farías, 10 January 1971 (J. Reddell, R. W. Mitchell, J. Cooke, S. Wiley, W. Elliott), male and two juvenile.

Leptoneta isolata Gertsch

Leptoneta isolata Gertsch, 1971, p. 51, Figs. 9-11. *Neoleptoneta isolata* Brignoli, 1972, p. 137.

Diagnosis—Pale, long-legged, essentially eyeless troglobite; first leg of female 7.8 times, of male 9.9 times as long as carapace; tarsus of male palpus with rounded lobe on retrolateral side; epigynum (Fig. 123).

Female—Total length 2.7 mm. Carapace 1.9 mm long, 0.8 mm wide. Abdomen 1.7 mm long, 1 mm wide.

Clypeus 0.15 mm high. Eyes obsolete, sometimes with trivial corneal vestiges. Chelicera (Fig. 94); promargin with nine small teeth; retromargin with three denticles.

Leg formula 1423. First leg 7.8 times, first femur 2.2 times as long as carapace.

Epigynum (Fig. 123) with heavy tube on each side similar to those of *coeca* group of Texas.

	I	II	III	Palpus
Femur	2.65	2.15	1.70	0.45
Patella	0.30	0.30	0.30	0.17
Tibia	2.65	2.00	1.70	0.35
Metatarsus	2.15	1.75	1.45	–
Tarsus	1.30	1.20	0.85	0.50
Total	9.05	7.40	6.00	1.47

Male holotype–Total length 2.7 mm. Carapace 1 mm long, 0.8 mm wide. Abdomen 1.5 mm long, 0.9 mm wide.

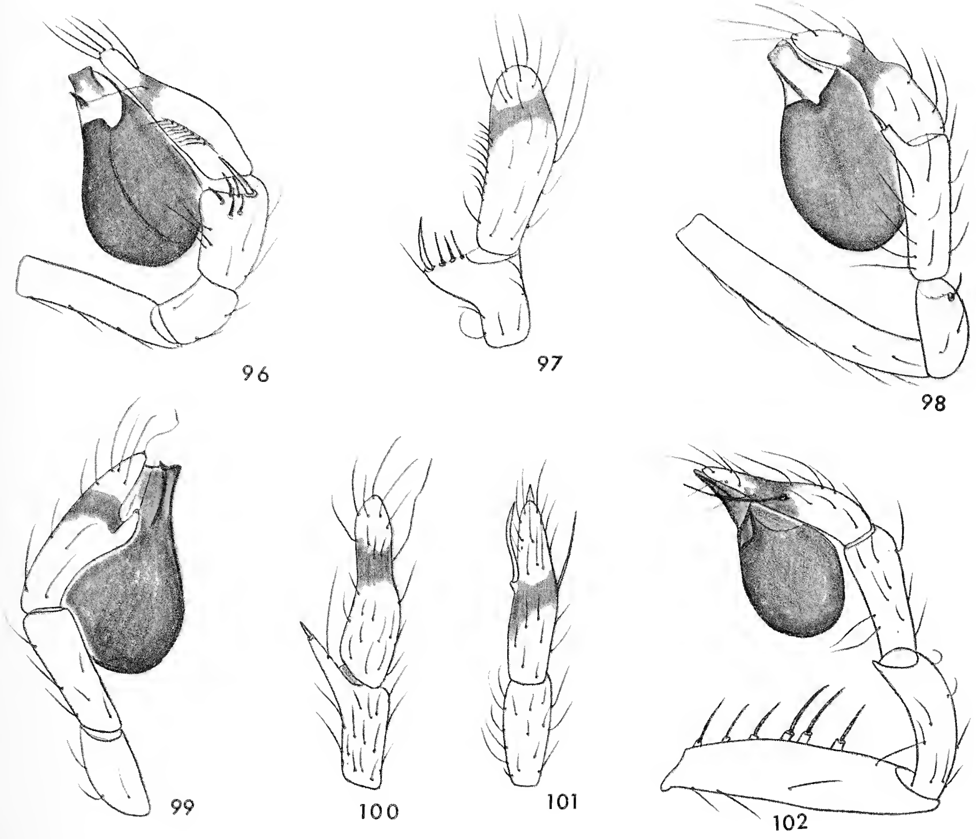
Leg formula 4123. First leg 9.9 times, first femur 2.7 times as long as carapace.

Male palpus (Figs. 107-108) with elongated segments; tarsus with shallow transverse groove and rounded retrolateral lobe; tibia with retrolateral apophysis bearing heavy spine.

	I	II	III	IV	Palpus
Femur	2.70	2.30	1.75	2.35	0.40
Patella	0.60	0.60	0.60	0.60	0.12
Tibia	2.80	2.20	1.70	2.60	0.29
Metatarsus	2.50	2.00	1.65	2.50	–
Tarsus	1.35	1.20	0.85	2.25	0.30
Total	9.95	8.30	6.55	10.30	1.11

Type Data–Male holotype from Grutas de García, Nuevo León, México, 14 June 1942, in American Museum of Natural History.

Distribution–Known only from above cave.



Figs. 96-102.–Left male palpi of species of *Leptoneta*: 96, *L. apachea*, whole palpus, retrolateral view; 97, *L. apachea*, tibia and tarsus, dorsal view; 98, *L. modica*, whole palpus, retrolateral view; 99, *L. modica* distal part of palpus, prolateral view; 100, *L. modica*, tibia and tarsus, dorsal view; 101, *L. brunnea*, tibia and tarsus, dorsal view; 102, *L. brunnea*, whole palpus, retrolateral view.

Leptoneta delicata Gertsch

Leptoneta delicata Gertsch, 1971, p. 52, Figs. 3-4. *Neoleptoneta delicata* Brignoli, 1972, p. 137.

Diagnosis—Pale, long-legged cavernicole; first leg of female eight times, of male 8.5 times as long as carapace; tarsus of male palpus grooved beyond middle, without retrolateral lobe, tibia with prominent, laterally directed process bearing short spine; epigynum (Fig. 124).

Female—Total length 1.9 mm. Carapace 0.8 mm long, 0.7 mm wide. Abdomen 1.1 mm long, 0.85 mm wide.

Eyes of female (Fig. 91).

Leg formula 1423. First leg eight times, first femur 2.4 times as long as carapace.

Epigynum as shown in Fig. 124.

	I	II	III	IV	Palpus
Femur	1.88	1.62	1.30	1.65	0.58
Patella	0.22	0.25	0.22	0.23	0.18
Tibia	2.00	1.50	1.15	1.85	0.38
Metatarsus	1.45	1.20	1.00	1.35	–
Tarsus	1.20	0.88	0.75	1.00	0.56
Total	6.80	5.45	4.42	5.08	1.70

Male—Total length 2 mm. Carapace 0.8 mm long, 0.7 mm wide. Abdomen 1.2 mm long, 0.8 mm wide.

Leg formula 1423. First leg 8.5 times, first femur 2.3 times as long as carapace.

Male palpus (Figs. 113-114) with greatly elongated segments; tarsus grooved beyond middle, pointed at apex, without retrolateral lobe or modified setae; tibia with prominent, laterally directed process armed with short spine.

	I	II	III	IV	Palpus
Femur	1.90	1.68	1.32	1.75	0.72
Patella	0.25	0.25	0.25	0.25	0.31
Tibia	2.00	1.60	1.25	1.80	0.32
Metatarsus	1.45	1.25	1.00	1.85	–
Tarsus	1.25	1.00	0.80	1.00	0.45
Total	7.03	5.78	4.62	6.65	1.80

Type Data—Male holotype from Iron Mine 2 km E Pinal de Amoles, Querétaro, México, in American Museum of Natural History.

Distribution—Known only from above mine.

Leptoneta pecki Gertsch

Leptoneta pecki Gertsch, 1971, p. 51, Figs. 7-8. *Neoleptoneta pecki* Brignoli, 1972, p. 137.

Diagnosis—Small, pale, short-legged species with reduced eyes; first leg of female and male about seven times as long as carapace; tarsus of male palpus with conical retrolateral lobe and tibia with spur bearing short spine; epigynum (Fig. 120).

Female—Total length 1.6 mm. Carapace 0.75 mm long, 0.6 mm wide. Abdomen 0.9 mm long, 0.6 mm wide.

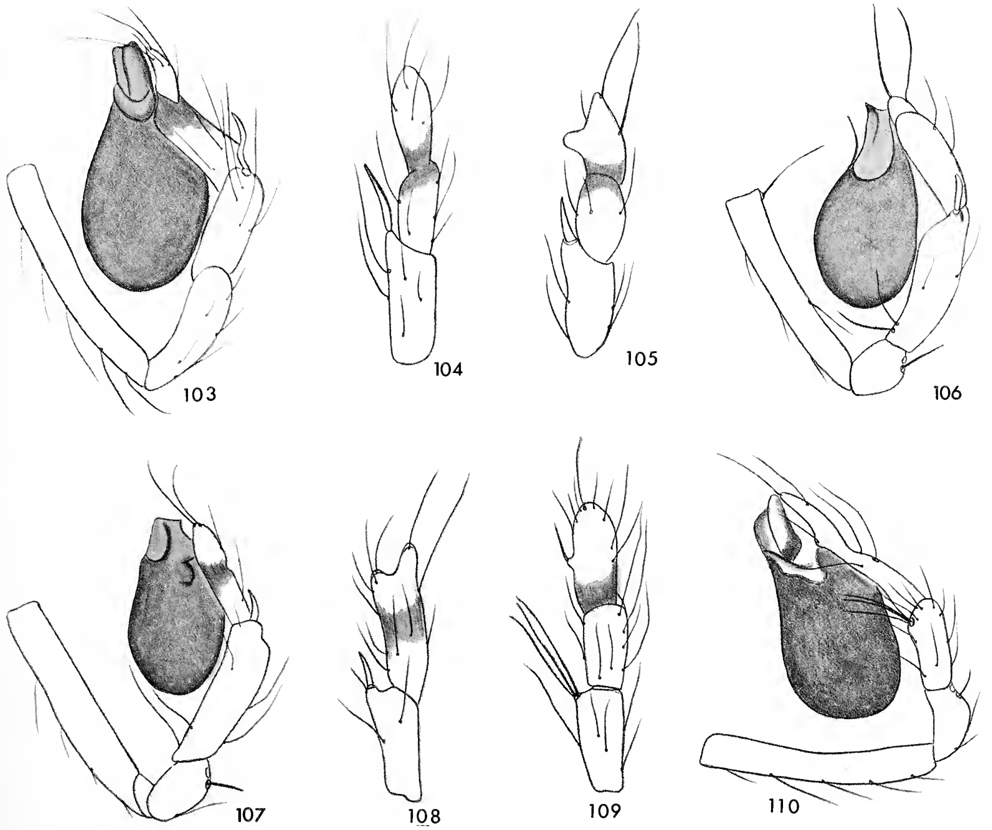
Eyes of female (Fig. 87).
Leg formula 1423. First leg seven times, first femur twice as long as carapace.
Epigynum as shown in Fig. 120.

	I	II	III	IV	Palpus
Femur	1.50	1.20	1.10	1.35	0.32
Patella	0.25	0.22	0.20	0.20	0.11
Tibia	1.60	1.15	1.15	1.60	0.21
Metatarsus	1.20	0.87	0.87	1.15	–
Tarsus	0.80	0.65	0.65	0.70	0.31
Total	5.35	4.09	3.45	4.95	0.95

Male holotype–Total length 1.5 mm. Carapace 0.6 mm long, 0.5 mm wide. Abdomen 0.8 mm long, 0.6 mm wide.

Leg formula 1423. First leg about seven times, first femur 1.8 times as long as carapace.

Male palpus (Figs. 105-106) with elongated segments; tarsus deeply grooved at middle and armed with conical retrolateral lobe without special spine; tarsus with retrolateral spur armed with short spine.



Figs. 103-110.–Left male palpi of species of *Leptoneta*: 103, *L. rainesi*, whole palpus, retrolateral view; 104, *L. rainesi*, tibia and tarsus, dorsal view; 105, *L. pecki*, tibia and tarsus, dorsal view; 106, *L. pecki*, whole palpus, retrolateral view; 107, *L. isolata*, whole palpus, retrolateral view; 108, *L. isolata*, tibia and tarsus, dorsal view; 109, *L. bonita*, tibia and tarsus, dorsal view; 110, *L. bonita*, whole palpus, retrolateral view.

	I	II	III	IV
Femur	1.10	0.85	0.72	1.05
Patella	0.21	0.21	0.19	0.19
Tibia	1.20	0.90	0.68	1.25
Metatarsus	0.95	0.75	0.60	1.00
Tarsus	0.64	0.53	0.43	0.59
Total	4.10	3.24	2.62	4.08

Type Data—Male holotype from Grutas de San Bartolo, 16 km SW Monterrey, Nuevo León, México, in American Museum of Natural History.

Distribution—Known only from above caves.

Leptoneta reclusa Gertsch

Leptoneta reclusa Gertsch, 1971, p. 53, Figs. 12-13. *Neoleptoneta reclusa* Brignoli, 1972, p. 137.

Diagnosis—Small, dusky, long-legged species with obsolescent eyes, probable troglobite; first femur of female 2.4 times as long as carapace; first leg of male nine times as long as carapace; male palpus with elongated segments, tarsus without lateral lobe, tibia armed with retrolateral spur bearing spine; epigynum (Fig. 117).

Female—Total length 2.2 mm. Carapace 0.9 mm long, 0.73 mm wide. Abdomen 1.3 mm long, 1 mm wide.

Eyes of female (Fig. 86); right chelicera (Fig. 95).

Legs fragmented; first femur 2.2 mm, second femur 1.75 mm, third femur 1.4 mm, fourth femur 2 mm. Palpus: femur 0.52 mm, patella 0.14 mm, tibia 0.37 mm, tarsus 0.5 mm, total 1.53.

Epigynum as shown in Fig. 117.

Male holotype—Total length 2.2 mm. Carapace 0.82 mm long, 0.7 mm wide. Abdomen 1.2 mm long, 0.85 mm wide.

Leg formula 4123. First leg nine times, first femur 2.6 times as long as carapace.

Male palpus (Figs. 111-112) with elongated segments; tarsus moderately grooved at middle, without lateral lobe or special setae; tibia with long retrolateral spur and thin apical spine.

	I	II	III	IV	Palpus
Femur	2.25	1.80	1.40	1.85	0.55
Patella	0.25	0.25	0.25	0.25	0.20
Tibia	2.20	1.80	1.40	2.50	0.23
Metatarsus	1.70	1.60	1.20	2.15	–
Tarsus	1.00	1.00	0.85	1.20	0.33
Total	7.40	6.45	5.10	7.95	1.41

Type Data—Male holotype from Cueva de Chorros de Agua, W of Montemorelos, Nuevo León, México, in American Museum of Natural History.

Distribution—Known only from above cave.

Record—México: *Nuevo León*: Cueva de Chorros de Agua, 20 km W. Montemorelos, 19 June 1969 (S. & J. Peck, R. Norton), female, immature.

Leptoneta rainesi Gertsch

Leptoneta rainesi Gertsch, 1971, p. 54, Figs. 5-6. *Neoleptoneta rainesi* Brignoli, 1972, p. 137.

Diagnosis–Small, dusky, short-legged species; first leg of female 5.8 times, of male 5.6 times as long as carapace; tarsus of male palpus slender, apically rounded, without accessory lobe; epigynum (Fig. 118).

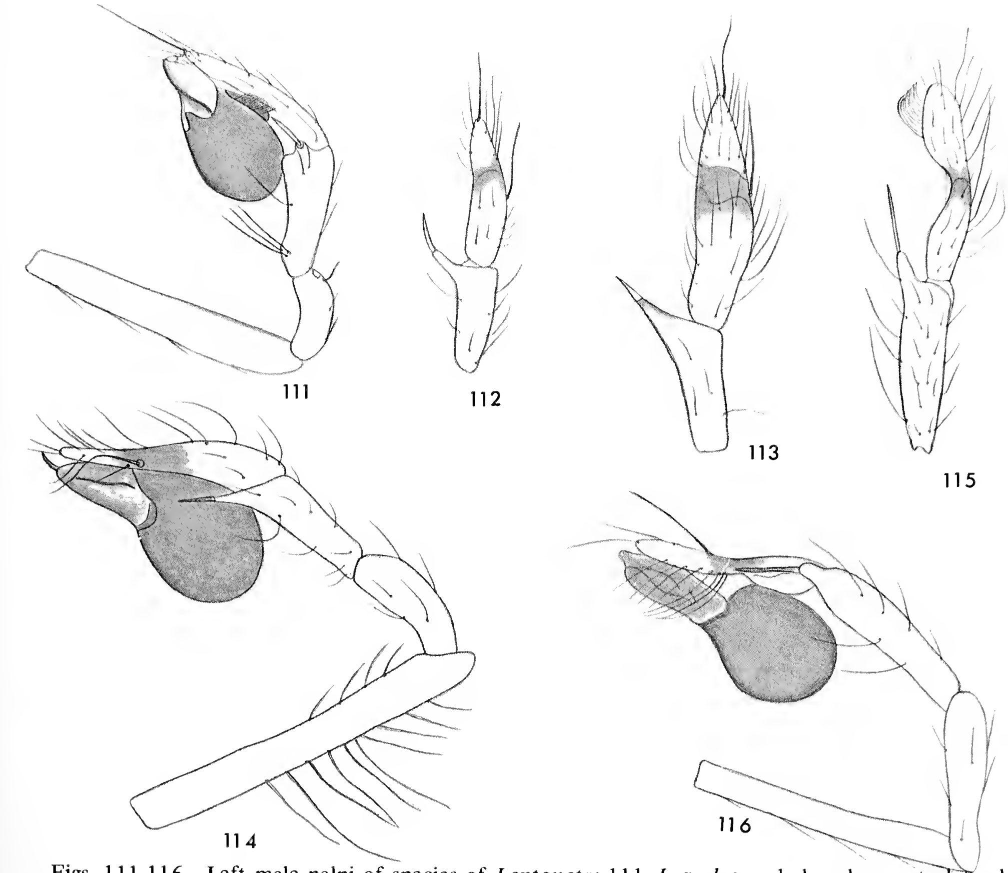
Female–Total length 1.6 mm. Carapace 0.55 mm long, 0.5 mm wide. Abdomen 1 mm long, 0.8 mm wide.

Eyes as shown in Fig. 89.

Leg formula 1423. First leg 5.8 times, first femur 1.5 times as long as carapace.

Epigynum as shown in Fig. 118.

	I	II	III	IV
Femur	0.85	0.75	0.63	0.85
Patella	0.15	0.17	0.16	0.19
Tibia	0.94	0.70	0.55	0.90
Metatarsus	0.75	0.60	0.54	0.65
Tarsus	0.55	0.45	0.40	0.50
Total	3.25	2.67	2.28	3.09



Figs. 111-116.–Left male palpi of species of *Leptoneta*: 111, *L. reclusa*, whole palpus, retrolateral view; 112, *L. reclusa*, tibia and tarsus, dorsal view; 113, *L. delicata*, tibia and tarsus, dorsal view; 114, *L. delicata*, whole palpus, retrolateral view; 115, *L. capilla*, tibia and tarsus, dorsal view; 116, *L. capilla*, whole palpus, retrolateral view.

Male holotype—Total length 1.6 mm. Carapace 0.65 mm long, 0.52 mm wide. Abdomen 0.9 mm long, 0.7 mm wide.

Leg formula 1423. First leg 5.6 times, first femur 1.5 times as long as carapace.

Male palpus (Figs. 103-104) with elongated segments; tarsus deeply grooved at middle, rounded at apex, without lobes or modified setae; tibia with blunt retrolateral spur bearing long spine.

	I	II	III	IV	Palpus
Femur	0.98	0.80	0.67	0.95	0.40
Patella	0.19	0.18	0.16	0.19	0.20
Tibia	1.00	0.78	0.62	0.96	0.15
Metatarsus	0.90	0.66	0.62	0.85	–
Tarsus	0.60	0.50	0.41	0.56	0.26
Total	3.67	2.92	2.48	3.51	1.01

Type Data—Male holotype from Cueva de El Pachón, 7.5 km NE Antiguo Morelos, Tamaulipas, México, in the American Museum of Natural History.

Distribution—Caves of Tamaulipas, México.

Record—México: *Tamaulipas*: Wet Cave, 8 km NW Gómez Farías, 2 June 1964 (J. Reddell, D. McKenzie), female.

Leptoneta bonita, new species

Leptoneta rainesi Gertsch, 1971, p. 55 (Cueva Bonita record only).

Diagnosis—Small, grayish cavernicole with dusky band on each side of carapace and eyes of medium size; first femur 1.9 times as long as carapace; male palpus without lobe on tarsus, with angle on tibia bearing thin spine.

Etymology—Specific name for Cueva Bonita, Spanish *bonita*, pretty.

Male—Total length 1.65 mm. Carapace 0.6 mm long, 0.57 mm wide. Abdomen 1 mm long, 0.6 mm wide.

Cephalothorax and legs grayish; carapace with broad dusky band on each side; front eyes enclosing black field and posterior eyes smudged with dusky; sternum brown; legs tinged with brown; abdomen whitish above but venter light brown.

Clypeus 0.13 mm high, equal to about length of eye group. Eyes (Fig. 90) of medium size, subequal; oval posterior eyes separated from front lateral by radius. Chelicera: promargin with eight subequal, closely spaced teeth; retromargin with four denticles.

First femur 1.9 times as long as carapace.

Male palpus (Figs. 109-110) with elongated segments; tarsus deeply grooved at middle, broadly rounded at apex, without retrolateral lobe but bearing one enlarged spine; tibia with slight retrolateral enlargement at apex with one long spine and two lesser ones.

	I	II	III	IV	Palpus
Femur	1.14	0.84	0.77	0.95	0.33
Patella	0.20	0.20	0.19	0.19	0.15
Tibia	–	0.90	0.62	–	0.16
Metatarsus	–	0.72	0.63	–	–
Tarsus	–	0.53	0.49	–	0.27
Total	–	3.19	2.70	–	0.91

Type Data—Male holotype from Cueva Bonita, 36 km SW Victoria, Tamaulipas, 18 July 1967 (J. Fish).

Leptoneta brunnea, new species

Diagnosis—Small, brown, short-legged epigean species; first femur 1.4 times as long as carapace; femur of male palpus armed with six heavy spines.

Etymology—Specific name from Latin *brunneus*, brown.

Female, subadult: Total length 1.6 mm. Carapace 0.7 mm long, 0.53 mm wide. Abdomen 1 mm long, 0.7 mm wide.

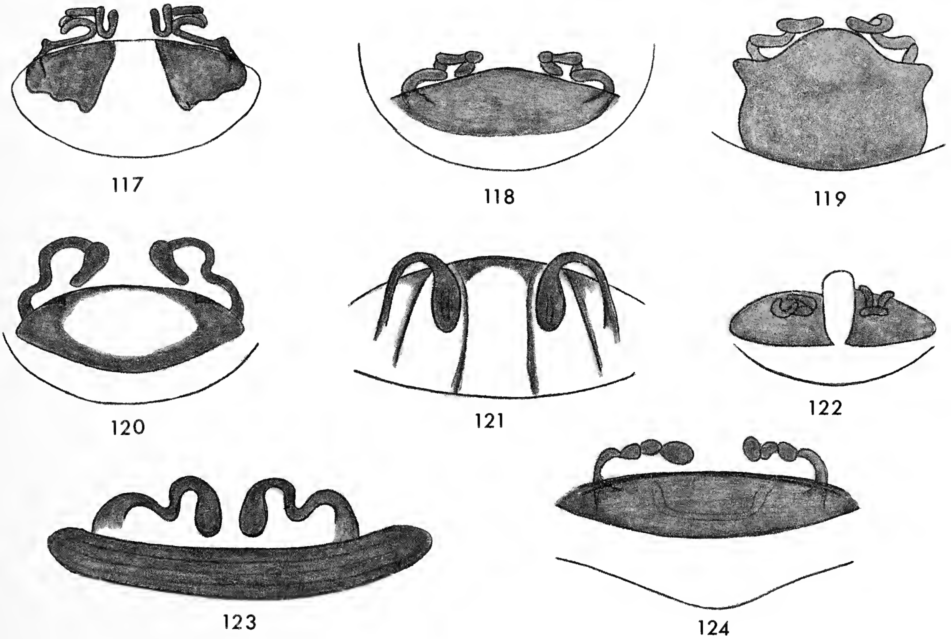
Carapace dusky brown, darker on sides, with small black linear groove and lateral radiations apparent; front eyes enclosing black area and posterior pair narrowly ringed with black; sternum, endites and labium dark brown; legs dusky brown. Abdomen brown with purplish cast.

Carapace and abdomen as shown in Fig. 83; clypeus 0.14 mm high, equal to width of front eyes, shorter than eye group. Eyes (Fig. 85) large, group of six nearly as broad as long; posterior eye separated from anterior lateral eye by radius. Chelicera (Fig. 93); promargin with seven slightly separated teeth; retromargin with four denticles.

First femur 1.4 times as long as carapace.

	I	II	III	IV	Palpus
Femur	1.02	0.86	0.77	–	0.42
Patella	0.24	0.22	0.21	–	0.14
Tibia	1.14	0.80	0.62	–	0.24
Metatarsus	0.70	0.70	0.63	–	–
Tarsus	–	0.55	0.50	–	0.42
Total	–	3.13	2.73	–	1.12

Male—Total length 2 mm. Carapace 0.76 mm long, 0.62 mm. Abdomen 1.2 mm long, 0.7 mm wide.



Figs. 117-124.—Dorsal view of epigyna of species of *Leptoneta*: 117, *L. reclusa*; 118, *L. rainesi*; 119, *L. capilla*; 120, *L. pecki*; 121, *L. chisosea*; 122, *L. furtiva*; 123, *L. isolata*; 124, *L. delicata*.

Leg formula 1423. First leg 5.7 times, first femur 1.5 times as long as carapace.

Male palpus (Figs. 101-102) with elongated segments; tarsus grooved beyond middle, unmodified except for long spine on retrolateral side; tibia unmodified; femur stout, with row of six heavy spines on elevated alveolae.

	I	II	III	IV	Palpus
Femur	1.15	0.82	0.80	1.05	0.50
Patella	0.22	0.20	0.20	0.20	0.28
Tibia	1.30	0.92	0.73	1.13	0.22
Metatarsus	1.00	1.00	0.70	0.92	–
Tarsus	0.70	0.60	0.58	0.63	0.34
Total	4.37	3.54	3.01	3.93	1.32

Type Data—Male holotype and subadult female from 18 km S. Tenango de Doria, 2500 m, Hidalgo, México, 24-28 July 1969 (S. & J. Peck), from can trap in open pine forest.

Leptoneta modica, new species

Diagnosis—Small, reddish brown, short-legged epigean species; carapace with pair of small erect spurs on posterior margin; first leg five times as long as carapace; tarsus of male palpus with spur at apex on prolateral side and long spur bearing apical spine on retrolateral side of tibia.

Etymology—Specific name from Latin *modicus*, moderate.

Male—Total length 1.5 mm. Carapace 0.65 mm long, 0.52 mm wide. Abdomen 0.83 mm long, 0.6 mm wide.

Cephalothorax and appendages light reddish brown; front eyes enclosing black area and posterior eyes narrowly margined in black; abdomen dusky brown with faint purplish cast.

Clypeus 0.13 mm high, much longer than width of front eyes and about as high as length of eye group. Eyes (Fig. 88) of medium size; posterior eyes smaller, separated from front lateral eye by nearly diameter. Carapace narrowed in front, with only faint trace of linear groove; posterior margin with pair of small, sharp spurs best seen in lateral view. Chelicera: promargin with eight subequal teeth; retromargin with three denticles.

Leg formula 1423. First leg five times, first femur 1.37 times as long as carapace. Palpus: femur 0.36 mm, patella 0.14 mm, tibia 0.2 mm, tarsus 0.24 mm, total 0.94.

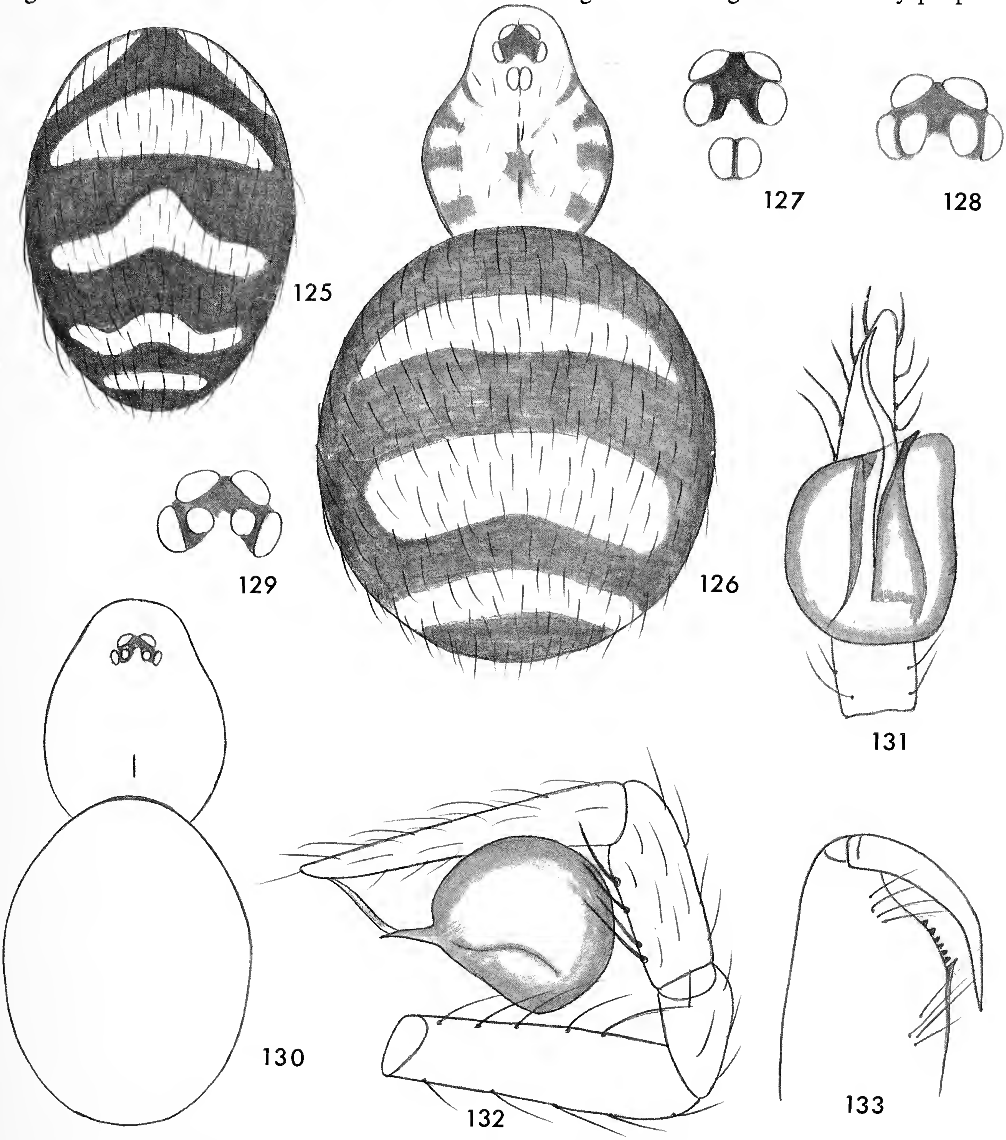
Male palpus (Figs. 98-100) with elongated segments; tarsus grooved beyond middle of segment, slender, with thin spur near apex on prolateral side; tibia with retrolateral process tipped with short spine.

	I	II	III	IV	Palpus
Femur	0.89	0.73	0.70	0.80	0.36
Patella	0.20	0.18	0.17	0.20	0.14
Tibia	0.89	0.62	0.52	0.88	0.20
Metatarsus	0.71	0.50	0.46	0.70	–
Tarsus	0.54	0.45	0.41	0.52	0.24
Total	3.23	2.48	2.26	3.10	0.94

Type Data—Male holotype from Chipinque, Monterrey, Nuevo León, México, 25, September 1943 (F. Bonet).

THE CALIFORNIAN FAUNA

This group of taxa is distributed from south California north into Oregon, mostly in the Coast Ranges and especially in the redwood country. The five known species live in various kinds of ground litter in mesic situations. All are quite large and average about 2 mm in length. Their legs are long, the first pair averaging about six times the length of the carapace, and they are set with quite robust spines. All are big-eyed types with yellowish to brown carapaces marked with dusky shadings on the sides and distinctly marked linear grooves. The sternum is brown with darker shadings on the margins. The usually purplish



Figs. 125-133.–Species of Leptonetidae: 125, *L. californica,* abdomen of subadult female, dorsal view; 126, *L. californica,* carapace and abdomen of subadult female, dorsal view; 127, *L. oasa,* eyes of male; 128, *Archoleptoneta obscura,* eyes of female; 129, *A. schusteri,* eyes of female; 130, *A. schusteri,* carapace and abdomen of female, dorsal view; 131, *A. schusteri,* tarsus of left male palpus, ventral view; 132, *A. schusteri,* left male palpus, retrolateral view; 133, *A. schusteri,* right chelicera of female, ventral view.

brown abdomens are provided with more or less distinct pale and dark chevrons on the dorsum, these being especially well marked in subadult specimens.

The *californica* group is here considered to be a complex derived from a single basic stock, even though the features of some taxa seem derivative ones. The large eyes are subequal in size and the front row forms a tight semicircle; the posterior eyes are separated from the front lateral by somewhat less than their diameter. The epigyna of the females present lightly sclerotized atrial pouches which give rise to small convoluted tubes lying on the dorsal surface and forming posteriorly directed coils. The male palpi of *oasa* and *wapiti* are little modified from the basic *Leptoneta* pattern: their tarsi bear deep transverse grooves and have retrolateral lobes each bearing a single stiff, modified seta; the suboval bulbs are of standard design and some have an accessory subapical appendage. *Leptoneta noyoana* shares these features but has the basal segments of the palpus greatly elongated, to the extent that the palpus is longer than the third leg. The male palpi of *californica* and *helferi* also have the segments elongated and the femora bear sublateral rows of stout spines on the ventral margins, these most numerous in the latter. Also in these species the palpal bulb is drawn out to a thin appendage projecting back along the venter of the tibia. The key to males is based only on palpal features. The four known females are of similar appearance and offer features mainly in their quite stereotyped epigyna for a key.

KEY TO THE MALES

1a. Bulb of male palpus with long, posteriorly directed appendage 2
1b. Bulb rounded behind, without thin appendage 3

2a(1a). Bulbal appendage reaching to end of tibia (Fig. 146) . . . . . *californica* Banks
2b. Bulbal appendage reaching only beyond middle of tibia (Fig. 148) . . . . *helferi*, new species

3a(1b). Tibia more than twice as long as tarsus (Fig. 142) . . . . *noyoana*, new species
3b. Tibia much shorter 4

4a(3b). Bulb with subapical appendage (Figs. 137-138) . . . . *wapiti*, new species
4b. Bulb lacking subapical appendage (Figs. 134, 136) . . . . . . *oasa*, new species

KEY TO THE FEMALES

1a. Front margin of epigynum in recurved line 2
1b. Front margin essentially straight 3

2a(1a). Epigynal pattern (Fig. 147), with tubular receptacles smaller . . . . *helferi*, new species
2b. Epigynal pattern (Fig. 150), with receptacles larger . . . . . *wapiti*, new species

3a(1b). Epigynal pattern (Fig. 151); Riverside County, California . . *oasa*, new species
3b. Epigynal pattern (Figs. 143, 149); Contra Costa County, California and northward . . . . *californica* Banks

Leptoneta californica Banks

Leptoneta californica Banks, 1904, p. 333; 1910, p. 6. Comstock, 1913, p. 307. Fage, 1913, p. 566. Moles, 1921, p. 40. Roewer, 1942, p. 313. Bonnet, 1957, p. 2392. *Leptoneta sylva* Chamberlin & Ivie, 1942, p. 9. Vogel, 1967, p. 88.

Diagnosis–Typical dark species of series; first leg of female 6.7 times, of male 7.7 times as long as carapace; bulb of male palpus with thin appendage reaching to patella; epigynum (Figs. 143, 149).

Female holotype of sylva–Total length 2.8 mm. Carapace 1.03 mm long, 0.9 mm wide. Abdomen 1.6 mm long, 1.3 mm wide.

Carapace dusky yellowish brown, with dusky shadings on sides, narrow marginal brown seam and black linear groove; front eye row enclosing black field, posterior eyes narrowly ringed with black; sternum dusky brown, darkened on margins; legs dusky yellow. Abdomen mostly purplish brown; dorsum paler, with faint traces of dark chevrons (see Fig. 126), with distinct chevrons in immature (Fig. 125); venter with dark lines on sides and in front of spinnerets.

Dorsal view of carapace and abdomen as in Fig. 126. Clypeus 0.12 mm high, subvertical, narrower than front eye row and much shorter than eye length. Eyes large (Fig. 126); front eyes subequal, subcontiguous, forming tight semicircle, front lateral eyes being separated by about long diameter; posterior eyes smaller, suboval, separated from front lateral eye by less than short diameter of former. Sternum 0.6 mm long and wide. Chelicera (Fig. 155); promargin with six or seven teeth, of which apical two are larger, more widely spaced, and basal one at end of carina largest; retromargin with three or four denticles. Abdomen subglobose, about as high as wide.

Leg formula 1423. First leg 6.7 times, first femur 1.8 times as long as carapace. Palpus: femur 0.63 mm, patella 0.23 mm, tibia 0.45 mm, tarsus 0.55 mm, total 1.86 mm.

Epigynum (Figs. 143, 149) presenting thin tube on each side usually directed posteriorly and between them shallow atriobursal pouch; Fig. 149 from female from Mt. Diablo.

	I	II	III	IV
Femur	1.90	1.40	1.24	1.66
Patella	0.35	–	0.32	0.30
Tibia	2.00	–	1.15	1.68
Metatarsus	1.62	–	1.14	1.46
Tarsus	1.03	–	0.65	0.80
Total	6.90	–	4.50	5.90

Male from Crescent City–Total length 2.2 mm. Carapace 1.03 mm long, 0.81 mm wide. Abdomen 1.1 mm long, 0.9 mm wide.

Coloration more yellow than that of female but pattern essentially same on cephalothorax and abdomen.

Carapace much longer than broad, moderately narrowed and subtruncated in front, in lateral view highest behind eyes, with thin, shallow linear depression distinct. Clypeus 0.15 mm high, subvertical, narrow, equal to width of front median eyes, narrower than front eye row and half as long and eye group. Eyes large, subequal in size, oval in shape; posterior eyes oval, separated from front lateral by nearly long diameter. Sternum 0.62 mm long, 0.61 mm wide, thinly clothed with erect setae. Endite 0.4 mm long, 0.3 mm wide. Chelicera (Fig. 154): promargin like that of female but both apical teeth larger, more widely spaced; retromargin with four denticles. Abdomen elevated, subglobose like that of female.

Leg formula 1423. First leg 7.7 times, first femur 2.1 times as long as carapace.

Male palpus (Figs. 144-146) with elongated segments; tarsus deeply grooved at middle, with rounded retrolateral lobe bearing short spine; tibia enlarged at apex and with heavy spine near apex on retrolateral side; femur with seven heavy spines mainly in single row below retromargin; bulb produced behind into long thin appendage with tip near patella, with series of spurs at apex of embolar portion.

	I	II	III	IV	Palpus
Femur	2.20	1.72	1.45	1.85	1.33
Patella	0.35	0.32	0.28	0.32	0.54
Tibia	2.43	1.77	1.33	1.83	0.86
Metatarsus	1.90	1.43	1.26	1.40	–
Tarsus	1.10	0.90	0.70	0.95	0.40
Total	7.98	6.14	5.02	6.35	3.13

Type Data—Female type of *L. californica* Banks from Mt. Diablo, Contra Costa County, California June (Fuchs collector), originally in California Academy of Sciences, presumed lost. Female type of *L. sylva* Chamberlin & Ivie from 19 mi N Wolf Creek, Oregon, 6 April 1937 (J. C. Chamberlin) in American Museum of Natural History (University of Utah Collection).

Distribution—North California and Oregon.

Records—*California*: Contra Costa County: Mt. Diablo, 23 April 1953 (R. Schuster), female. Oakland Hills, 9 January 1954 (R. Schuster), female. Napa County: Mt. St. Helena, 31 December 1953 (G. Marsh, R. Schuster, V. Roth), female, immature. Two mi W Oakville, 31 December 1953 (V. Roth), male, female. 10 mi S Monticello, 17 March 1957 (R. Schuster), female. Sonoma County: Mark West Springs, 31 December 1953 (G. Marsh, R. Schuster, V. Roth), two females, immature. One mi S Trenton, 15 May 1957 (R. Schuster), two females, immature. Armstrong Park, 14 March 1954 (J. Helfer), female. El Norte County: Near Crescent City, 9 November 1956 (J. Schuh), male from redwood duff. *Oregon*: Jackson County: Three mi N Gold Hill, 22 January 1972 (E. Benedict), two females. 10 mi NW Central Point, 1200 feet, 22 January 1972 (E. Benedict), female. Josephine County: 10 mi E Placer, 22 July 1962 (V. Roth), female. Grave Creek, 30 May 1952 (V. Roth), female. Curry County: 12 mi N Gold Beach, 1 October 1959 (V. Roth), two females. Douglas County: Canyonville County Park, two mi E Canyonville, 1000 feet, 6 November 1971 (E. Benedict), female from berlese duff. Uncertain stations: Summit Camas Mt., 27 April 1937 (J. C. Chamberlin), female. Middle Fork of Smith River, 4 September 1963 (J. & W. Ivie), penultimate male, immature. Eight mi S Divide Guard Station, 27 July 1955 (R. Roth), two females from pine-oak woods.

Leptoneta helferi, new species

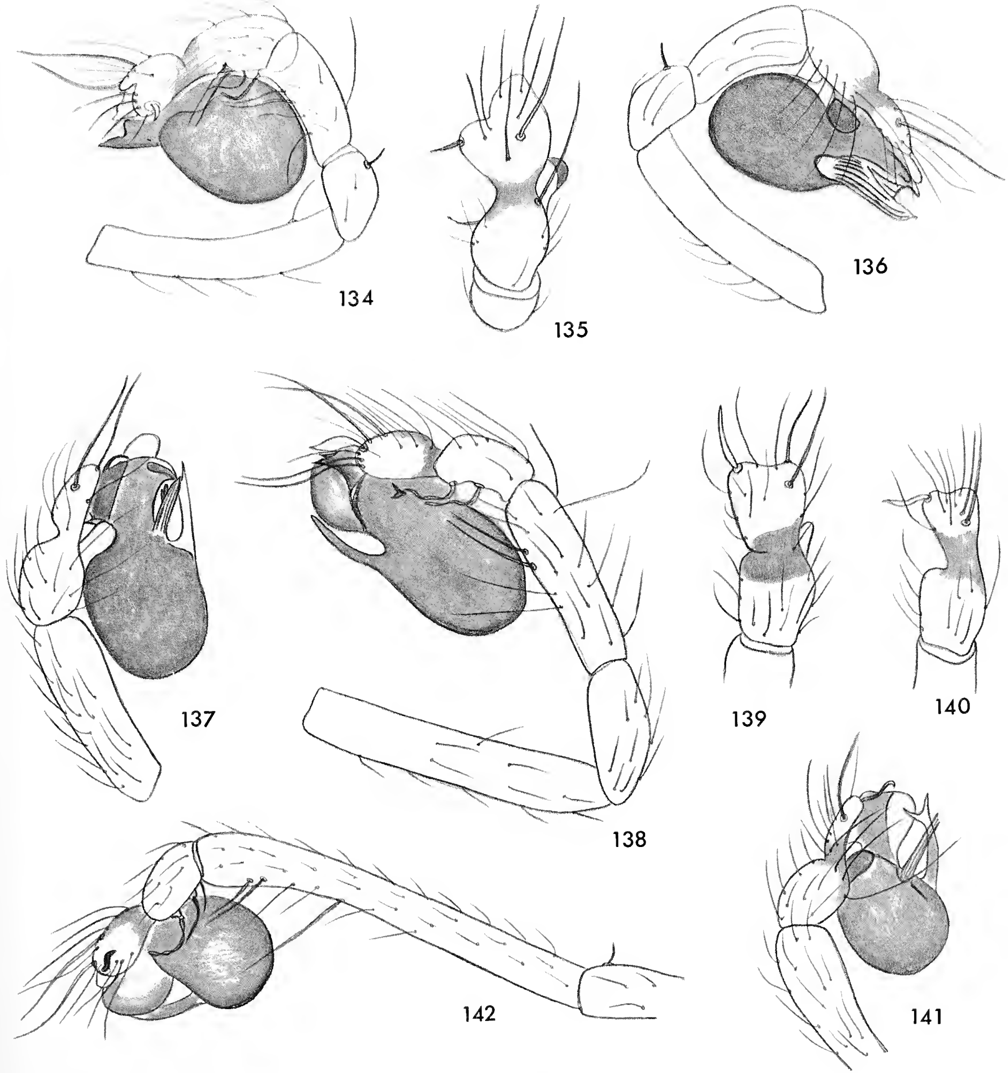
Diagnosis—Near relative of *californica* distinguished by genitalic features: first leg of female 6.6 times, of male 7.4 times as long as carapace; tibia of male palpus longer, with thin appendage of bulb not reaching patella; epigynum (Fig. 147).

Etymology—Named for Jacques R. Helfer of Mendocino, California.

Female—Total length 2 mm. Carapace 0.97 mm long, 0.75 mm side. Abdomen 1.1 mm long, 0.9 mm wide.

Coloration and structure like those of *californica*.
Leg formula 1423. First leg 6.6 times, first femur 1.8 times as long as carapace.
Epigynum as shown in Fig. 147.

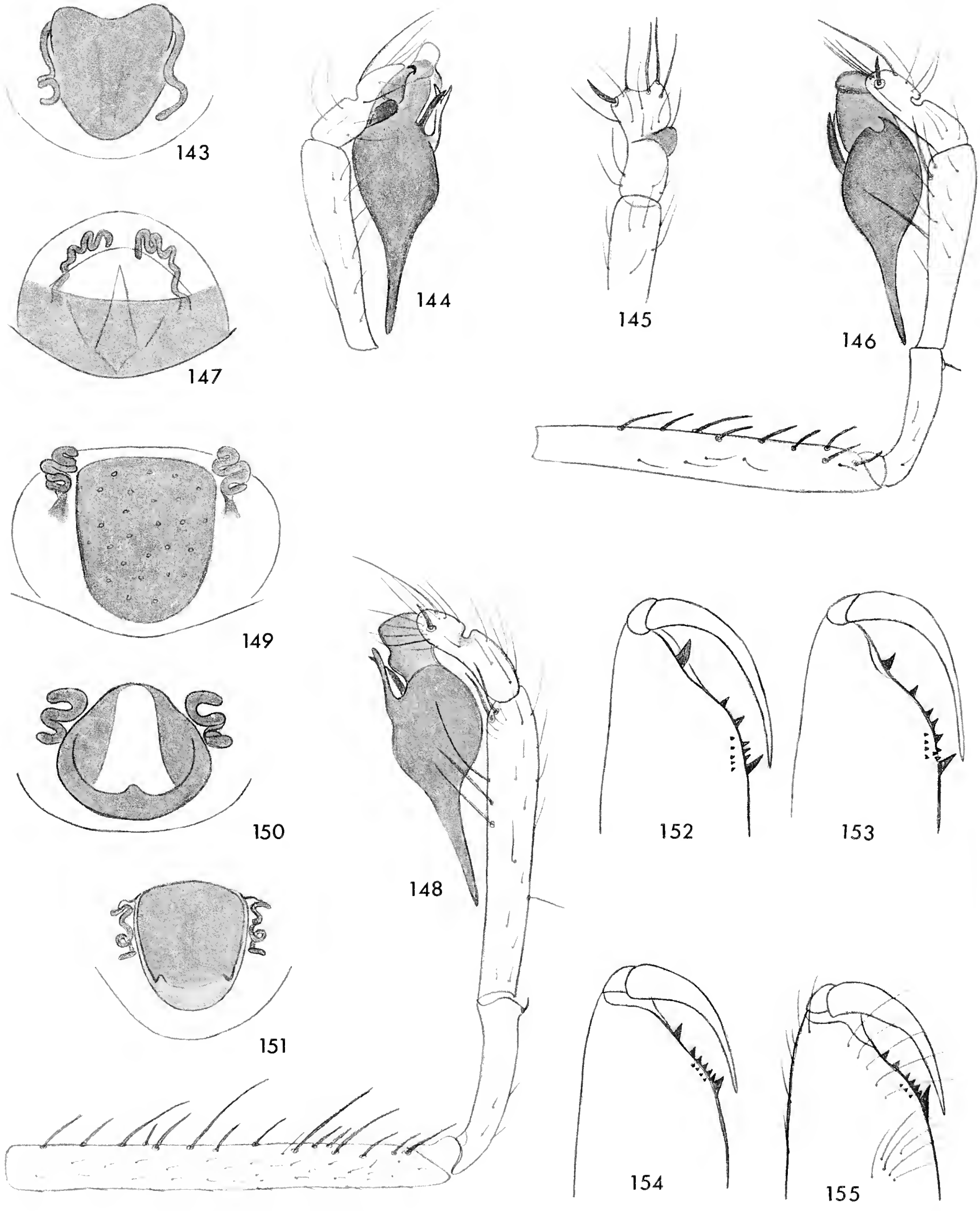
	I	II	III	IV	Palpus
Femur	1.75	1.40	1.20	1.60	0.65
Patella	0.32	0.28	0.26	0.24	0.19
Tibia	1.95	1.45	1.10	1.55	0.49
Metatarsus	1.47	1.12	0.95	1.34	–
Tarsus	0.94	0.80	0.65	0.80	0.55
Total	6.43	5.05	4.16	5.53	1.88



Figs. 134-142.–Left male palpi of species of *Leptoneta*: 134, *L. oasa*, whole palpus, prolateral view; 135, *L. oasa*, tibia and tarsus, dorsal view; 136, *L. oasa*, whole palpus, retrolateral view; 137, *L. wapiti*, tibia and tarsus, prolateral view; 138, *L. wapiti*, whole palpus, retrolateral view; 139, *L. wapiti*, tibia and tarsus, dorsal view; 140, *L. noyoana*, tibia and tarsus, dorsal view; 141, *L. noyoana*, tibia and tarsus, prolateral view; 142, *L. noyoana*, tibia and tarsus, retrolateral view.

Male—Total length 2.2 mm. Carapace 1.08 mm long, 0.9 mm wide. Abdomen 1.2 mm long, 1 mm wide.

Coloration and structure like those of *californica* unless otherwise noted. Chelicera



Figs. 143-155.—Species of *Leptoneta*: 143, *L. californica*, epigynum, dorsal view; 144, *L. californica*, tibia and tarsus of left male palpus, prolateral view; 145, *L. californica*, tibia and tarsus of left male palpus, dorsal view; 146, *L. californica*, left male palpus, retrolateral view; 147, *L. helferi*, epigynum, dorsal view; 148, *L. helferi*, left male palpus, retrolateral view; 149, *L. californica*, epigynum of female from Mt. Diablo, dorsal view; 150, *L. wapiti*, epigynum of female, dorsal view; 151, *L. oasa*, epigynum of female, dorsal view; 152, *L. noyoana*, right chelicera of male, ventral view 153, *L. helferi*, right chelicera of male, ventral view; 154, *L. californica*, right chelicera of male, ventral view; 155 *L. californica*, right chelicera of female, ventral view.

(Fig. 153) promargin with eight teeth, apical one widely separated from others; retromargin with four denticles.

Leg formula 1423. First leg 7.4 times, first femur twice as long as carapace.

Male palpus (Fig. 148) like that of *californica* but segments much longer; tarsus with deep transverse groove and rounded lobe bearing short spine; tibia much longer, far exceeding length of bulb; femur very long, with 15 heavy spines in linear series on ventral edge of retrolateral side.

	I	II	III	IV	Palpus
Femur	2.20	1.70	1.43	1.86	1.50
Patella	0.34	0.32	0.30	0.31	0.60
Tibia	2.45	1.73	1.37	1.84	0.96
Metatarsus	1.92	1.40	1.25	1.53	–
Tarsus	1.07	0.85	0.75	0.95	0.33
Total	7.98	6.00	5.10	6.49	3.39

Type Data—Male holotype from Carlotta, Humboldt County, California, 15 September 1961 (W. Ivie, W. J. Gertsch).

Distribution—Northwestern California.

Records—*California*: Mendocino County: 4.2 mi S Piercy, 17 February 1967 (V. Roth), male. Five mi N Piercy, 6 April 1960 (W. J. Gertsch, W. Ivie), female. Mendocino, 19 July 1962 (V. Roth), female. Humboldt County: 18 m S Klamath, 13 August 1953 (G. A. Marsh, R. O. Schuster), female. F. K. Lane State Park, near Phillipsville, 1 October 1959 (V. Roth), male. Two mi N Phillipsville, 14 September 1961 (W. Ivie, W. J. Gertsch), female, penultimate male. Miranda 4 June 1936, female, immature. Two mi S Weott, 1 October 1959 (V. Roth), penultimate male. Del Norte County: Two mi N Fort Dick, 21 November 1953 (V. Roth), female. Two mi E Fort Dick, 1 May 1951 (V. Roth), female.

Leptoneta wapiti, new species

Diagnosis—Pale species of *californica* group with standard genitalia; first leg of female 6.6 times, of male 6.8 times as long as carapace; tarsus of male palpus deeply grooved, with rounded retrolateral lobe bearing long spine, and bulb lacking posterior appendage; epigynum (Fig. 150).

Etymology—Specific name from Shawnee *wapiti*, American elk, in reference to type locality.

Female—Total length 1.9 mm. Carapace 0.93 mm long, 0.78 mm wide. Abdomen 1.05 mm long, 0.7 mm wide.

Coloration paler than that of *californica*; carapace dusky yellow; sternum yellowish brown; legs pale yellow; abdomen purplish with faint dusky chevrons on dorsum.

	I	II	III	IV	Palpus
Femur	1.66	1.42	1.20	1.60	0.60
Patella	0.31	0.30	0.25	–	0.20
Tibia	1.80	1.30	1.00	–	0.46
Metatarsus	1.40	1.07	0.95	–	–
Tarsus	0.95	0.80	0.65	–	0.70
Total	6.12	4.89	4.05	–	1.96

Clypeus 0.12 mm high, narrower than front eye row, half as long as eye group. Eyes large; front eyes subequal and subcontiguous; posterior eyes oval, equal to and separated from front eyes by narrow diameter. Sternum 0.54 mm long and wide. Chelicera with dentition of *californica.*

Leg formula 1423. First leg 6.6 times, first femur 1.7 times as long as carapace.

Epigynum as shown in Fig. 150.

Male—Total length 1.75 mm. Carapace 0.8 mm long, 0.66 mm wide. Abdomen 1 mm long, 0.8 mm wide.

Coloration and structure like those of female unless otherwise noted. Clypeus 0.13 mm high, about as long as width of front eye row. Eyes smaller, somewhat evanescent, without pigment.

Leg formula 1423. First leg 6.8 times, first femur 1.7 times as long as carapace.

Male palpus (Figs. 137-139) with elongated segments; tarsus deeply grooved near middle with rounded retrolateral angle bearing long spine and at base two twisted setae; tibia with two long spines on retrolateral side beyond middle; bulb suboval, with blunt rounded embolar part and thin subapical appendage.

	I	II	III	IV	Palpus
Femur	1.40	1.20	1.05	1.30	0.60
Patella	0.28	0.25	0.25	0.25	0.23
Tibia	1.57	1.22	0.90	1.32	0.30
Metatarsus	1.30	1.00	0.90	1.10	–
Tarsus	0.86	0.70	0.65	0.77	0.32
Total	5.41	4.37	3.75	4.74	1.45

Type Data—Male holotype from Cameron Road, Elk, Mendocino County, California, 16 February 1967 (V. Roth).

Distribution—Northwestern California.

Records—*California*: Mendocino County: Mendocino, 4 January 1958 (J. P. Helfer), male. Casper, 7 March 1954 (J. P. Helfer), immature. One mi N Piercy, S Fork Elk River 1 October 1959 (V. Roth), immature. Humboldt County: One mi S Dyerville, 19 September 1953 (R. Schuster), female. Big Lagoon, 13 August 1953 (G. A. Marsh, R. Schuster), immature. Blue Lake, 19 September 1953 (R. Schuster), three immature. 20 mi W Willow Creek, 20 July 1965 (V. Roth), penultimate male. Lake County: Scott Valley, 22 February 1954 (J. P. Helfer), two immature probably this species.

Leptoneta noyoana, new species

Diagnosis—Derivative species of group related to *wapiti*, with distinctive features of chelicera and palpus: first leg of male seven times as long as carapace; apical tooth of chelicera considerably enlarged; palpus as long as third leg, with tibia and femur greatly elongated and bulb of distinctive design.

Etymology—Based on Noyo, the type locality

Male—Total length 2.3 mm. Carapace 1.03 mm long, 0.83 mm wide. Abdomen 1.2 mm long, 0.9 mm wide.

Carapace light dusky brown, with sides darker and median linear groove distinct; front eyes enclosing dark field and posterior eyes narrowly ringed with black; sternum uniform purplish brown; legs dusky yellow; abdomen purplish brown, with indistinct pale chevrons above.

Clypeus 0.16 mm high, shorter than width of front eye row and much more than eye group. Eyes large; oval posterior eyes smaller than front eyes, separated from front lateral by nearly diameter of posterior eye. Sternum 0.6 mm long and wide. Chelicera (Fig. 152) evenly attenuated, thin at apex; promargin with seven teeth, apical one widely removed from others and larger; retromargin with five denticles.

Leg formula 1423. First leg seven times, first femur about twice as long as carapace.

Male palpus (Figs. 140-142) longer than third leg, with greatly elongated basal segments; tarsus short, deeply grooved at middle, subtruncated at apex and with trivial retrolateral lobe bearing short spines, and with twisted setae at base; tibia greatly elongated, with three large spines near apex on retrolateral side; femur long, thin, without heavy spination; bulb with bluntly rounded embolar part and small, apically forked appendage.

	I	II	III	IV	Palpus
Femur	2.04	1.60	1.30	1.78	2.06
Patella	0.35	0.30	0.27	0.30	1.27
Tibia	2.20	1.60	1.23	1.75	1.14
Metatarsus	1.75	1.31	1.15	1.40	–
Tarsus	1.05	0.82	0.65	0.85	0.42
Total	7.39	5.63	4.60	6.08	4.89

Type Data–Male holotype from 12-15 mi E Noyo, Mendocino County, California, 13 September 1961 (W. J. Gertsch, W. Ivie).

Leptoneta oasa, new species

Diagnosis–South California representative of *californica* group recognized by distinctive genitalia; first leg of female eight times, of male 9.1 times as long as carapace; palpus like that of *wapiti* but segments shorter and retrolateral lobe distinctive; epigynum (Fig. 151).

Etymology–Specific name based on Latin *oasis*, a green spot in the desert.

Female–Total length 2 mm. Carapace 0.9 mm long, 0.73 mm wide. Abdomen 1.35 mm long, 1 mm wide.

Carapace dull orange, with faint dusky marginal seam and dark linear groove; front eyes enclosing black field, posterior eyes narrowly ringed with black; sternum dusky brown; legs dull orange. Abdomen dirty white above, with indistinct chevrons broken on midline, dull purplish below.

Clypeus 0.16 mm high, subvertical, higher than width of front eye row and shorter than eye group. Eyes of medium size; front eyes subequal and subcontiguous; posterior eyes same size, suboval, separated from front side eye by short diameter. Sternum 0.54 mm long, 0.52 mm wide. Chelicera with dentition of *californica*.

Leg formula 1423. First leg eight times, first femur 2.2 times as long as carapace.

Epigynum as shown in Fig. 151.

	I	II	III	IV	Palpus
Femur	2.02	1.53	1.35	1.77	0.50
Patella	0.30	0.28	0.26	0.25	0.16
Tibia	2.07	1.53	1.16	1.56	0.34
Metatarsus	1.80	1.33	1.10	1.40	–
Tarsus	1.00	0.76	0.64	0.85	0.48
Total	7.19	5.43	4.51	5.83	1.48

Male—Total length 1.95 mm. Carapace 0.85 mm long, 0.7 mm wide. Abdomen 1.1 mm long, 0.75 mm wide.

Coloration basically like that of female; legs and mouth parts dull yellow with some dusky shadings; abdomen with purplish over whitish base, broad dark basal band and broken chevrons behind on dorsum, white patch behind genital groove and white spinnerets on venter.

Carapace broader in front than that of female. Clypeus 0.17 mm high, sloping forward, about as long as width of front eye row, much shorter than eye group. Eyes (Fig. 127) of medium size. Sternum 0.55 mm long, 0.5 mm wide. Chelicera and dentition of *californica*.

Leg formula 1423. First leg 9.1 times, first femur 2.6 times as long as carapace.

Male palpus (Figs. 134-136) with relatively short segments; tarsus deeply grooved at middle, with prominent, laterally directed retrolateral lobe bearing short spine, with two modified setae at base; bulb suboval, similar to that of *wapiti* but lacking subterminal appendage.

	I	II	III	IV	Palpus
Femur	2.20	1.70	1.40	1.80	0.48
Patella	0.30	0.27	0.23	0.26	0.16
Tibia	2.30	1.70	1.25	1.64	0.22
Metatarsus	2.00	1.50	1.20	1.52	–
Tarsus	1.00	0.82	0.64	0.78	0.32
Total	7.80	5.99	4.72	6.00	1.18

Type Data—Male holotype from Andreas Canyon, off Palm Canyon, near Palm Springs, Riverside County, California, 26 March 1960 (W. J. Gertsch).

Distribution—Riverside County, California.

Records—*California*: Riverside County: Andreas Canyon, 3 March 1956 (V. Roth), in Museum of Comparative Zoology; 26 March 1960 (V. Roth), male, female; 26 March 1960 (W. J. Gertsch), male. Black Mountain Camp Ground, San Jacinto Mts., 13 August 1959 (W. J. Gertsch, V. Roth), immature probably this species.

ARCHOLEPTONETINAE, NEW SUBFAMILY

Diagnosis—American leptonetids with posterior eyes in transverse row. Tarsus of male palpus leg-like segment without transverse constriction.

Archoleptoneta, new genus

Diagnosis—Characters of family except as indicated or modified below: Minute haplogyne spiders with oval carapace rounded in front and behind. Clypeus inclined forward, as high as width of eye group. Eyes six, close together in transverse row; anterior (lateral) eyes contiguous in front; posterior eyes in slightly recurved transverse row with median eyes moderately separated but nearly touching lateral eyes. Chelicera with row of small teeth on promargin. Labium much wider than long, rounded at apex, set with two long setae on each side. Leg formula 1423; legs thin, with rows of dusky hairs but mostly lacking spines. Pedipalp of female with long terminal claw. Abdomen suboval; tracheal tubes opening through single spiracle in front of spinnerets; colulus small lobe set with fine hairs. Details of female epigynum as yet unknown. Tarsus of male palpus long, leg-like appendage without transverse suture, with bulb attached in basal half.

Type of Genus—*Archoleptoneta schusteri*, new species.

Discussion—The discovery of North American leptonetids in which the posterior median eyes are retained in a transverse row with the posterior lateral eyes makes possible a clearer understanding of the entire family. In the past the classic eye pattern of *Leptoneta*, in which the posterior median eyes having retreated far to the rear now form a V-shaped figure with the posterior lateral eyes, has made identification of the family relatively easy. *Archoleptoneta* seems to represent the kind of ancestral stock from which the stereotyped modern representatives were derived. It retains the prime characters of *Leptoneta* except for the eye pattern and type of male palpus. In some respects *Archoleptoneta* is reminescent of *Telema*, of which the American genus *Usophila* seems to be an exact synonym, but lacks the pair of tracheal openings in the middle of the abdomen, having instead the single tracheal opening immediately in front of the spinnerets. The genera *Telema* and *Archoleptoneta* share the same kind of unspecialized, leg-like tarsus with trivial alveolae for attachment of the bulb, also similar in design, to the basal part of the tarsus. The close relationship of the leptonetids and telemids was affirmed by Fage (1913) who retained them as subfamilies in the single family Leptonetidae. Although the differences in the respiratory organs of *Telema* are weighty, the similarity in the male palpi of the two genera to some extent bridges the gap between the families. Similarly, the ochyroceratids also share many features of the group and are held separate by a few characters (notably lack of a tarsal claw on the female palpus) and unique features of the reproductive system.

Archoleptoneta schusteri, new species

Diagnosis—Pale species of California with posterior eye row slightly recurved and median eyes separated by nearly diameter.

Etymology—Named for Mr. Robert Schuster of the University of California, Davis, friend, colleague and collector of many of these tiny spiders.

Female—Total length 1.3 mm. Carapace 0.57 mm long, 0.45 mm wide. Abdomen 0.85 mm long, 0.55 mm wide.

Cephalothorax and appendages pale yellow; eyes enclosing dusky field; abdomen white; hairs on body dusky. Carapace and abdomen of female, Fig. 130.

Carapace smooth, with few weak setae; pars cephalica set off by faint sutures and trivial linear median groove present. Carapace longer than broad, broadly rounded behind and more narrowly in front; pars cephalica elevated, convex, highest near median groove. Clypeus 0.12 mm high, inclined forward, exceeding width of eye group. Eyes (Fig. 129) small, group occupying about third width of head at that point. Front eyes subcontiguous, slightly larger than others; posterior eye row procurved, with posterior median eyes separated by nearly diameter, touching slightly larger lateral eyes. Sternum 0.5 mm long and wide, subcordate, produced behind between posterior coxae and separating them by width of one, set sparsely with erect hairs. Labium with four setae at apex, lateral one of each side longer. Endite as long as basal width, broadly rounded at apex, only slightly convergent at ends, with conspicuous serrula and stout seta below it on side. Chelicera (Fig. 133) of medium stoutness, with evenly curved fang; promargin with seven teeth, basal one much larger; retromargin with single denticle. Abdomen elongate oval, as high as wide.

Leg formula 1423. First leg 4.5 times, first femur 1.2 times as long as carapace. Legs clothed with rows of fine hairs, almost none of spine size.

	I	II	III	IV	Palpus
Femur	0.73	0.64	0.60	0.75	0.24
Patella	0.24	0.21	0.20	0.21	0.11
Tibia	0.69	0.55	0.47	0.68	0.16
Metatarsus	0.56	0.50	0.46	0.53	–
Tarsus	0.36	0.34	0.30	0.36	0.25
Total	2.58	2.24	2.03	2.53	0.76

Male–Total length 1.3 mm. Carapace 0.54 mm long, 0.42 mm wide. Abdomen 0.8 mm long, 0.45 mm wide.

Coloration and structure like those of female. Posterior median eyes smaller. Clypeus 0.12 mm high.

Leg formula 1423. First leg five times, first femur 1.4 times as long as carapace.

Male palpus (Figs. 131-132) with segments of medium length; tarsus long cylindrical, apically narrowed, without transverse groove; tibia with four enlarged spines on retrolateral margin; bulb suboval, with short dark spur and long pale spur at apex.

	I	II	III	IV	Palpus
Femur	0.74	0.61	0.57	0.74	0.25
Patella	0.21	0.20	0.20	0.21	0.11
Tibia	0.73	0.55	0.47	0.70	0.15
Metatarsus	0.61	0.50	0.45	0.53	–
Tarsus	0.40	0.36	0.33	0.35	0.30
Total	2.69	2.22	2.02	2.53	0.71

Type Data–Male holotype from six mi SE Half Moon Bay, San Mateo County, California, 5 December 1953 (V. Roth).

Distribution–Widespread in California from San Diego County north to Humboldt County in coastal area and Butte and Placer Counties in the Sierras.

Records–*California*: San Diego County: Borrego State Park, 25 April 1955 (R. Schuster), six females. Sheep Canyon, Borrego State Park, 27 April 1955 (R. Schuster), four females. Between Ramona and Julian, 26 December 1958 (L. M. Smith), five females. Riverside County: Five mi SW Riverside, 2 March 1956 (I. Newell), female. Los Angeles California: Five mi S Gorman, 25 March 1959 (H. L. McKenzie), female. Contra Costa County: One mi W Orinda, 12 December 1953 (V. Roth), male, four females; 5 December 1953 (W. Ferguson), two females. Alameda County: Berkeley, 2 March 1958, two females. Marin County: Seven mi E Point Reyes, 1 March 1960 (L. M. Smith, R. Schuster). Inverness, 1 November 1953 (V. Roth), female. Santa Clara County: Mt. Madonna, 2 January 1954 (R. Burdick), five females. Stevens Creek, 25 June 1957 (R. Schuster), male, five females; 27 July 1957 (G. A. Marsh), female. Santa Cruz County: Ben Lomond, 21 June 1953 (C. D. MacNeill), female. 9.5 mi NE Soquiel, 31 December 1956 (S. M. Fidel), three males, 5 females. Napa County: Three mi N Calistoga, 31 December 1953 (G. A. Marsh, R. Schuster, V. Roth), female, egg sac. Mt. St. Helena, 31 December 1951 (G. A. Marsh, R. Schuster, V. Roth), two females. Sonoma County: Mark West Springs, 31 December 1953 (G. A. Marsh, R. Schuster, V. Roth), female. Solano County: Gates Canyon, 1 May 1952 (E. I. Schlinger), immature. Monterey County: Point Cypress, 4 mi NE Carmel, 23 February 1957 (G. A. Marsh), two females. Humboldt County: Freshwater, 13 August 1953 (G. A. Marsh, R. Schuster), immature. Placer County: Four mi W Newcastle, 10 March 1959 (L. M. Smith, R. Schuster), five females; 3 January 1959 (F. Raney, R. Schuster), two females. Amador County: Five mi N

Mokelumne River on Highway 49, 5 March 1958 (L. M. Smith, R. Schuster), female. Calaveras County: Two mi W San Andreas, 25 March 1958 (L. M. Smith, R. Schuster), female. Butte County: W. of Feather Falls, 27 November 1955 (R. Schuster), female.

Archoleptoneta garza, new species

Diagnosis–Pale Texas species related to *schusteri*; legs long, first femur being 1.5 times as long as carapace; promargin of chelicera with five teeth.

Etymology–Named for Garza County, Texas.

Female–Total length 1.1 mm. Carapace 0.44 mm long, 0.28 mm wide. Abdomen 0.75 mm long, 0.5 mm wide.

Carapace shiny white; eyes enclosing black field; appendages dusky white; abdomen snowy white.

Structure like that of *schusteri* except as follows: Clypeus 0.11 mm high, as long as width of eye group. Eyes small; posterior eye row straight, median eyes small, oval, separated by narrow diameter of larger lateral eye. Sternum 0.3 mm long and wide. Promargin of chelicera with five slightly separated teeth.

Leg formula 1423. First leg 5.2 times, first femur 1.5 times as long as carapace.

	I	II	III	IV	Palpus
Femur	0.64	0.56	0.54	0.64	0.19
Patella	0.17	0.14	0.13	0.15	0.08
Tibia	0.66	0.52	0.41	0.60	0.13
Metatarsus	0.47	0.42	0.39	0.47	–
Tarsus	0.37	0.30	0.30	0.35	0.22
Total	2.31	1.94	1.77	2.21	0.62

Type Data–Female holotype from 7 mi E Justiceburg, Garza County, Texas, 12 October 1972 (V. Roth, B. Firstman).

Archoleptoneta obscura, new species

Diagnosis–Dark species from Mexican cave with posterior median eyes in straight row and median eyes separated by radius.

Etymology–Specific name from Latin *obscurus*, dark, obscure.

Female–Total length 1.28 mm. Carapace 0.5 mm long, 0.4 mm wide. Abdomen 0.73 mm long, 0.55 mm wide.

Carapace light dusky brown; eye tubercles black; pars cephalica with dusky mottlings from eyes to median groove; pars thoracica with dusky striations and narrow dusky seam on side margins; sternum, labium, endites and chelicerae dusky brown; legs dull yellow; abdomen dull brown.

Structure like that of *schusteri* unless otherwise noted. Clypeus moderately inclined forward, equal in height to width of eye group. Eyes of medium size (Fig. 128); posterior row straight, median eyes separated by radius. Sternum 0.31 mm long and wide. Endites with three setae on outer side near apex. Chelicera of medium stoutness, with evenly curved fang; promargin with row of six small teeth; retromargin smooth.

Leg formula 1423. First leg 4.4 times, first femur 1.3 times as long as carapace; legs thin, set sparsely with dusky hairs.

	I	II	III	IV	Palpus
Femur	0.65	0.56	0.48	0.66	0.22
Patella	0.20	0.17	0.15	0.18	0.08
Tibia	0.57	0.42	0.35	0.58	0.14
Metatarsus	0.48	0.39	0.35	0.44	–
Tarsus	0.31	0.27	0.27	0.32	0.24
Total	2.21	1.81	1.60	2.18	0.68

Type Data—Female holotype from Cueva del Tío Ticho, 1.5 km S Comitán, Chiapas, México, 21 August 1967 (J. Reddell, J. Fish, T. R. Evans).

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TROGLOBITIC HARVESTMEN RECENTLY DISCOVERED IN NORTH AMERICAN LAVA TUBES (TRAVUNIIDAE, EREBOMASTRIDAE, TRIAENONYCHIDAE: OPILIONES)

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ABSTRACT

New troglobitic harvestmen are described from lava caves in the states of Washington and Idaho. They include species of Travuniidae: *Speleonychia sengeri*, new genus and species; Erebomastridae: *Speleomaster lexi*, new genus and species; *Speleomaster pecki*, new species. The occurrence of a species of Triaenonychidae is recorded. These species are highly modified for darkness and are unrelated to surface species. The family Travuniidae is represented for the first time in the New World. Morphological, ecological and phylogenetic considerations are discussed.

INTRODUCTION

Specialization of invertebrates in lava tubes and fissures has been found to be comparable to that in limestone caves. Howarth (1972) found examples of cavernicolous adaptation in the recent lava tubes of Hawaii, and others have noted lava cavernicoles in Japan and the United States. The realization that troglobites can occur in lava tubes has been slow in coming, however, and little serious collecting has been done in these caves.

Harvestmen are one of the primary groups of cavernicolous invertebrates. This study has found them to be well represented in lava tubes of western North America. Specimens collected in lava flows in Washington and Idaho include highly specialized laniatorid opilionids that are unrelated to surface populations. The surface laniatorids of the Washington lava fields are of the family Triaenonychidae while only travuniids are found in caves. In central Idaho the surface laniatorids are represented by the triaenonychids while only erebomastrids are found in caves. Eastern Idaho apparently has cavernicolous triaenonychids, but in a different genus from those on the surface.

An obvious evolutionary question arises from these recent discoveries. How did a large taxonomic gap develop between surface and subsurface populations? The answer to this question is related to the length of time these opilionids have been isolated in lava caves. Their lack of eyes, reduced ocular tubercles, elongated appendages and loss of pigment patterns suggest that they have been long isolated. Considered alone, lava caves are a poor choice for prolonged evolution because they can only deteriorate, not grow as limestone caves do. Therefore, lava flows must be rather permeable to invertebrates. If new lava tubes are continuously produced as is the case on Hawaii, cave life must travel through cracks in the lava to these new sites.

The discovery of travuniids in the Washington lava tubes was unexpected, but their presence in this isolated habit supports Vandel (1965) and others who regard these harvestmen as "living fossils." Previously, travuniids were known only from Eurasia, particularly from caves. In Europe only one of about seventeen species has been collected on the surface. Suzuki (1964) and others have found travuniids outside of caves in Japan and Korea. Of the European troglobites, three species are more specialized (eye tubercle absent) than the Washington travuniid.

Species of Travuniidae have a morphology that also indicates that they are an ancient group. Members of the family are distinguished by a spatulate process (peltonychium) on the hind claws. Some of the primitive structures have been discussed in a previous paper (Briggs, 1971a) that relates travuniids to other families. Unreported structures for travuniids were found on the Washington species. These include a relatively distinct ninth tergite, lateral sclerites and six branched hind claws on juveniles. The juvenile hind claws differ from those described by Roewer (1935) in his comprehensive paper on European travuniids. The juvenile claw illustrated in his paper (Fig. 3) resembles that of a late juvenile erebomastrid, a family which is represented in some European caves (Briggs, 1969). All New World juvenile travuniids that I have examined have a characteristic peltonychium bearing six branches on their hind claws. The aroleum, a possibly primitive structure, is not present or has been modified into an adhesive pad in these claws.

The morphology of the specimens from Idaho of the family Erebomastridae shows specialization for total darkness equal in degree to that of the Washington travuniids. The ocular tubercle is reduced and without corneas. Troglobitic modifications have not been previously reported in this family even though it occurs in limestone caves of eastern United States and Europe. Its presence in Idaho links the eastern United States populations to a single species described from Oregon (Briggs, 1969).

New juvenile erebomastrids have revealed a relationship between this family and the Travuniidae in the developing claws. Early instars have a short peltonychium which later disappears. The hind branches of this peltonychium are the ones that remain in the adult claw.

DISCUSSION OF HABITAT

The lava caves inhabited by travuniids are located in one of the Mount Adams lava flows of southern Washington and are described by Halliday (1972) as early postglacial in age. This youth makes the presence of troglobites difficult to explain without the interstitial penetration suggested by Howarth (1972). These caves are located in a dense taiga and are quite moist. The undisturbed habitat of the travuniids is under breakdown in the presence of an unidentified gelatinous slime about 200 meters inside the caves. This habitat has apparently extended into the twilight zone in a cave formerly used to store cheese on wooden racks.

Harvestmen collected in Idaho caves also were found in recent lava flows. One species of Erebomastridae was found in a single ice cave in Craters of the Moon National Monument. The air temperature is about 4°C in this cave, Boy Scout Cave, but specimens were collected adjacent to a permanent ice flow. Peck (1973) reports that millipedes (*Idagona westcotti*) acari (*Rhagidia*), collembola (Entomobyridae), campodeids (*Plusiocampa*), and the troglobitic beetle *Glacicavicola bathyscioides* were taken in Boy Scout Cave with this harvestmen. Even though this cave is only about 20 meters long all these inhabitants except *Idagona* are morphological troglobites. The walls and floor of Boy Scout Cave are significantly free of fungus and organic soil, so permanent moisture may be the chief attraction for cave fauna. Below freezing temperature must occur in this cave to maintain its permanent ice flows and ice floor.

A similar species of Erebomastridae was found in lava tubes south of Craters of the Moon on the Snake River plain. One cave that deserves special mention consisted of a single room about 100 meters long, separated from the surface by about 5 meters of crawlway. It was located in a prairie grassland well separated from the nearest stream. The room was a relatively warm 13.5°C and had a rock-strewn soil floor with fungus-encrusted walls and ceiling. A variety of troglophiles and troglobites comprised an unusually dense population of fauna in the cave. In addition to the troglobitic harvestmen there were leiodids (*Glacicavicola*), pale centipedes, crickets (*Ceuthophilus*), carabid beetles, and flies in the families Sciaridae (*Lycoriella*), Trixoscelididae and Sphaeroceridae (*Leptocera*, subgenus *Limosina*). The erebomastrid harvestmen in this cave were larger than those in Boy Scout Cave.

All specimens are deposited in the collection of the California Academy of Sciences.

TRAVUNOIDEA Kratochvil

TRAVUNIIDAE Absolon and Kratochvil

Speleonychia, new genus

Description–Abdominal scute with boundaries of fused segments not apparent, odor glands not elevated on tubercles. Eye tubercle low, rounded and deeply recessed from anterior margin. Tergites widely spaced with lateral apices rounded. Ninth tergite separate, articulates with anal plate. Lateral sclerites present, spiracles exposed. Palpi well developed and strongly armed. Chelicerae with comb of uniform teeth on movable finger. Legs unarmed, astragali of normal length. First tarsi with four or five segments, second with more than six, third and fourth tarsi with four segments. Distitarsi of first legs with two segments, of second legs with four or more segments. Tarsi III and IV with four or less branches of small size on peltonychia. Penis with simple distal segment. Female with fewer segments on second distitarsi. Juveniles with six-branched peltonychium on hind claws, aroleum reduced or absent.

Type-species–*Speleonychia sengeri* Briggs, new species.

Remarks–The tarsal segmentation in *Speleonychia* resembles that of the troglobitic European genera *Abasola* and *Dinaria*, but the distitarsi on the second legs have more segments. Also, *Speleonychia* differs from other genera in having reduced lateral spines on the peltonychium and a dimorphic segment count for the second tarsi.

Speleonychia sengeri, new species

(Figures 1-7)

Description–*Male*. Total body length, 1.79 mm. Scute length, 1.25 mm. Length of eye tubercle, 0.15 mm. Scute width, 0.93 mm. Width of eye tubercle, 0.15 mm.

Anterior margin of scute without tubercles, with shallow cheliceral sockets. Scute finely granulate, with slightly elevated shoulders. Fused segments not apparent, not demarked by setae or tubercles. Tergites widely spaced, sparsely setose, lateral apices rounded. Eye tubercle obsolete, low, rounded, widely separated from anterior margin of scute. No evidence of eyes. Sternum wedge-shaped, apex slender, posterior truncate. Labial processes rounded, extend slightly anterior to second endites. Lateral sclerites small, isolated, adjacent to sixth and seventh tergites. Spiracles very small.

Second endites setose, large, project ventrad and anterior to second coxae.

Operculum setose, subtriangular, with anterior apex rounded; does not reach third coxae.

Chelicerae setose, with fused pair of seta-bearing tubercles on distodorsal margin of basal segments. Distal segment with seta-bearing tubercles on dorsum. Fixed finger with five teeth, movable finger with comb of seven to eight teeth.

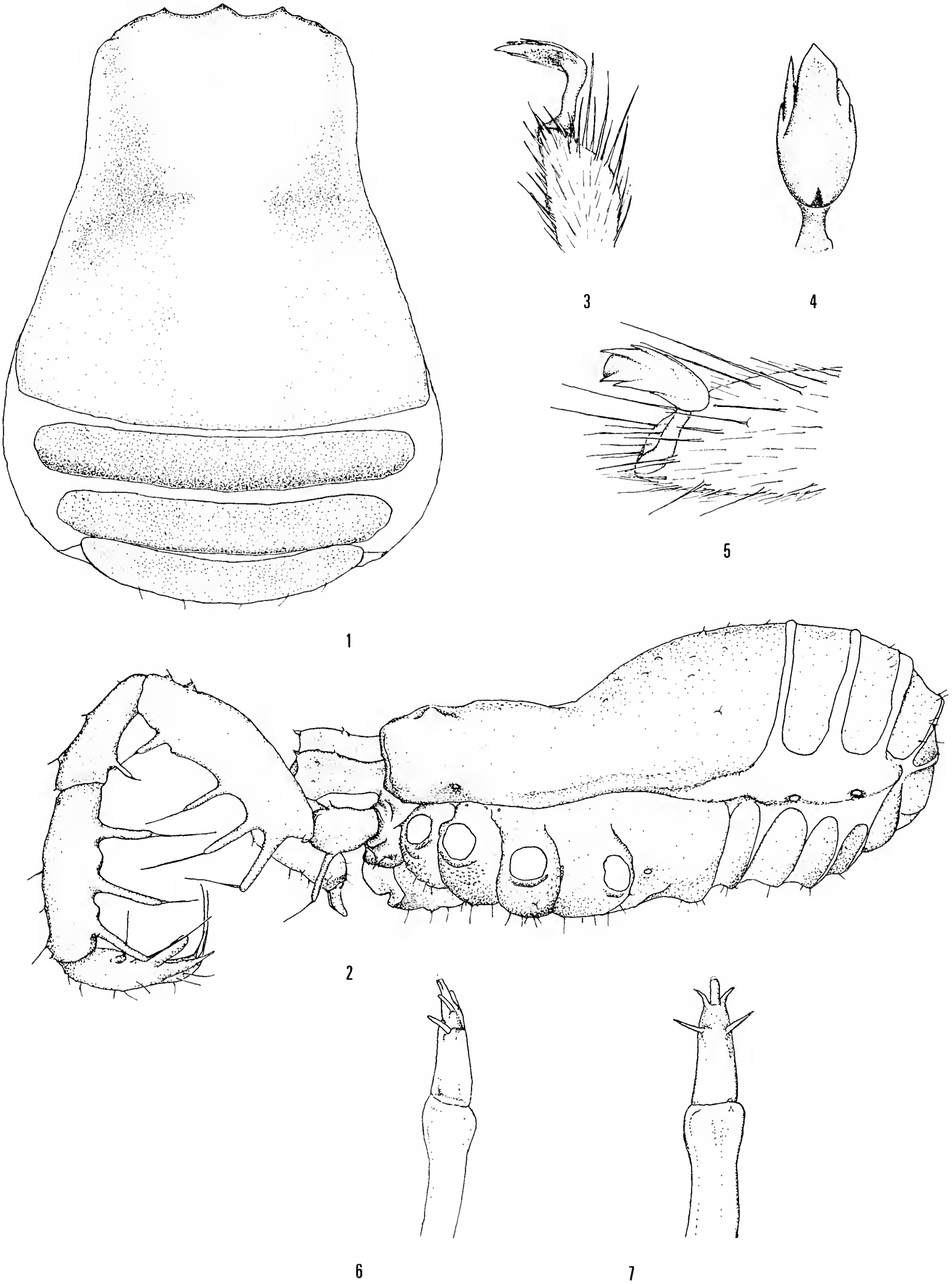


Fig. 1-7.–*Speleonychia sengeri*: 1-2, dorsal and lateral views of male; 3-4, lateral and dorsal views of hind claw of male; 5, hind claw of juvenile; 6-7, lateral and ventral views of penis.

Table 1.–Leg and palpus measurements of *Speleonychia sengeri* in mm.

	I	II	III	IV	Palpus
Trochanter	0.29	0.29	0.29	0.29	0.29
Femur	1.58	2.54	1.79	2.21	0.63
Patella	0.33	0.48	0.39	0.33	0.33
Tibia	1.05	2.09	1.31	1.73	0.54
Metatarsus	1.43	2.22	2.06	2.63	
Tarsus	0.96	2.22	0.93	1.10	0.72
Total	5.64	9.84	6.77	8.29	2.51

Palpi with elongate spines. Palpal coxae with ventral spine; trochanters with long ventral spine and short dorsal spine; femora with four to five ventral spines, two mesal spines and four short dorsal spines; patellas with one ventral spine and two mesal spines; tibia with three long ectal spines and four mesal spines. Tarsi slender, with four ectal spines and three mesal spines.

Tarsal formula of male holotype; 4-16,17-4-4. Tarsal formula of male paratypes: 4 to 5-15 to 20-4-4. Distitarsi of first legs with two segments, of second legs with seven segments. Astragali with faint false articulations, particularly on third legs. Tarsal claw of hind legs with four or less distolateral splinters on peltonychium.

Penis with simple ventral plate bearing a central pair and a small apical pair of lateral setae, apex narrow.

Color a uniform light yellow.

Female. Similar to male except larger in size, tarsal formula 4-11 to 14-4-4. Second distitarsi with four to five segments.

Ovipositor with four distal lobes; lateral pair largest, with apical setae,

Juvenile. Hind claws with six scale-like branches on peltonychium; apices without aroleum, but with clear adhesive secretion. Tarsi with typical juvenile segmentation. Body color a uniform white except for dusky peltonychia.

Type data–Holotype male, allotype female and 20 paratypes, Nielsen's Big Cave, 18 km W Trout Lake, Skamania County, Washington, 18 August 1972, under breakdown in slime zone about 200 meters inside cave, R. Lem, G. Wong, C. Senger, and T. Briggs. Seven adults and one juvenile, Cheese Cave, 2 km W Trout Lake, Klickitat County, Washington, 19 August 1972 and 25 August 1972, 620 meters, on wood in dark zone in both upper and lower sections and on breakdown in twilight, F. G. Howarth, N. C. Howarth, L. Ferguson and L. Nieuwenhuis. Two juveniles, Jug Cave, 7 km W Trout Lake, Kilickitat County, Washington, under breakdown slime zone, T. Briggs. Two adults, Trout Lake Caves, near Trout Lake, Klickitat County, Washington, 9 November 1969, C. Senger.

Etymology–This species is named for Dr. C. Senger, Western Washington State College, who brought specimens and localities to my attention.

EREBOMASTRIDAE Briggs

Speleomaster, New Genus

Scute smooth, with segment areas undifferentiated. Eye tubercle tuberculate, low mound well separated from anterior margin of scute. Tergites well separated. Ninth tergite not indicated on anal plate. Lateral sclerites absent, soft lateral integument exposed. Sternum with setae on center of broad posterior plate. Spiracles exposed. Labial processes do not extend anterior to second endites. Operculum small.

Palpal tarsi with five longest spines, two anterior pairs and one posterior mesodorsal. First tarsus with five or more segments, second tarsus with more than eight segments, third tarsus with five or more segments, fourth tarsus with six or more segments. Distitarsus of first legs with two segments, of second with four or more segments. Tibia of second leg with distal process on male. Tarsal claw of hind legs with two uniform branches meeting at 180° on stem nearly equal in length to branches.

Penis with simple dorsoventrally flattened distal segment, basal stem of sclerotized tube flared at apex. Apex of basal stem with cup-shaped receptical.

Juveniles with aroleum on posterior claws.

Type species–*Speleomaster lexi* Briggs, new species.

Remarks–*Speleomaster* is related to *Cryptomaster* Briggs, an epigean genus found along the coast of Southern Oregon. The similarity extends to the sexually dimorphic process on the second tibia and the structure of the hind claws. Significant differences occur in the structure of the penis and in the segmentation of the tarsi. *Speleomaster* species are apparently without a ventral plate on the penis. If subfamily designations are warranted for Erebomastridae, eastern and western United States fauna can be grouped into two subfamilies.

Speleomaster lexi, new species
(Figures 8-11)

Description–*Male*. Total body length, 2.86 mm. Scute length, 2.14 mm. Length of eye tubercle, 0.26 mm. Scute width, 2.41 mm. Width of eye tubercle, 0.35 mm.

Anterior margin of scute with shallow cheliceral sockets above, with projections along ectal margin of base of each chelicera and each palpus. Scute finely granulate, without indication of fused segments. Tergites with row of widely spaced setose tubercles. Eye tubercle small, tuberculate, conical, recessed, without indication of eyes. Sternum narrow, broadens between fourth coxae into pentagonal shape. Pair of setae present near center of pentagon. Groove between second and third sternites.

Second endites project anteroventrally, medially recurved at apices. Labial processes visible between second endites.

Operculum small, heart-shaped with invagination posterior, setose.

Chelicerae spinose, basal segments linear, anterior of distal segments with acute tubercles including a fused pair, fixed finger with larger teeth than movable finger.

Palpi with numerous elongate spines. Coxa with subaligned row of spines. Trochanter with two ventral spines. Femur with seven ventral spines, two mesal spines and four-five dorsal spines. Patella with one ventral spine and three mesal spines. Tibia with five mesal and five ectal spines. Tarsus with four ectal and seven mesal spines of which five are longest.

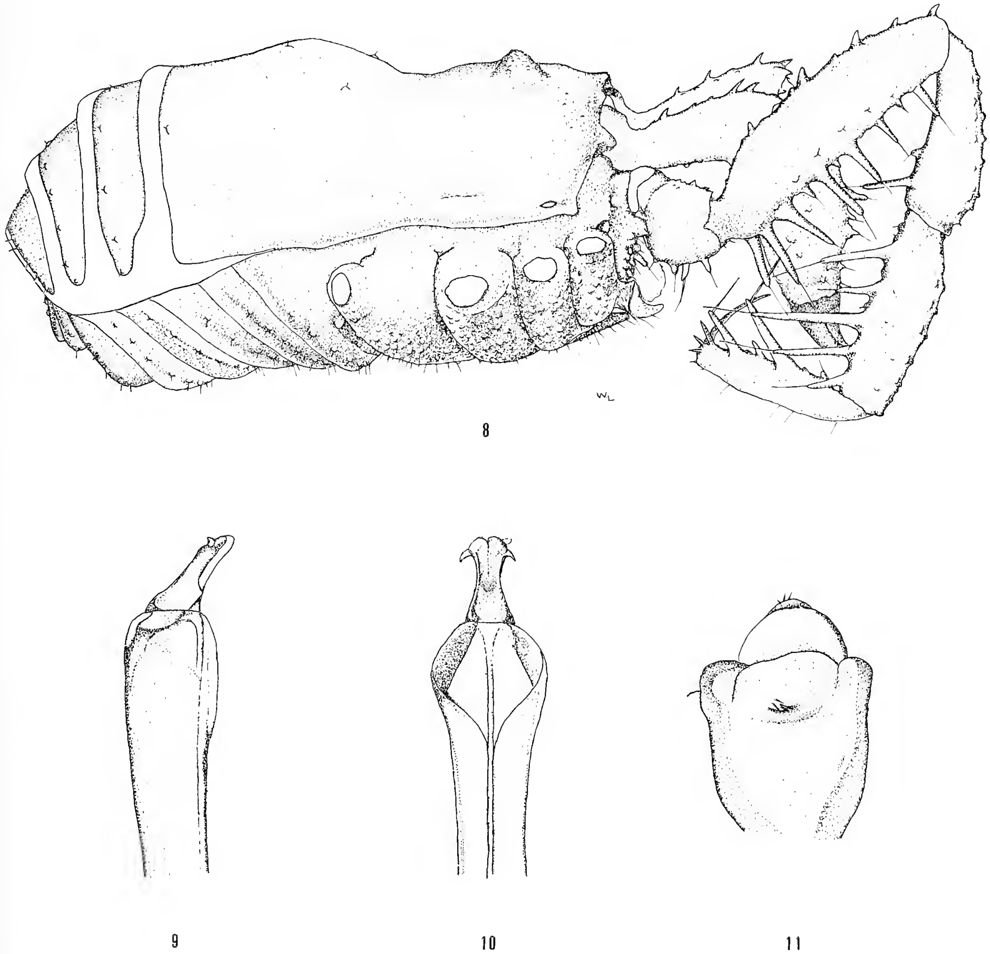
Tarsal formula of male holotype: 8, 9-20, 19-6-8. Tarsal formula of paratypes: 7 to 9-18 to 22-6 to 8-6 to 8. Distitarsi of first legs with two segments, of second legs with four segments. Astragali with numerous rigid false articulations. Venter of apical portion of second tibia with a broad seta-bearing tubercle. Tarsal claw of hind legs with base of stem swollen.

Penis with small, flattened dorsal plate bearing short lateral setae at narrow apex; dorsal plate folds ventrally into receptical at apex of basal segment. Basal segment an elongate, narrow, sclerotized tube that widens at apex.

Color a uniform light yellow-orange.

Female. Similar to male except larger in size, second tibia without apical tubercle.

Juvenile. Hind claws of early instars with apical aroleum and additional scale-like branches on short peltonychium. Hind claws of late instars with two apical branches on stem, spherical aroleum held between branches. Color a uniform white.



Figs. 8-11.–*Speleomaster lexi*: 8, lateral view of male; 9-10, lateral and ventral views of penis; 11, lateral view of ovipositor.

Table 2.–Leg and palpus measurements of *speleomaster lexi* in mm.

	I	II	III	IV	Palpus
Trochanter	0.38	0.41	0.47	0.44	0.47
Femur	2.94	4.70	2.31	3.76	1.32
Patella	0.74	0.97	0.80	0.74	0.94
Tibia	2.46	4.65	2.85	2.94	1.18
Metatarsus	3.47	5.00	4.40	6.92	
Tarsus	1.70	4.55	1.42	1.44	1.57
Total	11.69	20.28	12.25	16.22	5.48

Type data—Holotype male, allotype female and six paratypes, lava cave near Mammoth Cave, 37 km N Shoshone, Lincoln County, Idaho, 20 August 1972, under breakdown in soil floor of room near surface, 13.5°C, R. Lem and T. Briggs. One juvenile, Gwendolyn Cave, 37 km N of Shoshone, Lincoln County Idaho, 11 March 1972, low room 50-100 meters inside entrance, 5-8°C estimated temperature, J. Thornton, S. Lex and G. Huppert.

Etymology—This species is named for the first collector, Scott Lex.

Speleomaster pecki, new species
(Figures 12-15)

Description—*Female.* Total body length, 2.27 mm. Scute length, 1.94 mm. Length of eye tubercle, 0.21 mm. Scute width, 2.00 mm. Width of eye tubercle, 0.33 mm.

Anterior margin of scute with shallow cheliceral sockets above, with projections along ectal margin of each chelicera and each palpus. Scute finely granulate, without indication of fused segments. Odor gland on slightly elevated tubercle. Eye tubercle conical, tuberculate, recessed, without indication of eyes. Sternum narrow, broadens between fourth coxae into pentagonal shape. Groove between second and third sternites.

Second endites project anteroventrally, medially recurved at apices.

Operculum small, uniformly rounded, setose.

Chelicerae spinose, basal segments linear, anterior of distal segments with acute tubercles including a fused pair, fixed finger with larger teeth than movable finger.

Palpi with numerous elongate spines. Coxa with subaligned row of spines. Trochanter with two ventral spines. Femur with seven ventral spines, two mesal spines and four-five dorsal spines. Patella with one ventral spine and three mesal spines. Tibia with five mesal and five ectal spines. Tarsus with four ectal and seven mesal spines of which five are longest.

Table 3.—Leg and palpus measurements of *Speleomaster pecki* in mm.

	I	II	III	IV	Palpus
Trochanter	0.30	0.43	0.36	0.46	0.39
Femur	2.00	3.72	2.12	3.24	1.27
Patella	0.46	0.76	0.55	0.70	0.82
Tibia	1.88	3.64	2.18	3.54	1.03
Metatarsus	2.03	3.28	3.18	4.55	
Tarsus	1.45	3.58	1.09	1.39	1.40
Total	8.12	15.41	8.98	13.88	4.91

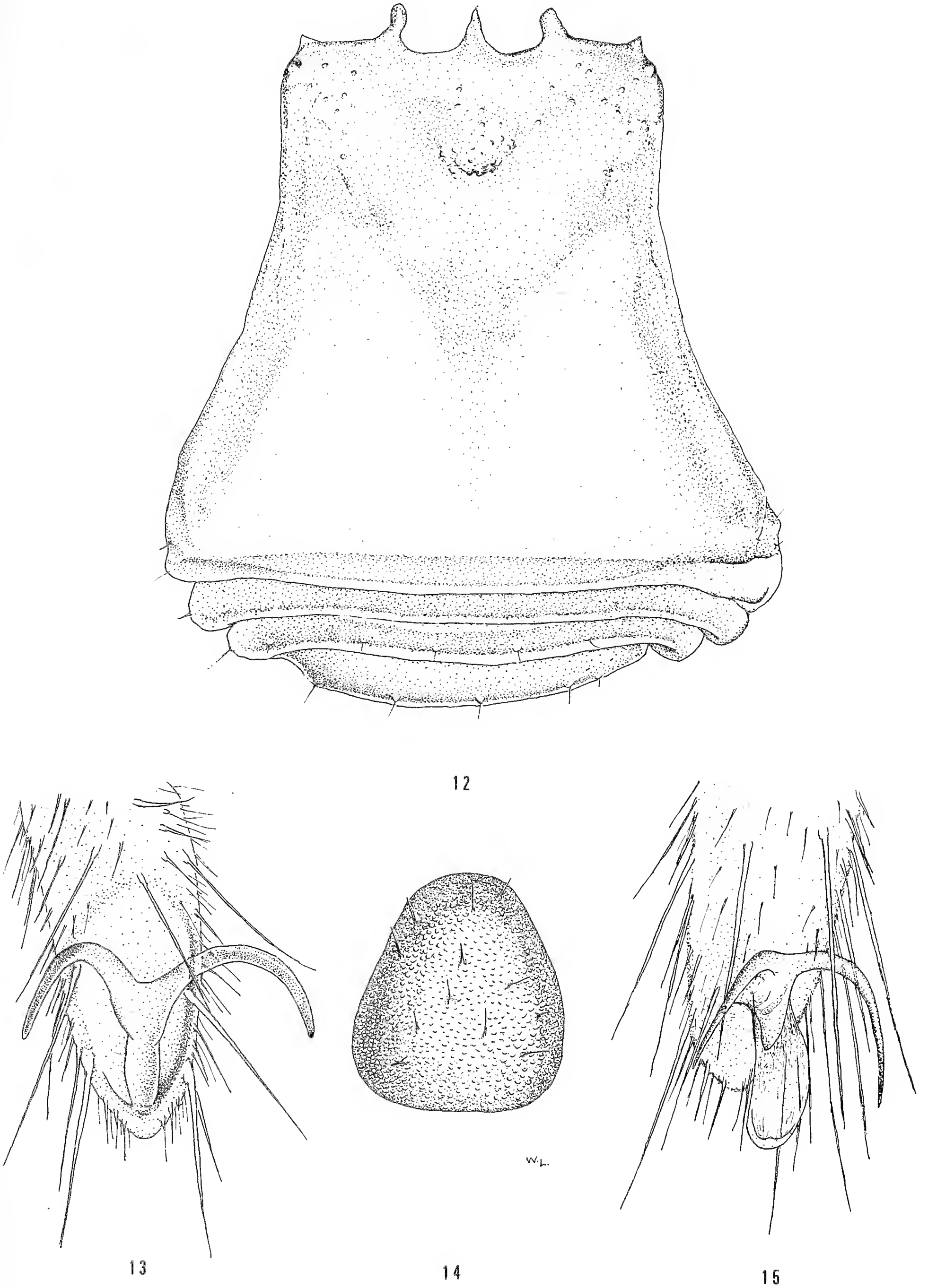
Tarsal formula of female holotype: 6,7-16-5-6,7. Distitarsi of first legs with two segments, of second legs with four segments. Astragali with numerous rigid false articulations. Tarsal claw of hind legs with a uniform stem.

Ovipositor without setae on distal lobes.

Color a uniform light yellow.

Male. Not known.

Juvenile. Hind claws of middle instars with two elongate branches from base of peltonychium, spherical aroleum held between branches, color a uniform white.



Figs. 12-15.–*Speleomaster pecki*: 12, dorsal view of female; 13, hind claw of female; 14, operculum of female; 15, hind claw of middle instar juvenile.

Type data–Holotype female, Boy Scout Cave (lava), Craters of the Moon National Monument, Butte County, Idaho, 1 October 1969, S. and J. Peck. Two juveniles, Boy

Scout Cave, same locality, 21 August 1972, under breakdown near ice, 4°C, R. Lem and T. Briggs.

Etymology—This species is named for the first collector, Dr. Stewart Peck, Carleton University.

Remarks—*Speleomaster pecki* differs notably from *Speleomaster lexi* in segmentation on the tarsi, the shape of the operculum and the overall size.

Triaenonychidae Pocock

A cavernicolous, juvenile triaenonychid was collected by R. Wescott in Crystal Falls Cave (lava), Clark County, Idaho. Its simple six-branched hind claws distinguish it from other related families and its tarsal formula of 2-2-3-3 is a characteristic of late instar Laniatorids (earlier instars are 1-1-1-1). Lack of pigmentation, spination of the first legs and shallow segmental folds distinguishes this juvenile from *Sclerobunus* Banks, the widespread surface triaenonychid genus, and places it near *Cyptobunus* Banks. Species of *Cyptobunus* have been found in a number of limestone caves in states adjacent to this locality, but have not been found on the surface (Briggs, 1971b). All known species in this genus and the juvenile from Crystal Falls Cave have functional eyes.

ACKNOWLEDGEMENTS

I wish to thank Frank G. Howarth, Robert Lem, Jerry Thornton, and George Huppert for assistance in gathering specimens. The staff of Craters of The Moon National Monument kindly permitted collecting in Boy Scout Cave. Identification of Diptera was kindly provided by Paul H. Arnaud, Jr., Wallace A. Steffan, and George Steyskal. The 1972 National Speleological Society national convention in Washington provided important collecting opportunities. William Lum performed all art work.

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DESCRIPTION OF THE MALE OF *BOTHRIURUS* (*ANDIBOTHRIURUS*) *PERUVIANUS* MELLO-LEITAO (SCORPIONIDA: BOTHRIURIDAE)

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ABSTRACT

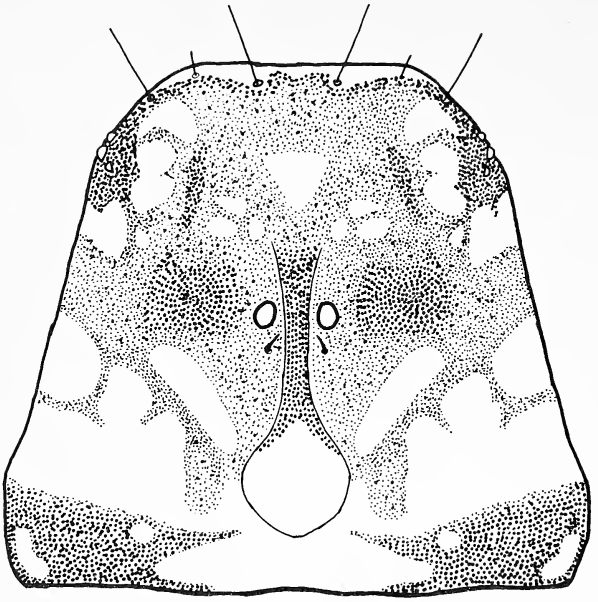
The male of *Bothriurus* (*Andibothriurus*) *peruvianus* Mello-Leitão (Scorpionida: Bothriuridae) is described. A single specimen was collected 2 km E of the type locality in Tarma, Junin, Peru. The taxonomic status of this species, previously known only from the holotype female, is cleared. *B.* (*A.*) *peruvianus* is related to *B.* (*A.*) *burmeisteri* Kraepelin, and possibly also to *B.* (*A.*) *lampei* Werner.

INTRODUCTION

Mello-Leitão described three new species of Peruvian scorpions in an important, but often overlooked, paper (Mello-Leitão and Araújo Feio, 1948). Among these was *Bothriurus* (*Andibothriurus*) *peruvianus* Mello-Leitão based on one adult female from Tarma, Junin, Peru. The taxonomic status of this species has remained uncertain. Bücherl (1962) studied the *Bothriurus* specimens deposited at the Museu Nacional do Río de Janeiro, Brasil, and stated that the type of *Bothriurus* (*A.*) *peruvianus* "no author" is deposited at that institution; evidently being unaware of Mello-Leitão's publication he treated it as a *nomen nudum*, and upon examination of the specimen decided that it represented the female of *Bothriurus* (*A.*) *titschaki* Werner (1939), which is known from a unique male from Chile.

Subsequently Bücherl, et al. (1962) revised the genus *Bothriurus* Peters (1861), recognizing three subgenera: *Bothriurus sensu stricto*, *Transbothriurus* Mello-Leitão (1945), and *Andibothriurus* Bücherl, et al. (1962). Here again no author is given for *Bothriurus* (*A.*) *peruvianus*, no reference to the original publication is made in the bibliography, and the species is not treated in the revision; the only remark made is in the discussion to the effect that it might be a valid species and not a synonym of *Bothriurus* (*A.*) *titschaki* Werner.

The author was able to collect one specimen, an adult male, of this species during a brief visit to Peru in December 1972-January 1973. The description which follows is aimed at clearing the confusion existing in the literature with regards to this species.



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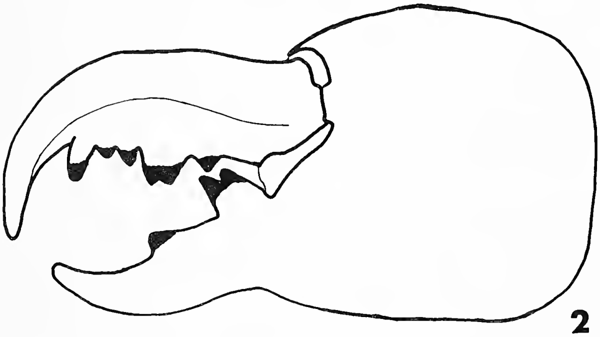

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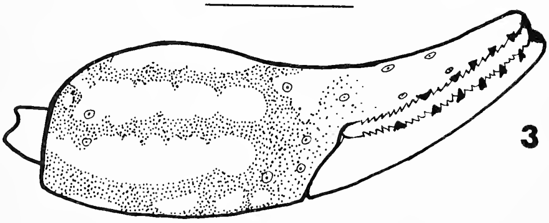

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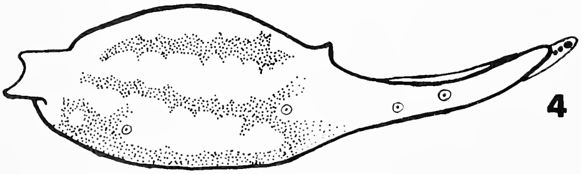

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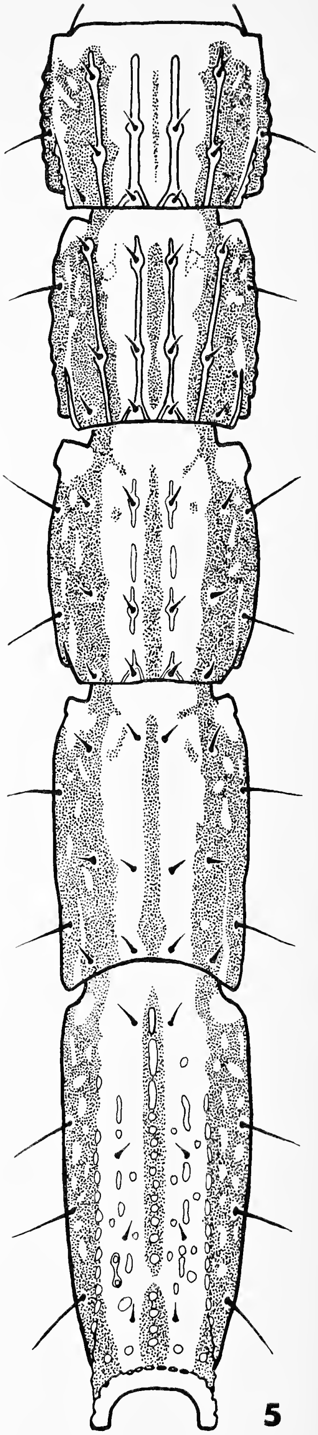

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Bothriurus (*Andibothriurus*) *peruvianus* Mello-Leitão
(Figs. 1-5)

Bothriurus peruvianus Mello-Leitão, 1948, p. 315-316, Fig. 2; ? *Bothriurus chilensis*, Blancas Sánchez, 1959 [non *B. chilensis* (Molina, 1782)]; *Bothriurus titschaki*, Bücherl, 1962, p. 198 (non *B. titschaki* Werner, 1939); *Bothriurus* (*A.*) *peruvianus*, Bücherl, et al., 1962, p. 222, *Bothriurus peruvianus*, Aguilar and Meneses, 1970, p. 2.

Diagnosis of Male—Medium sized (42.1 mm). Coloration; carapace with dense fuscous pattern. Mesosomal dorsum with two broad, dark longitudinal stripes. Metasoma pigmented on inferior and lateral intercarinal spaces, and along dorsomedian keels. Prosoma; median groove of carapace present. Superior margin of movable finger of chelicera with five teeth. Pedipalps with movable finger shorter than carapace length, fingers touching only at tips when closed. Mesosoma; tergites smooth, tergum 7 with two pairs of weak, crenulated keels. Sternites smooth, sternum 7 with median keels vestigial, lateral keels obsolete. Pectinal teeth 14-15 (12 teeth in female). Metasoma; inferior median keels smooth on segments I-II, vestigial on III, obsolete on IV. Inferior lateral keels weak, smooth on I-II, obsolete on III-IV. Segment V with inferior median and inferior lateral keels smooth to granulose, parallel; paramedian keels granulose, poorly defined, subparallel. Telson; dorsal surface of vesicle slightly concave (flat in female).

Description of Male—*Coloration.* Ground color light brown, metasoma and walking legs paler. Prosoma; carapace fuscous throughout in complex pattern (Fig. 1). Humerus and brachium of pedipalps heavily infuscate; chela pigmented where keels should occur, giving impression that latter are present (Fig. 3 and 4). Femur, tibia, and metatarsus of walking legs fuscous. Mesosoma; tergites heavily infuscate on lateral two-fifths, leaving narrow clear medial band. Sternites lightly fuscous on lateral portions, increasing in density and extent posteriorly so that on sternum 7 the lateral one-fourth is completely darkened. Metasoma; caudal segments with dorsomedian keels underlaid with dark pigment, lateral and inferior intercarinal spaces fuscous (Fig. 5). Vesicle with lateral areas weakly pigmented, defining a clear ventromedial zone.

Prosoma.. Carapace; (Fig. 1) anterior margin straight, armed with four large bristles. Lateral eyes small, subequal in size; three per side, posterior one forming an angle of approximately 105° with anterior pair. Median eyes separated by twice their diameter. Median groove originating as shallow depression at anterior margin, extending shallowly over ocular tubercle, ending in deep, wide conical pit centered four-fifths down carapace length. Posterior lateral furrows vestigial. Surface minutely punctate and vestigially granulose. Chelicera; (Fig. 2) distal inferior tooth of movable finger approximately three times longer than distal superior tooth. Superior margin bearing five teeth. Pedipalps; humerus with obsolete carinae, anterior surface sparsely granulose. Brachial dorsoanterior carina smooth, others obsolete; surfaces smooth. Chela (Figs. 3 and 4) smooth, all keels obsolete; only prominent structure is tubercle at inner surface commissure (male generic character). Fixed and movable fingers distinctly shorter than carapace length; fingers meeting only at tips when closed, leaving distinct space between. Five supernumerary teeth on fixed finger, six on movable finger. Walking legs; tarsomere II spine formula:

$$\frac{1\ 1}{1\ 1}:\frac{2\ 2}{2\ 2}:\frac{3\ 3}{3\ 3}:\frac{3\ 3}{3\ 3}.$$

⇦ Figs. 1-5.—*Bothriurus* (*A.*) *peruvianus* Mello-Leitão, adult male from 2 km E of Tarma, Junin, Peru: 1, dorsal view of carapace; 2, ventral view of left chelicera; 3, external view of right chela; 4, dorsal view of right chela; 5, ventral view of metasoma.

Mesosoma. Tergites; posterior halves vestigially granulose. Tergum 7 with two pairs of weak, crenulated keels interspersed with small granules. Genital operculi; triangular, fused along entire length. Genital papillae absent. Basal piece of pectines nearly twice as wide as long, with deep median notch extending more than half its length. Pectines; over five and one-half times as long as greatest width. Teeth angular, increasing in length distally from 0.4mm to 0.6mm; numbering 14-15. Middle lamellae subcircular, numbering 9-10. Anterior and middle lamellae, and fulcra moderately covered with short red setae. Sternites; vestigially punctate. Sternum 7 with median keels vestigial, lateral keels obsolete. Stigmata elliptical.

Metasoma. (Fig. 5) segment I wider than long, segment V more than twice as long as wide. Dorsal median keels weak, smooth on segments I-IV. Dorsal lateral keels crenulate to smooth on I-III, obsolete on IV. Lateral keels weak, smooth to crenulate on posterior half of I; vestigial on II; obsolete on III-IV. Inferior lateral keels smooth on I-II, obsolete on III-IV. Inferior median keels smooth on I-II, vestigial on III, obsolete on IV. Segment V; dorsal and lateral keels obsolete; inferior lateral keels vestigial to obsolete on anterior third, granulose on posterior two-thirds, parallel; inferior median keel weak, smooth on anterior third, granulose on posterior two-thirds; paramedian keels poorly defined, represented by scattered granules on posterior two-thirds, subparallel. Telson; slightly shorter than segment V. Dorsal surface of vesicle slightly depressed; ventral surface moderately hirsute and shallowly punctate. Aculeus reddish, moderately curved.

Measurements—Descriptive data of the male is compared with that given in the original description for the holotype female in Table I.

Locality—Male; 2 km E Tarma, Junin, Peru, 4 January 1973 (Neil F. Hadley and Oscar F. Francke). The single specimen was found dead under a rock that was resting on a dried grass clump. It is assumed that it had recently died, for no signs of decomposition nor desiccation were evident. The site is on a NNE exposed slope of 25°-30° and heavily eroded, at an elevation of 3,400 m (11,400 ft) covered with scant xerophytic vegetation. Over two hours of blacklighting (U. V. detection) on 1 January 1973 failed to reveal any scorpions in the area, and further attempts to use this method on 4 January 1973 were prevented by rain.

Type Data—Holotype female; Tarma, Junin, Peru (3,100 m), no date (W. Weyrauch). Deposited at the Museu Nacional do Río de Janeiro, Brasil.

DISCUSSION

Bothriurus (*A.*) *peruvianus* is related to *B.* (*A.*) *burmeisteri* Kraepelin (1894) from Argentina and Chile. Maury (1968) has studied the holotype of *B.* (*A.*) *burmeisteri*, and from his account the following similarities and differences become evident. Both species have subparallel paramedian keels on the posterior two-thirds of segment V; and they are the only species in the genus reported to have five teeth on the superior margin of the movable finger of the chelicera (other *Bothriurus* spp. have four). These two species can be easily separated by their pectinal tooth counts; *B.* (*A.*) *burmeisteri* with 24 in males and 16 to 22 in females, *B.* (*A.*) *peruvianus* with 14 to 15 in the male and 12 in the female.

B. (*A.*) *titschaki* differs from *B.* (*A.*) *peruvianus* in the structure of the metasomal keels, and in pectinal tooth counts. *B.* (*A.*) *titschaki* has granulose inferior median and

Table1.–Measurements (in millimeters) of *Bothriurus* (*Andibothriurus*) *peruvianus* Mello-Leitao (the figure given for the holotype female are those found in the original description).

			Adult ♂	Holotype ♀
Total length			42.1	40.0
Carapace:	length		4.6	
	Anterior width		3.3	
	Width at median eyes		4.0	
	Posterior width		5.3	
Mesosoma:	length		13.0	
Metasoma:	length		24.5	20.0
Segment I:		length	2.5	2.0
		width	3.1	
Segment II:		length	2.9	2.6
		width	2.8	
Segment III:		length	3.4	3.0
		width	2.8	
Segment IV:		length	3.8	3.4
		width	2.7	
Segment V:		length	6.0	4.6
		width	2.7	
Telson:	length		5.9	4.4
Vesicle:		length	4.4	
		width	2.6	
		depth	2.3	
Aculeus:		length	1.5	
Pedipalp:	length		15.1	13.7
Humerus:	length		3.7	3.0
	width		1.4	1.0
Brachium:	length		3.8	3.5
	width		1.5	1.5
Chela:	length		7.6	7.2
	width		2.5	2.0
	depth		2.3	
Movable finger:		length	4.0	4.0
Fixed finger:		length	3.2	
Pectinal teeth:	left/right		15/14	12/12
Middle lamellae:	left/right		10/9	

inferior lateral keels on segments III-IV; in *B.* (*A.*) *peruvianus* the inferior median keels are vestigial on III and obsolete on IV, and the inferior laterals are obsolete on III and IV. The pectinal tooth count on *B.* (*A.*) *titschaki* is 7 to 9 in the male. Werner (1939) does not mention the cheliceral dentition of *B.* (*A.*) *titschaki* in his original description. The holotype has been examined by Maury, and his study (in press) will probably reveal the number of teeth found on this structure, as well as any other similarities or differences existing between these two species.

Another possibly related species is *B.* (*A.*) *lampei* Werner (1916) described from a unique specimen (male?) from Peru. The original description leaves much to be desired, but the obvious differences of this species from *B.* (*A.*) *peruvianus* relate to the structure of the metasomal keels and the pectinal tooth counts. *B.* (*A.*) *lampei* has smooth inferior lateral keels on segments III-IV, and a pectinal count of 20 teeth. The study of Werner's type specimen by Maury (in press) will probably elucidate the nature of the keels on segment V, the cheliceral dentition, contribute to the knowledge of *B.* (*A.*) *lampei*, and increase the understanding of the species relationships in the subgenus *Andibothriurus*.

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OBSERVATIONS ON THE BIRTH AND POST-BIRTH BEHAVIOR OF *SYNTROPIS MACRURA* KRAEPELIN (SCORPIONIDA: VAEJOVIDAE)

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ABSTRACT

The birth and post-birth behavior of the scorpion *Syntropis macrura* Kraepelin (Scorpionida: Vaejovidae) is described and discussed. Birth of an entire litter of 33 young took approximately 37 hours. The young were precocious, with few of them ascending onto the mother's back. Mortality was high, with only two second instar young surviving. Post-birth associations of the first instar nymphs with the mother are described.

INTRODUCTION

On 23 March 1971, a female *Syntropis macrura* Kraepelin (Vaejovidae: Syntropinae) was collected by Vincent F. Lee at Puerto Balandra, Isla del Carmen, Baja California Sur, Mexico. On 3 January 1972, more than nine months later, this scorpion began giving birth to 33 young during a time span of approximately 37 hours. The birth appeared to be abnormal in several respects which will be discussed later, but is worthy of note for two reasons. First, it is the first observed for this genus, and second, it differed from the birth processes of other members of the family Vaejovidae.

The systematics of this primarily New World family of scorpions has been given considerable attention in recent years. However, behavioral studies have lagged behind. Stahnke (1966) mentioned that first instar *Hadrurus arizonensis* Ewing do not molt until at least 16 days after emergence. Williams (1969) discussed the birth behavior of 14 species of North American scorpions, including *Anuroctonus phaiodactylus* (Wood), *Hadrurus arizonensis* Ewing, *Uroctonus mordax* Thorell and five species of *Vaejovis*, all of the family Vaejovidae. While concluding that the birth process and post-birth association of the young was quite similar in the species of *Vaejovis*, there was insufficient comparative data for the other genera. Haradon (1972) described the birth behavior of *Uroctonus mordax*, observing that, unlike first instars of *Vaejovis* spp., first instars of *Uroctonus* spp. are randomly positioned on the mother's back. He concluded that significant variation of birth patterns exist in the family Vaejovidae and that this variation is of taxonomic significance and tends to support the maintenance of *Uroctonus* as a separate genus.

Based on the observations of the above-mentioned authors, several conclusions may be drawn about the birth behavior of New World vaejovid scorpions.

1. A stilting posture is assumed prior to delivery and is maintained until delivery is complete. This consists of raising the body high above the substrate with the pedipalps usually held out away from the body.

2. A "birth basket" is formed by the first two pairs of walking legs being held together close to the substrate. This basket furnishes a place for the young to extricate themselves from the birth membrane and increases the chances for ascent to the mother's back.
3. The length of time spent in parturition varies from one to 7½ hours, depending on the number and size of the young and on the occurrence of complications.
4. There is a gestation period of from eight to twelve months.
5. There is no preferred time of parturition.
6. Litter size ranges approximately between ten and seventy.
7. Nearly all of the young ascend to the mother's back.
8. The first stadium lasts for one week to at least 16 days.
9. Orientation on the mother's back may be either non-random, that is, facing anteriorly with the prosoma down and the metasoma curled over the back, as in *Vaejovis* spp., or random as in *Uroctonus*. The pattern of orientation of the first instars of *Anuroctonus* sp. and *Hadrurus* spp. is still open to question.
10. The mother remains sedentary until after the young have left her back.
11. The young are not precocious, but remain on the mother's back until after the first molt. Those which do not ascend to the mother's back die in a short time.

It will be seen that my observations of *Syntropis macrura* show significant differences from these conclusions.

METHODS

The mother was housed in a plastic box (178 mm X 83 mm X 45 mm) until all the young had emerged and were on the mother's back. At this time, she was transferred to a larger plastic box (381 mm X 278 mm X 172 mm) which was supplied with a dirt-gravel substrate and several large rocks with some vertical facings to simulate natural surroundings. The mother was kept well fed on crickets from the time of her arrival. The surviving second instar young were fed immature crickets which were readily accepted and eaten. Water was supplied in a dish for the mother and by an occasional sprinkling for the young.

THE BIRTH PROCESS

Delivery Posture—The mother prepared for delivery by assuming the stilting posture common to other vaejovids. All vaejovid births observed up until this time have revealed that the mother uses the first two pair of walking legs to form what has been called a "birth basket." The behavior of *Syntropis macrura* differs in that only the first pair of walking legs are used. Also, instead of being held close to the substrate, as in other vaejovids, the legs are held close to the body in a horizontal position just under the genital operculum (Fig. 1). The young, as they emerge, are caught by the legs at the junction of the carapace and mesosoma. During the birth process, the mother was quite active, giving up the stilting posture between births and walking around the box.

The young did not emerge in any set position. Of the 23 observed births, 14 young emerged head-first. Of these, eight emerged in a right-side-up position. Of the remaining six, three emerged upside-down and three sideways. Nine emerged tail-first. Of these, six were right-side-up, two upside-down, and the last sideways. There appeared to be a tendency toward a right-side-up orientation whether emergence was head-first or tail-first.

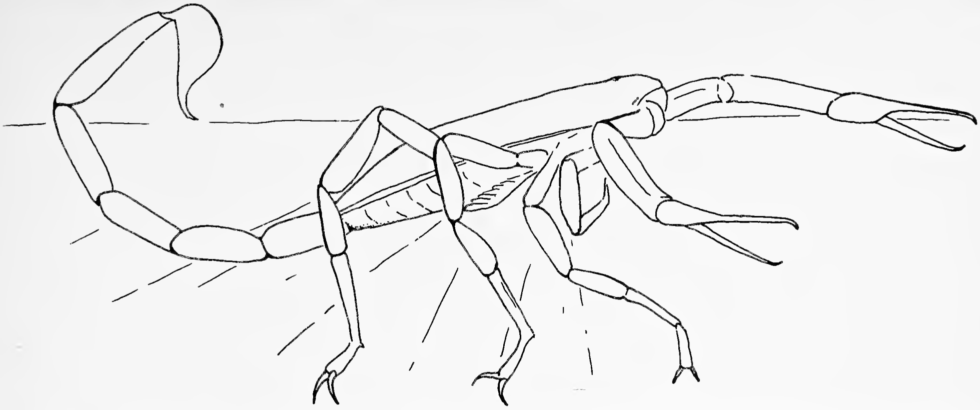

Fig. 1.–Illustration of the mother's posture during delivery. Note that only the first pair of walking legs are used to catch the young.

Delivery Time–Delivery of the entire litter of 33 young took approximately 37 hours, from sometime early in the morning of 3 January to sometime early in the evening of 4 January. This is an unusually long time compared to other vaejovids, even though the number of young cannot be considered unusually large. It can be seen from Fig. 2 that the hours between 1847 and 0032 appeared to be the preferred time of parturition, when one-third of the litter emerged on an average of 35 minutes apart. The average time between emergences over the entire 37 hours was 72 minutes (based on intervals between the 23 observed births). The actual times required for emergence ranged between 15 seconds and one minute. One scorpion was born dead in a shrivelled condition.

POST-BIRTH BEHAVIOR

Most of the young freed themselves completely from the birth membrane within 45 minutes, some in as little as 30 minutes. Others had some difficulty, one taking nearly two hours. The manner of shedding the membrane was the same in all cases. First, the pedipalps and carapace were freed, then each pair of walking legs, then the mesosoma and, finally, the metasoma. The stickiness of the birth membrane enabled the young scorpion to remain on the mother's legs until its own legs were free. At this point, the young scorpion began to walk about or ascend to the mother's back. The membrane sometimes became caught between metasoma V and the telson, in which case the scorpion simply carried it with him.

Surprisingly, and unlike other vaejovids, few of the young ascended onto the mother's back. The first to attempt the ascent was No. 17 (see Fig. 2). It took one hour and 38 minutes from the time of emergence to gain the mother's back. Ultimately, only five of the 33 young made the ascent.

Also unlike other vaejovids, the first instars were quite precocious. Two instances will serve to demonstrate this precocity. First, one which had ascended to the mother's back in the normal manner (that is, up the chelicerae, pedipalps or first two pair of walking legs), wandered down to metasoma IV of the mother (after having been on her back for at least two hours). The mother responded by flicking him off of her tail, turning around, picking him up with her pedipalps and transferring him to her chelicerae where she held him by the mesosoma. Two hours later, she released her hold and the young scorpion climbed over to the coxa of the right pedipalp. It then climbed back to the chelicerae, then under them, and made its way to the right side of the mother between the pedipalp and first walking leg. From there, it got onto the femur of the mother's pedipalp and

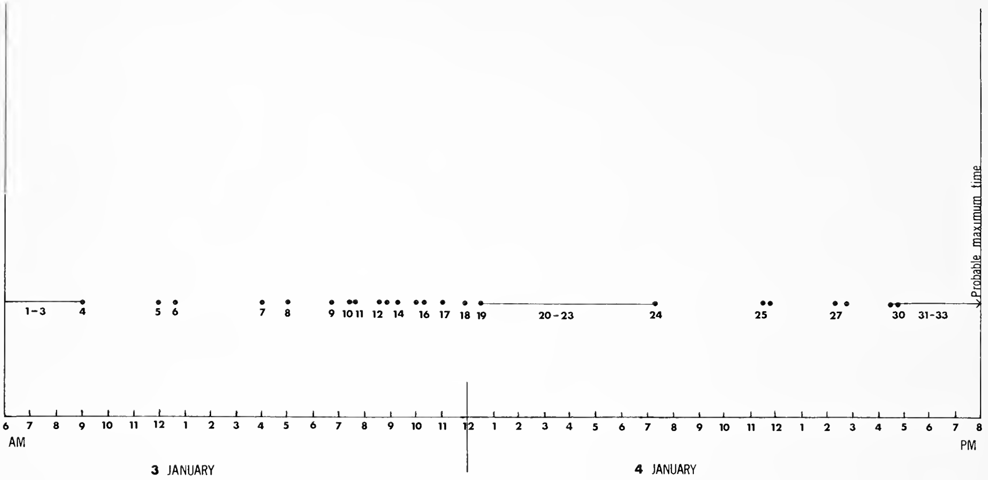

Fig. 2.–Duration of birth process, showing times of birth. Numbers refer to individual young; lines indicate births not observed. All births considered complete by 2000 hours based on the previous night's performance.

finally, 20 minutes after having been released from the mother's chelicerae, ascended the mother's back for a second time. In the second instance, one of those not immediately ascending to the mother's back walked to the opposite end of the container, up the side, back to the other end along the side of the box, and back to the ground. It then climbed onto the mother's tail at metasoma II and then onto her back.

The behavior of the mother toward the young also seemed unusual. Those which emerged onto the ground were picked at whenever they moved. In a seemingly hostile fashion, she would quickly grab at them with one or both pedipalps. This usually consisted of squeezing them and then quickly releasing them and drawing the pedipalps back. On more than one occasion, she picked one up with the fingers of one pedipalp and held it for some time. At other times, she would transfer it to her chelicerae. One was held this way for nearly 5½ hours but was alive and apparently healthy after being released. Those young that ascended onto her back were subjected to repeated attempts at removal during the first day. The mother would scratch at her back with the third and fourth pairs of legs much as a dog after fleas.

As of 5 January, five young were on the mother's back, seven were in the container with the mother (alive but not on her back), seven had been placed alive in a separate container for comparative purposes, seven had been removed and preserved in alcohol and the remaining seven appeared dead.

On the morning of 5 January, after all of the young had emerged, the five on the mother's back were all facing posteriorly. On the next morning, three of the young were facing anteriorly and two remained facing posteriorly. On the next day, four were facing anteriorly and only one was facing posteriorly. Finally, on 10 January, all five were facing anteriorly as in most other vaejovids. However, on 13 January, one was again facing posteriorly. This situation was maintained while the young remained on the mother's back.

On 20 January, all of those in the separate container were still alive, but only three of the seven in the container with the mother were alive. All of the bodies were accounted for, so it is certain that the mother did not eat them, and it is doubtful that she would kill them without eating them. The mother showed no interest in an introduced cricket.

The first molt occurred on 21 January, 18 days after the birth process began. By 22 January, four of the five young on the mother's back had molted, two of them already having left the mother. All molting was completed by 24 January. By 30 January, only two second instars were left alive, both under rocks. All of the other young had died. Of those that were not on the mother's back, only one completely shed its skin. The others either showed no signs of molting or else molted only partially. This would seem to indicate that, for reasons unknown, the first instars must ascend onto the mother's back in order to undergo a successful molt.

On 6 June, one of the young died while still in the second instar. The last specimen molted on 14 July and died a week later. Thus, the length of the second stadium, based on this single specimen, would be about 5½ months. The causes of death are unknown.

The first instars, like other scorpions, were completely white except for black eye spots; with blunt pretarsi and a blunt aculeus, and with no evidence of setae or trichobothria (Fig. 4). The second instars had the trichobothria visible, and the aculeus and pretarsi were darker and well-formed (Fig. 5). The body was lightly pigmented, with

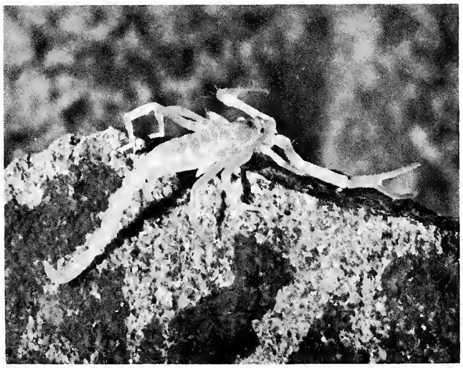

Fig. 3.–Female *Syntropis macrura* with newly molted second instar young on her back. Note the cast skin of one young attached partially to the mother's carapace.

Fig. 4.–First instar of *Syntropis macrura*. Note blunt aculeus and pretarsi and lack of pigmentation.

Fig. 5.–Second instar of *Syntropis macrura*. Note the formed, darkened aculeus and the presence of trichobothria.

a whitish band along the posterior margin of each mesosomal segment. Also, the second instars were more slender than the first instars, with the pedipalp fingers and other pedipalp segments being noticeably longer in relation to the rest of the body. The third instar was similar to the second but larger and more darkly pigmented.

DISCUSSION AND CONCLUSIONS

These observations revealed that there are similarities to the birth behavior of other vaejovids, yet showed some significant differences. The similarities were that *Syntropis* assumed a stilting posture, the gestation period fell within the normal range, an average number of young were produced, the first stadium lasted for 18-20 days (about the same as *Hadrurus*, but several days longer than that of *Vaejovis*), and that the first instar orientation had a tendency toward being non-random. However, as mentioned in the introduction, this birth appeared abnormal in several respects. First, the unnaturally long parturition time probably was due to the young being improperly oriented within the mother prior to birth. This would also explain why the young were oriented in so many different positions upon emergence, although this aspect apparently has not been observed in other vaejovids, and comparison is not possible.

It was very unusual for so few of the young to ascend to the mother's back. In other vaejovids, this appears to be a necessary part of the development of the young. That so few ascended in this instance may be again due to complications within the mother and the multi-oriented emergence of the young. Those young which emerged tail-first or upside-down had almost no chance of immediate ascent, but fell to the ground after breaking out of the birth membrane. Those that emerged head-first and right-side-up were able to grasp the mother's supporting legs after freeing themselves from the membrane. This is still not the full explanation, since eight young emerged in the ideal position and only five made the ascent. However, the possibility that first instar *Syntropis* are naturally precocious and could have survived under natural conditions still remains. Finally, the mother's restlessness and unusual behavior toward the young could also have been an indication of internal complications or also of outside influences.

There are two aspects of the behavior which I feel were normal even though they departed from the usual vaejovid behavior. First, the hours between 1800 and 0100 appeared to be a preferred time of parturition, and secondly, only the first pair of walking legs was used to catch the young rather than a "birth basket" being formed. These appear to be of such an instinctive nature that they would be unaltered by other influences and are a significant departure from the usual vaejovid behavior.

These observations would seem to reinforce Haradon's (1972) conclusion that significant variation of birth patterns exist in the family Vaejovidae. However, whether or not this variation is of taxonomic significance is open to question. Much more work needs to be done in the area of birth behavior in order to get a clear overall picture. In particular, much more data is needed on the genera *Anuroctonus*, *Hadrurus* and *Syntropis*. It seems possible that the behavior of *Anuroctonus* would differ from other genera because of the obligate burrowing habits of the genus. However, very little is known of any of these groups, and questions remain open until someone else is fortunate enough to obtain gravid females for comparative purposes.

ACKNOWLEDGEMENTS

Acknowledgements are given to Vince Lee, without whose tireless collecting these observations could not have been made, and to Carolyn Mullinex for her illustration. Dr. Robert X. Schick, California Academy of Sciences, and Dr. Stanley C. Williams, California State University, San Francisco, kindly read the manuscript.

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A PRELIMINARY CHECKLIST OF SPIDERS OF NACOGDOCHES, TEXAS

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ABSTRACT

A preliminary checklist (heretofore unpublished) of 25 families, 90 genera, and 147 species of spiders found in Nacogdoches, Texas or in nearby areas is presented. Of these, 66 species were found in mud-dauber nests. *Smeringopus elongatus* (Vinson) is reported for the first time in the U. S. Fifty-one species are additions to the 577 species having been reported from Texas (Vogel, 1970). Two of the 12 additions to the Texas Salticidae species are reported by Carpenter (1972).

INTRODUCTION

This study was undertaken in 1970 to add new species records and new information to nearly 600 species of spiders previously reported from Texas (Vogel, 1970).

In 1940 Gertsch and Mulaik published the results of an eight-year study of spiders in over 100 counties in Texas. Thirty-eight of the 43 families known to exist at that time in America north of Mexico were found in Texas. Most of the studies in Texas have been in the Big Bend area, the lower Rio Grande (especially Hidalgo and Cameron counties), around Austin (Travis County) and Dallas (Dallas County) leaving many areas in Texas, such as Nacogdoches County, a complete void in the literature of spiders of Texas. Recently (Carpenter, 1972) a list of jumping spiders has been published from Wichita County. This list includes *Metaphidippus galathea* and *Hentzia palmarum*, which in my list are reported as additions to Vogel's list (1970).

Among the better literature sources available for the study of spiders today are Comstock (1912, revised by Gertsch, 1948), Kaston (1948), and Fitch (1963). Kaston (1972) also is helpful in identification of the spiders. Since 1940 numerous additions and revisions have been published with over 13,000 new species of spiders being named from North America alone between 1940 and 1966 (Vogel, 1967).

This list is not intended as a complete checklist of all the spiders in Nacogdoches, Texas, but rather a survey of spiders collected for the most part over a period of six months. These are known to be only a portion of the species that exist in the Nacogdoches area, because many spiders which could be collected in quantity by sweeping vegetation were bypassed in view of the lack of literature for identification and time involved in collecting them.

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RESULTS AND DISCUSSION

From March 1970, when the taxonomic study of spiders was begun, and throughout the next six months, *Achaeranea tepidariorum*, *Filistata hibernalis*, and *Scytodes* sp. could be found. In April other spiders began to appear, particularly the fast-running Lycosidae. From May through the fall, when the study was halted, the number of spiders that were available greatly exceeded the number which could be microscopically examined.

In early June the organ pipe mud dauber wasps, *Trypoxylon* sp., began building their nests. These continued to appear throughout the summer, but nests of the common mud dauber, *Sceliphron cementarium*, soon greatly outnumbered them. About the middle of August there was a sharp decline in the construction of all mud dauber nests. Many of these were found invaded by the wasp, *Chalybion* sp., which empties out fresh nests of mud daubers and provisions them with her own spiders. About 10 of the 60 *Sceliphron* nests examined had been invaded by *Chalybion*. A total of 75 *Sceliphron* and *Trypoxylon* nests were studied, but some were devoid of spiders or had only a few. *Trypoxylon* and *Sceliphron* nests were found in garages, under house eaves and rafters, under bridges and overpasses, and in other protected areas.

In the beginning of my study of spiders in mud dauber nests dried and dismembered specimens were cast aside. Later, dehydrated specimens were soaked in water about 10 hours and often were reconstituted well enough to enable complete indentification. Colors of these spiders were far better than that of specimens preserved in alcohol. Several species were found such as *Mangora placida* and two male *Verrucosa arenata*, which would have been overlooked otherwise. The majority of the spiders in the nests were immature specimens, and many of these were not identified past genus.

Trypoxylon wasps showed a decided preference for species of *Neoscona*, but a few other spiders not found in other searches, such as the Bolas Spider, *Mastophora bisaccata*, were discovered in the nests. *Sceliphron* nests contained a tremendous variety of species.

Spiders in the recent mud dauber nests were alive but paralyzed, and ideal for studying and photographing. Spiders were either photographed when taken from these nests or, if found in other habitats, were anesthetized immediately before being photographed. After photographing the spiders, they were examined with a binocular microscope while anatomical features and colors were still in their natural state, observations recorded, and preserved in 75% ethanol. The spider specimens listed here are on loan at the Department of Biology, Stephen F. Austin State University, Nacogdoches, Texas, in the care of Dr. William W. Gibson.

Muma and Jeffers (1945) reported 10 families, 48 genera, and 81 species taken from mud dauber nests in Maryland. They reported that two-thirds of the spiders in *Chalybion* nests were Theridiidae. One-third of these were *Latrodectus mactans*, and one-tenth were *Achaearanea* [=*Theridion*] *tepidariorum*. I also found that nests invaded by *Chalybion* were filled predominantly with spiders of the family Theridiidae, but the majority of these were *A. tepidariorum* with only a few *L. mactans*.

Dorris (1970) reported 10 families, 23 genera, and 28 species found in a study of *Sceliphron* and *Trypoxylon* nests throughout Mississippi. Dorris (1970) and Muma and Jeffers (1945) reported that the *Trypoxylon* mud dauber had a preference for the genera *Neoscona* and *Eustala*.

In my study of spiders from mud dauber nests, in the summer of 1970, 10 families, 45 genera, and 67 species were identified although some of these are probably undescribed.

Thirty-four of these species were not included in the above reports of Muma and Jeffers (1945) and of Dorris (1970). This study also adds the families Oonopidae and Scytodidae to the above lists of spiders found in mud dauber nests. The families Araneidae and Salticidae were represented by more species than any other family. The mud daubers tended to gather those spiders that are normally the most conspicuous. Only Araneidae and a very few Salticidae and Theridiidae were found in the *Trypoxylon* nests.

Other spiders reported in this study were found in many habitats such as on the ground, in webs, dangling from drag lines, on vegetation, and in houses.

In this first preliminary checklist of spiders for the Nacogdoches area 25 families, 90 genera, and 147 species are reported. Not counting the genera for which species identification was not possible (unless that genus is otherwise entirely absent from the list) 51 species are additions to the 577 species reported from Texas by Vogel (1970).

In the following list the name of each taxon is followed by the author: state of development of specimen(s) examined, length in millimeters; situation in which collected; date; determiner. Unless otherwise stated, spiders were collected in Nacogdoches, Texas.

Explanation of abbreviations used in the list are as follows: Det. WJG, determined by Willis J. Gertsch; Det. BV, determined by Beatrice Vogel; Det. KMB, determined by Katharine M. Brown; S, *Sceliphron* mud dauber nest; SC, *Sceliphron* nest invaded by *Chalybion*; T, *Trypoxylon* mud dauber nest; IMM., immature; *, addition to the list of Vogel (1970); SFASU, Stephen F. Austin State University.

Agelenidae

Agelenopsis (*Barronopsis*) *texana* Gertsch: Female, 7mm, in grass near woods, 8 May 1970; Imm., 6mm, in grass in wooded lot, 17 June 1970; det. WJG.

**Agelenopsis naevia* (Walckenaer): Female, 17mm, in large funnel web across creek bed, 20 July 1970; det. WJG.

**Coras alabama* Muma: Females, 20.0mm, 9.5mm, 6.75mm, under boards in empty lot, 30 March 1970; det. WJG.

Amaurobiidae

Titanoeca americana Emerton: Imm., near warehouse, Center, Texas, 20 May 1970; det. WJG.

Anyphaenidae

Aysha decepta Banks: Male, 4.5mm, in house, 11 September 1970; Female 7.2 mm in in S in garage, 5 August 1970; det. WJG.

Araneidae

**Acacesia hamata* (Hentz): Penultimate Males, 7mm, 3.5mm; Female, 7.5mm, in S in garage, 25 July, 1970; det. WJG.

Acanthepiera stellata (Marx): Male, 6mm, in SC in garage, 25 July 1970; det. BV. Imms., 4mm, 6mm, 6mm, 6.5mm, in SC under bridge, 8 July 1970; det. WJG.

**Araneus marmoreus* Clerck: Imm., 6mm, in SC under bridge, 8 July 1970; det. WJG.

Araneus pegnia Walckenaer: Male, 3mm, in S under house rafters, 25 June 1970; male, 4.5mm in S in garage, 5 August 1970; Female, 5mm, in S under house rafters, 25 June 1970; Female, 5mm in S under house rafters, 19 July 1970; Imm., 5mm in S in box in garage, 18 July 1970; det. WJG.

**Araneus sericatus* Clerck: Penultimate Male, 7.9mm; Female, 10.25mm; Penultimate Females, 10.5mm; Male, 7.9mm; Imm. Female, 6.5mm; Imm., 4.5mm; in webs by Lake Rayburn, Texas, 23 August 1970; det. WJG.

Argiope aurantia Lucas: Penultimate Male, 6.5mm; Subadult Female, 11.5mm; Imm. Female, 7mm; in S in garage, 25 July 1970; Subadult Female, 12mm, in web, 10 August 1970; det. WJG, KMB.

**Conepeira* sp. No. 1: Imm., 5mm, in S in garage, 5 August 1970; det. WJG.

**Conepeira* sp. No. 2, *mineatus* group: Female, 4.75mm, in S in garage, 5 July 1970; det. WJG.

Cyclosa turbinata (Walckenaer): Females, 5mm, 6mm, in small web in shrubs, 27 April 1970; det. WJG.

Eustala sp.: Penultimate Male, 10mm, in T under house eaves, 27 June 1970; det. WJG.

Eustala anastera (Walckenaer): Female, 5mm, in S in garage, 29 August 1970; det. BV.

Gasteracantha cancriformis L.: Females (red and white), in webs near creek, 8 September 1968; Female (red), 9mm, in web near house, 12 September 1970; Female (white), 9mm, in web behind warehouse, Center, Texas, 18 September 1970; det. WJG, KMB. Females (red and white) in webs 15 ft apart near trees, 30 September 1970; det. KMB.

Gea heptagon (Hentz): Female, 7mm, on sidewalk under T nest being made, 26 May 1970; Female, 6mm; Imm. Female, 5mm, in T under house rafters, 19 July 1970; det. WJG.

**Larinia directa* (Hentz): Imm, Females, 6.75mm, 4.5mm, in S under bridge, 8 July 1970; det. WJG.

Leucauge venusta (Walckenaer): Imms., 4mm, 6.5mm, in sloping webs between shrubs in SFASU Experimental Forest, 21 April 1970; Imm., 1.75mm, in sloping web in bushes, 14 May 1970; det. WJG.

**Mangora gibberosa* (Hentz): Female, 4mm, in S in garage, 25 July 1970; Female, 3.5mm, in fine closely meshed web, 30 August 1970; det. WJG.

**Mangora placida* (Hentz): in S in garage, partly eaten by *Sceliphron* larva, 25 July 1970; det. BV.

**Mastophora bisaccata* (Emerton): Imm. Female, in T in garage, 25 June 1970; det. WJG.

Mecynogea basilica (McCook): Female, 8mm, in T in garage, 10 June 1970; Female, 7.5mm, in S in garage, 3 July 1970; det. WJG.

Metepeira labyrinthea (Hentz): Males, 6mm, 5mm; Penultimate Male, 3.25mm; Females, 5mm, 6mm; Imm. Female, 6mm; in S in garage, 3 August 1970; Female, 7mm, in S in garage, 25 July 1970; det. WJG, BV.

Micrathena gracilis (Walckenaer): Females, 9mm, in orb webs by creek, 8 July 1970; det. WJG.

**Micrathena mitrata* (Hentz): Imm. Male, 4mm, in web near creek, 20 August 1970; det. WJG.

Micrathena sagittata (Walckenaer): Female, 11mm, running over twigs near creek, 22 August 1970; Imm., 6.5mm, in S in garage, 29 August 1970; det. WJG.

Neoscona arabesca (Walckenaer): Male, 4.5mm, in T in garage, 10 June 1970; Females, 8mm, 8mm, in T in garage, 10 June 1970; Female, 4.5mm, in S in garage, 25 July 1970.

Neoscona benjamina (Walckenaer): Females, 16mm, 11.5mm, by front door, Alpine, Texas, August 1970; Imm. Females, 7mm, 7mm, 9mm, in T in garage, 25 June 1970;

Imm. Female, 8mm, in S in garage, 25 July 1970; Imm. Female, 10mm, in S in abandoned shack, 19 August 1970; Male, 10mm, in S in garage, 5 August 1970; det. WJG.

Neoscona minima F. Cambridge [=*N. arabesca* variant] : Male, 4.5mm, in S in garage, 16 August 1970; det. WJG.

**Nephila clavipes* (L.): Males, 5.25mm, 20.5mm, in same web in "Big Thicket" near Kountz, Texas, 3 October 1970; Female, 31mm, in web in SFASU Experimental Forest, 20 August 1970; det. WJG.

**Singa* sp. (could be *S. truncata* Banks): Females, 3.5mm, 3.5mm, in S under bridge, 8 July 1970; Female, 3mm, in S under house rafters, 19 July 1970; det. WJG.

Verrucosa arenata (Walckenaer): Males, in S in abandoned shack, 19 August 1970; Female, 7mm, in S in garage, 25 July 1970; det. BV.

Clubionidae

**Castianeira* sp., near *variata* Gertsch: Imm. Female, 6mm, on floor in house, 8 July, 1970; Imm., 5mm, in SC in abandoned shack, 27 June 1970; det. WJG.

**Castianeira* sp. No. 2: Female, 6.5mm, on ground near porch of house, 19 September 1970; det. WJG.

Chiracanthium inclusum (Hentz): Female, 5.2mm, in S in garage, 5 August 1970; det. BV.

Clubionoides excepta (Koch): Female, 7mm, on wall in house, June 1970; Female, 6mm, on bedroom ceiling, 10 July 1970; det. WJG.

**Meriola inornata* (Banks): Female (?), 4mm, on SFASU Science Building at night, 3 June 1970; det. WJG.

**Strotarchus piscatorius* (Hentz): Male, 6.5mm, running on ground, 25 April 1970; det WJG.

**Trachelas tranquillus* (Hentz): Male 6.5mm, in house, 28 April 1970; det. WJG.

Ctenizidae

Myremeciophila comstocki Bishop and Crosby: Male, 15mm, under newspaper in garage, 14 October 1968; det. WJG.

Filistatidae

Filistata hibernalis Hentz: Males, 9mm; Females, 12-19.5mm, in barns, under rafters, under bridges and overpasses, in garages, in storerooms, throughout year; Female, 15mm, in warehouse, Center, Texas, 18 September 1970; det. WJG, KMB.

Filistatinella crassipalpus Gertsch: Female, 3mm, in barn on farm between Nacogdoches and Alto, Texas, July 1970; det. WJG.

Gnaphosidae

sp. [could be *imbecilla* (Keyserling)] : Male, 2.5mm, on ground near house, 24 May 1970; det. WJG.

**Callilepis* sp. No. 2.: Imm., 2.5mm, in evening on floor in house, 30 May 1970; det. WJG.

Cesonia bilineata (Hentz): Female, 5.5mm, in bathroom, 7 July 1971; det. WJG.

Drassyllus devexus Chamberlin: Male, 5.9mm, on ground in woods, 27 April 1970; Female, 6.5mm on floor in house, 30 April 1970; det. WJG.

Drassylus mephisto Chamberlin: Female, 4mm, warehouse, Center, Texas, 24 May 1970; det. WJG.

Gnaphosa (*Cylphosa*) *sericata* (Koch): Male, 4mm, on ground near house, May 1970; Imm., 2.5mm, in house, May 1970; det. WJG.

**Herpyllus vasifer* (Walckenaer): Male, 6mm, on wall in house, 9 May 1970; Female, 8.2mm, on wall in house, 14 March 1970; Female, 7mm, on floor in house, 13 June 1970; det. WJG.

**Zelotes hentzi* Barrows: Male, 5mm; Female, 5mm, on patio in afternoon, 26 April 1970; det. WJG.

**Zelotes rusticus* Koch: Male, 8.5mm, on ground near house, 24 May 1970; Male, 8mm, on floor in house, 3 July 1970; det. WJG.

Linyphiidae

Eperigone sp. No. 1: Male, 2.5mm, in house, May 1970; det. WJG.

Eperigone sp. No. 2: Female, 2mm, in house at night, 20 May 1970; det. WJG.

Eperigone tridentata Emerton: Penultimate Male, 1mm, on wall in kitchen, 2 June 1970; Female, 1.75mm, on dragline in kitchen, 1 July 1970; Imm., 1mm, falling from rafter log boat house at Lake Striker near Rusk, Texas. 30 May 1970; det. WJG.

Erigoninae (not identified beyond subfamily): Imm., 1mm, blown by wind, 10 May 1970; Imm, 1mm, hanging by dragline in house, 16 May 1970; Imm, .75mm, blown by wind, 3 June 1970; det. WJG.

Erigone autumnalis Emerton: Male, 1.3mm, blown by wind, 5 June 1970; Male, 1.5mm, in rotting pine log 2 mi. N Nacogdoches, 14 June 1970; det. WJG.

**Florinda coccinea* (Hentz): Female, 3mm, in silk strands in bush, 10 May 1970; det. WJG.

Frontinella communis (Hentz): Male, 2.5mm, in bowl and doily web in woods, 7 May 1970; det. WJG.

**Meioneta* sp. No. 1: Male, 2mm, falling from tree on dragline, 14 May 1970; det. WJG.

**Meioneta* sp. No. 2: Female, 1.8mm, in old jar in bushes, 13 May 1970; det. WJG.

*Near *Meioneta* of Linyphiinae: Female, 1mm, hanging by dragline in house, 22 June 1970; det. WJG.

Loxoscelidae

Loxosceles reclusa Gertsch and Mulaik: Female, 9mm, in Center, Texas, warehouse, 20 May 1970; Imms., 4mm, 2mm, in empty lot under boards, 15 April 1970; Imm., 5.2mm, in closet, Palestine, Texas, August 1968; det. WJG, KMB.

Lycosidae

Lycosa antelucana Montogomery: Imm. Male, 11.5mm, in house, 24 March 1970; det. WJG.

Lycosa carolinensis Walckenaer: Male, 24mm, in New London, Rusk County, Texas, 11 June 1970; det. WJG.

Lycosa helluo Walckenaer: Male, 12mm, on floor in house, 22 June 1970; Female, 19mm, on ground in woods, 20 April 1970; det. WJG.

Lycosa rabida Walckenaer: Female, 18.5mm, in house, 15 June 1970; Imm., 12mm, in house, 13 May 1970; det. WJG.

Pardosa sp.: Imm. Male, 1.5mm, on patio, 10 May 1970; Imm., 2.5mm, in back yard, June 1970; Imm., 3mm, on floor in house, 29 May 1970; det. WJG.

Pardosa delicatula Gertsch and Wallace: Penultimate Male; Females, 4mm, 5mm, in grass by house foundation, Beaumont, Texas, 6 June 1970; det. WJG.

**Pardosa milvina* (Hentz): Male, 4.5mm; Female, 5.5mm, edge of pond two mi. N Melrose, Texas, 27 March 1970; det. WJG.

Pirata sp.; Female, 3.25mm, in grass near house, Beaumont, Texas, 6 June 1970; det. WJG.

Schizocosa sp.: Male, 6mm, in woods, 29 April 1970; Male, 8mm, in woods on ground, 14 May 1970; Male, 6mm, in house, 20 May 1970; Female, 8.5mm, in woods on ground, 26 April 1970; det. WJG.

**Schizocosa* sp., likely new species related to *arenata* Hentz: Male; Female, 9mm, on ground near trees, 29 April 1970; det. WJG.

**Schizocosa* sp., near *ocreata* Hentz: Male, 5mm; Female, 6mm, in woods, 29 April 1970; det. WJG.

**Trochosa* sp., near *sepulcharis* Montogomery: Imm., 7mm, on ground, 1 May 1970, det. WJG.

Mimetidae

**Mimetus interfector* Hentz: Male, 4mm, under eaves of house, 28 April 1970; Female, 4.5mm, in S in garage, 25 July, 1970, det. WJG.

Oecobiidae

Oecobius annulipes Lucas (=*O. parietalis* Hentz): Female, 2.5mm, in house along window sill, 5 December 1970; det. WJG.

Oonopidae

**Orchestina saltitans* Banks: Male, 1mm, in house hanging by drag line, 12 July 1970; det. WJG; Male, < 1.0mm, on bedspread in house, 17 July 1970; det. BV.

Oxyopidae

Oxyopes salticus Hentz: Female, 9mm, in S in garage, 5 August 1970; Imm. Female, 5mm, in bush near house, 24 May 1970; Imm. Female, 4mm, on folded sail of boat, 30 May 1970; det. WJG.

Oxyopes scalaris Hentz: Male, 5mm; Females, 7mm, 6.5mm, 6mm, 6mm, in S in garage, 16 August 1970; Female, 10mm, in S in garage, 3 July 1970; Female, 7mm, in S in garage, 25 July 1970; det. WJG.

Peucetia viriadans (Hentz): Male, in S under bridge, 8 July 1970; Female, 15mm, with egg sac in pine tree, September 1968; Imms, and Females, in S in garage, 25 July 1970; Imms. and Females in S in garage, 5 August 1970; Imm., 3.5mm, in web strands in tree, 9 May 1970; det. WJG, KMB.

Pholcidae

**Smeringopus elongatus* (Vinson): Imm. Female, 5mm, in warehouse, Center, Texas, 20 May 1970; det. WJG. [Introduced from Cuba or West Indies. Tropicopolitan. First U.S. record.]

Pisauridae

Dolomedes sexpunctatus Hentz: Female, 18mm, on ground in woods, 27 September 1970; det. WJG.

**Dolomedes tenebrosus* Hentz: Male, 9mm, at water edge, 2 April 1970; det. WJG, BV.

**Pisaurina mira* (Walckenaer): Male, 12mm, running on ground 14 mi. N Nacogdoches, Texas, 23 April 1970; det. WJG.

Salticidae

Agassa cyanea (Hentz): Female, 4mm, in S under bridge, 8 July 1970; det. WJG.

**Consingis* [=*Peckhamia*] *americanus* (Peckham and Peckham): Male, 3.5mm, in Pioneer Park, Nacogdoches, 27 April 1970; Male, 3.5mm, on car, 28 April 1970; Female, 4mm, in SFASU Microbiology Lab, 3 July, 1970; det. WJG, BV.

**Eris chrysis* (Walckenaer) [=Paraphidippus marginatus]: Female, 8mm, in S in garage, 3 July 1970; Female, 12mm, in S in garage, 25 July 1970; det. WJG.

Eris [=*Paraphidippus*] *marginatus* (Walckenaer); Male, 5mm, on car window, 13 May 1970; det. WJG.

**Eris pineus* (Kaston): Male, 6mm; Imm. Male, 4.3mm, in S in garage, 25 July 1970; Males, 5.25mm, 5.75mm; Female, 5mm, in S in garage, 20 July 1970; Imm., 3.9mm, in S in garage, 25 July 1970; det. WJG.

Habrocestum pulex (Hentz): Male, 2.9mm; Female, 3.9mm, on side of house, 20 May 1970; det. WJG.

**Hasarius adansoni* (Audouin): Female, 5mm, in culvert, 8 May 1970; Female, 5mm, on fence, October 1970; det. WJG, KMB.

**Hentzia mitrata* (Hentz): Male, 3.8mm, running on kitchen floor, 24 July 1970; Male, 3.75mm, in S in garage, 5 August 1970; det. WJG, BV.

**Hentzia palmarum* (Hentz): Imm., 2.25mm, on clothes line, 12 July 1970; det. WJG.

Marpissa (=*Hyctia*) *bina* (Hentz): Male, 8mm, on table on boat pier, Lake Striker, near Rusk, Texas, 30 May 1970; det. WJG.

Marpissa (=*Hyctia*) *pikei* (Peckham and Peckham); Female, 6mm, in S in garage, 5 August 1970; det. WJG.

Metacyrba taeniola (Hentz): Male, 5mm, on window screen, 27 May 1970; Female, 5mm, on table on patio, 27 May 1970; Female, 4mm, in house, 27 June 1970; det. WJG.

Metacyrba undata (DeGeer): Female, 10.5mm, on ground in woods, 27 April 1970; Female, 8mm, on bedroom rug 6 May 1970; det. WJG.

**Metaphidippus galathea* (Walckenaer): Males, 3mm, 3.5mm, 4mm, in S in abandoned shack, 27 June 1970; Male, 4.5mm, on thistle plant, 3 May 1970; Females, in S under bridge, 8 August 1970; Imm., 3mm, on sheet on clothes line, 8 August 1970; det. WJG, BV.

**Metaphidippus protervus* (Walckenaer) [=*M. capitatus*]: Female, 4mm, in S in garage; det. WJG.

Pellenes sp.: Female, 6.5mm, in SC in abandoned shack, 27 June 1970; Female, 8mm, in S in garage, 5 August 1970; det. WJG.

Pellenes (*Habronattus*) sp.: Female, 3.5mm, on boat pier at Lake Striker, near Rusk, Texas, 30 May 1970; det. WJG.

Pellenes (*Habronattus*) *coronatus* (Hentz): Male, 4mm, in T in garage, 19 August 1970; det. BV.

Pellenes (*Pellenes*) *limatus* (Peckham): Female, 3mm, in S under bridge, 8 August 1970; det. BV.

Phidippus audax (Hentz) [=*P. variegatus* Lucas]: Male, 10.5mm, on plants, 25 March 1970; Female, 10.5mm, on orange tree in Manuel, Brazoria County, Texas, June 1970; Female, 17.5mm, in bushes, April 1970; Imm., 4.5mm, in S in garage, 5 August 1970; Imm., 3.5mm, in S in abandoned shack, 19 August 1970; det. WJG.

Phidippus cardinalis (Hentz): Male, 7mm, on fence, October 1968; Imm. Female, 9mm, running on open ground in woods, 30 August 1970; det. WJG.

Phidippus sp., probably *carolinensis* Peckham and Peckham: Male, 6.5mm; Female, 11mm, in S in garage, 30 June 1970; det. WJG.

**Phidippus clarus* Keyserling: Imm., 10mm, in S under bridge, 8 July 1970; Imms., 12mm, 10mm, in S in abandoned shack, 19 August 1970; det. WJG.

Phidippus sp., probably *P. mccooki* (Peckham): Imm., 4.5mm, on clothes line, June 1970; Imm., 4.5mm, in S in abandoned shack, 27 June 1970; Imm., 4.5mm, in S under bridge, 8 July 1970; det. WJG, KMB.

Phidippus sp., probably *mystaceus* (Hentz): Imms., 5mm, 5mm, 6mm, in S in garage, 30 June 1970; det. WJG.

**Phidippus* sp., near *whitmani* Peckham and Peckham; Female, 11mm, in S under bridge, 1970; det. WJG.

**Sarinda hentzi* (Banks) [=*Myrmarachne albocinctus*]: Male, 3.5mm, on patio in afternoon, 26 April 1970; Male, 3.5mm, at house, 8 May 1970; det. WJG.

Thiodina puerpera (Hentz): Male, 5.5mm, in S in garage, 16 August 1970; Female, 5.5mm, in S under bridge, 8 July 1970; Imm. Female, 5.5mm, in S in garage, 5 August Imm., in S under house eaves, 27 June 1970; det. WJG.

Zygoballus bettini Peckham: Female, 3mm, in SC in abandoned shack, 27 June 1970; det. WJG.

Zygoballus sexpunctatus (Hentz): Male, 3mm, in SC in abandoned shack, 27 June 1970; Females, 3.5mm, 3.5mm, 3mm, in T under eaves of house, 27 June 1970; Female, 3.5mm, in S under bridge, 8 July 1970; det. WJG, BV.

Scytodidae

Scytodes sp.: Males and Females, on houses and in garages and storerooms, occasionally in S; throughout year; Female, 9mm, on house, 29 March 1970; Female, 9mm, on window screen at night, 11 September 1970; det. WJG, KMB. [For over 20 years this has gone under the name of *S. intricata* Banks, but it is an undescribed species.]

Segestriidae

Ariadna bicolor (Hentz): Female, 9mm, under bark of pine tree at end of sheet-like web, 21 September 1970; det. WJG.

Tetragnathidae

Tetragnatha elongata Walckenaer: Imm. Male, 10.9mm, in web in grass by creek, 10 September 1968; det. WJG.

**Tetragnatha seneca* Seeley: Males, 9.5mm, 8.5mm; Females 10.9mm, 8mm (after making egg sac), in webs by Lake Rayburn, Texas, 23 August 1970; det. WJG.

Theraphosidae

Dugesiella hentzi Girard: Male, 35mm; Female, 42mm, between Etoile and Nacogdoches, Texas, 20 June 1970; Male, 34mm, in service station, June 1970; det. WJG.

Theridiidae

Achaearanea porteri (Banks): Female, 3.4mm, in S in garage, 25 July 1970; det. WJG.

Achaearanea tepidariorum (Koch): Males, 4.5mm, 4mm, 2.5mm, 2mm; Females, 8mm, 7mm, 6mm, 4mm, on window screens, webs in storage areas, in S and SC throughout year; det. WJG, BV.

Latrodectus mactans (Fabricius): Penultimate Male, 3.5mm, in SC in garage, 25 July 1970; Female, 14mm, in warehouse, Center, Texas, 12 September 1970; under stones, under porch, roofs, in storerooms, throughout year; det. WJG.

Steatoda americana (Emerton): Female, 2.5mm, in S in garage, 25 July 1970; det. WJG.

Steatoda quadrimaculata (O.P. Cambridge): Male, 2.5mm, running on patio, 22 August 1970; Male, 2mm, on dirt, 28 August 1970; Females, 3.5mm, 3.25mm, 3mm, in SC under house rafters, 19 July 1970; Females, 3.5mm, 4mm, in S in garage, 25 July 1970; Imm., 1mm, on house, 19 July 1970; Imm., 2.5mm, in S in garage, 25 July 1970; det. WJG.

Steatoda triangulosa (Walckenaer): Male, 3.5mm; Female, 4mm, in S in garage, 5 August 1970; Female, 5mm, behind old boards in warehouse, Center, Texas, 24 May 1970; Female, 4mm, in culvert, 12 May 1970; Female, 6mm, under wooden bridge, 5 August 1970; Imm., 2.3mm, on house by door, 28 April 1970; det. WJG.

Theridion australe Banks: Female, 2.5mm, in S under house rafters; Female, 3mm, in SC under house rafters, 19 July 1970; det. WJG, BV.

Theridion sp. (possibly *differens* Emerton): Imm., 2mm, in latch of screen door under house, Austin, Texas, 17 June 1970; det. WJG.

Theridion flavonotatum Becker: Female, 1.75mm, in web in abandoned shack, 27 June 1970; det. WJG.

Tidarren sisyphoides (Walckenaer) (=*T. fordum* Keyserling): Female, 6.5mm, by door outside, 12 May 1970; Female, 6mm, in curled leaf with egg sac under covered bridge over creek, 26 September 1970; det. WJG.

Thomisidae

Misumema vatia Clerck: Female, 5mm, in S in garage, 30 June 1970; Imms., 5.25mm, 4.8mm, in S on house, 30 June 1970; det. WJG, BV.

Misumenops celer (Hentz): Male, 2.5mm, on lawn mower, 27 June 1970; Female, 6mm, on thistle plant, 7 May 1970; Males, 3mm, 3mm; Imm. Female, 4.25mm, in S in garage, 5 August 1970; det. WJG.

Misumenops oblongus (Keyserling): Imm., 3mm, on ground under clothesline, 13 June 1970; Imms., 3mm, 2mm, in S on house, 27 June 1970; det. WJG.

Philodromus sp. No. 1: Imm., 1.25mm, on garage ceiling by light at night, 18 June 1970; Imm., 4.5mm, in S in garage, 5 August 1970; det. WJG.

Philodromus sp. No. 2: Female, 5.5mm; Imm., 5.5mm, in S in garage, 5 August 1970; det. WJG.

Philodromus keyserlingi Marx: Female, 6mm, in S. in garage, 25 July 1970; det. BV.

**Thanatus vulgaris* Simon [=*T. peninsulanus* Banks]: Female, 7.5mm, in warehouse, Center, Texas 24 May 1970; det. WJG.

Tmarus angulatus (Walckenaer): Female, 7.5mm, in S in abandoned shack, 19 August 1970; det. WJG.

Tmarus floridensis Keyserling: Female, 7mm, in SC in garage; 30 June 1971; det. WJG.

Xysticus auctificus Keyserling: Male, 4.5mm, in S in garage, 16 August 1970; det. BV.

Xysticus sp., probably ferox (Hentz): Imm., 3.5mm, in SC in abandoned shack, 27 June 1970; det. WJG.

**Xysticus formosus* Banks: Female, 9mm, falling from tree, 8 May 1970; det. WJG.

Xysticus funestus Keyserling: Female, 8mm, on SFASU Clinic floor, 22 November 1968; det. WJG.

Xysticus texanus Banks: Male, 5.5mm, on house, 23 August 1970; Penultimate Male, 3.5mm, in S in abandoned shack, 27 June 1970; det. WJG, BV.

Uloboridae

**Uloborus* sp., probably *cinereus* O.P. Cambridge: Female, 3.5mm, in small orb web between bushes, 12 May 1970; det. WJG.

Uloborus glomosus (Walckenaer): Females, 4mm, 4mm, in webs near creek, 8 July 1970; det. WJG.

Table 1.—Spiders of Nacogdoches, Texas. A listing of represented families by numbers of genera and species in each.

FAMILY	GENERA	SPECIES
Agelenidae	2	3
Amaurobiidae	1	1
Anyphaenidae	1	1
Araneidae	20	29
Clubionidae	6	7
Ctenizidae	1	1
Filistatidae	2	2
Gnaphosidae	6	9
Linyphiidae	7	10
Loxoscelidae	1	1
Lycosidae	5	12
Mimetidae	1	1
Oecobidae	1	1
Oonopidae	1	1
Oxyopidae	2	3
Pholcidae	1	1
Pisauridae	2	3
Salticidae	14	30
Scytodidae	1	1
Segestriidae	1	1
Tetragnathidae	1	2
Theraphosidae	1	1
Theridiidae	5	10
Thomisidae	6	14
Uloboridae	1	2

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CONTENTS

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Feature Articles

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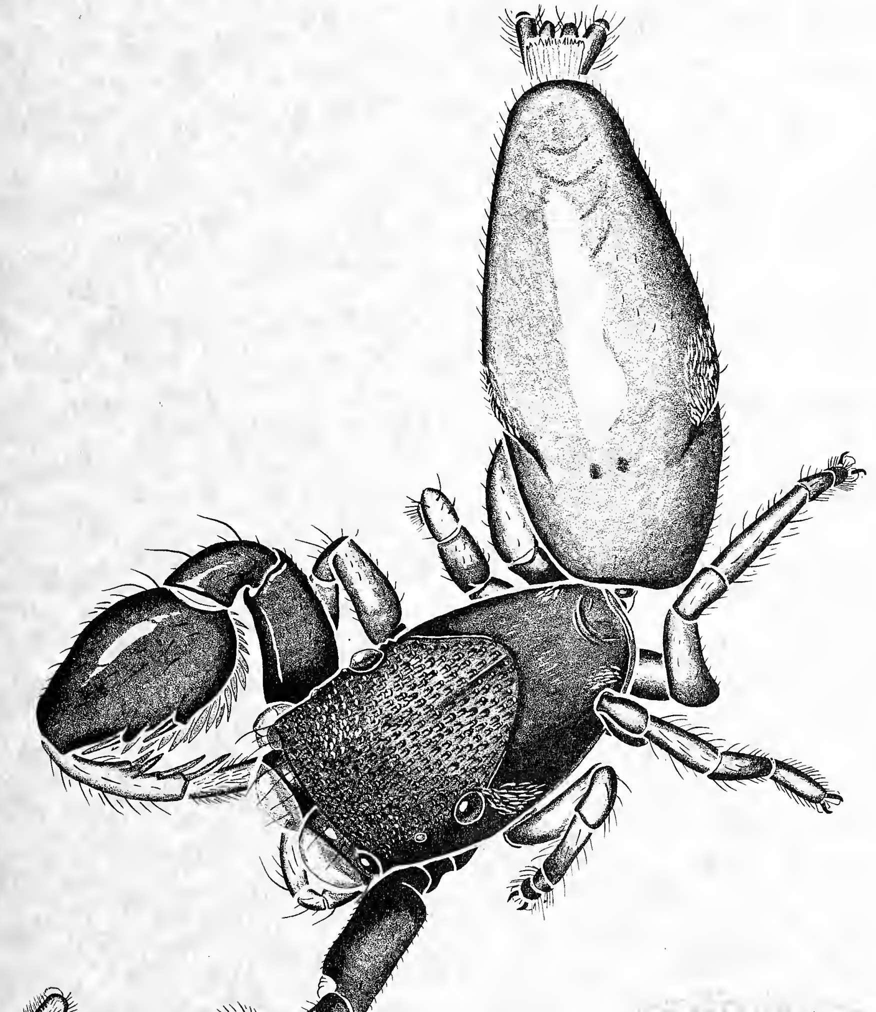

VLUME 2 JANUARY 1974 NUMBER 1

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Benedict, E. M., and D. R. Malcolm. 1974. A new cavernicolous species of *Mundochthonius* from the eastern United States (Pseudoscorpionida, Chthoniidae). J. Arachnol. 2:1-4.

A NEW CAVERNICOLOUS SPECIES OF *MUNDOCHTHONIUS* FROM THE EASTERN UNITED STATES (PSEUDOSCORPIONIDA, CHTHONIIDAE)

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ABSTRACT

A new pseudoscorpion species, *Mundochthonius holsingeri*, is described from a limestone cave in Virginia. It is the second species of this genus to be reported from a cave within the United States.

INTRODUCTION

The only currently described cavernicolous species of *Mundochthonius* from the United States is *M. cavernicolus* Muchmore (1968), collected in Saltpeter Cave, Illinois. The species herein described is based upon a specimen collected by John R. Holsinger from beneath mammal scat (probably racoon) 200 feet from the entrance in the dark zone of Helsley Cave, a 2,000 foot passage in limestone in the Shenandoah River drainage. It was first reported as "*Mundochthonius* sp." by Holsinger (1963) in his annotated checklist of the macroscopic troglobites of Virginia. The new species is named in honor of Dr. Holsinger who has contributed so extensively to the biospeleology of caves in Virginia.

Family **CHTHONIIDAE** Hansen
Subfamily CHTHONIINAE Daday
Tribe CHTHONIINI Chamberlin
Genus *Mundochthonius* Chamberlin
Mundochthonius holsingeri, new species
Figures 1-3

Type Record—Virginia, Shenandoah County, Helsley Cave, about six mi. NW of Mt. Jackson. Collected by John R. Holsinger, 3 November 1960, female holotype (DM-63.01001). Specimen is mounted in Canada balsam and deposited in the American Museum of Natural History.

Diagnosis—Medium-sized (male unknown, female 1.52 mm. long), apparently eyeless, cavernicolous species.

MALE. Unknown.

FEMALE. Carapace: about as long as broad, only slightly narrowed posteriorly; derm mostly reticular; anterior margin smooth, with a moderately-sized triangular, irregularly serrulate epistome (Fig. 1); chaetotaxy 6-4-4-2-2 = 18. Coxal area: chaetotaxy 2-1-2:mmm-2-1:2-4-CS:2-5:2-6; coxal spine (Fig. 2) on coxa II a single heavily sclerotized, deeply-incised blade with additional medial and lateral spicules, all arising from a translucent hillock; small, non-expanded, monosetose intercoxal tubercle.

Abdomen: ovate; pleural membrane finely papillate; tergal chaetotaxy 4:4:6:6:6: 6:6:6:?:?: 1T2T1:0; sternal chaetotaxy 12:(5)13±(5):(3)?(3):?:?:9:9±:9:?:0:mm.

Chelicera: somewhat shorter than carapace; galea small angular elevation; serrula exterior of 18 blades; serrula interior with approximately 12 blades; flagellum of 11 unilaterally pinnate setae; fixed finger with about 14 conical teeth, the distal three largest, others decreasing greatly in size basally, movable finger with about 10 teeth; hand with *is, es, sb, b,* and two accessory setae (total of six).

Palp: similar to epigean species but somewhat more slender; derm relatively smooth except for scaly granulations on dorsum of chelal hand and base of fingers. Palpal proportions: femur 1.00 and chela 1.62 times as long as carapace; trochanter 1.8, femur 4.5, and tibia 1.7 times as long as broad; chela 4.2 times as long as broad, 4.4 times as deep; fingers 1.7 times as long as hand. Chelal chaetotaxy and dentition as illustrated (Fig. 3); fixed finger with 58, movable finger with 64 contiguous, marginal teeth which in both cases range from quadrate-shape distally to rounded proximally; movable finger with a small rounded tubercle on the external surface situated one-third of the distance from ST to SB.

Legs: somewhat more slender than those of epigean species of genus; leg IV with differentiated tactile setae on tibia, metatarsus, and telotarsus. Proportions: leg I: basifemur 4.2, telofemur 2.1, tibia 3.4, and miotarsus 7.0 times as long as deep; leg IV: "miofemur" 2.5, tibia 3.5, metatarsus 2.2, and telotarsus 5.6 times as long as deep.

Measurements (in mm), Female. Body length 1.52; abdominal breadth 0.50±; carapace length (including epistome) 0.48, "ocular" breadth 0.50, posterior breadth 0.47. Chelicera 0.41± long by 0.22 broad. Palpal trochanter 0.21 by 0.11; femur 0.48 by 0.10; tibia 0.25 by 0.14; chela 0.77 by 0.183 broad and 0.175 deep; hand 0.29 long; fingers 0.50 long. Leg I: basifemur 0.25± by 0.06; telofemur 0.14 by 0.06; tibia 0.16 by 0.04; miotarsus 0.28 by 0.04; leg IV: "miofemur" 0.40 by 0.16; tibia 0.29 by 0.08; metatarsus 0.13 by 0.06; telotarsus 0.25 by 0.04.

NYMPHAL STAGES. Unknown.

Remarks—Although *Mundochthonius holsingeri* does not superficially appear to be especially modified as a troglobite, slight adaptation to a cavernicolous environment is revealed when its overall characteristics are subjected to the type of analysis discussed by the authors in a previous paper (Benedict and Malcolm, 1973). *M. holsingeri* shows no indication of corneal development even under phase contrast optics. The ocular area, however, appears very lightly sclerotized and does not stain as deeply as the immediately surrounding carapacal derm.

When compared to the seven North American epigean species included in the genus, the new species and *M. cavernicolus* both exhibit the larger size frequently observed among cave forms (Table 1). *M. holsingeri* may be distinguished from *M. cavernicolus* by

Table 1.—Comparison of Selected Measurements of the North American Species of *Mundochthonius* Chamberlin.

	Epigean Species	Cavernicolous Species
Body length	1.1 - 1.5 mm	1.52 mm
Femur length	0.27 - 0.39 mm	0.48 - 0.57 mm
Chelal length	0.42 -0.63 mm	0.77 - 0.92 mm

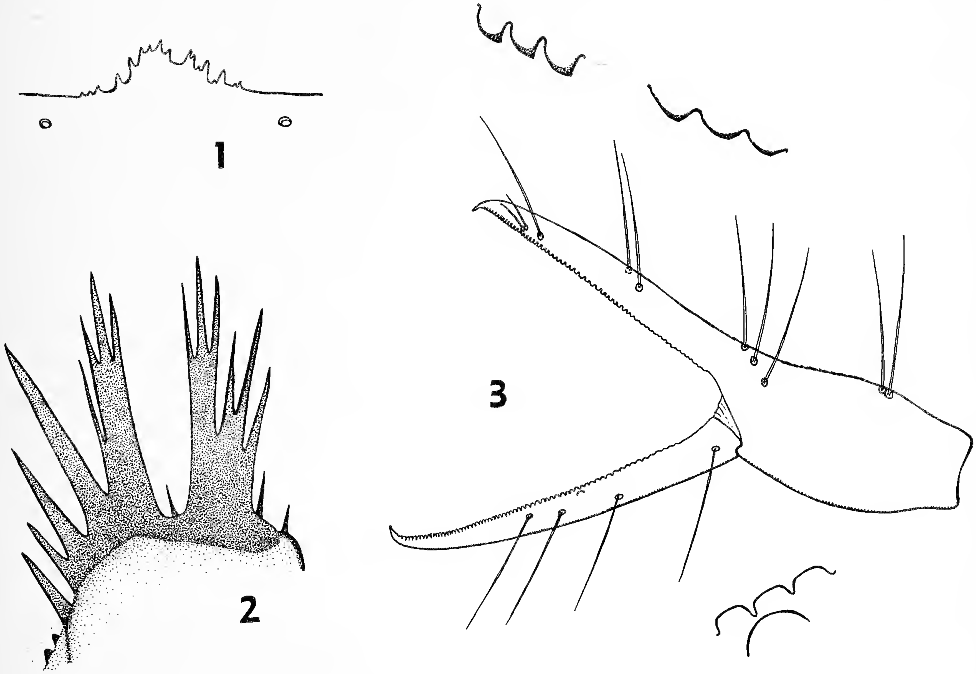

Fig. 1-3.–*Mundochthonius holsingeri*, n.sp., drawn from holotype female (DM-63.01001): 1, Epistomal area; 2, Coxal spine from right coxa II; 3. External aspect of chela; tubercle and details of teeth 48 to 50 of movable finger, and teeth 19 to 21 and 48 to 50 of fixed finger.

its geographic location; slightly smaller size, and the following structural differences: the spacing of the tactile setae and the position of the tubercle of the movable finger of the chela; the nature of the distal dentition of the fixed finger of the chela; the form of the coxal spine series; and various length to width ratios. In *M. holsingeri* seta ST is closer to T than it is in *M. cavernicolus*. Setae ST and SB, however, are about the same distance apart in spite of the greater chelal length of the latter species. In *M. holsingeri* the anterior denticles of the fixed finger of the chela form a more or less graded series merging with the remaining denticles, while in *M. cavernicolus*, the anterior six teeth, which are microdenticles, differ distinctly from the rest of the denticles. The tubercle of the movable finger of the chela is situated one-third the distance from ST to SB in *M. holsingeri*, while in *M. cavernicolus* it is almost opposite ST. For *M. holsingeri* the ratio of palpal femur length/carapace length is 1.00, of chela length/carapace length is 1.62, and of leg IV femur length/carapace length is 0.84. These same ratios for *M. cavernicolus* are 1.10, 1.75, and 0.96 respectively.

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Muma, M. H. 1974. Maturity and reproductive isolation of common solpugids in North American deserts. J. Arachnol. 2:5-10.

MATURITY AND REPRODUCTIVE ISOLATION OF COMMON SOLPUGIDS IN NORTH AMERICAN DESERTS[1]

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ABSTRACT

Geographical and seasonal distributions of 26 common, systematically-collected, North American solpugids are analyzed. Geographic isolation and the premating isolating mechanisms of season, habitat, morphology, behavior and activity-time are inferred to be operative in preventing interspecific breeding.

INTRODUCTION

Recent systematic collection of solpugids, Muma (1963, 1966-1967, and unpublished), Allred and Muma (1971) and Brookhart (1965 and 1972), have produced the first meaningful ecological data on North American solpugids. All studies were designed to obtain taxonomical, biological, geographical and numerical data on solpugid species. As a corollary they have also produced data on seasonal maturity and possible reproductive isolation mechanisms of common North American solpugids. These phenomena are indicated and discussed here.

Sources and delineation of the data that will be utilized in the discussions that follow are detailed in Table 1. Muma (1963) utilized data collected by Allred et al. (1963) on 28 species represented by 395 adults and nearly 1,000 specimens; only 11 common solpugids are discussed here. Muma (1966a-e,1967) collected previously unpublished numerical data on seven solpugid species represented by 300 adults and over 600 specimens during his studies on solpugid biology; only the five common species are discussed here. Recently, Muma (unpublished) has collected numerical data on 12 species represented by 96 adults and over 250 specimens; only the four common species are discussed below. Allred and Muma (1971) recorded seven species represented by 44 adults and 71 specimens but only two were sufficiently common for discussion here. Brookhart (1972) summarized published (Brookhart, 1965) and unpublished data on 13 species represented by 321 adults; the eight common species are discussed here.

All of the numerical data for the adults of species to be discussed are presented in Table 2. For reference convenience and brevity the data are organized by solpugid classification, collection sites and seasonal occurrence.

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RESULTS AND DISCUSSION

Although it is not apparent from the summarized data, with rare exception, males appeared, attained peak abundance and disappeared earlier in the year than females. Muma (1963) first noted this phenomenon and from it inferred that copulation must take place as soon as the females appeared. However, Muma (1966b and 1966e) noted that males will mate several times with different females and that females, probably those that have exhausted their sperm supply, will mate a second time. Therefore, it is possible that earlier appearance and peak abundance of males is simply a biological survival mechanism to assure fertilization of females. The occasional earlier and later occurrence of females of such species as *Eremobates durangonus* Roewer, *Eremobates pallipes* (Say) and *Hemerotrecha fruitana* Muma are probably the effect of adverse stress factors such as temperature, humidity and food availability on individuals. Collections of certain species including *Eremobates zinni* Muma and *Eremochelis plicatus* (Muma) must remain enigmas until more refined studies are conducted.

In general there was a tendency for species of the same species-group to mature at the same time regardless of the geographic location, latitude, or altitude of the desert area in which they occurred. For instance adults of the recorded species of the *magnus* species-group of *Eremorhax* Roewer reached peak abundance in May and June; those of the *scaber* and *pallipes* species-groups of *Eremobates* Banks reached peak abundance in July and August; those of the *bilobatus* species-group of *Eremochelis* Roewer became abundant in June and July; and those of the *texana* species-group of *Hemerotrecha* Banks attained peak abundance in both or either the spring or fall. On the other hand, the *palpisetulosus* species-group of *Eremobates* and the *branchi* species-group of *Eremochelis* contained species, the adults of which became abundant at irregular times from March through August. This variation in peak adult abundance of closely related species indicates that factors other than geographic isolation are operating to prevent interbreeding of sympatric representatives of the order in North America.

Mayr (1970) in his discussion of factors that prevent specific interbreeding, segregated geographic isolation from "isolating mechanisms" of closely related species. He then classified the latter into premating mechanisms including seasonal, habitat, ethological, and mechanical and postmating mechanisms including gametic and zygotic mortality, hybrid inviability, and hybrid sterility. Synecological data such as that under discussion permit analyses and inferences only on the basis of premating isolating mechanisms. These are referred to, when applicable, in the following discussions which view the data from the standpoint of the collection site. Prior to such discussions, however, it should be noted that isolating mechanisms are broadly interpreted here as applicable to species of different genera and different species-groups as well as to closely related species.

At the northern edge of the Great Basin Desert Allred and Muma (1971) found only two species common enough to evaluate. Since these species were morphologically distinct members of two different genera in two different subfamilies of the Eremobatidae and matured at different times, they may be morphologically and behaviorally as well as seasonally isolated from interbreeding.

The eight common solpugid species recorded by Brookhart (1972) were collected from two different geographic areas, one on the east slope of the Wet Mountains east of the Great Basin Desert, the other on the high plains north of the Chihuahuan Desert. All three of the species found east of the Great Basin Desert attained peak adult abundance

Table 1.—Sources and delineation of data utilized in discussion.

Authority	Desert Studied	Location	Methods Utilized	Study Duration	Source No.
Muma (1963)	Mojave-Great Basin	Mercury, . Nevada	Dry Can-traps	36 months	I
Muma (1966a-e, 1967)	Sonoran-Chihuahuan	Portal, Arizona	Selective-searching Night-lighting	Three years; May through September	II
Muma (unpublished)	Chihuahuan	Silver City, New Mexico	Killing-preserving Can-traps	12 months	III
Allred and Muma (1971)	North of Great Basin	Snake River Basin, Idaho	Dry Can-traps	15 months	IV
Brookhart (1972)	East of Great Basin-North of Chihuahuan	Southern Colorado	Dry Can-traps	Five years; May through October	V

during May, June and July, and so maybe either morphologically or behaviorally isolated from interbreeding. However, as noted by Brookhart, the three species also occupied three different habitats: *Eremobates mormonus* (Roewer) was a valley-high plains form, *Eremochelis bilobatus* (Muma) inhabited the thorn-thickets and shrubby area of the ridges and foothills, and *Hemerotrecha fruitana* Muma was a montane species. Since all eight species were collected north of the Chihuahuan Desert, the above remarks also apply to these three species taken in this latter area. The most abundant solpugid north of the Chihuahuan Desert was *E. pallipes*. Although it attained peak adult abundance later in the season than most other species, it was the only member of its species-group collected commonly and could be morphologically and behaviorally isolated from other species-groups of *Eremobates* and other genera. Two closely related members of the *palpisetulosus* species-group of *Eremobates*, *E. bantai* Brookhart and *E. palpisetulosus* Fichter, attained peak adult abundance during June according to Brookhart's collections. Although minor morphological differences between the two species perhaps operate as mechanical isolating mechanisms and behavioral isolating mechanisms may be inferred, further studies are needed. A similar situation is posed by the simultaneous peak abundance of *Eremorhax puebloensis* Brookhart and *E. mumai* Brookhart. However, in this instance the smaller size, minor morphological differences and limited habitat of *E. mumai* suggest that mechanical, ethological or habitat factors may be operative as isolating mechanisms.

Since the four common solpugids collected at the western edge of the Chihuahuan Desert near Silver City, New Mexico, during 1972-1973 are placed in two different genera representing three different species-groups, it is possible that both mechanical and ethological factors could be involved as isolating mechanisms for most of the species. However, the two closely related species of the *palpisetulosus* species-group of *Eremobates*, *E. hessei* Roewer and *Eremobates* undescribed species were seasonally isolated; peak adult abundance of the latter occurred in April and the former in July. In fact all of the solpugids collected at this site were somewhat isolated seasonally, *Eremobates*, undescribed species, attained peak adult abundance in April, *Eremorhax*, undescribed species, in May, *E. hessei* in July and *E. pallipes* in July and August.

Table 2.–Seasonal maturity of some common North American solpugids. Boldface emphasizes peak abundance.

Identity of Species		Number of Adults Collected						
	Source No.	J-F	M-A	M-J	J-A	S-O	N-D	Total
Eremobatidae								
Eremorhax Roewer								
magnus species-group								
pulcher Muma	I			**16**	11			27
undescribed species	III			**3**	1			4
mumai Brookhart	V			**4**				4
puebloensis Brookhart	V			**4**				4
Eremobates Banks								
scaber species-group								
zinni Muma	I				**11**			11
septentrionis Muma	IV				**16**			16
mormonus (Roewer)	V			2	**60**			62
palpisetulosus species-group								
kraepelini Muma	I		10	**14**				24
purpusi (Roewer)	I			**12**	2			14
palpisetulosus Fichter	II			**35**	10			45
hessei (Roewer)	II				**14**			14
hessei (Roewer)	III				**26**			26
undescribed species	III		14	**15**	3			32
palpisetulosus Fichter	V			**7**	1			8
bantai Brookhart	V			**10**	5			15
pallipes species-group								
durangonus Roewer	II			1	**80**	1		82
pallipes (Say)	III				**21**	2	1	24
pallipes (Say)	V			16	**139**	22		177
Eremochelis Roewer								
branchi species-group								
bidepressus (Muma)	I		**6**	**6**				12
insignitus Roewer	I			18	**50**			68
bilobatus species-group								
plicatus (Muma)	I			3	**13**			16
bilobatus (Muma)	II			45	**86**			131
bilobatus (Muma)	V			**8**	7	2		17
Hemerotrecha Banks								
banksi species-group								
californica (Banks)	I		1	**90**	19	4		114
serrata species-group								
serrata Muma	I			3	**20**	5		28
texana species-group								
proxima Muma	I					**6**	3	9
denticulata Muma	I	1	**5**	2		2	2	12
denticulata Muma	IV		3	2		**10**		15
fruitana Muma	V		1	**24**	3	1		29
Ammotrechidae								
Ammotrechula Roewer								
peninsulana (Banks)	II			**20**	8			28
Branchia Muma								
potens Muma	I			8	**13**			21

The five common solpugid species collected by Muma (1966a-e,1967) from the San Simon Valley of Arizona between the Sonoran and Chihuahuan Deserts may be morphologically and behaviorally isolated. On the other hand, prior to summarization in Table 2, the data showed that the two closely related species of the *palpisetulosus* species-group of *Eremobates*, *E. palpisetulosus* and *E. hessei* and one of the *pallipes* species-group, *E. durangonus* Roewer were also somewhat seasonally isolated. *E. palpisetulosus* attained peak adult abundance in June, *hessei* in July and *durangonus* in August. It should also be pointed out that the nearly equal-sized eremobatid, *Eremochelis bilobatus* (Muma), and the ammotrechid, *Ammotrechula peninsulana* (Banks), both inhabited the thorn-thickets in the foothills of the Chiricahua Mountains, and even though distinctive morphologically, also attained adult abundance during different months, the latter in June, the former in July.

Since the 12 common solpugids recorded from the Nevada Test Site at the conjunction of the Mojave and Great Basin Deserts by Muma (1963) were classified in two families, five genera and eight species-groups, the isolation mechanisms can be inferred to be largely mechanical and ethological. However, the *branchi* species-group of *Eremochelis* was represented by *E. bidepressus* (Muma) which attained peak adult abundance during April and May and *E. insignitus* Roewer which attained abundance during July, indicating a seasonal isolation. Also the *texana* species-group of *Hemerotrecha* was represented by *H. denticulata* Muma which attained peak female abundance in the spring and *H. proxima* Muma which attained peak female abundance in the fall, indicating a degree of seasonal isolation possibly reinforced by an associated male behavioral isolation. Another recorded species of this genus, *Hemerotrecha californica* (Banks), is worthy of special mention here. Although it could be both mechanically and seasonally isolated from all other members of the genus at this site, it and other members of the *banksi* group of the genus are also the only known diurnal species in North America, indicating the possible existence of a fifth premating isolation mechanism, temporal isolation. Only two closely related solpugids found at the Test Site were not seasonally or temporally isolated from interbreeding. These were *Eremebates kraepelini* Muma and *E. purpusi* (Roewer) of the *palpisetulosus* species-group. Minor morphological differences between these species may reflect the existence of mechanical and ethological isolating mechanisms, but such cannot be determined without additional study.

SUMMARY

Many genera and species-groups of North American solpugids contain species that are geographically isolated and tend to mature at the same time of the year regardless of the location, latitude or altitude of the desert areas in which they occur. However, certain species-groups, particularly those involving sympatric species, exhibit a wide range of species maturity dates. Broadly interpreted, the premating isolating mechanisms of season, habitat, mechanics and behavior can be inferred to be operative among such sympatric species for the prevention of interspecific breeding. In the case of *Hemerotrecha californica* (Banks) a temporal isolation can also be inferred since it and other members of the *banksi*-group are the only known diurnal solpugids in North America.

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ADAPTATIONAL BIOLOGY OF DESERT SCORPIONS

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ABSTRACT

A conspicuous faunal element in hot dry desert regions worldwide, scorpions rely on a combination of behavioral, morphological and physiological adaptations in adjusting to harsh conditions found in these habitats. Foremost among behavioral adaptations are the exploitation of burrowing and nocturnal habits which provide a temporary escape from extreme daytime temperatures and desiccating air at the surface. Associated with these habits may be enlarged pedipalps used in digging and the presence of negative phototactic responses and orthokinetic avoidance of high temperatures. Still, lethal temperatures (45° to 47°C) of desert scorpions are higher than most other desert arthropods, and the presence of water-proofing wax layers which are perhaps supplemented by cuticular proteins provide scorpions with an impervious integument. Water loss rates approaching 0.01% of their body weight per hour (25°C) are the lowest reported for desert animals and are especially significant in view of their high surface area-volume ratio. Evidence suggests that restrictive mechanisms in the cuticle may supplement the effective physical barrier of the exoskeleton in controlling cuticular transpiration. Their extremely low metabolic rate not only results in a reduced respiratory component of total water loss, but extends the time that scorpions can remain inactive during particularly stressful periods. Water loss is further minimized by the excretion of nitrogenous wastes in the form of guanine and the production of extremely dry fecal pellets. Replenishment of lost body water is provided primarily by body fluids of captured prey, although drinking by some species can serve as a supplementary source when bulk water is available. No scorpion species has demonstrated water uptake from either a near-saturated atmosphere or a moist substrate, regardless of its hydration state. Scorpions are able to withstand considerable dehydration (30% to 40% of their body weight) and apparently tolerate the increased hemolymph osmotic pressures and ionic concentrations until body fluids can be replenished. The importance of water-conserving versus water-regaining mechanisms are discussed in relation to the total adaptations of these animals to hot dry environments.

INTRODUCTION

Although scorpions are not restricted to desert regions, they usually comprise an important faunal element in these areas and are often among the few species that persist in extremely hot, dry habitats. It is not surprising, therefore, that this group has been the subject of numerous investigations concerning their ecological, physiological, and biochemical adaptations for withstanding the rigors of desert existence. The development of instrumentation and techniques for handling small samples and accurately measuring burrow microenvironments have stimulated much of this recent research. One tool of particular significance in this respect has been the use of ultraviolet light to detect scorpions in the field (Williams, 1968). This has permitted the collection of sufficient numbers for laboratory investigations of thermal and water relationships, and accurate observations of surface and burrowing activities without disturbing the scorpion in its natural environments as well as indicate areas requiring further investigation.

BEHAVIORAL MECHANISMS

Scorpions can escape the high temperatures and extreme drying power of the surface air by burrowing or seeking some form of cover during daylight and restricting surface activities to nighttime hours. This combination is no doubt the most important adaptive mechanism for scorpions inhabiting desert areas.

Burrowing—The burrowing habit in scorpions is closely, but not completely, related to their taxonomic position. For example, most members of the family Buthidae do not burrow but instead inhabit scrapes beneath rocks, decaying vegetation, or surface litter. Exceptions are *Leiurus quinquestriatus* and *Parabuthus hunteri* which normally live in holes dug deeply into the ground (Cloudsley-Thompson, 1961, 1965). Species belonging to the families Scorpionidae (*Scorpio, Palamnaeus*), Vaejovidae (*Hadrurus, Vaejovis*), and Chactidae (*Euscorpius*) inhabitat deep burrows which they either dig themselves or which have been excavated by lizards or small rodents. Burrow depths approaching 75 cm have been reported for *Scorpio maurus* in the Sahara Desert (Cloudsley-Thompson, 1965) and between 60 to 90 cm for *Hadrurus arizonensis* in the Sonoran Desert by Stahnke (1945). Burrows of the latter are usually dug at or near the bases of vegetation where the ground is soft due to root penetration and soil texture is favorable for packing. Other factors such as temperature reduction resulting from shading and increased soil moisture may also be important in site selection. The majority of burrows I have observed were located where there was adequate drainage and the chances of inundation from flash flooding minimal.

Morphological modifications may accompany the burrowing habit. Large, bulky pedipalps often characterize species which dig deep burrows such as members of *Scorpio* and *Hadrurus*, while non-borrowing buthid species such as *Centruroides sculpturatus* possess slender, elongate pedipalps. There are exceptions to this general trend which may reflect the role of the pedipalps in prey capture, courtship behavior, and defensive display. For example, small slender pedipalps are found in two closely related burrowing species, *Vaejovis confusus* and *V. spinigerus* which often occur in association with populations of *C. sculpturatus*. Also many burrowing species such as *Anuroctonus phaiodactylus* apparently use chelicerae and walking legs more than pedipalps in burrow construction (Williams, 1966). A comprehensive study involving species from several families and emphasizing the evolutionary origin of the groups would shed much light on this possible eco-morphological relationship.

Avoidance of high temperatures by burrowing is readily apparent; however, recent studies indicate scorpions are also able to behaviorally regulate their temperature through vertical movements within the burrow (Hadley, 1970a). To monitor burrow microenvironment over a 24-hour period, two thermocouples were attached to large individuals of the genus *Hadrurus*, one placed above the dorsal surface, the other inserted beneath the metasomal surface. The scorpions were then allowed to enter burrows, pulling the thermocouples along with them. Results showed that the diurnal temperature fluctuation experienced by individual scorpions was largely dependent on the depth of penetration and subsequent movements inside the burrow. In one case, the scorpion was able to prevent temperatures from reaching lethal levels by simply retreating deeper into the burrow during early afternoon. Other individuals at depths of 40 cm or more experienced relatively minor fluctuations in temperature during the 24 hours.

Marked and often abrupt temperature changes were experienced by scorpions which moved out of the burrows onto the surface during the study (Fig. 1). Because of rapid

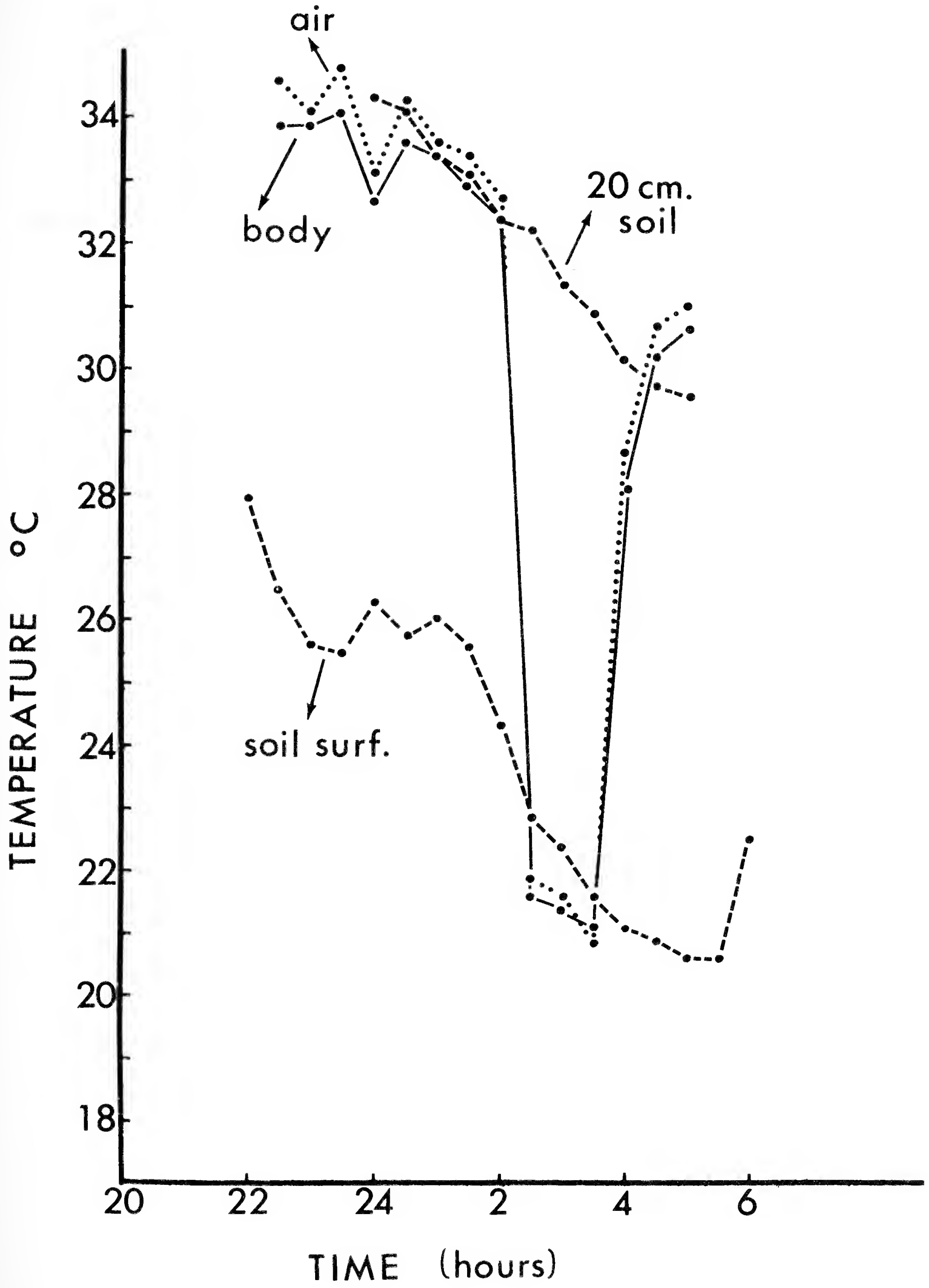

Fig. 1.–Temperature chances experienced by a scorpion moving from a burrow to the surface and returning to the burrow during the night. The scorpion carried both a thermocouple over its dorsal surface (air) and one inserted into the body cavity (body). Substrate and -20 cm soil temperatures are included for reference (Hadley, 1970a).

radiative cooling following sunset and the time lag in penetration of heat from the surface downward, the warmest region of the burrow in early evening was slightly beneath the surface with cooler temperatures above and below. Scorpions that remained in this region experienced temperatures 3° to 10°C higher than those recorded for individuals on the surface. Ultraviolet light detection in the early evening indicates that location at this depth is common in burrowing species. Since scorpions feed very effectively from this position, it is possible that they benefit from increased locomotor and digestive efficiences afforded by the warmer temperatures.

Nocturnal Surface Activity—The majority of scorpions are strictly nocturnal in their habits, particularly species inhabiting arid desert regions. The African scorpion, *Opisthophthalmus latimanus*, is found at the entrance to its burrow during daylight hours and exhibits a stilting behavior which is believed to reduce the heat load experienced at this location (Alexander and Ewer, 1958). Day-active species such as *Pandinus imperator* are usually restricted to subtropical forests where the heavy canopy and dense underbrush present light conditions quite similar to those of exposed habitats at night.

Night-active scorpions generally leave their burrow or shelter soon after sunset and occupy a stationary position on the surface or continue traveling over the substrate (Hadley and Williams, 1968). The time a scorpion remains on the surface varies between species, but generally surface occurrence is reduced as the evening progresses. Endogenous locomotor and oxygen consumption rhythms have been demonstrated in the laboratory for many species exhibiting the above behavior pattern. Diurnal activity rhythms of three Sudanese scorpions, *Buthotus minax, Leiurus quinquestriatus*, and *Pandinus exitialis* determined with an aktograph apparatus support observations that these scorpions exhibit strict nocturnal habits in nature (Cloudsley-Thompson, 1962b). Aktograph experiments on another nocturnal species, *Buthus hottentotta*, showed that 83.5% of its activity occurred during 18:00 to 21:00 hours, while the day-active species, *Pandinus imperator*, had 69.3% of its locomotory activity during the daytime (Toye, 1970).

Several scorpions also exhibit increased oxygen consumption rates during nighttime hours which persist for several days under conditions of constant temperature and darkness (Dresco-Derouet, 1961; Hadley and Hill, 1969). In the buthid scorpion, *Centruroides sculpturatus*, abrupt changes in illumination such as sunset initiate brief but large outbursts of respiratory activity which may signify movement onto the surface and subsequent locomotor activities.

Recent studies indicate that enzymatic and neurophysiological functions are correlated with the diurnal activity patterns exhibited by scorpions. Levels of muscle dehydrogenase activity in *Heterometrus fulvipes* are highest at times when this species exhibits increased locomotor activity and oxygen consumption (Rao and Govindappa, 1967). In a related study, Venkatachari and Dass (1968) found a positive correlation between spontaneous electrical activity of the ventral nerve cord and cholinesterase activity in the same species. These processes also show a regular circadean rhythm which coincides with the observed nocturnal activities of the scorpion in nature.

Most scorpions tested under laboratory conditions exhibit a positive response to high humidity but are negatively phototactic and avoid high temperatures orthokinetically (Cloudsley-Thompson, 1969). An exception is *Opisthophthalmus latimanus* which shows a striking photopositive response to directional light, but becomes photonegative at high temperatures (Alexander and Ewer, 1958). The sensory mechanisms responsible for these responses are poorly known. The distal-tarsal segments of the legs possess hair sensillae that are sensitive to humidity, while short, thin hairs distributed over the general body surface apparently function as thermal exteroceptors (Abushama, 1964). The initiation of behavioral responses to temperature by internal thermoreceptors has not been studied.

TEMPERATURE TOLERANCE

Lethal temperature and water loss rates of scorpions indicate these arthropods are quite tolerant of hot, dry desert conditions and support the idea that ecological factors such as predator avoidance are as much responsible for their nocturnal surface activity as are physiological factors. Accurate comparisons are difficult owing to differences in experimental procedures; however, upper lethal temperatures for scorpions are generally several degrees above those of other desert arthropods. Upper lethal temperatures for two Sudanese scorpions, *Leiurus quinquestriatus* and *Buthotus minax*, after 24-hour exposure to relative humidities below 10% were 47° and 45°C, respectively (Cloudsley-Thompson, 1962a,b). For two North American species, *Hadrurus arizonensis* and *Centruroides sculpturatus*, LD_{50}'s were obtained at 45°C after a two-hour exposure at approximately 40-50% relative humidity during oxygen uptake determinations (Hadley, 1970b; Hadley and Hill, 1969). It is likely that scorpions exhibit greater temperature tolerance during summer months resulting from seasonal acclimatization. Cloudsley-Thompson reported an enhanced temperature resistance in *L. quinquestriatus* which had been preconditioned at higher temperatures for 24 hours. Comparative data on lethal temperatures of species from cooler, moister habitats are not available.

WATER LOSS

Total water loss values for scorpions are given in Table 1. Comparisons between species are approximate at best because of the variety of experimental techniques employed, discrepancies in sample size used in compiling mean values, and differences in weight and hydration state of experimental animals. In spite of these limitations, water loss rates for scorpions, both Old and New World species, are comparable and generally lower than those for other desert arthropods (see Hadley, 1970b). The highest transpiration rates are found in *Pandinus imperator*, the black African scorpion which inhabits lowland rain forest zones. Significantly lower water loss rates characterize the remaining species which are either true desert forms or have geographical ranges which extend into arid regions. These data clearly indicate a relationship between scorpion transpiration rates

Table 1.—Water Loss in Scorpions. ([1] Mean of three newly molted individuals.)

Species	Temperature °C	Rate of Water Loss mg/cm²/hr	Source
Leiurus quinquestriatus	33 ± 2	.021	Cloudsley-Thompson 1961
Androctonus australis	19 ± 2	.014	Cloudsley-Thompson 1956
Buthotus minax	33 ± 2	.037	Cloudsley-Thompson 1962b
Campsobuthus werneri	19 ± 2	.010	Cloudsley-Thompson 1962b
Parabuthus hunteri	19 ± 2	.030	Cloudsley-Thompson 1962b
Pandinus imperator	25 ± 1	.233	Toye 1970
Pandinus imperator	25 ± 1	.413[1]	Toye 1970
Buthus hottentotta	25 ± 1	.131	Toye 1970
Centruroides sculpturatus	25 ± 1	.131	Hadley (unpublished)
Hadrurus arizonensis	25 ± 1	.029	Hadley 1970b
Paruroctonus mesaensis	25 ± 1	.038	Hill (unpublished)

and distribution in terms of habitat dryness. However, no direct correlation is evident between the degree of nocturnalism shown by scorpions and their rate of water loss (Toye, 1970).

Cuticular Transpiration—The extremely low transpiration rates of scorpions can be attributed largely to the presence of an epicuticular wax layer or layers in their integument which provides an effective water-proofing barrier. Supplementing this lipid barrier may be either the tanned chitin-protein complex of the exocuticle or extensions of the lipid material into the underlying cuticular layers (Krishnan, 1953; Kurup, et al., 1969). I have been unable to correlate cuticular hardness and appearance with impermeability in scorpions examined to date, although individuals undergoing molting or recently molted generally exhibit significantly higher water loss rates than do intermolt individuals. Toye's (1970) results on *Pandinus imperator* support this observation (Table 1).

"Critical temperatures" can usually be demonstrated in arthropods with organized lipid water-proofing layers. These are temperatures at which the lipid molecules apparently lose their orientation causing a rapid and marked increase in cuticular transpiration. The cuticular temperature-transpiration curve for *Hadrurus arizonensis* indicates that the cuticle of this species does not exhibit abrupt changes in permeability until temperatures reach approximately 65°C, although a smaller break in the curve appears at 35° to 40°C (Fig. 2). Another desert species, *Scorpio maurus*, also exhibits a critical temperature at approximately 65°C (Cloudsley-Thompson, 1956). The ecological significance of this relationship is not readily apparent since lethal temperatures for both species lie between 45° and 50°C. However, since many arthropods species with higher transpiration rates have lower critical temperatures (35° to 40°C), the cuticular thermostability observed in scorpions may reflect the general impermeable nature of their integument.

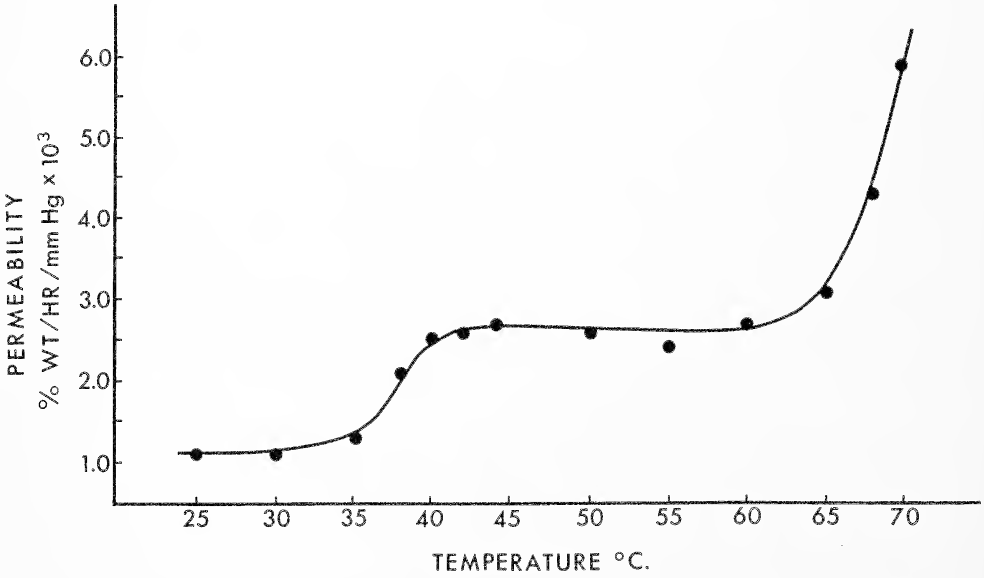

Fig. 2.—The effect of temperature on the permeability of the cuticle of *H. arizonensis*. Dark circles represent mean water-loss values from a minimum of two scorpions. Air, not cuticle, temperatures were measured (Hadley, 1970b).

The cuticular component of total water loss in scorpions can be demonstrated by killing the scorpion with cyanide vapors and sealing its book lungs with nail polish or some other water-proofing substance. However, when living versus dead scorpions are compared at low temperatures, transpiration rates for the latter often exceed water loss rates for living animals. This relationship over time is illustrated in Fig. 3 for *Hadrurus arizonensis* (Hadley, 1970b). In the same study, transpiration rates for dead sealed *Centruroides sculpturatus* were three times those for live specimens. Similar results have been observed for *Paruroctonus mesaensis* (Hill, unpublished). The apparent discrepancy between water loss rates reported for *Pandinus imperator* by Toye (1970) (0.233 mg/cm^2/hr) and Cloudsley-Thompson (1959) (1.25 mg/cm^2/hr) under similar temperature and humidity conditions may reflect the fact that the latter rate was obtained from a dead specimen. These data strongly suggest that some energy-requiring process(es) in the cuticle may supplement the physical barrier of the exoskeleton in controlling cuticular transpiration. Further research is necessary to determine if any of the mechanisms postulated for other arthropods which also exhibit this relationship can be applied to scorpions.

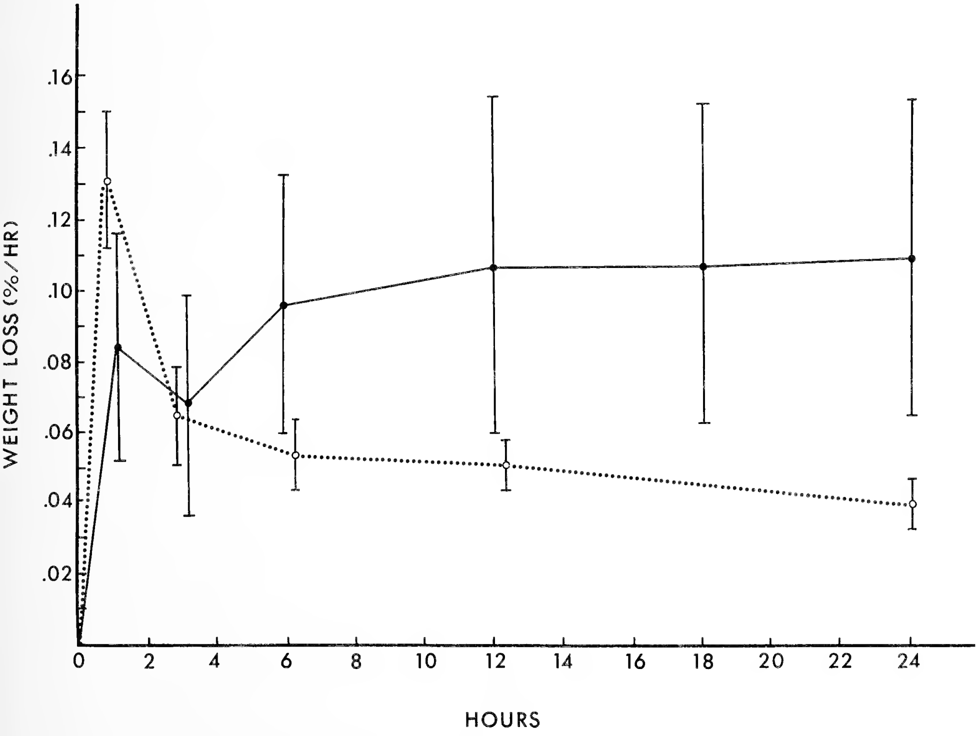

Fig. 3.–Changes in water-loss rates with time in living scorpions (open circles) versus dead scorpions (dark circles) at 38°C in dry air. Vertical lines represent 95% confidence limits (Hadley, 1970b).

Respiratory Transpiration–In spite of the impermeable integument, cuticular transpiration is responsible for much of the total water loss of scorpions over their normal temperature range. Metabolic rates of scorpions are very low (Sreenivasa Reddy, 1963; Dresco-Derouet, 1964; Hadley and Hill, 1969); individuals with only one of the eight book lungs functional continued to live and feed for six months following the operation (Millot and Paulian, 1943). Because of the low metabolic demands, respiratory evaporation can be almost negligible at low temperatures. However, increased ventilation rates at higher temperatures (> 40°C) may result in respiratory transpiration far surpassing cuticular transpiration, even though the latter also increases with temperature. Such is the case for *Hadrurus arizonensis*, the only species for which the relative contributions of the two water loss pathways over an extended temperature range have been determined (Hadley, 1970b). There is also some evidence of more stringent spiracular control in scorpions as they become dehydrated or when microclimatic conditions dictate water conservation.

Not only does the low metabolic rate reduce respiratory transpiration, it extends the time scorpions can remain inactive during particularly stressful periods of the year. It is well known that scorpions can go several weeks without food or water. During this time, glycogen which is stored in high concentrations in the liver and muscles serves as a nutrient reserve (Sinha and Kanungo, 1967). The glycogen is broken down into glucose and released into the blood so that even during extended starvation periods blood sugar levels remain fairly constant (Padmanabhanaidu, 1966).

Excretory Water Loss—The elimination of nitrogenous end-products and fecal material in a very dry state further reduces water loss in scorpions. In contrast to insects, the principle nitrogenous waste of scorpions appears to be the purine compound guanine, with uric acid second in importance (Table 2). Only in the Indian scorpion, *Palamnaeus bengalensis;* is this trend reversed. It is likely that the presence of uric acid in some species reflects dietary purines since scorpions feed principally on uricotelic insects; however, interspecific variation in nitrogenous end-products may reflect true differences in some cases (Horne, 1969). Horne also states that guanine rather than uric acid excretion might indicate more efficient water conservation for species in hot dry climates since guanine contains one more nitrogen atom than uric acid and is less soluble in water.

In addition to transpiration and water accompanying elimination of nitrogenous wastes and fecal material, trace amounts of water can be lost through venom release and a process called "washing" or "sponge bathing". The former probably represents a minor constituent of total water loss in laboratory determinations only because of scorpions striking at their containers. "Sponge bathing" refers to the use of exudate by scorpions to clean their pedipalps, chelicerae, telson, and first two pairs of walking legs (Williams, 1966; Kinzelbach, 1967). Williams reports that even though the fluid is exuded in large quantities in the preoral cavity, surface tension between the gnathobases and on the chelicerae prevents any extensive loss to the substrate. Because evaporation of the exudate would still be a factor, this cleaning behavior in nature is probably restricted to periods following fluid intake or times when water needs are not critical.

RESISTANCE TO DESICCATION

One of the most widespread adaptations to desert environments is the ability of organisms to endure desiccation and recover unharmed (Hadley, 1972). Even if scorpions become inactive in burrows during unfavorable seasons or adjust their activity periods so that their surface occurrence coincides with times of reduced heat and high humidities, they are likely to encounter a water deficit. This is particularly true if there is an absence of insect prey to replenish body water needs. As indicated by the length of time they can go without food or water, scorpions obviously show an enhanced ability to survive

Table 2.–Nitrogenous Excretion in Scorpions. ●, major end-product; ⊕, present; ○, not detectable or present in trace amounts only.

Species	Nitrogenous end-products				Source
	Uric Acid	Guanine	Adenine	Hypoxanthine	
Centruroides vittatus	⊕	●	○	○	Horne (1969)
Centruroides marginaritatus	⊕	●	○	○	Horne (1969)
Vaejovis mexicanus	○	●	○	○	Horne (1969)
Heterometrus sp.	○	●	○	○	Horne (1969)
Vaejovis sp.	○	●	○	○	Horne (1969)
Heterometrus fulvipes	⊕	●	○	○	Rao & Gopalakrishnareddy (1962)
Lycas tricarinatus	⊕	●	○	○	Rao & Gopalakrishnareddy (1962)
Buthus tamulus	⊕	●	○	⊕	Rao & Gopalakrishnareddy (1962)
Leiurus quinquestriatus	⊕	●	○	○	Haggag & Fouad (1965)
Palamnaeus bengalensis	●	○	⊕	⊕	Kanungo, et al. (1962)
Androctonus australis	○	●	○	○	Gregoire, et al. (1955)
Androctonus amoreuxi	○	●	○	○	Gregoire, et al. (1955)

desiccation. Depletion of body water levels approaching 30% of their initial weight have been observed for scorpion species in our laboratory, while Cloudsley-Thompson (1962b) reported a loss of approximately 40% body weight before death occurred in *Buthotus minax*. Unfortunately, information about the possible regulation of hemolymph concentration and composition during dehydration is lacking for scorpions. Preliminary results from a study in progress on *Hadrurus arizonensis* suggest that this species simply tolerates increased osmotic pressure and ion concentrations until lost body water can be replenished.

WATER GAIN

Potential sources of water available to scorpions include fluids of captured prey, bulk surface water, atmospheric and substrate moisture, and metabolic water. Water contained in the juices of prey is the most important and the only source necessary for most species. The immobilized prey is subjected to both mechanical and external chemical digestion, with the resulting juices being drawn into the mouth by the pumping action of the pharynx. Water uptake by drinking is essential in some tropical species such as the Phillipine forest scorpion, *Palamnaeus longimanus*, which must replace water lost due to high transpiration rates (Schultze, 1927). Desert species will drink in the laboratory, especially when dehydrated, but have access to bulk water only infrequently in nature. An exception is the non-burrowing scorpion, *Centruroides sculpturatus*, which has been observed drinking from irrigation canals in the Salt River Valley, Arizona. The mean drinking rate for eight individuals was 10 mg/min. They were able to regain a mean of 70.8% of the weight they lost through desiccation; however, no correlation was evident between extent of desiccation and milligrams of water drunk (Hadley, 1971). Although *C. sculpturatus* is capable or rapid rehydration via drinking, it also survives well in xeric habitats where bulk water is absent and, therefore, like other desert species is not dependent upon this avenue of water gain.

In some desert species, water formed from the oxidation of foodstuffs is necessary for survival; however, its role in scorpions remains obscure since they usually obtain sufficient water with their food. Scorpions, like all arthropods, utilize metabolic water since it enters the total water pool, but its overall contribution to water balance is meager in comparison to the preformed water of the prey. There is good evidence that scorpions are very efficient in retaining metabolic water. Sinha and Kanungo (1962) reported that *Palamnaeus bengalensis* individuals starved for 12 days showed no change in the water content of liver and muscles. This observation also reflects the ability of scorpions to excrete dry fecal material and to decrease the amount of excreta produced with increased time of starvation.

The ability of arthropods to absorb atmospheric or substrate moisture has been the subject of much recent experimentation. This phenomenon has been observed in a number of different species, but is rare among truly desert forms. Scorpions appear to be no exception. It was thought that scorpions such as *Hadrurus arizonensis* which are abundant along desert coastal areas in Northern México might supplement their water intake by absorbing moisture from the near-saturated air or moist ground surface during the summer nights (Williams and Hadley, 1967). Laboratory experiments have failed to substantiate this hypothesis. Even highly desiccated individuals were unable to take up significant quantities of water from moist sponge strips (Fig. 4) and no individuals exhibited a weight increase after 24 hours exposure to 98% relative humidity (Hadley, 1970b). Water loss in the latter group, however, was only 1/7th the rate for hydrated individuals in dry air and 30°C (Table 1). Additional desert species must be investigated before the results obtained for *H. arizonensis* can be applied to scorpions as a group. Tropical species with more permeable integuments and high transpiration rates might provide some interesting contrasts to this general pattern.

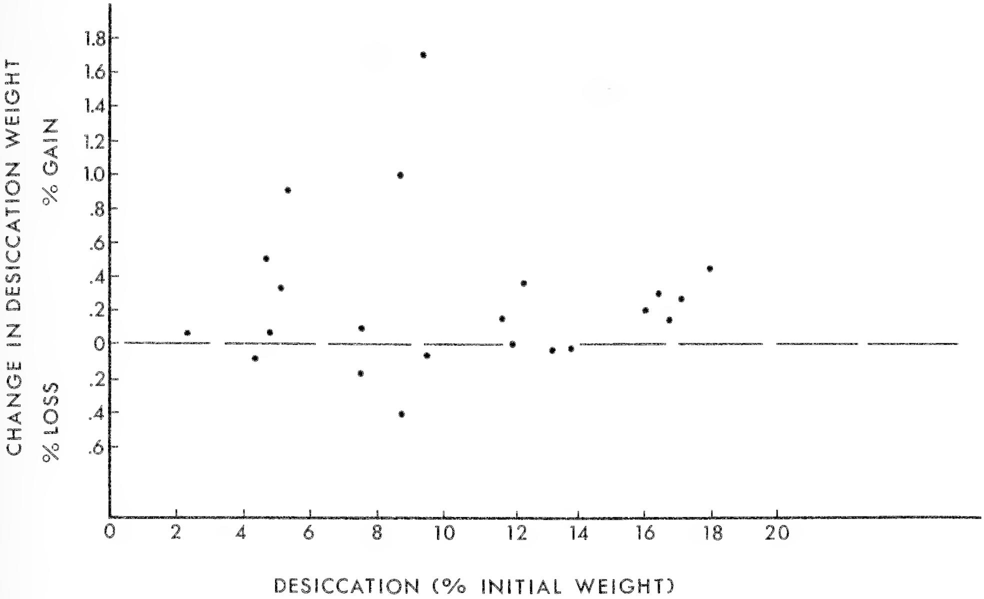

Fig. 4.–Changes in desiccation weight of *H. arizonensis* after 24 hour exposure to a moist sponge substrate (25°C). Position of dark circles along horizontal axis indicated degree of dehydration of individual scorpions (Hadley, 1970b).

SUMMARY AND CONCLUSIONS

A combination of behavioral, morphological, and physiological adaptations enable scorpions to tolerate environmental stresses encountered in desert habitats. Paramount among these are the avoidance of climatic extremes by burrowing, nocturnal surface activity, increased heat resistance, an extremely impermeable cuticle with active mechanisms for water retention, a low metabolic rate, efficient elimination of excreta, and increased desiccation resistance. Mechanisms for conserving rather than regaining water are emphasized. The majority of adaptations exhibited by scorpions are not unique to these arachnids, but are highly developed and efficiently utilized.

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CLARIFICATION OF THE GENERA *HESPEROCHERNES* AND *DINOCHEIRUS* (PSEUDOSCORPIONIDA, CHERNETIDAE)[1]

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ABSTRACT

The chernetid genera *Hesperochernes* Chamberlin and *Dinocheirus* Chamberlin are redefined in the light of recent knowledge and are compared with *Chernes* Menge, type genus of the family Chernetidae. Redescriptions of the type species *Hesperochernes laurae* Chamberlin and *Dinocheirus tenoch* Chamberlin and three new combinations, *Hesperochernes mirabilis* (Banks), *Hesperochernes occidentalis* (Hoff and Bolsterli) and *Dinocheirus bouvieri* (Vachon), are included.

INTRODUCTION

As I have pointed out earlier (Muchmore, 1972), the pseudoscorpion family Chernetidae is in urgent need of revision. Large numbers of genera have been assigned to the family over the years, but the relationships among them have not been reviewed carefully in the light of recent knowledge and are not at all clear. In spite of its venerable age and the commonness of its species, *Chernes* Menge, type genus of the family, is actually not very well known. Further, its relations to the common American genera *Hesperochernes* Chamberlin and *Dinocheirus* Chamberlin have been so misunderstood that an unnatural grouping of genera has been adopted; specifically, the subfamily Chernetinae Beier, which itself is suspect (see Muchmore, 1972, p. 113), has been divided into the tribes Chernetini Beier and Hesperochernetini Beier mainly on the basis of a supposed difference in the number of setae in the cheliceral flagellum. As it turns out, members of *Chernes*, type genus of the Chernetini, like *Hesperochernes*, type genus of the Hesperochernetini, possess four setae in the cheliceral flagellum (although species of many genera usually placed in the Chernetini do in fact have a flagellum of only three setae). Though the possibility that Hesperochernetini and Chernetini are synonymous was suggested by Hoff a number of years ago (1956, p. 13), Beier (1963) persisted in considering that members of *Chernes* have only three flagellar setae (except teratologically) and in maintaining the distinction between the two tribes. It is clear to the present author that the Chernetini and Hesperochernetini as defined by Beier are indistinguishable, that the subfamilies Chernetinae and Lamprochernetinae are poorly conceived, and that a great amount of work must be done before a satisfactory understanding of chernetid relationships can be attained. Restudy of the species of most genera, together with extensive critical comparisons, is a necessary first step in this process. The present paper

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makes a beginning to the work by redefining the genera *Hesperochernes* and *Dinocheirus* and comparing them with *Chernes.*

FAMILY CHERNETIDAE CHAMBERLIN

Chernetidae Chamberlin, 1931, p. 241. Beier, 1932, p. 80. Hoff, 1956, p. 4. Beier, 1963, p. 248.

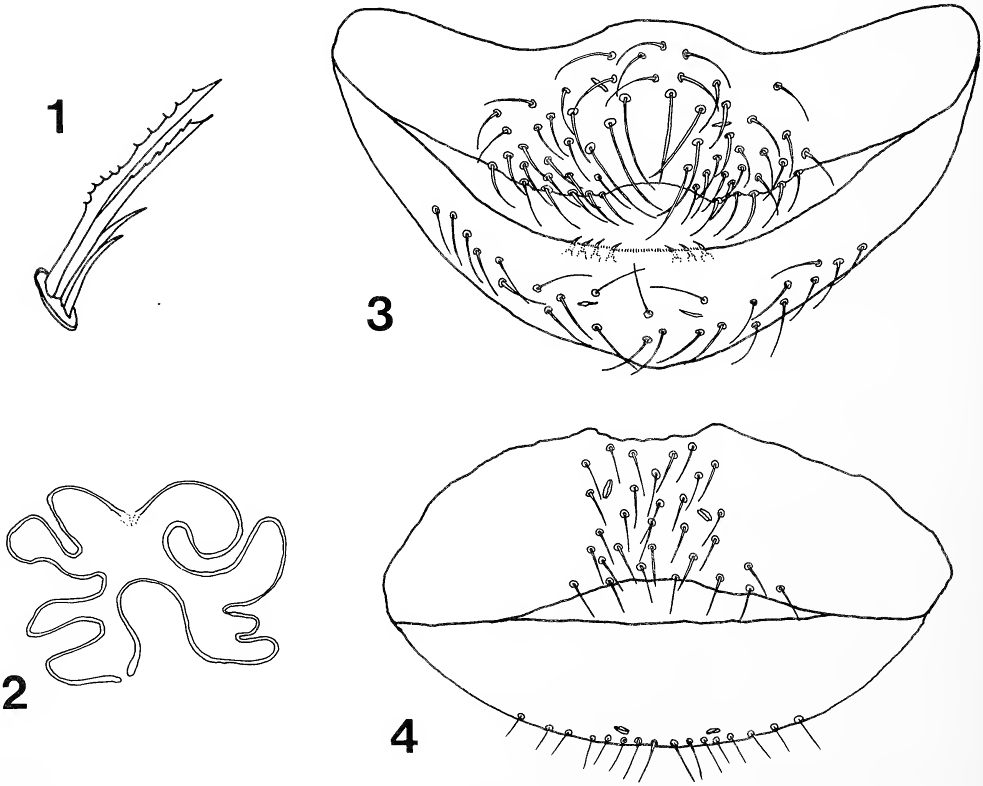
Members of the family Chernetidae may be diagnosed simply as follows: all legs monotarsate; venom apparatus well developed only in the movable chelal finger, poorly developed or absent in fixed finger; chelal fingers usually with accessory teeth external and internal to the marginal row; each tarsus with an elevated slit sensillum ("sense dome") on the outer margin proximad of the middle.

Genus *Chernes* Menge

Figs. 1-4.

Chernes Menge, 1855, p. 39. Beier, 1932, p. 154 (see this paper for other synonymy). Beier, 1963. p. 273.

While a complete redefinition of *Chernes* is desirable, it is not possible for me to accomplish that task at the present time. Nevertheless, it is necessary to emend the



Figs. 1-4.–*Chernes cimicoides* (Fabricius): 1, cheliceral flagellum; 2, spermathecae of female; 3, genital opercula of male; 4, genital opercula of female.

diagnosis of the genus by acknowledging the presence of *four setae in the cheliceral flagellum* (Fig. 1). In my experience four setae occur regularly in representatives of *Chernes*, though it is conceivable that in some species or some populations the number has been reduced to three (as implied by Beier, 1963, p. 273). A broad critical survey of European forms will be necessary in order to resolve this problem.

Also it must be noted here that, according to all the evidence I can find, the spermathecae of *Chernes* females are paired and in the form of long, thin tubules *without distinct terminal enlargements* (Fig. 2). This is in clear contrast to the closely allied genera *Hesperochernes* and *Dinocheirus*, which have conspicuous spherical or ovoid enlargements of the ends of paired tubular spermathecae (Figs. 9 and 16).

Experience has shown that the chelicera of *Chernes* species usually has seta *sb* terminally denticulate while *b* and *es* are acuminate. This is similar to the situation in *Dinocheirus* species, but different from that in *Hesperochernes* species where both *sb* and *b* are denticulate (see below).

The chaetotaxies of male and female genital opercula of *Chernes cimicoides*, generally characteristic of the Chernetidae, are shown in Figs. 3 and 4.

Genus *Hesperochernes* Chamberlin

Hesperochernes Chamberlin, 1924, p. 89. Beier, 1932, p. 174. Hoff, 1949, p. 476. Hoff and Clawson, 1952, p. 14. Hoff, 1956, p. 31. Hoff, 1958, p. 22; p. 48. Hoff, 1963, p. 3.

Type species—*Hesperochernes laurae* Chamberlin, 1924.

Diagnosis (emended)—A genus of the family Chernetidae. Surfaces of carapace, abdominal sclerites and palps generally granulate; dorsal vestitural setae denticulate and often expanded distally, ventral setae acuminate or denticulate; setae of genital opercula and spiracular plates acuminate; 11th tergite and sternite with or without long, acuminate tactile setae; pleural membranes roughly, longitudinally striate; carapace with two distinct transverse furrows; eyes absent, or present as two very faint spots; cheliceral hand with five setae, *b* and *sb* terminally denticulate, the others acuminate; flagellum of four setae, including two long ones distally and two short ones lying close together proximally, the distalmost seta heavily dentate along margin, the others often finely denticulate at distal ends; palpal chela of male sometimes larger and stouter than that of female; venom apparatus well developed in movable chelal finger, vestigial or absent in fixed finger; trichobothrium *st* of movable finger closer to *t* than to *sb* and near middle of finger; *ist* on fixed finger distinctly distad of *est*, which is near middle of finger; tarsus of each leg with an elevated slit sensillum on extensor margin within basal half of segment; tarsus IV without a long, acuminate tactile seta, but sometimes with an elongated seta distally which is terminally denticulate; anterior gential operculum of male with a group of 20-25 setae, including 4-6 larger ones medially; posterior operculum of male with 2-3 small setae on either side beneath middle of anterior margin and 15-25 setae on face and along posterior margin; female anterior genital operculum with about 20-30 setae centrally on face and posterior operculum with a row of about 10-15 small setae along posterior margin; spermathecae of female paired and in form of long, thin tubules with conspicuous ovoid or spheroid terminal enlargements.

Remarks—Hoff and Clawson (1952, p. 14) stated that, "At the present authors' request, Chamberlin has reexamined the type material [of *Hesperochernes laurae*] and reports that seta *b* is apparently non-denticulate, although it is possible that minute denticles may be present." From this, the authors concluded that, "It now becomes impractical to use the denticulate character of seta *b* for separating related genera." However, my own observation of the type material of *H. laurae* reveals that *b* is clearly denticulate at the tip on all chelicerae but one, where it does appear acuminate; and in other *Hesperochernes* material it is only very rarely that *b* is not at least finely denticulate terminally. Thus it seems clear that the denticulate character of *b*, as well as of *sb*, is sufficiently constant in species of *Hesperochernes* to be useful for diagnostic purposes. On this basis, then, members of *Hesperochernes* are distinguishable from those of *Chernes* and *Dinocheirus*, in both of which species have cheliceral seta *b* clearly acuminate.

It should be noted that Chamberlin's statement (1924, p. 89) that the seminal receptacles (=spermathecae) of *Hesperochernes* species are like those of *Chernes* species is confusing, because of Chamberlin's imperfect understanding of *Chernes* at that time. Actually, the spermathecae of members of *Hesperochernes* and *Chernes* are similar in consisting of long, thin tubules, but in the former the ends are greatly expanded while in the latter the ends are very little if any larger than the tubules themselves.

While females of *Hesperochernes* and *Chernes* can easily be separated on the basis of the spermathecae, the males are not distinguishable by means of their genitalia because the details of these structures are not yet understood. It is to be hoped that further work along the lines of Legg (1971) will result in the recognition of male genital characters which will be useful in the taxonomy of chernetid genera.

Hesperochernes laurae Chamberlin

Figs. 5-10.

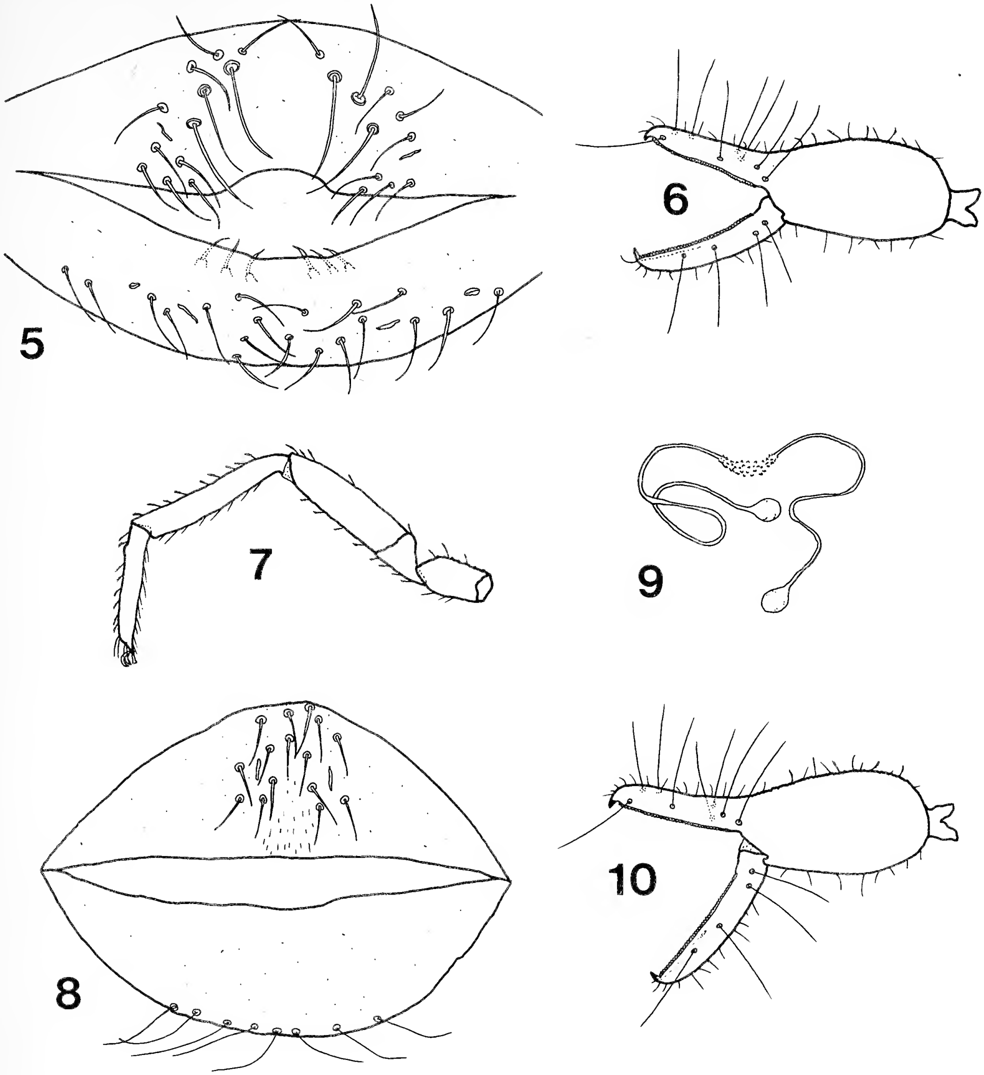
Hesperochernes laurae Chamberlin, 1924, p. 90, Figs. A-L. 1931, Figs. 12D, 13A, 51G, 52I.

Material examined–Holotype male (JC 530.01001), allotype female and four paratypes (three males, one female) all from a nest of the wasp, *Vespa occidentalis*, at Stanford University, San Mateo County, California [J. C. Chamberlin Collection].

Description of male–The original description by Chamberlin (1924, p. 90) is generally satisfactory but a few additions and measurements are desirable (figures given are for the holotype or ranges for the four types). Carapace longer than broad, with two distinct transverse furrows; surface granulate; no eyes present; about 70 vestitural setae, four at anterior and nine along posterior margin. Tergites 1-10 and sternites 4-10 divided. Tergal chaetotaxy 9:9:8:11:11:12:12:10:11:11:8:2; sternal chaetotaxy 22:(3)$\frac{3\text{-}3}{19}$(2):(1)7(1):12:15:12:11:10:9:6:2; eleventh tergite and sternite without acuminate tactile setae; setae of anal plates acuminate; anterior genital operculum with six long setae flanked by 16 smaller ones (Fig. 5); posterior genital operculum with two sets of three small setae beneath anterior margin and 19 setae scattered over face and along posterior margin; setae of spiracular plates acuminate.

Chelicera one-third as long as carapace; hand with five setae, *sb* terminally denticulate, *b* very finely denticulate terminally, *es* shorter than *b* and acuminate; flagellum of four setae, distal one dentate along margin, others variably denticulate terminally; galea usually with six small rami.

Palp essentially as figured by Chamberlin (1924, Figs. A, B). Trochanter 1.7-1.8, tibia 3.2-3.3, femur 2.6-2.7, and chela (without pedicel) 2.9-3.2 times as long as broad; hand



Figs. 5-10.–*Hesperochernes laurae* Chamberlin: 5, genital opercula of male; 6, lateral view of left chela of male; 7, leg IV; 8, genital opercula of female; 9, spermathecae of female; 10, lateral view of left chela of female.

(without pedicel) 1.55-1.7 times as long as deep. movable finger 0.95-1.0 times as long as hand. Lateral view of chela shown in Fig. 6. Fixed chelal finger with 37-40 and movable finger with 41-44 contiguous marginal teeth; each finger with 2-4 external and internal accessory teeth. Venom apparatus well developed only in movable finger, nodus ramosus nearer to *st* than to *t*.

Legs fairly slender; leg IV with entire femur 4.55-4.75 and tibia 5.9-6.0 times as long as deep (Fig. 7). Each tarsus with a prominent slit sensillum at basal quarter of outer margin. Leg IV without an acuminate tactile seta on tarsus.

Female–Much like male but very slightly larger and more robust. Anterior genital operculum with central group of about 15 setae, posterior operculum with row of nine setae along posterior margin (Fig. 8). Spermathecae paired, each consisting of a long, thin tubule with an ovoid terminal enlargement (Fig. 9). Palpal trochanter 1.8-1.9, tibia 3.0-3.1, femur 2.3-2.5, and chela (without pedicel) 2.8-2.95 times as long as broad; hand (without pedicel) 1.5-1.65 times as long as deep; movable finger 1.0-1.03 times as long as hand. Lateral view of chela as shown in Fig. 10. Fixed finger with 40-41 and movable finger with 46-47 marginal teeth. Leg IV with femur 4.45-4.5 and tibia 5.85-5.9 times as long as deep; tarsus without an acuminate tactile seta.

Measurements (mm)—Ranges for the four males are given first, followed in parentheses by those of the two females. Body length 2.09-2.26(2.67-2.74). Carapace length 0.74-0.755(0.77-0.815). Chelicera 0.245-0.25(0.26) by 0.12-0.125(0.13). Palpal trochanter 0.385-0.41(0.415-0.45) by 0.215-0.245(0.23-0.235); femur 0.66-0.76(0.71-0.725) by 0.20-0.23(0.235); tibia 0.60-0.68(0.66-0.665) by 0.22-0.25(0.265-0.29); chela (without pedicel) 0.985-1.08(1.08-1.095) by 0.33-0.355(0.37-0.385); hand (without pedicel) 0.525-0.56(0.555) by 0.33-0.34(0.34-0.37); pedicel about 0.09 long; movable finger 0.525-0.54(0.555-0.57) long. Leg IV: entire femur 0.59-0.62(0.635-0.67) long; basifemur 0.185-0.21(0.22-0.23) by 0.125-0.13(0.14); telofemur 0.43-0.445(0.465-0.47) by 0.13(0.14-0.15); tibia 0.53-0.54(0.555-0.56) by 0.09(0.095); tarsus 0.39-0.43(0.43-0.435) by 0.06-0.065(0.065).

On the basis of adequate original descriptions or reexamination by the present author, it is clear that the following belong to the genus *Hesperochernes* as defined above: *Hesperochernes laurae* Chamberlin, 1924, p. 90; *H. tamiae* Beier, 1930, p. 214; *H. utahensis* Hoff and Clawson, 1952, p. 15; *H. riograndensis* Hoff and Clawson, 1952, p. 19; *H. mimulus* Chamberlin, 1952, p. 292; *H. molestus* Hoff, 1956, p. 33; *Chelifer mirabilis* Banks, 1895; *Pseudozaona occidentalis* Hoff and Bolsterli, 1956.

Hesperochernes mirabilis (Banks), new combination

Chelifer mirabilis Banks, 1895, p. 4. *Chelodamus mirabilis*: R. V. Chamberlin, 1925, p. 237. *Parachelifer mirabilis*: Beier, 1932, p. 241. *Pseudozaona mirabilis*: Hoff, 1946b, p. 201; Hoff, 1958, p. 24.

After careful reexamination of the types and study of much additional material from numerous caves in southeastern United States, I have concluded that *Chelifer mirabilis* Banks actually belongs to the genus *Hesperochernes*. The species possesses all of the characters of that genus as defined above, notably; lack of an acuminate tactile seta on the tarsus of leg IV; cheliceral seta *b* and *sb* both denticulate terminally; spermathecae of female in form of long, thin tubules with conspicuous, ovoid terminal enlargements; trichobothrium *st* closer to *t* than to *sb*, and *ist* distinctly distad of *est*, which is near middle of finger. There appears to be no basis for placing the species in another genus except for its large size and the attenuation of palps and legs, which are, however, only modifications for its cavernicolous existence. Contrary to the view of Hoff (1946b), it is not congeneric with *Pseudozaona communis* Beier (which, as a matter of fact, belongs in yet another genus) as will be shown in detail in a subsequent paper.

Hesperochernes occidentalis (Hoff and Bolsterli), new combination.

Pseudozaona occidentalis Hoff and Bolsterli, 1956, p. 170; Hoff, 1958, p. 24.

This species, as shown by Hoff and Bolsterli, is quite similar to *H. mirabilis* (Banks). Like the latter, it possesses the characters diagnostic of *Hesperochernes* species, and is modified for cave dwelling by its increased size and attenuated appendages.

Reexamination of the types of the following species by the present author has revealed that they do not belong in *Hesperochernes*, but apparently are representatives of the genus *Chernes* Menge as will be discussed fully in a subsequent paper: *Chernes sanborni* Hagen, 1869 (see Hoff, 1946a, p. 100); *Reginachernes ewingi* Hoff, 1949, p. 466; *R. lymphatus* Hoff, 1949, p. 467; *Hesperochernes amoenus* Hoff, 1963, p. 3.

The status of the following species is still in doubt inasmuch as the descriptions in the literature do not allow firm decisions and the types have not yet been reexamined: *Chelanops pallipes* Banks, 1893 (see Hoff, 1947, p. 506); *C. unicolor* Banks, 1908 (see Hoff, 1947, p. 511); *C. paludis* Moles, 1914 (see Hoff, 1958, p. 24); *Hesperochernes montanus* Chamberlin, 1935, p. 37; *H. canadensis* Hoff, 1945, p. 1; *H. thomomysi* Hoff, 1948, p. 341.

Genus *Dinocheirus* Chamberlin

Dinocheirus Chamberlin, 1929, p. 171. Beier, 1932, p. 137. Chamberlin, 1934, p. 128. Hoff, 1947, p. 513. Hoff, 1949, p. 471. Hoff, 1956, p. 43. Hoff, 1958, p. 47. *Epaphochernes* Beier, 1932, p. 173.

Type species–*Dinocheirus tenoch* Chamberlin, 1929.

Diagnosis (emended)–A genus of the family Chernetidae. Usually heavily sclerotized and darkly colored; surfaces of carapace, abdominal sclerites and palps generally granulate; pleural membranes longitudinally rugose; vestitural setae of dorsal surfaces clavo-dentate or strongly denticulate, those of ventral surfaces finely denticulate or acuminate; setae of genital opercula and spiracular plates acuminate; eleventh tergite with two and eleventh sternite with four, long, acuminate, tactile (?) setae; carapace with two distinct transverse furrows; no eyes present or two faint eyespots; cheliceral hand with five setae, all acuminate except *sb* which is terminally denticulate; flagellum of four setae, including two long ones distally and two short ones lying very close together proximally, the distalmost seta heavily dentate along margin, the others often finely denticulate near tips; galea with several lateral rami, usually better developed in female than in male; palps rather robust, palpal chela of male usually larger and stouter (often markedly) than that of female; venom apparatus well developed in movable chelal finger, vestigial or apparently absent in fixed finger; both chelal fingers with conspicuous accessory teeth, externally and internally; trichobothrium *st* of movable finger closer to *t* than to *sb* and near middle of finger; trichobothrium *ist* of fixed finger a little distad of *est*, both near middle of finger; tarsus of each leg with an elevated slit sensillum on extensor margin within basal quarter of segment; tarsus III and IV each with prominent, acuminate tactile seta located distad of midpoint of extensor margin; male anterior genital operculum with a more or less compact group of 20-50 or more setae, including 4-12 longer and heavier ones medially, and posterior operculum with 2-4 small setae on either side beneath middle of anterior margin and 20-40 larger setae on face and along posterior margin; female anterior genital operculum with a more or less compact group of about 20-30 setae of equal lengths, and posterior operculum with a single marginal row of about 10-20 smaller setae; female with paired spermathecae in form of long, thin tubules with conspicuous spheroid or ovoid terminal enlargements.

Remarks–The species of *Dinocheirus* are moderately variable in their special morphology. There is usually a sexual dimorphism, often marked, in the size and proportions of the palps in a given species, and the palps of different species show a wide range of form, evidently associated with their different modes of life (about which we know very little).

Dinocheirus tenoch Chamberlin

Figs. 11-16.

Dinocheirus tenoch Chamberlin, 1929, p. 172. Chamberlin, 1931, Figs. 16H, 16P, 18K, 18L, 20H, 30H, 30I. Chamberlin, 1934, Figs. G and M.

Material Examined—Holotype male (JC 320.01001), allotype female and four paratypes (two males and two females) from litter in a garden in Mexico City, Mexico [J. C. Chamberlin Collection].

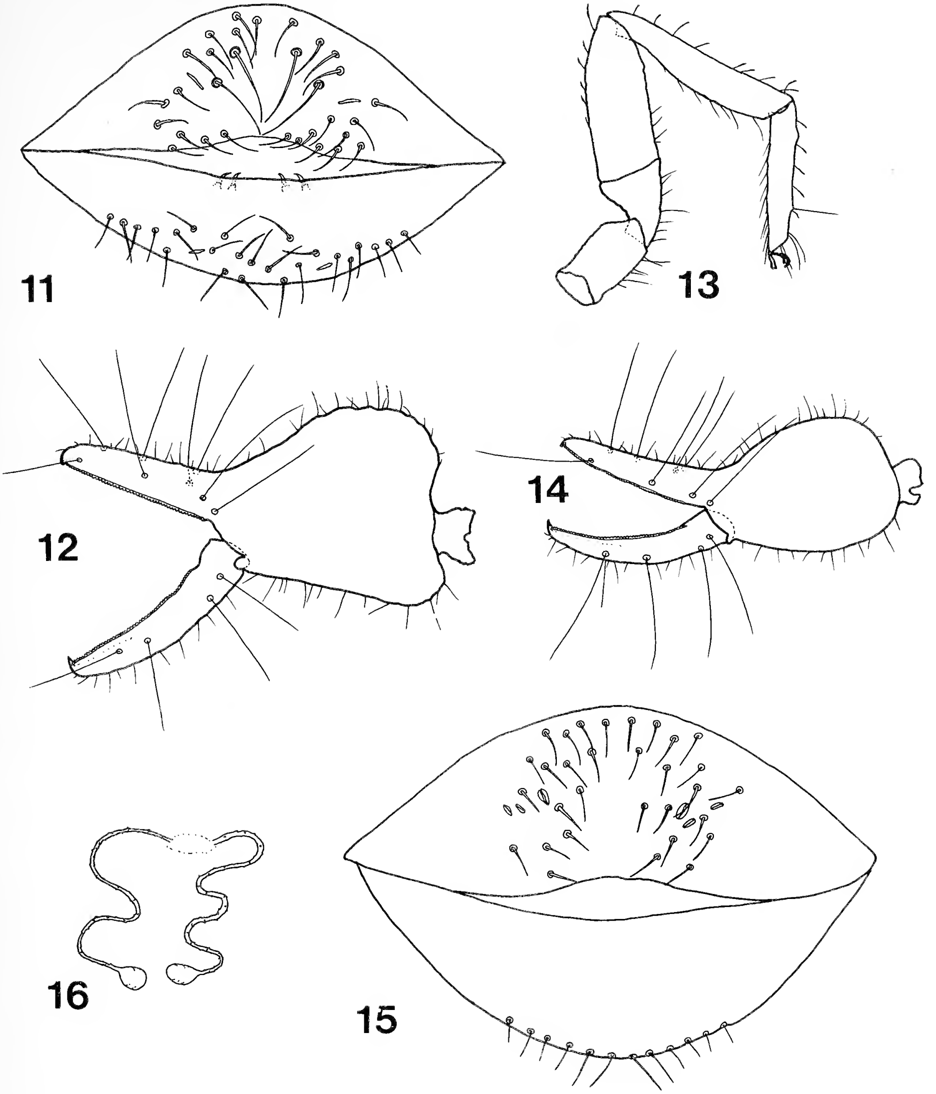
Description of Male—The original description by Chamberlin (1929, p. 172) together with the supplementary information included in Chamberlin (1934, p. 128) is generally satisfactory, but a few additions and measurements are necessary. (Figures given are for the holotype or ranges for the three types.) Carapace longer than broad and with two distinct transverse furrows; surface heavily granulate; with two very faint eye spots; about 100 vestitural setae in all, four at anterior margin and 12-14 at posterior margin. Tergites 1-10 and sternites 4-10 divided; tergal chaetotaxy 14:16:16:19:18:18:18:16:19:16:T9T:2; sternal chaetotaxy 32:(3)$\frac{2\text{-}2}{22}$(3):(1)17(1):27:29:26:27:20:18:T1TT2T:2; anterior genital operculum with four large setae flanked by 28 smaller ones (Fig. 11); posterior operculum with two sets of two small setae beneath anterior margin and 22 setae scattered on face; setae of spiracular plates and anal plates acuminate.

Chelicera about one-third as long as carapace; hand with five setae, *sb* terminally dentate, *b* and *es* acuminate, *es* shorter than *b*; flagellum of four setae, distal one denticulate along margin, others subterminally; galea short, with 3-4 small subterminal denticulations (see Chamberlin, 1931, Fig. 18K).

Palp essentially as figured by Chamberlin (1931, Fig. 30I); trochanter 1.5-1.6, femur 2.65-2.75, tibia 2.2-2.25, and chela (without pedicel) 2.05-2.1 times as long as broad; hand (without pedicel) 0.90-1.1 times as long as deep; movable finger 0.96-0.99 as long as hand. Lateral view of chela shown in Fig. 12. Fixed chelal finger with 44-48 and movable finger with 49-51 marginal teeth; fixed finger with 7-8 external and 6-7 internal accessory teeth, and movable finger with 4-7 external and 7-8 internal accessory teeth; venom apparatus well developed only in movable finger, nodus ramosus about midway between trichobothria *t* and *st*.

Legs moderately slender; leg IV with entire femur 3.5-3.9 and tibia 4.85-5.0 times as long as deep (Fig. 13). Each tarsus with an elevated slit sensillum in basal quarter of outer margin. Leg IV with rather short, acuminate tactile seta on tarsus 0.64-0.69 length of segment from proximal end.

Female (allotype and two paratypes)—Generally similar to male but slightly smaller and less robust, especially in proportions of palp (see Chamberlin, 1931, Figs. 30H and 30I). Palpal trochanter 1.6-1.8, femur 2.55-2.7, tibia 2.15-2.4, and chela (without pedicel) 2.45-2.65 times as long as broad; hand (without pedicel) 1.25-1.45 times as long as deep; movable finger 1.01-1.07 times as long as hand. Lateral view of chela shown in Fig. 14; fixed finger with 44-45 and movable finger with 45-46 marginal teeth. Leg IV with femur 3.55-3.8 and tibia 5.0-5.25 times as long as deep, and with short tactile seta on tarsus 0.66-0.69 length of segment from proximal end. Anterior genital operculum of allotype with group of 29 setae on face; posterior operculum with row of 12 small setae along



Figs. 11-16.—*Dinocheirus tenoch* Chamberlin: 11, genital opercula of male; 12, lateral view of left chela of male; 13, leg IV; 14, lateral view of left chela of female; 15, genital opercula of female; 16, spermathecae of female.

posterior margin (Fig. 15). Spermathecae paired, each consisting of a long, thin tubule with a wrinkled, ovoid, terminal enlargement (Fig. 16).

Measurement (mm)—Ranges for the three males given first, followed in parentheses by those for the three females. Body length 2.89-2.99(3.48-3.56). Carapace length 1.04-1.05(1.00-1.07). Chelicera 0.355-0.38(0.34-0.355) by 0.17-0.19(0.155-0.185). Palpal trochanter 0.56-0.58(0.52-0.53) by 0.355-0.39(0.295-0.325); femur 0.96-0.985(0.84-0.895) by 0.355-0.37(0.32-0.33); tibia 0.895-0.90(0.755-0.79) by 0.40-0.41(0.33-0.35); chela (without pedicel) 1.48-1.59(1.33-1.41) by 0.725-0.755(0.52-0.58); hand (without pedicel) 0.815-0.84(0.69-0.725) by 0.74-0.90(0.50-0.57); pedicel about 0.14(0.125) long; movable finger

0.78-0.83(0.70-0.77) long. Leg IV: entire femur 0.85-0.89(0.80-0.85) long; basifemur 0.325-0.33(0.30-0.32) by 0.215-0.23(0.185-0.22); telofemur 0.605-0.635(0.56-0.605) by 0.23-0.245(0.21-0.23); tibia 0.725-0.75(0.65-0.71) by 0.15(0.13-0.14); tarsus 0.55-0.585(0.495-0.54) by 0.09-0.095(0.09-0.095).

On the basis of adequate original descriptions or reexamination by the present author it can now be stated with confidence that the following American species do belong to the genus *Dinocheirus* as defined above: *Dinocheirus tenoch* Chamberlin, 1929, p. 172; *Chelanops pallidus* Banks, 1890 (see Hoff, 1949, p. 272); *C. dorsalis* Banks, 1895 (see Hoff, 1947, p. 523); *C. validus* Banks, 1895 (see Hoff, 1947, p. 526); *C. arizonensis* Banks, 1901 (see Hoff, 1946b, p. 200); *Dinocheirus sicarius* Chamberlin, 1952, p. 279; *D. astutus* Hoff, 1956, p. 44; *D. imperiosus* Hoff, 1956, p. 54; *D. horricus* Nelson and Manley, 1972, p. 217.

Reexamination of the types of *Chelanops tristis* Banks (1891) and *Chelanops tumidus* Banks (1895), which were placed in *Dinocheirus* by Hoff (1947) (and see Weygoldt, 1966), reveals that they actually belong in quite a different genus, which will be described and discussed in a subsequent paper.

There is still some uncertainty about the following, which have been assigned to *Dinocheirus* by other authors but have not been reexamined by me: *Chelanops aequalis* Banks, 1908 (see Hoff, 1947, p. 520); *C. obesus* Banks, 1909 (see Hoff, 1947, p. 517); *C. partitus* Banks, 1909 (see Hoff, 1947, p. 514); *C. serratus* Moles, 1914 (see Hoff, 1958, p. 28); *Dinocheirus solus* Hoff, 1949, p. 474; *D. texanus* Hoff and Clawson, 1952, p. 27; *D. venustus* Hoff and Clawson, 1952, p. 31; *D. athleticus* Hoff, 1956, p. 48.

No attempt has yet been made to examine the validity of the many species of *Dinocheirus* described from Central and South America. However, it can be predicted that many will be found to be properly assigned while others will have to be placed in other genera.

It is also apparent that the genus *Dinocheirus* is represented in Europe as well as in the Americas.

Dinocheirus bouvieri (Vachon), new combination

Epaphochernes bouvieri Vachon, 1936, p. 141.

It is perfectly clear from the original description and the figure of the spermathecae (Vachon, 1938, p. 99) that this species belongs in *Dinocheirus* as here defined. If further study should prove that this species is indeed the same as *Chelifer anachoreta* Simon as Beier indicates (1963, p. 257), then further action will be necessary.

Finally, there is strong presumption that some species presently assigned to *Toxochernes* also belong here (at least, some specimens considered to represent *T. panzeri* may be diagnosed as belonging to *Dinocheirus*). Resolution of this problem will depend upon much further study, including reexamination of the types of species assigned to *Toxochernes*.

SUMMARY

Members of the chernetid genera *Chernes*, *Hesperochernes*, and *Dinocheirus* are closely related and are quite varied. As a result it is often difficult to identify material

from these genera, especially if only a single individual is available in a collection. The following key usually allows proper placement into the genera, though incomplete, improperly prepared, or (occasionally) aberrant specimens may still give trouble.

The three genera belong to the Chernetidae and the species have as common characters: four setae in the cheliceral flagellum; cheliceral seta *sb* denticulate; on movable chelal finger, trichobothrium *st* closer to *t* than to *sb*; on fixed chelal finger, trichobothrium *ist* distad of *est*; no unusual protuberances on palpal chela; no setae unusual in being strongly expanded or feather-like; spermathecae of female paired, long, looped tubules. They can be distinguished as follows:

1a. Fourth tarsus with an acuminate tactile seta distal to midpoint of segment . . . . *Dinocheirus*
1b. Fourth tarsus without an acuminate tactile seta 2
2a. Setae *b* and *sb* of cheliceral hand both usually denticulate; spermathecae of female terminally expanded . . . . *Hesperochernes*
2b. Seta *sb* of cheliceral hand denticulate, *b* acuminate; spermathecae of female not terminally expanded . . . . *Chernes*

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EFFECTS OF D-AMPHETAMINE SULFATE AND DIAZEPAM ON THREAD CONNECTION FINE STRUCTURE IN A SPIDER'S WEB[1]

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ABSTRACT

Dextro-amphetamine and diazepam were administered orally to the spider *Araneus diadematus*. Thread connections from the spider's orb web were examined by photomicroscopy. Amphetamine altered fine structure but diazepam did not. Results are discussed in terms of disturbed spinning behavior.

INTRODUCTION

When a spider constructs its web, it produces a record of its web-building behavior which can be readily measured and quantified. Through the spider's web, we have a very sensitive measure of drug effects (Witt and Reed, 1968), and motor coordination disturbance has been indicated for a number of drugs. Previous studies, using such measures as radial angle regularity, spiral regularity, and total thread length, have dealt with the gross structure of the web. However, the spider does not merely place the threads in space according to a certain configuration, but fastens threads to each other at over 1000 distinct locations. The complex fine structure of thread connections has been described (Jackson, 1971), but the details of how the spider forms a thread connection are not known. Probably, fine coordination of body, leg, and spinneret movements plus coordinated functioning of several glands are involved. The present study investigated the possibility of using thread connection fine structure as a measure of drug effects on fine motor coordination.

Dextro-amphetamine, a central nervous system stimulant, was chosen because studies on web gross structure indicate that it causes motor coordination disturbance (Witt, Brettschneider, and Boris, 1961), and therefore it would be a likely candidate to produce alteration in thread connection fine structure, if the fine structure is sensitive to drugs. Diazepam, a tranquilizer, causes curtailment of thread expenditure with no effect on silk synthesis, but at the concentration used in the present study, motor coordination disturbance is not indicated (Reed and Witt, 1968). This drug was chosen because of the possibility that fine motor coordination disturbance might occur when a drug is administered to a spider and yet not be detected in the gross structure of the web.

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METHODS

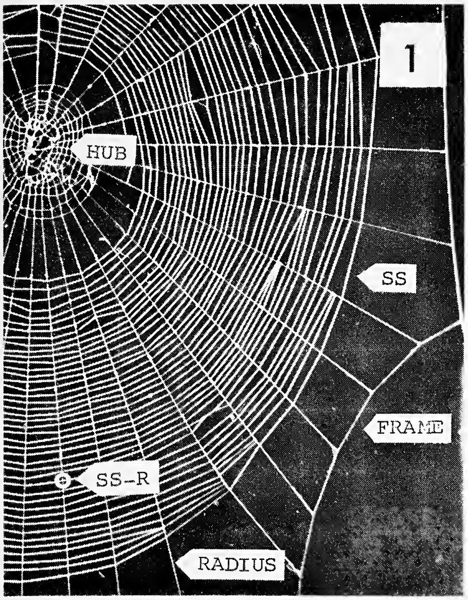
Adult females of *Araneus diadematus* Clerck were administered drugs in the previously determined effective doses of 100 mg/kg for diazepam (Reed and Witt, 1968) and 300 mg/kg for d-amphetamine sulfate (Witt et al., 1961). The pure substance was dissolved (or suspended) in sugar water and given to the spider in a volume of 100 μl with a Hamilton microsyringe. The spider drank the drop from the syringe as she sat on her web. Drugs were administered approximately 24 hours (diazepam) and 12 hours (amphetamine) previous to the spider's next web-building period. Once it was determined that the spider had consumed the drug, the old web was destroyed. Sticky spiral to radius connections (SS-R's) from the spider's next web were examined. This is the most abundant type of connection in the spider's web (Fig. 1). Thirteen SS-R's for amphetamine (amphetamine SS-R's) from 2 webs built by different spiders and 6 SS-R's for diazepam (diazepam SS-R's) from 2 webs built by different spiders were compared with 49 normal SS-R's from 15 webs of 8 spiders which were not given drugs. These normal SS-R's were described in a previous study (Jackson 1971). Procedures for maintaining the spiders and obtaining photomicrographs of thread connections were identical to those previously described (Jackson, 1971; Witt, 1971).

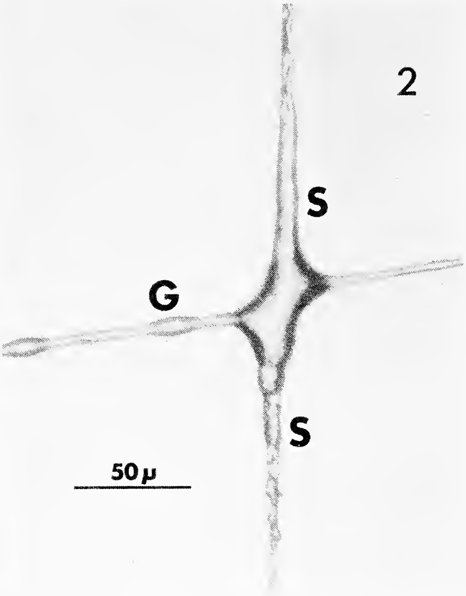
RESULTS

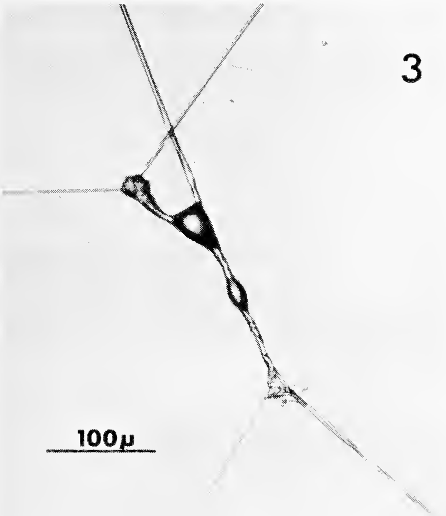
The fine structure of a normal SS-R is shown in Fig. 2. The appearance of a sleeve, i.e., a rougher appearing area on a radius or spiral thread near the junction, was one of the most characteristic features of a normal SS-R, but these were less abundant at amphetamine SS-R's. At normal and diazepam SS-R's there was always a sleeve on the radius at the side of the connection closer to the frame of the web, but 4 out of 13 amphetamine SS-R's did not have a sleeve at this location (Fig. 3 and 4). This was significantly different from normal SS-R's ($X^2 = 11.422$, df = 1, $P < 0.05$). There was a sleeve on the radius at the side of the connection closer to the hub of the web for 23 out of 49 normal SS-R's and 2 out of 6 diazepam SS-R's, but there was a sleeve at this location for only 1 out of 13 amphetamine SS-R's. Diazepam and normal SS-R's were not significantly different at the 0.05 level ($X^2 = 0.039$, df = 1, n. s.). Amphetamine SS-R's were significantly different from normal SS-R's ($X^2 = 5.118$, df = 1, $P < 0.05$). The thickness of spiral threads varied over a greater range at amphetamine SS-R's. The maximum thickness at normal and diazepam SS-R's was 5 μ; for amphetamine SS-R's it was 7 μ. The minimum for normal and diazepam SS-R's was 3 μ; for amphetamine SS-R's it was 2 μ. Three amphetamine SS-R's had globules on the radius (Fig. 4), which appeared to consist of the same substance as the globules on the spiral. Globules were not found on radii at normal and diazepam SS–R's. Due to the differences described here plus others which are less easily described, the overall appearance of amphetamine SS-R's was often rather bizarre when compared to normal and diazepam SS-R's (Fig. 3 and 4). For statistical analysis, no distinction was made between data from different webs for a given treatment. However, the effects reported for amphetamine occurred in both webs, and there were no obvious differences between the two webs of spiders treated with diazepam or among the webs of normal spiders.

DISCUSSION

This study has shown that, like the gross structure of the web, the fine structure of thread connections can be used as a measure of drug effects. Consistent with studies on







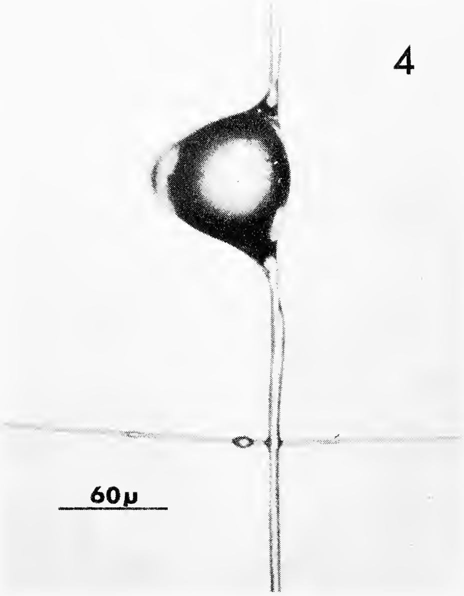


Fig. 1.—Lower right quarter of a normal web of *Araneus diadematus*. Note that sticky spiral to radius connections (SS-R) are the most common type of connection in the web. SS: sticky spiral.

Fig. 2.—Sticky spiral to radius connection from normal web. In photomicrograph, spiral runs horizontally, radius runs vertically, and upward is toward frame of web. Note sleeves (S) on radius and globules (G) on spiral.

Fig. 3.—Bizarre appearing sticky spiral to radius connection produced by amphetamine treated spider.

Fig. 4.—Sticky spiral to radius connection produced by amphetamine treated spider. In photomicrograph, spiral runs horizontally, radius runs vertically, and upward is toward frame of web. On radius, note large globule and absence of sleeves.

the gross structure of the web, there is evidence of motor coordination disturbance for amphetamine in the fine structure of thread connections, but at low doses not for diazepam. However, in the case of diazepam, the small sample size should be considered.

We would like to know precisely what components of the spider's spinning behavior were deleted or altered in those spiders which were administered amphetamine. This would be useful not only for understanding how drugs affect behavior but also in understanding how the normal spider fastens threads in the web. The normal spider goes through a fixed sequence of leg and body movements as it constructs a SS-R (Jacobi-Kleemann, 1953). Frame by frame motion picture analysis has shown that this sequence is still there after amphetamine has been administered (Peters, 1950), but the rhythm is altered, the spider sometimes moving significantly more slowly or more rapidly than usual (Witt, Reed, and Jackson, 1972). Altered rhythm may be at least partly responsible for the altered thread connection fine structure. For example, the plasticity of substances from the silk glands, either the silk itself of special glue substances (Jackson, 1971), may decrease radidly after leaving the spinnerets. Stretching movements slightly earlier or later that usual may produce very different effects. However, there is another possibility that needs to be considered. The spinnerets are capable of complex movements (Wilson, 1969), and the spider has 6 different types of silk glands (Peakall, 1969); but the fine motor coordination of spinneret movement and gland functioning during thread connection construction has not been analyzed in detail. Perhaps amphetamine produces disturbances at this level.

Some amphetamine SS-R's resembled artificial thread connections (Jackson, 1971) in general appearance, in lacking sleeves, and, in some cases, by having a globule on the radius. The artificial thread connections were made by taking a sticky spiral thread from the web and simply placing it across a radial or frame thread and, in some cases, stretching the spiral thread with an oil coated insect pin (Jackson, 1971). These connections were never securely fastened. Points at which threads touch but are not securely fastened are rare in the vertical web of *A. diadematus*; however such points are frequent in the horizontal orb web of *Uloborus diversus* (Eberhard, 1972). Perhaps amphetamine treated spiders sometimes do something similar to making an artificial connection, i.e. placing the threads and jerking the spiral but somehow failing to properly perform the more subtle behavior involved in fastening the threads.

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ON THE ARACHNID ORDER PALPIGRADI

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ABSTRACT

The opinion that the Palpigradi are a more primitive order of Arachnida that are the scorpions is taken as evidence that the Arachnida are a polyphyletic class. Their probably marine or littoral ancestors may have been of diverse character.

There has long been a habit, amounting almost to a tradition, of describing the scorpions as the most primitive order of Arachnida. This opinion, which dates back at least to 1902, when E. Ray Lankester wrote his long article on the class for the tenth edition of the Encyclopaedia Britannica, was based, no doubt soundly, on the resemblances between scorpions and some of the extinct Eurypterida. A relationship can hardly be gainsaid.

The primitive nature of the scorpions was assumed because of this resemblance. They were widely commended as being the first invertebrates to invade the land, and applauded for their success in establishing themselves in their new environment. But the uncritical acceptance of this must lead to the, perhaps unspoken, deduction that the arachnids of the other orders have arisen by evolution from this ambitious and pioneering stock. In other words, the implication is that the class Arachnida is monophyletic; and for this assumption there is, I believe, no evidence.

Two considerations arise. First, scorpions exhibit in their bodies many instances of elaborations. The large size and the chelate form of the pedipalpi, the existence of venom glands and sting in the telson, the presence of the mysterious pectines on the second abdominal sternite are external examples; the characteristic method of nourishing the young is internal and is associated with the birth of nymphs instead of the laying of eggs. This short list of specialisations is comparable to any similar list of the specialisations that help to characterise each and every one of the other orders, and recalls the important dictum that there are really no wholly primitive organisms but only primitive organs.

Secondly, there can be no justification for assuming that the exploring eurypterid which came ashore and lived to become the ancestor of *Protoscorpius* was the sole successful immigrant. The nature of the sea, from which the discontented creatures were compelled to escape, was no doubt unattractive to all; and it is only reasonable to suppose that several, perhaps many or very many, different types were similarly obliged to attempt the same landfall. It may well be true that "Animals are always attempting the impossible, and always achieving it," but side-by-side with their achievements there must have been many failures.

The successes may have been due to some form of pre-adaptation that unexpectedly became a vital attribute that made survival possible. Among the early terrestrial "Urarachnida" such pre-adaptation may have been the easy functioning of the gill-books of aquatic creatures as the lung-books of terrestrial animals, and perhaps also the presence of a layer of wax in the epidermis.

There is, however, another possibility, which should not be overlooked.

One obstacle to the exchange of the water for the land may have been the difficulty of using gills, adapted to take in oxygen from solution, as lungs adapted to the oxygen of the air. But if there were no respiratory organs the problem presents another aspect.

A very small animal has a surface large enough to admit by diffusion all the oxygen that it requires; and as long as the surface is wet its efficiency as a respiratory organ remains unimpaired. The small animals that live continuously under conditions of high relative humidity are known as the cryptozoa.

One of the chief general features of the cryptozoa as we know them is the high proportion of primitive types that are numbered among them. Indeed, it has been said that where a vetebrate palaeontologist looks for fossils an invertebrate palaeontologist looks for cryptozoa.

Our interpretation of the taxonomic position of the Palpigradi now becomes obvious. We may reasonably imagine a small marine 'proto-arachnid' leaving the almost uninhabitable sea and seeking asylum under the organic debris that littered the primaeval shore. Here, "in the dark and the damp" it was able to survive, its outer surface always sufficiently moist. Provided only that it could feed itself on whatever it may have been that its new home provided, continued life was reasonably assured.

Here, then, is a possible pedigree for the order that was discovered by P. Grassi in 1883 and placed at once in a new order which he called Microthelyphonidae. The order now contains about four dozen species and five genera, *Eukoenenia* Börner, 1901; *Prokoenenia*, Börner, 1901; *Allokoenenia* Silvestri, 1913; *Koeneniodes* Silvestri, 1913. *Leptokoenenia* was added by Condé in 1965 and is of special interest because its species live in the littoral zone, between the tide-marks.

The conclusion towards which we are now moving receives support from three different sources. The first of these is the high proportion of the organs of Palpigradi that have retained their primitive condition, and to make this plain one may follow the arachnid body from chelicerae to telson and note the state of the regions and organs one by one. This is conveniently demonstrated in Table 1, from which it may be seen that 80% of the attributes considered show no specialisations.

Table 1.—Comparison of primitive and advanced conditions in Palpigradi.

Part or Organ	Primitive State	Advanced State	State in Palpigradi
Carapace	Segmented	Uniform	Primitive
Opisthosoma	Segmented	Uniform	Primitive
Pedicel	Absent	Present	Primitive
Flagellum	Present	Absent	Primitive
Chelicerae	Three podomeres	Two podomeres	Primitive
Pedipalpi	Pediform	Chelate	Primitive
Sternum	Segmented	Uniform	Primitive
Legs I	Motor organs	Sensory organs	Advanced
Legs II-IV	Seven podomeres	Sub-segmentation	Advanced
Gnathobases	Absent	Present	Primitive

The second source is the somewhat unexpected quality of toughness in the animal as a whole, which contributed not a little to its ability to withstand the trauma of its original migration. This quality it has retained, as two striking examples confirm. In 1914 Lucien Berland reported the presence of a species acclimatised to life in the Museum de Paris; and in 1933 another was found living on Mount Osmound, near Adelaide. These occurrences are probably the results of chance transport in the baggage of man, and their existence supports the idea that Koenenia is both resistant and adaptable, as long as the precise milieu is tolerable.

Thirdly, there is geological evidence to be considered.

Unmistakable fossil Palpigradi have not been found, but the Jurassic *Sternarthron* from Germany demands some consideration. Its chief difference from recent Palpigradi is the existence of six distinct sternites in the prosoma, so that it has been placed in a family of its own, the Sternarthonidae. Millot has, however, stated that "il ne lui appartient vraisemblablement pas."

Whichever view is accepted, it is reasonable to see in *Sternarthron* either the ancestor of *Koenenia* or a type closely allied to it. Two features are significant. The size of *Sternarthron*, about 14 mm in length, is some six times the length of any living Palpigrade. So, too, was *Gigantoscorpius* at 36 mm, or nearly three times the size of the larger living species of scorpion.

Moreover, both *Gigantoscorpius* and *Sternarthron* are remarkable for their slender legs, which must have been too delicate to support their body weight. The deduction from this is that both lived in the shallows, where they were partly supported by the water, and where the opportunity for excursions ashore would be most favourable. The presence today of *Leptokoenenia* in just such a habitat gives welcome support to this speculation.

The general conclusion is, therefore, that the Palpigradi represent the earliest type of arachnid to have been evolved; and that they have brought from the sea, and have retained, a higher proportion of ancestral characteristics than has any other order. Thus they may properly occupy a subclass by themselves.

Other subclasses may well have had similar histories, as indeed have the scorpions, by general consent. These pedigrees may well go back to other adventurous kinds of Eurypterida, but since these were neither *Sternarthron* nor its relation, they represent distinct and parallel origins for the modern Arachnida.

The class Arachnida should therefore be regarded as a polyphyletic group, comprising several lines of descent from eurypterid-like ancestors. The temptation to describe and figure a single hypothetical archearachnid should be avoided.

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REMARKS ON THE NAMES OF FAMILIES AND HIGHER TAXA IN SPIDERS

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ABSTRACT

The following names for suprageneric taxa are discussed, and for some of them an indication of their status is given: Dionycha, Trionycha, Dionychae, Trionychae, Dionychi, Trionychi, Hypochilina, Hypochilomorphae, Dipneumonina, Dipneumonomorphae, Quadrostiatae, Quadrostiati, Araneae, Aranei, Araneida, Araneidae, Argiopidae, Linyphiidae, Micryphantidae, Erigonidae, Scytodidae, Sparassidae, Eurparassidae, Amaurobiidae, Ciniflonidae, Drassidae, Drassodidae, and Gnaphosidae.

INTRODUCTION

In the course of preparing the Supplement to my 1948 work, the Spiders of Connecticut, it has been necessary to take into account various name changes. While most of these concern generic and specific names there are a few instances where the names of higher taxa are involved. The possibility that I might have to consider changing these names is occasioned by the appearance since 1948 of two large contributions by Petrunkevitch (1955, 1958), and of course the great Bibliographia Araneorum of Bonnet. I find myself in a position somewhat analogous to that in which Bonnet found himself, which necessitated his publishing a whole series of notes, "Difficultés de Nomenclature chez les Aranéides," or with a similar title.

THE ENDINGS OF THE NAMES OF SUPERFAMILIES AND OTHER HIGHER TAXA.

In 1955 Petrunkevitch listed a number of names of superfamilies with the comment that he had "corrected" the spelling so that they would end in -oidea. As a matter of fact this ending for superfamilies had already been used by Berland (1932), Bristowe(1938), myself (1948), and Gertsch (1949). I had used this ending to conform with Section 110 of the Banks and Caudell Entomological Code, and now the most recent edition of the International Code of Zoological Nomenclature (ICZN) recommends it.

Petrunkevitch also changed the endings of the names of some still higher taxa. What in 1928 he had called the Dionycha and Trionycha (Latin, neuter plural ending), became Dionychae and Trionychae (feminine plural ending) in 1933, and Dionychi and Trionychi (masculine plural ending) in 1955. The Hypochilomorphae, Dipneumonomorphae and Quadrostiatae, among others of 1933 became the Hypochilina, Dipneumonia, and Quadrostiati of 1958. I am unable to suggest an explanation of all these changes.

Although the Order name Araneae had been in use for more than a century it was changed by Petrunkevitch (1958) to Aranei, and this orthography has also been used by Chrysanthus, Proszynski, and Thaler. Undoubtedly they reasoned that the name Araneae being the Latin plural for Linnaeus' *Aranea* (=spider) it would have to be supplanted by the plural form for the masculine *Araneus* after the legalizing of the Clerkian name in 1948. However, since the ICZN does not deal with the names of higher categories there is nothing that requires such a change, or that indicates how the names of Orders are to be formed.

ARANEAE–ARANEIDA

For many workers this omission is of no concern because they, especially the French (except Simon who used Araneae) prefer the orthography Araneida. But this then would appear to come in conflict with the family name Araneidae, and on this account Bonnet rejects Araneidae and prefers Argiopidae. Levi (1968:320) states "Bonnet, in his authoritative Bibliographia Araneorum reasoned that the name Araneidae is so similar to the name of the Order Araneae as to create confusion." That the confusion is with Araneida (not Araneae) can be seen from the following quotation from Bonnet's work (1955:700): "en effet c'est *Araneidae* (ainsi que certains auteurs l'ont fait) qu'aurait dû normalement s'appeler cette famille; mais cela aurait créé une grande confusion avec tout l'ordre des *Araneidae* [sic]." This very confusion was undoubtedly responsible for the misspelling of the last word, since he meant, of course, *Araneida*!

While Levi (1968:320) correctly indicated that Latreille's Araneides and Leach's Araneadae can be considered as family names it should be pointed out that these two writers included *all* spiders in one family, so that the name was really used by them in an Order sense. The taxon family in a modern sense had not yet come into use.

MICRYPHANTIDAE–ERIGONIDAE

Araneologists are still not in agreement as to which name should be used for a very large family of small spiders, and which is by some workers considered merely as a subfamily of the Linyphiidae. Locket and Millidge (1953) have given reasons why Micryphantidae may be questionable from the point of view of taxonomy, a matter to which I had briefly referred in my 1943 paper. Platnick and Levi (1973) discuss it further. Petrunkevitch had used Erigonidae in 1939 and 1958, but Micryphantidae in 1933, 1942, and 1955. In this latter paper the name was correctly credited to Bertkau, though the date should have been given, not as 1885, but 1872. Further, Petrunkevitch gave Erigonidae as a synonym "(ex: Erigoninae Simon 1926)." In the 1958 paper he stated his reasons for changing, and these were not based on taxonomy, but were purely nomenclatorial. The following remarks concern that aspect.

On page 148 of the 1958 paper appears the following: "Family Erigonidae Walck. 1837 Nom correct. pro Erigonides (Latin given by Walck. himself on p. 345 of vol. II) (=Micryphantidae)." In the first place the date of Walckenaer's Histoire Naturelle des Insectes Aptères, volume II has long been known to be 1841, not 1837. In the second place the correction in spelling is not from the orthography "Erigonides" but from "Erigonae." The orthographic form "Erigonides" was used not for family but for race. In a footnote on page 375 Petrunkevitch has these data correctly given, and then states that he prefers Erigonidae over the name Micryphantidae because of page priority, the latter appearing on page 348, but the former on page 345. The reader is given to understand that Walckenaer was using the two terms for members of what Petrunkevitch considers the same family.

Now if one analyzes Walckenaer's work one finds that he included 36 species in the genus *Argus*, and that these were arranged in eight "races," which in turn were placed in three "familles," viz., the Erigonae, the Micryphantes, and the Melicerides. Quite obviously the terms "race" and "famille" are meant for subgeneric taxa! That this is so can also be seen by the fact that he included his Famille Epeirides, his Famille Theridionides, and his Famille Linyphides as groups within the genus *Linyphia*, while his genus *Epeira* contains eight families. A selection of familiar species from this genus (with their currently accepted names) include: *Araneus diadematus* in the Family Ovalaires; *A. cucurbitinus* in the Fam. Inclinees; *Nephila clavipes* in the Fam. Elongatae; *Argiope aurantia* in the Fam. Decoratae; *Acanthepeira stellata* in the Fam. Encarpatae; *Wixia ectypa* in the Fam. Triangularae gibbosae; and *Verrucosa arenata* in the Fam. Irregulares. Still another indication that Walckenaer was not using his "Famille" in the sense that we understand "Family" is that the same names were used in more than one place. For example, besides putting the Fam. Epeirides in *Linyphia* he also put it in the genus *Plectana*, and has a Fam. Ovatae in *Theridion*, one in *Linyphia*, and another in *Epeira*!

I believe it is clear that if the name Erigonidae *is* to be used is should certainly not be credited to Walckenaer. There is no more reason to accept his name for this family than to accept his Fam. Saltatoriae, which appears under the genus *Attus*, or his Sparassoides under *Olios*, or his Clubionides under *Sparassus*. The spiders he placed in *Clubiona* are not included in his Fam. Clubionides. To be consistent, since he credited Walckenaer with the name Erigonidae, Petrunkevitch should have also credited Walckenaer with the family names Salticidae, Sparassidae, Clubionidae, and Linyphiidae! The latter name he had first (1955) credited to Dahl 1913, then later (1958) to Blackwall 1861. The name *does* go back to Blackwall, but to an 1859 paper. That he had known of the peculiarities of Walckenaer's system is indicated by the fact that in his 1955 paper he commented on this, and included a footnote on page 135 discussing the way in which DeGeer treated the term family, and concluded with the remark "Walckenaer followed this same principle."

I had previously (1938) stated that the name Erigonidae dated from Gerhardt 1923. But Bonnet (1957:2913) correctly indicated that the name should actually be credited to Simon 1884. This would be in accordance with Article 36 of the ICZN, since Simon had used the term "Section Erigonini" for a taxon quite clearly in the family group category. Bonnet conceded that the name Micryphantidae might have priority over Erigonidae, but nowhere in his extensive work is there mention of Walckenaer's terms Erigonae and Erigonides.

THE USE OF MIHI. SPARASSIDAE–EUSPARASSIDAE

It was the common habit of many workers to include the word "mihi" after names which they themselves had introduced in nomenclature. Sometimes this word was used in error, particularly by Bertkau in 1878, as I have already pointed out (1938:638). Bonnet called attention to this (1958:4037) in connection with the name Scytodidae, expressing concern and wonderment that Bertkau "se soit attribué la création d'une famille qui existait déjà depuis quatorze ans." In actual fact the name was introduced (by Blackwall) not 14, but 26 years earlier. Bertkau also appended "mihi" to Sparassidae. In this connection Bonnet remarked (1958:4096), "Il est étrange que Bertkau s'attribue la paternité du nom de cette famille que Simon avait créé quatre ans plus tôt et que Kaston n'ait pas repéré la citation originale de Simon." But in *this* case Bertkau was perfectly justified, for as I have shown, he used the name for the first time not 1878, as Bonnet and also Petrunkevitch (1955:146) imply, but in 1872, two years before Simon used it. And contrary to Bonnet's statement I had not overlooked Simon's contribution, but supplied a lengthy discussion (1938:638).

For workers who consider *Sparassus* a synonym of *Eusparassus* the family name Eusparassidae would be proper, and Bonnet (1956:1835) credits this latter name to Gravely 1931. But in the title of his paper Gravely used Sparassidae, and where in the paper proper he *did* use Eusparassidae it was credtied to Petrunkevitch 1928, not to himself. Petrunkevitch (1958) credits the name to himself but as of 1939. Presumably this refers to its use for family rather than subfamily) status. However, according to Platnick and Levi (1973) credit should go to Jarvi 1912, and not to Caporiacco as I had erroneously indicated in 1943.

AMAUROBIIDAE–CINIFLONIDAE

Petrunkevitch (1955:140) credits the name Amaurobiidae to C. L. Koch 1868. Since C. L. Koch died in 1857 the latter's son, L. Koch, must have been meant. Yet reference to L. Koch's 1868 paper reveals no mention of the name Amaurobiidae, though the name Ciniflonidae does appear. This kind of *lapsus* as well as numerous other kinds abound in the writings of Petrunkevitch, and Bonnet (1953:156), in attempting an explanation of the many errors by this author assumed it likely that careless clerical assistants were to blame. In Petrunkevitch's 1955 and 1958 papers very many of the names were credited to the wrong authors, or were given with incorrect dates. Although it was Bertkau who in 1878 first used the name Amaurobiidae, Bonnet is correct in crediting authorship to Thorell who in 1870 first used the name for a family group (Amaurobiinae). Whether we should use Amaurobiidae or Ciniflonidae depends on the status of the genus name. Besides my own comments (1943:765) additional remarks have been published by Bonnet (1955:272), Cloudsley-Thompson (1957:135), and Kraus (1962). Levi and Kraus (1964), in the interest of continuing stability have requested the International Commission on Zoological Nomenclature to suppress *Ciniflo* and Ciniflonidae, and to place *Amaurobius* and Amaurobiidae on the Official Indices of Generic and Family Names in Zoology. As pointed out by Platnick and Levi (1973) "existing usage [by the majority of workers] (Amaurobiidae) is to be maintained until the decision of the Commission is published."

DRASSIDAE–DRASSODIDAE–GNAPHOSIDAE

Petrunkevitch (1955, 1958) continued his rejection of the name Gnaphosidae, and even dates the name Drassodidae from his own usage of 1942. Not only was Drassodidae first used by Berland in 1932, but despite the lengthy discussion given by Bonnet (1956:1554) the reasons against its use as a substitute for Drassidae are just as valid today as when I previously discussed the matter (1943:766, 1948:341). Gnaphosidae is the valid name and has many years of usage going back to 1898.

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REARING METHODS FOR SPIDERS

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ABSTRACT

A rearing method is reported which provides spiders with a continual supply of food and water. Using this method, spiders have been reared from egg to adult with low mortality. Other rearing methods for spiders are reviewed.

Rearing and maintaining spiders in captivity is often a rather laborious task, especially when large numbers are involved. Three basic problems must be dealt with: providing food and water, preventing cannibalism, and minimizing maintenance time. Numerous rearing and maintenance methods for spiders have been described in books on spiders, in papers on rearing spiders, and in the methods sections of papers on original research. I will review a number of these and describe a convenient rearing method which I have used for jumping spiders (Salticidae). Of course, the optimal rearing method will depend on the species of spider and the interest of the researcher; also new methods will undoubtedly be continually designed. The review and method presented in this paper should offer a useful source of ideas.

The most common rearing method seems to consist of confining the spider in a container of some sort, opening the container from time to time to add food and water. The containers used have included: a. glass jars and tumblers covered by wire screen (Bonnet, 1930), cheesecloth (Burger, 1937), mosquito netting (Crane, 1948), and cotton cloth (Hollis and Branson, 1964); jars with holes in the metal lids (Rovner, 1968); and jars stoppered with either polyurethane foam or cotton wrapped in cheesecloth (Kaston, 1972); b. glass vials and tubes stoppered with corks (Bonnet, 1930; Branch, 1942; Cooke, 1962), cotton (Branch, 1942; Peck and Whitcomb, 1967; Nakamura, 1968; Miyashita, 1969), and polyurethane foam (Kaston, 1970); c. finger bowls covered by glass (Rovner, 1968); d. plastic boxes (Cooke, 1962; Miyashita, 1968); e. cardboard ice cream containers covered by petri dishes or glass plates (Whitcomb and Eason, 1965); f. for orb weavers (Araneidae), aluminum frames with removable glass doors (Witt, 1971).

Maintaining each spider in a separate container has been the most commonly used means of preventing cannibalism. Live insects, usually house flies (*Musca domestica*) and Drosophila, have been used for food most often, although some work has been done with artificial diets (Peck and Whitcomb, 1968). Feeding methods frequently include anesthetizing the flies for sorting and transferring, although Brown (1946) described a useful method for transferring individual Drosophila without using anesthesia. Depending on the species, water for drinking (Parry, 1954) and/or humidity may be important.

Some provisions include placing the following items inside the spider's container: a glass dish filled with water (Bonnet, 1930), a wet cork (Brown, 1946), wet cotton (Hollis and Branson, 1964), wet cotton covered with filter paper (Nakamura, 1968), a wet cotton roll (dental wad) (Crane, 1948), small vials and tubes filled with water and plugged with cotton (Miyashita, 1968; Rovner, 1968), wet plaster of Paris (calcium sulfate) (Edgar, 1971), and wet plaster of Paris mixed with sand (Cooke, 1962). Another method used by Bonnet (1930) was to fill the bottom of jars with water. A ring of cork floating in the water, or a stick of wood propped against the inside of the jar served as a substrate for the spider. Parry (1954) kept spiders in glass covered flower pots containing soil. Soil wetness was maintained by keeping the flower pots in trays of water. Burger (1937) used cheesecloth covered glass tumblers. Food and water were introduced through a thistle tube inserted in a hole in the cheesecloth. Cooke (1962) stoppered glass tubes with corks in which there were two holes. Each hole contained a smaller glass tube. One was filled with water and stoppered with cotton at both ends. The other tube, used for ventilation and introduction of prey, was stoppered at one end with cotton.

Concurrent with a study (in progress) of the reproductive biology of a jumping spider *Phidippus johnsoni* Peckham, a rearing cage was designed which provides a continual food and water supply to the spider without frequent opening of the cage (Fig. 1). Using these cages, large numbers of spiders have been conveniently reared from egg to adult with low mortality. For example, in a life history study (in progress) data were kept on 39 individuals from the time they departed from the egg cocoon. Nine either escaped, were accidentally killed, or were intentionally killed and preserved. Of the remaining 30, 26 lived to become adults.

In the following discussion, refer to Fig. 1 for explanation of abbreviations appearing in parentheses. The cages were made from 11 X 8 X 6 cm clear perplex freezer dishes (sandwich boxes). A 45 mm diameter ventilation hole (H) was covered by mesh No. 40 milk strainer cloth (brass screen). Moisture was continually provided to the interior of the cage by means of a 10 X 75 mm cotton roll (dental wad) (CR), the top of which protruded into the cage through a hole in the cage and the bottom of which was set in a 45 X 85 mm glass jar filled with water (JW). Sometimes mold growth appeared on the cotton roll. When this occurred, the cotton roll was easily discarded and replaced by a new one. The top of a 25 X 95 mm shell vial (V) protruded through a hole in the cage. The bottom of the vial was set in a 45 X 85 mm jar which supported the cage. Usually a single spider was kept in each cage. When the cage was used for a small spiderling, vestigial winged *Drosophila melanogaster* were reared in the shell vial, using Instant Drosophila Media (Carolina Biological Supply Co.) plus yeast. A strip of paper was placed in the vial to enable the Drosophila to more easily climb into the cage. With this method, emerging adult Drosophila were continually present in the cage with the spiderling. By exchanging the vials, old Drosophila cultures were easily replaced by new ones as needed. Usually this was necessary no more than once every two weeks. Larger spiderlings and adults were fed houseflies (*Musca domestica*). The shell vials were then provided with sugar cubes as a source of food for the houseflies, and new houseflies were introduced as necessary to maintain a supply of 3 to 8 in the spider's cage at all times. Using this procedure, new flies had to be provided no more than once or twice a week. Adult houseflies were obtained from our Entomology Department, and maintained on sugar and water in a 125 X 155 X 155 mm metal, screen box. Flies were taken from the box individually by hand with a piece of cheesecloth and introduced into the spider's cage through a 10 mm diameter cork hole (CH). Holding the cheesecloth between one's thumb and fingers, a fly

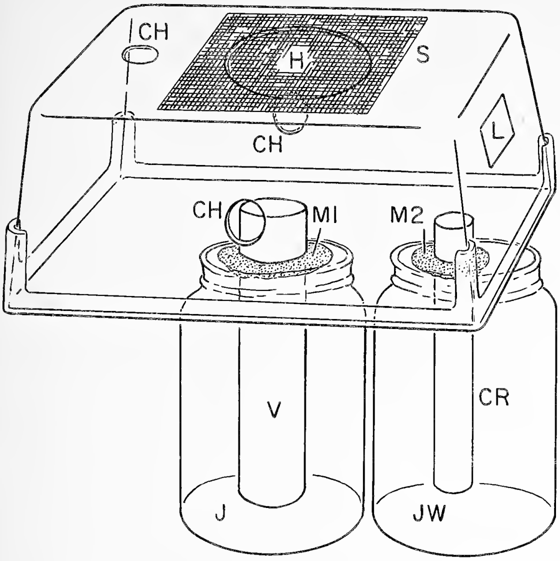

Fig. 1.–Rearing cage. CH, cork hole; CR, cotton roll (dental wad); H, ventilation hole; J, glass jar; JW, glass jar filled with water; L, label; M1, modeling clay around hole for vial; M2, modeling clay around hole for cotton roll; S, brass screen (milk strainer).

could be pinned to the side of the box and picked up without anesthesia and with no obvious injury to the fly. The cage had more than one cork hole. When the spider built its nest (retreat) on one of the corks, the flies could be introduced through a different cork hole without damaging the nest.

Modeling clay (plasticene) was used to hold the shell vial and cotton roll in position. Holes for corks and cotton rolls were burned through the plastic with a soldering iron. The larger holes for the vial and ventilation were burned through with heated metal pipes. The brass screen was fastened by melting the plasticene with a soldering iron and allowing it to solidify around the screen.

In addition to *P. johnsoni*, these cages have been used for rearing two other jumping spiders from egg to adult, *P. regius* C. L. Koch and *Plexippus paykulli* Andouin. However, this rearing method should be readily adaptable to a wide variety of spider species. Numerous modifications of this basic design are possible. For example, larger cages (100 X 265 X 400 mm) with two cotton rolls and three shell vials have been used for maintaining more that one spider in a single cage.

ACKNOWLEDGEMENTS

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FEEDING ON EGGS BY SPIDERLINGS OF *ACHAEARANEA TEPIDARIORUM* (ARANEAE, THERIDIIDAE), AND THE SIGNIFICANCE OF THE QUIESCENT INSTAR IN SPIDERS[1]

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ABSTRACT

Feeding on inviable eggs by spiderlings is known to occur in several families. This activity has been observed in the first (quiescent) instar only, leading to the general belief that this first instar always undertakes the utilization of such eggs. However, the present study indicates that egg feeding occurs in the second instar in *Achaearanea tepidariorum* (Theridiidae), with the reduction in time period of the quiescent instar. There seems to be a tendency in the Theridiidae (and, perhaps, in some related families as well) toward the elimination of the quiescent instar. Egg-feeding considerably extends the life span of spiderlings and, sometimes, provides enough nourishment to carry spiderlings to the third instar without additional food intake.

INTRODUCTION

It should be readily apparent to arachnologists that, in many cases, some of the spiderlings emerging from an egg sac are heavier than the rest, having a more bulky abdomen. This condition is correlated with the presence of dried eggs inside the sac. The consumption of unfertilized (or otherwise inviable) eggs is known to occur in several families of spiders (Lecaillon, 1904; Holm, 1940; Schick, 1972), although seldom observed and photographed (Peck and Whitcomb, 1970). This feeding activity has been directly observed only in the first instar (i.e., before the first true molt), leading many workers to suppose that egg-feeding takes place only in this instar. However, the data herein reported on *Achaearanea tepidariorum* (C. L. Koch) reveal the presence of a different strategy.

MATERIALS AND METHODS

Several adult female spiders were kept under controlled conditions to provide fresh eggs of known age. Egg sacs were separated from the maternal web and kept in a constant temperature (24.5 ± 0.3°C) cabinet. Some hatched spiderlings were individually isolated in vials before the first true molt (i.e., while in the first instar). Others were permitted to molt and emerge from the sac, and then were isolated. These two groups of

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spiderlings were kept without food to measure their survival capacity. The vials were checked daily and the number of dead spiderlings recorded. Groups of eggs were checked daily under the dissecting microscope to study morphological changes related to reversion, rupture of chorion and first molt. Some eggs were submerged in paraffin oil according to the method of Holm (1940) to render the chorion transparent so that the embryo could be observed.

RESULTS AND COMMENTS

In the group of spiderlings isolated before the first molt, all individuals had died by the 23rd day. In the group of individuals isolated after emergence from the egg sac, (thus, after the first molt), about 25% survived beyond the 23rd day (Fig. 1). Furthermore, over 3% of these spiderlings molted to the third instar (Table 1).

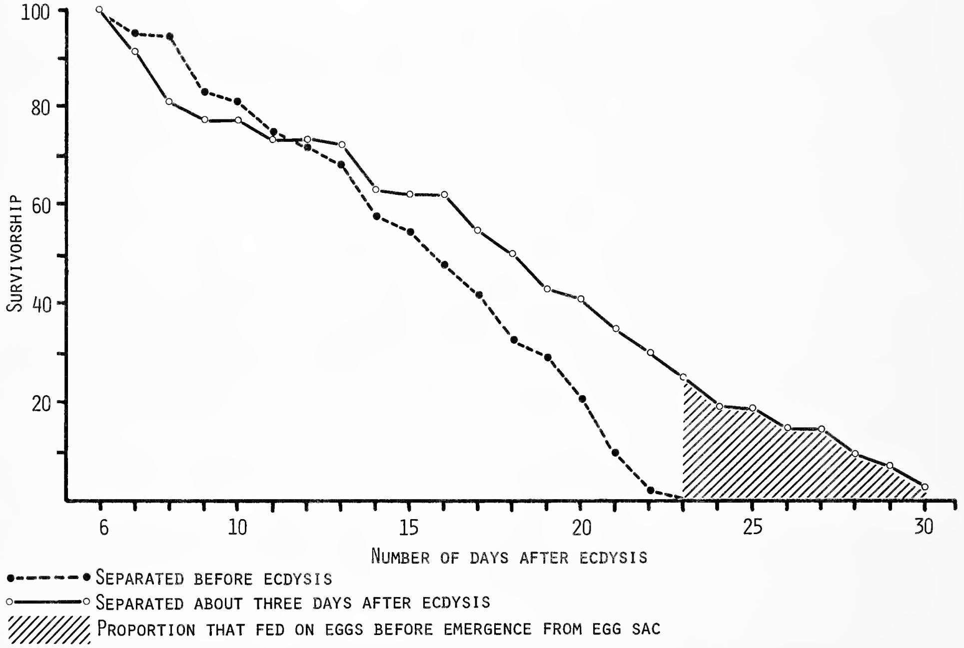

Fig. 1.—Survival in unfed spiderlings of *Achaearanea tepidariorum* kept individually isolated.

Early Development—During their development, all spiders pass through one or more quiescent stages immediately following eclosion. A variety of names has been applied to these stages in the literature: incomplete stadia (Holm, 1940), nymphs (Vachon, 1953) and deutova (Gertsch, 1949), among others. Many embryonic characteristics are retained, e.g., lack of segmentation in the appendages and traces of abdominal segmentation in some species. Hairs and pigmentation are absent, and motility is very poorly coordinated.

In species with more than one such stages, feeding on inviable eggs seems to be a widespread phenomenon in the families Scytodidae (Hite, et al., 1966; Galiano, 1967), Clubionidae (Lecaillon, 1904; Peck and Whitcomb, 1970), Gnaphosidae (Holm, 1940) and Thomisidae (Schick, 1972). However, species with only one quiescent stage of short

Table 1.–Survival in unfed spiderlings (*Achaearanea tepidariorum*) kept individually isolated ([1] molted to third instar).

	Isolated immediately after emergence from egg sac		Isolated just before ecdysis (or during the process)	
Day after ecdysis	Numbers	Percentage	Numbers	Percentage
6	90	100.00	77	100.00
7	82	91.11	74	96.10
8	73	81.11	73	94.80
9	69	76.67	64	83.12
10	60	76.67	62	80.50
11	66	73.33	58	75.33
12	66	73.33	56	72.73
13	65	72.22	52	67.53
14	57	63.33	45	58.40
15	56	62.22	43	55.84
16	56	62.22	37	48.05
17	50	55.56	33	42.86
18	45	50.00	26	33.77
19	39	43.33	22	28.57
20	37	41.11	16	20.78
21	31	34.45	8	10.39
22	27	30.00	2	2.60
23	22	24.45	0	–
24	17	18.89		
25	16	17.78		
26	13	14.45		
27	13	14.45		
28	8	8.89		
29	5	6.67		
30	3[1]	3.33		

duration, like *A. tepidariorum* and possibly all theridiids, have their digestive tracts still full with yolk (Dawydoff, 1949) and feeding is unlikely to occur, if in fact it is not impossible. This assumption is further supported by the particularly feeble and uncoordinated movements in this second group. Yet survival in this stage in *A. tepidariorum* is very high (98.46% in laboratory rearings).

Several literature reports on feeding by this stage in the family Theridiidae (Juberthie, 1957; Bouillon, 1957; Kaston, 1970) appear to be the result of incomplete observations. Feeding does occur inside the egg sac by the second-instar spiderlings, as is reported herein (see below) but not by the quiescent instar. Information on related families is completely lacking.

Adaptative value of this first instar has been questioned by Gertsch (1949), since it represents an unnecessary exposure with apparently no adaptive gain (the stage could have been passed inside the egg). This situation is comparable to the life cycle of insects with complete metamorphosis, in which a quiescent stage also occurs (pupa). But in the latter case the pupa follows active feeding instars, and provides a protective structure for important physiological and morphological changes. It has been suggested by Schick (1972) that the sole function of quiescent stages in spiders is to allow feeding on inviable eggs, to produce stronger spiderlings in the next instar. This latter hypothesis seems tenable where the phenomenon is known to occur. In theridiids, however, and perhaps in other related families, there is an associated tendency for temporal reduction of the quiescent instar.

Nomenclatural Systems—Presently used terminology for different stages in the development of spiders is chaotic. Some workers seem to ignore or misunderstand terms used by previous investigators. In other cases, apparent conflicts between systems are just the effect of differences among the species under study. For instance, the phenomenon of "reversion" is considered a basic turning point in some systems, and totally ignored by others.

After analysis of the literature and comparisons among the main systems and opinions, I have concluded that all developmental sequences can be grouped into three nomenclatural categories. This division is based on two simple characteristics: 1) Reversion or eclosion can be considered the end of the embryonic period; 2) Free hunting stages can be considered totally different or a nomenclatural continuation of quiescent stages (Fig. 2).

The three categories are characterized as follows:

I. The embryonic stage is defined as continuing until eclosion. The same nomenclature is used for the quiescent and active instars. This category includes the ideas of Ewing (1918), Hite, et al. (1966), and Peck and Whitcomb (1970).

II. The embryonic stage is also considered to continue until eclosion. However, a different nomenclature is used for the quiescent and active stages. Authors supporting this system are Holm (1940), Juberthie (1964), Eason and Whitcomb (1965), and Gertsch (1949).

III. The embryonic stage is considered to end with reversion. A different nomenclature is used for the quiescent and active instars. This system was basically developed by Vachon (1953, 1957) and was followed or modified by Galiano (1967, 1969) and Schick (1972).

Reversion (from the German *umrollumg*; *inversion* in French and Spanish) is, basically, the moving of the ventral structures derived from the germ layer to a dorsal position (Dawydoff, 1949). It is exclusively characteristic of arachnids, and well studied in the Araneae by embryologists, although largely overlooked or totally ignored by workers doing life history studies.

In *A. tepidariorum* reversion is completed by the fifth day (at 217 hours, according to Montgomery, 1909). As a result of reversion and of developmental changes associated with it, the exuvial liquid is absorbed by the embryo and then the chorion outlines the body and the appendages. This new appearance is easily detected, even with the naked eye.

Four days after reversion, eclosion occurs (i.e., shedding of the chorion and vitelline membrane, simultaneously in this species). The stage resulting after eclosion is then not enveloped in any membrane and molts directly into the active instar. The egg teeth were not observed, but the egg inclosure ruptures along the anterior margin of the clypeus.

Duration of the First Instar—The first instar is composed, then, of a single stage of a two-day duration. Almost half of the duration of this quiescent instar is actually the pharate second instar. That is, the second instar is anatomically achieved (apolysis) some 30 hours after eclosion, but the old skin is not shed (ecdysis) until some 18 hours later. The nomenclature here follows Jenkin (1966) and Jenkin and Hinton (1966). The hairs and well-pigmented eyes of this pharate second instar can be easily seen through the first instar skin.

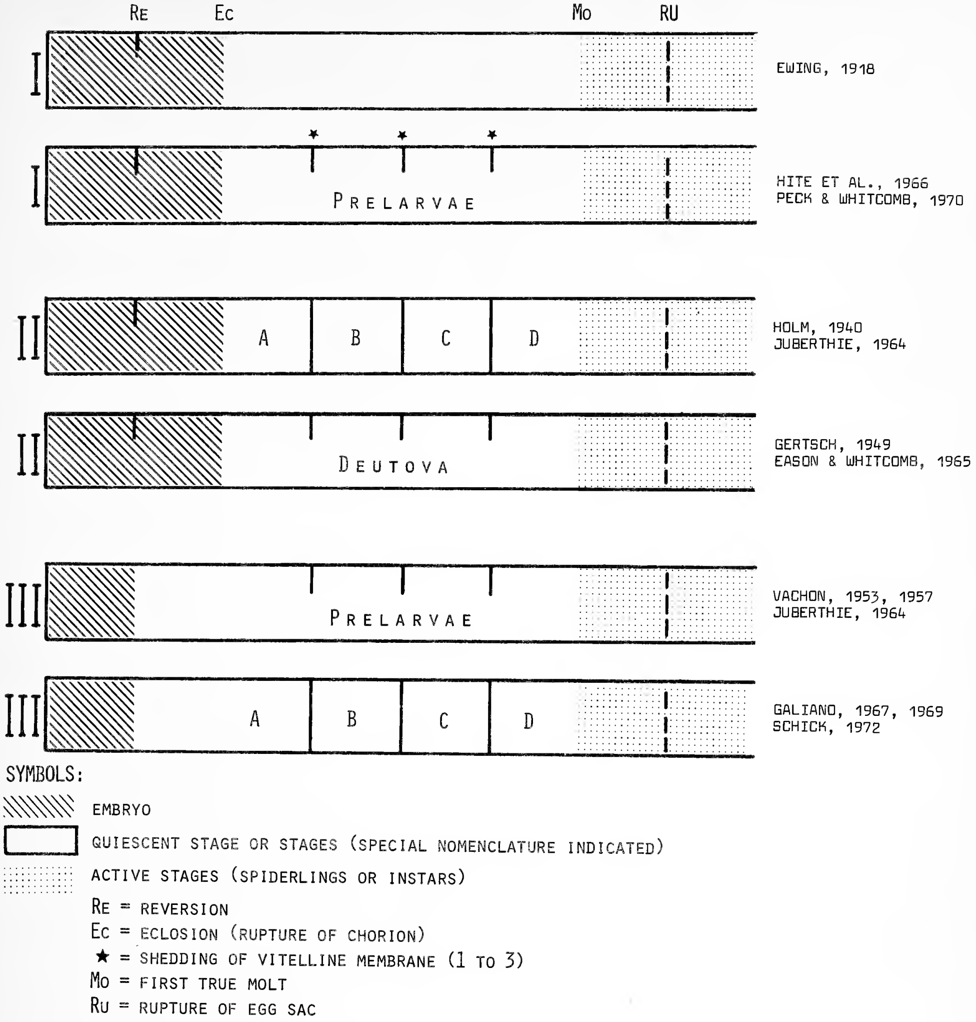

Fig. 2.—Principal nomenclatural systems in spider embryology and early development.

Feeding—After ecdysis the first active spiderlings (second instar) remains inside the egg sac for four days, a period during which the spiderlings normally feed on eggs that did not complete development. This period seems to vary with ambient temperature and other ecological factors such as wind and humidity; after which one or sometimes two holes are cut in the sac wall, and the spiderlings emerge. When a large number of inviable eggs are available and few spiderlings develop they molt to the next instar without any additional food intake (Table 1, 30th day).

CONCLUSIONS

Very short duration of the quiescent period (i.e., first instar) in this species seems to indicate a trend toward the elimination of this stage in the family Theridiidae and related groups. This elimination would be possible since its presumable function, (Schick, 1972) seems to be taken by the first active instar (second instar) during the period of life within the egg sac. Utilization of inviable eggs, originally a role for the quiescent instar (1 to 4 stages), seems to be undertaken by the second instar with a consequent temporal reduction of the first instar.

Difference in survival in the two groups of spiderlings is clearly attributed to egg-feeding before abandonment of the egg sac. If such feeding does not take place, the maximum life expectancy for a starving second instar spiderling is 22 days (Table 1). The spiderlings that feed on eggs, even though this feeding may not be sufficient in itself to lead to molting, stand a greater chance for survival since the life span is extended considerably by such early nutritional procurement.

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ERRATA

Stahnke, H. L. 1974. Revision and Keys to the higher catagories of Vejovidae (Scorpionida). J. Arachnol. 1:107-141.

Page 112, line 12, word 8: Change "fornication" to "formication."
Page 114, line 10, word 6: Change "six" to "five."
Page 116, line 24: Change "(Fig. C,D)" to "(Fig. 5C,D)."
Page 128, line 14: Change "98" to "89."
Page 129, line 7: Change "*Physoconus*" to "*Physoctonus.*"
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CONTENTS

THE JOURNAL OF ARACHNOLOGY

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Feature Articles

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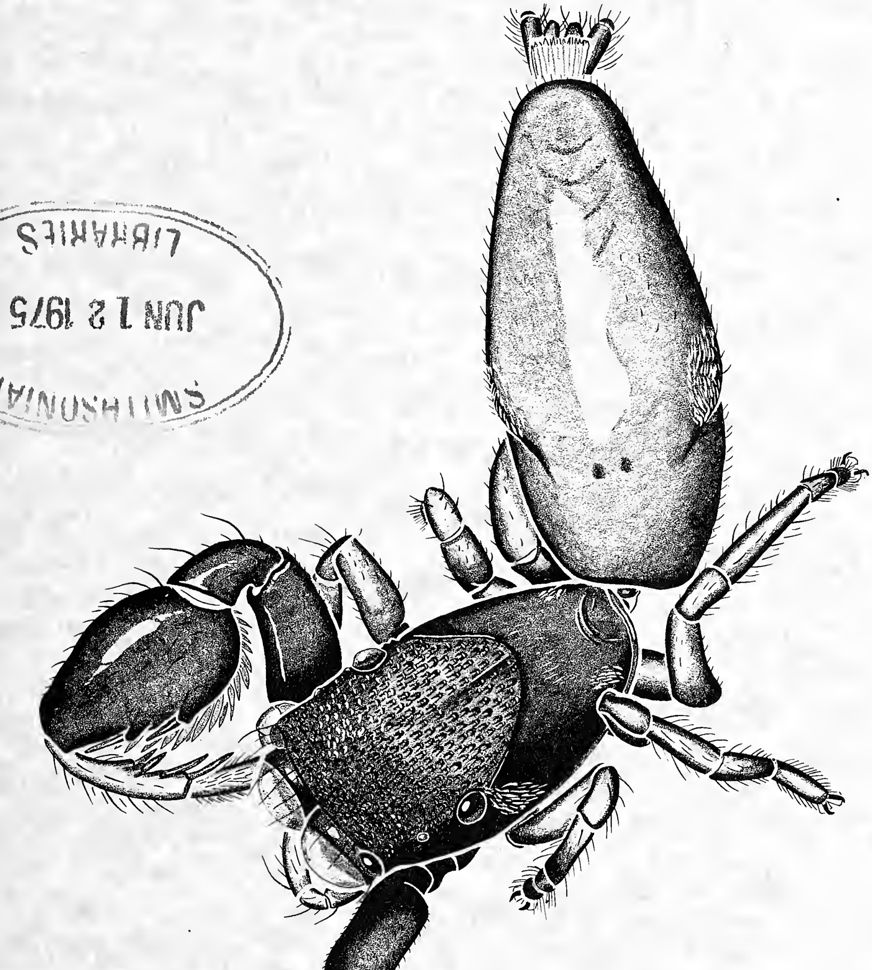

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Shear, W. A. 1975. The opilionid family Caddidae in North America, with notes on species from other regions (Opiliones, Palpatores, Caddoidea). J. Arachnol. 2:65-88.

THE OPILIONID FAMILY CADDIDAE IN NORTH AMERICA, WITH NOTES ON SPECIES FROM OTHER REGIONS (OPILIONES, PALPATORES, CADDOIDEA)

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ABSTRACT

Species belonging to the opilionid genera *Caddo*, *Acropsopilio*, *Austropsopilio* and *Cadella* are herein considered to constitute the family Caddidae. The subfamily Caddinae contains the genus *Caddo*; the other genera are placed in the subfamily Acropsopilioninae. It is suggested that the palpatorid Opiliones be grouped in three superfamilies: Caddoidea (including the family Caddidae), Phalangioidea (including the families Phalangiidae, Liobunidae, Neopilionidae and Sclerosomatidae) and Troguloidea (including the families Trogulidae, Nemostomatidae, Ischyropsalidae and Sabaconidae). North American members of the Caddidae are discussed in detail, and a new species, *Caddo pepperella*, is described. The North American caddids appear to be mostly parthenogenetic, and *C. pepperella* is very likely a neotenic isolate of *C. agilis*. Illustrations and taxonomic notes are provided for the majority of the exotic species of the family.

INTRODUCTION

Considerable confusion has surrounded the taxonomy of the order Opiliones in North America, since the early work of the prolific Nathan Banks, who described many of our species in the last decade of the 1800's and the first few years of this century. For many species, no additional descriptive material has been published following the original descriptions, most of which were brief and concentrated on such characters as color and body proportions. Only recently have a few generic revisions begun to appear. This paper is the first in a projected series of generic and familial revisions of North American opilionids, beginning with those of the superfamily Troguloidea (roughly, but not completely, equivalent to the old "Group" Dyspnoi). The family Caddidae was at first thought to belong to this group, and therefore seemed like a good starting point, but later study has shown that it is best considered a separate superfamily as will be explained below.

Species of the family Caddidae are small, inconspicuous, superficially mite-like opilionids usually found in leaf litter, moss, and vegetable debris, or running about on tree trunks and fallen logs. They may be immediately distinguished from any other opilionids by the enormous eyes, which occupy most of the carapace.

The first species of the family, *Caddo agilis*, was described from Long Island, New York, by Banks in 1892. Crosby (1904) described two more American species, *C. glaucopis* and *C. boopis*, in a rather confusing paper in which a figure of *C. boopis'* pedipalp was labelled as pertaining to *C. glaucopis*. This error was perpetuated by Roewer

(1923) in his enormous compendium *Die Weberknechte der Erde*. Crosby (1924) realized his error and published a correction, also stating that *C. glaucopis* was a synonym for *C. agilis*. Crosby had been misled by Banks' published description of *agilis*, which neglected to mention that the type was not a mature specimen—this information appeared in a short paragraph by Banks (1924; printed on the same page as the last paragraph of Crosby's description of *C. glaucopis*!) in which Banks reported *C. agilis* from the area of Washington, D.C. As a further complication, the type series of *C. agilis* contained a second, until now undescribed species, from which Banks' description was at least partly drawn.

Meanwhile, Silvestri (1904) described a peculiar, *Caddo*-like opilionid from Chile under the name *Acropsopilio chilensis*. Roewer (1923) established the new family Acropsopilionidae for this species, but because of his limited view of family level characters placed it incorrectly in the "Group" Dyspnoi. Roewer did not see specimens, but Silvestri's Latin description contains all the information necessary for a proper placement. Hirst (1925) and Lawrence (1931, 1934) described a total of three species in this nominal family from South Africa. Forster (1948, 1955) and Hickman (1957) described five species from New Zealand and Australia.

Further developments in *Caddo* proper are the description of *Caddo chomulae* from Mexico by Goodnight and Goodnight (1948), and the report by Suzuki (1958) of *C. agilis* from Japan. Although males of *Caddo agilis* Banks have been "described" several times in the literature, authentic members of this sex were only recently discovered. Males of the other New World species remain unknown, and indeed may not exist; there is evidence that they are parthenogenetic.

Unless indicated otherwise, all specimens mentioned in the distribution sections are in the American Museum of Natural History. Other museums and private collections as designated as follows: Chicago Natural History Museum (CNHM), Museum of Comparative Zoology (MCZ). Private Collections of W. A. Shear (WAS), Arlan L. Edgar (ALE), Joseph A. Beatty (JAB), Andrew A. Weaver (AAW), George Klee (GK), Charles R. McGhee (CRM), and R. L. Hoffman (RLH).

PROBLEMS IN HIGHER CLASSIFICATION OF THE CADDIDAE

The problem of generic groupings in the Caddidae has not been closely examined up to this time, and several redundant generic names have been proposed. *Oonopsopilio* Lawrence was later recognized by its describer to be a synonym of *Caddella* Hirst (Lawrence, 1934). *Zeopsopilio* Forster is here placed in the synonymy of *Acropsopilio* Silvestri, and *Tasmanopilio* Hickman is placed in the synonymy of *Austropsopilio* Forster. These synonymies will be found in the appropriate sections. Furthermore, two species described in *Caddo*, *C. boopis* Crosby, and *C. chomulae* Goodnight and Goodnight, are clearly members of *Acropsopilio*.

On the family level, there has been great confusion. Banks (1892) considered *Caddo agilis* to represent a distinct tribe which he called Caddini, but subsequently treated as a subfamily of Phalangiidae. Roewer, while placing *Acropsopilio* in a family of its own, put *Caddo* first in the subfamily Oligolophinae of the family Phalangiidae (Roewer, 1923). Later, Roewer (1957) placed the name Acropsoplionidae in the synonymy of the subfamily Caddoinae under the Phalangiidae, attributing the name to Banks but ignoring Banks' original orthography.

In a short paper on higher classification of the order Opiliones in general, Silahvy (1962) essentially retained Roewer's placement.

After the relationship of *Caddo* to the acropsopilionines was recognized, several authors speculated on the position of the group. Kauri (1950-1951) discussed species of *Caddella* in detail but came to no certain conclusions regarding *Caddo*. He retained the name Acropsopilionidae in the "Dyspnoi," Ringuelet (1962), in a restudy of *Acropsopilio*, using the sets of characters that classically have divided "Eupnoi" and "Dysponi," decided that *Caddo* should remain in the Oligolophinae and that the acropsopilionines should also be left as they were. However, some of Ringuelet's observations on *Caddo* were not correct, and he did not emphasize the mixture of features exhibited by species of *Caddella* and *Austropsopilio*. Suzuki (1967) felt that *C. agilis* bridged the classical groups, and depending on the key characters used, could go in either category. A perusal of the descriptive material below will demonstrate clearly the validity of Suzuki's position. Furthermore, the relictual distribution of the family indicates that we have to deal with an ancient group whose subunits have long been isolated from one another.

All of the authors cited above have indicated that some caddids may fit in either of the classical Hansen-Sorensen "groups," Dyspnoi or Eupnoi (Some Opilionid taxonomists have called these *tribes*, but treated them as superfamilies. The tribe is usually considered a division of the subfamily.). However, I think the time has come for bold measures with regard to this outmoded dichotomy. Too much effort has been spent surveying the literature and erecting higher categories without reference to species or actual specimens. Higher categories in taxonomy derive their standing from groupings of lower categories and do not exist as *a priori* pigeonholes in which the lower categories must be stuffed. I have earlier pointed out, in studies on diplopod taxonomy, that it is not inconsistent to have large actively speciating genera or families, or even superfamilies, in the same orders with small, perhaps even monobasic genera or families which qualified investigators feel represent the ends of old, expiring phyletic lines. Thus it follows that to consider certain single characters of "family value," or some such procedure, is logically inconsistent. Categories above the genus should be based on a holistic, not reductionistic, view.

Within the suborder Palpatores, two groups are well-defined and probably monophyletic: one includes the Trogulidae, Nemastomatidae, Ischyropsalidae and Saboconidae and the other families Neopilionidae, Phalangiidae, Liobunidae and Sclerosomatidae. Silhavy (1961) rejects the division of the Opiliones into the suborders Laniatores, Palpatores and Cyphophthalmi–instead he breaks the Laniatores up into two suborders, Gonyleptomorphi and Oncopodomorphi and raises the old names "Eupnoi" and "Dyspnoi" to subordinal status, leaving Cyphophthalmi as it stands. The evidence for this arrangement is not very clear, and it essentially involves the same reductionistic views as the arrangement of Roewer. I think that a greater level of stability would be maintained by continuing with the three classical, well-established suborders and by using superfamily names for divisions within them. The use of superfamily names to replace the "group" names Eupnoi and Dyspnoi has some clear advantages: 1) superfamily names are protected by the ICZN and thus finding and using the oldest indentifiable name will lend stability to the nomenclature; 2) such names will reflect at least partially the content of the group by being based on the name of a type-genus; 3) a hierarchy of categories, rather than a series of coordinate categories, is established.

Thus, I propose to group the suborder Palpatores into three superfamilies. The superfamily Troguloidea Sundevall, 1833 contains the families Trogulidae, Nemastomatidae, Ischyropsalidae and Sabaconidae. The type-genus is *Trogulus* Latrielle, 1802. The superfamily Phalangioidea Sundevall, 1833 contains the families Phalangiidae, Neopilionidae, Liobunidae and Sclerosomatidae. The type-genus is *Phalangium* Linnaeus, 1758. The superfamily Caddoidea Banks, 1892 contains only the family Caddidae; the type genus is *Caddo* Banks, 1892. All three of these are formed and characterized by the included families, rather than by more or less arbitrarily chosen diagnostic characters.

The superfamily status of the Caddoidea is justified by the combination of characters elaborated on at length in the section below. This action removes from the Troguloidea the nonconforming element of the family Acropsopilionidae and from the Phalangioidea the nonconforming element of the subfamily Caddinae. A greater uniformity within superfamilies is thus achieved. When an overview of the order Opiliones in general has been completed, it will be possible to discuss these categories more fully.

DESCRIPTIONS OF THE CADDIDS OF NORTH AMERICA

Superfamily CADDOIDEA Banks, 1892, NEW STATUS

A superfamily of the suborder Palpatores, containing only the family Caddidae Banks, 1892, as defined below.

Type-genus—*Caddo*, Banks, 1893.

Diagnosis—Differs from the superfamily Phalangioidea in lacking accessory spiracles on the tibiae of the legs, and in having the abdominal spiracles comparatively large and partially bridged over with granules; and from the superfamily Troguloidea in having pedipalps with usually large, sometimes movable claws and armed with spine-bearing processes.

Description—The characters of the superfamily are the same as those of the Family Caddidae.

Family Caddidae Banks, 1892

Caddini Banks, 1892, Canadian Entomol. 25:205; Roewer, 1957 (Caddoinae), Senck. Biol. 38:331; Silhavy, 1961, 11th Int. Cong. Entomol. 1:267. Acropsopilionidae Roewer, 1923, *Die Weberknechte der Erde*, p. 678; Lawrence, 1931, Ann. South African Mus. 29(2):469; Kauri, 1950-51, S. Afr. Animal Life 8:135; Ringuelet, 1959, Rev. Mus. Arg. Cien. Nat. 5(2):206; 1962, Physis 23:77-80; NEW SUBJECTIVE SYNONYMY.

Type-genus—*Caddo* Banks, 1892.

Diagnosis—See superfamily diagnosis above.

Description—Carapace nearly as broad as long, thoracic tergites well-marked, cuticle leathery, unarmed. Eye tubercle occupying nearly all of carapace, deeply depressed in middle, in some species extending forward over chelicerae (*Austropsopilio*, see Fig. 17). Eyes large, nearly at lateral margins of carapace. Scent gland pores at anteriolateral margins of carapace, small, not conspicuous. Abdominal tergites not heavily sclerotized, usually unarmed, not well separated from one another. Labrum subtriangular, small. Labium rounded, as wide as long. Sternum well-sclerotized, armed with setae, usually wider than long, sometimes with long processes (*Caddella africana*, Fig. 29). Chelicerae with toothed fingers, with or without a ventral spine on the basal article. Palpus with spined processes, lacking a claw in females of some species. Coxal endites of pedipalp large, mostly membranous, sclerotic protion crescentic, sometimes with a large spine; of coxae I with membranous part longer than wide, sclerotic part longer than wide, armed with setae; of coxae II longer than wide, about one-third the size of those of coxae I; of coxae III and IV vestigal, not movable. Gential operculum large, blunt, coverning sternum or articulating with it (*Caddela africana*, Fig. 29). Spiracles large, partially operculate, partially bridged over with enlarged cuticular granules. Male genitalia poorly known, variable, see subfamilies. Ovipositor usually ringed, with large furcae each bearing single sensory organ.

Distribution—Appalachian Mountains of North America, including area surrounding the Great Lakes; Chiapas, Mexico; southern South America, including parts of Chile, Argentina and Brazil; Union of South Africa; Queensland and Tasmania, Australia; New Zealand; Japan.

KEY TO SUBFAMILIES AND GENERA

1a. Basal articles of chelicerae each with a ventral spur; North America, Japan . . . . Subfamily Caddinae Banks, *Caddo* Banks

1b. Basal articles of chelicerae without ventral spurs; all southern hemisphere localities, Great Lakes region of North America, and Chiapas, Mexico . . . . Acropsopilioninae Roewer 2

2a(1b). Palpal tibia unarmed (Figs. 23, 28, 31); South Africa . . . . . . *Caddella* Hirst

2b. Palpal tibia armed with spine-bearing tubercles (Figs. 8, 18) 3

3a(2b). Basal spined tubercles of palpal femora blunt, rounded (Fig. 18), Australia . . . . *Austropsopilio* Forster

3b. Basal spined tubercles of palpal femora acute, tipped with a large terminal spine (Fig. 8); New Zealand, Chile, Chiapas, Great Lakes region of U.S. . . . . *Acropsopilio* Silvestri

Subfamily Caddinae Banks, 1893

Caddini Banks, 1892, Canadian Ent. 25:205.

Type-genus—*Caddo* Banks, 1892.

Diagnosis—Distinct from the Acropsopilioninae in being generally more phalangioid in appearance; in having the palpal tarsus longer than the tibia, armed with a movable claw; ovipositor with more than three annuli; male genitalia simple, symmetrical.

Description—With the characters of the family, and in addition: palpus of females with femur armed with three evenly spaced acute spined tubercles and a mesal apical lobe; tibia not armed, shorter than tarsus; tarsus with movable claw. Chelicerae with basal article armed ventrally with short, sharp spur. Ovipositor with 10-12 annuli distinctly sclerotized; sensillae of furcae small articulated lobes with socketed setae. Penis (when males are known) simple, shaftlike, symmetrical, not twisted, apically bifurcate.

Distribution—North America and Japan, with a single fossil species from the Baltic Amber [*Caddo dentipalpis* (Koch and Berendt); see Bishop and Crosby, 1923].

Included genera—*Caddo* Banks, 1892.

Genus *Caddo* Banks, 1892

Caddo Banks, 1892, Proc. Entomol. Soc. Washington 2:249; Crosby, 1904, J. New York Entomol. Soc. 12:253; Roewer, 1912, Abh. Geb. Naturwiss. 20:33; 1923, *Die Weberknecthe der Erde*, p. 712; 1957, Senck. Biol. 38:331; Bishop and Crosby, 1924, New York State Mus. Dir. Rep. 1923:83; Bishop, 1949, Proc. Rochester Acad. Sci. 9:174-175 (complete references to 1948).

Type-species—*Caddo agilis* Banks.

Description—With the characters of the subfamily, and in addition: palpus of female with three large spine-bearing tubercles on ventral surface of femur, large spine-bearing knob on inner distal surface of femur; of male (when known) with large subquadrate lobe in place of spine-bearing tubercles. Ovipositor with 6-12 chitinous rings, deeply bifurcated distally, each furca with 10 setae arranged as in Fig. 4; seminal receptacles of most specimens obsolete; penis (when males are present) simple, shaftlike, with dorsal spinous branch and ventral glans.

Distribution—(Maps 1, 2) North America, from North Carolina to the Great Lakes region, New England, and southern Canada; Japan, region of Mt. Hoki-Daisen, Tottori Pref.

Key to Species of *Caddo*

1a. Width of eye tubercle of *adults* 1.3-1.5 mm; body strongly marked purplish brown and silver; north-eastern United States and southern Canada, south to North Carolina and Tennessee in mountains, Japan . . . . *C. agilis* Banks

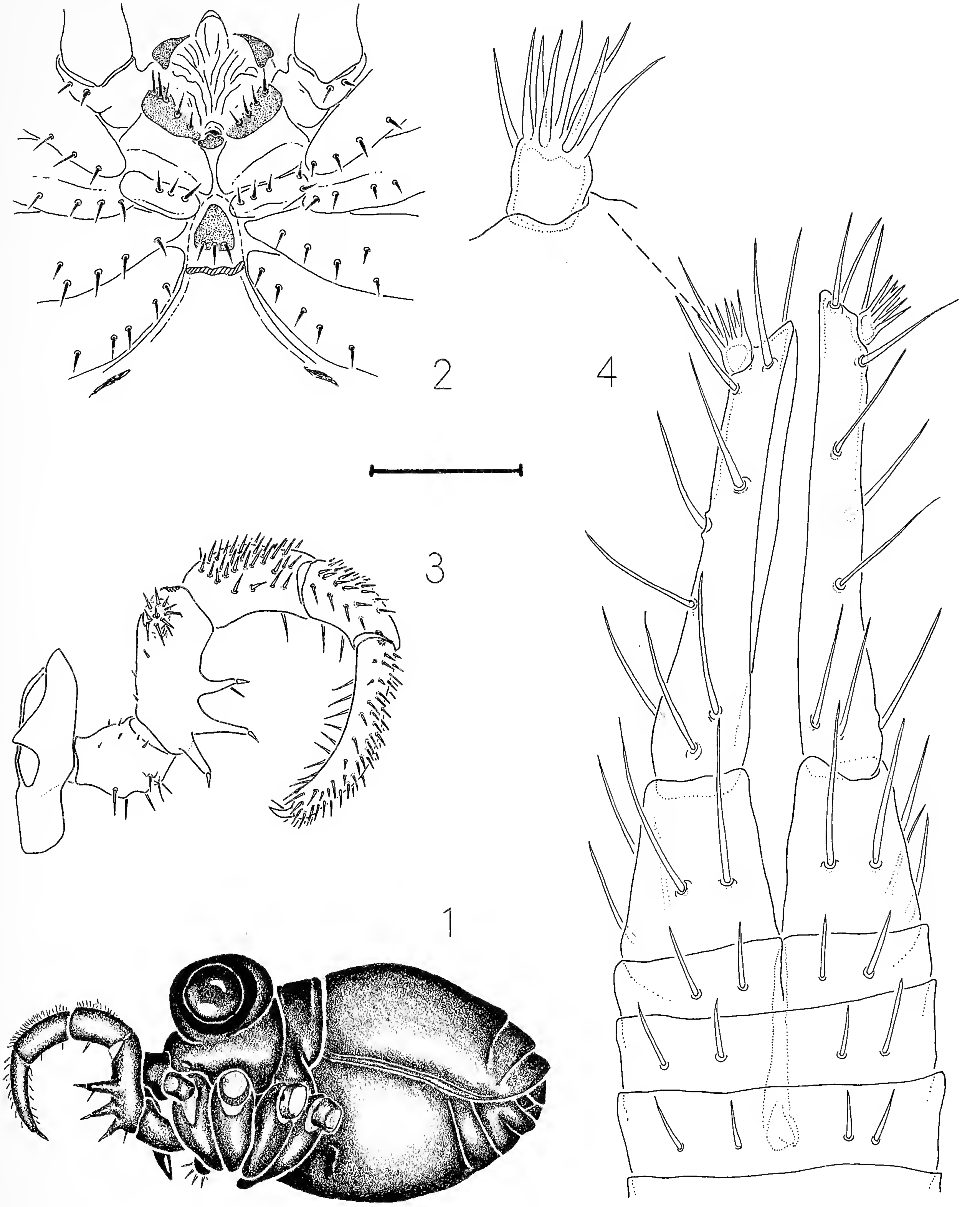
1b. Width of eye tubercle of *adults* 0.6-0.8 mm; body more or less evenly colored medium brown; eastern New York, Long Island, southern New England . . . . *C. pepperella* n. sp.

Caddo agilis Banks

Figs. 1-4, Map 1

Caddo agilis Banks, 1892, Proc. Entomol. Soc. Washington 2:249-251, Figs. 1-6, ♀; Roewer, 1912, Abh. Geb. Naturwiss. 20:33, no figures, 1923, *Die Weberknechte der Erde* p. 712-713, Figs. 889a-889b; ♀; 1957 Senck. Biol. 38:331, no figures; Bishop and Crosby, 1924, New York State Mus. Bull. 1923:83-84, Fig. 3, ♀; Bishop, 1949, Proc. Rochester Acad. Sci. 9:175-176, Pl. 1, Figs. 9-14, ♀ (complete references to 1948); Suzuki, 1958, Ann. Zool. Japan, 31:226-228, Figs. 1-6, ♀. *Caddo glaucopis* Crosby, 1904, J. New York Entomol. Soc. 12:253-254 [Fig. 4, labelled as pretaining to *C. glaucopis*, depicts palpus of *Caddo* (=*Acropsopilio*) *boopis*]; Roewer, 1928, *Die Weberknechte der Erde*, p. 713-714.

Types—Female cotypes from Long Island, New York deposited in Museum of Comparative Zoology, Harvard University, Cambridge, Mass. The type series consists of several females of both *Caddo agilis* and the heretofore unrecognized species *C. pepperella*. It is obvious from Banks' original description, particularly of the color pattern, that his concept of *C. agilis* was drawn mostly from specimens of *C. pepperella*. In 1904, Banks published a brief note mentioning that the type of *C. agilis* was immature; *C. pepperella* closely resembles immature *C. agilis*. It is possible that Banks added the "mature" specimens (real *C. agilis*) at a later date; this was a common practice of taxonomists of the day. Despite the evidence that the name *Caddo agilis* ought to be applied to the newly recognized species referred to here as *C. pepperella*, and that the more widespread familiar species now known as *C. agilis* ought to be called *C. glaucopis* (a name proposed by Crosby for mature specimens of the present *C. agilis* before publication of Banks' note on the maturity of the types of *agilis*) I think that stability and



Figs. 1-4.–Anatomy of *Caddo agilis*: 1, body, lateral view; 2, ventral side of cephalothorax, ventral view; 3, left palpus of female, mesal view; 4, ovipositor, ventral view; enlargement: right sensillum. Scale line = 1.00 mm for Fig. 1, 0.35 mm for Figs. 2, 3. Fig. 4 not to scale, 400X enlargement 900X.

continuity of nomenclature would best be preserved by continuing to refer to the larger, widespread species as *Caddo agilis*, and providing a new name for the smaller, more restricted species. In accordance with this, I have designated as a neolectotype a mature specimen of *Caddo agilis* from the original type series.

The female holotype of *C. glaucopis* is from Ithaca, N.Y., collected on a tree trunk in August, 1903. It is in the AMNH (specimen examined). Because of the great difference, particularly in color and size, between his specimen and the original description of *C. agilis*, Crosby described *C. glaucopis*. In the same journal, and actually on the very page carrying the last few paragraphs of Crosby's article, Banks published a note on a collection of opiliones from Washington, D.C., which mentioned in passing that the types of *C. agilis* were immature. Actually, as shown above, they belonged to a different species. Bishop and Crosby (1923) synonymized the two names, but Roewer's *Die Weberknechte der Erde* (1923) had already been published, including *C. glaucopis* as a valid species, largely because a drawing of the palpus of *Caddo boopis* had been labelled as pertaining to *C. glaucopis*.

All of this remarkable confusion has been further compounded by the fact that although "males" have been repeatedly described and recorded (Roewer, 1923; Bishop, 1949, etc.), true males of this species were not found until very recently. The state of development of American opilionid taxonomy is indicated by the fact that no one has described the genitalia of some of the commonest species.

Description—Female from Coudersport, Pennsylvania: Length of body (Fig. 1), 3.0 mm; width of eye tubercle, 1.4 mm. Eye tubercle occupying nearly entire width of cephalothorax, deeply divided along median line by broad furrow; eyes circular in outline, somewhat protruding when seen from above. Free thoracic tergites separated from carapace by lightly impressed suture, from dorsum of abdomen by deeper suture running laterally and ventrally behind coxae IV. Dorsum of abdomen indistinctly segmented, cuticle soft, leathery. Dorsal surface without tubercles, spines, or prominent setae. Ventral surface as in Fig. 2. Labium small, moderately sclerotized, dark, vaguely divided into three anterior lobes. Endites of pedipalps with unsclerotized part posterior, three times size of sclerotized parts; sclerotized parts three times as long as wide, armed with row of stout black setae. Endites of first coxae not strongly sclerotized, slightly more than twice as long as wide, armed with row of setae. Coxae with rows of stout black setae, somewhat irregular on posterior coxae. Sternum subtriangular, apex anterior, posteriorly with row of three stout setae, covered by genital operculum. Segments of venter with scattered small setae. Palpus as in Fig. 3. Trochanter with a few setae on small prominences. Femur with three large, pointed tubercles bearing apical and sometimes subapical setae, distally with a large mesal setose lobe. Patella, tibia and tarsus heavily armed with stout setae, mostly on mesal surfaces. Claw large, movable, heavily sclerotized. Tarsus about twice length of tibia. Legs long, slender. Femora I-IV 1.3, 1.8, 1.3, 1.7 mm long respectively. Tibiae I-IV 1.8, 2.6, 1.6, 2.6 mm long respectively. Metatarsi with 1-6 false articulations; tarsi multiarticulate, claw single, not toothed. Ovipositor as in Fig. 4, seminal receptacles vestigal, sensilla setose lobes. Coloration: cephalothorax bright metallic silver, eye tubercle tinged dusky brown, eyes heavily ringed in black. Dorsum dark brown to purplish brown with median and lateral silver stripes; impression is one of silver background with parallel rows of brown spots. Venter off-white to silver, variable in specimens from the same population. Legs yellowish white proximally, darkening to medium brown on tibiae and metatarsi.

Notes—No genuine males of *Caddo agilis* have been described, and indeed, probably do not exist in most populations. A single real male was collected with numerous females, in 1956, by the late Wilton Ivie, near Jamison, Pennsylvania. Previous descriptions of males allude to slender females probably not as yet carrying eggs, or to juveniles. In all of the populations examined by me, the seminal receptacles of the females were virtually vestigal, indicating that even if males sporadically appeared, the females probably could not be fertilized by them.

The male collected by Ivie was given to Herr Jürgen Gruber of the Vienna Natural History Museum. In 1970, Herr Gruber very kindly sent me a copy of his manuscript on the animal and Xerox copies of his illustrations. At this writing (June, 1973) his paper has not to my knowledge appeared. A full description of the male will be presented by Gruber, but for the time being, Gruber's drawings show that the pedipalp of the male differs from that of the female in having a single, quadrate femoral lobe in place of the three acute tubercles of the female and in having the tarsus set with very stout, black setae. The penis consists of a long shaft with a short, tubular glans and a dorsal (?) spinous process. Taking into account the complexity of the male genitalia of related forms, it seems likely that this organ is either not functional or represents a rather drastic simplification.

The rarity of males (one having been collected for literally hundred of females) forces the conclusion that *Caddo agilis* is usually parthenogenetic. This might also help to account for the lack of variability, even when Japanese specimens are compared to ones from eastern North America, if parthenogenesis became established before the animal reached its present wide distribution. *Caddo dentipalpis* (Koch and Berendt), a fossil from the Baltic Amber of Oligocene Age, does not differ in any important respects, according to the account of Crosby and Bishop (1923), from *C. agilis*. There is a strong possibility that they are really the same species, and this indicates a much wider previous distribution for *Caddo*.

Most mature specimens are taken in late summer and fall, and the species probably winters over in the egg stage or as very small young. Detailed collection notes are sparse, but specimens are usually found in very humid, densely shaded areas, such as ravines, and there is usually a coniferous element in the forest, most frequently hemlock. Specimens have also been taken from moss, from beneath logs and stones, from tree trunks and the outside walls of buildings. The southwesternmost record (Pickett Co., Tenn.) is from a cave. In North Carolina, I collected *C. agilis* on the slopes of Mt. Mitchell. *Caddo agilis* is a rapid runner; the body is held high, and the excellent vision makes individuals even harder to catch. The diet is unknown, but they are undoubtedly predators.

Distribution—New England and southern Canada; south, mostly in the mountains, to Virginia, North Carolina, and Tennessee; northwest through Kentucky (?) to Ohio (Map 1). CANADA: QUEBEC: St. Joseph d'Alma (Alma), 29 July 1934, C. Crosby and H. Zorsch, ♀; Bagotville, 26 July 1934, H. Zorsch, juvs. ONTARIO: Sandford, June 1906, no. coll., juv. UNITED STATES: VERMONT: *Washington Co.*, Marshfield, 4 July 1969, A. M. Chickering, ♀♀ (MCZ). MASSACHUSETTS: *Barnstable Co.*, Cape Cod, South Chatham, from oak-pine woods, 16-18 June 1971, H. and L. Levi, juvs. (MCZ). CONNECTICUT: *New Haven Co.*, Bethany Bog, 29 May 1963, W. Ivie, ♀ (ALE). NEW JERSEY: *Warren Co.*, Jenny Jump State Forest, 27 June 1966, F. Coyle, juv. (WAS). NEW YORK: *Suffolk Co.*, Montauk Point, 24 May 1924, N. Banks, juv.; Cold Spring Harbor, July 1932, no coll., juv.; *Leviw Co.*, Michigan Mills, 1 Sept. 1926, no coll., ♀♀; *Catteraugus Co.*, Rock City Park, Olean, 22 July 1962, W. Shear, ♀♀ (WAS); Alleghany State Park, 21 May 1957, R. L. Hoffman, juv. (RLH); *Albany Co.*, E. N. Huyck Preserve, Rensselaerville, 8 July 1948, S. Bishop, juv.; *Oneida Co.*, Boonville, 23 July 1931, no coll., ♀; *Herkimer Co.*, Big Moose Lake, 14 June 1931, S. Bishop, juv.; *Tompkins Co.*, Woodwardia Swamp, Freeville, 10 Aug. 1924, no coll., ♀; Ithaca, 2 May 1926, Seeley and Fletcher, juv.; *Franklin Co.*, Wawbeek, 19 July 1931, C. Crosby, juv.

Bishop (1948) reports the following New York localities: *Delaware Co*., Delhi, May; *Niagara Co*., Olcott, Sept.; *Seneca Co*., Covert, July. PENNSYLVANIA: *Potter Co*., 4 mi east of Coudersport, on buildings and tree trunks in dense woods, 10 June 1963, 2 Aug. 1970, W. Shear, ♀♀ (WAS); *Bucks Co*., Neshaminy Cr. near Jamison, 23 May 1965, W. Ivie, ♀♀ (this collection also contained the male Ivie sent to Gruber). MICHIGAN: *Cheboygan Co*., Gorge, 2 Aug. 1967, A. Edgar, ♀♀ (ALE). OHIO: *Ashland Co*., Mohican State Forest, 31 May 1962, ♀♀ juvs., J. Beatty (JAB), R. MacArtor (WAS), A. Weaver (AAW); *Hocking Co*., Cantwell Cliffs State Park, 30 May 1927, M. Walker, ♀♀; *Wayne Co*., Ohio State Agricultural Experiment Station, Wooster, 4 Sept. 1963, J. Beatty, juv. (JAB); Funks Hollow, R14W, T15N, Sec. 23, A. Weaver, ♀ (AAW). WEST VIRGINIA: *Mercer Co*., immediate vicinity of Athens, 1966-1969, W. Shear, numerous collections, ♀♀ (WAS); Cove Branch Hollow, 3 mi northwest of Athens, 14 May 1967, W. Shear, juv. (WAS); Brush Creek Falls, *Rhododendron* and hemlock litter, 9 May 1967, juv. (WAS); *Pocahontas Co*., Hills Creek Falls Scenic Area, Monongahelia National Forest, 8 July 1967, W. Shear, ♀♀ (WAS); VIRGINIA: *Augusta Co*., Ramsey's Draft, 18 mi north of Staunton, virgin cove forest dominated by hemlock, 19 June 1969, W. Shear, ♀♀ (WAS); *Carroll Co*., Fancy Gap, pine forest, 27 Apr. 1969, H. Levi, juv. (MCZ); *Grayson Co*., south slope of Mt. Rogers, *ca*. 4500′ 20 Oct. 1963, R. Hoffman, ♀ (RLH); *Craig Co*., Clover Hollow Mtn., 6 June 1957, R. Hoffman, juv. (RLH); NORTH CAROLINA: *Yancey Co*., slopes of Mt. Mitchell above Black Mountain Campground near Busick, 14 July 1969, W. Shear, ♀♀ (WAS); TENNESSEE: *Pickett Co*., Pickett State Park, Hazard Cave, 25 June 1967, C. R. McGhee, ♀♀ (CRM). Bishop (1948) reports: Princeton, N.J., Washington, D.C., Mt. Katahdin, Maine, Swannanoa Valley, North Carolina.

Caddo pepperella, new species

Fig. 5, Map 2

Types—Female holotype from Pepperell, Middlesex Co., Massachusetts, collected July 1964 by H. W. Levi, deposited in MCZ. The specific epithet is derived from the type locality.

Diagnosis—Differs from *C. agilis* in color, size, and form of the ovipositor. *Caddo agilis* is marked with metallic silver, while *C. pepperella* is an even, dark brown dorsally. *Caddo pepperella* is about 1.6-1.9 mm long, and *C. agilis* is from 2.8 to 3.2 mm long. The apical sensory lobes of the ovipositor of *C. pepperella* are much smaller than those of *C. agilis*.

Description of female holotype—Length of body, 1.7 mm; width of eye tubercle, 0.72 mm. Structure essentially as in *Caddo agilis*. Legs short, somewhat stouter than in *C. agilis*; femora I-IV 0.52, 0.91, 0.65, 0.78 mm long respectively, tibia I-IV 0.78, 1.17, 0.78, 1.04 mm long respectively. Ovipositor with 7-9 sclerotized rings, seminal receptacles completely lacking, apical sensory organ (Fig. 5) reduced in size. Coloration: eye tubercle and cephalothorax white, dorsum of abdomen medium to dark brown, with two narrow, parallel white stripes on posterior part. Venter and legs yellowish white.

Males unknown, probably do not exist.

Notes—This species has gone unrecognized for many years, even making up a part of the collection from which Banks described *C. agilis*, and, as mentioned above, his concept of that species was apparently based primarily on *C. pepperella*.

The problem of the relationship of this species to *Caddo agilis* is most interesting. I might postulate, in the absence of any real evidence, that *C. pepperella* originated from *C. agilis* by neoteny in one parthenogenetic population sometime during the Pleistocene, probably on the glacial margins. Neoteny would shorten the life cycle of the population in the severe periglacial climate, and thus be a definite selective advantage. During the final retreat of the glaciers, such a form would be in an excellent position to invade newly exposed glaciated territory, but might be extinguished in the south by competition from surviving populations of the ancestral form moving north into the new forest. This view is supported by the present limited distribution of *C. pepperella*, in a corner of the glaciated territory of southern New England, southeastern New York and Long Island. Throughout most of this range, both species of Caddo are sympatric, and at least on Long Island, they are syntopic.

I am aware that naming this form "opens a can of worms" in that the status of parthenogenetic or neotenic isolates is controversial. But since *C. pepperella* is a recognizable, distinct genetic entity, I feel it is nameworthy.

Distribution–(Map 2) CONNECTICUT: *Litchfield Co.*, Mohawk Mtn. 21 Aug. 1956, R. L. Hoffman, ♀ (RLH). MASSACHUSETTS: *Middlesex Co.*, Pepperell July 1964, H. and L. Levi, ♀ (MCZ). NEW YORK: *Albany Co.*, E. N. Huyck Preserve, 21 July 1956, ♀♀ 25 Aug. 1954, ♀♀ R. L. Hoffman, (RLH); *Suffolk Co.* Brookhaven National Laboratory, from *Sphagnum* spp., 11-17 July 1960, G. Klee, ♀ (GK), "Long Island (type locality of C. agilis)" no collector or date, ♀♀ (MCZ).

Subfamily Acropsopilioninae Roewer

Acropsopilionidae Roewer, 1923, *Die Weberknechte der Erde*, p. 678; Lawrence, 1931, Ann. South Africa Mus. 29(2):469-470; Ringuelet, 1959, Rev. Mus. Arg. Cien. Nat. "Bernardo Rivadavia" 5(2)206-207.

Type genus–*Acropsopilio* Silvestri 1904, by original designation.

Diagnosis–Generally more troguloid in appearance; the palpal tibia is longer than the tarsus, and in some species a claw is absent in females, ovipositor with at most three annuli; male genitalia, when known, complex (Figs. 19, 25-27), sometimes twisted.

Description–With the characters of the family, and in addition: palpus with patella and tibia armed with spine-bearing tubercles, armature of femur various, tarsus shorter than tibia, with small, fused claw, or without a claw. Basal article of chelicera not armed ventrally. Ovipositor short, with at most three annuli, sensilla complex branched setae. Penis (when males are known) complex, composed of several plates and articulated spines, bearing a membranous glans and sometimes subject to 180 degrees of torsion.

Distribution–Great Lakes region and northern Appalachian Mts. in the United States and Canada; Chiapas, Mexico; southern South America, Australia; Tasmania and New Zealand; South Africa.

Included genera–*Acropsopilio* Silvestri 1904; *Cadella* Hirst 1925; *Austropsopilio* Forster 1955. See the key given under the discussion of the family.

Genus *Acropsopilio* Silvestri

Acropsopilio Silvestri, 1904, Redia 2:254-255. Canals 1932, Physis 11:150; Mello-Leitao, 1938, Ann. Acad. Bras. Sci. 10:317; Roewer, 1923, *Die Weberknechte der Erde*, p. 678; Ringuelet, 1959, Rev. Mus. Arg. Cien. Nat "Bernardo Rivadavia" 5(2)207; 1962, Physis 23:77-80. *Zeopsopilio* Forster, 1948, Trans. Royal Soc. New Zealand 77(1):140; NEW SUBJECTIVE SYNONYMY.

Type species–*A. chilensis* Silvestri by monotypy and original designation. Type species of *Zeopsopilio*, *Z. neozealandiae* Forster, by monotypy.

Diagnosis–*Acropsopilio* is nowhere sympatric with other members of the subfamily. A comparison of the figures given here will suffice to separate members of the genus *Cadella* and *Austropsopilio* species.

Description–With the characters of the subfamily, and in addition: palpus with patella armed with two or three spine-bearing tubercles femur with two basal one ventromedial and one distal spined tubercle, also with a lobe bearing macrosetae near the dorsomedial distal end of femur, or group of stout macrosetae in that position, patella with one or two ventral spined tubercles, tibia and tarsus with ventral rows of macrosetae on low tubercles, claw stout, not movable. Ovipositor (when known) with three chitinized rings, or such rings reduced and indicated by rows of setae, seminal receptacles (in *A. boopis*) absent or vestigal, apical sensilla branched setae. Males unknown.

Distribution–Great Lakes region of U.S. and Canada, and northernmost Appalachian Mountains; mountains of Chiapas, Mexico; southern South America (parts of Argentina, Chile, and Brazil); New Zealand.

KEY TO SPECIES OF *ACROPSOPILIO*

1a. Femur of palpus with distal medial lobe bearing setae (Fig. 7); United States and Canada . . . . *A. boopis*

1b. Femur of palpus without such a lobe; with or without a group of setae in its place 2

2a.(1b). Femur of palpus without a group of distal setae (fig. 11); Chiapas Mexico . . . . *A. chomulae*

2b. Femur with distal group of setae 3

3a(2b). Trochanter of palpus with two spined tubercles (Fig. 15); New Zealand . . . . *A. neozealandiae*

3b. Trochanter of palpus with three spined tubercles (Fig. 13); Chile, Argentina, Brazil . . . . *A. chilensis*

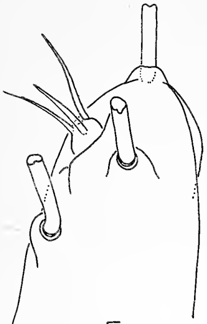
Of the four species considered as valid, the two most closely related are *A. chomulae* and *A. chilensis*, while *A. neozealandiae* is more distantly related to the first two, and *A. boopis* distinct from the other species.

Acropsopilio boopis (Crosby), new combination

Figs. 6-9, Map 1

Caddo boopis Crosby, 1904, J. New York Entomol. Soc. 12(4):255, Fig. 4, ♀; Roewer, 1912, Abh. Geb. Naturwiss. 20(1):35-36; 1923, *Die Weberknechte der Erde* p. 714, Fig. 890, ♀; Bishop, 1949, Proc. Rochester Acad. Sci. 9(3):176-177, Figs. 15-18, ♀.

Types–A female specimen in the American Museum of Natural History (examined) is labelled as a lectotype, but the designator is not known. Locality data: ' Ithaca, N.Y. VIII-1904." In the original description, the palpus of *A. boopis* was illustrated but labelled as being that of *Caddo glaucopis*, a synonym of *C. agilis*. Roewer (1923) perpetuated the error in *Die Weberknechte der Erde*. Bishop (1949) claims to figure a male, but the specimen was probably not dissected, and no genuine males are known from the 25-30 specimens of *A. boopis* in collections.



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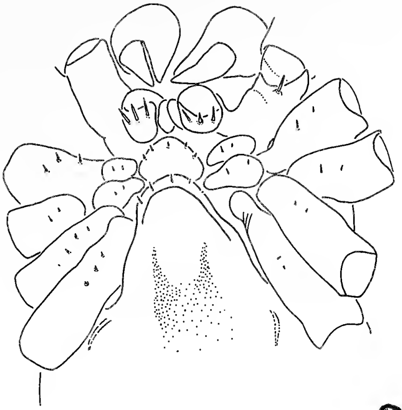

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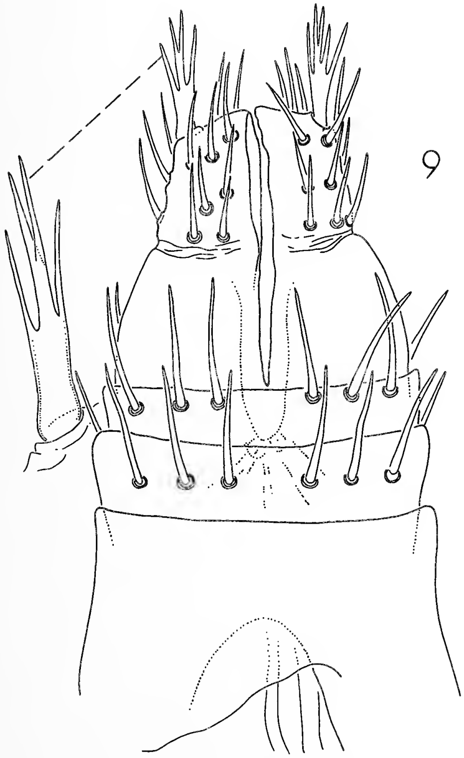

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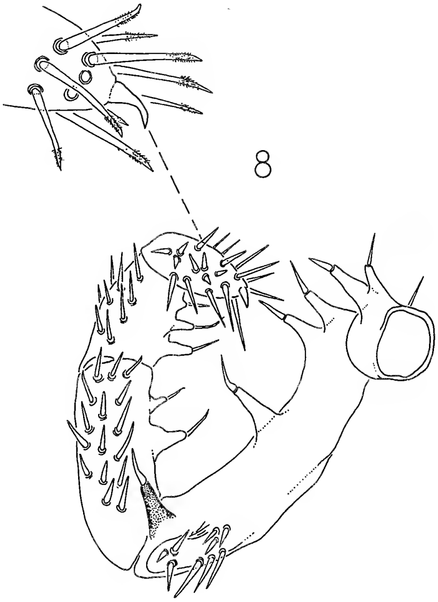

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Fig. 5.–Anatomy of *Caddo pepperella*, right furca of ovipositor, ventral view.

Figs. 6-9.–Anatomy of *Acropsopilio boopis*: 6, body of female, lateral view; 7, anterior ventral part of female, ventral view; 8, left palpus of female, mesal view; enlargement; claw and glandular setae; 9, ovipositor, ventral view; enlargement: seft sensillum. Scale line = 0.65 mm for Fig. 6, 0.25 mm for Figs. 7, 8. Figs. 5, 9, not to scale, Fig. 9 400X, Fig. 5 900X.

Description–Drawn from female specimen from bog 4 mi east of Columbiaville, Michigan, in Field Museum of Natural History, Chicago. Length of body (Fig. 6), 0.91 mm; width of eye tubercle, 0.44 mm. Eye tubercle occupying entire width and length of cephalothorax when seen from above, deeply impressed along median line; eyes circular in outline, protruding when seen from above. Free thoracic tergites not distinct from cephalothorax, set off from abdomen by suture. Body soft, leathery, not strongly sclerotized. Dorsal surface without spines or tubercles. Labrum prominent, pointed. Labium rounded, small, 2-lobed. Only endites of pedipalp coxae show sclerotized part; coxae and endites (Fig. 7) about as in *Caddo agilis*. Spiracles very small and indistinct, covered in some specimens by fourth coxae. Palpus as in Fig. 8; trochanter with two basally fused ventral spined tubercles; femur with two tubercles at base, one near middle of segment, one distal; tubercle bearing macrosetae present near distal end; patella with three vague rows of median macrosetae, two ventral spined tubercles. Tibia with area of macrosetae more dorsal, with three ventral spined tubercles; tarsus about 80% length of tibia, heavily set with macrosetae; claw (Fig. 8) stout, not movable. Legs relatively short, fourth leg much the longest (all specimens studied lacked legs II). Femora I, III, IV 0.30, 0.40, 0.73 mm long respectively, tibiae I, III, IV 0.34, 0.38, 0.43 mm long respectively. Ovipositor as in Fig. 9, with three chitinous rings, distal two with single rows of setae, apex bifurcate, with three vague rows of setea; sensilla flattened, complexly branched setae (Fig. 9). Coloration; eye tubercle and cephalothorax off-white, remainder of body medium brown, dorsum unmarked. Venter slightly lighter, speckled black. Pedipalps and legs dark brown.

Notes—No males are known; the species is probably parthenogenetic. *Acroposopilio boopis* may be rare, or it may be that the small size of the species makes it difficult to collect. Ecological data on labels is sparse, but the species is usually taken by sifting or in Berlese samples from *Sphagnum* moss or from pine needles. In Quebec and Indiana, it has been sifted from leaf litter. Most of the labels (see below) refer to lakes, ponds and streams, so *A. boopis* may have an affinity for littoral situations. Curiously, all records are from glaciated territory.

Distribution—In addition to Map 1, detailed records are given here to establish for the first time the range of the species: CANADA: QUEBEC: Latérriere, Laurentide Park, from leaf litter, 29 Aug. 1956, H. Dybas, ♀, juv. (CNHM). ONTARIO: Island 1024, Lake Temagami, 15-25 Aug. 1946, C. Goodnight and T. Kuarata, ♀♀. UNITED STATES: CONNECTICUT: *Litchfield Co*., Salisbury, Wachocastinook Creek, 29 June 1930, no coll., 3 ♀♀. INDIANA: *Porter Co*., Dune Acres leaf litter, 16 Oct. 1948, H. Dybas, ♀ (CNHM). MAINE: *Aroostook Co*., Presque Isle, 26 Aug. 1925, no. coll ♀. MICHIGAN: *Lapeer Co*., bog 4 mi east of Columbiaville, from nonsphagnum mosses 25 Aug. 1963, Suter and Graves, 3 ♀♀, 3 juvs. (CNHM); *Montmorency Co*., T31N, R6E, Sec. 3, Berlese of moss from jack pine plantation, 10-20 Aug. 1967, G. V. Manley, ♀ (GK). NEW YORK: *Saratoga Co*., Ballston Lake, 5 Aug. 1923, A. Wolf, ♀; *Franklin Co*., Wawbeek 9 Aug. 1931, N. W. Davis, ♀; *Fulton Co*., East Caroga Lake, 14 July 1934, no. coll ♀; *Oswego Co*., North Pond, 27 July 1935, C. Crosby, ♀; *Albany Co*., Uly Creek near Voorheesville, 30 Aug. 1923, D. Leonard, ♀; *Tompkins Co*., Six Mile Creek, Ithaca, 24 Apr. 1926, Seeley and Fletcher, ♀; *Queens Co*., Flushing, Spring 1938, K. Cooper, ♀.

NOTES ON CADDID SPECIES FROM OTHER REGIONS

Special collecting will be required for a worldwide revisionary treatment of the family, but in the course of this study, I have compiled the following notes on some of the other species.

Acropsopilio chomulae (Goodnight and Goodnight)

Figs. 10, 11

Caddo chomulae Goodnight and Goodnight, 1948, J. New York Entomol. Soc. 55:201, Figs. 1, 2 juvenile. *Acropsopilio "chommulae"* [sic], Ringuelet 1962, Physis 23(64):79.

Type–Juvenile from San Cristobal de las Casas Chiapas, Mexico, collected 22 July 1947 by M. Goodnight, in AMNH, examined.

The detailed description of the juvenile holotype by Goodnight and Goodnight (1948) needs no amplification, but I here present a lateral view of the holotype (Fig. 10) and a mesal view of the trochanter and femur of the right palpus (Fig. 11). In 1950, Goodnight and Goodnight, reproting on a collecting trip to Chiapas, stated, "The interesting species *Caddo chomulae* Goodnight (sic) was found in large numbers." (Goodnight and Goodnight, 1950, p. 143). However, no specimens other than the holotype were in the American Museum, nor could any be located in the Goodnights' collection (C. Goodnight, in litt.). Mature specimens are needed to complete the description, and in particular, males, if they exist, should be searched for.

Ringuelet (1962) first placed *A. chomulae* in the proper genus, but did not mention *A. boopis.*

Acropsopilio chilensis Silvestri

Figs. 12, 13

Acropsopilio chilensis Silvestri, 1904, Redia 2:256, Figs. 35-48, ♀; Roewer, 1923, *Die Weberknechte der Erde*, p. 678, Figs. 846-848, ♀ (copies of Silvestri's figures); Canals, 1932, Physis 11:151, 2 figures unnumbered, ♀ (copies of Silvestri's figures); Ringuelet, 1959, Rev. Mus. Arg. Cien. Nat. "Bernardo Rivadavia" 5(2):207, Fig. 14, (supposed to be a male, but this cannot be verified; no figures of the genitalia given). *Acropsopilio chilensis* var. *ogloblini* Canals, 1932, Physis 11:152, 5 figures, sex not indicated. *Acropsopilio ogloblini*, Ringuelet, 1959, Rev. Mus. Arg. Cien. Nat. "Bernardo Rivadavia" 5(2):209, no figures; NEW SYNONYMY.

Type–Female holotype from Pitrufquén, Chile, whereabouts unknown.

Acropsopilio chilensis was described from the southern Andes, near Pitrufquén, Chile, and has also been collected at Laguna Frías, Rio Negro, Argentina (Ringuelet, 1959). Canals (1932) described *A. ogloblini* as a "variety" from Loreto, Misiones, Argentina, and Ringuelet (1959) raised the name to species status but at the same time indicating that there were no significant differences between the two, and that *ogloblini* might be at most a subspecies. In a subsequent paper, Ringuelet (1962) used the name *A. ogloblini* to indicate a separate species from *A. chilensis*, without further comment, except to report a population he regarded as *A. ogloblini* from the subtropical jungle of Punta Lara, on the Río de la Plata, Argentina, where it was collected in a Berlese sample of mosses. No figures were presented. Since no one has ever demonstrated any significant degree of difference between the three widely separated populations, and as several other caddid species have wide, disjunct distributions, I think *A. ogloblini* should be relegated to the synonymy of *A. chilensis.*

According to Ringuelet (1962), the ovipositor of his specimens is short and not ringed, and he considers this as a troguloid ("Dyspnoi-like") character. Undoubtedly, this is really of little importance and is an adaptation to small size, the ovipositor is definitely ringed in *A. boopis*, and rings of setae indicating such structures occur in *A. neozealandiae* and in two species of *Caddella.*

I illustrate here an immature specimen (Figs. 12, 13) from Pinares, Province Concepción, Chile, collected Oct. 23, 1971, and forwarded to me through the kindness of Dr. T. Cekalovic of the Universidad de Concepción, Chile. Dr. Cekalovic is preparing a detailed treatment of South American *Acropsopilio* populations from new material. When properly searched for, *A. chilensis* may actually prove to be a rather common species in southern South America.

Acropsopilio neozealandiae (Forster)

Figs. 14, 15

Zeopsopilio neozealandiae Forster, 1948, Trans. Royal Soc. New Zealand 77(1):140, Figs. 1-4, sex not indicated. NEW COMBINATION.

Types—Female cotypes from Johnson's Park, Fielding, collected 25 March 1943, by R. Forster, in Dominion Museum, Wellington, examined.

Forster (in litt.) states that he has collected males of this species, but none could be located. The cotypes are both females; Forster (1948) makes no reference to the sex of his specimens in the original description, which is very complete as regards nonsexual characters. The ovipositor *apparently* lacks seminal receptacles; the specimen I dissected was in poor condition and almost transparent. The outer form of the ovipositor is much as it is in *A. boopis*, but definite chitinous rings are lacking. However, the setae of the ovipositor are arranged in rows that indicated a derivation from a three-ringed condition, and the apical sensilla are large, bifurcate setae.

According to Forster (1948), the species occurs under logs, in moss and leaf litter, and in other similar habitats over most of New Zealand, without significant variation.

The figures provided here of the body (Fig. 14) and palpus (Fig. 15) will demonstrate the above synonymy.

Genus *Austropsopilio* Forster

Austropsopilio Forster, 1955, Aust. J. Zool. 3(3):357. Type species, *A. novahollandiae* Forster 1955, by original designation and monotypy. *Tasmanopilio* Hickman, 1957, Papers Proc. Royal Soc. Tasmania 91:65. Type species, *T. fuscus* Hickman 1957, by original designation; NEW SUBJECTIVE SYNONYMY.

The genus *Tasmanopilio* was distinguished from *Austropsopilio* solely on the basis of the elongate eye tubercle (Fig. 16) in the latter genus. Since the foundation of the generic category is the grouping of related species, and since no differences of the level of significance separating other acropsopilionine genera are to be found between species of the two Australian nominate genera, no purpose is served by having two generic names. Unfortunately, I was unable to obtain material of either of the Tasmanian species for detailed study.

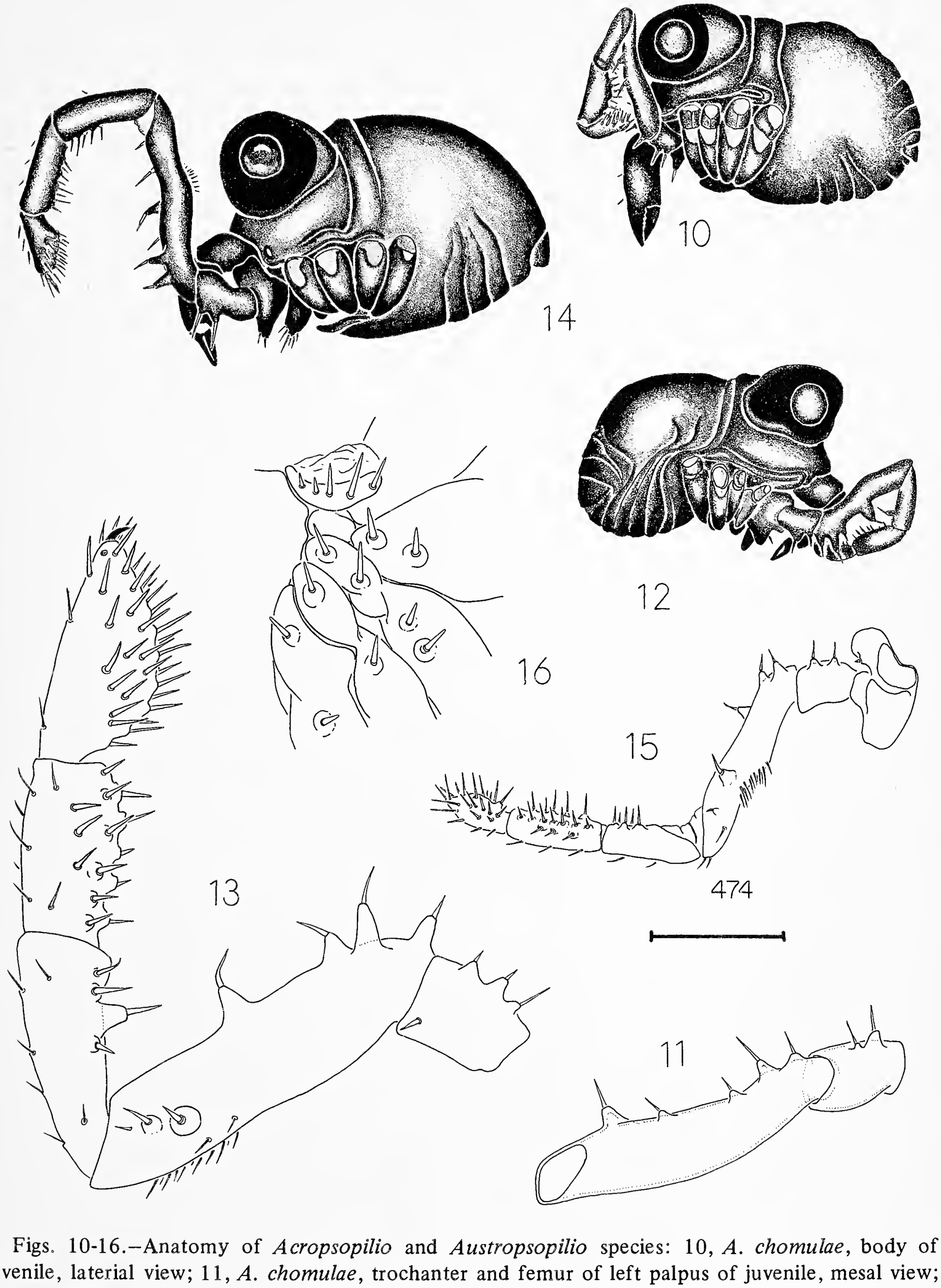
Austropsopilio novahollandiae Forster

Figs. 16-18

Austropsopilio novahollandiae Forster, 1955, Aust. J. Zool. 3(3):358-359, Figs. 8-11, juvenile.

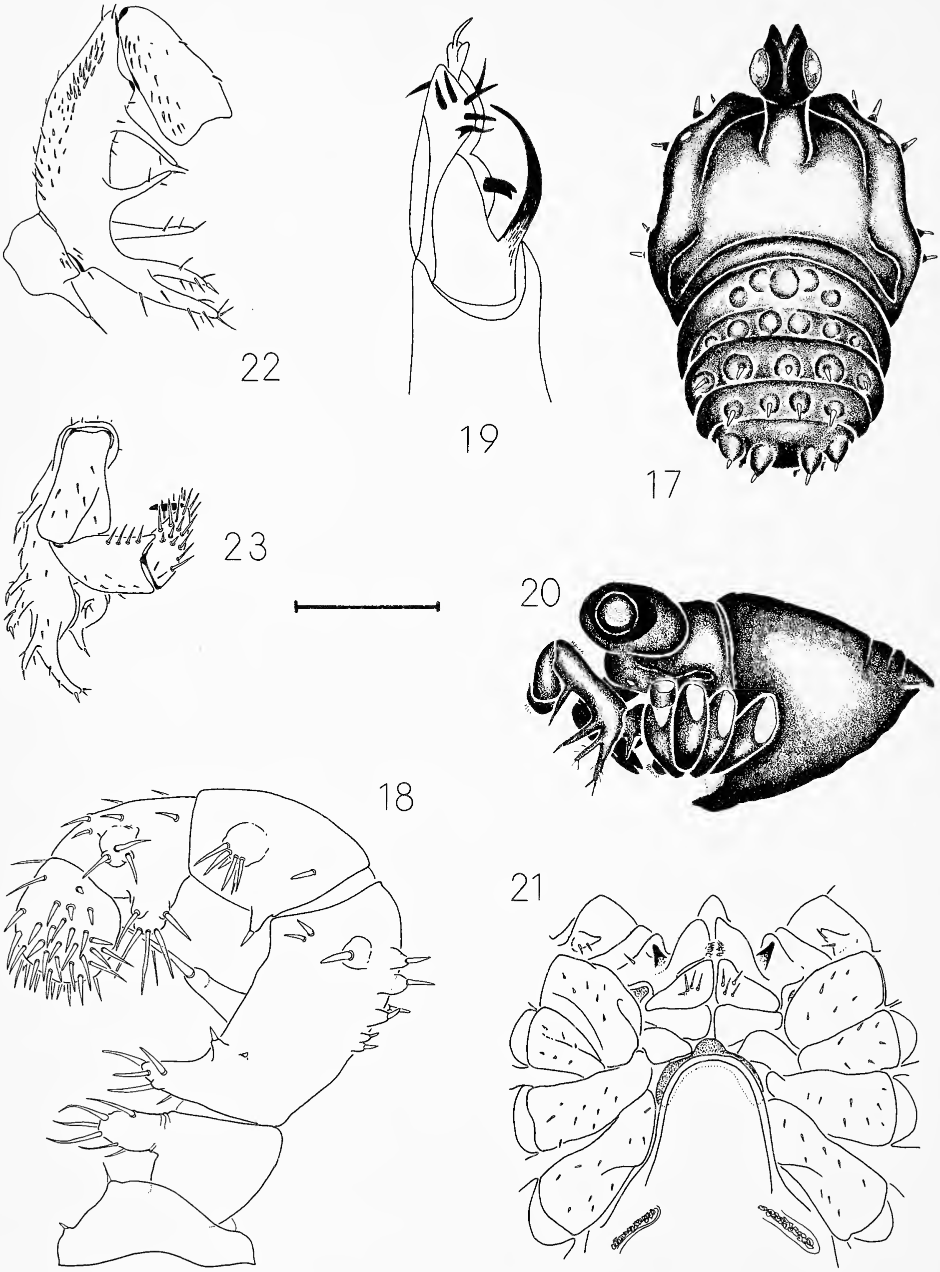
Types—Juvenile holotype from Mt. Hobwee, Lamington Plateau, south Queensland, collected from leafmold, 27 August 1953, by T. W. Woodward, in Queensland Museum, examined.

This species is unique in the elongate eye tubercle (Fig. 16), which projects forward from the anterior edge of the cephalothorax; the eyes are much smaller than in other



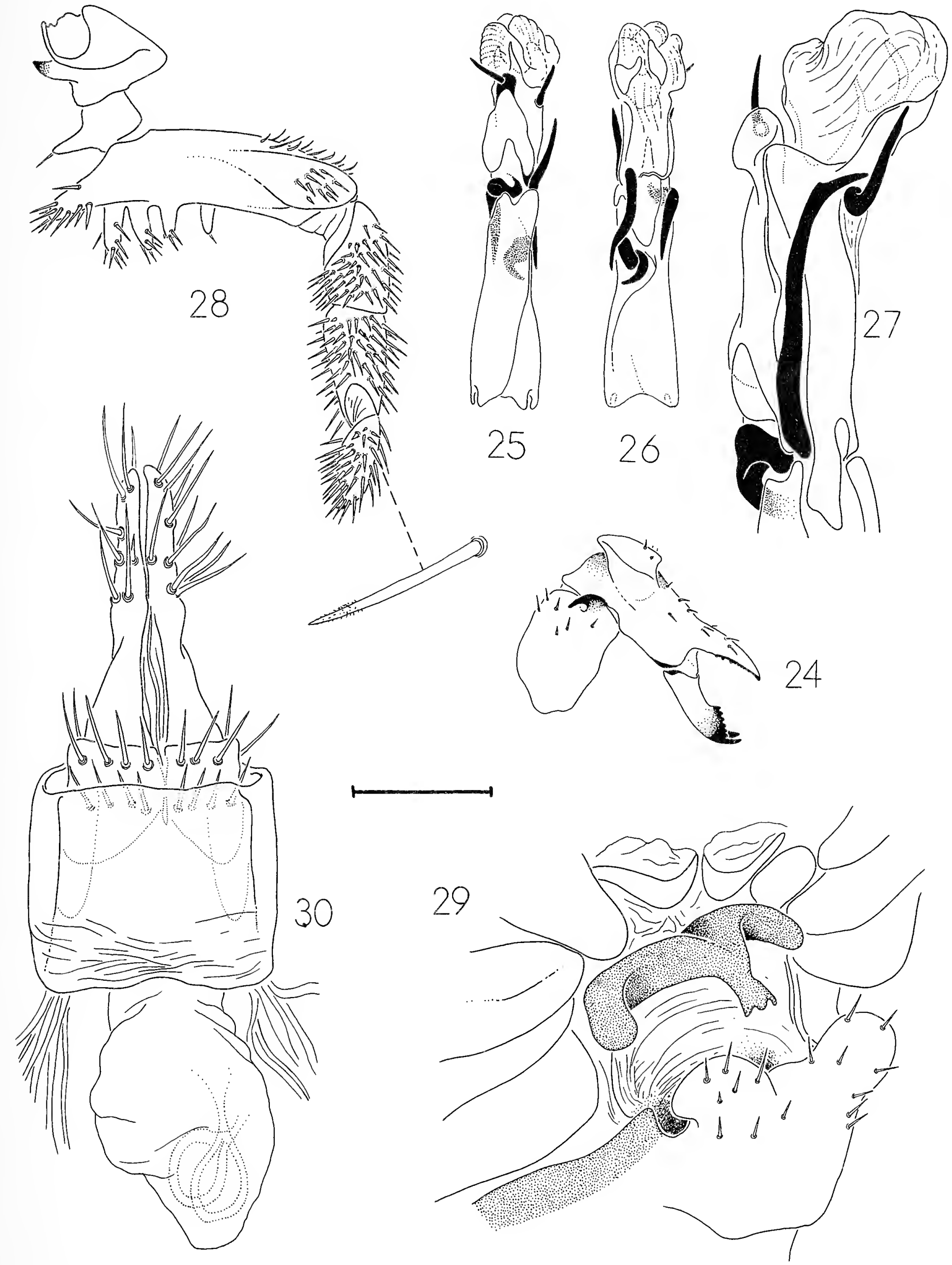
Figs. 10-16.–Anatomy of *Acropsopilio* and *Austropsopilio* species: 10, *A. chomulae*, body of juvenile, laterial view; 11, *A. chomulae*, trochanter and femur of left palpus of juvenile, mesal view; 12, *A. chilensis*, body of juvenile, lateral view; 13, *A. chilensis*, left palpus of juvenile, mesal view; 14, *A. neozealandiae*, body of female, lateral view; 15, *A. neozealandiae*, left palpus of female, mesal view; 16, *Austropsopilio novahollandiae*, left coxal endites of juvenile, ventral view. Scale line = 0.5 mm for Figs. 10, 12, 14, 0.35 mm for Fig. 15, 0.20 mm for Figs. 11, 16, 0.15 mm for Fig. 13.

caddids. The dorsal surface of the body (Fig. 16) is ornamented with rows of stout setae on tubercles. Ventrally, the coxal endites (Fig. 17), which are more prominent than in other members of the family, are likewise studded with stout setae. The species *A.*



Figs. 17-23.–Anatomy of *Austropsopilio* and *Caddella* spp: 17, *A. novahollandiae*, body of juvenile, dorsal view; 18, *A. novahollandiae*, right palpus of juvenile, mesal view; 19, *A. fuscus*, penis (after Hickman); 20, *C. capensis*, body of male, lateral view; 21, *C. capensis*, venter of cephalothorax of male, ventral view; 22, *C. capensis*, left palpus of male, lateral view; 23, *C. capensis*, left palpus of male, anterior view. Scale line = 1.00 mm for Fig. 20, 0.5 mm for Figs. 17, 21-23, 0.25 mm for Fig. 18.

cygneus Hickman, (Hickman, 1957) probably represents mature material of *A novahollandiae*, but the species synonymy should be confirmed by an examination of the type of *A. cygneus*, which I was unable to obtain.



Figs. 24-27.–Anatomy of *Caddella capensis*: 24, left chelicera of male, mesal view; 25, penis, dorsal view; 26, penis, ventral view; 27, penis, lateral view.

Figs. 28-30.–Anatomy of *Caddella africana*: 28, left palpus of female, mesal view; enlargement: glandular seta from tarsus; 29, sternum and genital operculum of female, oblique view; 30, ovipositor, dorsal view. Scale line = 0.5 mm for Figs. 24, 28, 0.20 mm for Fig. 29, 0.10 mm for Fig. 30, Figs. 25-27 not to scale, 400X.

Austropsopilio fuscus (Hickman), originally described as the type of *Tasmanopilio*, would appear from Hickman's (1957) illustrations to be somewhat intermediate in form. The eye tubercle projects slightly forward, the eyes are somewhat smaller than usual, and the palpi are of the *Austropsopilio* type. The dorsal surface lacks armed tubercles. Males and females of *A. fuscus* have been described, and there is some sexual dimorphism, as the palpus of the female lacks a claw, while that of the male is somewhat less robust and has a stout black claw. The penis (Fig. 19, redrawn from Hickman, 1957) is engimatic, but could be construed as being intermediate between the complex organ of species of *Caddella* and the simple one of *Caddo agilis*. A third species, *A. megalops* (Hickman), is known only from females (Hickman, 1957).

Genus *Caddella* Hirst

Caddella Hirst, 1925, Proc. Zool. Soc. London 1925:1276. Type species, *C. capensis*, by monotypy. Kauri, 1950-1952, S. Afr. Anim. Life 8:137. *Oonopsopilio* Lawrence, 1931, Ann. S. Afr. Mus. 29(2):470. Type species, *A. africanus*, by monotypy. *Caddella*, Lawrence, 1934, Ann. S. Afr. Mus. 30.

Lawrence (1934) recognized the synonymy of his generic name *Oonopsopilio* with *Caddella*. The genus itself forms a fairly compact group most closely related to species of *Austropsopilio*, and showing about the same range of species types. Three species have been described from South Africa and are discussed individually below. *Caddella* species are large, about the size of *Caddo agilis*.

Caddella capensis Hirst

Figs. 20-27

Caddella capensis Hirst, 1925, Proc. Zool. Soc. London 1925:1276-1277, Figs. 5A-C, ♂; Kauri, 1961, S. Afr. Anim. Life 8:137-138, Figs. 77-78, ♀.

Types—Male holotype collected by J. Hewitt, at Port Alfred, South Africa, in the British Museum (Natural History). I examined it through the characteristic generosity of the late Mr. D. Clark.

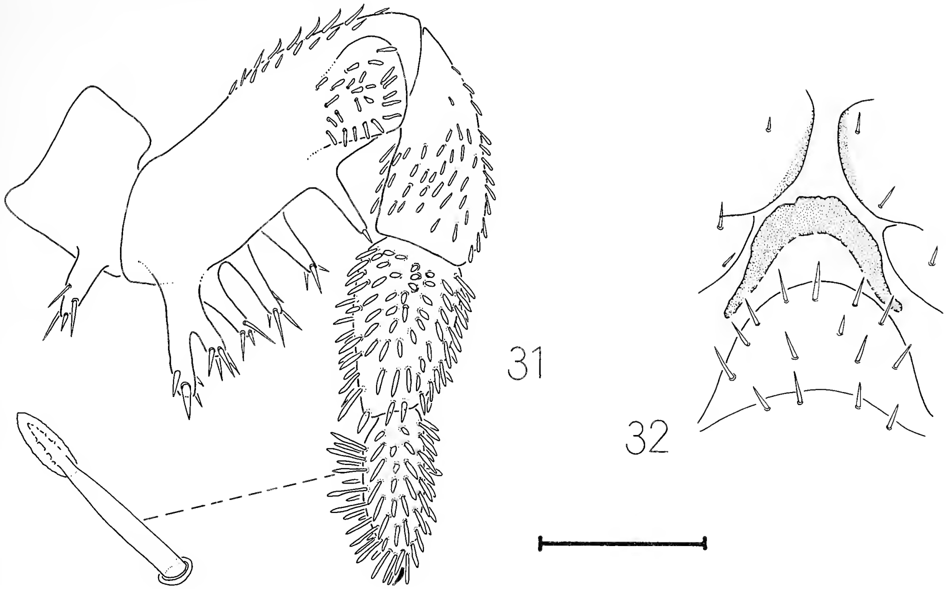
Kauri (1961) reported a female specimen from the Tzitzikama Forest, Stormsrivierpiek. I was unable to obtain this specimen. I illustrate here the body (Fig. 20), pedipalp (Figs. 22, 23) and chelicera (Fig. 24) of the male holotype. Of particular interest is the mesal sclerotized hook on the basal arrticle of the chelicera. The relationship of this structure to the ventral spine of the same article in *Caddo agilis* is not known. The anvil-like process of the distal article is not glandular.

The penis of the male (Figs. 25-27) is unique in the Opiliones, but shows some relationship with that of *Austropsopilio fuscus* (Fig. 19), as illustrated by Hickman (1957), which also could conceivably be simplified to the form found in *Caddo agilis*. There appear to be four basic plates, two proximal and two distal, fitted with heavy, curved spines. The glans is membranous, and the seminal duct could not be traced with certainty. The relative positions of the plates and spines indicate that the penis has, at some time in its ontogeny or phylogeny, undergone 180 degrees of torsion.

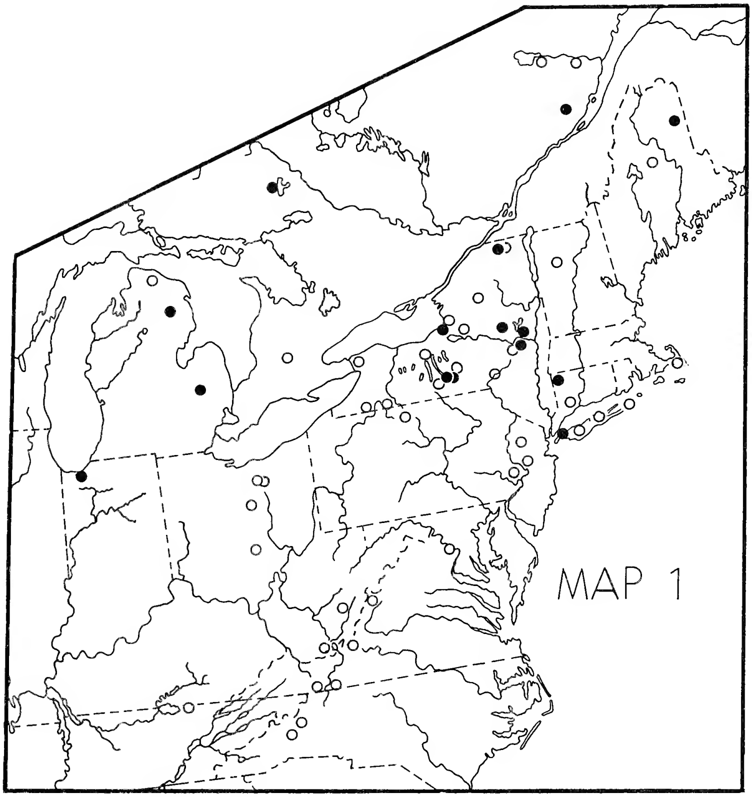
Caddella africana (Lawrence)

Figs. 28-30

Oonopsopilio africanus Lawrence, 1931, Ann. S. Afr. Mus. 29(2):470-472, Figs. 66A-E, sex not indicated. *Caddella africana*, Lawrence, 1934, Ann. S. Afr. Mus. 30:584; Kauri 1961, S. Afr. Anim. Life 8:139-140, Figs. 76-78, ♂.



Figs. 31-32.–Anatomy of *Caddella spatulipalpis*: 31, left palpus of female, mesal view; enlargement: glandular seta from tarsus; 32, sternum and genital operculum of female, ventral view. Scale line = 0.5 mm for Fig. 31. Fig. 32 not to scale, 250X.



Map 1.–Northeastern United States and southeastern Canada, showing distribution of *Caddo agilis* (circles) and *Acropsopilio boopis* (dots).

Type—Female holotype from Ladismith, Cape Province, South Africa, in South African Museum (examined).

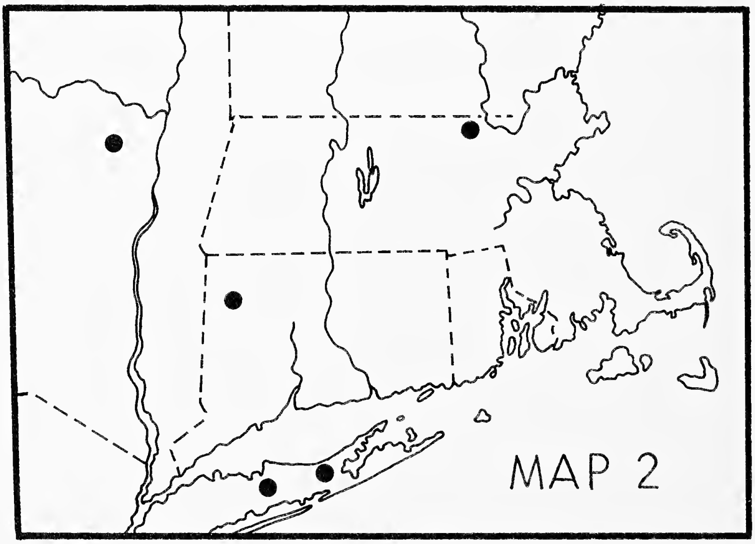
The palpus differs from that of *C. capensis*, and resembles that of *C. spatulipalpus*, in having rounded setose lobes rather than spined tubercles. The coxa, as in *capensis*, has a sharp basal thorn. The body form is typical of *Caddella*. The penis is illustrated by Kauri (1950-1951), and is much like that of *C. capensis*. The ovipositor (Fig. 30) is likewise typical, with obvious seminal receptacles. Most peculiar is the interlocking apparatus involving the sternum and the genital operculum of the female (Fig. 29). Kauri (1961), in describing the female of *C. capensis*, mentions no such structure, and it is not present in females of *C. spatulipalpis*.

The species is known from a number of localities in South Africa, generally to the west of the range of *C. capensis*.

Caddella spatulipalpis Lawrence
Figs. 31-32

Caddella spatulipalpis Lawrence, 1934, Ann. S. Afr. Mus. 30:582-584, Fig. 18, ♀; Kauri, 1961, S. Afr. Anim. Life 8:140-141, no. figs.

This species is known only from the type collection from Jonkershoek, Cape Province, South Africa, and is closely related to *C. africana*, differing mostly in the details of the palpus (Fig. 31). Also, the sternum and genital operculum of the female of *C. spatulipalpis* (Fig. 32) are not modified as in *C. africana*. Males have not been collected. The type is in the South African Museum, Cape Town (examined).



Map 2.—Southern New England, showing distribution of *Caddo pepperella* (dots).

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A COMPARISON OF NORTHERN AND SOUTHERN FORMS OF *PHIDIPPUS AUDAX* (HENTZ) (ARANEIDA, SALTICIDAE)

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ABSTRACT

Phidippus audax (Hentz) has been considered a single variable species by some taxonomists and two or more distinct species by others. Individual northern and southern specimens, though similar, can usually be distinguished by differences in size and markings evident even to the naked eye. Closer examination, however, failed to reveal consistent differences in morphology between northern and southern populations. Observed behavioral patterns that were compared also failed to show discernible differences. Laboratory cultures of separate and mixed populations were maintained through three generations.

Conversely, inter-geographical cross-matings indicated a degree of incompatibility between the populations. Matings between northern and southern specimens were less successfully achieved than intra-geographical matings. The number of viable young produced by cross-mated females was consistently less than the number produced by females mated to males from their own region. Further, the progeny of cross-bred spiders, when they were mated after maturity, produced even fewer viable young. Such evidence of incompatibility between northern and southern forms may indicate a clinal population.

INTRODUCTION

One of the most commonly seen spiders in the United States is a large black jumping spider that has a prominent white or red patch in the center of the dorsum and other less evident white markings on the carapace and abdomen. Usually it is known as *Phidippus audax* (Hentz), but it has also been recorded as *P. variegatus*, *P. a. bryantae*, and *P. tripunctatus* among other names by various authors. It occurs from Mexico to Canada, and there has been no agreement as to whether it is a variable single species or several. Some of the differences between typical northern and southern specimens are readily evident to the naked eye. A comparison of 44 northern and 35 southern specimens, for example, showed northern females having an average total length of 12.5 mm (range, 10.5-14 mm) compared to an average total length of 14.3 mm (range, 12-18 mm) in southern females. The size of the males showed a similar difference, an average length of 10.6 mm (range, 10-12.5 mm) in northern specimens compared with an average of 12.2 mm (range, 10-14.5 mm) in southern specimens. There was also a considerable individual variation in the quantity of white scales on the carapace and abdomen, hence

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different color patterns. Southern specimens generally were more vividly marked, but no standard regional pattern could be discerned. The shape of the embolus, a characteristic often used taxonomically to separate spider species, was consistently different in northern and southern males, sickle-shaped and pointed in northern specimens and straight and blunt in southern specimens.

MATERIALS AND METHODS

Collection and maintenance of specimens—*Phidippus audax* over-winters as a penultimate or younger instar. In order to have virgin females to work with, immature specimens were collected in January, February and March in Hidalgo and Victoria Counties in south Texas and near Warrensburg, Missouri. In the laboratory they were transferred to transparent plastic containers, 80 X 78 mm, which provided the visability necessary for observing the spiders' daily behavior. A hole was burned through the lid and covered with tape to facilitate feeding without disturbing the spider. For economy of space and ease of maintenance small spiderlings were kept in short lengths of glass tubing. The reduced living area of the tubing also improved the capability of second and third instar spiderlings to capture live *Drosophila* which were their main diet. (Peck and Whitcomb, 1967)

Satisfactory observation of the courtship behavior required a mating chamber that would provide both adequate room for the spiders to maneuver and good visability and also affort a means of introducing the male to the female with the least amount of disturbance. Juxtapositioning the clear plastic rearing chambers on a block of styrofoam carved to hold them in place was very efficient. The aggressiveness of the female suggested the placing of a transparent partition between the containers to protect the male until he started courtship. Once the male started signaling, the partition was removed allowing both spiders free access to the commom mating chamber (Fig. 1).

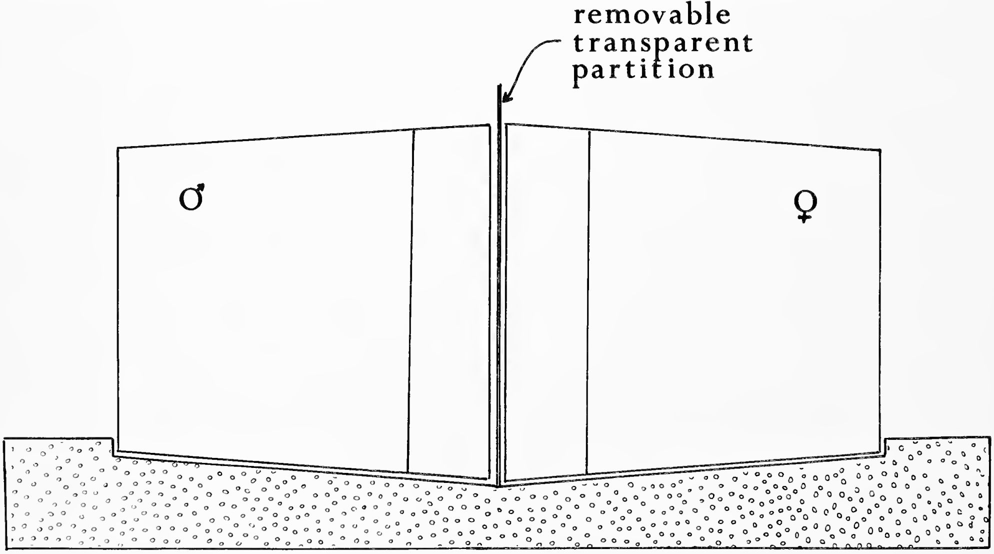

Fig. 1.—Mating chamber for the observation of courtship and copulation.

Vagrant, diurnal *P. audax* are known to feed on a variety of prey (Bailey, 1968), and a variety of food sources was used to supply as natural a diet as possible. During the first three instars, *Drosophila* sp. was the main diet. When the spiderlings grew larger, almond moths, *Caudra cautella* (Walker) and meal worms, *Tenebrio* sp. were offered regularly. During the summer months, orthopterans, homopterans, and other insects were fed, and cultures of wax worms, *Galleria mellonella* (Linn.), were established to provide a steady supply of prey of an appropriate size.

It seemed necessary to prevent the adult spiders with their acute vision from seeing each other continuously if valid courtship behavior was to be observed later. Hence the individual transparent containers were placed in low boxes and separated by partitions. With 12 containers to a box, handling for daily observations and feeding was simplified and the spiders were kept visually isolated. An enclosed glass cabinet roughly maintained an average relative humidity of 52% or higher, and moistened cotton provided ingestible water in each container. The photoperiod was controlled and gradually increased from 10 to 16 hours at the proper time of the year as recommended for optimal rearing conditions by Miyashita (1968). The temperature remained unchanged at about 80°F.

DISCUSSION AND RESULTS

Various species of *Phidippus* and some other salticids have been extensively studied by a number of researchers (Peckham, 1895; Gerhardt, 1928, 1933; Bristowe, 1926, 1929; Kaston, 1936; Crane, 1949; Bailey, 1968; Wild, 1969; Horner and Starks, 1972), but certain detailed aspects of the bionomics and behavior of *Phidippus audax* that became evident during this study are reported herein for their intrinsic value.

Courtship and mating–The chain of inherited, instinctive actions that forms a fixed behavior pattern such as found in spider courtship has as its links a series of specific releasers that are provided only by the other sex of the same species. A specific action by the male acts as the releaser for a specific response by the female, which, in turn, elicits another response by the male. The patterns are as characteristic of a species as its physiology or its structural features. Hence they may serve as isolating factors that prevent interbreeding between true species.

The courtship pattern of pairs of spiders in which both members had been collected from the northern portion of the studied range was carefully observed and compared with that of pairs from the southern portion of the range. Differences in the patterns, if any, eluded the human observer. Trial matings between northern males and southern females, and the reciprocal, were also attempted and successfully accomplished although some evidences of incompatibility were revealed (Table 1).

Table 1.–Mating northern and southern forms of *Phidippus audax* under laboratory conditions.

Mating pairs	Successful on 1st mating trial	Unsuccessful on 1st mating trial
Northern ♂ X Southern ♀	8	1
Southern ♂ X Southern ♀	2	0
Total intra-geographical trials	10	1
Northern ♂ X Southern ♀	6	9
Southern ♂ X Northern ♀	9	1
Total inter-geographical trials	15	10

When the male and female, each in its own container, were placed on the mating stage, they were generally quite inactive due to having been disturbed. Neither showed signs of seeing the other until one of them moved. If the female saw the male first, she normally began a typical hunting behavior pattern as described by Gardner (1964). That is, she would orient herself toward, pursue, or jump at the male. The male, upon seeing her movement, would begin his courtship signaling by elevating the carapace, raising the first pair of legs at a 45° angle and bending them slightly at the femur-patellar joint. He continued by moving his raised front legs in two jerky motions, drumming his palpi, and moving laterally. Intermittently the male would "pose" holding his elevated legs and palpi motionless. If the male's "epigamic rhythm," as reported by Crane (1949), was at a low tone, he might strike back at the female rather than court. If the male saw the female first, he would orient toward her, watch her quietly, move toward her, or start signaling immediately. The male's signal was normally started when the female made a move in his direction.

The female responded to the male's signaling by raising her body and swaying in his direction when he moved laterally. She might elevate her front legs slightly as she swayed. As the male continued his display he often completely circled the female, gradually closing the distance between them. The female became totally attentive to the male as he approached, lowered her body, retreated slightly, and ultimately allowed the male to touch her with his front legs. If she did not move after several taps, the male mounted, ending courtship and commencing copulation. Although the partition between the containers of the male and female was removed only after the male had signaled and initiated courtship, the female attacked on several occasions. Usually the male escaped without being killed, and in several instances after being attacked a male again initiated courtship and successfully mated. Fig. 2 shows the sequential pattern of courtship.

The mating position is a slight modification of position No. 1 described by Kaston (1948). Insertions of the embolus were made alternately on each side several times. Successful copulation was indicated by rhythmic pulsations by the male shortly after he was in position. A total of 25 successful and 11 unsuccessful mating attempts were observed under laboratory conditions. An average mating lasted for one hour and 18 minutes but the time ranged from 14 minutes to two hours and 48 minutes. The female normally terminated copulation by moving while the male was attempting to change sides. When this occurred the male moved quickly off of the female posteriorly and was typically signaling with raised front legs by the time the female turned to face him. A male usually tried to court the female again but was never observed to succeed.

Table 1 shows the results of mating attempts between pairs from the same geographical area and pairs with one northern and one southern member. Whereas there were successful matings in all combinations, it is interesting to note that although more than 90% of the intra-geographical mating attempts were successful, only 60% of the inter-geographical attempts succeeded. There is a considerable difference in the size of northern and southern specimens and this difference was most readily evident when a northern male was paired with a southern female. Although initially all of the pairings were made by random selection, later combinations of size-compatible mates were tried. It was found that the largest of the northern males in the culture would mate with moderate sized southern females, but the average, smaller northern male when paired with a typically larger southern female could never be made to mate. The progeny that resulted from each of these mating combinations, discussed in the next section, showed some of the same incompatibility that was evident in the mating.

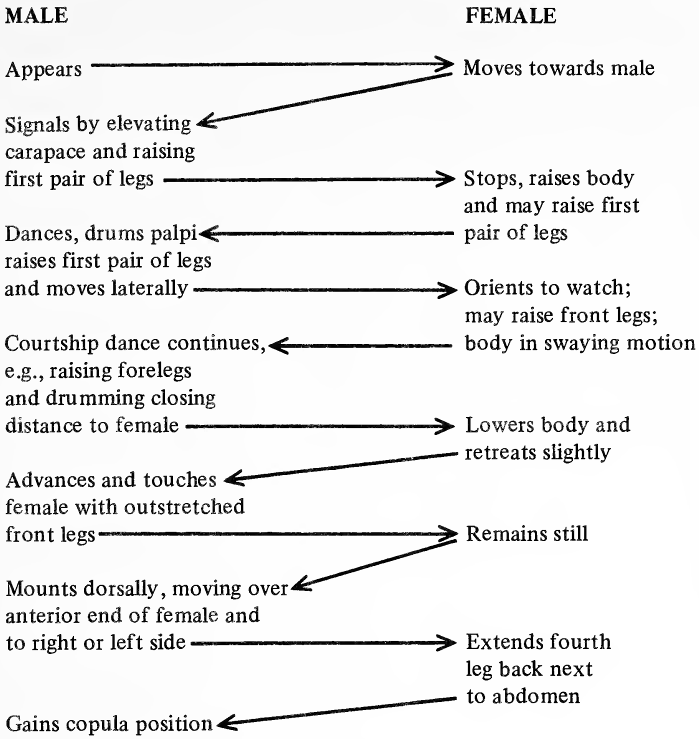

Fig. 2.–Sequential pattern of courtship in *P. audax.*

Progeny–All mating combinations produced viable young, and some of the "hybrid" progeny of inter-geographical matings were reared to maturity, mated, and produced a viable F_2 generation. A noticeable discrepancy in the production of young from the different mating combinations was shown, however. The mean number of egg sacs, of young per egg sac, and of total viable young for each mating combination is shown in Table 2. Southern females produced more egg sacs per individual and averaged a greater number of young per egg sac regardless of the origin of the male with which they were mated. Southern females that were mated with northern males, however, produced only about 65% of the young that were produced by those that were mated with males from their own geographical region. Northern females that were mated with southern males, furthermore, produced scarcely 50% of the average production of northern females that were mated with northern males.

Table 2.–Production of egg sacs, young per egg sac, and total young in each mating combination. The number of females from which means were derived is shown in parentheses.

	N♂ X N♀ (8)	S♂ X N♀ (7)	S♂ X S♀ (8)	N♂ X S♀ (6)
Mean number egg sacs	3.5	2.7	4.1	3.5
Mean number of young per egg sac	63.9	41.7	85.5	65.6
Mean number of young per female	224	113	353	230

Females produced from one to six egg sacs during the productive period, and it has been noted in spiders generally that each successive oviposition contains fewer eggs (Peck and Whitcomb, 1970; Kaston, 1970). The young that emerged from each of the first four egg sacs produced by several females in all mating combinations were recorded. The mean production for each is tabulated in Table 3. The difference in the production at each oviposition parallels the difference in the total production.

One female from inter-geographically mated parentage, when mature, was mated with a male of southern parentage. She produced 58 viable young in the only egg sac recorded. Two males resulting from inter-geographical matings were mated with females of southern parentage. The latter produced 45 and 54 young in the first and only egg sac recorded for each of them. This production is far below the mean number of young from first egg sacs, but whether the reduced number of young in these cases could be attributed to the mixed parentage involved or to two generations of life in the laboratory is an unanswered question.

Table 3.—Mean production of young from each of the first four egg sacs in each mating combination. The number of egg sacs from which means were derived is shown in parenthesis.

Egg sac	N ♂ X N ♀	S ♂ X N ♀	S ♂ X S ♀	N ♂ X S ♀
1st	(8) 88.6	(5) 69.8	(7) 125.6	(5) 107.4
2nd	(7) 76.7	(5) 49.8	(7) 115.5	(4) 83.2
3rd	(7) 65.2	(3) 73.6	(7) 83.2	(3) 56.0
4th	(1) 66.0	(2) 35.0	(6) 70.5	(2) 12.5

Development—The total progeny from 29 egg sacs was observed daily to record morphological and behavioral details in the developing spiderlings throughout postembryonal development in an effort to discern any variability between the young of the southern and northern forms and their "hybrids." Although none could be detected, again the detailed observation that was required revealed certain developmental aspects that may be intrinsically of value.

Oviposition occurred inside a typical resting cell, an ovate, dome-shaped structure of silk that measured about 45 X 30 X 10 mm, varying somewhat with the size of the female. Guy lines attached to the outer surface apparently provide structural stability, and the cells were open at both ends. Preparation for oviposition by the gravid female began with the construction of a silk platform inside the resting cell. The egg mass was deposited on this disc-like platform in a viscous mound that measured 4-10 mm in diameter depending upon the number of eggs it contained. When oviposition was complete, the female covered the mass by passing silk lines back and forth over it and attached them to each side of the base until a complete, lenticular capsule was formed.

To observe egg development, it was necessary to remove one side of the egg sac, which is rather easily done along the lateral seam. One layer of eggs is thus exposed nested in the saucer-like remains of the egg sac. In this form the eggs were then placed in a watch glass which was in turn placed in another closed container with water to maintain a high humidity as described by Holm (1940).

The color of the eggs varied from pale yellow, which was most common, to light green. The same female was found to produce both yellow and green eggs at different ovipositions although all eggs in any one egg mass were homogeneously colored. Egg diameters ranged from 1.13 to 1.33 mm. The first sign of change occurred five to seven days after oviposition when the tightly packed eggs began to expand and automatically dislodge from the mass due to a bulging that changed the egg shape from spherical to ovate. Nine to 12 days after oviposition a faint outline of the embryos' legs, chelicerae, carapace, and abdomen could be seen through the chorion. Egg teeth could be detected as two dark spots, one at the base of each chelicera.

Eclosion began with slight pulsations along the lateral areas of the outlined carapace about two days after this outline was visible. The chorion began to part over the egg tooth and split posteriorly along a line following the base of the carapace. Over a period of about an hour it slipped off the carapace and abdomen, passed ventrally over the chelicerae and legs, and remained attached in a wad at the spinnerets. Following the suggestion of Galiano (1969) for observing egg membranes, an ink spot was applied on the vitelline membrane that still encompassed the embryo. Although the membrane itself was difficult to see, this ink spot and the egg teeth which are on the vitelline membrane could be followed in their movement when this membrane was shed. After this membrane is shed the spiderling's abdomen is still positioned at right angles to the carapace and the legs are pressed, fully extended, length-wise along the body as in the previous stage because the spiderling is still encased in a third membrane. Since it was all but impossible to see this membrane, a second ink spot applied at the point vacated by the previous one was an effective means of observing the progress of its sloughing. The shedding of this third membrane required several hours, but at its completion the body setae began to stand erect, and the spiderling's abdomen assumed the same plane as the carapace. Although now free from any enclosing membranes, the spiderling lay immoble on its side or back with its legs extended straight out from the body. The only movement evident was a slow flexing of the tarsi.

The newly emerged spiderling was essentially the same color as the egg. Within eight to ten hours the integument of the carapace and abdomen began to darken. Eye spots were visible but remained colorless except for a dark, heavily pigmented border. They appeared to be light sensitive as leg movements increased noticeably when a light beam was directed on the spiderlings. The spinnerets were present but presumably not functional (Vachon, 1958). The chelicerae and fangs were separately articulated and probably functional to some extent. Previously, Kaston (1948) and others believed that the spiderling never fed at this stage but depended wholly upon vitelline reserves. However, it has since been noted, reported by Peck and Whitcomb (1970), Galiano (1969), Kaston (1970) and Schick (1972) that some of these newly hatched spiderlings develop swollen abdomens typical of older spiders after they have ingested a substantial quantity of food. These spiderlings were almost always found near a dead, deflated, embryonal spiderling that had not completed eclosion and some have been observed feeding. A few spiderlings at this stage in this study were also observed feeding on uneclosed eggs. There was no evidence of predation upon fully eclosed spiderling.

For the first two days after eclosion movement was principally limited to desultory flexing of the legs although an increasing degree of coordination was evident during this time. By the end of the two days the spiderling was able to right itself and move feebly from place to place. Their mobility on the silk of the egg case was much better than it was on the smooth surface of the container where they could scarcely maneuver at all. Since they would still be enclosed in the egg sac under normal conditions their mobility needs at this time are very slight.

The first true molt under natural conditions occurs inside the egg sac about ten days after eclosion, and the second instar spiderling remains in the egg sac for four to seven days before emerging. Spiderlings that hatched from egg sacs that had been opened for observation remained congregated on the egg sac silk for several days in this same way before scattering. Kaston (1965) believed that this voluntary scattering is a result of changes in their tropistic behavior that occur at this time.

Morphological changes in immature spiderlings—The second instar spiderlings were fully equipped to fend for themselves away from the egg sac. Their evident awareness of their surroundings and their ability to stalk and capture prey indicated functional eyes. Better coordination and claw tufts, which were lacking in the previous stage,

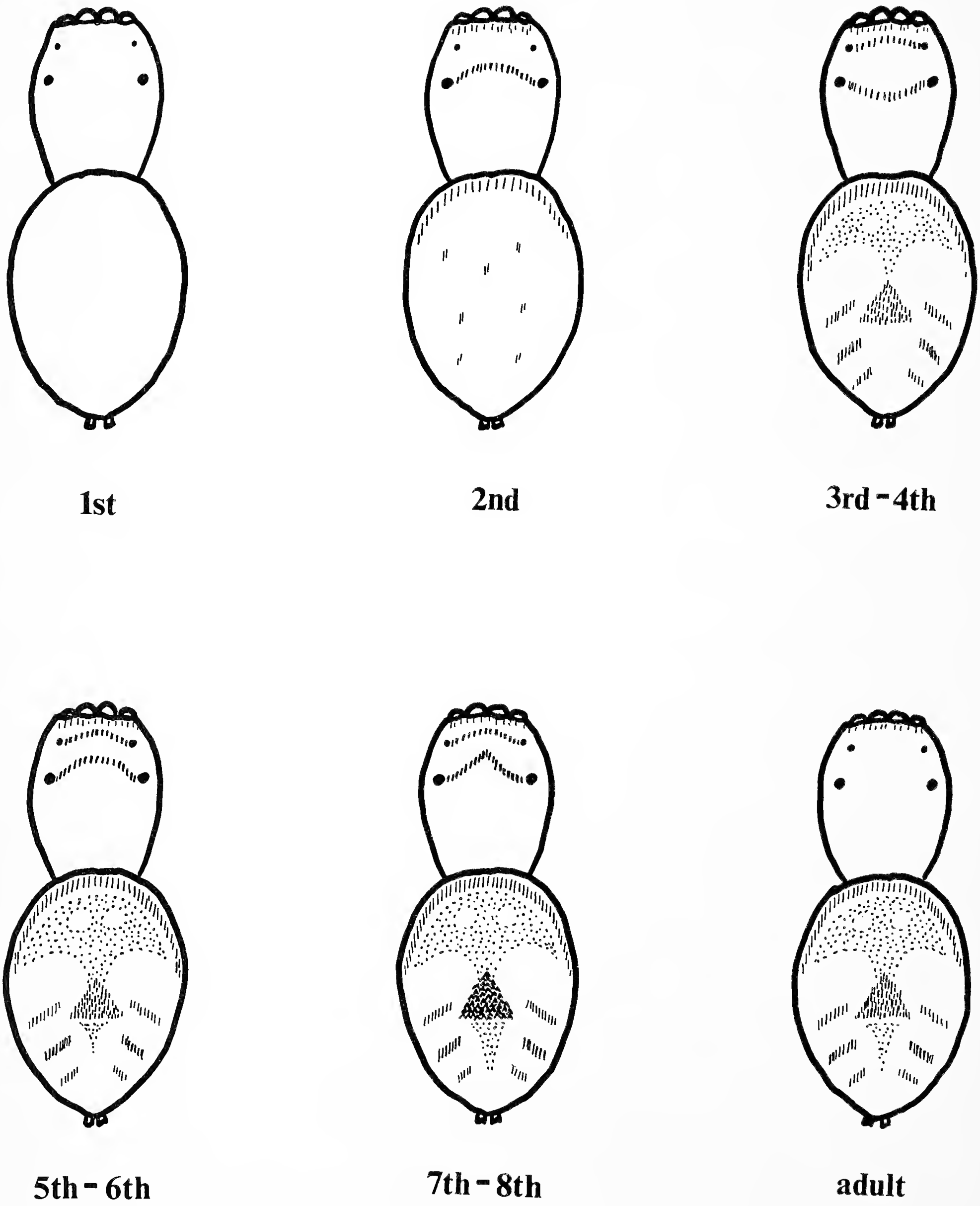

Fig. 3.—Progressive changes in color patterns typical of the developmental stadia.

allowed them to move on any surface and in any plane. That the spinnerets were functional was obvious from the myriad drag lines that began to cover the container and the small resting cells that were built.

Superficial, sequential, changes in the pattern of color scales, and the pigmentation of the integument of the carapace, abdomen, and legs became evident, but they were apparently uniform in all spiderlings regardless of parentage. The features noted hereafter were typical progressive changes in all the spiderlings reared. The first instar darkened from the yolk color of the egg at eclosion to jet black by the time of the first molt. Unlike succeeding instars, these spiderlings lacked color scales altogether, but the banded color pattern of the integument of the legs was much the same as that of other immature instars. This banded appearance resulted from the contrast of the black coxae, trochanters, and femora with the reddish brown patellae. The tibiae, metatarsi and tarsi each are reddish brown proximally and black distally. This pattern remained unchanged until maturity except that the bands became more distinct with age.

Other changes that occurred in the color patterns of the carapace and abdomen hereafter described, were due to an increasing quantity of scales that appeared at each successive instar. The black second instar spiderlings had a few white scales scattered sparingly on the carapace, around the large anterior median eyes, and in a band that crossed the carapace between the third eye row. The abdomen was marked with a faint dorso-anterior band of white scales, and a few others were scattered over the dorsum.

A considerable change in both the amount of scales and their pattern was seen in the third instar. The clypeus and the area between the eyes of the anterior eye row were densely covered with yellowish or off-white scales. A recurved band of scales of this same color crossed the carapace between the PME (second eye row) and a procurved band crossed between the PLE (third eye row). The anterior band of scales wore off toward the end of the instar due to the spiderling's moving about and brushing this high point of the carapace against the resting cells as it entered and left them. The posterior band was not affected, and the result was that of leaving the carapace unscaled and black in the center just prior to the molt.

The black abdomen of the third instar was marked with a distinct dorso-anterior band of white scales that extended posteriorly along the sides of the abdomen about one third of its length. Each side of the cardiac area was covered with some rather inconspicuous dark metallic scales, and posterior to them, and almost in the center of the dorsum, there was a triangular-shaped patch of white scales. To each side of this spot and separate from it were small bars of white scales extending laterally, and posterior to them and to the white patch were two more pairs of white bars that angled posteriorly.

Later instars displayed only slight variations of this same pattern. A greater abundance of metallic scales forming a more dense pattern occurred in the fourth instar. The fifth instar showed a slight posterior curve in the band of scales between the PLE which became more pronounced in the sixth instar and darkened to a reddish-yellow. In the sixth instar the metallic scales on the abdomen extended more posteriorly also to an area posterior to the central white patch. This white patch, in one instance, became red in this instar as well.

The color change of the abdominal markings from white to red was apparently characteristic of the antepenultimate and the penultimate instars. Thirty two percent of the spiderlings showed the change in their seventh instar, 35% in the eighth, and 20% in the ninth. The change occurred in spiderlings of both sexes, and all regained white markings as mature males or females. Fig. 3 graphically outlines the sequence of the changes in the pattern as spiderlings develop.

Growth rate—Neither males or females attained maturity in a standard number of instars, and no pattern of difference in growth rate between northern and southern forms or in the progeny of inter-geographical matings was evident in 31 specimens whose entire life cycle was recorded. Table 4 illustrates the instar of maturity of individuals from nine broods. Males seem typically to mature in the eighth and ninth instar and females in the tenth, but a considerable number completed their development earlier or later.

Table 4.—Maturity instar of males and females from different mating combinations.

Parentage	8th Instar		9th Instar		10th Instar	
	Male	Female	Male	Female	Male	Female
S ♂ X S ♀ (5 broods)	0	0	4	2	0	5
N ♂ X N ♀ (1 brood)	0	1	0	0	0	0
S ♂ X N ♀ (1 brood)	3	0	2	0	0	6
N ♂ X S ♀ (1 brood)	0	0	0	0	0	6

The total number of days required to reach maturity varied greatly but no pattern relative to parentage could be considered conclusive. Four males from three broods of S ♂ X S ♀ parentage required a mean number of 244 days to reach maturity. However, five males from a single brood of S ♂ X N ♀ parentage reached maturity in a mean of 174 days, and all reached maturity within a period of 15 days. On the other hand six females from the same egg mass just cited (of S ♂ X N ♀ parentage) matured in a mean of 273 days and all within 30 days of each other while six females from the three broods mentioned earlier (S ♂ X S ♀ parentage) required a mean of only 256 days to reach maturity and the span between the earliest and the latest to mature was 101 days.

Both males and females displayed similar patterns in instar length for the first four instars. The mean duration of the instars for females was 10, 11.7, 14.8, and 17.3 days respectively compared with 10, 10.8, 13, and 15 days respectively for males. Deviation from these means did not exceed four days in these instars. Beginning with the fifth instar, however, the close uniformity of instar durations was lost, and deviation from the mean duration was as much as 23 days. The last two immature stadia were the longest regardless of sex or the instar of maturity. An inherent "diapause" of this sort may be correlated with the habit of these spiders to hibernate during the winter months in these later instars.

A rise in the mortality rate at the completion of the fifth instar was also evident. High survival rates of 100, 98, 96, and 96% were recorded for the first through the fourth instars. Eighty percent survived the fifth instar, but the rate dropped to 40% in the sixth and remained low thereafter. No external change in the environmental condition could be attributed to causing this change in mortality. And because it occurred in all broods, it, along with the onset of much less uniformity in the stadia duration, may indicate that this is a critical stage of growth that may be correlated with physical changes in the spider.

CONCLUSION

Slight morphological differences in the embolus, differing patterns of color scales, and a considerable variation in size, all traditionally bases for separating spider species taxonomically, and ones which have been used previously to separate the northern and southern forms of *Phidippus audax* (Hentz) as different species were confirmed in this study. It was shown, however, that these differences are not sufficient for reproductive isolation in this spider since viable young resulted from all mating combinations. On the other hand, the reproductive efficiency of inter-geographically mated pairs was noticeably reduced indicating the possibility of some degree of genetic incompatibility. There is no evidence that the northern and southern populations are or have been geographically isolated, and they doubtless represent a single, but widely dispersed gene pool with little interaction between individuals of the geographic extremes.

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ANNUAL AERIAL DISPERSAL OF JUMPING SPIDERS IN OKLAHOMA (ARANEAE, SALTICIDAE)[1]

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ABSTRACT

An annual dispersal study of jumping spiders (Araneae: Salticidae) was conducted at Oklahoma State University, Stillwater. A total of 215 spiders, representing 12 gerera, were collected from two Johnson-Taylor suction traps. Of these, 190 (ca. 88%) were immature. The remainder included 18 males and seven females. Dispersal was detected each month of the year except January.

INTRODUCTION

Available information on spider dispersal includes data on the process of ballooning (Blackwall, 1827, and McCook, 1877), climatic conditions (Emerton, 1908; Bristowe, 1929; Freeman, 1946), height records, (Crosby and Bishop, 1936; Glick, 1939, 1960), and dispersal of known spider populations (Duffey, 1956). Little information is available on the seasonal dispersal of given families. The present study was designed to determine the dispersal trends, monthly dispersal rate, and identification of ballooning spiders in the family Salticidae during one year. At least seven other families were collected but the individuals have not been identified.

MATERIALS AND METHODS

Aerial dispersal of salticids was studied by collecting immature and adult forms in two Johnson-Taylor suction traps. The suction traps were capable of pulling air into the trap from several feet above and around the opening. A fine mesh funnel screen terminated in a one-pint jar. Specimens were trapped, killed and preserved in the jar which contained 80% ethyl alcohol.

Trap No. 1 was located on top of a building (ca. 50 ft.) on the main campus at Oklahoma State University, Stillwater. The surrounding area consisted of streets parking lots and campus buildings. Vegetation in the area was that of the landscaped campus (shrubs, trees, and grass). The second trap, No. 2, was on a 10 ft. roof of the Insectary. This placed the opening about 17 ft. above ground level. The Insectary is one mile west of the main campus. Vegtation to the south and east consisted of experimental station test crops of sorghum, small grain, etc. Southeast and west of the trap stretched pecan orchards, catalpa grove, and native vegetation. To the north, most of the vegetation was native grass.

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Salticids were separated from other spiders and insects in the trap samples, then stored in 70% ethyl alcohol. Samples were made daily during late spring, summer, and early fall due to rapid rate of alcohol evaporation and heavy insect populations. During the remainder of the year, samples were taken every 3 or 4 days. During times of heavy rainfall, some samples were lost when the alcohol was diluted to the point that preservation did not occur.

RESULTS AND DISCUSSION

Table 1 presents the taxa, number and ontogenetic stage of salticids collected from each of the two traps. The traps yielded 215 specimens, of which 190 were immature and of indeterminate sex, 18 were mature males and 7 mature females. The vast majority of the immatures were very early instar (probably second). This was expected since, early instars are the common ballooners. Although the number of adults taken was small, the data show that some adults of the smaller salticids do use ballooning as a means of dispersal.

Table 1.—Number and ontogenetic stage of salticids collected from Johnson-Taylor suction traps.

	Immature	Mature Male	Female	Total Specimens	Immature	Mature Male	Female	Total Specimens
Taxa	Trap No. 1				Trap No. 2			
Icius sp.	19			19	5			5
Hentzia ambigua (Walckenaer)	10	3	2	15	5	4		9
Marpissa pikei (Peckham)	1	2		3				
Habronattus sp.	10			10	15			15
Metaphidippus sp.	13			13	7			7
Phidippus sp.	41			41	26			26
Metaphidippus unknown sp.		1		1				
Metaphidippus galathea (Walckenaer)	12	6	3	21	6	2	1	9
Eris sp.	2			2	2			2
Eris marginatus (Walckenaer)			1	1				
Tutelina sp.	6			6	2			2
Salticus sp.	1			1	5			5
Peckhamia sp.					1			1
Gertschia					1			1
GRAND TOTAL				133				82

The genus *Phidippus* was represented by a total of 67 specimens, followed by 50 for *Metaphidippus*, 25 for *Habronattus* and 24 for *Hentzia*. Species of *Peckhamia* and *Gertschia* were each collected once. These latter two were only collected in the higher trap.

Of the total spiders collected in the traps 13.5% of those in trap No. 1 were adults compared to 8.5% in trap No. 2. This is probably due to the difference in height of the traps. The adults are heavier and may not drift so high as the spiderlings.

Table 2 shows ontogenetic stage and number of each taxon for each month. July had the greatest number with 62 individuals, followed by November with 31. June, August and October had 28, 29 and 29 respectively. Winter and early spring months yielded fewer than 10 each month, and January yielded none.

Table 2.–Taxa of salticids collected monthly from Johnson-Taylor suction, traps, Stillwater, Oklahoma. I = Immature, F = Female, M = Male

Month	Taxon	Stage	Number Collected	Monthly Total
January 1971				
	(None Collected)			0
February 1971				
	Phidippus sp.	I	3	3
March 1971				
	Hentzia ambigua (Walckenaer)	M	1	1
April 1971				
	H. ambigua	I	1	
	Phidippus sp.	I	2	3
May 1971				
	Metaphidippus galathea (Walckenaer)	I	2	
	Tutelina elegans (Hentz)	I	2	
	Habronattus sp.	I	1	
	H. ambigua	I	1	
	Phidippus sp.	I	2	8
June 1970				
	Icius sp.	I	9	
	H. ambigua	F	1	
	H. ambigua	M	1	
	Marpissa pikei (Peckham)	M	1	
	Habronattus sp.	I	4	
	Metaphidippus sp.	I	4	
	Phidippus sp.	I	4	
	M. galathea	I	1	
	Eris sp.	I	1	
	M. galathea	M	1	
	T. elegans	I	1	28
July 1970				
	Icius sp.	I	7	
	Phidippus sp.	I	35	
	Habronattus sp.	I	7	
	Metaphidippus sp.	I	7	
	Peckhamia sp.	I	1	
	Salticus sp.	I	1	
	M. pikei	M	1	
	Hentzia sp.	I	1	
	M. galathea	M	1	
	Metaphidippus sp.	M	1	62
August 1970				
	Phidippus sp.	I	7	
	M. galathea	I	5	
	Metaphidippus sp.	I	2	
	M. galathea	M	4	
	M. galathea	F	2	
	Habronattus	I	4	
	Icius sp.	I	4	
	Eris sp.	I	1	29

Table 2.-Continued

Month	Taxon	Stage	Number Collected	Monthly Total
September 1970				
	Icius sp.	I	2	
	Phidippus sp.	I	2	
	Metaphidippus sp.	I	3	
	M. galathea	F	2	
	M. galathea	I	2	
	H. ambigua	F	1	
	Hentzia	I	1	
	Habronattus sp.	I	3	
	Gertschia sp.	I	1	17
October 1970				
	Habronattus sp.	I	5	
	Metaphidippus sp.	I	1	
	M. pikei	I	1	
	Icius sp.	I	2	
	Phidippus sp.	I	6	
	Eris sp.	I	1	
	E. marginatus (Walckenaer)	F	1	
	Hentzia sp.	I	3	
	H. ambigua	M	4	
	Tutelina sp.	I	2	
	M. galathea	I	2	
	Salticus sp.	I	1	29
November 1970				
	Hentzia sp.	I	6	
	H. ambigua	M	1	
	Salticus sp.	I	3	
	Phidippus sp.	I	6	
	Metaphidippus sp.	I	3	
	M. galathea	I	6	
	M. galathea	M	2	
	Eris sp.	I	1	
	Tutelina sp.	I	2	
	Habronattus sp.	I	1	31
December 1970				
	Hentzia sp.	I	3	
	Tutelina sp.	I	1	4

It is difficult to establish specific trends for the species listed. In general it seems that salticids are active annually, at least under climatic conditions present in this area of Oklahoma. Through no salticids were collected in January, some dispersal probably occurs then since a few were collected in December and February.

The Johnson-Taylor suction traps are well adapted to this type of survey. Some spiders may have been overlooked in the sorting process and some samples were lost to spoilage during periods of heavy precipitation. Further study of aerial dispersal is desired. Needed information about the relationship between specific climatic conditions and individual species dispersal habits can be obtained with the suction traps.

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A NEW SPECIES OF *DIPLOCENTRUS* FROM NEW MEXICO AND ARIZONA (SCORPIONIDA, DIPLOCENTRIDAE)

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ABSTRACT

The scorpion *Diplocentrus peloncillensis* new species (Scorpionida, Diplocentridae) is described from specimens collected in the Peloncillo Mts. and Guadalupe Mts. of New Mexico and Arizona. Related to *D. spitzeri* Stahnke and *D. keyserlingi zacatecanus* Hoffmann, it can be separated from these two species by the tarsomere II spine formula and by several morphometric differences, most important of which are the relative lengths of the pedipalp humerus and metasoma segment V. Brief ecological observations on the new species are reported.

INTRODUCTION

Taxonomically, the species belonging to the genus *Diplocentrus* Peters (1861) have been largely neglected in the United States, with most published records before 1967 being erroneously referred to either Mexican or Antillean taxa. Since then, two species belonging to this genus have been described from the continental United States. *Diplocentrus bigbendiensis* Stahnke (1967) is a large species, with adults commonly reaching 65-75 mm in total length. It has a dark brown to black coloration and occurs in the Big Bend region of Texas. *Diplocentrus spitzeri* Stahnke (1970) is smaller, with the adults never exceeding 50 mm in total length. It is medium brown in coloration and has been found only in Santa Cruz Co., Arizona, and in adjacent areas in Sonora, Mexico. The new species described in this paper is closely related to *D. spitzeri*, but comes from the Peloncillo Mts., Hidalgo Co., New Mexico, and Guadalupe Mts., Cochise Co., Arizona. The physiological study by Crawford and Wooten (1973) on specimens from the Peloncillo Mts., reported as being *D. spitzeri*, is here referred to this new species.

Diplocentrus peloncillensis, new species

Diagnosis–Medium sized, adult length not exceeding 50 mm. Light brown with well defined, light fuscous pattern; median ocular tubercle not contrasting sharply with surrounding areas by its coloration. Carapace shorter than movable finger of pedipalp chela. Metasoma V shorter than pedipalp humerus in adult males, approximately equal in length in females and immatures; humerus with dorsal surface flat. Tergum VII with indistinct keels, sternum VII four keeled. Cheliceral fixed finger approximately half as long as chela. Tarsomere II spine formula:

$$\frac{5\,5}{6\,6} : \frac{6\,6}{6\,7} : \frac{6\,6}{7\,7} : \frac{6\,6}{7\,7}.$$

Pectinal teeth count 13-14 in males, 11-12 in females.

Holotype—Male (measurements in Table 2).

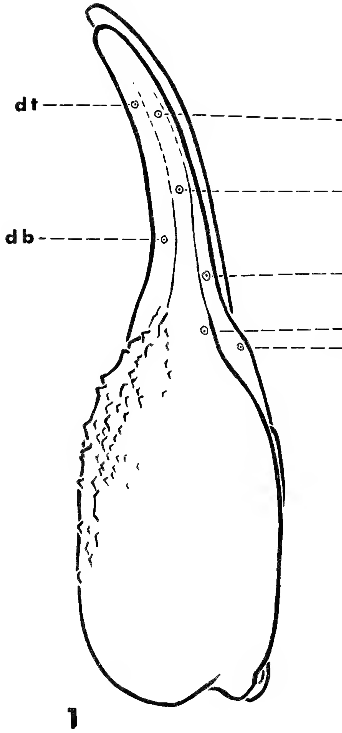
Prosoma. Carapace light brown with well defined, light fuscous pattern, slightly darker on median ocular tubercle but not contrasting sharply with surrounding areas. Lateral eyes with uniform black pigment, sharply contrasting with surrounding areas. Anterior median notch obtusely angular, not extending beyond posterior margin of second pair of lateral eyes. Antero-lateral margins sparsely hirsute, with three pairs of lateral eyes. Anterior median furrow shallow, vestigial towards and over median ocular tubercle. Posterior median furrow distinct, shallow on anterior two-thirds, abruptly deeper distally for one-fifth total carapace length to posterior margin. Posterior marginal furrow moderately deep, not connected to posterior lateral furrows. Posterior lateral furrows obtusely angular; posterior two-fifths vestigial, parallel to posterior median furrow; anterior three-fifths divergent, moderately deep, ending abruptly at lateral sixth of posterior carapace width. Anterior submargin moderately granulose; carapace surface densely, minutely granulose. Maxillary lobes light yellow; internal surface with dense, white microchaetae; ventral surface with sparse, erect, brown macrochaetae. Coxae light yellow, with sparse macrochaetae marginally. Sternum light yellow; subpentagonal, posterior third with deep longitudinal furrow; anterior half moderately hirsute, posterior half sparsely hirsute.

Mesosoma. Terga light brown with well defined, light fuscous pattern; posterior and lateral margins sparsely hirsute. Terga I-VI surfaces with dense, minute granules. Tergum VII with median and lateral keels indistinct, lateral lobes moderately granulose; posterior submargin vestigially granulose dorsally, weakly granulose laterally; surface granules dense, minute. Genital operculi light yellow, ovoid, divided, with sparse macrochaetae. Genital papillae large, extending beyond posterior margins of operculi. Pectines white; basal plate approximately twice as broad as long, anterior margin slightly notched medially. Marginal and middle lamellae with sparse to moderate, erect macrochaetae; middle lamellae 4-5. Fulcra subtriangular, with 1-2 depressed white microchaetae distally. Pectinal teeth count 12-14, each tooth approximately 3.5 times longer than broad. Sterna light yellow, lateral and posterior margins feebly hirsute. Sterna III-VI smooth; stigmata slightly depressed, three times longer than broad. Sternum III with disc moderately hirsute, with posteriorly depressed and suberect macrochaetae irregularly set on inverted "V" pattern, outlining resting position of pectines. Sterna IV-VI with inverted "V" macrochaetal pattern vestigial. Sternum VII four keeled, each keel with 4-5 erect macrochaetae; median keels with anterior half obsolete, posterior half indistinct to weak; lateral keels with anterior third vestigial to weak, posterior two-thirds moderately strong.

Metasoma. Proximally light brown, distally darkening gradually to medium brown. Dorsal surfaces bare; lateral and ventral surfaces sparsely to moderately hirsute, with slight density increase distally. Inferior median keels parallel: feebly crenate, moderately strong on I-II; weak, smooth on III; obsolete on IV. Inferior lateral keels subparallel: crenate, strong on I-II; moderately strong, smooth on III; vestigial on IV. Lateral keels: moderately strong, coarsely crenate, complete on I; vestigial on II; obsolete on III-IV. Dorsal lateral keels: moderately strong, coarsely crenate on I; weak, smooth to feebly crenate on II-III; vestigial on IV. Dorsal median keels weak: short, granular on I; feebly crenate to smooth on II-IV. Metasoma V shorter than pedipalp humerus. Inferior median and inferior lateral keels irregular; proximal one-fourth vestigial, central half weakly to moderately granulose, distal fourth with large conical granules. Lateral and dorsal keels obsolete. Distal crescent with convex margin with large conical granules; disc with six medium to small, irregularly placed granules. Anal arc circular, weakly lobed; anterior transverse anal crest strong, with nine oblong granules; posterior transverse anal crest weak, vestigially granulose. Telson slightly wider than metasoma V: vesicle dorsally smooth, sparsely hirsute; lateral and ventral surfaces smooth, moderately hirsute, proximal submargin with clusters of 3:3:3 medium sized granules. Subaculear tubercle strong, rounded, densely covered with erect white microchaetae. Aculeus dark brown, short, sharply curved.

Chelicera. Chela light yellow, movable and fixed fingers light brown, teeth dark brown to black. Inferior surfaces of chela and fingers densely covered with long, anteriorly depressed and suberect, distally curved white hairs. Chela length measured dorsally along midline to fixed finger internal base; width measured dorsally at widest point; chela width/length ratio 0.66. Fixed finger sharply curved distally, internal margin with two teeth; basal tooth with two subequal cusps, distal tooth pointing to finger tip. Length measured from proximal base of bicuspid tooth to finger tip; fixed finger length/chela length ratio 0.50. Movable finger sharply curved distally; forked, inferior tine four times longer than superior tine. Internal dorsal margin with three teeth; middle tooth largest, distal tooth on superior tine base. Length measured from dorsal external articulation to extreme tip of inferior tine; movable finger length/chela length ratio 0.88.

Pedipalps. Humerus light brown. Internal dorsal and internal ventral keels strong, irregularly granulose; external dorsal keel with proximal half moderately strong, granulose, distal half vestigial; external ventral keel obsolete. Dorsal face flat, surface feebly granulose on internal margin, with one proximal trichobothrium on external margin. Internal face slightly concave dorsoventrally, with dense irregular granules; margins sparsely hirsute, with one proximal trichobothrium on dorsal margin. External face smooth, with one dorsal trichobothrium approximately one-third of humerus length from base. Brachium light brown. Dorsal keel strong, smooth; internal ventral keel weak to moderate, irregularly granulose; external ventral keel smooth, proximal two-thirds weak, distally vestigial. Internal face densely and minutely granulose, with three trichobothria on dorsal margin. Ventral face flat, smooth; external margin with three trichobothria on proximal half. External face with two vestigial keels, feebly reticulate; 13 trichobothria as follows: five basal, two suprabasal, two median, one subterminal, three terminal. Chela medium brown, trichobothrial pattern as in Figs. 1-4 (nomenclature after Vachon, 1973). Dorsal margin of manus irregularly granulose; proximal half with small granules, distally with coarse overlapping granules extending to base of fixed finger. Digital keel smooth, strong to fixed finger base, abruptly weaker at base and along fixed finger. Ventral keel smooth, strong, oblique to midpoint of movable finger articulation. Dorsal secondary keel vestigial to obsolete. External secondary keel moderately strong, smooth, parallel to digital keel, ending gradually approximately three-fourths length of latter. Dorsal face (dorsal margin to digital keel) feebly convex proximally, with distal third flat to slightly concave; bare, weakly reticulate with dense, minute pores on ridges. External face (digital keel to ventral keel) longitudinally divided by external secondary keel, upper and lower surfaces obtusely angular; upper surface bare, weakly reticulate with moderate, minute pores on ridges; lower surface vestigially reticulate, moderately hirsute. Internal face with median longitudinal concavity where chela flexes against brachium, dorsal and ventral margins of concave area weakly granulose distally. Internal dorsal surface convex, with coarse irregular granules distally. Internal ventral surface convex, one vestigial longitudinal keel oriented towards internal base of movable finger; vestigially reticulate, moderately hirsute. Fixed finger gently curved,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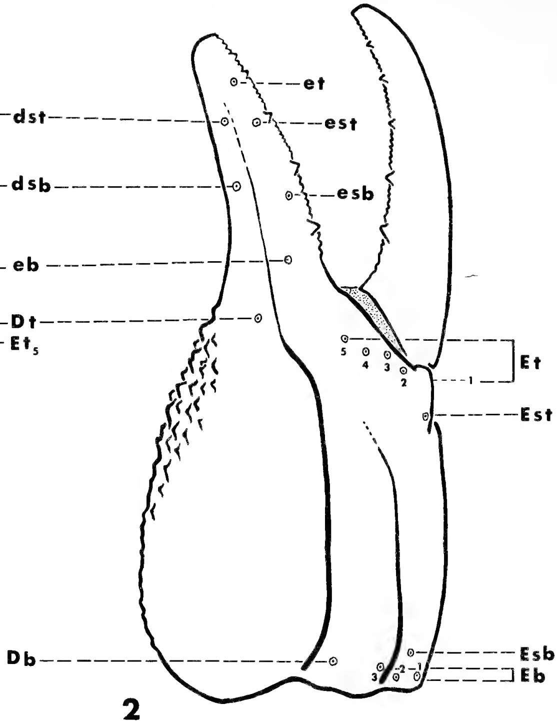
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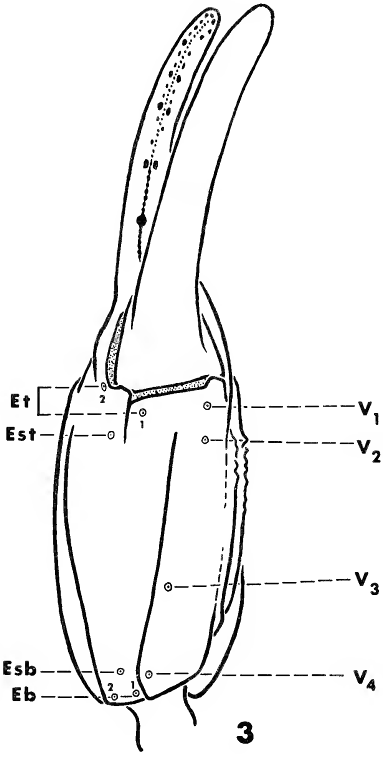
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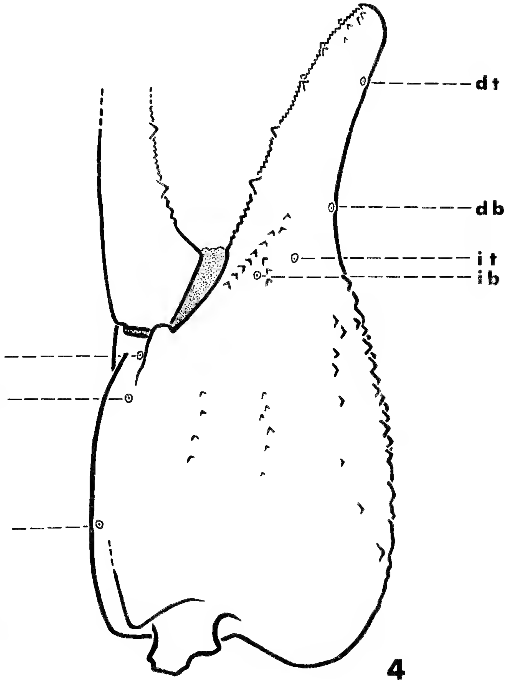
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dorsal and digital keels vestigial to obsolete; densely hirsute, setae arising from shallow pits creating regularly punctate appearance. Movable finger longer than carapace, densely hirsute.

Walking legs. Light yellow. Trochanter, femur, tibia sparsely hirsute; tarsomeres I and II moderately hirsute. Femoral dorsal margin vestigially granulose, ventral margin weakly granulose. Tarsomere II spine formula:

$$\frac{5\ 5}{7\ 6}:\frac{6\ 6}{7\ 6}:\frac{6\ 6}{7\ 7}:\frac{6\ 6}{7\ 7}.$$

Allotype–Female (measurements in Table 2), differs from holotype as follows.

Prosoma. Carapace anterior submarginal granules weak. Surface smooth; anterolateral region behind lateral eyes with minute, vestigial granules.

Mesosoma. Terga I-VI with surfaces smooth. Tergum VII with keels indistinct, lateral lobes weakly granulose; lateral surfaces moderately, minutely granulose. Genital operculi ovoid, fused; genital papillae absent. Pectines: right pectine broken off proximally, teeth absent; left pectine with second marginal lamellae fused to middle lamellae, vestigial sutures outline two middle lamellae. Pectinal teeth count ?-12, each tooth approximately 2.5 times longer than broad. Sterna: sternum III with discal macrochaetae sparse, on irregular inverted "V" pattern; sternum VII lateral keels weak to vestigial, not reaching anterior margin.

Metasoma. Inferior median and inferior lateral keels on I-III granulose. Metasoma V length equal to pedipalp humerus length; anterior transverse anal crest with ten oblong granules. Telson conspicuously wider than metasoma V.

Chelicera. Chela length/width ratio is 0.69, fixed finger length/chela length ratio is 0.51, movable finger length/chela length ratio is 0.93.

Pedipalps. Brachium internal face with dense, extremely minute granules; external face smooth, keels and reticulation obsolete. Chela with dorsal margin weakly and irregularly granulose distally; reticulation on all surfaces obsolete, minute pores retaining reticular configuration. Digital keel obsolete on chela and fixed finger, vestigial at fixed finger base. Dorsal secondary and external secondary keels obsolete.

Walking legs. Femora I-II with dorsal and ventral margins vestigially granulose, femora III-IV with margins smooth. Tarsomere II spine formula:

$$\frac{6\ 5}{6\ 6}:\frac{6\ 6}{6\ 6}:\frac{6\ 6}{7\ 6}:\frac{6\ 6}{7\ 6}.$$

Improper preservation has resulted in general darkening of cuticle to deep red-brown in all structures.

Type data–Holotype male: Geronimo Pass (1780 m), Peloncillo Mts., Hidalgo Co., New Mexico, 8 June 1973 (O. F. Francke). Collected by ultra-violet detection and preserved according to the method recommended by Williams (1968). Deposited in the collection of the American Museum of Natural History, New York. Allotype female: same locality as holotype, August 1969 (Nick Bucknall). Deposited in the collection of the American Museum of Natural History.

In addition to the primary types, the following specimens were studied: five paratopotype males; two adults deposited in the collection of the California Academy of

⇦Figs. 1-4.–*Diplocentrus peloncillensis* holotype male from Geronimo Pass (1,780 m), Peloncillo Mts., Hidalgo Co., New Mexico. Trichobothria on the right pedipalp chela: 1, dorsal; 2, external; 3, ventral; 4, internal.

Sciences, San Francisco, two adults and one immature in the author's collection. One immature female from Guadalupe Canyon, Guadalupe Mts., 28 mi E Douglas, Cochise Co., Arizona, 11 June 1968 (Vincent Roth); in the collection of the Southwestern Research Station of the American Museum of Natural History at Portal, Arizona.

Etymology–This species is named after the Peloncillo Mts. of New Mexico and Arizona.

COMPARATIVE DESCRIPTION AND ANALYSIS OF VARIABILITY

Diplocentrus peloncillensis is closely related to *D. spitzeri*; the separation of these two taxa often requires the use of more than one character, most of which are subject to intraspecific variation and require special consideration. Color differences exist between adults: in *D. spitzeri* the carapace and terga have a diffuse, indefinite fuscous pattern, and the median ocular tubercle is uniformly dark brown or black, contrasting sharply with the surrounding areas; in *D. peloncillensis* the carapace and terga have a well defined, light fuscous pattern, and the median ocular tubercle does not contrast sharply with the surrounding areas. Immatures of both species are pale yellow, without fuscosity on the carapace and terga.

A slight tendency towards a lower pectinal teeth count occurs in *D. peloncillensis* males as compared to *D. spitzeri* males (Table 1). Whether this tendency is present in females also cannot be determined at this time due to the small sample size. This character is known to be fixed at birth, and the data given for *D. spitzeri* include ten first instar counts (8 ♂♂, 2 ♀♀).

Tarsomere II spine counts variability and differences given in Table 3. From this table it can be determined that the "typical" spine formulas are: *D. peloncillensis*

$$\frac{5\,5}{6\,6} : \frac{6\,6}{6\,7} : \frac{6\,6}{7\,7} : \frac{6\,6}{7\,7},$$

and *D. spitzeri*

$$\frac{6\,6}{6\,6} : \frac{6\,6}{6\,7} : \frac{7\,7}{7\,7} : \frac{7\,7}{7\,7}.$$

The posterior margin of tarsomere II on the second pair of legs has 6-7 spines with equal frequency. These spines do not appear until the second instar, but from this point in life they are fixed, and the variability observed is not due to either age or sex. It must also be mentioned that in Stahnke's (1970) original description of *D. spitzeri* two different tarsomere II formulas are given; on p. 26 it is

$$\frac{6\,6}{7\,7} : \frac{6\,6}{7\,7} : \frac{7\,7}{7\,7} : \frac{7\,7}{7\,7},$$

whereas on p. 28 it becomes

$$\frac{6\,6}{6\,6} : \frac{6\,6}{7\,7} : \frac{7\,7}{7\,7} : \frac{7\,7}{7\,7},$$

with discrepancy on the posterior margin of the first pair of legs. Based on 42 specimens studied from several localities, I conclude that the former is definitely incorrect; the latter approximates the one found in this study, but since no variability is considered its usefulness decreases.

Morphometric differences are quite significant between *D. peloncillensis* and *D.*

Table 1. Pectinal teeth counts.

		D. peloncillensis		*D. spitzeri*	
		No. Observed	Percent	No. Observed	Percent
Males	16			1	1.72
	15			23	39.66
	14	4	33.33	30	51.72
	13	8	66.67	4	6.90
		12	100.00	58	100.00
Females	13			8	19.05
	12	1	33.33	17	40.48
	11	2	66.67	14	33.33
	10			3	7.14
		3	100.00	42	100.00

Table 2. Measurements (in millimeters) of *Diplocentrus peloncillensis* Francke, new species, holotype and allotype.

	Holotype ♂	Allotype ♀
Total length	46.10	48.50
Carapace: length	6.00	6.20
width, anterior/posterior	3.20/6.00	3.60/6.80
width at median eyes	5.05	5.60
Mesosoma length	15.60	18.00
Metasoma length	24.50	24.30
I length/width	3.10/3.20	3.00/3.30
II length/width	3.50/2.90	3.30/2.90
III length/width	3.80/2.75	3.60/2.80
IV length/width	4.10/2.55	4.00/2.60
V length/width	5.20/2.10	5.20/2.20
Telson length	4.80	5.20
Vesicle length/width	4.00/2.30	4.20/2.70
depth	1.80	2.10
Aculeus length	0.80	1.00
Pedipalp length	22.10	21.80
Humerus: length/width	5.50/2.05	5.20/2.10
Brachium: length/width	5.30/2.10	5.30/2.30
Chela: length/width	11.30/4.95	11.50/5.20
depth	3.05	3.40
Movable finger length	6.70	6.90
Fixed finger length	4.85	4.90
Chelicera: chela length/width	2.10/1.40	2.25/1.55
Movable finger length	1.85	2.10
Fixed finger length	1.05	1.15

spitzeri, as shown in Table 4. These ratios were not chosen haphazardly; all the structures listed in Table 2 were measured in *D. spitzeri* (n=39), *D. peloncillensis* (n=8), *D. bigbendiensis* (n=43), and an undescribed species of *Diplocentrus* (n=63). Correlation coefficients were determined for all possible combinations of paired measurements; initially for the entire sample of each species, subsequently for each sex and age class considered in Table 4 so that these variables would be eliminated from the correlation coefficients analysis. Significant correlation at the 95 percent level of confidence (Steel and Torrie, 1960) was found in 180 instances, and ratios were figured in each case. Analysis of these 180 ratios showed that 102 of them did not reflect any differences at the specific level and were discarded, 31 are useful in separating *D. peloncillensis*

Table 3. Variability and differences observed in tarsomere II spine counts.

			D. peloncillensis n. sp.		*D. spitzeri* Stahnke	
Leg	Margin	No.	Frequency	Percent	Frequency	Percent
I	anterior	5	11	73.33	29	36.71
		6	4	26.67	50	63.29
			15	100.00	79	100.00
	posterior	5			1	1.27
		6	11	73.33	60	75.95
		7	4	26.67	18	22.78
			15	100.00	79	100.00
II	anterior	5	2	12.50	4	4.94
		6	14	87.50	71	87.65
		7			6	7.41
			16	100.00	81	100.00
	posterior	6	9	56.25	39	48.15
		7	7	43.75	42	51.85
			16	100.00	81	100.00
III	anterior	6	11	68.75	20	25.64
		7	5	31.25	58	74.36
			16	100.00	78	100.00
	posterior	6	3	18.75	1	1.28
		7	12	75.00	73	93.59
		8	1	6.25	4	5.13
			16	100.00	78	100.00
IV	anterior	6	11	68.75	11	13.58
		7	5	31.25	70	86.42
			16	100.00	81	100.00
	posterior	6	1	6.25	3	3.70
		7	14	87.50	70	86.42
		8	1	6.25	8	9.88
			16	100.00	81	100.00

and *D. spitzeri* from the other two species included in this study, and 47 indicated the presence of morphometric differences between the two species under discussion. Further analysis of the structures involved in the significant ratios revealed that 28 reflected differences between the pedipalps and other structures, seven involved two separate measurements of the pedipalps, seven showed differences between telson measurements and structures other than the pedipalps, and the remaining five dealt with carapacial and metasomal structures. Redundancy and repetition were eliminated by pooling measurements in some ratios, e.g., total pedipalp length (B and C), and metasoma I-V length (C); and by creating composite ratios (C, F, and J).

The differences appearing in Table 4 are subjectively summarized in Table 5. In both *D. peloncillensis* and *D. spitzeri* the only ratio showing marked allometric growth differences in both sexes is B (carapace length/pedipalp length), and since neither ratio A (carapace length/metasoma V length) nor B indicate sexual dimorphism in immatures, it can be concluded that the observed differences are the result of a relative elongation of the pedipalps in adults, especially males. The moderate allometricity indicated by ratio D (carapace length/pedipalp chela width) is also due to a relative increase in pedipalp chela width with age.

In ratios A, C (metasoma I-V length/pedipalp length), F (vesicle width + vesicle depth/telson length), and J (humerus length + brachium length/pedipalp chela length)

Table 4. Morphometric ratios for *Diplocentrus peloncillensis* and *D. spitzeri* Stahnke, listed as follows: high, low, mean.

		D. peloncillensis				*D. spitzeri*			
	NUMERATOR/ DENOMINATOR	ADULTS		IMMATURES		ADULTS		IMMATURES	
		♂	♀	♂	♀	♂	♀	♂	♀
		n=5	n=1	n=1	n=1	n=17	n=9	n=4	n=9
A	Carapace L/	1.154				1.137	1.378	1.370	1.405
	Metasoma V L	1.110				1.058	1.265	1.329	1.310
		1.124	1.192	1.298	1.333	1.096	1.296	1.344	1.348
B	Carapace L/	0.272				0.305	0.337	0.364	0.356
	Pedipalp L	0.258				0.288	0.319	0.338	0.340
		0.264	0.282	0.308	0.331	0.297	0.328	0.352	0.349
C	Metasoma I-V L/	0.916				1.033	0.952	0.967	0.966
	Pedipalp L	0.881				0.960	0.906	0.915	0.914
		0.894	0.868	0.901	0.887	0.996	0.930	0.946	0.937
D	Carapace L/	1.212				1.244	1.350	1.500	1.520
	Pedipalp chela W	1.183				1.125	1.220	1.347	1.333
		1.193	1.192	1.359	1.419	1.192	1.277	1.414	1.417
E	Metasoma I W/	1.625				1.600	1.550	1.528	1.444
	Metasoma V W	1.524				1.429	1.364	1.333	1.357
		1.554	1.500	1.562	1.438	1.483	1.462	1.422	1.411
F	Vesicle W + D/	0.854				0.956	1.070	1.088	1.054
	Telson L	0.814				0.857	1.010	1.000	0.960
		0.837	0.923	0.938	1.031	0.903	1.039	1.036	1.013
G	Metasoma V L/	0.817				0.912	0.824	0.879	0.879
	Movable finger L	0.743				0.810	0.759	0.839	0.771
		0.773	0.754	0.788	0.825	0.872	0.787	0.851	0.821
H	Pedipalp chela W/	0.755				0.836	0.836	0.828	0.811
	Movable finger L	0.700				0.769	0.783	0.788	0.750
		0.729	0.754	0.753	0.775	0.801	0.798	0.810	0.781
I	Humerus L/	1.068				0.926	0.978	0.926	0.926
	Metasoma V L	1.028				0.865	0.898	0.862	0.862
		1.050	1.000	1.000	0.970	0.895	0.927	0.899	0.898
J	Humerus L +	0.985				0.978	0.917	0.927	0.926
	Brachium L/	0.941				0.919	0.865	0.888	0.873
	Pedipalp chela L	0.954	0.913	0.918	0.928	0.952	0.890	0.908	0.895
K	Metasoma V W/	1.024				1.278	1.278	1.364	1.364
	Humerus W	0.974				1.059	1.111	1.200	1.125
		1.000	1.048	1.067	1.067	1.176	1.206	1.272	1.242
L	Pedipalp chela L/	2.385				2.111	2.150	2.154	2.320
	Pedipalp chela W	2.204				1.956	1.979	2.038	2.026
		2.313	2.212	2.297	2.226	2.056	2.057	2.105	2.142

Table 5. Synthesis of information provided by morphometric ratios A-L presented in Table 4 (● ranges do not overlap, ○ range overlap 10 percent or less).

	Ratios	A	B	C	D	E	F	G	H	I	J	K	L
Allometry	♂♂	●	●	○	●		●				○		
	♀♀		●		○								
Dimorphic		●	●	●			●				●		
Specific			●	●			●	●	●	●		●	●

where allometric growth differences are present only in males, it is found that immature males are morphometrically indistinguishable from females, both adult and immature, so the differences point to male secondary sexual characters: metasoma V, and telson being relatively longer and narrower; the pedipalps are longer, with the humerus and brachium contributing proportionately more than the chela to this increase in length. Also very interesting is the fact that those ratios indicating allometric growth rates are the same ones that reflect marked sexual dimorphism in the adults.

Analyzing the differences present at the specific level it can be seen that despite sexual dimorphism and allometric growth rates, ratios B, C, and F are useful in separating *D. peloncillensis* from *D. spitzeri*. However, ratios G(metasoma V length/movable finger length), H (pedipalp chela width/movable finger length), I (humerus length/metasoma V length), K (metasoma V width/humerus width), and L(pedipalp chela length/pedipalp chela width) are especially significant in that they do not change with age or sex in either species, yet reflect significant differences at the specific level. In *D. peloncillensis* metasoma V is slightly longer and narrower, the brachium and humerus are considerably longer and narrower, the pedipalp chela is longer but its width remains the same, and the movable finger of the pedipalp chela is proportionately longer while maintaining the same relationship to the chela length.

At this time it can only be guessed as to what biological function these morphometric differences reflect, since very little is known of the biology, ecology, and behavior of scorpions, Diplocentrids in particular.

Other less noticeable differences between *D. spitzeri* and *D. peloncillensis* have been found. With most trichobothria intraspecific variability is as great as if not greater than interspecific variability; but in *D. peloncillensis* Eb_1, Eb_2, and Esb form and equilateral triangle, and in *D. spitzeri* these form a scalene triangle. In *D. peloncillensis* the dorsal face of the humerus is completely flat, and in *D. spitzeri* it is convex on the proximal third to one-half.

Variability in the number of lateral eyes occurs at low frequencies, but indicates that this is not as stable a character as it has been thought to be, and its use in scorpion classification at the supraspecific level should be carefully reconsidered. One paratopotype of *D. peloncillensis* has four lateral eyes on the right side instead of the "normal" three, and two adult males of *D. spitzeri* have only two lateral eyes on the left side.

Diplocentrus peloncillensis is also related to *D. keyserlingi zacatecanus* Hoffmann (1931), but in the latter species the humerus is shorter than metasoma V in adult males, the pedipalp chela is shorter (chela length/chela width ratio is 1.859), and the tarsomere II spine formula is

$$\frac{5\ 5}{7\ 7} : \frac{6\ 6}{7\ 7} : \frac{7\ 7}{7\ 7} : \frac{7\ 7}{7\ 7}.$$

ECOLOGICAL NOTES

Geronimo Pass in the Peloncillo Mts., Hidalgo Co., New Mexico, consists of a small saddle (approximately 300 m × 80 m) at an elevation of 1,780 m (5,840 ft) with an E-W orientation. The north-facing and south-facing slopes are moderately steep (approximately 18°-20°). The north-facing slope has a moderate amount of rocks (10 cm-50 cm greatest dimension) resting loosely on fine soil. The south-facing slope has large boulders and rock outcrops on similar type of soil, but few loose rocks.

Unlike other north- and south-facing slopes at this latitude (31°30′N), in Geronimo Pass the south-facing slope has higher vegetation density than the north-facing slope. The south-facing slope has a moderate to dense cover of low shrubs, predominantly scrub oak (*Quercus* sp.) and several species of grasses (Gramineae). The saddle and north-facing slope show signs of overgrazing and the vegetation includes scrub and tree oaks (*Quercus* sp.), pinyon pine (*Pinus edulis* Engelmann), one-seed juniper [*Juniperus monosperma* (Engelmann) Sargent], bear-grass (*Nolina microcarpa* Watson), cholla (*Cylindropuntia* sp.), prickly-pear (*Opuntia* sp.), soap tree yucca (*Yucca elata* Engelmann), and grasses (Gramineae).

Some of the larger rocks on the north side of the saddle, and at the base of the north-facing slope have burrows underneath. Excavating five of them produced one large centipede (*Scolopendra* sp.), and two *D. peloncillensis*: one immature male from a vertical burrow 13 cm deep, elliptical in cross section; one adult male from a vertical burrow 21 cm deep, also elliptical in cross section, that terminated in a small chamber (4 cm X 2.5 cm X 1.5 cm) at 45° from the vertical axis of the burrow. Two specimens of the dark phase of the scorpion *Centruroides sculpturatus* Ewing were also collected under rocks lacking burrows.

Black-lighting (U. V. detection) for scorpions produced negative results on the south-facing slope, but the saddle and north-facing slope yielded four additional males of *D. peloncillensis*, seven *C. sculpturatus*, one adult *Uroctonus apacheanus* Gertsch and Soleglad, and two adult *Vaejovis vorhiesi* Stahnke. Crawford and Wooten (1973) also found *D. peloncillensis* only on north-facing slopes, in burrows under rocks.

It is reasonable to assume that the occurrence of *D. peloncillensis* on north-facing slopes in the Peloncillo Mts. is determined by the availability of suitable microhabitats, and that rock cover is the limiting factor in south-facing slopes. A rock over the entrance of a vertical burrow shields these photonegative scorpions from direct sunlight, reduces temperatures inside the burrow, prevents flooding by rains, and might deter potential predators.

ACKNOWLEDGMENTS

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STABILIMENTA AND BARRIER WEBS IN THE ORB WEBS OF *ARGIOPE ARGENTATA* (ARANEAE, ARANEIDAE) ON DAPHNE AND SANTA CRUZ ISLANDS, GALAPAGOS

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ABSTRACT

Stabilimenta and barrier webs in *Argiope argentata* orb-webs were investigated on Daphne and Santa Cruz Islands in the Galapagos. Based on this census, I propose that the barrier web supports and strengthens the orb-web and is therefore common in webs found in windy areas, while the stabilimentum is most likely an anti-predator device.

INTRODUCTION

Orb webs of many Araneidae and Uloboridae have ribbons or tufts of silk arranged in a species specific pattern in addition to the web proper. These structures have been variously termed decorations (McCook, 1889), stabilimenta (Comstock, 1912), or devices (Hingston, 1927; Ewer, 1972). Stabilimenta are often variable within webs of a species at any given locality, both in frequency of occurrence and in form or pattern (Marson, 1947a, 1947b; Marples, 1969; Robinson and Robinson, 1970; Ewer, 1972).

Stabilimenta may either reduce the effectiveness of visual predators (Hingston, 1927) or strengthen the web (McCook, 1889; Simon, 1895). Robinson and Robinson (1970) reviewed the functions attributed to stabilimenta by various authors. They argued that although some stabilimenta may serve to conceal the spider on its web, the "cross" stabilimentum of adult *Argiope argentata* in Panama may actually cue visually orienting predators; flycatchers learned to use stabilimenta as cues in prey location.

Another feature of some orb webs (e.g., those of *Argiope* species, *Nephila*, and *Metepeira*) is the barrier web or stopping maze, an irregular tangle of non-sticky threads on one or both sides of the orb web. The barrier web may protect the spider from predators by acting as a mechanical barrier, early warning system, or deterrent to visually orienting flying predators.

Observations reported here of webs of *Argiope argentata* on Santa Cruz and Daphne Islands in the Galapagos archipelago suggest that the barrier web may function as a strengthening device, while the stabilimentum is most likely important as an anti-predator device.

METHODS

Presence or absence of barrier webs and stabilimenta, and patterns of stabilimenta where present were noted on Daphne Island and at Bahia Borrero on the north shore of Santa Cruz Island during December, 1973. Most webs were of young spiders; very few adults were seen. In all study areas, *A. argentata* webs tended to concentrate on or beneath *Opuntia* (prickly pear cactus) plants up to a height of about 2 meters. Spiders were separated into four easily recognizable size classes: ⩽ 2 mm, 3-4 mm, 5-7 mm, and ⩾ 8 mm. Some 12 mm individuals were adults.

Daphne Island is a small (0.34 km^2), extinct volcanic cone, about 8 km off the north shore of Santa Cruz Island. It is topped by two adjoining craters: a small upper crater and a large lower crater. The vegetation is of the "arid zone" type (Wiggins and Porter, 1971), dominated by *Bursera* (Palo Santo) trees, *Opuntia*, *Croton*, and *Chamaesyce*. *Croton* and *Bursera* were mostly leafless and the ground vegetation was sparse and patchy, giving the island a dry appearance (Fig. 1). Strong, gusting winds from the east

Fig. 1.–The lower crater floor and east wall, Daphne Island.

prevailed during the day; these were especially strong on the rim of the craters ("the plateau"), and somewhat less strong and less consistent in direction inside the craters. *A. argentata* webs were examined both on the plateau and on the lower, inner slopes of the lower crater.

Bahia Borrero is a sheltered bay on the north coast of Santa Cruz Island (902 km^2). Webs of *A. argentata* were observed in the flat "grassland" area immediately behind the beach (Fig. 2). Vegetation in this area consisted mainly of *Opuntia*, leafless *Bursera, Croton,* clumps of *Alternanthera* and *Waltheria* shrubs, and in contrast to the sparse ground vegetation on Daphne, patches of dried grass and annuals. A mild breeze usually came off the land during the day and from the sea at night. Strong winds were not encountered during a seven day stay at Bahia Borrero.

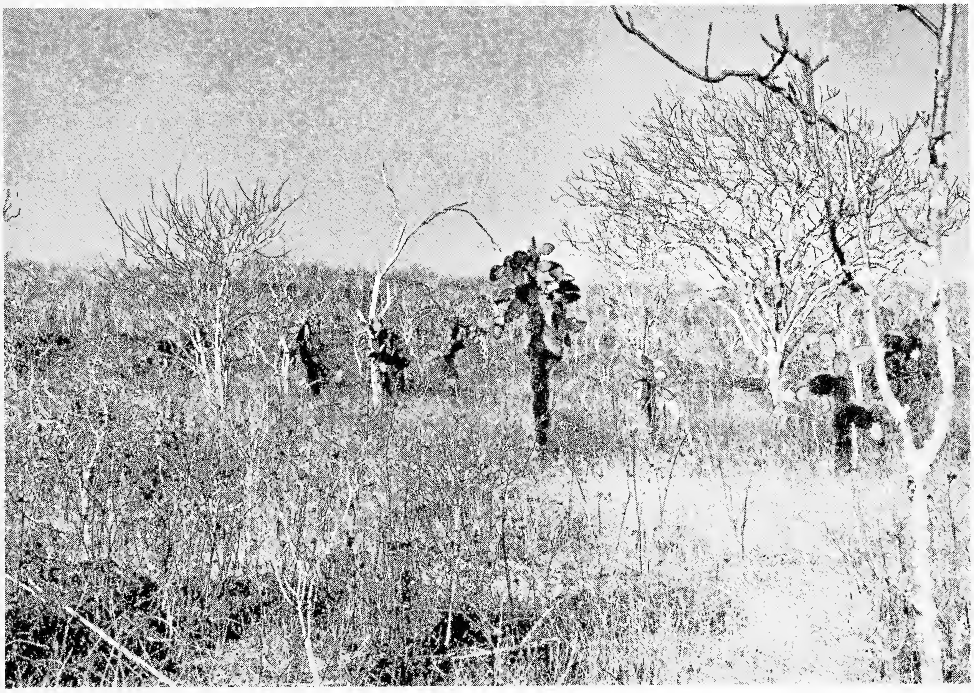

Fig. 2.–"Grassland" habitat, Bahia Borrero, Santa Cruz Island.

RESULTS AND DISCUSSION

1. **The stabilimentum**–Two basic stabilimentum patterns are found in webs of *A. argentata*: (a) the "disc" stabilimentum, a tightly woven disc of white silk covering the hub (Robinson and Robinson, 1970, Fig. 6), and (b) the "cross" stabilimentum, four ribbons of zigzag silk forming the arms of a diagonal cross, but without crossing each other at the hub (Fig. 1). Incomplete cross stabilimenta may be found, with one to three arms of the cross in several possible combinations.

The frequencies of occurrence of webs without stabilimenta and webs with various patterns of stabilimentum of Bahia Borrero and on Daphne Island are shown in Table 1. The percentages of webs with stabilimenta of three size classes of spiders on Daphne and on Bahia Borrero are shown in Fig. 3.

Table 1.–Numbers and percentages of *A. argentata* webs (all size classes combined) with and without stabilimenta on Daphne Island and on Bahia Borrero, Santa Cruz Island. Stabilimenta are separated into six patterns. The hub is represented by + and the stabilimentum by diagonal lines.

Stabilimentum Type		Daphne Island				Bahia Borrero	
		Plateau		Lower Crater			
		No.	%	No.	%	No.	%
None		46	73.0	61	78.2	78	58.2
⟍+⟍	diagonal	12	19.0	7	9.0	24	17.9
⟋+⟋		4	6.4	8	10.2	16	11.9
⟋+	below hub	0		1	1.3	3	2.3
+⟍		1	1.6	0		5	3.7
╳	cross	0		1	1.3	1	0.8
Disc (trace)		0		0		4	3.0
Other		0		0		3	2.2
Total		63		78		134	

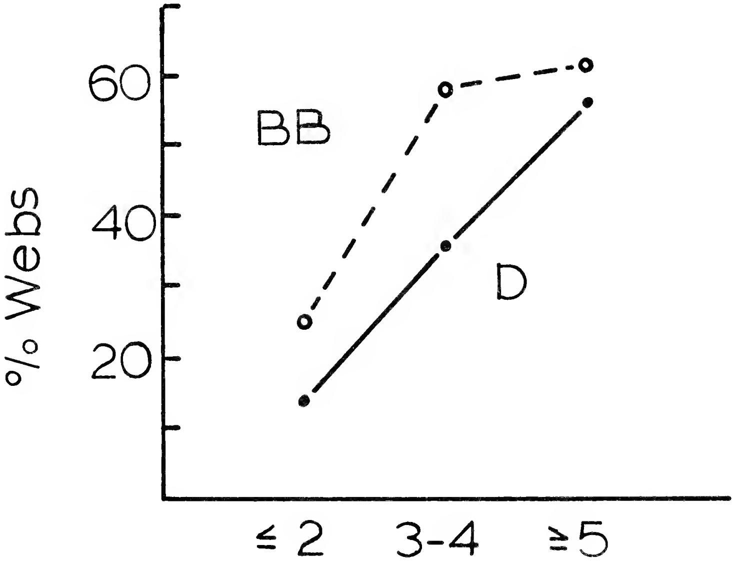

Fig. 3.–Percent *A. argentata* webs with stabilimenta (all forms combined) for three size classes of individuals: ⩽ 2 mm, 3-4 mm, and ⩾ 5 mm. BB = Bahia Borrero, Santa Cruz Island, D = Daphne Island (two sites combined).

Several points emerge from these comparisons:

(a) Stabilimenta were almost twice as common in Bahia Borrero webs (41.8% of webs with stabilimenta) than in Daphne webs (27.0% and 21.8% of webs with stabilimentum).

(b) The most common stabilimentum type at all locations was a single diagonal line ⟋+⟋ or ⟍+⟍ . This is in marked contrast with Robinson and Robinson (1970) who found the most common form in webs of adult individuals in Panama to be one or two arms below the hub, ⟋+ , +⟍ , or ⟋+⟍ .

(c) The complete cross stabilimentum was rare at all locations.

(d) Disc stabilimenta were not found in Daphne webs, and only rarely in Bahia Borrero webs. These latter were faint discs in webs of 2 mm individuals. Two webs of 3-4 mm spiders had a diagonal line with a trace of a disc at the hub.

(e) The frequency of occurrence of stabilimenta increased with size (age) of the spider, both on Daphne and on Bahaia Borrero.

2. **The barrier web**—Barrier webs may occur on one or both sides of the orb. Those occurring on one side only usually face the spider's dorsal side (dorsal barrier web). The frequencies of occurrence of webs with and without barrier webs at all three sites are shown in Table 2. Percentages of webs with barrier webs of three size classes of spiders are shown in Fig. 4.

Table 2. Numbers and percentages of *A. argentata* (all size classed combined) with and without barrier webs on one or both sides of the web.

Barrier web Type	Daphne Island				Bahia Borrero	
	Plateau		Lower Crater			
	No.	%	No.	%	No.	%
None	17	27.0	28	35.9	89	66.4
One-sided Barrier Web	45	71.4	47	60.3	24	25.4
Two-sided Barrier Web	1	1.6	3	3.8	11	8.2
Total	63		78		134	

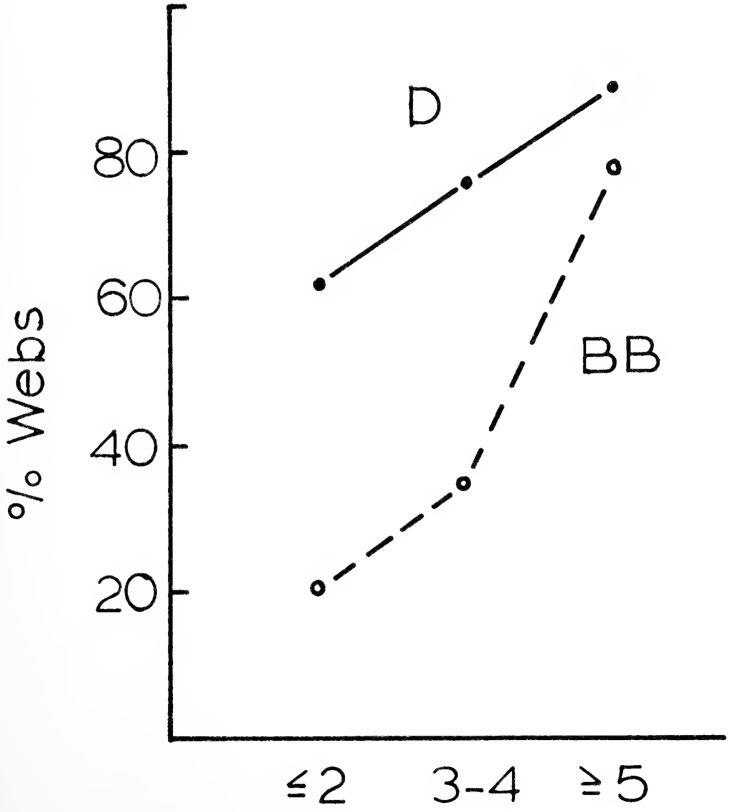

Fig. 4.—Percent *A. argentata* webs with barrier webs (one and two-sided combined) for three size classes of individuals: ≤ 2 mm, 3-4 mm, ≥ 5 mm.

The following results are emphasized:

(a) More than two-thirds of the webs on Daphne Island had barrier webs, as compared with about one-third of the webs on Bahia Borrero.

(b) A slightly greater proportion of plateau webs on Daphne had barrier webs (73.0%) than did lower crater webs (64.1%). This is consistent for all size classes of spiders.

(c) Dorsal barrier webs were most common; only a small proportion of webs had mazes on both sides of the orb.

(d) The frequency of occurrence of barrier webs increased with size (age) of the spider. This is less obvious on Daphne, where a high proportion of webs of all size classes had barrier webs.

If stabilimenta are indeed web strengthening elements, then one would expect to find a higher frequency of occurrence in Daphne webs which were exposed to persistent high winds. This is not the case; stabilimenta were less common on Daphne than on the sheltered grassland site at Bahia Borrero. Robinson and Robinson (1970) suggested that since the lower part of an *Argiope* web is the larger, this section would need the most strengthening, thereby explaining the high frequency (61.4%) of webs in Panama with a stabilimentum consisting solely of one or two ribbons below the hub. This was not the case on Daphne of Bahia Borrero: only 5.9% of the webs with stabilimenta on Daphne, and 14.3% of those with stabilimenta on Bahia Borrero had ribbons beneath the hub alone.

I suggest that the infrequent occurrence of stabilimenta in Daphne webs is due to a lack of visually hunting predators. Predation on *Argiope* was never observed; a list compiled of possible predators on *A. argentata* and their occurrence on Daphne Island and on Bahia Borrero (Table 3) suggests, however, that the latter site has more avian

Table 3.—Possible predators of *A. argentata* on Daphne Island and on Bahia Borrero, Santa Cruz Island (S = Sighted, NS = Not sighted, (S) = Sighted, but rare, + = Probable predator, low level ++ = Probable predator, high level, – = Unlikely predator). The list of birds is derived from Harris (1973).

Birds	Daphne	Bahia Borrero
Coccyzus melacoryphus (dark-billed cuckoo)		NS, ++
Myiarchus magnirostris (large-billed flycatcher)		S, +
Nesomimus parvulus (Galapagos mockingbird)		S, ++
Dendroica petechia (yellow warbler)	(S), +	S, +
Geospiza scandens (cactus finch)	S, –	S, –
Chamarynchus parvulus (small tree-finch)		S, ?
Certhidea olivacea (warbler finch)	S, –	S, –
Lizards		
Tropidurus sp.	S, –	S, –

predators. These include such species as the cuckoo (*Coccyzuz melacoryphus*) and the Galapagos mockingbird (*Nesomimus parvulus*) which are highly insectivorous and may prey extensively on spiders. It is generally thought that the disc stabilimentum, typical of immature individuals, is a concealing device (McCook, 1889; Hingston, 1927; Robinson and Robinson, 1970); when disturbed the spider shuttles through the web and hides behind the disc. The low incidence of disc stabilimenta in Galapagos webs, and in Daphne webs in particular, further argues for a paucity of predators.

The increase in frequency of occurrence of stabilimenta with spider size remains unexplained: perhaps avian predators are more likely to take larger individuals. Daphne and Bahia Borrero *Argiope* may be protected to some extent by *Opuntia* cacti; small individuals are less conspicuous (to humans) among *Opuntia* spines than are large individuals. The effects of web location and the degree of protection afforded by surrounding vegetation need to be examined.

Orb webs on Daphne tended to be associated with barrier webs; this is particularly true of plateau webs which were exposed to strong winds. Less than half the Bahia Borrero webs had barrier webs. The orb web of *A. argentata* is torn down and renewed daily or every two days (with the exception of females about to spin coccoons or young about to molt). The barrier web, however, is a permanent structure that is not renewed unless the spider moves to a new location, and may be particularly useful under conditions where (a) web supports are scarce, and (b) strong winds make it necessary to anchor the web securely.

It is likely that barrier webs have more than one function. In some locations their main function may be protective, as suggested by Comstock (1912), and in others it may be mechanical support for the orb web. Other web types that are adapted to conditions of either high winds or heavy rainfall, e.g., *Cyrtophora* spp. (Blanke, 1972; Lubin, 1973) and perhaps *Metepeira* sp. (personal observations on the Galapagos), also have complex barrier webs. These may also serve as moisture gathering devices.

CONCLUSIONS

The high incidence of barrier webs and low frequency of stabilimenta in webs of *A. argentata* on Daphne Island in comparison with those on Bahia Borrero, Santa Cruz Island led me to reconsider the functions of these structures. I suggest that barrier webs help support the orb web and are, therefore, more common in Daphne webs which are exposed to strong winds. If stabilimenta are protective devices, one would predict a higher incidence in webs on Bahia Borrero where there are more potential predators.

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RESEARCH NOTE

PLATYBUNUS TRIANGULARIS AND *PAROLIGOLOPHUS AGRESTIS*: TWO PHALANGIDS INTRODUCED TO NORTH AMERICA (ARACHNIDA, OPILIONES)

Platybunus triangularis (Herbst) 1799, and *Paroligolophus agrestis* (Meade) 1855 (family Phalangiidae) have been collected from locations on the west coast of North America. Until now these species have been reported only from Europe (Roewer, 1923; Spoek, 1963). Their taxonomic descriptions closely follow those given by Spoek (1963), and so are not repeated here. The indentifications have been verified by Dr. G. L. Spoek.

Numerous specimens of both series of these species have been collected from British Columbia and Washington. The localities are as follows: *P. triangularis* (British Columbia: Burnaby, Coquitlam, Haney, Pitt Meadows, Vancouver; Washington: Seattle); *P. agrestis* (British Columbia: Burnaby, Haney, Parksville, Richmond, Vancouver; Washington: Seattle). Mature specimens of *P. triangularis* were collected late March to July, and of *P. agrestis* late August to late October (data from 1963 to 1973). These periods of maturity coincide with those reported for the species in England (Todd, 1949).

These species appear to be introduced. Banks (1894, 1901, 1911), who made comprehensive studies of the west coast phalangids, did not list them. Although small, *P. agrestis* is commonly found near human habitations and so, if present, should have been collected. The occurrence of these species in North America, which seems to be limited to the seaports of Seattle and Vancouver, also supports this hypothesis. The only other phalangid definitely known to be introduced to North America is *Trogulus tricarinatus* (L.) 1758, which was reported from Rochester, New York (Muchmore, 1963).

We thank Dr. G. L. Spoek of Emmen, The Netherlands for confirming our identifications; R. Crawford for the loan of specimens from the Thomas Burke Memorial Washington State Museum, Seattle; and Dr. A. L. Turnbull of Simon Fraser University for reading the manuscript.

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support). 4) By-line: Include name(s) of author(s) as customarily written (less titles) and complete address(es) including zip code or other postal zone designation. Include footnote indication(s) if appropriate (e.g., to indicate change of address). 5) Body of Text: Use whatever form seems to best accommodate the necessary description of the research. Be concise. Conform to the *CBE Style Manual* in all abbreviations. 6) Acknowledgments: Take care to give credit where it is due. 7) Literature Cited: Include only those publications to which reference is made in the text. Adhere to style in *CBE Style Manual* or refer to a previous issue of *The Journal of Arachnology*. Do not abbreviate place names. 8) Figure Legends: Do not type on facing pages but type consecutively in numerical sequence. 9) Abstract: Keep abstracts concise, not exceeding 2-3% of the text. Abstracts should contain a summary of the basic findings. Papers written in a language other than English must be accompanied by an English abstract as well as an abstract in the language of the text. 10) Footnotes: Other than appropriate page 1 footnotes, no other footnotes are permitted. 11) Running Head: Construct this shortened title so that it, along with the author(s)' last names, does not exceed 55-60 characters and spaces. 12) Tables with Legends: Prepare all tables precisely as they are to be typeset. It is essential to construct tables as simply as possible. Place legend at top of each table. Incorporate into legend all information necessary to make the data presented clearly understandable. Do *not* resort to the use of footnotes. Make marginal notations in the text which clearly indicate the appropriate point of insertion of each table. 13) Figures: Since the figures are the only part of the paper for which each author is responsible for preparing camera-ready material, they must be done with the greatest of care. 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Remember that whole views of animals, while not necessarily required for a diagnosis, give the reader an instructive general appreciation of the animal which is impossible to impart with words or by a collection of drawings of pieces. Avoid the use of whole views comprised of ½ dorsum and ½ venter. Illustrate species descriptions. This is in accord with General Recommendation 17, *International Code of Zoological Nomenclature*, which states, "The description of a new taxon of the species-group should be accompanied by a satisfactory illustration or by a bibliographic reference to such an illustration." 13) Put items 3, 4, and 5 above on page 1 and number *all* other pages consecutively.

RESEARCH NOTES

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CONTENTS

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Feature Articles

Research Note

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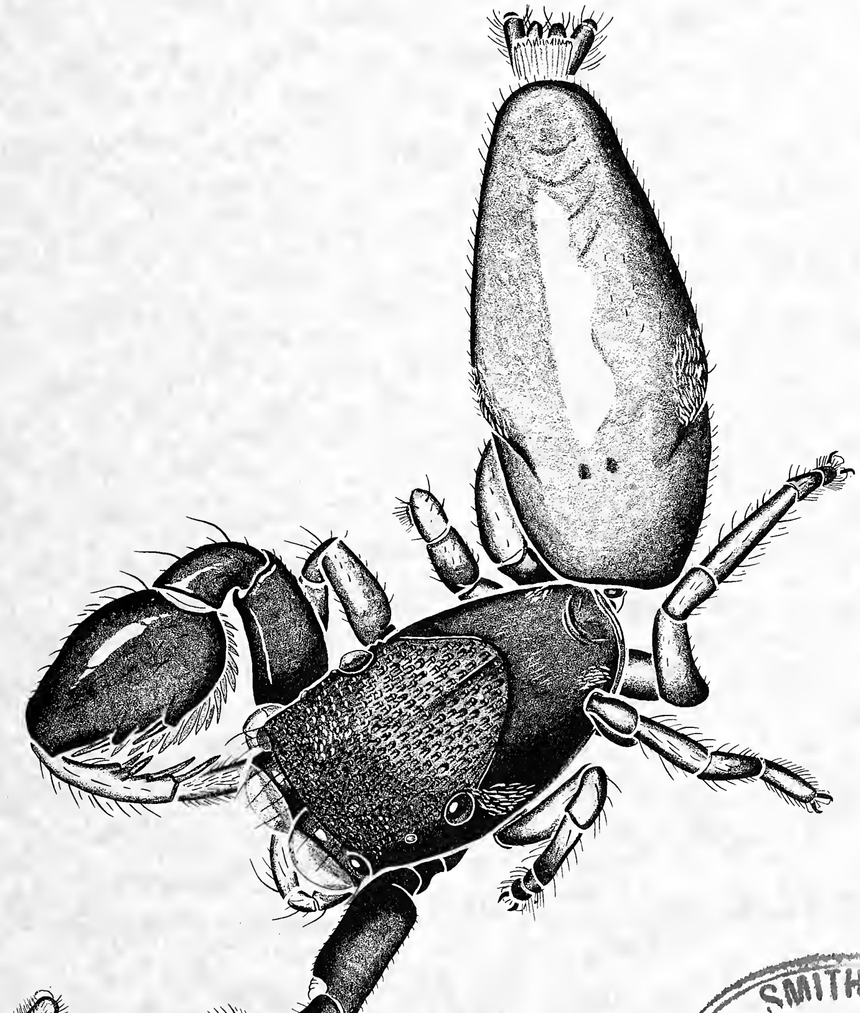

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(continued on inside back cover)

Dondale, C. D.; and J. H. Redner. 1975. The genus *Ozyptila* in North America (Araneida, Thomisidae). J. Arachnol. 2:129-181.

THE GENUS *OZYPTILA* IN NORTH AMERICA (ARANEIDA, THOMISIDAE)

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CONTENTS

ABSTRACT

The generic name *Ozyptila* Simon, 1864 is stabilized by the identification of the type-species *O. claveata* (Walckenaer) 1837 as conspecific with *O. nigrita* (Thorell) 1875, the latter becoming a junior synonym of *claveata.*

The 22 species and two subspecies comprising the genus *Ozyptila* in North America are described or redescribed, keyed, and illustrated. The *floridana* group contains five species from eastern or southeastern United States and Mexico. *O. peon* Gertsch, 1953 and *O. imitata* Gertsch, 1953, known hitherto from female and male, respectively, are newly recognized as conspecific under the name *imitata*. The *brevipes* group contains 15 species and two subspecies from various regions of North America, of which *O. distans* and *O. curvata* are described as new species and *O. sincera canadensis* and *O. sincera oraria* are described as new subspecies. *O. bryantae* Gertsch, 1939 is synonymized under *O. conspurcata* Thorell, 1877, *O. bison* Gertsch, 1953 under *O. beaufortensis* Strand, 1916, *O. barrowsi* Gertsch, 1939 under *O. americana* Banks, 1895, and *O. belma* Gertsch, 1953 under *O. trux* (Blackwall) 1846. The *rauda* group contains two species of the north or west. *O. schusteri* Schick, 1965 is synonymized under *O. yosemitica* Schick, 1965. *O. sincera* Kulczynski, 1926 and *O. septentrionalium* L. Koch, 1879, are recognized as Holarctic for the first time, bringing the number known to be Holarctic to five. *O. nevadensis* Keyserling, 1880 is shown to belong in the genus *Xysticus,* where it becomes a senior synonym of *X. knowltoni* Gertsch, 1939. *O. infumata* (Walckenaer) 1837 is designated a *nomen dubium.*

INTRODUCTION

The pioneer work on the genus *Ozyptila* in North America was done by the European arachnologists Thorell (1877), Keyserling (1880, 1884), and Strand (1916), who altogether described five species from various parts of the United States. Four of these species are still valid, though early American workers redescribed them under new names, not having access to the types which had been deposited in various European museums. Banks (1895) and Bryant (1930) gave their interpretation of these early species, and described several more as new to science. Gertsch's (1939, 1953) papers have served as the definitive work on the genus in this continent up to the present time. Schick (1965) described three species from California, bringing the total for North America to 22, which represent about one-quarter of the described species of the world.

A preliminary review of *Ozyptila* revealed the existence of a number of nomenclatural and identification problems. The identity of the type-species of the genus, for example, was clouded with uncertainty [compare Bonnet's (1958) account with that of Roewer (1954)]. The ranges of some of the early-described species (*e.g.*, *O. conspurcata* Thorell) did not agree with those resulting from our examination of the material available in North American museums. Females of many species were difficult to identify with certainty on the available characters, and several species were known from only one sex. A new revision that would meet and propose solutions to these problems seemed to be needed.

Simon's (1875) summary of the way of life of *Ozyptila* is still accurate: "Les *Oxyptila* ont des moeurs analogues à celles des *Xysticus*; elles sont seulement plus lentes et plus exclusivement terrestres; on les trouve sous les pierres ou sous les touffes de plantes; quand on veut les saisir, elles rapprochent leurs pattes et restent immobiles. La plupart des *Oxyptila* ont une coloration uniforme et terne en rapport avec celle des terrains qu'elles habitent. Leurs téguments rugueux se recouvrent, dans certains cas, de terre et de sable qui y adhèrent fortement et qui dissimulent plus ou moins la coloration véritable. Le cocon est blanc, lenticulaire, relativement très-gros; la femelle le tient entre ses pattes." Bristowe (1971) notes that "they are sluggish spiders and most of them live amongst moss, detritus and low vegetation like diminutive toads," though some of the moss and detritus dwellers are known to climb into low herbs at night. The biology of North American species is virtually unknown.

THE TYPE-SPECIES OF THE GENUS *OZYPTILA*

> "Pour les genres décrits, autrefois, par nor pères
> Qui de types vraiment ne se souciaient guères,
> La chose est déjà faite et les types choisies
> Sans conteste devront être toujours admis.
> Nul n'aura donc le droit de démolir un type,
> Même s'il a raison de l'avoir pris en grippe".
>
> (Bonnet 1948)

It is not clear why Simon (1864, 1895) designated two different species as type of the genus *Ozyptila*. We assume that *Thomisus claveatus* Walckenaer, the first designated, no longer conformed to his concept of the genus and that *T. brevipes* Hahn would serve better. In any case his act, although accepted by subsequent workers [including the bibliographers Bonnet (1958) and Roewer (1954)], contravenes Article 68 of the International Code of Zoological Nomenclature (1964 Edition), and we must return to *T. claveatus* as type-species.

Thomisus claveatus is usually interpreted as a name proposed for a desert-dwelling spider from Egypt, the species having been misidentified by Savigny and Audouin (1825) as *Thomisus hirtus* Latreille (Bonnet, 1958). Examination of Savigny's (1817) illustration of the Egyptian species, and of preserved material of "*Ozyptila claveata* (Walckenaer)" in the Muséum National d'Histoire Naturelle, Paris establishes that "*claveatus*" and *hirtus* are indeed two very different species. The former is a heavy-bodied, *Xysticus*-like spider which, however, bears many clavate setae on its body and legs, whereas the latter, now known as *Heriaeus hirtus* (Latreille), is a hairy spider that lives on plants both in North Africa and Europe.

Examination of Walckenaer's (1837) description of *claveatus* reveals that the identification of his species with that illustrated by Savigny (1817) and curated under the name *O. claveata* is equally unacceptable. Savigny illustrated a spider of 5-6 mm length having slender tibiae I which bear three pairs of ventral macrosetae. Egyptian specimens of "*Ozyptila claveata*" further reveal that the spider is yellow in color, and that the epigynum has a heavily-sclerotized, raised median septum with the copulatory openings close beside it. Except for its coat of clavate setae this species presents the habitus of representatives of *Xysticus* (a few Nearctic species of *Xysticus* bear these setae, *e.g.*, *X. nigromaculatus* Keyserling). Walckenaer (1837), on the other hand, described a smaller spider of 3-4 mm length with a fawn and brown body and swollen front leg segments. His material consisted of females (the male is mentioned but not described) collected under stones in the Basses-Pyrénées of France.

We now believe that it was this French species rather than the Egyptian one on which Simon (1864) erected the genus *Ozyptila*. Unfortunately Walckenaer's material has long been lost, and the identity of the species, in modern terms, is unknown. Roewer (1951) regarded *claveatus* as a *nomen dubium*, but his only contribution to the problem was the proposal of a new name for the large Egyptian species, namely, *Ozyptila audouini* Roewer.

Clearly the characters of *Thomisus claveatus* Walckenaer place the species in the genus *Ozyptila* as herein defined, the critical characters being its clavate setae and swollen front legs. Stability of the generic name *Ozyptila* would best be served by (1) the identification of *T. claveatus* with one of the species now known to inhabit the Pyrénées Mountains, provided such a species can be shown to agree with Walckenaer's description, and (2) the designation of a neotype for *T. claveatus*.

Our study of the several species of *Ozyptila* recorded from the Pyrénées indicates that only *O. nigrita* (Thorell) fits the description of *T. claveatus*. Walckenaer's (1837) characters are compared with those observed by us in Pyrénées females of *O. nigrita* in the following:

	O. claveata	*O. nigrita*
Body length:	1.5 lines (3.12 mm)	2.7 to 3.0 mm
Carapace:	". . . . petit, rugueux, avec cinq raies longitudinales, obscures, alternativement fauves et brunes, dont la plus visible et la plus large est celle du milieu, qui est fauve."	1.1 to 1.3 mm wide, coriaceous, with broad, yellow-brown median band flanked by pair of red-brown longitudinal bands; lateral margins yellow. Bands often obscure, occasionally absent.
Abdomen:	"fauve ou brun, aussi large que long, mais plus large dans son milieu que dans le reste du corps . . . il y a sur le dos de gros crins cylindriques, noirs, courts, séparés par des intervalles réguliers. Ces crins sont plus gros à leur extrémité supérieur, et paraissent comme autant de petits clous fixés par leurs points. . . ."	Yellow-brown, with indistinct grey or black markings; as wide as long but wider at middle than cephalothorax; dorsum armed with many short, dark, clavate setae that are regularly spaced.
Legs:	"brunes, mêlées de fauves, avec des piquants longs, les antérieures renflées."	almost uniform orange-yellow to orange-red; leg I, particularly femur and tibia, swollen.
Epigynum:	"offre sur une éminence conique une petite ouverture en forme de boutonnière."	A transverse curved slit, bordered posteriorly by a lip and situated near the base of a conical eminence.

There appear to be no important discrepancies between the two sets of characters. *O. nigrita* is variable in color, some specimens, particularly males, being dark grey or black. Thorell's (1875a, 1875b) syntype males, from Denmark and Germany, are of this dark color. The difference in body length is probably not significant. *O. nigrita* is the only known species of *Ozyptila* possessing an epigynum of the kind described by Walckenaer.

The foregoing gives the following synonymy:

Ozyptila Simon

Ozyptila Simon, 1864, p. 439. Type-species: *Thomisus claveatus* Walckenaer, by monotypy. Original spelling maintained by Article 32, International Code of Zoological Nomenclature (1964 Edition). *Oxyptila* is an unjustified emendation (Article 33), even though highly desirable from the standpoint of orthography.

Ozyptila claveata (Walckenaer)

Thomisus claveatus Walckenaer, 1837, p. 510. Syntypes from the Vallée d'Ossau (42°54′N, 0°27′W), Basses-Pyrénées, France (lost). Neotype female with label "*Ozyptila claveata* (Walck.). Neotype ♀. P. France (E. Simon)" desposited in the Muséum National d'Histoire Naturelle, Paris, here designated.

Ozyptila claveata: Simon, 1864, p. 439.

Xysticus nigritus Thorell, 1875a, p. 104; 1875b, p. 140. Male syntype (palpus only) from Möen, Denmark (Schiödte) deposited in the Thorell Collection, Riksmuseet, Stockholm, No. 197/4102b. Examined. NEW SYNONYM.

Oxyptila nigrita: Simon, 1875, p. 238; 1932, pp. 797, 806, 872, Figs. 1172, 1173, 1200. Bösenberg, 1903, p. 361, Figs. 530A-530E (not Fig. 531). Tullgren, 1944, p. 77, Figs. 140-143. Locket and Millidge, 1951, p. 189, Figs. 94D, 95A. Bonnet, 1958, p. 3258. Vilbaste, 1969, p. 78, Figs. 65, 66A, 66B.

Ozyptila nigrita: Roewer, 1954, p. 877.

Female–Total length 2.50 mm. Carapace 1.25 mm wide, widest and highest at level of legs II and III, distinctly narrowed in anterior fifth; with indistinct yellow-brown median band and red lateral areas; set with numerous clavate setae, those on front longest. Legs rather short and stout, yellow-brown, paler basally; femur I swollen near middle on prolateral side, with one or two prolateral clavate macrosetae. Tibia I with one dorsal clavate macroseta and two pairs of slender ventrals, neither of which is terminal. Abdomen flattened dorsally, widest at middle, yellow-brown, veined with dark grey; dorsum with numerous short, semi-erect, regularly-spaced clavate setae. Epigynum with conical, anteriorly-directed sclerite, posterior to which is a deep, procurved slit.

Comments and diagnosis–Searches made in various European museums in recent years for Walckenaer material have all proven fruitless, and it is now generally believed that his collection is completely lost or destroyed. The need for a reference specimen of *O. claveata* prompted us to designate a neotype. The specimen selected conforms generally with Walckenaer's original description of *claveata* and particularly with the details of epigynal structure, which are unique to the species as defined above. The specimen is believed to have been collected in the Pyrénées Mountains, the region from which Walckenaer's original material was collected.

The disadvantage of identifying *claveata* with *nigrita* is that the latter name, much used by European arachnologists, must now become a junior synonym of *claveata*. We believe, however, that the stability accruing to the generic name *Ozyptila* warrants this course of action.

TRANSFER OF *OZYPTILA NEVADENSIS* KEYSERLING TO GENUS *XYSTICUS*

The type of *O. nevadensis* Keyserling is a female from the State of Nevada deposited in the Simon Collection and now in the Muséum National d'Histoire Naturelle, Paris. Its overall length is about 4.8 mm. Its carapace, abdomen, and legs are richly invested with clavate setae. Tibia I has three pairs of ventral macrosetae, one pair of which is terminal, and femur I does not have the characteristic prolateral swelling found in most species of *Ozyptila*. The epigynum, which bears no hood, is in agreement with Keyserling's illustration. The spermathecae show this spider to be identical to *Xysticus knowltoni* Gertsch as illustrated by Schick (1965, Fig. 249). The synonymy is as follows:

Ozyptila nevadensis Keyserling, 1880, p. 50, Fig. 25. Female holotype from Nevada, deposited in the Muséum National d'Histoire Naturelle, Paris, labelled "3005. *Ox. nevadensis* Key. Nevada." Examined. Bonnet, 1958, p. 3258 (part). Not *O. nevadensis* of American authors.

Ozyptila nevadensis: Roewer, 1954, p. 884 (part). Not *O. nevadensis* of American authors.

Xysticus knowltoni Gertsch, 1939, p. 399, Figs. 244, 245. Holotype male from Vernon, Utah, 2 May 1936 (G. F. Knowlton), deposited in the American Museum of Natural History, New York. Not examined. Gertsch, 1953, p. 452, Fig. 58. Roewer, 1954, p. 920. Bonnet, 1959, p. 4880. Schick, 1965, p. 167, Figs. 247-249, Map. 38. NEW SYNONYM.

OZYPTILA INFUMATA (WALCKENAER), NOMEN DUBIUM

Walckenaer (1837) described *Thomisus infumatus* from an unpublished color illustration of a Georgian spider by John Abbot. Chamberlin and Ivie (1944, p. 161) decided the species belonged to the genus *Oxyptila*, and, without giving reasons, made the name a senior synonym of *O. floridana* Banks. Gertsch (1953) took note of this proposal but did not accept the synonymy.

We examined, through the courtesy of Dr. H. W. Levi, a color slide of Abbot's original illustration in the Museum of Comparative Zoology. The spider was a subadult male collected on oak in December. The carapace is rather strongly narrowed toward the front, and the abdominal dorsum is transversely wrinkled, both characters commonly found in species of *Ozyptila*. Its banded legs and the presence of four pairs of ventral macrosetae on tibia I place the species in the *floridana* group of the present work. Beyond this, however, we cannot go, as the species of this group are separated on characters of the genitalia. The name *Thomisus infumatus* Walckenaer is therefore best regarded as a nomen dubium, *i.e.*, a name not applicable with certainty to any known species.

DEFINITION AND DIAGNOSIS OF GENUS *OZYPTILA*

Total length 3 to 4 mm, occasionally as short as 2 mm or as long as 5 mm. Carapace 1.25 to 1.75 mm wide, occasionally as narrow as 1.16 mm or as wide as 2.50 mm; male and female of the same species usually little different in size. Carapace rounded at sides, abruptly narrowed at level of posterior row of eyes (ratio of width at level of posterior eyes to maximum width 0.42 to 0.62); highest at level of dorsal groove (approximately 1.5 times higher at level of leg III than at level of posterior eyes); nearly always clothed with clavate setae (males of some species in the *floridana* group may lack them). Lateral eye tubercles close together (distance from anterior lateral to posterior lateral on one side equal to, or slightly less than, distance from anterior median to posterior median); anterior laterals largest; median ocular quadrangle usually slightly longer than wide, occasionally equal in length and width, or wider than long. Carapace red-brown, orange, or nearly black, with pale red or yellow eye area, median band, and V-shaped mark in front of the dorsal groove; dark lateral area often partly divided from behind by yellow longitudinal band. Legs rather short and stout, I and II usually with femur distinctly swollen on prolateral side; femur I usually with two prolateral clavate macrosetae, zero dorsals; tibia

I usually with one short dorsal clavate macroseta and two pairs of nonclavate ventrals, neither of which is terminal (more than two pairs, one pair terminal, in the *floridana* group); basitarsus I with zero or one prolateral macroseta, three pairs of nonclavate ventrals (rarely four pairs); tarsus I with two or three (rarely four) mid-dorsal trichobothria in distal half. Abdomen flattened dorsally, widest just behind middle, clothed dorsally with curved rows of short, clavate setae; often transversely wrinkled.

Tibia of male palpus with two or three apophyses, the intermediate apparently reduced to a small tooth, or absent, in most species. Tegulum rather flat, unarmed (*floridana* group) or with a hard apophysis at or near centre (*brevipes* and *rauda* groups); basal tegular ridge sometimes bearing one or two teeth. Embolus short, usually arising distally or prolaterodistally on tegulum, appressed to cymbium except in *O. georgiana* Keyserling, in which it hangs free (Fig. 34).

Epigynum usually with hood, wrinkled area posterior to hood, and sclerites associated with the copulatory openings. Copulatory openings located laterally, often close to lateral margins of epigynum. Spermathecae slender and segmented by transverse grooves (*floridana* group), divided into two parts, the posterior part bulbous (*brevipes* group) or undivided and expanded (*rauda* group), never in contact at midline, usually separated by a distance less than the width of one of them.

Representatives of *Ozyptila* most resemble those of *Coriarachne* and *Xysticus*. In *Coriarachne*, however, the distance from anterior lateral to posterior lateral eye is greater than that from anterior median to posterior median, the carapace is as low at the level of leg III as at the level of the posterior eye row, and tarsus I bears four mid-dorsal trichobothria. It is more difficult to distinguish between *Ozyptila* and *Xysticus*, there being much overlap in size, coloration, height of carapace, setation of body and legs, and eye relations in specimens of these two genera. A specimen of *Oxyptila* can, however, be recognized by the combined presence of clavate setae on the body (at least the abdominal dorsum) and the modification of leg I, *i.e.*, swollen femur and the presence of only two pairs of ventral macrosetae, neither of which is terminal, on the tibia. Representatives of a few species of *Xysticus* also have clavate body setae (*e.g.*, *X. nigromaculatus* Keyserling), but these do not have the modifications of leg I, nor do they have a prominent epigynal hood anterior to the female copulatory openings or less than two prolateral macrosetae on basitarsus I. Representatives of some species of *Ozyptila* in turn lack the modifications of leg I (*i.e.*, members of the *floridana* group); these have no more than one prolateral macroseta on basitarsus I, and the epigynum has a hood.

Measurements of the carapace, in this paper, are given by the mean and standard deviation whenever more than ten specimens were available for measurement.

KEY TO NORTH AMERICAN SPECIES GROUPS, SPECIES, AND SUBSPECIES OF *OZYPTILA* (EXCEPT MALES OF *HARDYI, INGLESI, CREOLA*, AND *TRUX*)

1a. Male 2
1b. Female 20

2a(1a). Tegulum of palpus without sclerotized, toothlike apophyses near centre. Femur I slender, not swollen near middle of prolateral side (*floridana* group) . 3
2b. Tegulum of palpus with sclerotized apophysis near centre. Femur I swollen near middle on prolateral side 6

3a(2a). Tibia I with more than two pairs of ventral macrosetae, one pair terminal. Retrolateral apophysis of palpal tibia without rounded lobe, with pointed process (Figs. 4, 5). Carapace unbanded 4

3b. Tibia I with two pairs of ventral macrosetae, neither pair terminal. Retrolateral apophysis of palpal tibia with rounded lobe at its base (Figs. 6, 8). Carapace with pair of red longitudinal bands close to lateral margins of pale median area 5

4a(3a). Retrolateral apophysis of palpal tibia two-pointed (Fig. 4) .... 1. *okefinokensis* Gertsch

4b. Retrolateral apophysis of palpal tibia three-pointed (Fig. 5) .... 2. *imitata* Gertsch

5a(3b). Tip of embolus truncate (Fig. 3) .... 3. *floridana* Banks

5b. Tip of embolus pointed (Fig. 7) .... 4. *modesta* (Scheffer)

6a(2b). Ventral apophysis of palpal tibia oriented transversely (Figs. 35, 36). Intermediate apophysis a well-developed process lying close to retrolateral apophysis (Figs. 38, 39)(*rauda* group) 19

6b. Ventral apophysis of palpal tibia not transverse. Intermediate apophysis lying close to ventral apophysis, or absent (*brevipes* group) 7

7a(6b). Retrolateral apophysis of palpal tibia bent ventrally at approximately 90° near base (Fig. 12). Lateral areas of carapace with yellow radiating lines .... 6. *praticola* (C. L. Koch)

7b. Retrolateral apophysis of palpal tibia bent distinctly less than 90°, or straight. Lateral areas of carapace without yellow radiating lines 8

8a(7b). Retrolateral apophysis of palpal tibia slender, extending beyond mid-point of cymbium (Figs. 13, 31, 37) 9

8b. Retrolateral apophysis of palpal tibia not extending beyond mid-point of cymbium 11

9a(8a). Embolus long, slender, curling free of tegulum (Figs. 34, 37) .... 20. *georgiana* Keyserling

9b. Embolus short, not free of tegulum 10

10a(9b). Tooth near prolaterobasal margin of tegulum broad, concave (Fig. 32) .... 19. *formosa* Bryant

10b. Tooth near prolaterobasal margin of tegulum low, slender (Fig. 10) .... 7. *gertschi* Kurata

11a(8b). Basal tegular ridge without teeth (Figs. 11, 15, 17, 18) 12

11b. Basal tegular ridge toothed (*e.g.*, Figs. 19, 23, 25) 15

12a(11a). Retrolateral apophysis of palpal tibia erect, set parallel with long axis of tibia (Fig. 14). Tegular apophysis divided (Fig. 11) ..... 8. *conspurcata* Thorell

12b. Retrolateral apophysis of palpal tibia not erect, not parallel with long axis of tibia. Tegular apophysis not divided 13

13a(12b) Tegulum of palpus with pale swelling basad of tegular apophysis (Fig. 16) .... 9. *monroensis* Keyserling

13b. Tegulum of palpus without pale swelling basad of apophysis .... 10. *sincera* Kulczynski 14

14(13b). Range restricted to Atlantic coast of United States (Map 4, open circles) . . . . 10b. *sincera oraria*, ssp. n.
14b. Range in inland Canada and northern United States (Map 4, closed circles) . . . . 10a. *sincera canadensis*, ssp. n.

15a(11b). Basal tegular ridge bearing one tooth (Figs. 19, 25, 30) 16
15b. Basal tegular ridge bearing two teeth (Figs. 23, 26, 27) 18

16a(15a). Retrolateral apophysis of palpal tibia nearly parallel with long axis of tibia (ventral view, Figs. 19, 25) 17
16b. Retrolateral apophysis of palpal tibia set at approximately 45° with long axis of tibia (ventral view, Fig. 30). Tegulum with large, concave tooth near prolaterobasal margin (Figs. 30, 33) . . . . 15. *americana* Banks

17a(16a). Prolaterobasal margin of tegulum with broad sclerotized area (Fig. 19). Range in eastern North America (Map 5, closed circles) . . . . 12. *distans*, sp. n.
17b. Prolaterobasal margin of tegulum without broad sclerotized area but with small tooth (Fig. 25). Range in Rocky Mountains (Map 5, triangles) . . . . 13. *beaufortensis* Strand

18a(15b). Teeth on basal tegular ridge distinctly separated (Figs. 23, 24). Prolaterobasal margin of tegulum with sharp tooth (Fig. 23). Pacific coast (Map 4, triangles) . . . . 17. *pacifica* Banks
18b. Teeth on basal tegular ridge not distinctly separated (Figs. 26, 27, 29). Prolaterobasal margin of tegulum with blunt tooth or ridge (Figs. 26, 27). Range east of Rocky Mountains (Map 6, open circles) . . . . 14. *curvata*, sp. n.

19a(6a). Tegular apophysis of palpal tibia concave basally (Fig. 35). Intermediate tibial apophysis inclined ventrally at approximately 45° with long axis of tibia (Fig. 38) . . . . 21. *septentrionalium* L. Koch
19b. Tegular apophysis of palpal tibia concave ventrally (Figs. 36, 39). Intermediate tibial apophysis parallel with long axis of tibia (Fig. 39) . . . . 22. *yosemitica* Schick

20a(1b). Epigynum with hood that is usually distinct as in Figs. 43, 55, 80, more rarely thin and transparent as in Fig. 45 21
20b. Epigynum without hood, with distinct rimmed atrium and median septum (Figs. 103, 104, 106)(*rauda* group) 41

21a(20a). Posterior part of spermatheca divided into many segments by transverse grooves, sometimes coiled as in Figs. 42, 44, etc. Femur I slender, not swollen near middle on prolateral side (*floridana* group) 22
21b. Posterior part of spermatheca not divided into segments, never coiled. Femur I swollen near middle on prolateral side (*brevipes* group) 26

22a(21a). Epigynum with hood distinct (Figs. 40, 43, 47, 50). Posterior part of spermatheca not coiled (Figs. 42, 44, 48, 49, 51, 52) 23
22b. Epigynum with hood indistinct (Fig. 45). Posterior part of spermatheca coiled (Fig. 46) . . . . 5. *hardyi* Gertsch

23a(22a). Epigynal hood a raised, triangular plate (Figs. 43, 47, 50) 24

23b. Epigynal hood not a raised, triangular plate (Fig. 40) .... 1. *okefinokensis* Gertsch

24a(23a). Anterior part of spermatheca approximately as broad as posterior part (Figs. 48, 49, 51, 52) 25
24b. Anterior part of spermatheca much narrower than posterior part (Fig. 44) .... 2. *imitata* Gertsch

25a(24a). Anterior part of spermatheca not widest at point of junction with posterior (Figs. 48, 49) .... 3. *floridana* Banks
25b. Anterior part of spermatheca widest at point of junction with posterior part (Figs. 51, 52) .... 4. *modesta* (Scheffer)

26a(21b). Epigynum with transversely wrinkled area between hood and copulatory openings 27
26b. Epigynum without wrinkled area between hood and copulatory openings (Fig. 53). Hood very small. Lateral areas of carapace with radiating yellow lines .... 6. *praticola* (C. L. Koch)

27a(26a). Epigynum with large pale "Y" posterior to hood (Fig. 58). Anterior part of spermatheca directed anterolaterad (Fig. 59) ...... 8. *conspurcata* Thorell
27b. Epigynum without pale "Y." Anterior part of spermatheca not directed anterolaterad 28

28a(27b). Copulatory openings surrounded by hard sclerites (Figs. 72, 97) 29
28b. Copulatory openings not surrounded by hard sclerites 30

29a(28a). Copulatory openings and sclerites approximately as large as hood (Fig. 72) .... 11. *creola* Gertsch
29b. Copulatory openings and sclerites much larger than hood (Fig. 97) .... 19. *formosa* Bryant

30a(28b). Wrinkled area posterior to hood with less than six transverse wrinkles ... 31
30b. Wrinkled area posterior to hood with more than six transverse wrinkles (Figs. 99, 101) .... 20. *georgiana* Keyserling

31a(30a). Epigynum with W-shaped plate posterior to hood (Fig. 95) .... 15. *americana* Banks
31b. Epigynum without W-shaped plate 32

32a(31b). Epigynum with paired, rounded sclerites at approximate level of hood (Figs. 61, 64, 67, 68) 33
32b. Epigynum without paired, rounded sclerites at level of hood 35

33a(32a). Epigynum with deep V-shaped groove posterior to hood (Fig. 61). Anterior part of spermatheca less than one-third as long as posterior part (Figs. 62, 63) .... 9. *monroensis* Keyserling
33b. Epigynum without V-shaped groove posterior to hood (Figs. 64, 67, 68). Anterior part of spermatheca more than one-third as long as posterior part (Figs. 65, 66, 69-71) .... 10. *sincera* Kulczynski 34

34a(33b). Anterior part of spermatheca approximately as long as posterior part (Figs. 65, 66). Range in inland Canada and northern United States (Map 4, closed circles) .... 10a. *sincera canadensis*, ssp. n.

34b. Anterior part of spermatheca approximately one-half as long as posterior part (Figs. 69-71). Range on Atlantic coast of United States (Map 4, open circles) .... 10b. *sincera oraria*, ssp. n.

35a(32b). Epigynum with broad U-shaped sclerite, the copulatory openings situated under its mesal margins (Figs. 55, 74, 84, 86, 89, 90, 92) 36

35b. Epigynum without broad U-shaped sclerite. Copulatory openings situated at lateral margins of epigynum (Figs. 77, 80, 82) 39

36a(35a). Anterior part of spermatheca approximately as long as posterior part, approximately the same width throughout (Figs. 56, 57). . 7. *gertschi* Kurata

36b. Anterior part of spermatheca not as long as posterior part, not same width throughout (Figs. 75, 76, 85, 87, 88, 91, 93, 94) 37

37a(36b). U-shaped sclerite slender (Fig. 74) .... 12. *distans*, sp. n.

37b. U-shaped sclerite not slender 38

38a(37b). Epigynum with transverse wrinkles strongly procurved (Figs. 84-88). Rocky Mountain species (Map 5, triangles) .... 13. *beaufortensis* Strand

38b. Epigynum with transverse wrinkles not procurved (Figs. 91, 93, 94). Range east of Rocky Mountains (Map 6, open circles) .... 14. *curvata*, sp. n.

39a(35b). Paired sclerites posterior to hood with sharp bend (Fig. 82) .... 16. *trux* (Blackwall)

39b. Paired sclerites posterior to hood not bent (Figs. 77, 80) 40

40a(39b). Spermathecae not converging anteriorly (Fig. 81) .... 18. *inglesi* Schick

40b. Spermathecae converging anteriorly (Figs. 78, 79) ..... 17. *pacifica* Banks

41a(20b). Spermatheca looped (Fig. 105) .... 21. *septentrionalium* L. Koch

41b. Spermatheca not looped (Fig. 107) .... 22. *yosemitica* Schick

THE *FLORIDANA* GROUP

The *floridana* group is coextensive with Gertsch's (1939) Group A and with his (Gertsch, 1953) subgenus *Modysticus*, except that we include *O. hardyi*. *O. hardyi* was accorded group status in the subgenus *Ozyptila* by Gertsch (1953) mainly because of the terminal pair of macrosetae under tibia I and the eye relations of specimens of *hardyi*. We have found the leg character to relate adults of *hardyi* to the *floridana* group, and the eye character too variable to provide a basis for group separation. The spermathecal structure of *hardyi* females is consistent with that found in the *floridana* group.

In this group femur I is slender rather than swollen near the middle on the prolateral side as in representatives of the *brevipes* and *rauda* groups. Tibia I bears more than two pairs of ventral macrosetae, of which one pair is terminal. The tegulum of the male palpus lacks an apophysis near its centre, and the basal tegular ridge is smooth (Figs. 1-8) and never toothed. A small tutacular apophysis is present, though not so well developed as in species of *Xysticus*. The spermathecae are divided into many segments by transverse grooves (as in Figs. 42, 44, 46, etc.) rather than into two ungrooved parts. We place here five species.

1. *Ozyptila okefinokensis* Gertsch
Figs. 1, 4, 40, 42. Map 2.

Oxyptila okefinokensis Gertsch, 1934, p. 13. Female holotype from Billy's Island, Okefenokee Swamp, Georgia, June 1912 (Crosby), deposited in the American Museum of Natural History, New York (Cornell University Collection). Examined. Chamberlin and Ivie, 1944, p. 161. Bonnet, 1958, p. 3259. Original spelling maintained by I.C.Z.N., Article 32 (1964 Edition).
Ozyptila okefenokensis: Gertsch, 1939, p. 342, Figs. 130, 138.
Oxyptila okefenokensis: Gertsch, 1953, p. 465.
Ozyptila okefinokensis: Roewer, 1954, p. 884.

Male—Total length about 3.3 mm. Carapace 1.85 mm wide (one specimen). Median ocular quadrangle slightly wider than long; carapace dark red-brown, somewhat paler in median area and near lateral margins; pair of dark spots near mid-line at posterior declivity; eye area off-white; with short untapered setae, those on front longest. Sternum pale red-brown, with Y-shaped black mark in posterior two-thirds and a small black spot in each anterolateral angle. Legs I and II red-brown, the femora with indistinct yellow patches; legs III and IV yellow-brown with a few irregular, paler or darker spots; femur I long and slender, with three or four prolateral macrosetae, two short dorsals near middle; tibia I with one short, untapered dorsal macroseta near base, three pairs of ventrals (distal pair apical); basitarsus I with one prolateral macroseta, one retrolateral, three pairs of ventrals. Abdomen widest behind middle; dorsum pale red with scattered black spots; with several curved, transverse rows of short clavate setae; venter yellow-white with small, scattered black spots.

Tibia of palpus with erect, hooked ventral apophysis and a stouter, two-pointed retrolateral (Figs. 1, 4). Tegulum unarmed (Fig. 1). Embolus short, slender, arising distally on tegulum. Small tutacular apophysis present.

Female—Total length about 4.8 mm. Carapace 2.50 mm wide (one specimen). Median ocular area slightly wider than long. Carapace essentially as in male; sternum yellow with large black area which is broken into smaller spots anteriorly. Legs light brown with irregular, yellow or dark brown patches; femur I with three prolateral macrosetae, no dorsals; tibia I with four or five pairs of ventral macrosetae plus one or two unpaired; basitarsus I with four pairs of ventral macrosetae, one prolateral, one retrolateral. Abdomen widest behind middle; dorsum off-white with many small, irregular black patches, set with transverse rows of clavate setae; venter yellow-white, with small, scattered black spots.

Epigynum with shallow atrium surrounded by low, ill-defined rim; hood small, well separated from copulatory openings (Fig. 40). Spermathecae slender, posterior part angled and divided externally by many transverse grooves (Fig. 42).

Localities—*Georgia:* Billy's Island, Okefenokee Swamp. *Florida:* Three miles southwest of Micanopy, Marion Co.

Range—Georgia and Florida (Map 2).

Comments and diagnosis—The male of *O. okefinokensis* is described here for the first time. Adults of this rare species are separated from those of the other members of the *floridana* group by the two-pointed retrolateral apophysis in the male (Fig. 4) and by the small but distinct, non-triangular hood in the female (Fig. 40).

2. *Ozyptila imitata* Gertsch

Figs. 2, 5, 43, 44. Map 1.

Oxyptila imitata Gertsch, 1953, p. 464, Figs. 77, 78. Male holotype from ten miles north of Victoria, Tamaulipas, 13 April 1941 (A. M. Davis), deposited in the American Museum of Natural History, New York. Examined.

Ozyptila imitata: Roewer, 1954, p. 881.

Oxyptila peon Gertsch, 1953, p. 465, Fig. 79. Female holotype from Huatusco, Veracruz, 11 October 1945 (M. Cardenas), deposited in the American Museum of Natural History, New York. Examined. NEW SYNONYM.

Ozyptila peon: Roewer, 1954, p. 881.

Male–Total length approximately 3.1 mm. Carapace 1.71 to 2.03 mm wide (mean of three specimens 1.84 mm). Median ocular quadrangle wider than long. Carapace dark red-brown with off-white eye tubercles, with some large yellow spots along lateral margins; lateral areas subdivided in posterior half by distinct yellow or red band; small yellow spot behind dorsal groove; with tapered or untapered setae, those on front longest. Sternum red, mottled with yellow or black. Legs yellow-brown, the femora, patellae, and tibiae spotted with yellow or black; femur I with three or four prolateral macrosetae, one or no dorsal; tibia I with three pairs of ventral macrosetae (one pair terminal), one or two short dorsals; basitarsus I with three pairs of ventral macrosetae, one prolateral (which may occur almost in line with the three proventrals), one retrolateral. Abdomen widest behind middle; dorsum red or yellow, with paired indistinct black spots; with many clavate setae; venter yellow, with broken transverse black lines.

Tibia of palpus with hooked ventral apophysis and two-lobed retrolateral (Figs. 2, 5). Tegulum without apophysis, the basal tegular ridge forming a concavity at its centre. Embolus thin, arising distally.

Female–Total length approximately 4.2 mm. Carapace 2.11 mm wide (mean of two specimens). Median ocular quadrangle as in male. Coloration as in male but generally paler; lateral margins of carapace entirely yellow or red; yellow spot at dorsal groove larger; dorsum of abdomen with little black pigmentation; sternum with distinct Y-shaped black mark. Leg macrosetation as in male except that basitarsus I has four pairs of ventral macrosetae (or three pairs plus one unpaired).

Epigynum with small triangular hood, which is well separated from copulatory openings; openings marked posteriorly and mesally by curved, slender sclerites (Fig. 43). Spermathecae convoluted and very slender in anterior part; posterior part curved and transversely grooved (Fig. 44).

Localities–*Tamaulipas*: Ten miles north of Victoria. *San Luis Potosí*: El Salto; 18 miles south of Tamazunchale. *Querétaro*: 17.8 miles east of Landa de Matamoros, 5300 ft elevation. *Veracruz*: Huatusco.

Range–Eastern Mexico (Map 1).

Comments and diagnosis–A study of the size, color, and distribution of the male of *O. imitata* Gertsch and the female of *O. peon* Gertsch indicates that they are the sexes of a single species. Males of *O. imitata* can be separated from those of the other species of the *floridana* group by the three-pointed retrolateral apophysis of the male palpal tibia (Fig. 5). Females differ from those of the other species of the group in having both a raised, triangular hood and a very narrow anterior part of the spermatheca (Figs. 43, 44).

Specimens of *O. imitata* are recorded from tropical deciduous forest in Mexico.

3. *Ozyptila floridana* Banks

Figs. 3, 6, 47-49. Map 1.

Oxyptila floridana Banks, 1895, p. 243. Female holotype from Punta Gorda, Florida (Mrs. A. T. Slosson), deposited in the Museum of Comparative Zoology, Harvard University. Examined. Gertsch, 1953, p. 464. Bonnet, 1958, p. 3256.

Ozyptila floridana: Bryant, 1930, p. 380, Figs. 3, 4, 17 (not Fig. 18). Gertsch, 1939, p. 341, Figs. 106, 107, 129. Roewer, 1954, p. 882.

Male—Total length approximately 2.5 mm. Carapace 1.43 to 1.49 mm wide (mean of three specimens 1.46 mm). Median ocular quadrangle slightly longer than wide or equal in length and width, slightly wider in front than behind. Carapace dark red-brown, with yellow eye tubercles and yellow streaks in pale median area; lateral areas with small to large red spots along side margins, and each lateral area broadly or narrowly divided by irregular, longitudinal band that lies close to pale median area; with clavate setae, those on front longest. Sternum yellow, speckled with red-brown or black. Legs red-brown to orange-brown, the femora, patellae, and tibiae spotted with black and off-white; coxae with one or more small black spots; femur I with four prolateral macrosetae, one or no dorsal; tibia I with three pairs of ventral macrosetae (one pair terminal, sometimes reduced), one short dorsal; basitarsus I with three pairs of ventral macrosetae, one prolateral, one retrolateral. Abdomen widest behind middle; dorsum red-brown, irregularly spotted with off-white and black; venter red or yellow, with thin, transverse black lines.

Tibia of palpus with hooked ventral apophysis and with lobe at base of retrolateral apophysis (Figs. 3, 6). Tegulum without apophyses; basal tegular ridge rather broad, raised on one margin and forming cup-like depression at centre of tegulum. Embolus broad and thin, truncate at tip.

Female—Total length approximately 3 mm. Carapace 1.34 to 2.05 mm wide (mean of seven specimens 1.63 mm). Median ocular quadrangle as in male. Coloration and macrosetation as in male.

Epigynum with small hood remote from copulatory openings; openings nearly surrounded by slender sclerites (Fig. 47). Spermathecae with anterior part curved, broad (Figs. 48, 49).

Localities—*Florida*: Punta Gorda; Dunedin; Winter Park; Tall Timbers Research Station, Leon Co.; Archbold Biological Station, near Sebring. *South Carolina*: Georgetown. *Tennessee*: Montvale Springs.

Range—Southeastern United States (Map 1).

Comments and diagnosis—Males of *O. floridana* can be separated from those of the other species of the *floridana* group by the truncate embolus (Fig. 3). Females differ from those of *O. okefinokensis, O. imitata*, and *O. hardyi* by the epigynal sclerites, which nearly surround the copulatory openings (Fig. 47). *O. floridana* females can be separated from those of *O. modesta* by the width of the anterior part of the spermatheca (Figs. 48, 49).

4. *Ozyptila modesta* (Scheffer)

Figs. 7, 8, 50-52. Map 2.

Xysticus modestus Scheffer, 1904, p. 257, Fig. 1. Female syntypes from Manhattan, Kansas, 10 June, deposited in the Museum of Comparative Zoology, Harvard University, of which only one remains. Examined.

Oxyptila modesta: Scheffer, 1905, p. 184. Gertsch, 1953, p. 464, Fig. 82. Levi and Field, 1954, p. 461, Figs. 82, 90. Bonnet, 1958, p. 3257.

Ozyptila modesta: Bryant, 1930, p. 383, Fig. 20 (part, not Fig. 6). Gertsch, 1939, p. 340, Figs. 104, 105, 127, 128. Chamberlin and Ivie, 1944, p. 161. Roewer, 1954, p. 883 (part).

Oxyptila marshalli Barrows, 1919, p. 357, Pl. 15, Fig. 2. Male holotype from Sugar Grove, Ohio, 11 Sept. 1917 (W. M. Barrows) deposited in the collection of the Ohio State University, Columbus, Ohio. Not examined. Bryant, 1930, p. 382, Figs. 8, 10.

Male–Total length approximately 3.5 mm. Carapace 1.66 ± 0.12 mm wide (11 specimens). Median ocular quadrangle wider than long (mean width and length in 11 specimens 0.27, 0.23 mm). Carapace orange with black pattern; eye tubercles off-white; dark lateral areas divided by broad, irregular red band that lies close to pale median area; with tapered or untapered setae, those on front longest. Sternum yellow-orange, often lightly speckled with black. Legs orange-brown or yellow-brown, tibiae I and II dark brown, the femora and coxae with few indistinct black spots; femur I with three or four prolateral macrosetae, one or no dorsal; tibia I with two pairs of ventral macrosetae (neither terminal), one short dorsal; basitarsus I with three pairs of ventral macrosetae, one prolateral, one retrolateral. Abdomen widest behind middle; dorsum orange-brown, with many indistinct black spots and streaks; venter yellow with transverse black spots or lines.

Tibia of palpus with hooked ventral apophysis, and with lobe at base of retrolateral apophysis (Figs. 7, 8). Tegulum without apophysis; basal tegular ridge rather narrow, raised at one edge and forming depression at centre of tegulum. Embolus broad, drawn to a point (Fig. 7). Small tutaculum present.

Female–Total length approximately 4 mm. Carapace 2.10 ± 0.17 mm wide (11 specimens). Median ocular quadrangle wider than long (mean width and length in 11 specimens 0.32, 0.28). Coloration essentially as in male; legs with more dark spotting. Macrosetation as in male.

Epigynum with small, distinct hood; copulatory openings nearly surrounded by narrow, prominent sclerite (Fig. 50). Spermathecae curled, anterior part as wide as posterior part at point of junction (Figs. 51, 52).

Localities–*Michigan*: Calhoun Co. *Indiana*: Pine. *Ohio*: Sugar Groove; Clear Creek, Hocking Co. *West Virginia*: Minnehaha Springs, Pocahontas Co. *Kansas*: Manhattan. *Missouri*: Columbia; Warrensburg, Johnson Co. *Arkansas*: Berryville; Bradley Co. *Georgia*: Talullah Falls.

Range–Kansas to West Virginia, north to Michigan and south to Arkansas and Georgia (Map 2).

Comments and diagnosis–Adults of *O. modesta* most closely resemble those of *O. floridana*. The distinctive embolus tip of the male of *O. modesta* readily separates it from that of *O. floridana*. In the female there is a pair of epigynal sclerites which surround the copulatory openings, as in *O. floridana*, but the anterior part of the spermatheca is widest at its point of junction with the posterior part (Figs. 51, 52).

Specimens of *O. modesta* have been collected in litter in Missouri, and under rocks in Kansas.

5. *Ozyptila hardyi* Gertsch

Figs. 45, 46. Map 3.

Oxyptila hardyi Gertsch, 1953, p. 471, Fig. 83. Female holotype from Laguna Madre, 25 miles southwest of Harlingen, Texas, 22 August 1945 (Hardy and Wooley),

deposited in the American Museum of Natural History. Examined. Female paratype from the type locality (same data). Examined.
Ozyptila hardyi: Roewer, 1954, p. 883.

Male–Unknown.

Female–Total length approximately 2.2 mm. Carapace 1.16, 1.17 mm wide (two specimens). Carapace strongly narrowed along sides at level of leg I, depressed behind posterior eye row; brown or orange-brown, with a row of off-white spots along lateral margins, off-white eye tubercles, off-white or yellow area at dorsal groove; with clavate setae, those on front longest. Sternum yellow with black bands at mid-line and along posterolateral margins. Legs yellow-brown or orange-brown, the femora dark brown on distal half or third, spotted with off-white; coxae brown; femur I without macrosetae; tibia I with four pairs of ventral macrosetae (one pair terminal and reduced) plus some unpaired macrosetae, no dorsals; basitarsus I with four pairs of ventral macrosetae, no prolaterals (or one prolateral which has apparently fallen in line with proventral row), no retrolaterals; ventral macrosetae of legs I and II set on long bases. Abdomen widest behind middle; yellow with off-white or black spots and streaks; with pale, clavate setae; venter off-white, without dark markings.

Epigynum with short, broad, flat, transparent hood (Fig. 45). Spermathecae long, slender, transversely grooved, and coiled (Fig. 46).

Locality–*Texas*: Laguna Madre, 25 miles southwest of Harlingen.

Range–Known only from the type locality (Map 3).

Comments and diagnosis–Adults of *O. hardyi* are distinguished by their small size, narrowed carapace, and slender, coiled spermathecae (Fig. 46). The types were collected in a nest of *Neotoma micropus.*

THE *BREVIPES* GROUP

This group comprises the majority of the species of *Ozyptila*, both in the Palaearctic and in the Nearctic. Gertsch (1953) regards them as "typical" of the genus.

Femur I is swollen near the middle, on the prolateral side, and tibia I bears only two pairs of ventral macrosetae. These characters are found as well in species of the *rauda* group but not in those of the *floridana* group. The male palpal tegulum bears a tooth or ridge near its centre (as in Figs. 9-34), though this is less protruding than in species of the *rauda* group. The basal tegular ridge is often armed with one or two sharp teeth (*e.g.*, 19, 22, 23, 24). The epigynum has a hood and lacks the rimmed atrium and median septum found in species of the *rauda* group. The spermathecae are not segmented but divided into a variable anterior part and a bulbous posterior part (*e.g.*, Figs. 54, 56, 59, 62), characters that separate species of this group from those of both the *floridana* and *rauda* groups. The group contains fifteen species.

6. *Ozyptila praticola* (C. L. Koch)

Figs. 9, 12, 53, 54. Map 3.

Xysticus praticola C. L. Koch, 1837, p. 26. Types from Europe, depository unknown.
Oxyptila praticola: Simon, 1875, p. 222; 1932, pp. 803, 811, 873, Figs. 1188, 1189, 1210. Tullgren, 1944, p. 78, Figs. 144-146. Locket and Millidge, 1951, p. 190, Figs. 96A, 97C. Gertsch, 1953, p. 470, Figs. 92, 93. Lindroth, 1957, p. 105. Bonnet, 1958, p. 3259.

Ozyptila praticola: Roewer, 1954, p. 881.

Male–Total length approximately 3 mm. Carapace 1.55 mm wide (one specimen). Median ocular quadrangle slightly longer than wide. Carapace dark red-brown, with yellow eye area, median band, and radiating lines in the lateral areas; yellow V-shaped mark at dorsal groove; with clavate setae, those on front longest. Sternum with black spots at centre and near margins. Legs red-brown, femora spotted with black or yellow; tibiae III and IV dark at base; femur I slightly swollen near middle on prolateral side, with two prolateral macrosetae, one or two dorsals; tibia I with two pairs of ventral macrosetae, one or two short clavate dorsals; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red-brown with off-white or black spots and transverse streaks; with clavate setae; venter red with thin transverse black lines.

Tibia of palpus with slender, hooked ventral apophysis and stout, blunt intermediate apophysis, both inclined toward retrolateral side, and slender, slightly sinuous retrolateral apophysis, which is inclined toward ventral side (Figs. 9, 12). Tegulum with thin ridge-like tooth near centre; basal tegular ridge broad and flat, without teeth. Embolus ribbon-like, curved ventrally at tip.

Female–Total length approximately 4 mm. Carapace approximately 1.7 mm wide. Median ocular quadrangle as in male. Coloration essentially as in male but generally paler. Macrosetation as in male.

Epigynum with small hood and shallow, smooth-floored atrium with distinct, sclerotized rim (Fig. 53). Spermathecae inclined toward mid-line anteriorly (Fig. 54).

Localities–*Washington*: Seattle. *Massachusetts*: unspecified locality. *Europe.*

Range–Pacific and Atlantic coasts of United States (Map 3).

Comments and diagnosis–*O. praticola* is a widespread and common European species, and its two North American coastal records (one specimen for each) suggest separate unintentional introductions into this continent. Gertsch (1953) and Lindroth (1957) regard its distribution in this way. The yellow radiating lines on the carapace, strongly bent retrolateral apophysis on the male palpal tibia, and unwrinkled epigynum separate adults of *O. praticola* from those of all other North American members of the *brevipes* group.

O. praticola inhabits undergrowth and detritus in Britain (Locket and Millidge, 1951).

7. *Ozyptila gertschi* Kurata

Figs. 10, 13, 55-57. Map 1.

Ozyptila gertschi Kurata, 1944, p. 1, Figs. 1, 2, 5, 6. Male holotype No. 7072 from Fort Albany, James Bay, Ontario, 22 June 1942 (F. A. Urquhart), deposited in the Royal Ontario Museum, Totonto, Ontario. Not examined. One male paratype from the type locality (same data) in each of the American Museum of Natural History, New York and the Museum of Comparative Zoology, Harvard University. Examined. Roewer, 1954, p. 883. Lindroth, 1957, p. 105.

Oxyptila gertschi: Gertsch, 1953, p. 470, Figs. 89-91. Sauer, 1972, p. 319. Wunderlich, 1973, p. 425, Figs. 45-50.

Oxyptila simplex: Vilbaste, 1969, p. 85, Figs. 73A, 73B (male only). Not *O. simplex* (Pickard-Cambridge), 1862.

Male–Total length approximately 3 to 4 mm. Carapace 1.47 ± 0.08 mm wide (21 specimens). Median ocular area as wide as long, or slightly less wide than long. Carapace dark red to nearly black, with red-brown median stripe, and with V-shaped yellow mark at dorsal groove; dark lateral areas partly divided from behind by band of yellow-brown spots; set with tapered or untapered setae, those on front longest. Sternum without conspicuous color spots. Legs yellow-brown to brown, the femora speckled with dark brown below; femur I swollen prolaterally at middle, with one or two prolateral macrosetae, one or no dorsal; tibia I with two pairs of ventral macrosetae, one slim dorsal; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum mottled off-white, yellow-brown, and black; venter red or purple, with numerous thin, transverse, black or brown bands.

Tibia of palpus with short, hooked ventral apophysis, small intermediate apophysis that arises from base of ventral apophysis, and long, slender retrolateral apophysis (Figs. 10, 13). Tegulum armed with toothed apophysis at centre, prominent basal tegular ridge, and hard tooth near proximal margin. Embolus short, bent near base.

Female—Total length approximately 3.5 to 5 mm. Carapace 1.54 ± 0.10 mm (20 specimens). Coloration and macrosetation as in male.

Epigynum with wide hood that overhangs wrinkled area (Fig. 55). Atrium shallow, its rim composed of low, dark lobes (Fig. 55). Spermathecae as in Figs. 56, 57.

Localities—*Yukon Territory*: Swim Lake, 62°15′N, 133°W (3100 to 3200 ft elevation); Gravel Lake, 58 miles east of Dawson (2050 ft elevation). *Northwest Territories*: Aklavik; Fort Simpson. *Alberta*: Clyde; Medicine Hat; Waterton Lakes National Park. *Saskatchewan*: 13 miles east of Saskatoon; 2 miles north of Laura; Pasqua; Montmartre; Lady Lake. *Manitoba*: 2 miles east of Pipestone; 9 miles west of Souris; Winnipeg; Fort Churchill. *North Dakota*: Kelley; Bottineau Co.; Burke Co.; Cavalier Co.; Divide Co.; Walsh Co. *Ontario*: Fort Albany, James Bay; Gregoire Mills. *Quebec*: Hull. *Labrador*: Cartwright. *Nova Scotia*: Greywood, Annapolis Co.

Range—Yukon Territory to Labrador, south to southern Alberta, North Dakota, and Nova Scotia (Map 1). Europe.

Comments and diagnosis—*O. gertschi* is apparently a boreal Holarctic species, having been reported from Sweden by Lindroth (1957). More recently Vilbaste (1969) illustrated the male palpus of *gertschi* under the name *O. simplex* (Pickard-Cambridge) from the Estonian S.S.R., and Wunderlich (1973) gives the European localities for *O. gertschi*.

The male of *O. gertschi*, as in *O. formosa* and *O. georgiana*, has an unusually long retrolateral apophysis on the palpal tibia. The embolus of *gertschi*, however, does not curl free of the tegulum as it does in *georgiana*, and the tegulum itself bears a low, slender ridge, rather than the broad concave tooth found near the prolaterobasal margin in the male of *formosa*. The epigynum of the female bears a prominent U-shaped sclerite as in females of *O. distans*, *O. curvata*, and *O. beaufortensis*, but the shape and relative length of the anterior and posterior parts of the spermatheca separate females of *gertschi* from these others.

Specimens of *O. gertschi* have been collected in *Carex-Salix* marsh in Saskatchewan, and from "hummocks" at Hull, Quebec.

8. *Ozyptila conspurcata* Thorell

Figs. 11, 14, 58-60. Map 2.

Oxyptila conspurcata Thorell, 1877, p. 496. Female holotype from Manitou Springs, Colorado, 13 July 1875 (A. S. Packard, Jr.), presumed lost. Bonnet, 1958, p. 3255 (part).

Ozyptila nevadensis: Gertsch, 1939, p. 347, Figs. 112, 113, 132. Roewer, 1954, p. 884. Schick, 1965, p. 173, Figs. 256-258, Map 40. Not *O. nevadensis* Keyserling, 1880.

Oxyptila nevadensis: Gertsch, 1953, p. 467, Fig. 84. Bonnet, 1958, p. 3258 (part). Sauer, 1972, p. 319. Not *O. nevadensis* Keyserling, 1880.

Ozyptila bryantae Gertsch, 1939, p. 348. Female holotype from "Norwalk, Connecticut," 4 June 1933 (Gertsch), deposited in the American Museum of Natural History, New York. Examined. Roewer, 1954, p. 883 (part). NEW SYNONYM.

Oxyptila bryantae: Kaston, 1948, p. 420, Fig. 1536 (female only). Bonnet, 1958, p. 3254.

Male–Total length approximately 2.8 mm. Carapace 1.39 ± 0.12 mm wide (32 specimens). Median ocular quadrangle slightly longer than wide. Carapace dark red-brown, faintly mottled with yellow; with yellow V-shaped mark at dorsal groove; set with clavate setae, those on front longest. Sternum pale red-brown, sometimes with minute brown speckles or white spots. Legs pale red-brown, the femora nearly black, or with small off-white spots in some specimens; femur I swollen near middle on prolateral side, with one prolateral macroseta, no dorsal; tibia I with two pairs of ventral macrosetae, one short dorsal; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum pale red-brown to black, set with short clavate setae; venter mottled off-white, yellow, and black.

Tibia of palpus with three short apophyses (Figs. 11, 14). Tegulum armed with small divided tooth near centre; basal tegular ridge broad, without teeth; embolus short.

Female–Total length approximately 3 to 4 mm. Carapace 1.47 ± 0.23 mm wide (32 specimens). Coloration essentially as in male but generally paler. Macrosetation as in male.

Epigynum with short, wide hood and shallow, Y-shaped atrium (Fig. 58). Spermathecae set at angle to long axis of body (Figs. 59, 60).

Localities–*Alberta*: Ft. McLeod; Lethbridge. *Manitoba*: Glenlea, 10 miles south of Winnipeg. *Washington*: Spokane. *Oregon*: Corvallis; Peavine Ridge, near McMinnville. *Idaho*: St. Charles Canyon; 7 miles south of Downy, 5200 ft elevation. *Montana*: 18 miles west of Lolo, Missoula Co., 3900 ft elevation. *North Dakota*: Billings Co.; Burleigh Co.; Dunn Co.; Emmons Co.; Grand Forks Co.; Grant Co.; LaMoure Co.; MacKenzie Co.; Morton Co.; Richland Co.; Slope Co. *South Dakota*: Custer State Park. *Nebraska*: Hays Springs. *Minnesota*: Minneapolis. *Wisconsin*: 2 miles north of Coloma, Waushara Co. *California*: Northfork, Madera Co. *Utah*: Zion National Park; Fish Lake, Sevier Co.; Fruita; Salt Lake City; Dry Canyon, near Salt Lake City; White River, Uinta Co. *Arizona*: North Fork of White River, Apache Co., 7000 ft elevation; Mormon Lake; Santa Catalina Mtns., Pima Co., 4000 ft elevation. *Colorado*: Copper Creek Valley, Gunnison Co.; Gothic, 9700 ft elevation; Piedra, Archuleta Co., 7000 ft elevation; Biebel Spring, 7 miles northeast of Gunnison, 9200 ft elevation; 7 miles south of Estes Park, Larimer Co.; Buckhorn Mtn. Road, west of Fort Collins; Fort Collins, 6300 to 6700 ft elevation; Manitou Springs. *New Mexico*: Sand Springs, Quay Co.

Range–Southern Alberta east to Wisconsin and south to California and New Mexico (Map 2). The Illinois and North Carolina records of Gertsch (1953) could not be confirmed.

Comments and diagnosis–*O. conspurcata* was described by the European arachnologist Thorell (1877) from a female specimen from Manitou Springs, Colorado, sent to him by the entomologist A. S. Packard, Jr. It seemed remarkable that all other localities given for this species by subsequent workers, and confirmed by us as *conspurcata* [sensu Gertsch (1939, 1953)], fell east of the Rockies. The search for the type specimen was therefore renewed in hopes of resolving this apparent anomaly.

The type female of *O. conspurcata* was apparently sent back to Prof. Packard in the United States after its description by Thorell in Sweden. It is not now in the Riksmuseet, Stockholm (T. Kronestedt, *in litt.*). Emerton (1894) saw the type, but there is no record of it after that time. Enquiries at the Peabody Museum of Salem, Massachusetts, where the Packard entomological collection was originally deposited, and at the Museum of Comparative Zoology, Harvard University, to which the Packard collection was later moved, proved fruitless. We therefore assumed the type to be lost, and resorted to a scrutiny of Thorell's original description.

The description is long and detailed, but largely filled with undiagnostic characters. The epigynum, however, is described as having "a small Y-shaped depression (the fore margin of the vulva having the form of a triangular lobe) bordered behind by two tubercles, one on each side". Our study of the species of *Ozyptila* inhabiting the Rockies leads us to conclude that the only one possessing this set of characters is that defined here as *conspurcata*. *O. conspurcata* may therefore be regarded as a distinctive species widespread west of the Great Lakes, and not to be confused with either *O. nevadensis* Keyserling, *O. georgiana* Keyserling, or with any of the past interpretations of these species.

Gertsch (1939) described *O. bryantae* from a female labelled "Norwalk, Connecticut". The specimen belongs to *O. conspurcata*, and its locality is in doubt. The allotype male of *bryantae* is not conspecific and is herein made the holotype of the new subspecies *O. sincera oraria*.

Males of *O. conspurcata* can be separated from those of similar species in the *brevipes* group by the lack of teeth on the basal tegular ridge and the divided tegular apophysis (Fig. 11), and females are identified by the pale, Y-shaped figure in the epigynum (Fig. 58).

Specimens of *O. conspurcata* have been collected from a field edge in Alberta, from talus at 10,000 ft elevation and from Juniper-Douglas fir forest in Colorado, from the nest of a house sparrow in North Dakota, and from pine litter in Wisconsin.

9. *Ozyptila monroensis* Keyserling

Figs. 15, 16, 61-63. Map 3.

Oxyptila monroensis Keyserling, 1884, p. 671, Fig. 19. One female and one immature male, syntypes, from Fort Monroe, Virginia, deposited in the United States National Museum collection in the American Museum of Natural History, New York. Examined. Gertsch, 1953, p. 466. Bonnet, 1958, p. 3257.

Ozyptila monroensis: Banks, 1895, p. 242 (part). Bryant, 1930, p. 385 (part, Fig. 19). Gertsch, 1939, p. 346, Figs. 110, 111, 131. Roewer, 1954, p. 883.

Ozyptila neglecta: Bryant, 1930, p. 386, Figs. 11, 14. Male holotype from Hayden Falls, Columbus, Ohio, 13 June 1926 (W. M. Barrows) deposited in the Museum of Comparative Zoology, Harvard University. Examined.

Male—Total length approximately 2.5 to 3 mm. Carapace 1.41 ± 0.10 mm wide (20 specimens). Median ocular quadrangle varying from slightly longer than wide to slightly wider than long. Carapace dark red-brown to nearly black; with yellow eye area and median longitudinal band, the latter often reduced to Y-shaped mark at dorsal groove; set with clavate setae, those on front longest. Sternum red-brown, mottled with black and off-white. Legs red-brown, the femora darkest and the patellae and distitarsi lightest; femur I swollen prolaterally near middle, with one or two prolateral macrosetae, no dorsal; tibia I with two pairs of ventral macrosetae, one or two short clavate dorsals; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum pale red-brown with black pattern, set with short, clavate setae; venter red-brown, marked with black or off-white transverse lines.

Tibia of palpus greatly expanded distally, bearing ventral and retrolateral apophyses, the intermediate apophysis apparently reduced to a tiny ridge (Figs. 15, 16). Tegulum armed with short tooth near centre; basal tegular ridge broad and thick, not raised at edge, without teeth (Fig. 15). Embolus short, strongly narrowed, bent near tip.

Female–Total length approximately 3 to 4 mm. Carapace 1.46 ± 0.09 mm wide (20 specimens). Coloration essentially as in male but generally paler, the carapace and legs often orange or brown-orange (in alcohol). Leg macrosetation as in male.

Epigynum with small hood and shallow, ill-defined atrium; copulatory openings marked by rounded sclerites (Fig. 61). Spermathecae with inconspicuous anterior part and large, rounded posterior part (Figs. 62, 63).

Localities–*Wisconsin:* Eagle Bluff, 5 miles south of Sauk City; Devils Lake State Park; Parfrey's Glen, Sauk Co.; Wyalusing State Park, Grant Co.; 3 miles northeast of Coon Valley, LaCrosse Co. *Michigan:* Gull Lake Biological Station, Kalamazoo Co. *Ontario:* Pelee Island, Lake Erie. *Kansas:* Douglas Co. *Missouri:* St. Louis; Columbia; Johnson. *Illinois:* Urbana; Chester, Randolph Co.; Pine Hills, Union Co.; 5 miles north of Alto Pass, Union Co. *Indiana:* Lafayette. *Ohio:* Put-in-Bay, Ottawa Co.; Columbus. *Kentucky:* Natural Bridge State Park, Wolff Co. *Pennsylvania:* Neshaminy Creek, northeast of Jamison. *Virginia:* Falls Church; Fort Monroe, near Hampton. *Maryland:* Baltimore. *Arkansas:* Bradley Co.; Cove Creek, Walsh Co. *Texas:* Raven Ranch, Kerr Co.

Range–Wisconsin to Pennsylvania, south to Texas (Map 3). The literature records cited by Gertsch (1939, 1953) from Georgia, Florida, and Alabama were not confirmed.

Comments and diagnosis–The male of *O. monroensis* can be separated from those of similar species in the *brevipes* group by the lack of teeth on the basal tegular ridge (Fig. 15), and by the pale swelling on the tegulum basad of the tegular apophysis (Fig. 16). In the female the paired, rounded sclerites at the level of the hood, and the deep, V-shaped groove (Fig. 61) of the epigynum are diagnostic.

The *monroensis* type vial, which Keyserling (1884) stated to contain a female and an immature male, actually contains two female spiders. Both are of *O. monroensis* as defined here. Re-examination of the holotype of *O. neglecta* confirms the synonymy of this name with *monroensis* given by Gertsch (1939, 1953).

Specimens of *O. monroensis* have been collected from abandoned fields and from leaf mold and litter in oak, maple, or basswood forest.

10. *Ozyptila sincera* Kulczynski

Figs. 17, 18, 20, 21, 41, 64-71. Map 4.

Oxyptila sincera Kulczynski, 1926, p. 62, Fig. 24. Female holotype from "Klutschevskoje" [Klyuchevskaya Sopka], Kamchatka, 31 May 1909, deposited in the Zoological Institute of the Polish Academy of Sciences, Warsaw. Examined. Schenkel, 1930, p. 28, Figs. 11a-11c. Bonnet, 1958, p. 3265.

Ozyptila sincera: Roewer, 1954, p. 879.

Ozyptila bryantae Gertsch, 1939, p. 348 (part, allotype male. Examined). Roewer, 1954, p. 883 (part).
Oxyptila bryantae: Gertsch, 1953, p. 467 (part). Sauer, 1972, p. 318.

Comments and diagnosis—A study of the type material of Kulczynski's (1926) three species of *Ozyptila* from Kamchatka revealed that one of them, *O. sincera*, was conspecific with a widespread North American species that has been identified in the past as *O. bryantae* Gertsch [holotype ♀ *bryantae* = *O. conspurcata*; allotype ♂ and all remaining *bryantae* in Gertsch (1939, 1953) = *O. sincera*]. We therefore regard *O. sincera* as an Holarctic species, and further subdivide it into geographic populations as follows: *O. sincera sincera* Kulczynski from Kamchatka, *O. sincera canadensis*, ssp. n. from Alaska to Ontario, and *O. sincera oraria*, ssp. n. from the Atlantic coast of the United States. Only the two North American forms are treated in this paper.

The male of *O. sincera* most resembles those of *O. monroensis* and *O. conspurcata*, but lacks the tegular swelling found in males of *monroensis* and the divided tegular apophysis found in males of *O. conspurcata*. The female of *O. sincera* also lacks the V-shaped epigynal groove found in females of *O. monroensis* and the triangular sclerite posterior to the hood found in females of *O. conspurcata*.

10a. *Ozyptila sincera canadensis*, ssp. n.

Figs. 17, 20, 41, 64-66. Map 4.

Ozyptila bryantae: Gertsch, 1939, p. 348, Figs. 108, 109 (part). Roewer, 1954, p. 883 (part).
Oxyptila bryantae Gertsch, 1953, p. 467 (part). Sauer, 1972, p. 318.

Male—Total length approximately 2 to 3 mm. Carapace 1.36 ± 0.07 mm wide (24 specimens). Median ocular area slightly longer than wide. Carapace orange-brown to brown, the lateral areas faintly mottled with yellow; with yellow V-shaped mark, which is often margined with a dark brown line, at dorsal groove; set with tapered or untapered setae, those on front longest. Sternum yellow-brown, marked at centre and near margins with indistinct brown spots. Legs light orange-brown to black, often yellow at bases of femora and on distitarsi, the femora lightly speckled with brown below; femur I swollen near middle on prolateral surface, with one or two prolateral macrosetae, one or no dorsal; tibia I with two pairs of ventral macrosetae, one or two short dorsals; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum nearly black, set with short, clavate setae; venter off-white or yellow, transversely lined with black.

Tibia of palpus with short ventral and intermediate apophyses broadly united at their bases, and short, finger-like retrolateral apophysis (Figs. 17, 20). Tegulum armed near centre with short, broad tooth; basal tegular ridge broad, its proximal margin raised, without teeth. Embolus short, narrowed and bent near tip.

Female—Total length approximately 3 mm. Carapace 1.40 ± 0.07 mm wide (21 specimens). Coloration essentially as in male but generally paler; lateral areas of carapace often divided by yellow longitudinal band, sternum unspotted, and dorsum of abdomen with less extensive black pattern (Fig. 41). Macrosetation as in male.

Epigymum with broad, pale hood, shallow atrium, and distinct round sclerites at copulatory openings (Fig. 64). Spermathecae with slender anterior part, bulbous posterior part (Figs. 65, 66).

Localities—*Alaska*: Fort Richardson; Tolovana, Yukon River. *Yukon Territory*:

Dawson. *Northwest Territories*: Fort Simpson; Wrigley; Alexandra Falls, Hay River (60°30'N, 116°17'W). *Alberta*: Edmonton; George Lake (53°57'N, 114°06'W); Spring Creek Basin (53°30'N, 117°40'W); Mt. Edith Cavell, Jasper National Park; Jasper; Fawcett; Morley, near Calgary; Canmore; Ft. McLeod; Judson; Elkwater Lake, Cypress Hills Provincial Park. *Saskatchewan*: 50 miles north of Lac La Ronge; Saskatoon; Lady Lake; Cypress Hills Provincial Park. *Manitoba*: Aweme, near Brandon; Darwin; Rennie; Seddon's Corner; Riverton; Agassiz Provincial Forest; Elm Creek; Spruce Woods Provincial Park. *Ontario*: 20 miles east of Kenora; Petersen Lake, 35 miles east of Kenora; Raith, near Thunder Bay; Sandstone Lake, near Thunder Bay; Black Sturgeon Lake (49°20'N, 88°50'W); Nipigon; Ramore; 9 miles north of New Liskeard; Oxford Mills, near Kemptville. *Colorado*: 10 miles west of Estes Park, Rocky Mountain National Park. *North Dakota*: Bottineau Co. *Minnesota*: Minneapolis; Itasca Park.

Range–Boreal North America, from Alaska to eastern Ontario, south to Colorado and Minnesota (Map 4).

Comments and diagnosis–This widespread North American subspecies was reported questionably (as *O. bryantae*) from Newfoundland by Gertsch (1953) and Hackman (1954). Dr. Hackman kindly sent us a drawing of the spermathecae of his specimen, but it is a newly-moulted individual and difficult to identify with certainty. Further collecting east of Ontario may confirm these eastern records.

Gertsch's (1939) allotype male of *O. bryantae* is assigned here to *O. sincera oraria*, ssp. n., though his Figs. 108 and 109 definitely pertain to *O. sincera canadensis*, ssp. n.

Adults of *O. sincera canadensis* closely resemble those of *O. sincera oraria*, ssp. n. in size, color, and structure. In males, however, there are slight differences in the shape of the tegular apophysis and basal tegular ridge (compare Figs. 17 and 18). In females the shape of the rounded sclerites of the epigynum seems to differ (compare Figs. 64 and 67, 68), as do the structural details of the anterior part of the spermatheca (compare Figs. 65, 66 and 69-71). The female holotype of *O. sincera sincera* has a wrinkling on the anterior part of the spermatheca which is not found in *sincera canadensis*. Cross-breeding tests would perhaps show whether or not our interpretation of these forms is accurate.

Specimens of *O. sincera canadensis* have been collected from litter and sphagnum moss in larch swamps, from the floor of spruce-poplar or lodgepole pine forest, and from frog stomachs.

Type locality–Wrigley, Northwest Territories, Canada.

Type material–Holotype male and paratype female from the type locality, 6-12 June 1969 (G. E. Shewell), deposited in the Canadian National Collection, Ottawa. Paratype male and female from 20 miles east of Kenora, Ontario, 10 May-16 June 1963 (A. L. Turnbull), deposited in Museum of Comparative Zoology, Harvard University. Paratype male from Minneapolis, Minnesota, 4 May 1932 (W. J. Gertsch), and paratype female, Alexandra Falls, Hay River, Northwest Territories, 16 August 1965 (Jean and Wilton Ivie), deposited in the American Museum of Natural History, New York. Other paratypes in the above institutions, and in the Royal Ontario Museum and Michigan State University.

10b. *Ozyptila sincera oraria*, ssp. n.

Figs. 18, 21, 67-71. Map 4.

Oxyptila monroensis: Banks, 1895, p. 242 (part).
Ozyptila monroensis: Bryant, 1930, p. 385 (part, Fig. 9, male).

Ozyptila bryantae Gertsch, 1939, p. 348, (part, allotype male. Examined). Roewer, 1954, p. 883 (part).

Oxyptila bryantae: Kaston, 1948, p. 420, Fig. 1494 (male only). Gertsch, 1953, p. 467 (part).

Male—Total length approximately 2 to 3 mm. Carapace approximately 1.29 mm wide (mean of six specimens). Median ocular quadrangle slightly longer than wide, or equal in length and width. Carapace orange-brown, the lateral areas faintly mottled with yellow or divided by yellow longitudinal bands; with yellow V-shaped mark at dorsal groove, the yellow area sometimes extending forward to eyes; set with tapered or untapered setae, those on front longest. Sternum red-brown, indistinctly marked with brown spots at centre and near margins. Legs light orange-brown to brown, paler at bases of femora and on distitarsi; femur I with one or two prolateral macrosetae, one or no dorsal; tibia I with two pairs of ventral macrosetae, one or two short dorsals; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red-brown, patterned with black, set with short, clavate setae; venter yellow, sometimes with a few black transverse lines.

Tibia of palpus with short ventral and intermediate apophyses broadly joined at their bases, and short, finger-like retrolateral apophysis (Figs. 18, 21). Tegulum armed near centre with short, broad tooth; basal tegular ridge broad, its proximal margin raised, without teeth. Embolus short, narrowed and bent near tip.

Female—Total length approximately 3 mm. Carapace 1.34 ± 0.19 mm wide (16 specimens). Coloration and macrosetation essentially as in male. Epigynum variable, with pale hood, shallow atrium, and distinct round sclerites (Figs. 67, 68). Spermathecae variable, with slender anterior part and bulbous posterior part (Figs. 69-71).

Localities—*Massachusetts*: Monposett; Chatham, Barnstable Co. *New York*: Sea Cliff; Cold Spring Harbor; Long Pond, Suffolk Co.; Riverhead; Montauk Point. *New Jersey*: Lakehurst; Whitesbog, near Browns Mills. *Maryland*: Baltimore. *Virginia*: 12 miles south of Portsmouth.

Range—Eastern coastal United States from Massachusetts to Virginia (Map 4).

Comments and diagnosis—Adults of this eastern coastal form closely resemble those of *O. sincera canadensis*, ssp. n. There appear to be minor differences in the shape of the tegular apophysis and basal tegular ridge in males (compare Figs. 17 and 18), in the shape of the rounded sclerites of the female's epigynum (Figs. 64, 67, 68), and in the structural details of the anterior part of the spermatheca (Figs. 65, 66, 69, 71). The type female of *O. sincera sincera* has a wrinkling on the surface of the anterior part of the spermatheca not found in *sincera oraria*. Further collecting and cross-breeding tests are needed.

Type locality—Baltimore, Maryland.

Type material—Holotype male and paratype female from the type locality (no other data), deposited in the American Museum of Natural History, New York. Paratype male and four females from Sea Cliff, Long Island, New York, deposited in the Museum of Comparative Zoology, Harvard University. Paratype male and female from Sea Cliff, Long Island, New York, deposited in the Canadian National Collection, Ottawa. Other paratypes in the American Museum of Natural History and the Museum of Comparative Zoology, Harvard University.

11. *Ozyptila creola* Gertsch

Figs. 72, 73. Map 3.

Oxyptila creola Gertsch, 1953, p. 469, Fig. 88. Female holotype from Tallulah Falls, Georgia, 18 June 1930, deposited in the American Museum of Natural History, New York. Examined.

Ozyptila creola: Roewer, 1954, p. 883.

Male–Unknown.

Female–Total length approximately 4 mm. Carapace 1.65 mm wide (holotype). Median ocular quadrangle slightly longer than wide. Carapace red-brown with yellow eye area and median band, and with darker radiating lines in lateral areas; median band enclosing large brown area behind eyes and forming yellow V-shaped figure at dorsal groove; with clavate setae, those on front longest. Sternum red-brown, darkest at margins and in posterior half. Legs red-brown, paler at bases of femora and on distitarsi, lightly mottled with off-white or yellow; tips of femora III and IV, patellae, and tibiae IV nearly black; femur I swollen near middle on prolateral surface, with one prolateral macroseta, no dorsal; tibia I with two pairs of ventral macrosetae, one short clavate dorsal; basitarsus I with three pairs of ventral macrosetae, one prolateral, one retrolateral. Abdomen widest behind middle; dorsum off-white and pale red, with a few black transverse marks; venter yellow with indistinct transverse black lines.

Epigynum with small, hard hood, the openings marked by rounded sclerites (Fig. 72). Spermathecae with short anterior part and bulbous posterior part (Fig. 73).

Locality–*Georgia*: Tallulah Falls.

Range–Known only from the type locality (Map 3).

Comments and diagnosis –The female of *O. creola* is one of the most distinct among the species of the *brevipes* group. It is separated from females of all other species by the small hard sclerites surrounding the copulatory openings (Fig. 72).

12. *Ozyptila distans*, sp. n.

Figs. 19, 22, 74-76. Map 5.

Ozyptila americana: Bryant, 1930, p. 377 (part, Fig. 1). Gertsch, 1939, p. 345 (part, Figs. 114, 115, 134). Roewer, 1954, p. 882 (part). Not *O. americana* Banks, 1895.

Oxyptila americana: Chickering, 1940, 199 (part, Figs. 16, 17). Kaston, 1948, p. 420, Figs. 1493, 1519, 1535. Gertsch, 1953, p. 466. Bonnet, 1958, p. 3248 (part). Not *O. americana* Banks, 1895.

Male–Total length approximately 3-3.5 mm. Carapace 1.59 ± 0.12 mm wide (19 specimens). Carapace dark red-brown with yellow eye area and V-shaped mark at dorsal groove; lateral areas divided by yellow longitudinal bands; with mixture of tapered, untapered or clavate setae, those on front longest. Sternum yellow. Legs yellow-brown to red-brown, with tip of femur III and patellae and tibiae III and IV nearly black; femur I swollen at middle on prolateral side, with two or three prolateral macrosetae, two to no dorsals; tibia I with two pairs of ventral macrosetae, one or two short dorsals; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red-brown with many small black bands or spots, set with numerous clavate setae; venter off-white or yellow, with thin, transverse black lines.

Tibia of palpus with hooked ventral apophysis, intermediate apophysis closely united with the base of the ventral, and finger-like retrolateral apophysis (Figs. 19, 22); with membranous lobe between intermediate and retrolateral apophyses. Tegulum armed with ridge-like tooth near centre, and with low ridge near prolaterobasal margin; basal tegular ridge broad, bearing one tooth. Embolus short, bent near tip.

Female–Total length approximately 3 to 4 mm. Carapace 1.58 ± 0.08 mm wide (21 specimens). Coloration and macrosetation essentially as in male. Legs sometimes with off-white mottling.

Epigynum with short hood and shallow atrium; with oblique sclerites at copulatory openings (Fig. 74). Spermathecae with anterior part short, posterior part bulbous (Figs. 75, 76).

Localities—*Wisconsin*: Copper Falls State Park, Ashland Co.; Point Beach State Park, Manitowoc Co.; Eau Plaine Reservoir, Marathon Co.; Camp Tesoma, Rhinelander, Oneida Co. *Illinois*: Volo-Bog, Lake Co. *Michigan*: Marquette; Crawford Co.; Wexford Co.; Roscommon Co.; Cheboygan Co.; Wilderness State Park, Emmet Co.; Mackinac Co.; Charlevoix. *Ontario*: Lake Timagami; Deux Rivières; Lake Opeongo and South Tea Lake, Algonquin Provincial Park; Mazinaw Lake; Odessa; Chatterton, north of Belleville; Newmarket. *Quebec*: Chelsea; Bagotville. *Newfoundland* (Hackman, 1954): South Side Hills, St. John's; Gambo, Bonavista North Co.; Glenwood, Grand Falls Co. *Prince Edward Island*: Rustico Island. *Nova Scotia*: Kentville; Cow Bay, near Dartmouth; Greywood; Granville Ferry. *New Brunswick*: Priceville; Fredericton. *Maine*: Jefferson, Lincoln Co.; Presque Isle. *New Hampshire*: White Mountains (unspecified locality); Intervale; Jackson; North Woodstock. *Massachusetts*: Hanover. *Connecticut*: Norwalk; Washington (Kaston, 1948). *New York*: Ithaca; Presho; Trenton Falls, north of Utica; Pinekill, Sullivan Co.; Slide Mountain, Ulster Co.; Guyanoga, Yates Co.; Connecticut Hill, Tompkins Co.; McLean; Danby; Peru. *Pennsylvania*: Potters Mills, Center Co.; Loganton. *New Jersey*: High Point State Park, Sussex Co. *Maryland*: Baltimore. *Virginia*: Mountain Lake, Giles Co. *Tennessee*: Mollies Gap and Brushy Mountain, Great Smoky Mountains National Park. *North Carolina*: Grandfather Mountain, Avery Co.

Range—Wisconsin to Newfoundland, south in the Appalachian Mountains to Tennessee and North Carolina (Map 5).

Comments and diagnosis—Individuals of this eastern species were previously confused with those of *O. americana*. The male does closely resemble that of *americana* and also that of the Rocky Mountain species *beaufortensis*, but can be separated from both by the presence of a broad, sclerotized area near the prolaterobasal margin of the palpal tegulum (Fig. 19). The female of *O. distans* resembles those of *O. gertschi*, *O. beaufortensis*, and *O. curvata*, sp. n. in possessing a U-shaped epigynal sclerite. In *O. distans* the anterior part of the spermatheca is shorter than the posterior part (Figs. 75, 76), a condition not found in *O. gertschi*. The relative slenderness of the U-shaped sclerite in *distans* separates the female of this species from those of *beaufortensis* and *curvata* (Figs. 74, 84, 86, 89, 90, 92).

Specimens of *O. distans* have been collected from a sphagnum bog in northern New York, from old fields and hazel swamps in Ontario, and from pine litter.

Type locality—Chatterton, Hastings Co., Ontario (44°15′N, 77°29′W).

Type material—Holotype male and paratype female from the type locality, 26 June-5 July 1967 (holotype) and 1 August-6 September 1962 (paratype) (C. D. Dondale) deposited in the Canadian National Collection, Ottawa. Paratype male and four paratype females from Sproule Bay, Opeongo Lake, Algonquin Provincial Park, Ontario, 26 June-7 July 1945 (W. Ivie and T. B. Kurata), deposited in the American Museum of Natural History, New York. One paratype male and one paratype female from North Woodstock, New Hamsphire, 4 June 1908 (J. H. Emerton), deposited in the Museum of Comparative Zoology, Harvard University. Other paratypes in the above institutions, and in the Royal Ontario Museum and Michigan State University.

13. *Ozyptila beaufortensis* Strand

Figs. 25, 28, 84-88. Map 5.

Oxyptila conspurcata: Emerton, 1894, p. 417, Pl. IV, Fig. 7d (not *O. conspurcata* Thorell, 1877).

Oxyptila beaufortensis Strand, 1916, p. 124. Two syntype males from "Beaufort, N-California (A. Reichardt)," "N.-Carolina: Beaufort (U.S.A.)," deposited in the Senckenberg Museum, Frankfurt (Numbers 4305, 4306). Examined. Gertsch, 1953, p. 471. Bonnet, 1958, p. 3251.

Ozyptila beaufortensis: Roewer, 1954, p. 882.

Oxyptila bison Gertsch, 1953, p. 468, Figs. 85-87. Male holotype from Buffalo Lake, near Victor, Colorado, 11,000 ft elevation, July 1941 (C. and M. Goodnight), deposited in the American Museum of Natural History, New York. Examined. NEW SYNONYM.

Ozyptila bison: Roewer, 1954, p. 882.

Male–Total length approximately 3 mm. Carapace 1.27 to 1.50 mm wide (mean of seven males 1.44 mm). Median ocular quadrangle slightly longer than wide. Carapace dark red-brown, with yellow eye area and yellow V-shaped mark at dorsal groove; lateral areas divided by longitudinal paler band; with clavate setae, those on front longest. Sternum orange-yellow, with small brown spots near margins and at mid-line. Legs red-brown, the trochanters and femora speckled with black; femur I swollen near middle on prolateral side; with two prolateral macrosetae, no dorsals; tibia I with two pairs of ventral macrosetae, one short dorsal; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red-brown, with many indistinct black spots or bands; venter pale red-brown, with transverse black lines.

Tibia of palpus with hooked ventral apophysis, small intermediate apophysis united at base with the ventral, and finger-like retrolateral apophysis (Figs. 25, 28). Tegulum with toothed ridge near centre and short, slender tooth near prolaterobasal margin; basal tegular ridge broad, raised along proximal margin, armed with large tooth. Embolus short, bent near tip.

Female–Total length approximately 3.5 to 4 mm. Carapace 1.48 to 1.67 mm wide (mean of nine specimens 1.56 mm). Coloration much as in male but somewhat paler. Macrosetation as in male.

Epigynum with broad hood, shallow atrium, oblique, curved sclerites at copulatory openings (Figs. 84, 86). Spermathecae with short, inconspicuous anterior part, bulbous posterior part (Figs. 85, 87, 88).

Localities– *Alberta*: Lake Louise (formerly Laggan). *Idaho*: St. Charles Canyon, Bear Lake Co. *Wyoming*: Bridge Bay, Yellowstone Lake. *Utah*: Smith and Morehouse Canyon, 40°47′N, 111°06′W. *Colorado*: Florissant; Buffalo Lake, near Victor, 11,000 ft elevation.

Range–Rocky Mountains, from Alberta to Colorado (Map 5).

Comments and diagnosis–Bryant (1930) synonymized the name *beaufortensis* with *modesta*. Gertsch (1953), however, thought it best to reserve judgment on *beaufortensis* until "an opportunity arises to see the type or authentic specimens." Our study of the two syntype males deposited in the Senckenberg Museum in Frankfurt indicates them to represent a valid species conspecific with *O. bison* Gertsch from Colorado.

The type locality of *beaufortensis* can hardly be "Beaufort, N.-California" as published by Strand (1916); it is equally unlikely to be "N-Carolina: Beaufort (U.S.A.)" as recorded on the labels of the syntypes. No similar material has been collected in the east, whereas several specimens (including the type of *O. bison*) have been collected in the Rocky Mountains. The collector of the two syntype males of *beaufortensis*, A. Reichardt, also collected spiders in Yellowstone National Park ("Jellowstone Park"), Wyoming, and possibly this is the true locality of these males. Until new evidence indicates otherwise, therefore, we regard *beaufortensis* as a species of the Rocky Mountains.

The female of *O. beaufortensis* was until now undescribed.

The male of *O. beaufortensis* most resembles those of *O. distans*, sp. n. and *O. americana*, but differ in having neither a large, concave tooth nor a broad, sclerotized area near the prolaterobasal margin of the palpal tegulum (Fig. 25). The female is most similar to those of *O. gertschi*, *O. distans*, sp. n., and *O. curvata*, sp. n., but the anterior part of the spermathecae is shorter than the posterior part (Figs. 85, 87, 88), unlike the condition found in females of *gertschi* (Figs. 56, 57); the U-shaped epigynal sclerite is less slender than in females of *distans* (compare Figs. 84, 86, and 74), and the epigynal wrinkles are procurved (Figs. 84-88) rather than straight as in females of *curvata* (Figs. 91, 93, 94).

14. *Ozyptila curvata*, sp. n.

Figs. 26, 27, 29, 89-94. Map 6.

Oxyptila barrowsi: Sauer, 1972, p. 318. Not *O. barrowsi* Gertsch, 1939, a junior synonym of *O. americana* Banks, 1895.

Male—Total length approximately 3 mm. Carapace 1.41 to 1.54 mm wide (mean of five specimens 1.47 mm). Median ocular quadrangle slightly longer than wide. Carapace dark red-brown to black, sometimes with yellow eye area and indistinct V-shaped mark, the latter divided by brown or black mid-dorsal streak, at dorsal groove; lateral areas sometimes indistinctly divided by pale red longitudinal band; with clavate setae, those on front longest. Sternum red-brown, sometimes with divided pale spot on front of centre. Legs dark red-brown to nearly black, sometimes spotted with off-white on femora, patellae, and tibiae; basal part of femora II to IV, and tarsi of all legs, pale yellow; femur I swollen near middle on prolateral side, with one or two prolateral macrosetae, one or no dorsal; tibia I with two pairs of ventral macrosetae, one short dorsal; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red-brown with off-white or black spots; venter red-brown with black or off-white transverse lines.

Tibia of palpus with hooked ventral apophysis, small intermediate apophysis that is apparently reduced to a small tooth on the margin of the ventral, and finger-like retrolateral apophysis that is bent ventrally (Figs. 26, 27, 29). Tegulum with ridge-like tooth near centre and flattened blunt tooth on prolateral margin; basal tegular ridge broad, armed with two stout teeth. Embolus short, bent proximally and ventrally at tip.

Female—Total length approximately 4 mm. Carapace 1.36 to 1.79 mm wide (mean of eight specimens 1.55 mm). Coloration essentially as in male, the yellow parts on carapace and legs more extensive. Macrosetation as in male.

Epigynum with small hood and prominent, oblique sclerites at copulatory openings (Figs. 89, 90, 92). Spermathecae with inconspicuous anterior part and bulbous posterior part (Figs. 91, 93, 94).

Localities—*Manitoba*: Telford; Riverton; Seddon's Corner (50°04'N, 96°18'W). *Minnesota*: Otter Tail Co. *Massachusetts*: Chatham, Barnstable Co. *Virginia*: Stumpy

Lake Reservoir, Norfolk.

Range–Manitoba to Massachusetts, south to Virginia (Map 6).

Comments and diagnosis–Adults of *O. curvata* are similar to those of *O. pacifica* in that the basal tegular ridge of the male bears two teeth rather than one as found in *O. beaufortensis* and similar species. The teeth in male *curvata*, however, are close together (Figs. 26, 27). The U-shaped epigynal sclerite appears to relate *curvata* to *gertschi*, *distans*, and *beaufortensis*. The short anterior part of the spermatheca (Figs. 91, 93, 94) separates females of *curvata* from those of *gertschi*; the relatively thick U-shaped epigynal sclerite separates females of *curvata* (Fig. 89, 90, 92) from those of *distans*; and the straight transverse epigynal wrinkles separate females of *curvata* from those of *beaufortensis*.

Type locality–Riverton, Manitoba.

Type material–Holotype male from Riverton, Manitoba, 2 July 1963 (W. Ives), deposited in the Canadian National Collection, Ottawa. Paratype female from the type locality, 18 June 1963 (W. Ives), deposited in the Canadian National Collection, Ottawa. Paratype male from Otter Tail County, Minnesota, 4-12 July 1966 (R. J. Sauer), and paratype female from Seddon's Corner, Manitoba, 10 July 1963 (W. Ives), deposited in the American Museum of Natural History, New York. Paratype male and two females from Chatham, Barnstable County, Massachusetts, 10 June 1920 (J. H. Emerton), deposited in the Museum of Comparative Zoology, Harvard University. Other paratypes in the Canadian National Collection and the Museum of Comparative Zoology, Harvard University.

15. *Ozyptila americana* Banks

Figs. 30, 33, 95, 96. Map 6.

Oxyptila conspurcata: Emerton, 1894, p. 417 (part, Figs. 7a, 7c). Not *conspurcata* Thorell, 1877.

Oxyptila americana Banks, 1895, p. 242. One female and two immature syntypes from Ithaca, New York (N. Banks) deposited in the Museum of Comparative Zoology, Harvard University. Examined. Chickering, 1940, p. 199 (part, Fig. 18). Bonnet, 1958, p. 3248 (part).

Ozyptila americana: Bryant, 1930, p. 377 (part, possibly Fig. 15). Gertsch, 1939, p. 345 (part, Fig. 133). Roewer, 1954, p. 882 (part).

Ozyptila modesta: Bryant, 1930, p. 383 (part, Fig. 6). Not *O. modesta* (Scheffer) 1904.

Ozyptila barrowsi Gertsch, 1939, p. 348, Figs. 120, 121. Male holotype from "Pine," Indiana (N. Banks) deposited in the Museum of Comparative Zoology, Harvard University. Examined. Roewer, 1954, p. 882. NEW SYNONYM.

Oxyptila barrowsi: Gertsch, 1953, p. 466, Fig. 80. Bonnet, 1958, p. 3251.

Male–Total length approximately 3 to 3.5 mm. Carapace 1.71 ± 0. 19 mm (20 specimens). Median ocular quadrangle slightly longer than wide. Carapace dark red-brown to nearly black, with yellow eye area and yellow V-shaped mark at dorsal groove; sometimes with dark streak at mid-line in front of dorsal groove; lateral areas subdivided by longitudinal band of red-yellow spots; with clavate setae, those on front longest. Sternum yellow to red-brown. Legs dark red-brown, the tarsi yellow, femora II to IV off-white on basal half; femur I swollen near middle on prolateral side, with two or three prolateral macrosetae, two, one, or no dorsals; tibia I with two pairs of ventral macrosetae, one short dorsal; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum pale red-brown, with off-white or black spots and transverse streaks; venter yellow, with transverse grey or black lines.

Tibia of palpus with hooked ventral apophysis, small intermediate apophysis that is apparently reduced to a small tooth on the side of the ventral, and a stout, finger-like retrolateral apophysis (Figs. 30, 33). Tegulum with small, ridge-like tooth near centre and concave tooth near prolaterobasal margin; basal tegular ridge broad, raised along proximal margin, with large tooth (Fig. 30). Embolus short, bent in two planes near tip.

Female—Total length approximately 3.5 to 4 mm. Carapace 1.72 ± 0.15 mm wide (20 specimens). Coloration essentially as in male, but generally paler; lateral areas of carapace dark at posterolateral margins but often nearly yellow; femora and tibiae sometimes brown with darker speckling. Macrosetation as in male.

Epigynum with moderately large hood, W-shaped atrium, large oblique sclerites marking copulatory openings (Fig. 95). Spermathecae with broad anterior part and rather small, bulbous posterior part (Fig. 96).

Localities—*Iowa*: Sioux City; Ames. *Kansas*: Manhattan. *Indiana*: Pine (holotype of *O. barrowsi* Gertsch). *Michigan*: Mosherville, Hillsdale Co.; Tekonsha and Albion, Calhoun Co.; Gratiot Co.; Midland Co.; Grandville, Kent Co.; East Lansing. *Ontario*: Point Pelee; Newburgh, Lennox and Addington Co.; Oxford Mills, near Kemptville; Ottawa. *New York:* Ithaca. *Connecticut:* Norwalk. *Virginia:* Falls Church. *Arkansas:* Mississippi Co. *Texas:* Dallas; Palmetto State Park, Gonzales Co.

Range—Iowa to eastern Ontario, south to Texas and Virginia (Map 6).

Comments and diagnosis—Adults of *O. americana* Banks have been confused in the past with those of the species herein described as *O. distans* sp. n. Our study of the relevant type material indicates that *americana* and *barrowsi* are conspecific and that the species interpreted by Gertsch (1939, 1953) as *americana* was undescribed.

The 45° angle of the retrolateral apophysis, and the large concave tooth near the prolaterobasal margin of the palpal tegulum (Fig. 30), separate *americana* males from those of all other members of the *brevipes* group. The W-shaped epigynal plate is diagnostic for females (Fig. 95).

Specimens of *O. americana* have been collected on the ground under hawthorn scrub and in hayfields and swamps (Ontario). One specimen was taken from the stomach of a frog (New York).

16. *Ozyptila trux* (Blackwall)

Figs. 82, 83.

Thomisus trux Blackwall, 1846, p. 300. Male holotype from Oakland, England, June 1846. Presumed lost.

Oxyptila trux: Simon, 1874, p. LXXIII; 1932, pp. 804, 809, 873, Figs. 1193, 1194, 1206. Tullgren, 1944, p. 74, Figs. 133-135. Locket and Millidge, 1951, p. 190, Figs. 96B, 97D. Bonnet, 1958, p. 3266.

Ozyptila trux: Roewer, 1954, p. 880.

Oxyptila belma Gertsch, 1953, p. 467, Fig. 81. Female holotype from Montreal, Quebec deposited in the American Museum of Natural History, New York. Examined. Roewer, 1954, p. 882. NEW SYNONYM.

Male—Not studied. See, for example, Locket and Millidge, (1951, p. 190, Fig. 96B).

Female—Total length approximately 3 mm. Carapace 1.42 mm wide (one specimen). Median ocular quadrangle slightly longer than wide. Carapace brown-orange or yellow-orange, with yellow eye area and indistinct yellow V-shaped mark at dorsal groove; lateral areas broadly divided by pale longitudinal band; margins pale; with clavate setae, those on front longest. Sternum yellow. Legs yellow-orange, with minute brown speckles on femora; femur I swollen at middle on prolateral side, with two prolateral macrosetae, no dorsal; tibia I with two pairs of ventral macrosetae, one short dorsal; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest slightly behind middle; dorsum yellow with few pairs of brown spots or transverse bands; venter yellow with a few thin, transverse, black or brown bands.

Epigynum with broad hood and sinuous, or bent, sclerites at copulatory openings (Fig. 82). Spermathecae with borad anterior part and rather small, bulbous posterior part (Fig. 83).

Locality–*Quebec*: Montreal.

Range–Montreal. Europe (Bonnet, 1958; Roewer, 1954).

Comments and diagnosis–*O. trux* is known in North America from a single female specimen, which Gertsch (1953) designated as holotype of his new species *O. belma*. This type matches a female specimen of *trux* in the Canadian National Collection from Wytham Wood, England. Locket and Millidge (1951) and other European workers illustrate the male. *O. trux* may have been accidentally introduced into North America; the lack of subsequent collections suggests that it may not have become established.

Adults of *O. trux* appear to resemble those of *O. distans*, sp. n. (male palpus), *O. pacifica*, and *O. inglesi* in the North American fauna. Females can be readily separated from those of the latter species by the shape of the sclerites at the copulatory openings (Fig. 82).

O. trux is reported common "in undergrowth, amongst grass, etc." in Britain (Locket and Millidge, 1951).

17. *Ozyptila pacifica* Banks

Figs. 23, 24, 77-79. Map 4.

Oxyptila pacifica Banks, 1895, p. 243. One female and one immature syntype from Olympia, Washington (Trevor Kincaid), deposited in the Museum of Comparative Zoology, Harvard University. Examined. Gertsch, 1953, p. 468. Bonnet, 1958, p. 3259.

Ozyptila pacifica: Bryant, 1930, p. 386, Figs. 12, 13, 21. Gertsch, 1939, p. 349, Figs. 122, 123, 137. Roewer, 1954, p. 884.

Male–Total length approximately 3 to 3.5 mm. Carapace 1.46 to 1.59 mm wide (mean of nine specimens 1.54). Median ocular quadrangle slightly longer than wide. Carapace red-brown with yellow eye area and with yellow V-shaped mark extending forward from dorsal groove; lateral areas divided by longitudinal yellow or red bands; with clavate setae, those on front longest. Sternum yellow, sometimes with black spots near margin. Legs red-brown or yellow-brown, the femora and trochanters usually spotted with black and off-white; tibiae with dark ring near base; femur I swollen at middle on prolateral surface, with two prolateral macrosetae, no dorsal; tibia I with two pairs of ventral macrosetae, one or two short dorsals; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red-brown, with off-white or black bands and spots, with short, clavate setae; venter with many transverse black lines.

Tibia of palpus with hooked ventral apophysis and small, closely associated intermediate apophysis; with finger-like retrolateral apophysis (Figs. 23, 24). Tegulum armed with short, sharp tooth near prolaterobasal margin; basal tegular ridge broad, raised and bearing two sharp teeth. Embolus short, bent near tip.

Female—Total length approximately 4 mm. Carapace 1.42 to 1.71 mm wide (mean of eight specimens 1.62 mm). Coloration much as in male but paler generally; carapace and legs usually with little or no black pigmentation, the leg spots brown. Macrosetation as in male.

Epigynum with short hood and V-shaped, paired, rounded sclerites (Fig. 77). Spermathecae with expanded anterior part, bulbous posterior part (Figs. 78, 79).

Localities—*British Columbia*: Masset, Graham Island; Terrace; Metlakatla, near Prince Rupert; Vancouver; Mission City. *Washington*: Olympia. *Oregon*: Elk City and Burnt Woods, Lincoln Co.; 10 miles west of Philomath; 8 miles southeast of Colton, Clackamas Co.; Walton, Lane Co.; Comstock, Douglas Co.; Allegany.

Range—Coastal British Columbia to Oregon (Map 4). The Alaskan record of Lindroth and Ball (1969) was not confirmed.

Comments and diagnosis—Adults of *O. pacifica* differ from those of all other species in the *brevipes* group in having the two teeth on the basal tegular ridge of the male palpus well separated and of different sizes (Figs. 23, 24). The female of *pacifica* most resembles those of *O. inglesi* and *O. trux*, but can be separated from that of *inglesi* by the posteriorly diverging spermathecae (Figs. 78, 79) and from that of *trux* by the shape of the epigynal sclerites posterior to the hood (Fig. 77).

Specimens of *O. pacifica* have been collected from Berlese samples of moss, bark, and litter in hemlock or cedar-hemlock forest in British Columbia and Oregon.

18. *Ozyptila inglesi* Schick

Figs. 80, 81. Map 4.

Ozyptila inglesi Schick, 1965, p. 173, Figs. 259, 260, Map 40. Holotype female from Huntington Lake, 7000 ft elevation, Fresno County, California, 27 September 1957 (L. G. Ingles) deposited in the American Museum of Natural History, New York. Examined.

Male—Unknown.

Female—Total length approximately 4 mm. Carapace 1.93 to 2.14 mm wide (mean of five specimens 2.02 mm). Median ocular quadrangle as wide as long. Carapace dark red-brown, with yellow eye area and with yellow V-shaped mark at dorsal groove; dark lateral areas divided by paler longitudinal bands; with clavate setae, those on front longest. Sternum pale red-brown, with small, scattered, brown spots. Legs red-brown, trochanters and femora spotted with black or off-white below, femora III and IV and patella IV marked with black; tibia IV sometimes with black ring near base; femur I swollen near middle on prolateral side, with two prolateral macrosetae, no dorsal; tibia I with two pairs of ventral macrosetae, one or two short, clavate dorsals; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red-yellow, with few irregular black spots and with numerous short, clavate setae; venter yellow with scattered black spots or thin bands.

Epigynum with short hood, shallow atrium, elongate sclerites at copulatory openings (Fig. 80). Spermathecae with broad anterior part and rather small, bulbous posterior part

(Fig. 81).

Locality–*California*: Huntington Lake, Fresno County.

Range–Known only from the type locality (Map 4).

Comments and diagnosis–The male of *O. inglesi* is unknown. The female resembles those of *O. pacifica* and *O. trux*, but can be separated from females of *pacifica* by the posteriorly converging spermathecae (Fig. 81) and from those of *trux* by the shape of the epigynal sclerites (Fig. 80).

The type specimen of *O. inglesi* was collected in an alpine meadow habitat.

19. *Ozyptila formosa* Bryant

Figs. 31, 32, 97, 98. Map 7.

Ozyptila formosa Bryant, 1930, p. 381, Figs. 5, 7, 18 (not 17). Male holotype from Royal Palm Park, Florida, 6-24 March 1925 (W. S. Blatchley), deposited in the Museum of Comparative Zoology, Harvard University. Examined. Three female paratypes from the type locality, March and April (W. S. Blatchley) in the same institution. Examined. Gertsch, 1939, p. 344, Figs. 118, 119, 136. Roewer, 1954, p. 882.

Oxyptila formosa: Kaston, 1948, p. 420, Figs. 1495, 1537. Gertsch, 1953, p. 466. Bonnet, 1958, p. 3256.

Male–Total length 2.5 to 3 mm. Carapace 1.39, 1.61 mm wide (two specimens). Median ocular quadrangle slightly longer than wide. Carapace dark red-brown to nearly black, with yellow eye area and divided, yellow lance-shaped or V-shaped mark at dorsal groove; lateral areas lightly mottled with red-yellow; with clavate setae, those on front longest. Sternum yellow with dark spots near margins. Legs red-brown, femora II to IV off-white on basal half, tarsi yellow; femur I with one or two prolateral macrosetae, no dorsal; tibia I with two pairs of ventral macrosetae, one short dorsal; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red-brown, mottled with off-white and black; venter yellow with transverse black lines.

Tibia of palpus with hooked ventral apophysis, intermediate apophysis apparently reduced to small tooth near base of ventral, and slender, sinuous retrolateral apophysis (Figs. 31, 32). Tegulum with small ridge-like tooth near centre and broad concave tooth on prolateral margin (Fig. 32); basal tegular apophysis with stout tooth. Embolus short, bent proximally and ventrally near tip.

Female–Total length approximately 3.5 mm. Carapace 1.74 to 1.85 mm wide (mean of four specimens 1.79 mm). Coloration much as in male but generally paler, the median band on carapace yellow, lateral areas mottled with off-white, femora mottled with off-white, dorsum of abdomen with very few black markings. Macrosetation as in male.

Epigynum with small hood, shallow and elongate atrium, copulatory openings encircled by prominent sclerites (Fig. 97). Spermathecae with short, narrow anterior part, bulbous posterior part (Fig. 98).

Localities–*Florida*: Royal Palm Park; Belle Glade; two miles south of Florida City; Big Bend region, Jefferson Co. *New York*: Cold Spring Harbor. *Massachusetts*: Nantucket.

Range–East coast from Florida to Massachusetts (Map 7).

Comments and diagnosis–The male of *O. formosa* resembles that of *O. georgiana* and of *O. gertschi* in having a long retrolateral apophysis on the palpal tibia, but differs from both in having a broad concave tooth near the prolaterobasal margin of the tegulum (Fig. 32). The female resembles that of *O. georgiana* but differs from the latter in the large size of the copulatory openings in relation to that of the sclerites (Fig. 97).

The habitat of *O. formosa* is recorded as litter under pecan trees in Florida.

20. *Ozyptila georgiana* Keyserling
Figs. 34, 37, 99-102. Map 7.

Oxyptila georgiana Keyserling, 1880, p. 52, Pl. 1, Fig. 26. Syntype females "In der Sammlungen der Herren Dr. Koch und E. Simon mehrere aus Peoria und Georgia stammende Examplare." [One syntype female from Georgia in the Muséum National d'Histoire Naturelle, Paris (tube 2432, Bocal 1507). Examined. One syntype female from Peoria, Illinois in the British Museum (Natural History), London (No. 3718). Examined].

Oxyptila conspurcata: Banks, 1895, p. 242 (part). Chickering, 1940, p. 201, Figs. 19-21. Kaston, 1948, p. 419 (part, Figs. 1492, 1534). Bonnet, 1958, p. 3255 (part). Sauer, 1972, p. 319. Not *O. conspurcata* Thorell, 1877.

Ozyptila conspurcata: Bryant, 1930, p. 379 (part, Figs. 2, 16). Gertsch, 1939, p. 343 (part, Figs. 116, 117, 135). Roewer, 1954, p. 883 (part).

Oxyptila americana: Sauer, 1972, p. 318. Not *O. americana* Banks, 1895.

Male—Total length approximately 3 to 4 mm. Carapace 1.52 ± 0.10 mm wide (20 specimens). Median ocular quadrangle slightly longer than wide. Carapace dark red to nearly black, the pale median area enclosing a brown area behind the eyes and with a yellow V-shaped mark at dorsal groove; dark lateral areas partly subdivided from behind by pale red bands; eye area yellow. Sternum red-brown, sometimes with black spot at mid-line. Legs I and II with femora mottled red-brown, black, and yellow, and with tibiae and distal segments yellow-brown; legs III and IV with femora (basal half), basitarsi and distitarsi yellow, femora (distal half), patellae, and tibiae nearly black; femur I swollen prolaterally near middle, with one or two prolateral macrosetae, one or no dorsal; tibia I with two pairs of ventral macrosetae, one short clavate dorsal; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red-brown with paired off-white or black spots, set with short clavate setae; venter yellow with several black streaks or spots.

Tibia of palpus with stout, curved ventral apophysis, minute intermediate apophysis near base of ventral apophysis, and long, slender, sinuous retrolateral apophysis (Figs. 34, 37). Tegulum armed with small tooth near centre and with second tooth near proximal margin; basal tegular ridge bearing large, blunt tooth (Fig. 34). Embolus long and sinuous, arising on prolateral side of tegulum, tip free of tegulum.

Female—Total length approximately 3.5 to 4.5 mm. Carapace 1.72 ± 0.14 mm wide (29 specimens). Coloration and macrosetation essentially as in male. Some specimens show indistinct speckling under the femora, and the V-shaped mark on carapace less distinct.

Epigynum with small hood, shallow atrium, copulatory openings nearly encircled by raised sclerites; copulatory tubes visible through epigynal wall (Figs. 99, 101). Spermathecae with small anterior part and bulbous posterior part (Figs. 100, 102).

Localities—*North Dakota*: Richland Co.; Cass Co. *Minnesota*: Clay Co.; Minneapolis. *Iowa*: Ames. *Illinois*: Chicago; Peoria. *Michigan*: Livingston Co.; Grandville, Kent Co.; East Lansing; Bath and Burke, Clinton Co.; Gull Lake Biological Station, Kalamazoo Co.; Midland Co.; Montcalm Co.; Tekonsha and Albion, Calhoun Co. *Ontario*: Chatterton, 13 miles northwest of Belleville; Belleville; Sand Banks Provincial Park, Prince Edward County. *New York*: Ithaca; Sea Cliff; Staten Island. *Massachusetts*: Holliston; Sharon; Nantucket; Woods Hole. *Connecticut*: Norwalk. *New Jersey*: Ramsey; Newfoundland. *Georgia*: unspecified locality.

Range–North Dakota to Massachusetts, south to Georgia (Map 7).

Comments and diagnosis–*O. georgiana* was early made a junior synonym of *O. conspurcata* (of authors) by Banks (1895), who was followed by all subsequent revisers. We find this disposition unacceptable. The curled embolus of the male of *georgiana* is unique (Figs. 34, 37). The female differs from that of other species in the extensively wrinkled area posterior to the epigynal hood and in the long, oblique copulatory tubes visible through the epigynal wall (Figs. 99, 101).

Specimens of *O. georgiana* have been collected in hawthorn scrub, abandoned fields, and on a lawn, in Ontario, in pitfall traps "near water" in North Dakota, and on the open prairie in Illinois.

THE *RAUDA* GROUP

This group was not known to occur in North America until Schick (1965) described *O. yosemitica* from inland California. Although he recognized the female of this species as quite unique in genitalia, Schick surprisingly did not propose any taxon for it above species level. We propose here a species group to include this and the Holarctic *septentrionalium*, using the oldest name applied to a member of the group.

The diagnostic characters of the group are the transversely-oriented ventral apophysis (Figs. 35, 36) and long, well-developed intermediate apophysis (Figs. 38, 39) on the palpal tibia in males and the absence of a hood coupled with the presence of a distinct, rimmed atrium and median septum in the epigynum of females (Figs. 103, 106). The femoral swelling on leg I and the presence of only two pairs of macrosetae (neither terminal) under tibia I appear to relate the species of this group to those of the *brevipes* group. There are two North American species.

21. *Ozyptila septentrionalium* L. Koch

Figs. 35, 38, 103-105. Map 5.

Oxyptila septentrionalium L. Koch, 1879, p. 96, Pl. 3, Figs. 11, 11a (male, not female). Male syntype from "Surgutskoj" (between Alinskoye and Lebed'), 18 September 1875, and male syntype from "Anninskoj" (Alinskoye), 17 September 1875 deposited in the Naturhistoriska Riksmuseet, Stockholm. Examined. Male syntype from "Surgutskoj" hereby designated as lectotype of *O. septentrionalium*. Note: two females respectively from "Troitzkoj" and "Intsarewo" (Lebed'), and forming part of the syntype series, belong to the related species *O. rauda* Simon. Bonnet, 1958, p. 3264.

Ozyptila rauda: Roewer, 1954, p. 878 (part, not *O. rauda* Simon).

Male–Total length approximately 3 mm. Carapace 1.24 to 1.69 mm wide (mean of six specimens 1.37 mm). Median ocular quadrangle approximately as long as wide. Carapace dark red-brown to nearly black, with yellow eye area and divided yellow V-shaped mark at dorsal groove; lateral areas divided by longitudinal band of yellow spots; with clavate setae, those on front longest. Sternum red-brown. Legs red-brown or yellow-brown, femora darkest but with indistinct brown or yellow spots; femur I swollen at middle on prolateral side, with one or two prolateral macrosetae, no dorsal; tibia I with two pairs of ventral macrosetae, one short clavate dorsal; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, one or no retrolateral. Abdomen widest behind middle; dorsum red or yellow, with small, off-white, paired spots; with rows of short clavate setae; venter red with off-white or black transverse lines.

Tibia of palpus with transverse, hooked ventral apophysis, slender curved intermediate apophysis, and retrolateral apophysis that lies close to cymbium (Figs. 35, 38). Tegulum with stout, fluted apophysis near centre; basal tegular ridge not divided into two parts (Fig. 35). Embolus rather broad, terminating in slender, angled piece.

Female—Total length approximately 3 mm. Carapace 1.21 to 1.55 mm wide (mean of ten specimens 1.38 mm). Median ocular area as in male. Coloration essentially as in male; legs yellow or red-brown, femora and tibiae streaked and spotted with brown to black. Macrosetation as in male.

Epigynum without hood, with distinct, depressed atrium and with median septum (Figs. 103, 104). Spermathecae looped (Fig. 105).

Localities—*Alaska*: Deering, Seward Peninsula; Tangle Lakes, approximately 63°10'N, 146°W. *Yukon Territory*: North Fork Pass, Ogilvie Mountains, 65°21'N, 138°15'W, 4100 ft elevation. *Northwest Territories*: 20 miles west of Inuvik; 7 miles southeast of Tununuk; 20 miles east of Tuktoyaktuk; Lac Maunoir, 67°30'N, 124°55'W; Plains of Abraham, Mackenzie Mountains, 64°32'N, 127°44'W, 4300-5600 ft elevation; Salmita Mines, 64°05'N, 111°15'W. *British Columbia*: Summit Lake, Mile 392 Alaska Highway.

Range—Alaska to the western part of the Northwest Territories and northern British Columbia (Map 5). Siberia and Europe.

Comments and diagnosis—*O. septentrionalium* has been regarded as a junior synonym of *O. rauda* Simon by recent European authors. Our study of the syntype series of *septentrionalium* from Siberia, and of *rauda* material from the Basses-Alpes of France, indicates that these are distinct species, of which the former is Holarctic in range. As the syntype series contains representatives of both species we designate here a lectotype of *septentrionalium* (see synonymy) and redefine the species accordingly.

Adults of *O. septentrionalium* most resemble those of *O. yosemitica* in the North American fauna. The former differ from the latter in the shape of the tegular apophysis and in the angle of the retrolateral apophysis of the tibia in males (compare Figs. 35, 38 with 36, 39), and in the looped spermathecae of the female (compare Fig. 105 with 107).

Specimens of *O. septentrionalium* have been collected from shrub tundra in the Mackenzie Delta.

22. *Ozyptila yosemitica* Schick

Figs. 36, 39, 106, 107. Map 3.

Ozyptila yosemitica Schick, 1965, p. 173, Figs. 261, 262, Map 40. Holotype female from Wawona Camp, Mariposa County, California, 17 September 1941 (W. Ivie), deposited in the American Museum of Natural History, New York. Examined.

Ozyptila schusteri Schick, 1965, p. 175, Map 40. Holotype female from Riverton, El Dorado County, California, 22 February 1958 (R. O. Schuster), deposited in the American Museum of Natural History, New York. Examined. NEW SYNONYM.

Male—Total length approximately 3 mm. Carapace 1.50, 1.59 mm wide (two specimens). Median ocular quadrangle slightly longer than wide. Carapace dark red-brown with yellow eye area and divided yellow V-shaped mark at dorsal groove; lateral areas with few yellow spots; with clavate setae, those on front longest. Sternum red-brown. Legs red-brown to brown, femora darkest, coxae and tarsi yellow-brown; femur I swollen near middle on prolateral surface, without macrosetae; tibia I with two pairs of ventral macrosetae, one or two short clavate dorsals; basitarsus I with three pairs of ventral macrosetae, one or no prolateral, no retrolateral. Abdomen widest behind middle; dorsum nearly black; with short clavate setae; venter red with off-white or black transverse lines.

Tibia of palpus with hooked, transversely-oriented ventral apophysis, straight, erect intermediate apophysis, and slender retrolateral apophysis lying against cymbium (Figs. 36, 39). Tegulum with long, fluted apophysis at centre; basal tegular ridge narrow, passing under embolus tip. Embolus tip long and slender, making one complete turn within space between tegular apophysis and basal tegular ridge.

Female–Total length approximately 3.5 mm. Carapace 1.53 to 1.74 mm wide (mean of ten specimens 1.65 mm). Median ocular quadrangle as in male. Coloration essentially as in male; carapace lateral areas with yellow spots; femora and tibiae sometimes showing off-white spots; sternum partly yellow; dorsum of abdomen red-brown, lightly patterned with black. Macrosetation as in male.

Epigynum with distinct atrium, which has grooved floor, narrow median septum, and distinct raised margin (Fig. 106). Spermathecae with long, expanded anterior part and small posterior part (Fig. 107).

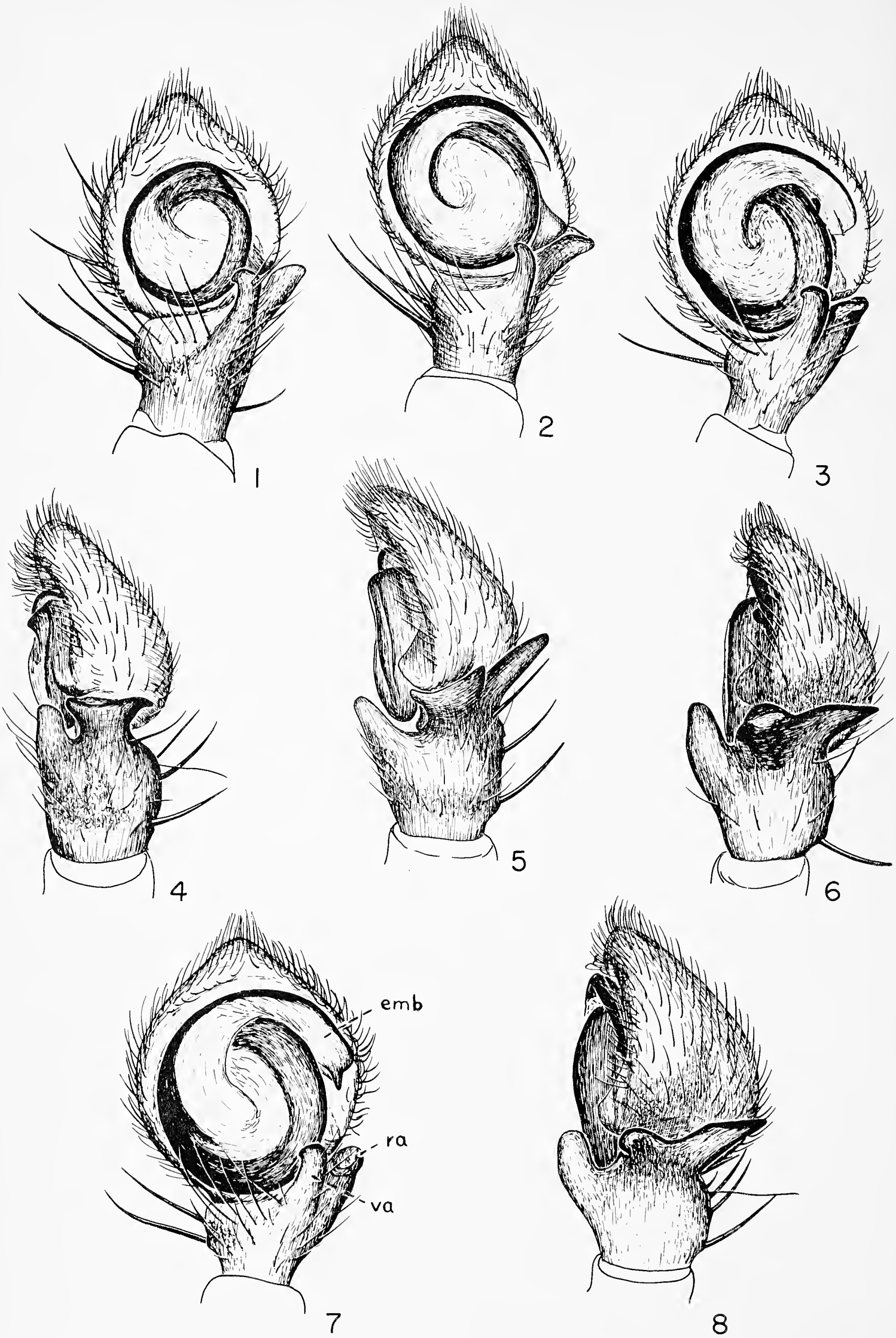
Localities–*California*: Bridalveil Falls and Wawona Camp, Yosemite National Park; Riverton, El Dorado Co.; Quincy; Burney Falls, Shasta Co.; near Leggett, Mendocino Co. *Oregon*: Ruch and 15 miles southwest of Ruch, Jackson Co.; southeast of Steamboat, Douglas Co.; Agnes Pass, Curry Co.

Range–California and Oregon (Map 3).

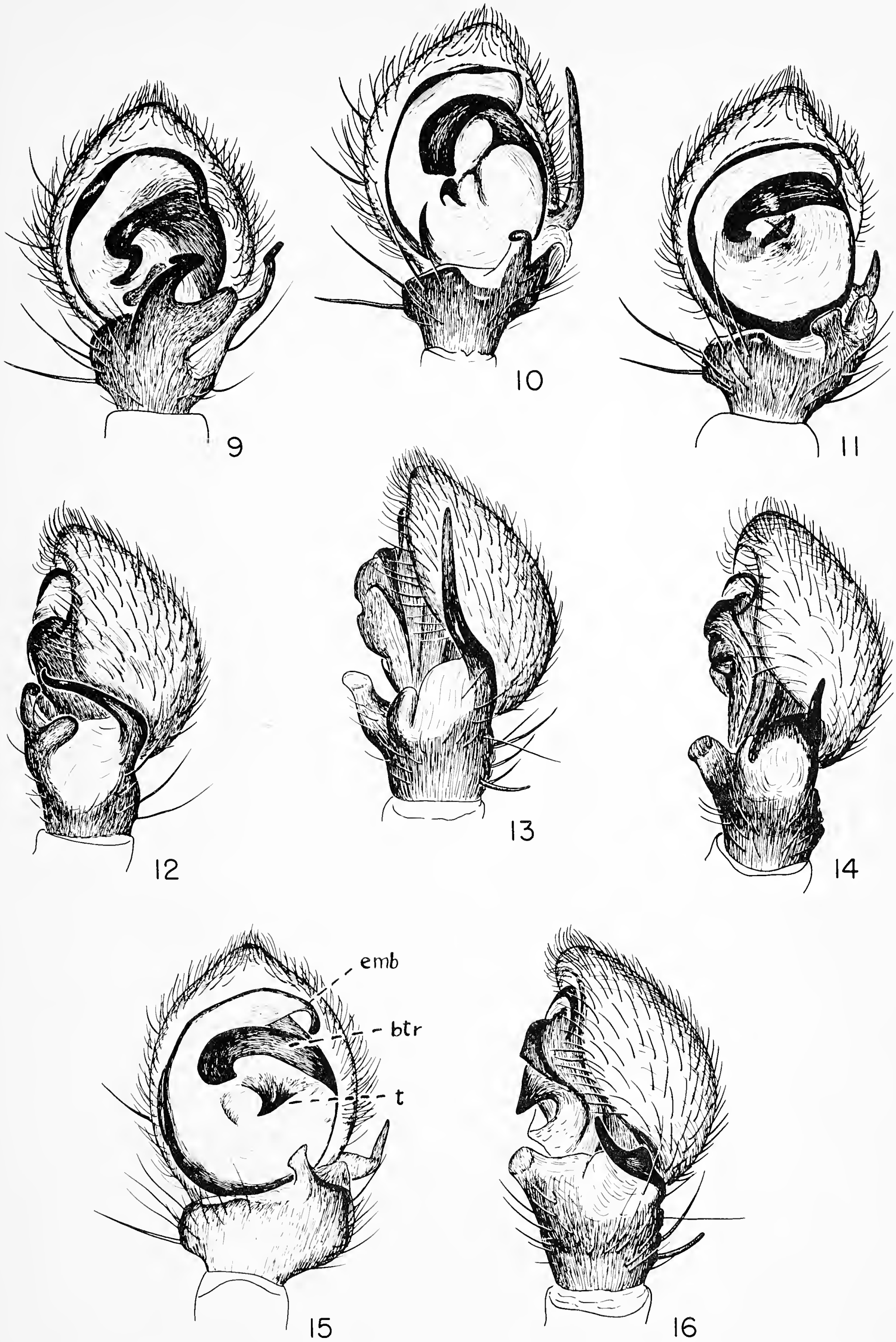
Comments and diagnosis–*O. yosemitica* is a western species apparently related to the Holarctic species *O. septentrionalium*. The male is described here for the first time. Schick's (1965) *schusteri* was based on a female that was stated to have an unusually narrow "pars cephalica." Whereas Schick gives a "pars cephalica" width index of 3.7 for the holotype female of *schusteri*, compared with 4.8-5.0 for females of *yosemitica*, we find the female of *schusteri* to be 4.6 and females of *yosemitica* 4.6-5.0 in this character. The female genitalia of *yosemitica* and *schusteri* are identical. We therefore synonymize *schusteri* under *yosemitica*.

The shape of the tegular apophysis and the angle of the retrolateral apophysis of the palpal tibia in males (Fig. 35), and the non-looped spermathecae in females (Fig. 107), separate *yosemitica* from *septentrionalium*.

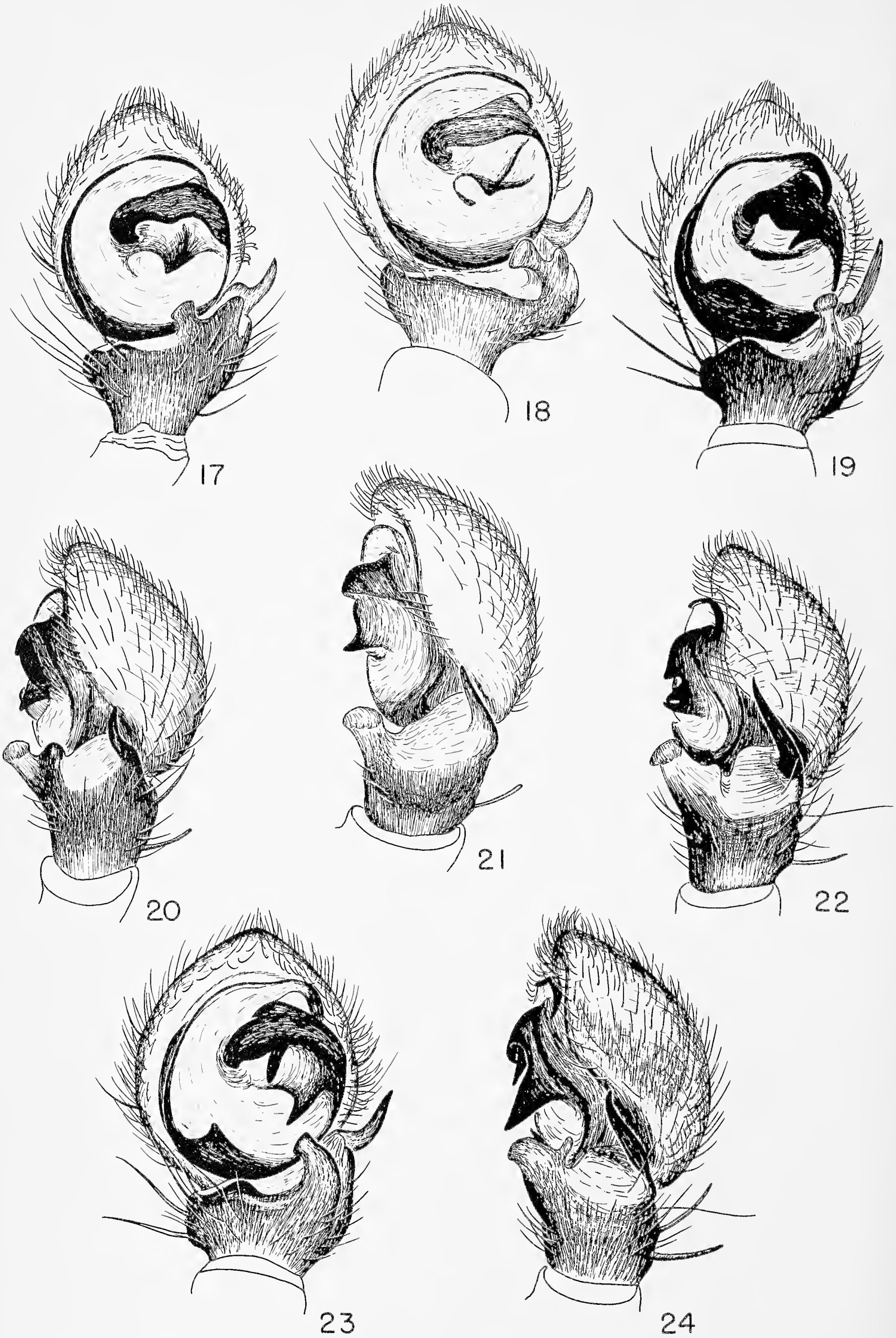
Adults of *O. yosemitica* have been collected from Berlese samples of moss, bark, and litter in a hemlock forest in Oregon.



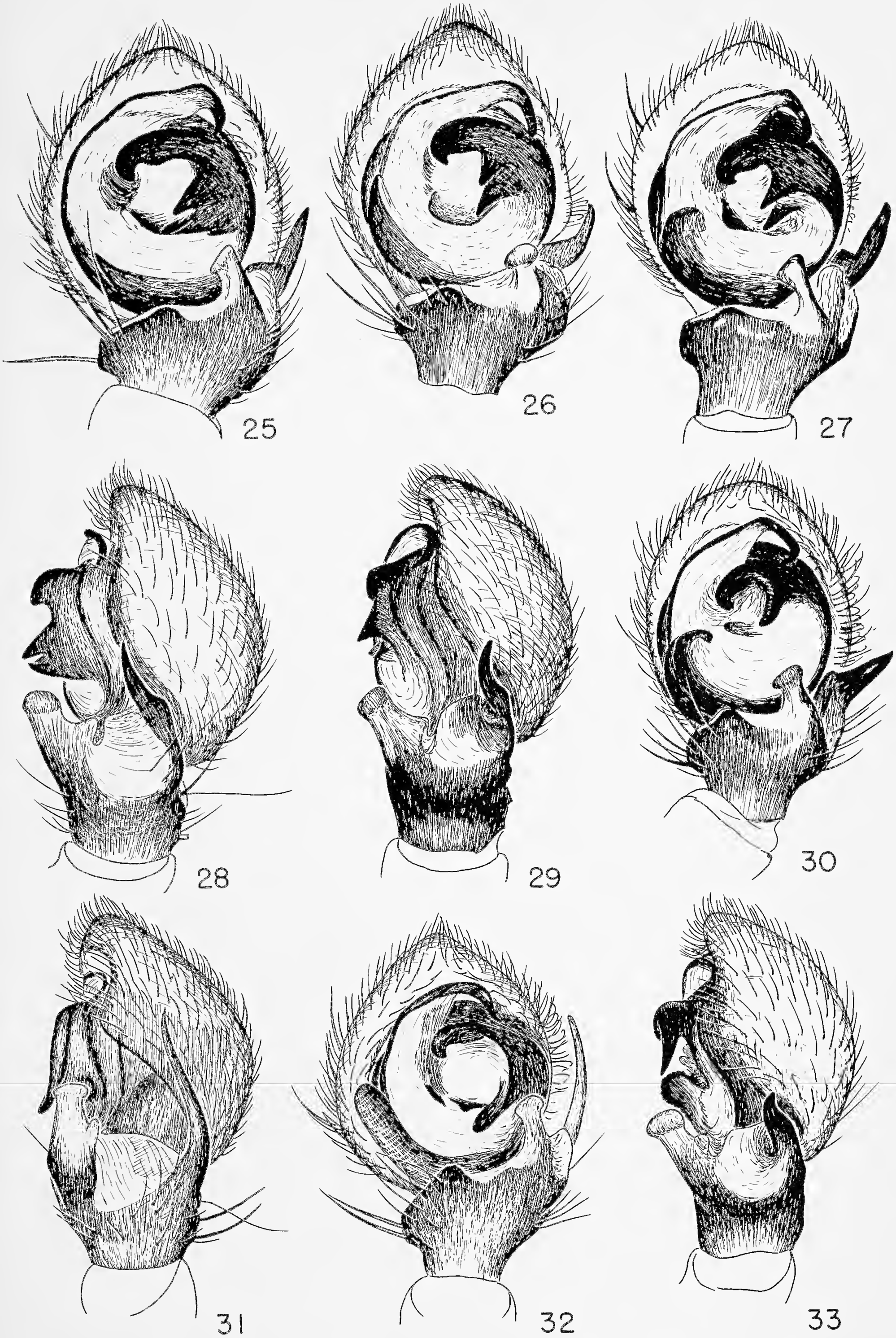
Figs. 1-8.—Male palpi of *Ozyptila* spp.: 1, 4, *O. okefinokensis* Gertsch; 2, 5, *O. imitata* Gertsch; 3, 6, *O. floridana* Banks; 7, 8, *O. modesta* (Scheffer). **emb**, embolus; **ra**, retrolateral apophysis of tibia; **va**, ventral apophysis of tibia.



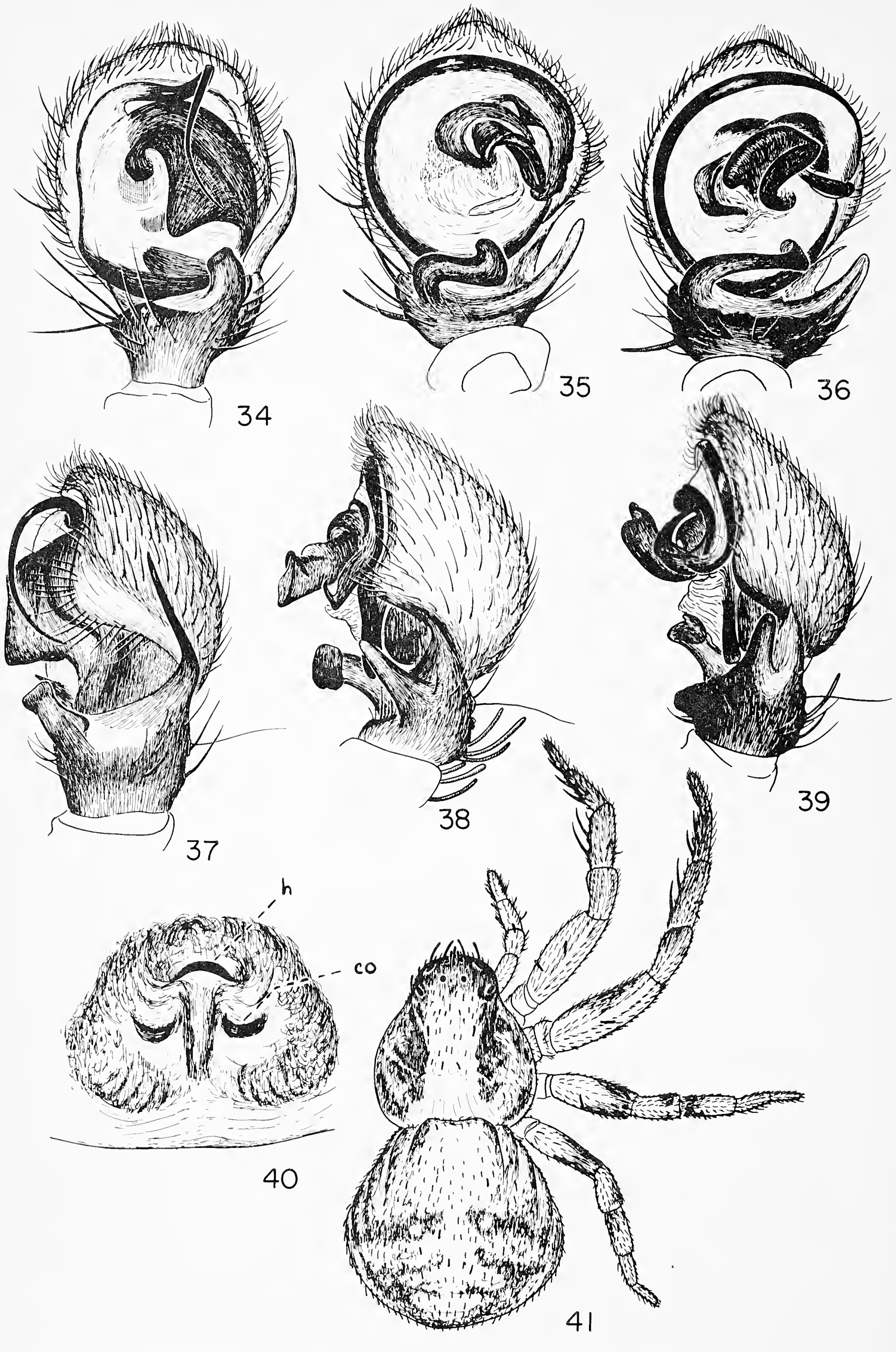
Figs. 9-16.–Male palpi of *Ozyptila* spp.: 9, 12, *O. praticola* (C. L. Koch); 10, 13, *O. gertschi* Kurata; 11, 14, *O. conspurcata* Thorell; 15, 16, *O. monroensis* Keyserling. **emb**, embolus; **btr**, basal tegular ridge; **t**, tooth of tegular apophysis.



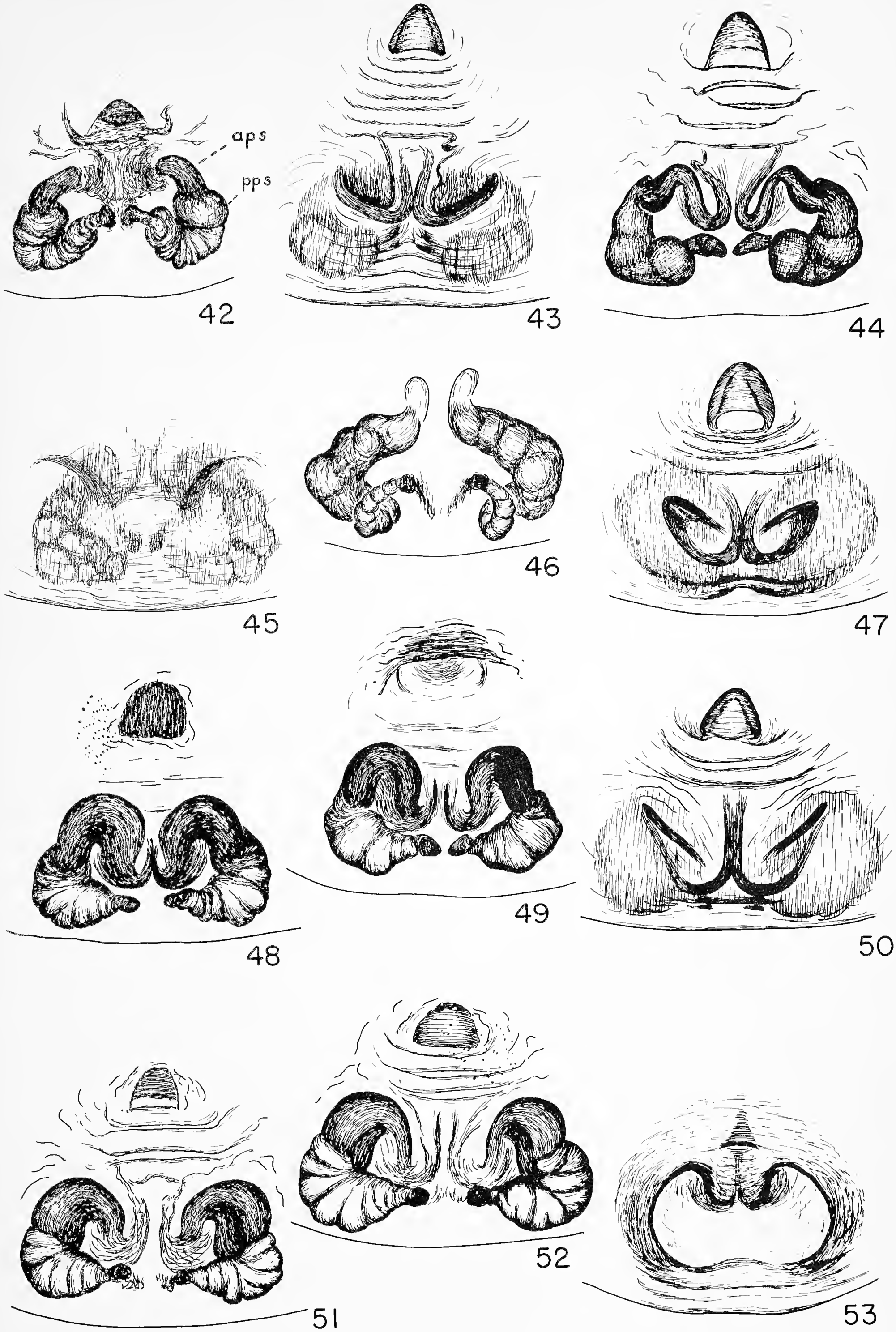
Figs. 17-24.–Male palpi of *Ozyptila* spp.: 17, 20, *O. sincera canadensis* ssp. n.; 18, 21, *O. sincera oraria* ssp. n.; 19, 22, *O. distans*, sp. n.; 23, 24, *O. pacifica* Banks.



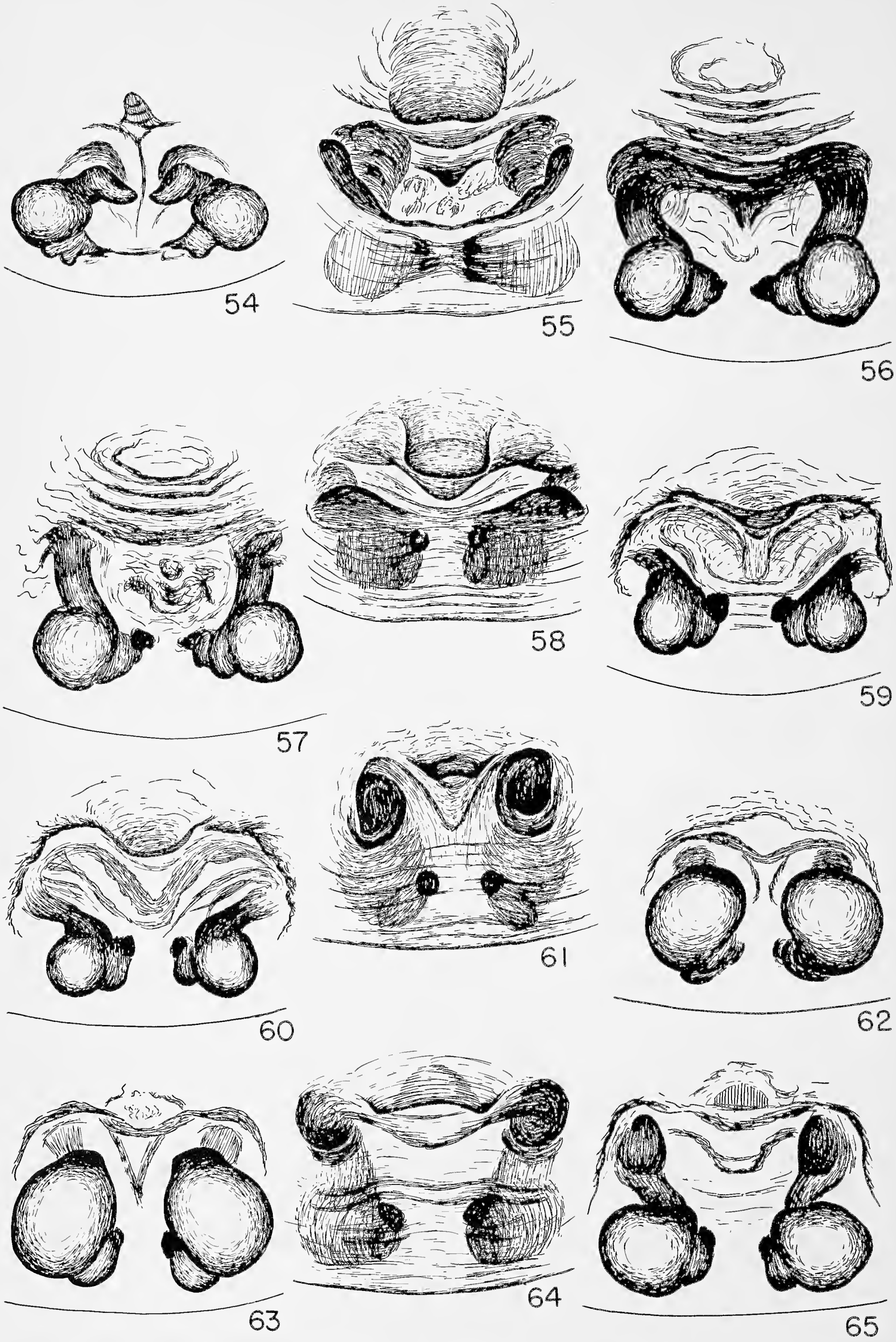
Figs. 25-33.–Male palpi of *Ozyptila* spp.: 25, 28, *O. beaufortensis* Strand; 26, 27, 29, *O. curvata* sp. n. (26, Massachusetts, 27, 29, Minnesota); 30, 33, *O. americana* Banks; 31, 32, *O. formosa* Bryant.



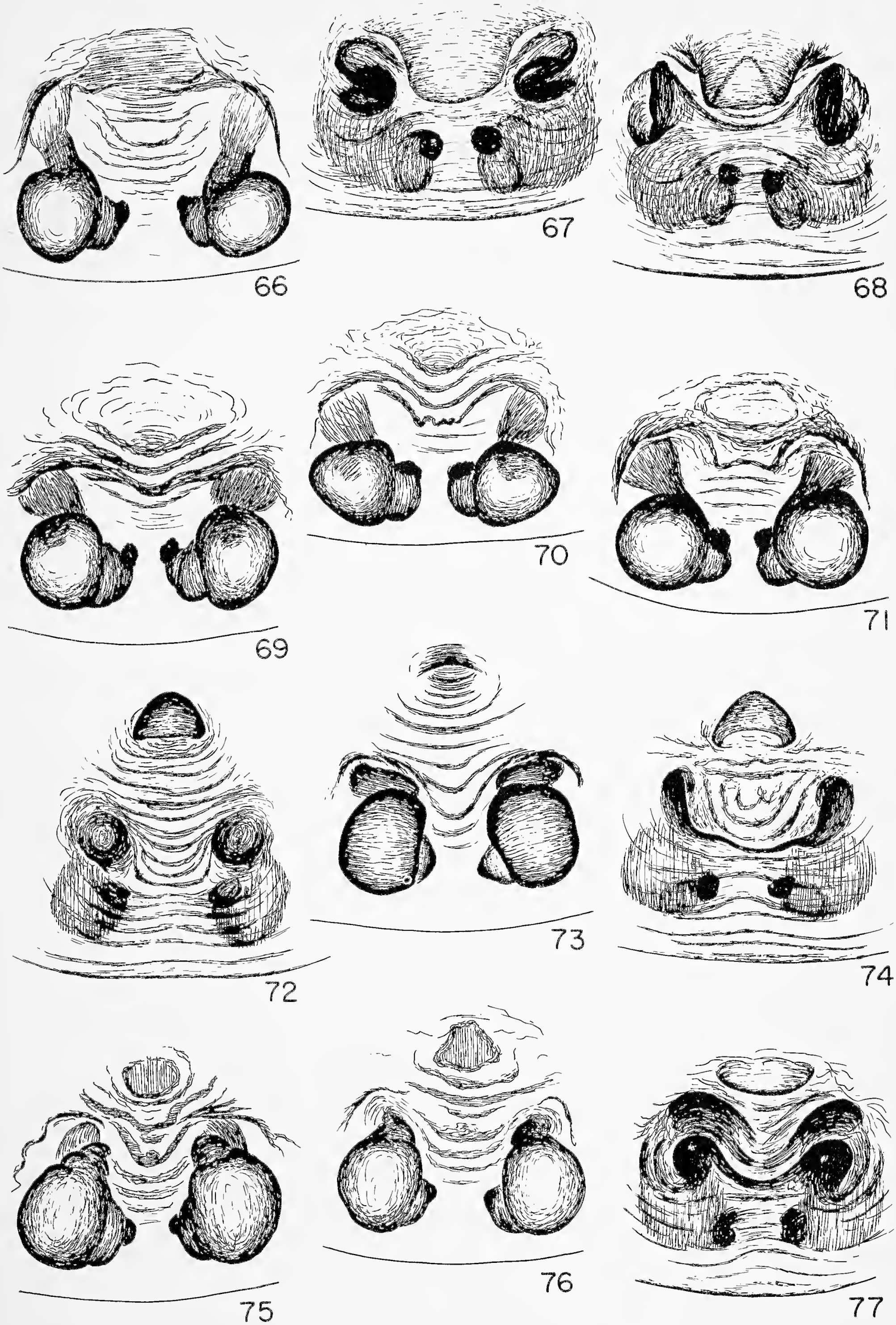
Figs. 34-39.—Male palpi of *Ozyptila* spp.: 34, 37, *O. georgiana* Keyserling; 35, 38, *O. septentrionalium* L. Koch; 36, 39, *O. yosemitica* Schick; 40, Epigynum of *O. okefinokensis* Gertsch; 41, body of *O. sincera canadensis* ssp. n. **h**, hood; co, copulatory opening.



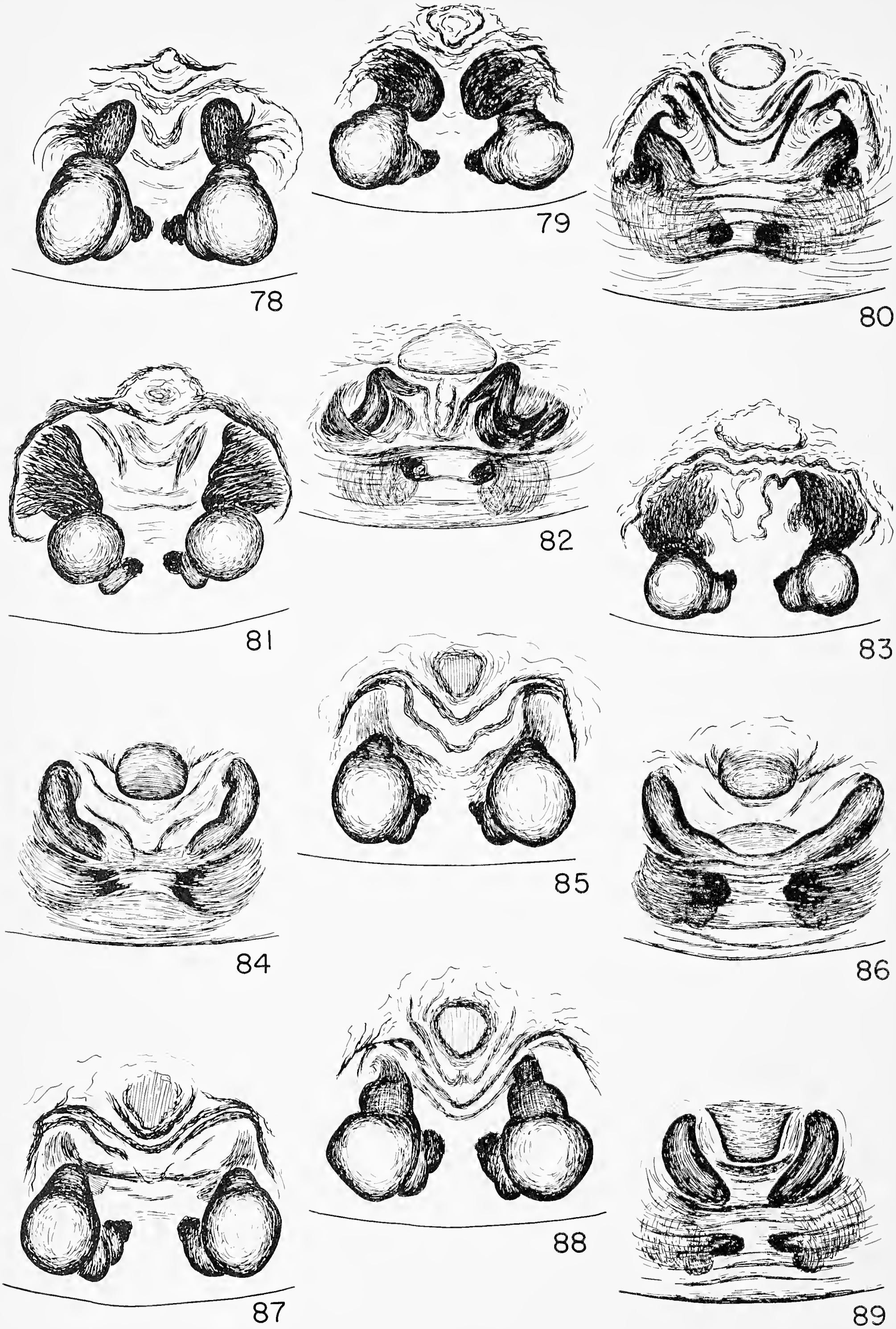
Figs. 42-53.–Epigyna and spermathecae of *Ozyptila* spp.: 42, *O. okefinokensis* Gertsch; 43, 44, *O. imitata* Gertsch; 45, 46, *O. hardyi* Gertsch; 47-49, *O. floridana* Banks (47, 48, Florida, 49, Tennessee); 50-52, *O. modesta* (Scheffer) (50, 52, Ohio, 51, Indiana); 53, *O. praticola* (C. L. Koch). **aps**, anterior part of spermatheca; **pps**, posterior part of spermatheca.



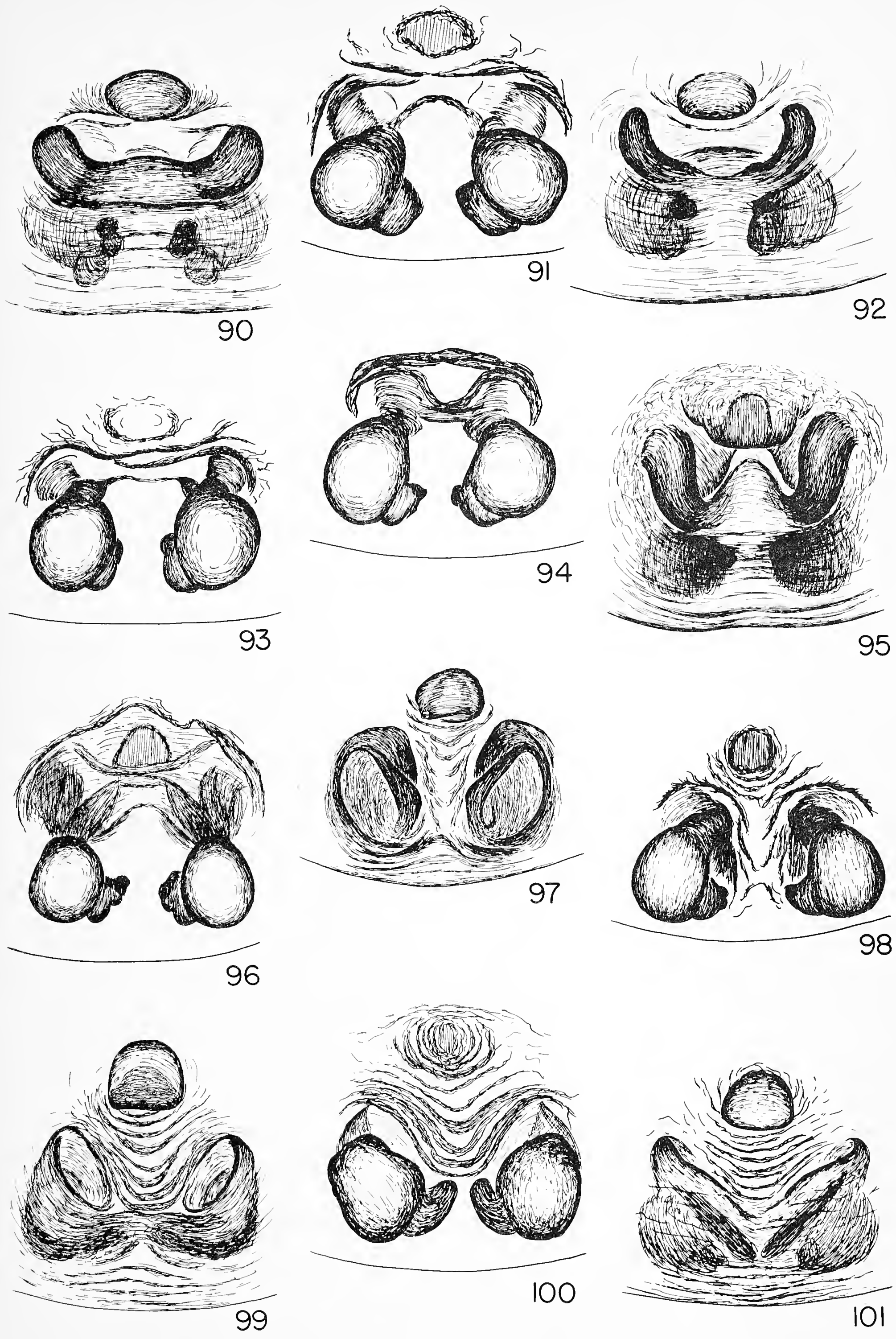
Figs. 54-65.–Epigyna and spermathecae of *Ozyptila* spp.: 54, *O. praticola* (C. L. Koch); 55-57, *O. gertschi* Kurata; 58-60, *O. conspurcata* Thorell; 61-63, *O. monroensis* Keyserling; 64, 65, *O. sincera canadensis* ssp. n.



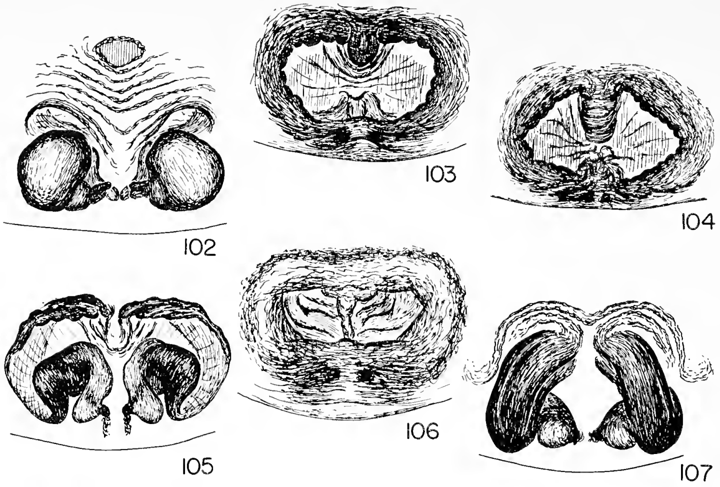
Figs. 66-77.–Epigyna and spermathecae of *Ozyptila* spp.: 66, *O. sincera canadensis* ssp. n.;67-71, *O. sincera oraria* ssp. n.; 72, 73, *O. creola* Gertsch; 74-76, *O. distans* sp. n.; 77, *O. pacifica* Banks.



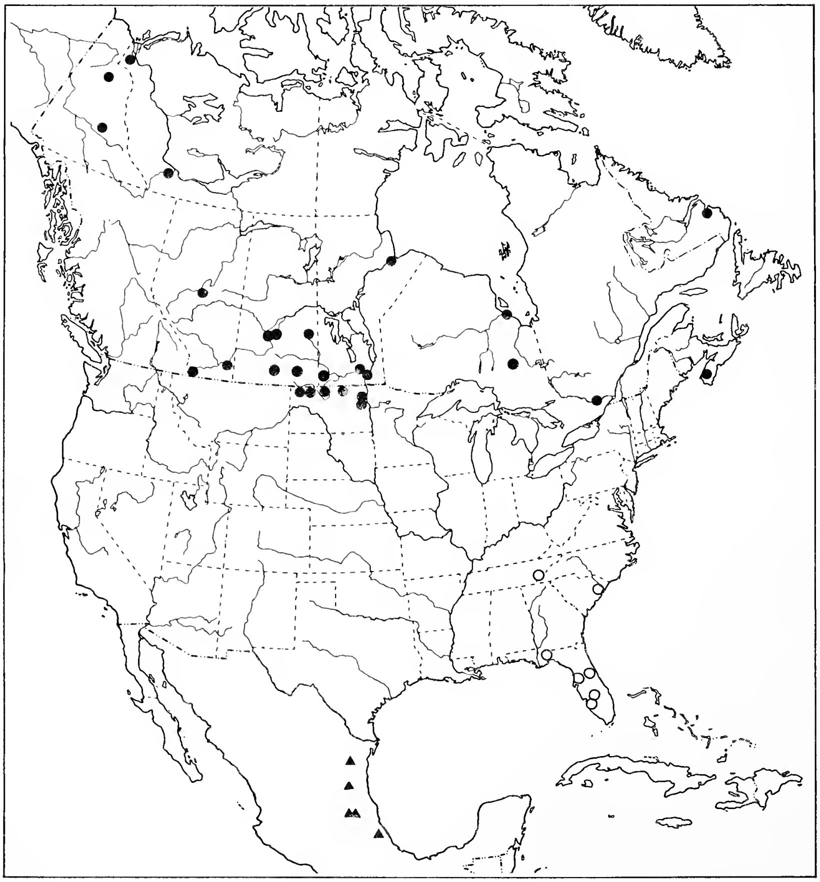
Figs. 78-89.–Epigyna and spermathecae of *Ozyptila* spp.: 78, 79, *O. pacifica* Banks; 80, 81, *O. inglesi* Schick; 82, 83, *O. trux* (Blackwall); 84-88, *O. beaufortensis* Strand; 89, *O. curvata* sp. n.



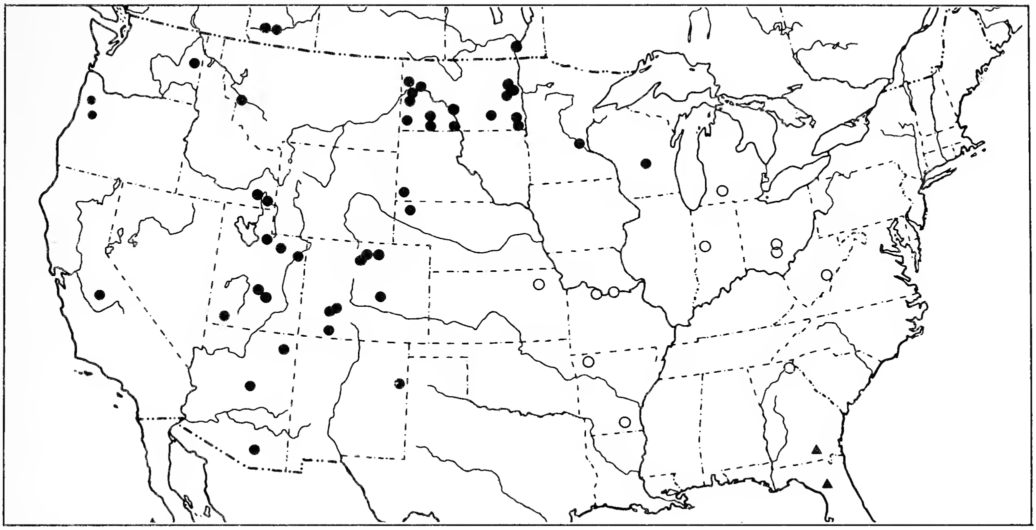
Figs. 90-101.–Epigyna and spermathecae of *Ozyptila* spp.: 90-94, *O. curvata* sp. n. (90-93, Manitoba and Minnesota, 94, Massachusetts); 95, 96, *O. americana* Banks; 97, 98, *O. formosa* Bryant; 99-101, *O. georgiana* Keyserling (99, 100, Ontario, 101, Connecticut).



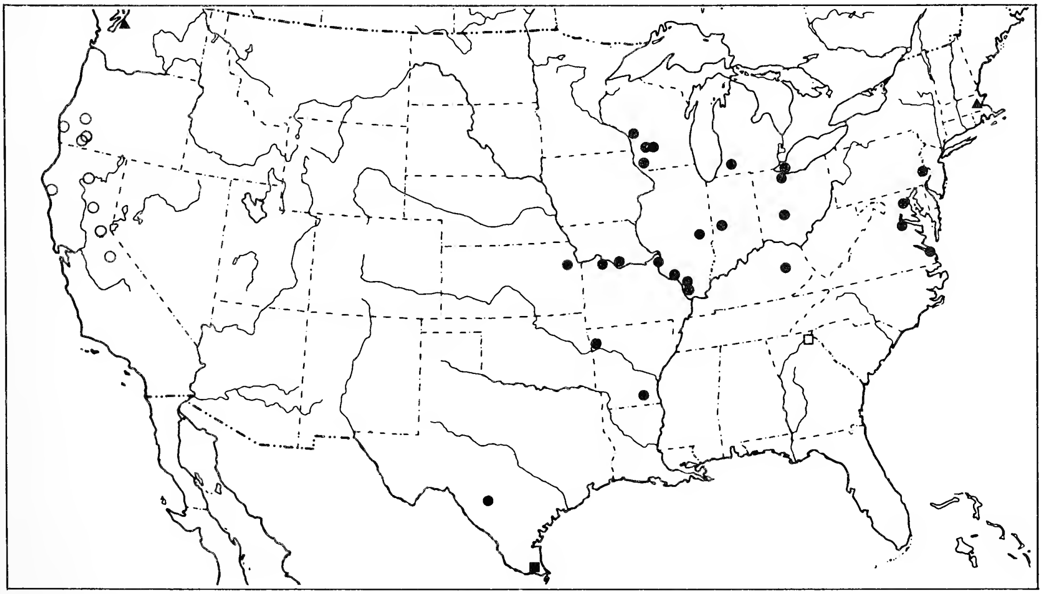
Figs. 102-107.–Epigyna and spermathecae of *Ozyptila* spp.: 102, *O. georgiana* Keyserling (Connecticut); 103-105, *O. septentrionalium* L. Koch; 106, 107, *O. yosemitica* Schick.



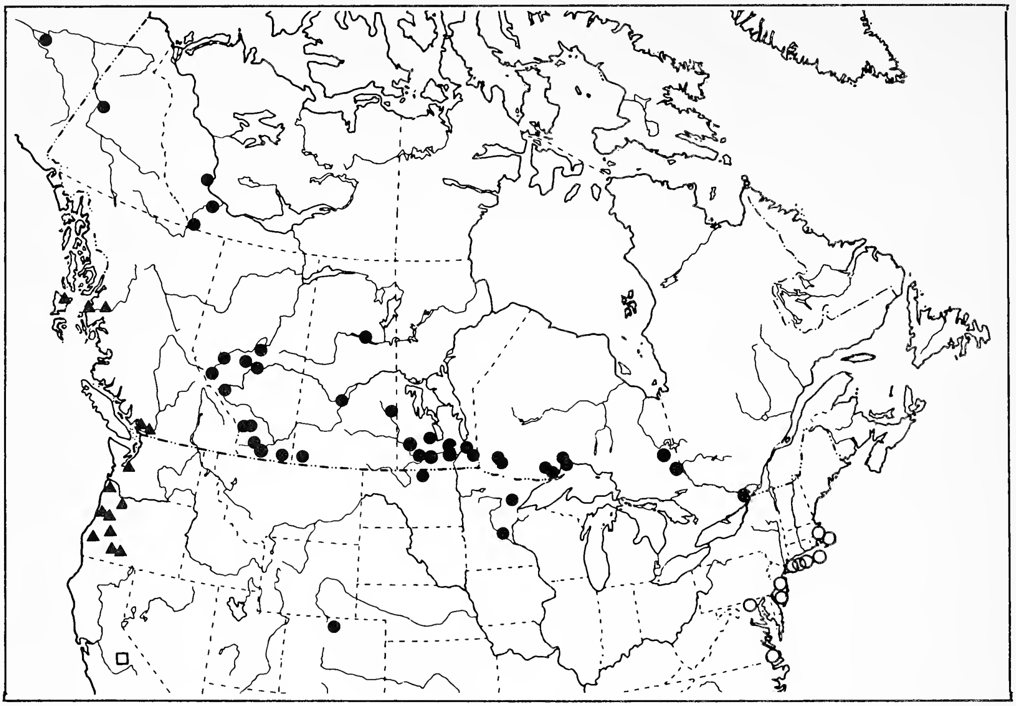
Map 1.–Collecting localities of *Ozyptila* spp.: Closed circles, *O. gertschi* Kurata; open circles, *O. floridana* Banks; triangles, *O. imitata* Gertsch.



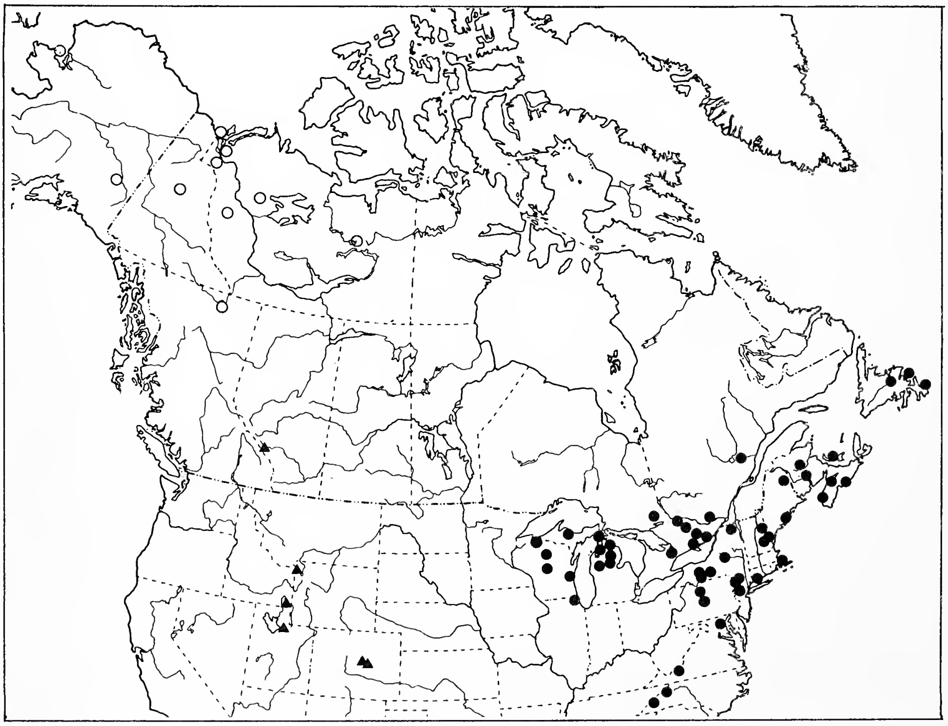
Map 2.–Collecting localities of *Ozyptila* spp.: Closed circles, *O. conspurcata* Thorell; open circles, *O. modesta* (Scheffer); triangles, *O. okefinokensis* Gertsch.



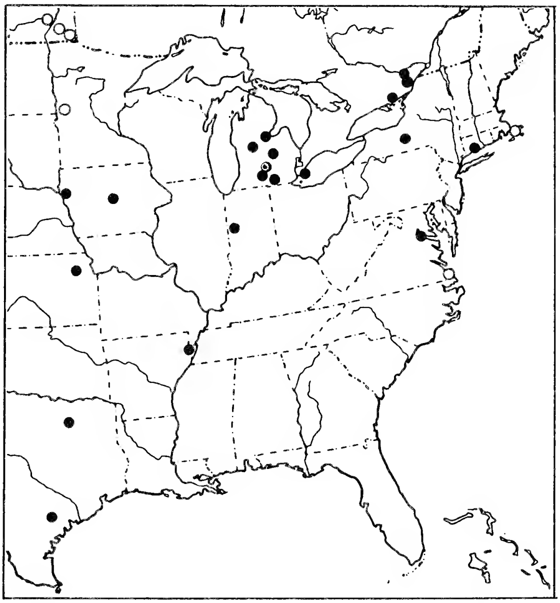
Map 3.–Collecting localities of *Ozyptila* spp.: Closed circles, *O. monroensis* Keyserling; open circles, *O. yosemitica* Schick; triangles, *O. praticola* (C. L. Koch); closed square, *O. hardyi* Gertsch; open square, *O. creola* Gertsch.



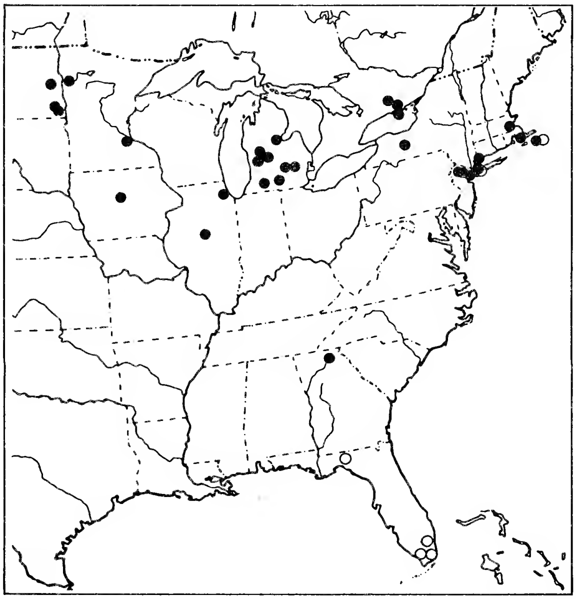
Map 4.–Collecting localities of *Ozyptila* spp.: Closed circles, *O. sincera canadensis* ssp. n.; open circles, *O. sincera oraria* ssp. n.; triangles, *O. pacifica* Banks; square, *O. inglesi* Schick.



Map 5.–Collecting localities of *Ozyptila* spp.: Closed circles, *O. distans* sp. n.; open circles, *O. septentrionalium* L. Koch; triangles, *O. beaufortensis* Strand.



Map 6.–Collecting localities of *Ozyptila* spp.: Closed circles, *O. americana* Banks; open circles, *O. curvata* sp. n.



Map 7.–Collecting localities of *Ozyptila* spp.: Closed circles, *O. georgiana* Keyserling; open circles, *O. formosa* Bryant.

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A TAXONOMIC REVISION OF THE CRAB SPIDER GENUS *CORIARACHNE* (ARANEIDA, THOMISIDAE) FOR NORTH AMERICA NORTH OF MEXICO[1]

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ABSTRACT

The four known species of the genus *Coriarachne* that occur in Canada and the United States are described and illustrated. A key to species and distribution maps are provided. *Coriarachne nakina* Gertsch 1953 is synonymized under *Coriarachne brunneipes* Banks 1893, and *Coriarachne aemula* (O. P.-Cambridge) 1898 is synonymized under *Coriarachne versicolor* Keyserling 1880.

INTRODUCTION

The purpose of this revision is to aid in the identification of spiders of the thomisid genus *Coriarachne* from Canada and the United States. To this end keys, illustrations, and descriptions are provided. Descriptions are limited to include only morphological characters that are important to species delimitation. Only important and significant literature citations are included here. For a complete bibliography biologists who are interested are referred to works by Gertsch (1939, 1953), Roewer (1954), and Bonnet (1956).

A small, but world-wide genus, *Coriarachne* is found in boreal and temperate regions. The greatest number of species are found in North America where there are four. *Coriarachne depressa* (C. L. Koch) is the only species recorded from Europe. Little is known of the Oriental fauna except for *C. fulvipes* (Karsch), which was recorded from Japan by Yaginuma (1970), and *C. nigrostriata* Simon is cited by Bonnet (1956), from Indochina.

Spiders of the genus *Coriarachne* are rather slow-moving and robust with the typical crab-like appearance characteristic of the subfamily Thomisinae. As with the rest of the subfamily, species of *Coriarachne* wait to ambush their prey rather than actively pursuing it. They are found almost exclusively on tree bark, wooden fence posts and the like where their color camouflages them. Often these spiders will congregate under loose bark, leaf litter, or similar situations to spend the winter either in the adult or penultimate stage (Jennings, 1972; Holmquist, 1926; Kaston, 1948; Lowrie, 1948).

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[1] Journal article No. 6704, Agricultural Experiment Station, Michigan State University.

This review deals primarily with species found in Canada and the United States, although it likely will also identify any species of *Coriarachne* from Mexico. All locality records included here were confirmed by examination of specimens. No records from the literature were relied upon. Common anatomical terms used can be defined by referring to Kaston (1948), Schick (1965), and Figs. 1-3. All measurements were based on at least twenty-five individuals of each sex for each species.

Genus *Coriarachne* Thorell

Coriarachne Thorell, 1870, On European spiders, N. Act. reg. Soc. Sci. Uppsala (3)7:186. Type species: *C. depressa* (C. L. Koch), designated by Thorell, 1870.

Coriarachne, Gertsch, 1939, Bull. Amer. Mus. Nat. Hist. 76:277.

Bassania P.-Cambridge, O., 1898, Biol. Cent.-Amer., Arachnida, Araneida, 1:249. (preoc.) Type species: *B. aemula* P.-Cambridge, O., designated by O. P.-Cambridge, 1898.

Bassaniana Strand, 1928, Miscellanea nomenclatorica et palaeontologica, I-II, Arch. Naturg. 92A(8):30. (n. Nov.)

Platyxysticus Gertsch, 1932, Amer. Mus. Novit. 563:1. Type species: *C. versicolor* Keyserling, designated by Gertsch, 1932.

Description—Carapace as broad or slightly broader than long, strongly flattened, clothed with long thin setae or shorter filiform to subspatulate setae; cephalic sutures very obvious; front vertical and very low; color, mottled with yellow, white, dark brown, and russet. Eyes: anterior eye row straight to modestly recurved when viewed from front; posterior eye row more strongly recurved when viewed from above; median ocular area (MOA) as broad as or slightly broader than long; lateral eyes larger than medians; posterior median eyes (PME) closer to anterior lateral eyes (ALE) than posterior lateral eyes (PLE); lateral eye tubercles discrete, not confluent.

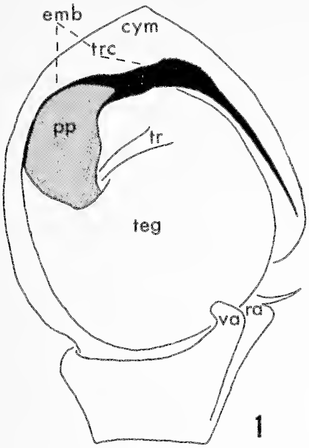
Legs: color similar to carapace; terminal segments lighter than basal segments; legs I and II subequal; III and IV also subequal; moderately stout, more robust in females than males.

Abdomen: colored like cephalothorax but usually lighter in overall appearance; white patches may form indistinct transerve bands. Abdominal sulci, a pair of elongate grooves or with two or three pairs of shallow pits; venter lightly mottled, overall a dirty white.

Male palpus: tibia broader than long, with strongly developed ventral and retrolateral apophyses; retrolateral apophysis often with a terminal spur; cymbium about as broad as long; tegulum either circular or slightly longer than broad; tegular surface smooth except for a small tegular ridge; embolus with pars pendula broad basally, narrowing apically; truncus usually evenly arched, sometimes terminating in a short spiral.

Epigynum: atrium indistinct; septum subtriangular to parallel sided; spermathecae somewhat kidney-shaped with numerous folds and occasionally scattered pits; copulatory tubes variable in length.

⇨ Figs. 1-9.—Species of *Coriarachne*: 1, male palp: cym, cymbium; emb, embolus; pp, pars pendula; ra, retrolateral apophysis; teg, tegulum; tr, tegular ridge; trc, truncus; va, ventral apophysis; 2, female epigynum: ms, median septum; 3, internal view of epigynum: spr, spermathecae; ct, copulatory tubes; 4, *C. floridana* Banks, male palp, ventral view; 5, *C. brunneipes* Banks, male palp, ventral view; 6, *C. versicolor* Keyserling (lectotype), male palp, ventral view; 7, *C. versicolor* Keyserling, male palp, ventral view; 8, *C. utahensis* (Gertsch), male palp, ventral view; 9, *C. versicolor* X *utahensis*, male palp, ventral view.



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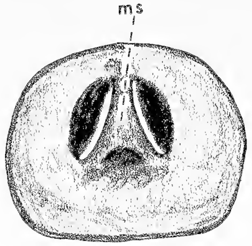

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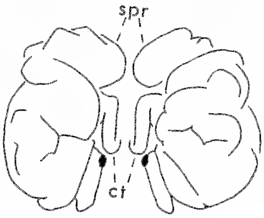

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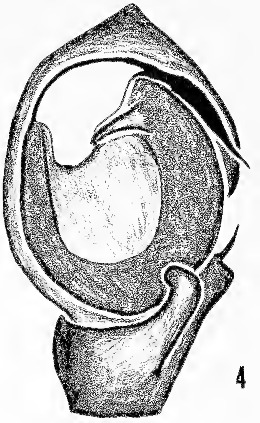

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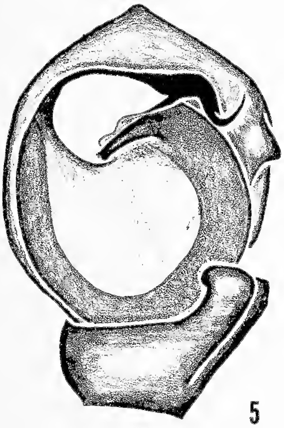

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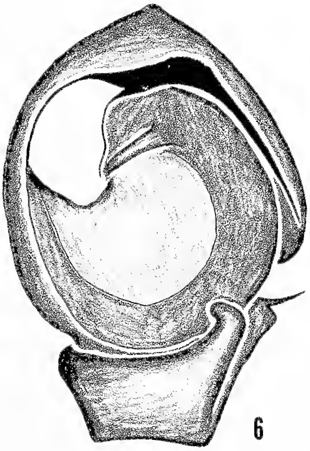

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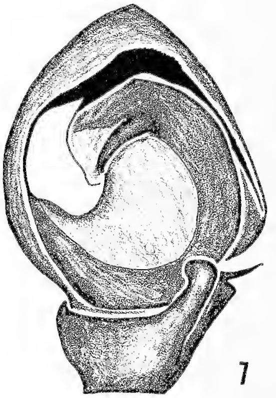

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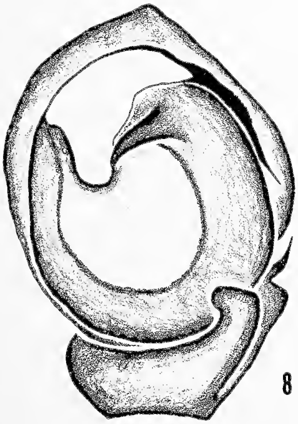

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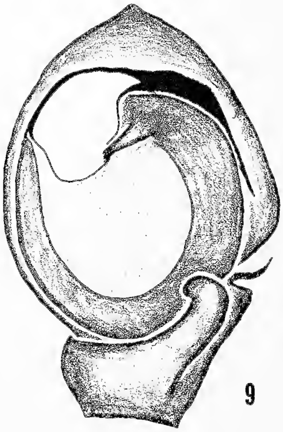

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Diagnosis and comments—*Coriarachne* can be separated from all other North American thomisid genera by the accentuated flatness of the carapace and by the anterior eye row being either straight or slightly recurved.

Of the nine genera of the subfamily Thomisinae in Canada and the United States, the discrete lateral eye tubercles of *Coriarachne* separate if from *Misumena*, *Misumenoides*, and *Misumenops*. *Tmarus* has a distinctive abdominal protuberance and a sloping front. Both *Synema* and *Diaea* have rather shiny and very convex carapaces. In addition, they are usually more brightly colored. *Xysticus* and *Ozyptila* are the genera most similar to *Coriarachne*. However, these groups are readily separated by the arched condition of the carapace as it is much flatter in *Coriarachne*. Also *Xysticus* nearly always has a pale median band on the carapace which is lacking in *Coriarachne*.

The structure of the genitalia and accessory organs has proven to be important in the separation of species. In males the terminal segment of the pedipalp serves as an intromittant organ and nearly always has a characteristic structure for each species. The length and shape of the embolus is of primary importance. In *brunneipes*, for example, the embolus is short and spiral-shaped at the apex, while in *versicolor* it is long and relatively straight. In previous works (Gertsch, 1939, 1953), the shape of the septum has been used to separate the females. However, because of its variability, this character has been found to be unreliable, except for *brunneipes* in which the broad and parallel-sided septum is easily recognized. In other species, the length of the copulatory tubes is a much more consistent character.

KEY TO NORTH AMERICAN SPECIES OF *CORIARACHNE* THORELL

1a. Carapace extremely flat, anterior eye row straight, abdominal sulci a pair of elongate grooves, setae setaform, genitalia as in Figs. 5, 16, and 17 .... *brunneipes*
1b. Carapace not so flattened, anterior eye row at least slightly recurved, abdominal sulci two or three pairs of pits, setae not setaform 2

2a(1b). Anterior eye row definitely recurved, anterior legs quite mottled in both sexes, maculations on posterior declivity of female carapace usually well separated, setae on female carapace coarse but not subspatulate, carapace slightly convex 3
2b. Anterior eye row weakly recurved, anterior legs of male only slightly mottled, maculations on posterior declivity of female carapace contiguous or nearly so, setae on female carapace subspatulate, genitalia as in Figs. 4, 10 and 13.......... *floridana*

3a(2a). Embolus short, copulatory tubes short, slightly visible if at all between spermathecae (Figs. 8, 12, 15 and 18) .... *utahensis*
3b. Embolus long, copulatory tubes long and easily visible between spermathecae (Figs. 6, 7, 19, 20, 21) .... *versicolor*

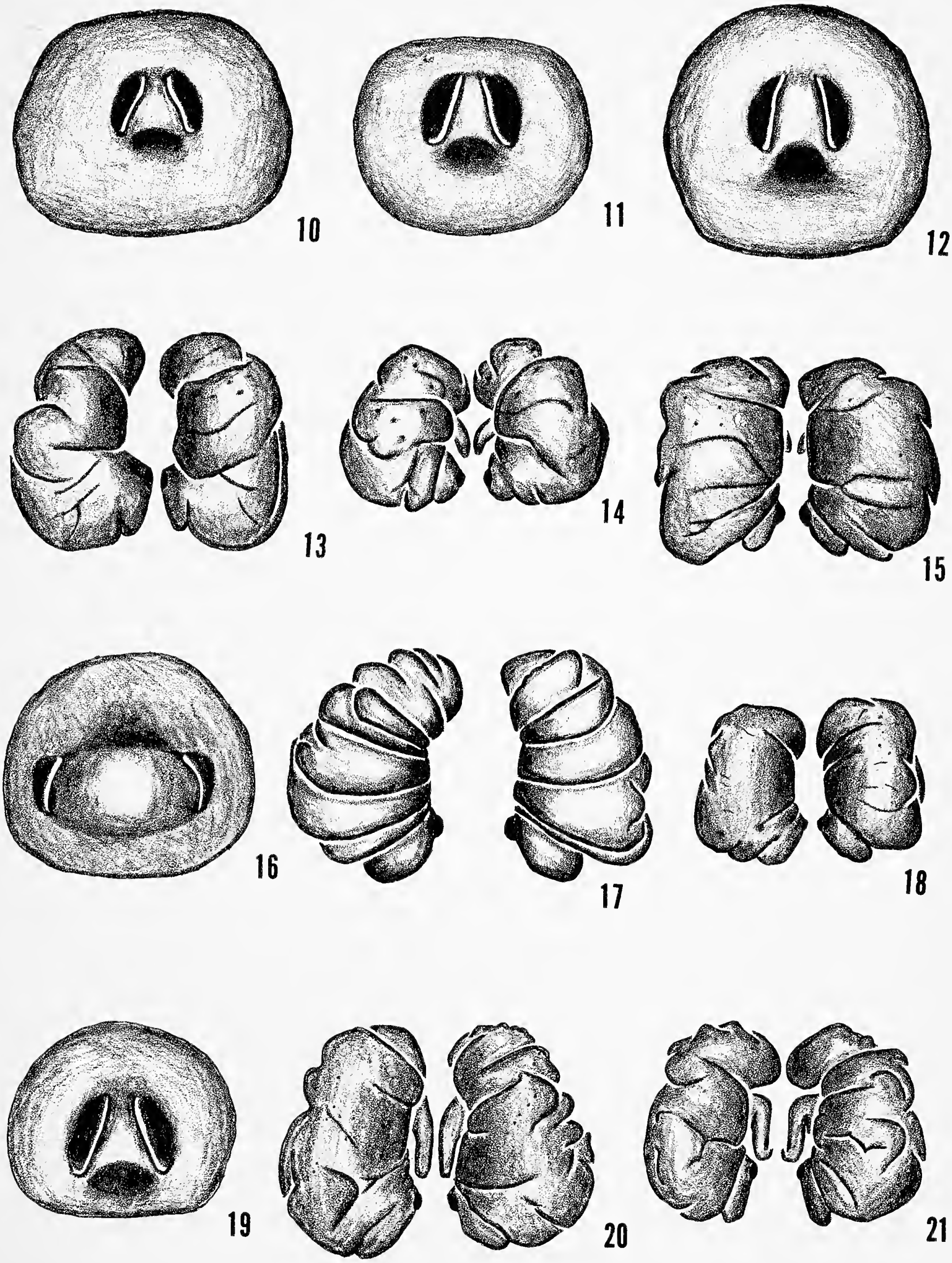
Coriarachne brunneipes Banks

Coriarachne brunneipes Banks, 1893, Jour. N.Y. Ent. Soc. 1:133. Gertsch, 1939, Bull. Amer. Mus. Nat. Hist. 86:410, Figs. 258, 259, 271; 1953, Bull. Amer. Mus. Nat. Hist. 102:461, Figs. 74-76. Roewer, 1954, Katalog der Araneae 2 (Pt. 2):832. Bonnet

1956, Bibliographia Araneorum 2 (Pt. 2):1204. Schick, 1965, Bull. Amer. Mus. Nat. Hist. 129:171, Figs. 253-255.

Platyxysticus brunneipes, Gertsch, 1933, Amer. Mus. Novit. 563:2, Fig. 4.

Coriarachne nakina Gertsch, 1953, Bull. Amer. Mus. Nat. Hist. 102:462, Figs. 69-72. NEW SYNONYM.



Figs. 10-21.–Female epigyna, internal and external views: 10 and 13, *C. floridana* Banks; 11 and 14, *C. versicolor* X *utahensis*; 12, 15 and 18, *C. utahensis* (Gertsch); 16 and 17, *C. brunneipes* Banks; 19 (lectotype), 20 (lectotype) and 21, *C. versicolor* Keyserling.

Type—Male and female syntypes of *C. brunneipes* from Olympia, Washington in Museum of Comparative Zoology, examined. Types of *nakina* are deposited in the Royal Ontario Museum and are from the following locations: male holotype, Attawapiskat, Ontario; female allotype, Nakina, Ontario; female paratypes, Lake Abitibi, Ontario; all were examined.

Male—Total length, 3.83-6.33 mm, mean 5.25 mm: cephalothorax length, 2.00-3.08 mm, mean 2.47 mm; width, 1.92-3.00 mm, mean 2.45. Carapace extremely flat, clothed with long setaform spines, uniform dark reddish brown occasionally broken by a dull yellow or white patch. Anterior eye row straight or very slightly recurved. Legs concolorous with carapace, distal segments lighter than basal segments. Dorsum of abdomen mottled with brown, black, yellow, and white. Sulci an elongate pair of grooves. Venter like dorsum only lighter. Palp as in Fig. 5.

Female—Total length, 6.25-11.17 mm, mean, 8.24 mm; cephalothorax length, 2.32-4.08 mm, mean 3.25 mm; width, 2.36-4.04 mm, mean 3.37 mm. Coloration similar to male, sightly lighter overall. Epigynum as in Figs. 16, 17.

Range—Western United States from Rocky Mountains to Pacific coast, in Canada from British Columbia eastward to northern Ontario (see Map 1).

Localities—*Ontario*: Lake Abitibi; Nakina; Attawapiskat. *Manitoba*: Telford; Picnic Bog. *Alberta*: Banff. *Mackenzie*: Fort Smith. *British Columbia*: Burnaby Island; Queen Charlotte Island; Langford; Terrace; Victoria, Vancouver Island; Williamshead. *Washington*: Island Co.; King Co; San Juan Co.; Snohomish Co.; Mason Co.; Thurston Co.; Yakima Co.; Cottage Lake; Tomino. *Oregon*: Josephine Co.; Lane Co.; Multnomah Co.; Polk Co.; Douglas Co.; Benton Co; Deschutes Co.; Jackson Co.; Columbia Co.; Yamhill Co.; Klamath Co.; Marion Co.; Wheeler Co.; Clackamas Co. *California*: Sonoma Co.; Siskiyou Co.; Santa Cruz Col; Mono Co.; Eldorado Co.; Yosemite National Park. *Colorado*: Gunnison Co.; El Paso Co. *Idaho*: Bear Lake Co. *Wyoming*: Yellowstone National Park; Sublette Co. *Nevada*: Elko Co.; Clark Co.; Charleston Mtns. *Arizona*: White Mtns. *Alaska*: Haines.

Diagnosis and comments—*Coriarachne brunneipes* is easily distinguished from the other species by its relatively uniform color and extremely flattened carapace. Also characteristic of this species is the semi-coiled appearance of the embolus of the male and the extremely wide septum of the female. Both of these characters show similarity to the European species *C. depressa.*

Gertsch (1953) described specimens from Ontario as *C. nakina* based almost entirely on the slightly longer than broad carapace as opposed to *brunneipes* which is slightly broader than long. He also mentions small differences in the male palp. Subsequent examination has shown these characters to vary and appear in specimens of *brunneipes* throughout the range of the species. In addition, *brunneipes* is now known to range eastward to Ontario. For these reasons *C. nakina* Gertsch 1953 is synonymized under *C. brunneipes* Banks 1893.

Coriarachne floridana Banks

Coriarachne floridana Banks, 1896, Trans. Amer. Ent. Soc. 23:71. Gertsch, 1939, Bull Amer. Mus. 76:409, Figs. 256, 257, 270; 1953, Bull. Amer. Mus. 102:461, Figs. 65, 66. Roewer, 1954, Katalog der Araneae 2 (Pt. 2):832. Bonnet, 1956, Bibliographia Araneorum 2, (Pt. 2):1206.

Platyxysticus floridana, Gertsch, 1932, Amer. Mus. Novit. 563:2. Fig. 3.

Type–Male and female syntypes from Punta Gorda, Florida in the Museum of Comparative Zoology, examined.

Male–Total length, 3.42-5.25 mm, mean, 4.48 mm: cephalothorax length, 1.64-2.64 mm, mean, 2.26 mm; width, 1.72-3.00 mm, mean, 2.53 mm. Carapace mottled with brown, yellow, and white; anterior eye row very weakly recurved, posterior eye row more strongly recurved. Legs same color as carapace with an evenly tawny-colored stripe on the ventral surface. Abdomen with irregular maculations of dark brown, yellow, and white. White maculations may appear as irregular transverse bands. Venter of same color but more diffuse pattern. Palp as in Fig. 4.

Female–Total length, 4.92-7.92 mm, mean 6.19 mm: cephalothorax length, 2.20-3.16 mm, mean, 2.71 mm; width, 2.56-3.48 mm, mean, 3.00 mm. Overall similar to male's general color through somewhat lighter; posterior declivity of carapace with two contiguous, or nearly so, brown maculations; spines on carapace subspatulate. Abdomen with a more diffuse pattern than male. Epigynum as in Figs. 10, 13.

Range–Southeastern United States extending northward into New England and southern Ohio (see Map 1).

Localities–*Florida*: Liberty Co.; Alachua Co.; Baker Co.; Leon Co.; Marion Co.; Duval Co.; Pinelas Co.; Highlands Co.; Polk Co.; Charlotte Co. *Georgia*: Daugherty Co.; Baker Co.; Thomas Co.; Clark Co.; Bartow Co.; Charlton Co.; Mitchell Co.; Thompson's Mill; Oconee Forest. *Alabama*: Lee Co.; Shelby Co. *Texas*: Sabine Co. *Arkansas*: Calhoun Co.; Grant Co.; Ashley Co. *Mississippi*: Greene Co. *Louisiana*: Caddo Parrish. *South Carolina*: Pickens Co.; Abbeville Co. *Virginia*: Giles Co.; Fall's Church. *Maryland*: Prince Co. *New Jersey*: Ocean Co.; Suffolk Co.; Nassau Co. *Ohio*: Hocking Co.; Franklin Co.

Diagnosis and comments–The brown stripe on the ventral surface of the legs and the nearly straight anterior eye row along with the subspatulate spines and contiguous maculations on the carapace of the female serve to separate *floridana* from other North American species.

This is an interesting species in that although it differs quite obviously from *utahensis* in appearance, the structure of the epygina of the two species is virtually identical.

Coriarachne versicolor Keyserling

Coriarachne versicolor Keyserling, 1880, Die Spinnen Amerikas, Laterigradae, 1:53, Pl. 1, Fig. 27. Gertsch, 1939, Bull. Amer. Mus. Nat. Hist. 76:405, Figs. 254, 255, 269. Gertsch, 1953, Bull. Amer. Mus. Nat. Hist. 102:458, Figs. 60, 61 and 64. Roewer, 1954, Katalog der Araneae, 2 (Pt. 2):1206. *Xysticus versicolor*, Simon, 1895, Histoire naturelle des Araignees, 1(2):1035.

Bassania aemula P.-Cambridge, O., 1898, Biol. Cent.-Amer., Arachnida, Araneida, 1:249, Pl. 31, Figs. 5, 5a-5f. NEW SYNONYM.

Bassaniana aemula, Strand, 1928, Arch. Naturg. 92A(8):30.

Platyxystucys utahensis Gertsch, 1932, Amer. Mus. Novit. 563:3 (in part: paratypes from Zion Nat'l. Park; not holotype). NEW SYNONYM.

Platyxysticus versicolor, Gertsch, 1932, Amer. Mus. Novit. 563:3. Fig. 1.

Xysticus banksi Gertsch, as used by Chickering and Bacorn, 1933, Papers Mich. Acad. Arts, Sci. and Letters, 17:523.

Coriarachne lenta Chamberlin and Ivie, 1944, Bull. Univ. Utah Biol. serv., 8(5):156. NOMEN DUBIUM.

Coriarachne aemula, Gertsch, 1953, Bull. Amer. Mus. 102:459, Figs. 67, 68.

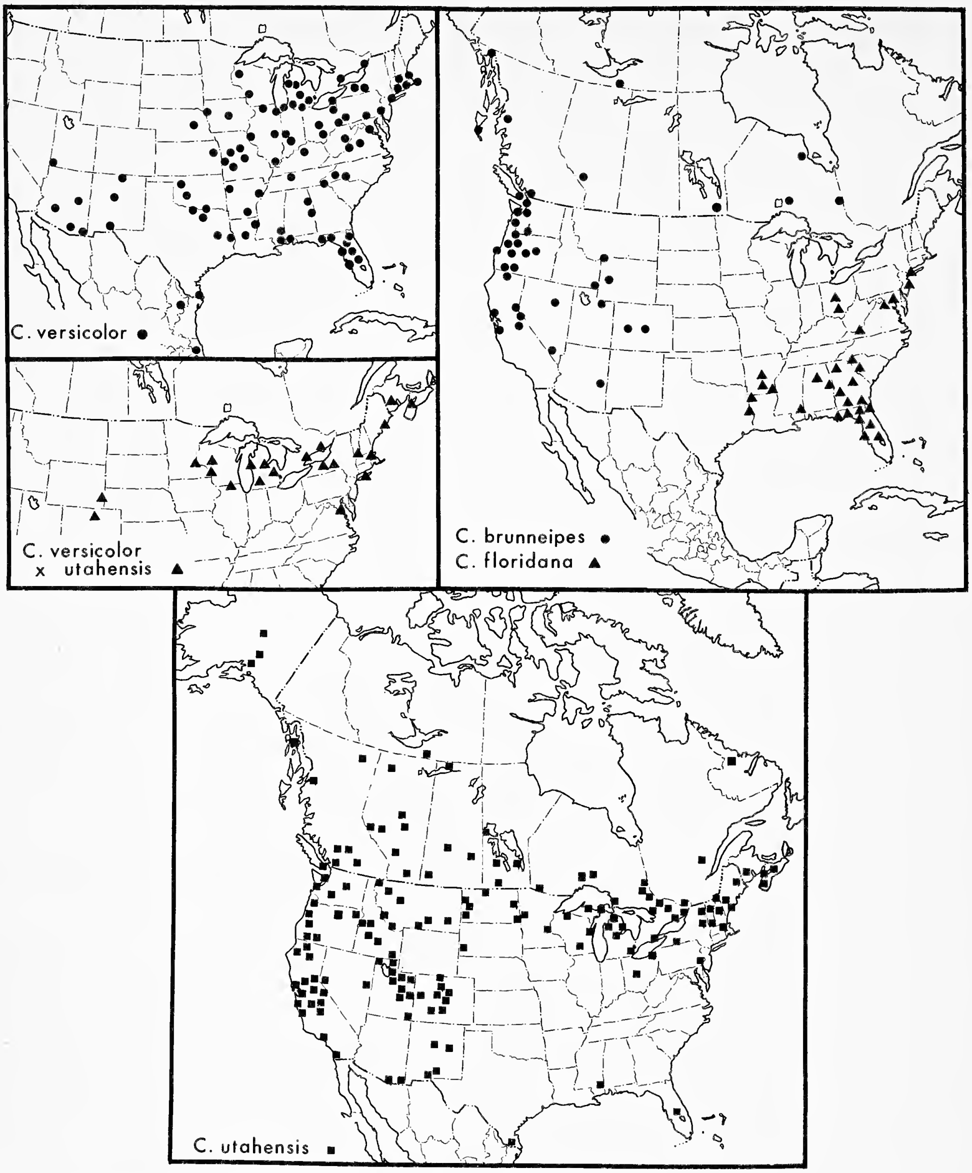


Fig. 22.–Distribution of *Coriarachne spp.* in North America north of Mexico.

Type–Syntypes of *C. versicolor* from Mariposa, California; Boston, Massachusetts; Peoria, Illinois; and Georgia. Syntypes from Georgia in British Museum of Natural History, others in Museum National d'Histoire Naturelle of Paris. Lectotype and paralectotypes are designated here by the authors from Keyserling's syntypes from Georgia deposited in the British Museum of Natural History. This designation was made since from the Georgia material alone there were three different species, all called *vesicolor* by Keyserling. Female type of *aemula* from Orizaba, Veracruz, Mexico was reported by Gertsch (1953) to be in the British Museum of Natural History. Communication with the curator, Mr. Keith Hyatt, reveals it is no longer there and presumably lost.

Male–Total length, 3.92-5.75mm, mean 4.72 mm: cephalothorax length, 2.04-2.96 mm, mean, 2.35 mm; width, 2.20-3.00 mm, mean, 2.49 mm. Carapace similar to that of *floridana* in color, more convex, anterior eye row definitely recurved. Setae filiform. Legs mottled around entire circumference. Abdomen as in *floridana*. Palp as in Figs. 6, 7.

Female–Total length, 4.42-7.67 mm, mean, 5.77 mm: cephalothorax length, 3.24-3.92 mm, mean, 3.52 mm; width, 2.32-3.24 mm, mean 2.67 mm. Overall similar to male, though somewhat lighter, mottling more diffuse on carapace and abdomen. Epigynum as in Figs. 19, 20, 21.

Range–Eastern United States and southern Ontario westward to the Rocky Mountains, in the Southwest as far as western Arizona also extending into eastern Mexico at least as far as Orizaba, Veracruz (see Map 1).

Diagnosis and comments–*C. versicolor* and the following species, *utahensis*, are very similar with respect to coloration and spination. However, *versicolor* males have a longer embolus than their *utahensis* counterparts as a comparison of Figs. 6, 7 with Fig. 8 will show. It should be noted that in addition to the sclerotized truncus varying in length between the two species, the length and position of the pars pendula also varies. In *versicolor* it extends from 260°-270° to 340°-350°, whereas in *utahensis* it extends from 270°-280° to 360°-380°.

Females can be separated by the length of the copulatory tubes. In *versicolor* the tubes are well exposed and long (Figs. 20, 21). *C. utahensis* has much shorter copulatory tubes which are not visible or only slightly so. A second character that sometimes is of some value is the width of the septum, it being typically wider in *utahensis* than in *versicolor*. This is not completely reliable, however, and can lead to misidentification as was the case with Gertsch (1932). Specimens he used as paratypes of *utahensis* from Zion National Park indeed looked similar to the typical septum of *utahensis*. Examination of the spermathecae and copulatory tubes showed, however, that these spiders were actually *versicolor.*

Gertsch (1953) was the first to realize that *Bassania* O. P.-Cambridge was a synonym of *Coriarachne*. At the time, he left the single species of the genus, *aemula*, as a valid species of *Coriarachne*. As was mentioned earlier, the type of *aemula*, a female, could not be located. Therefore, specimens from Mexico determined by Gertsch as *aemula* and figures by O. P.-Cambridge (1898) were relied upon for characters to compare with *versicolor*. Examination of these representatives showed no consistent differences between the two species. Consequently, *aemula* is treated here as a synonym of *versicolor.*

The male associated with *aemula* is described by Gertsch (1953) as being quite similar to *utahensis*, differing only on the angle of the spur on the retrolateral apophysis of the palp. This character has been found to be quite unreliable. Therefore, the placement of this male must be regarded to be in error and actually represents an extension of the range of *utahensis.*

There has been a recurring problem of nomenclature associated with *versicolor*. Occasionally in the literature one finds *C. lenta* (Walckenaer) as a senior synonym of *versicolor*. The description of *Coriarachne lenta*, (Walckenaer), like many of Walckenaer's, was based on drawings of spiders from Georgia by John Abbot. In personal communication, Dr. C. D. Dondale advises that neither Abbot's drawings nor Walckenaer's description is clear enough to tell what species is being dealt with - *versi color*, *utahensis*, or *floridana*. In fact it may not even be *Coriarachne*. For this reason *Coriarachne lenta* (Walckenaer) must be regarded as a nomen dubium.

Coriarachne utahensis (Gertsch)

Platyxysticus utahensis Gertsch, 1932, Amer. Mus. Novit. 563:5, Fig. 2. (in part: not paratypes from Zion Natl. Park).

Coriarachne utahensis, Gertsch, 1939, Bull Amer. Mus. Nat. Hist. 76:408. Gertsch, 1953, Bull. Amer. Mus. 102:460, Figs. 62, 63. Roewer, 1954, Katalog der Araneae, 2 (Pt. 2):833. Bonnet, 1956, Bibliographia Araneorum 2(Pt. 2):1206. Schick, 1965, Bull. Amer. Mus. 129:169, Figs. 250-252.

Type—Salt Lake City, Utah, male holotype, female allotype, and male and female paratypes; Bluff, Utah, female paratypes; Zion National Park, female paratypes (actually *versicolor*). Types in American Museum of National History collection, examined.

Male—Total length, 4.08-6.25 mm, mean, 4.65 mm: cephalothorax length, 2.12-3.80 mm, mean 2.68 mm; width 1.12 -3.00 mm, mean 2.49 mm. Structure and color essentially identical to *versicolor*. Palp as in Fig. 8.

Female—Total length, 4.50-9.92 mm, mean, 6.28 mm: cephalothorax length, 2.12-3.80 mm, mean, 2.68 mm; width, 2.20-3.80 mm, mean 2.79 mm. Coloration is essentially the same as *versicolor*. Epigynum as in Figs. 12, 15, 18.

Range—Trans-Canadian and northern United States, along Gulf coast states from Florida into Mexico, also from central Alaska south along mountain ranges into Mexico (see Map 1).

Diagnosis and comments—Males can be identified by the short embolus and recurved anterior eye row. Females are distinguished by the maculations on the posterior declivity being separate, anterior eye row recurved, and copulatory tubes barely, if at all, visible.

Often in areas where the range of *utahensis* overlaps with *versicolor* a form occurs that has genitalia characteristics intermediate to those two species (see Figures 9, 11, 14). Since both parental forms and the intermediate have been recorded from the same area (see Map 1), it is likely that this intermediate is a hybrid resulting from cross-breeding of *versicolor* and *utahensis.*

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DIEL ACTIVITY IN SYMPATRIC POPULATIONS OF THE SCORPIONS *CENTRUROIDES SCULPTURATUS* (BUTHIDAE) AND *DIPLOCENTRUS SPITZERI* (DIPLOCENTRIDAE)[1]

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ABSTRACT

Field observations of sympatric *Centuroides sculpturatus* and *Diplocentrus spitzeri* scorpions in the Peloncillo Mountains in New Mexico revealed that during the warmer months nocturnal extra-rock surface activity was relatively great in the former species. In contrast, *D. spitzeri* tended to remain beneath rocks near the openings of its burrows. During the day *C. sculpturatus* also used the rocks as shelter, clinging to the underside. Actograph studies of both species showed them both to have nocturnal activity when imposed photoperiod was the only variable; however, only *C. spitzeri* displayed an endogenous circadian rhythm in constant darkness.

Rooftop observations of *D. spitzeri* confined to containers, each with soil and a rock for shelter, indicated that under poor shelter conditions extra-rock nocturnal activity is common for early instars through adults. In another rooftop study *D. spitzeri* adults exhibited random choice of available rock shelter.

It was concluded that different spatial and temporal strategies may make possible avoidance of competition between these two species.

INTRODUCTION

The dichotomous terms "bark" scorpion and "ground" scorpion have been used to roughly describe scorpion behavior in relation to habitat. Stahnke (1966) points out that the highly venomous buthid *Centruroides sculpuratus* is a bark scorpion because it occurs frequently under loose tree bark; when hiding under rocks it often displays negative geotaxis by clinging to the underside. Like other bark scorpions, it has a tendency to enter crevices.

In parts of the Peloncillo Mountains in southwestern New Mexico *C. sculpturatus* is sympatric with the diplocentrid ground scorpion *Diplocentrus spitzeri* (Figs. 1, 2). Nine visits were made to the area between February, 1972 and January, 1974; all seasons were covered. During each visit, which lasted at least two days, hundreds of rocks were raised in a search for *D. spitzeri* and a species of centipede, both of which were being analyzed for cold-hardiness development.

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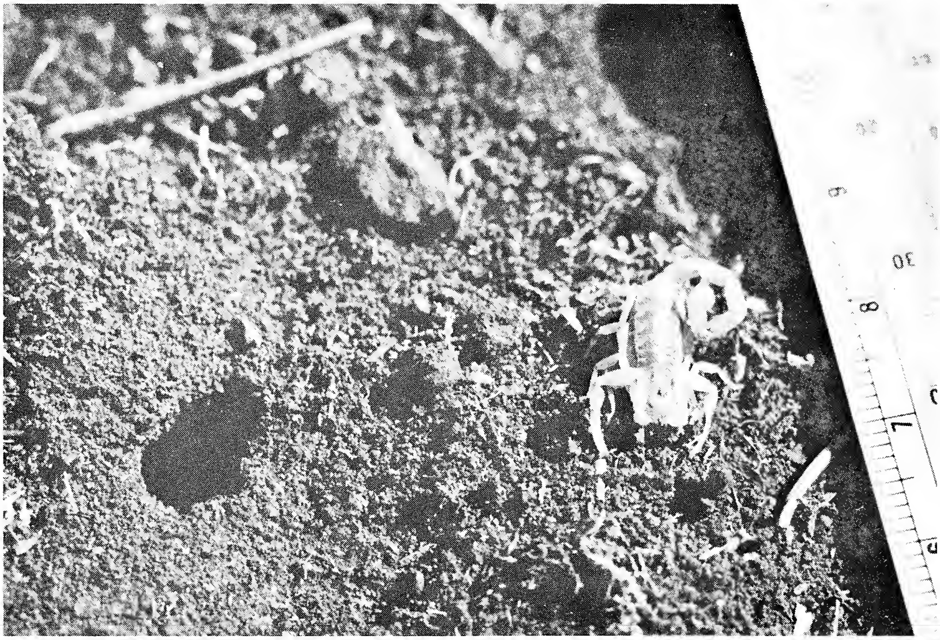

Fig. 1.–Immature *Centuroides sculpturatus* directly following removal of its rock shelter. Peloncillo Mountains, New Mexico.

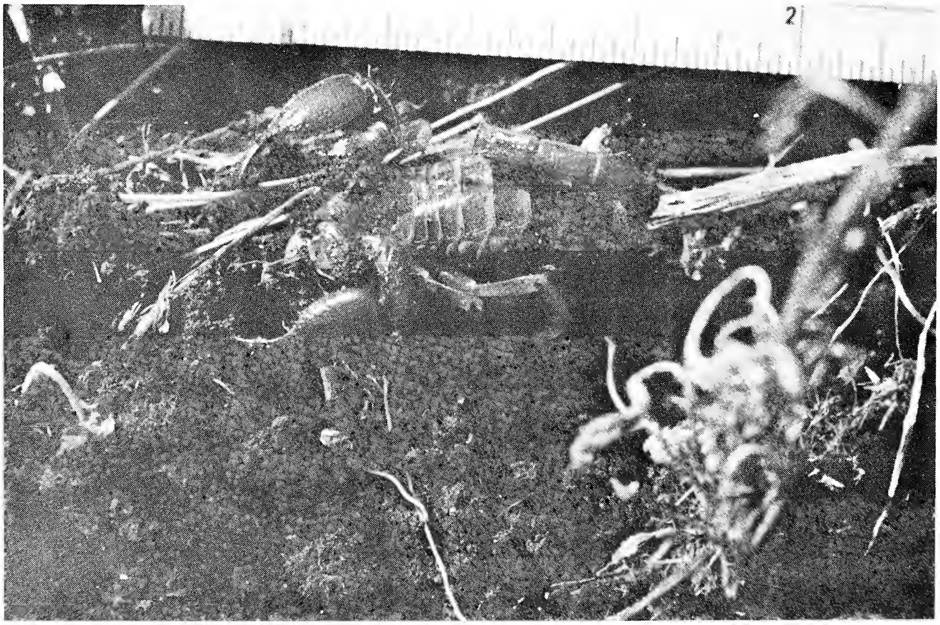

Fig. 2.–Adult female *Diplocentrus spitzeri* directly following removal of its rock shelter. Peloncillo Mountains, New Mexico.

During the warmer months both scorpion species were found under exposed rocks on moderately grazed ridges and upland slopes at 1500-1800 m elevation (Figs. 3, 4). As

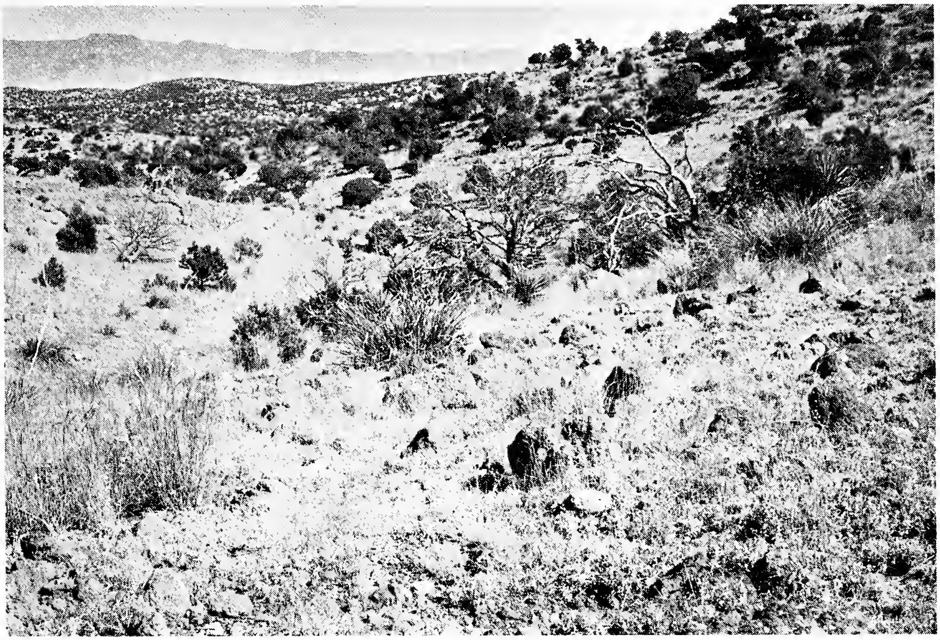

Fig. 3.–Typical habitat of both scorpion species in the Peloncillo Mountains, New Mexico.

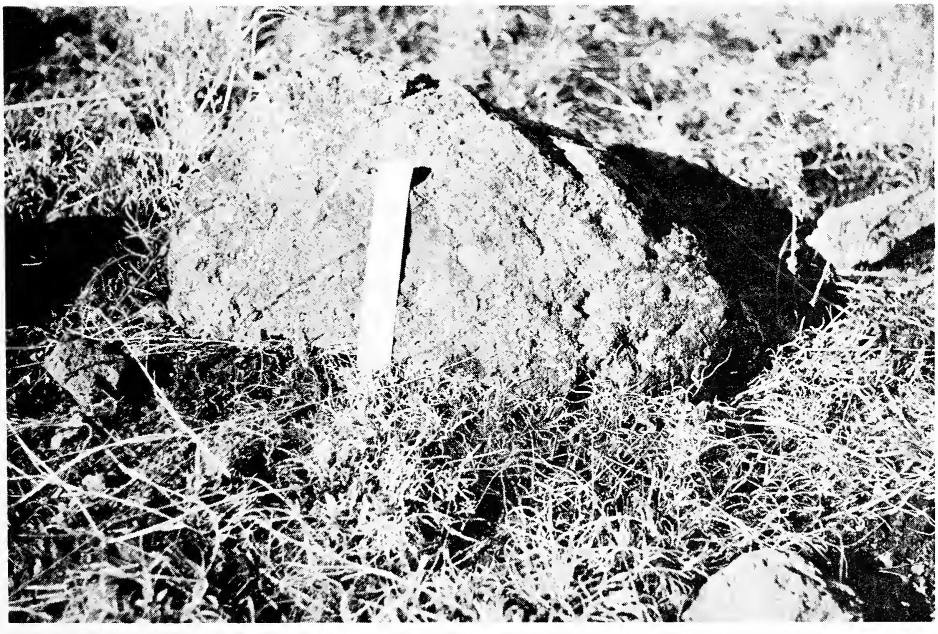

Fig. 4.–Rock typical of those affording shelter for both scorpion species in the Peloncillo Mountains, New Mexico.

with some other ground scorpions, *D. spitzeri* is an effective burrower and was most frequently seen at its burrow entrance beneath a rock. Thus, both species occupy the same general microhabitat during part of the year. The two are occasionally even encountered under the same rock.

Being scorpions, both species should be expected to prey on a variety of local arthropods (Cloudsley-Thompson, 1968; Stahnke, 1966; personal observations). If food and shelter are to some extent shared, then the question of competition—or of its avoidance—must be raised. This paper describes field observations that shed some light on this question, and also reports the results of rhythm studies designed to do the same.

Initially, we wished to characterize the diel periodicity of *D. spitzeri* relative to a possible association between photoperiod and cold-hardiness development (Crawford and Riddle, 1974). Therefore, the present study includes results of outdoor experiments performed with confined *D. spitzeri* and describing extra-rock activity at night.

FIELD OBSERVATIONS OF DIEL ACTIVITY—BOTH SPECIES

Field studies were usually conducted 1-5 km south of Geronimo Pass in the Peloncillo Mountains. Sporadic night collecting was undertaken using black lights. Results of six post-dusk excursions to the habitat in question are given in Table 1. Clearly, *C. sculpturatus* was the more common surface scorpion at night. All but two of the *D. spitzeri* seen were adults. Of the two species, there was a much greater immature: adult ratio in *C. sculpturatus*, although we made no actual counts of immatures.

Table 1.—Nocturnal surface observations of relative numbers of scorpions in the Peloncillos, made while continually walking back and forth over areas varying in size.

Date	Hours (MDT) of observation	Weather	No. of *D. spitzeri*	No. of *C. sculpturatus*
10-1-71	2245-2315	cool, windy	0	0
6-16-72	2115-2230	sultry, warm	7	> 20
6-18-72	2030-2230	warm	5	> 20
9-10-72	1200-2200	cool, moist	3	15
7-22-73	2030-2200	cool, dry	3	8
10-18-73	2000-2100	very cool	0	1

During hours of daylight no scorpions were seen except for those under rocks. The great majority of those seen were *D. spitzeri* and they were present all year long in or near their burrow entrances. *Centuroides sculpturatus* was never abundant in the daytime, and although it was not actually counted (because it was usually not being collected), it was encountered no more than once for every 10 or so *D. spitzeri* observed. As might have been expected (Stahnke, 1966), *C. sculpturatus* generally clung to the underside of the rocks that were raised.

ACTOGRAPH STUDIES OF DIEL LOCOMOTOR ACTIVITY—BOTH SPECIES

An attempt to characterize the influence of photoperiod relative to possible endogenous rhythms was made for both species in the absence of temperature variation. Following seven days of insectary conditioning at 26°C and the appropriate photoperiod eight recently collected scorpions of each species were placed in separate units of two actographs (Fig. 5). Fig. 6 indicates the photoperiods employed. The activity-measuring units consisted of large plastic petri dishes (diam 15 cm) balanced so that any movement of the scorpion within caused each dish to tilt. Each tilt of a dish in turn caused an electrical circuit to be either completed or broken, thus producing a needle deflection on one channel of an event recorder. Needle deflections were recorded on chart paper moving at 15 cm hr^{-1}. An 8-channel event recorder was used so that locomotor activity of eight animals could be analyzed at a time.

Activity was recorded for five days at an existing insectary photoperiod at 35°N at the time of year (autumn) an actograph run was made. Onset of each dark period began at 2100 hours. At the beginning of the sixth dark period actographs were covered with lightproof boxes for the following five days.

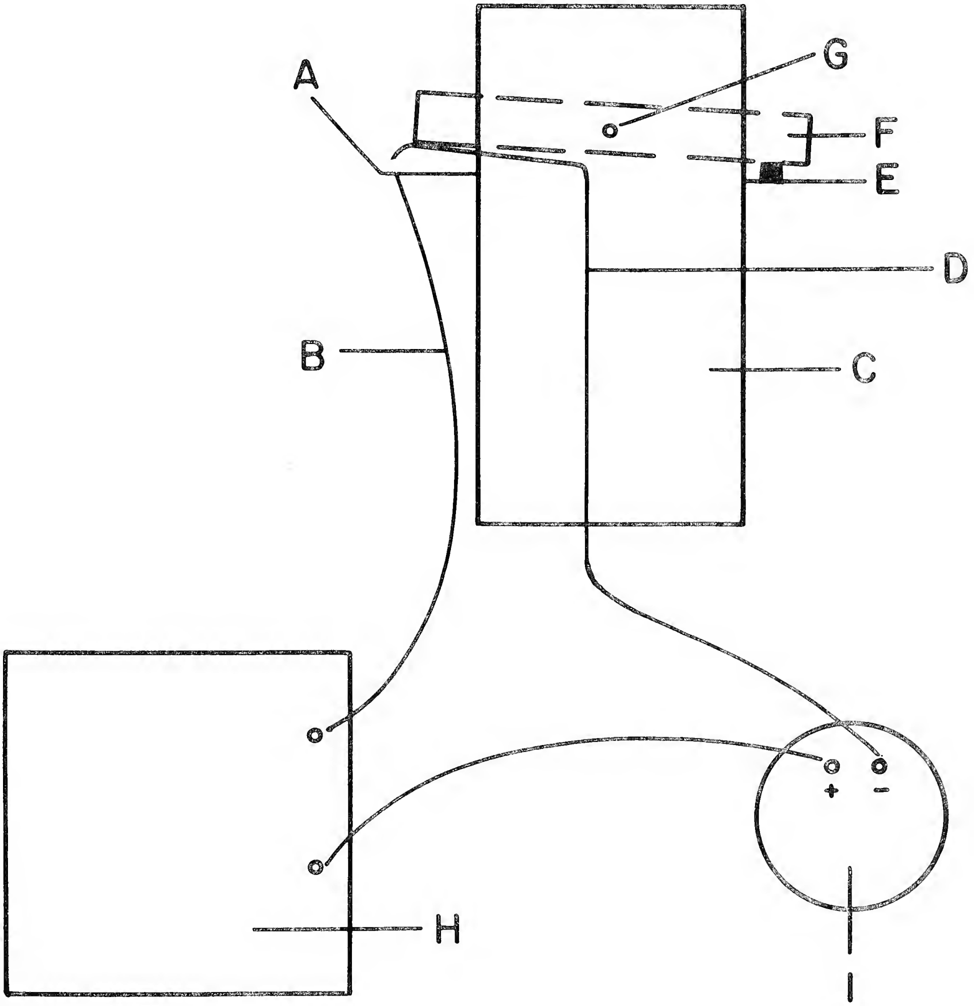

Fig. 5.–Diagrammatic representation of an actograph used to measure scorpion diel periodicity. A: copper plate, B: wire, C: wooden frame, D: wire, E: dish stop, F: petri dish, G: balancing pin, H: recorder, I: power supply.

Fig. 6 presents the results of the actograph tests. As expected from results of other activity-rhythm studies with scorpions, rhythms of locomotor activity in both species are nocturnal and are influenced by photoperiod. The presence of an endogenous circadian clock can be ascertained for *C. sculpturatus* because that species displayed a pronounced diel rhythm of activity in constant darkness. In contrast, a breakdown in the activity rhythm of *D. spitzeri* in constant darkness was soon apparent.

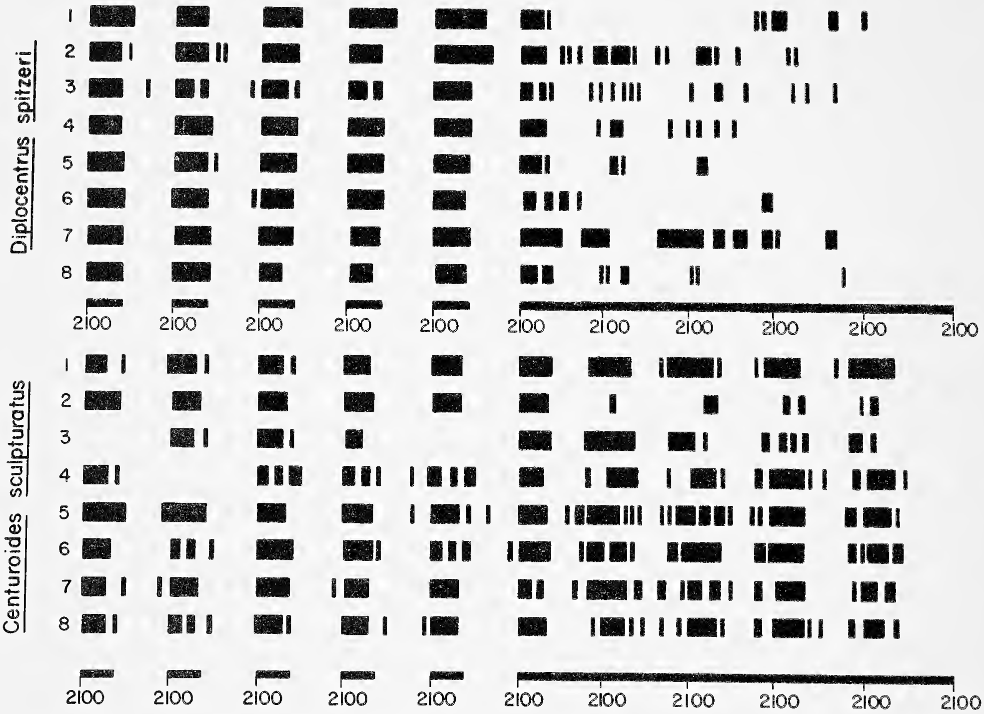

Fig. 6.—Condensed actograph records of eight acclimated *D. spitzeri* and eight acclimated *C. sculpturatus*. Acclimation consisted of a week of exposure to 26°C and the appropriate photoperiod. Five days of photoperiod (alternating black and white bars; LD 14:10 for *D. spitzeri* and 15:9 for *C. sculpturatus)* are followed by five days of constant darkness (long, black bars). The repeated values of 2100 on the horizontal axis refer to the time (MDT) at which a light-dark transition occurred during each photoperiod. Within each 24-hr period the black areas indicate the extent of activity (in excess of 1.5% of a possible day's total) that took place during any given hour.

ROOFTOP STUDIES OF DIEL ACTIVITY–*D. SPITZERI*

Observations in the field at night suggested that the influence of the sub-rock environment was generally strong enough in *D. spitzeri* to override exogenous and endogenous factors promoting surface exploration. We tested this idea by observing the extra-rock activity of specimens confined individually to buckets about 25 cm in diameter. The buckets were kept on the roof of the Biology Building at the University of New Mexico. They were covered by an elevated sloping roof of corrugated sheet metal that was designed to minimize heat buildup below and to keep off rain. Each bucket was one-third filled with habitat soil that was moistened periodically. A habitat rock averaging about 10 cm in diameter and 5 cm in height was placed centrally on the soil to provide a somewhat natural shelter. Beneath each rock a simulated burrow about 10 cm long was fashioned at a 45° angle.

Regular evening observations of adults, medium-sized juveniles, and second-instar specimens (seven of each) collected in June, 1972 are given in Table 2. Exploratory activity tended to begin shortly after sunset and to increase during the next hour. All scorpions considered in Table 2 were given mealworms (pieces of mealworm for small specimens) the afternoon of June 29, 1972.

Table 2.–Evening activity of *D. spitzeri* (seven in each group) in individual soil-filled buckets and exposed to natural photoperiod and temperature.

	No. of scorpions emerged from rock shelters								
	Sunset to sunset –15 min.			Sunset to sunset + 30 min.			Sunset + 30 min. to sunset + 60 min.		
Date (1972)	Adults	Juv.	2nd inst.	Adults	Juv.	2nd inst.	Adults	Juv.	2nd inst.
6-30	0	0	0	1	1	1	4	2	4
7-2	0	0	0	1	0	0	3	2	4
7-4	0	0	1	0	1	3	0	1	5
7-6	0	0	0	0	0	0	3	1	3
7-8	0	0	0	1	1	2	4	4	5
7-10	0	0	0	1	1	0	1	2	4
7-12	0	1	3	1	2	4	1	4	5

Two all-night studies were made of the same scorpions in late August and early September 1972 (except that three second-instars were missing by that time and that four adults were added in early August). The first night of observations was made 11 days after a mealworm feeding; the second was made four nights after the first and one day after a feeding. To check on feeding effectiveness all rocks were raised the morning following the second observation night. In nearly all cases at least some evidence of recent feeding was noted.

Respective times of sunset were 1935 and 1928 hours, while times of sunrise were 0639 and 0642 hours (MDT). Air temperatures ranged from about 17-25°C both nights, during which time there were intermittant breezes. A slight rain occurred the second night.

Table 3.–Nocturnal activity of *D. spitzeri* in individual soil-filled buckets and exposed to natural photoperiod and temperature, August 31-September 1, 1972.

	No. of scorpions emerged from rocks shelters			
Hour (MDT) beginning	Adults n=11	Juveniles n=7	2nd instar n=4	Total % active
1930	5	2	1	36
2030	8	3	2	59
2130	9	2	2	59
2230	10	3	2	68
2330	9	4	2	68
2430	9	4	2	68
0130	9	5	2	73
0230	7	3	2	55
0330	7	3	2	55
0430	6	2	2	45
0530	6	2	2	45
0630	4	0	1	23

Results of nocturnal-activity observations are condensed in Tables 3 and 4. They indicate that a majority of scorpions emerged from beneath their rock shelters on both nights. They also show that peak activity took place in the middle hours of both nights, and that all hours of darkness supported some activity. The extent of nocturnal activity so recorded is in agreement with the pattern recorded during an imposed photoperiod. No noticeable difference in activity that can be attributed to feeding is evident in Tables 3 and 4.

Table 4.—Nocturnal activity of *D. spitzeri* in individual soil-filled buckets and exposed to natural photoperiod and temperature, September 5-6, 1972.

Hour (MDT) beginning	No. of scorpions emerged from rock shelters Adults n=11	Juveniles n=7	2nd instar n=4	Total % active
1930	9	3	1	59
2030	8	5	2	68
2130	8	6	1	68
2230	11	6	1	82
2330	10	6	1	77
2430	10	6	2	82
0130	7	4	1	55
0230	6	3	2	50
0330	3	4	2	41
0430	4	2	2	36
0530	2	2	2	27
0630	1	1	1	14

SHELTER-PREFERENCE STUDIES—*D. SPITZERI*

Because most of the life of *D. spitzeri* is spent in a burrow that opens directly beneath a rock, we questioned whether or not preference is shown for a particular rock. To test the possibility of preference we created an artificial habitat under the rooftop shelter. It consisted of a child's plastic swimming pool, about 0.3m high and 2 m in diameter, and partly filled with habitat soil. Ten habitat rocks measuring about 20 cm in diameter and 10 cm in height were placed on the surface so that they were equidistant from each other; none was closer to the container side than to another rock. Each was numbered with paint, and beneath each was a simulated burrow similar to the type described above.

For purposes of identification each of 10 adult scorpions except one was lightly spotted on the carapace with combinations of red, yellow, or white acrylic paint. On July 2, 1972 they were placed in the artificial habitat, each beneath a separate rock. Rocks were slightly raised on eight subsequent days in order to detect whatever final dispersion had taken place the previous night. Occasional nighttime visits to the shelter informed us that the scorpions wandered throughout the night; however, we did not note how many times (if at all) in a night each animal crawled under a given rock or emerged from beneath it.

Results of this experiment are given in Table 5. It is apparent that in only one case was a scorpion found beneath the same rock after more than two consecutive nights. In three instances the same sub-rock microhabitat was occupied by two specimens. Rock utilization was apparently random, with increasing use of the pool side as a "shelter" after the first night.

Table 5.–Shelter preferences of *D. spitzeri* in an artificial habitat of equidistantly placed rocks on habitat soil in a 6-m diameter container exposed to natural photoperiod and temperature. † = side of shelter.

Specimen	Rock number or other location where specimens were found during the day in July							
No.	3	4	5	6	7	9	10	11
1	10	9	9	†	†	7	9	†
2	5	6	†	8	†	†	†	†
3	6	1	8	6	†	†	†	†
4	7	†	†	†	†	†	†	†
5	2	2	2	7	7	†	8	8
6	8	5	5	5	5	5	†	8
7	9	3	†	1	†	8	1	1
8	3	10	†	9	9	3	7	3
9	4	7	7	8	†	9	†	9
10	1	8	†	6	8	†	†	†

DISCUSSION AND CONCLUSIONS

Our observations corroborate the well known fact that scorpions as a group are active nocturnally. Cloudsley-Thompson (1973) showed that regardless of varying abilities to resist water loss, three species of scorpion exhibited similar patterns of nocturnal locomotor activity. He used this information to support the view that scorpions have tended to become secondarily nocturnal for reasons not associated with water loss. In fact, rates of water loss for *C. sculpturatus* and *D. spitzeri* differ considerably at 30°C (Hadley, 1970; Crawford and Wooten, 1973), the former species being much more resistant to desiccation.

Our field observations consistently indicated that extra-rock nocturnal activity is more common in *C. sculpturatus* than in *D. spitzeri*. Therefore, a greater degree of spatial separation appears to occur at night than in the daytime when *C. sculpturatus* clings to the rock underside while *D. spitzeri* remains near its burrow entrance. Surface foraging has been described previously for *C. sculpturatus* (Hadley and Williams, 1968). In the Peloncillos this scorpion tends to move about at night, perhaps reflecting the hunting possibilities in a varied terrain. Such behavior is reminiscent of that shown by *C. sculpturatus* at Puerto Penasco, Sonora, in comparison to the scorpion's motionless presence on the desert surface in the Tempe-Mesa, Arizona area (Hadley and Hill, 1969).

The endogenous circadian rhythm of activity shown for *C. sculpturatus* seems typical of a number of scorpions (Cloudsley-Thompson 1956, 1963, and 1973). Entrainment of a circadian rhythm by existing photoperiod should be advantageous to predaceous arthropods that utilize food resources some distance from their diurnal shelters. The endogenous nature of this kind of movement has the potential disadvantage of bringing about exposure to nocturnal enemies. It also precludes daytime foraging in the reduced illumination of a shelter.

Such a circadian foraging pattern is apparently not the strategy to which *D. spitzeri* is restricted. Instead, this species seems to have the option of a potentially continuous period of foraging in its normally dark habitat. Our not infrequent daytime observations of its feeding on freshly killed arthropods (especially larvae and adults of Tenebrionidae) substantiate this view.

Although we did not satisfactorily demonstrate that foraging is related to hunger in *D. spitzeri*, there is little question that when the only available rock shelter is smaller than usual (and perhaps less appropriate in other ways as well) extra-rock foraging becomes a common event. This suggests that decreasing illumination perceived in an incompletely darkened sub-rock environment can provide sufficient stimulus to promote such behavior. Presumably, there are occasions in the natural habitat when *D. spitzeri* becomes exposed to this kind of illumination and responds accordingly. Another reason for leaving the shelter of small rocks may well be that they provide relatively little prolonged moisture for this moderately desiccation-resistant scorpion and for its prey as well. Departure from a rock shelter may enable *D. spitzeri* to find prey in the open, and to enter a new shelter before dawn. The occasional presence of two adults of the same sex beneath the same rock attests to this possibility.

Williams (1970) compared regional diversity of scorpion species with that of other arachnids and concluded that diversity is relatively restricted in the former group. He attributed this to the similarity of food sources, habitat requirements, morphology, and generalized behavior of scorpions, and contended that these could result in the competitive exclusion of all but a limited number of species within a regional fauna. On the other hand, according to Williams, there must be mechanisms that allow for species coexistence.

We conclude that in warmer months in the Peloncillo habitat, competition between *C. sculpturatus* and *D. spitzeri* for similar food and shelter may be avoided because of different spatial and temporal foraging strategies. An important physiological basis for this difference is the presence of an endogenous circadian rhythm of activity in the former species and its absence in the latter species. Competition is apparently avoided in the colder months because of species separation, as we found only one *C. sculpturatus* beneath a rock in winter, compared on an average of 15 or more *D. spitzeri* collected per winter day.

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BOOK REVIEW

SPIDERS OF THE UNITED STATES by Richard Headstrom. A. S. Barnes & Co., Cranbury, N.J. $9.50, 267 pp. [viii + 259], Ill., 1973.

The author's stated aim in writing this book is to "provide one with the identity of a spider whose name one might wish to know" and to supply information to those "who might like to know more about [spiders]." But any one of the ten references in his bibliography would supply the reader with more information, and that based upon years of individual first hand study. As to identifying specimens, the inexperienced will have difficulty using *any* book, but their task would be immeasurably easier were they to use either one of the two books from which Headstrom copied most of his material.

Treatises, handbooks, and manuals are more or less expected from experienced araneologists, who have previously published in various journals. Considering that Headstrom had never before published on spiders, and presumably hasn't done any research on these animals, one wonders why the publishers accepted the manuscript without having it reviewed by some actively working araneologist. Moreover, when the manuscript was set up in type it was not proof-read carefully, and many errors in spelling were allowed to slip by. Some names were spelled one way on one page and another elsewhere, e.g., *Tamarus* and *Tmarus, abbotti* and *abbottii*, *Habronattus* and *Hebronattus*. Most important, the key to families on pages 49 and 50 does not show the numbers at the end of a line indicating the next couplet to which the reader should proceed. The publishers' representative admitted that this slip was not discovered until after copies of the book had already been sent out, but that a corrected sheet had been prepared, and tipped in, for future purchasers. Yet this reviewer knows of cases (including his own) where the book was sent out later without such a sheet.

The first 40 pages of the book are given over to a general discussion of spider structure, their habits, webs, etc. This is followed by a two page key to the 31 families treated in the book. These families are all in the Suborder Labidognatha, the tarantulas, trap-door spiders, and their allies being completed omitted. The next 200 pages are devoted to descriptions of the 265 species he has chosen to include. The book closes with a brief discussion of how to collect and preserve spiders, a glossary, and an index.

In general, the sequence followed for families and species is virtually the same as that used in the 1940 revised edition of Comstock's Spider Book. In fact, much of the text and many of the illustrations are copied right out of that book. On occasion, where Comstock had copied from others he used quotation marks, and credited comments and drawings, e.g., from Marx, Peckham, Emerton, or Keyserling. But Headstrom used no quotation marks, and gave no credit to others. The same applies to the over 100 illustrations copied from Kaston's 1953 edition of *How to Know the Spiders*, along with very many selections copied verbatim, or almost so. Unfortunately the drawings supplied by Headstrom were very crudely done, with most of them apparently being reproduced in the book without any reduction. The last one in the book is numbered 305, but there are 30 that must have been added as an afterthought, after the numbers had been assigned, and so therefore indicated with an "A," "B," or "C," and on page 111 there is one figure without any number or legend! Most of the drawings are of abdomens and of these more than a dozen are mere outlines, or almost so, all looking alike. Then there are those where the outline has been evenly stippled in, so *they* all look alike, even though the label "purplish" may be used for one (as for *Orchestina*) and "gray" for another (as for

Plectreurys). All these drawings might just as well have been omitted for all the help they are to one seeking to identify a specimen. In the case of those species where sexual dimorphism is responsible for a different pattern on the abdomen he does not indicate which sex is being illustrated.

Fig. 29 shows a leg segment of *Mimetus* labeled "tarsus" although it is quite obvious from the spination that "metatarsus" is meant, but he had merely copied the typograph error from Comstock. His Fig. 32 is likewise copied from Comstock, to illustrate a trochanteric notch. Here the femur is shown much shorter than the trochanter! His Fig. 33 shows a tarsus bearing trichobothria, but the latter are drawn in far heavier than all of the spines and bristles also shown. A novice matching up this drawing with his specimens would come to the conclusion that *no* spiders have trichobothria. Although Headstrom refers to the abdomen of *Ariadna* as "cylindrical in form" his drawings shows it as an oval four-fifths as wide as long. His Fig. 270 of *Thiodina* distinctly shows three white lines on the abdomen even though the text indicates only two.

Perhaps the most serious defect in his drawings concerns the manner in which eyes are shown. There are many drawings of the head end showing the eyes, but without any indication as to whether the view is from the front or above. Considering how much importance araneologists give to the relative size, spacing, and position of the eyes the author's neglect of detail is indeed unfortunate. His Fig. 236 of *Dolomedes* shows all the eyes of the same size; Fig. 40 of *Hyptiotes* shows only six eyes; Fig. 7 of *Lyssomanes* shows the eyes in only three rows, even though the text refers correctly to four. In the case of *Loxoceles* Figs. 62 and 65 are not in agreement with respect to size and spacing of eyes. Fig. 57 of *Orchestina* shows the median eyes separated even though in actual fact they are virtually contiguous. It is doubtful that Headstrom actually examined a specimen, but he states in his text "median eyes widely separated" probably copying carelessly from Comstock who had written "median eyes widely separate the anterior lateral eyes." There are many slips of this kind.

In the key to families the filistatids are taken out together with the dysderids and segestriids on the basis of having a pair of spiracles (rather than a single one) and his Fig. 18 has a spiracle labeled immediately behind each book lung (with the spiracle the same shape and almost the same size as the lung). This most certainly is not the situation in filistatids. Lacking the awareness of a working araneologist Headstrom still uses names like *Glyptocranium*, *Zilla*, and *Aranea* for *Mastophora*, *Zygiella* and *Araneus* respectfully. Nor could he be expected to know that "*Dendryphantes* (*Paraphidippus* [sic!] *capitatus*) *aestivalis*" on page 235 and *Metaphidippus protervus* on page 247 are synonyms, or that *Phidippus clarus* on page 233, and *P. rimator* of page 234 are likewise.

To enumerate all the errors of fact, misspellings, and misinterpretations would more than fill the space allotted here. Here are just a few. He repeats from Comstock the error that the mouth "is suitable only for the reception of liquid food" although farther along he correctly indicates the manner in which a spider can digest solid portions of its prey before swallowing. On wishes that the author had been more consistent. Again, copying unthinkingly from Comstock he indicates that the tarsus "usually" bears two or three claws; are there any spiders that sometimes bear some other number? His difficulty with numbers extends also to his description of the spinnerets, of which the anterior and posterior may each have two or more segments, but the median "none at all." Although it has long since been shown that chitin is not the substance which makes an arthropod skeleton hard he still adheres to this false belief. His key to families is basically dichotomous, though in a few places it is trichotomous. But if one reaches line 12 one has to choose from among *six* "alternatives," 12a through 12f. And here one is asked to contrast "12a. Spinnerets In A Single Transverse Row" with (among other characters)"12b. Tarsi Long And Flexible" and "12f. Tarsi Of Fourth Pair Of Legs Not With Spurious Claws." It is not clear why the first letter of every word in his key must be capitalized.

Beyond the family key there are no others, the reader having to depend upon eliminating possibilities as he reads the descriptions. The latter are based mostly on color, with relatively little attention given to morphological characters other than the eyes. In the opinion of this reviewer there will be very few places where the spider will be correctly determined. This book has already been reviewed in a periodical widely read by high school biology teachers, and will probably have a wide sale in the schools. It is a shame that once again we have a situation where the blind is leading the blind. The best thing about the book is that it is clearly printed on good quality paper, nicely bound in hard covers, and includes a good discussion of autotomy on page 37. But unfortunately none of this will enable the inquiring student to achieve the goal hoped for. **B. J. Kaston**, Department of Zoology, San Diego State University, San Diego, California 92182.

(continued from inside front cover)

support). 4) By-line: Include name(s) of author(s) as customarily written (less titles) and complete address(es) including zip code or other postal zone designation. Include footnote indication(s) if appropriate (e.g., to indicate change of address). 5) Body of Text: Use whatever form seems to best accommodate the necessary description of the research. Be concise. Conform to the *CBE Style Manual* in all abbreviations. 6) Acknowledgments: Take care to give credit where it is due. 7) Literature Cited: Include only those publications to which reference is made in the text. Adhere to style in *CBE Style Manual* or refer to a previous issue of *The Journal of Arachnology*. Do not abbreviate place names. 8) Figure Legends: Do not type on facing pages but type consecutively in numerical sequence. 9) Abstract: Keep abstracts concise, not exceeding 2-3% of the text. Abstracts should contain a summary of the basic findings. Papers written in a language other than English must be accompanied by an English abstract as well as an abstract in the language of the text. 10) Footnotes: Other than appropriate page 1 footnotes, no other footnotes are permitted. 11) Running Head: Construct this shortened title so that it, along with the author(s)' last names, does not exceed 55-60 characters and spaces. 12) Tables with Legends: Prepare all tables precisely as they are to be typeset. It is essential to construct tables as simply as possible. Place legend at top of each table. Incorporate into legend all information necessary to make the data presented clearly understandable. Do *not* resort to the use of footnotes. Make marginal notations in the text which clearly indicate the appropriate point of insertion of each table. 13) Figures: Since the figures are the only part of the paper for which each author is responsible for preparing camera-ready material, they must be done with the greatest of care. Poor illustrative material will be returned forthwith to authors for further attention. Those drawings which present the least difficulties in printing are the type done with black ink on high quality, smooth, white, heavy paper. Drawings done in some manner not employing black ink (e.g., shaded pencil drawings) are difficult to print, more so than are photographs. Authors should keep this in mind. When such a technique is used, the drawings should be fairly dark, have good contrast, and be well-executed. Prepare all drawings, graphs, etc., at least twice the anticipated printed size, but do not make them so large that mailing is inconvenient nor so large that they exceed 17 in. (43 cm) in shortest dimension nor 22 in. (56 cm) in longest dimension. Furnish only originals, not photographic reproductions. The *largest* dimensions on the printed page to which illustrative material will be reduced is 5 in. (127 mm) by 8 in. (203 mm). 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Remember that whole views of animals, while not necessarily required for a diagnosis, give the reader an instructive general appreciation of the animal which is impossible to impart with words or by a collection of drawings of pieces. Avoid the use of whole views comprised of ½ dorsum and ½ venter. Illustrate species descriptions. This is in accord with General Recommendation 17, *International Code of Zoological Nomenclature*, which states, "The description of a new taxon of the species-group should be accompanied by a satisfactory illustration or by a bibliographic reference to such an illustration." 13) Put items 3, 4, and 5 above on page 1 and number *all* other pages consecutively.

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CONTENTS

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Feature Articles

Book Review

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