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## The Urticating Hairs of Theraphosid Spiders

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### ABSTRACT

The dorsal surface of the abdomen of many New World spiders belonging to the family Theraphosidae—popularly called tarantulas in the United States—bears a dense covering of specialized hairs that can provoke intense skin irritation in man on contact. Four main types of urticating hair, studied for the first time, are described and illustrated with the aid of a scanning electron microscope. The role of the hairs in nature is wholly defensive, apparently most effective against small mammals attacking spiders in their burrows. The urticarious effect of the hairs seems to be due solely to mechanical irritation and thus far there is no evidence of any chemical irritant being involved. It is shown that the urticating hairs possess considerable potential value in the confused field of theraphosid systematics.

### INTRODUCTION

It has been known for more than 150 years that some of the large, hirsute mygalomorph spiders of tropical countries—called in the United States tarantulas—can cause considerable skin irritation when handled, an effect attributed to their body hairs. Although many of the general works on spiders (e. g. Savory, 1928; Berland, 1932; Kaestner, 1968) make

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brief mention of this phenomenon, the majority of references to it in the literature may be traced back to the popular accounts given by von Langsdorff (1812, 1813) and Bates (1863) when describing their travels in South America. There are, however, a number of corroborative firsthand reports of urticaria following the handling of spiders (e. g. Vellard, 1936; Bristowe, 1941; Baerg, 1958) and many arachnologists have personally described their experiences to us. The fullest published accounts are probably those of Torres (1921), Gertsch (1949), and Bücherl (1951). Although these authors established the defensive role of the hairs in response to attacks by small mammal predators, they gave no indication of the structure of the hairs and only speculated about the nature of the effect they produce.

The observations reported in the present paper are the outcome of two essentially independent investigations, the first of which was initiated by Roth in 1969, who studied the urticating hairs of several species of theraphosid spider and recognized four main hair types. He also studied the effects of the hairs from *Aphonopelma* species in Arizona on a variety of local desert animals. By combining these findings with the results of a second investigation by Cooke and Miller that began toward the end of 1970, we are now able to report on the urticating hairs of more than 40 spider species. The structure of the four main hair types as revealed by the scanning electron microscope (SEM) is described, and we also consider the manner in which the hairs are used and how they produce their urticating effect in both man and rodents. Finally we draw attention to the potential value of urticating hairs in systematic studies of theraphosid spiders.

#### MATERIALS AND METHODS

Urticating hairs from representatives of all seven theraphosid subfamilies were gathered from preserved material in the collections of the American Museum of Natural History and the British Museum (Natural History). Hairs for experimental purposes came from living spiders collected in the field or lent by colleagues.

Hairs for microscopical examination were collected and preserved in 70 percent ethanol. A sample from each specimen was mounted on slides in dimethyl hydantoin formaldehyde (DHF) (Cooke, 1970) for reference and for measuring. Hairs from selected species were prepared for examination under the scanning electron microscope as follows. Hairs collected from preserved specimens tended to be rather dirty and although an attempt was made to clean them ultrasonically as suggested by Shear and Levi (1970) the best results were obtained by cleaning them in lactophenol.

After mounting on metal specimen stubs, using aluminum paint as cement, the cleaned hairs were air dried and then coated with approximately 200 Å. of gold in a vacuum evaporator. Examination was at 20 kv. with a Cambridge Stereoscan Mark II Scanning Electron Microscope.

The effects of the hairs on man were investigated by biopsy following application to the skin of the upper arm. The effects on small mammals were studied in laboratory white mice, which were subsequently killed and serially sectioned for histological examination. Surface view SEM pictures of hairs penetrating the skin were obtained from newborn mice, which were impregnated with epon after fixation. Subsequently the surface epon was washed off with propylene oxide, leaving the skin still supported and relatively free from distortion during the evaporation process.

The reactions of potential predators to *Aphonopelma* hairs were tested under artificial conditions using well-fed captive vertebrates with the spiders outside their burrows.

Measurements used in compiling tables 2, 3, and 4 were taken from camera lucida drawings of material mounted on slides. Between five and 10 hairs of each species were measured to an accuracy of  $\pm 0.005$  mm.

Authors' names of spider species mentioned in the body of the text will be found in table 1, which lists the species examined in systematic order.

#### ACKNOWLEDGMENTS

We express our gratitude to the many colleagues who have recounted their experiences with theraphosids to us and to those who have provided us with living specimens. In particular we thank Drs. W. J. Gertsch and H. W. Levi, Miss Alice Gray, and Mr. A. L. Bordes. Special thanks are due to Corinne Chubb, whose generous hospitality enabled Cooke to collect and observe theraphosids in the British Virgin Islands. We are grateful to the Southwest Traildust Zoo, Bisbee, Arizona, and the Sonora Desert Museum, Tucson, Arizona, for the loan of many of the vertebrate predators used in the experiments. We also thank Prof. G. F. Knowlton for information on spiders as the prey of lizards, Dr. J. L. Duffy for examining biopsy specimens, and Prof. R. E. Wheeler for allowing us to quote from his notes.

#### ABDOMINAL HAIRS

The integument of spiders is richly endowed with hairs. These are of many different types but are, for the most part, of unknown function. For example, the dorsal integument of the Arizona theraphosid *Aphonopelma chalcodes* carries at least four distinct types of hair. The basic pelage

consists of strongly pilose hairs approximately 0.5 mm. in length at a density of 300–400 per square mm. Interspersed with these are stouter, more finely pilose hairs slightly over 1 mm. in length and present at a density of roughly 100 per square mm. Projecting above the basic pelage and conspicuous because of their brownish orange color are finely pilose “guard” hairs about 4 mm. at a density of two or three per square mm. Hairs of the fourth type are short (0.3 mm.), sharply pointed and barbed, and are present in enormous numbers—10,000 to 12,000 per square mm. These are the urticating hairs, which form a characteristic dorsal patch on the rear part of the abdomen. Contrary to von Langsdorff’s (1813) statement, the urticating hairs do not cover the whole body of the spider.

#### URTICATING HAIRS

Urticating hairs appear to be restricted to New World representatives of the theraphosid subfamilies Ischnocolinae, Grammostolinae, Theraphosinae, and Aviculariinae, but do not occur on every species. So far as we can determine there is nothing to suggest that urticating hairs are found outside the New World and certainly none was present on the extensive material we examined. The report attributed to the explorer Henry Stanley [quoted by Schwarz (1890) on the basis of a newspaper article appearing in “Das Ausland”] may be dismissed as journalistic embellishment. Distant (1898), making reference to Bates’s (1863) experiences in Brazil, attributed the near death of a cat in South Africa to the effects of urticating hairs on a specimen of *Harpactira gigas* Pocock, which it had eaten. Nothing in Distant’s account, however, indicates that urticating hairs were really involved and in view of our failure to find urticating hairs on any African spiders, including members of the genus *Harpactira*, we believe this report should be discounted.

According to Bücherl (1951), urticating hairs first appear on *Grammostola* in the third instar, the stage following the first light covering of hairs on the body, when, it is believed, the young spiders leave the parental burrow to lead independent lives. In many young spiders the urticating hairs form a conspicuous dark, velvety spot (fig. 1), which may persist throughout life in some species. In others, however, the edges of the hair field become increasingly indistinct as the spiders age and the body becomes more hirsute. In *Avicularia surinamensis* the spiderlings leaving the cocoon—presumably in the third instar—have a limited number of Type II urticating hairs (see below) only a little smaller than those occurring on the adults, lying flush with the abdominal surface.

In the majority of spiders molting ceases at maturity. However female mygalomorph spiders (and a few other long-lived forms such as female



FIG. 1. Young specimen (third or fourth instar) of *Aphonopelma* sp., showing conspicuous patch of Type I urticating hairs on posterior dorsum of abdomen.

Filistatidae) continue to molt approximately every year throughout life, acquiring at each molt a fresh vestment of hairs (fig. 2). Theraphosids that have not molted for some months in many cases present a rather moth-eaten appearance (fig. 3) and individuals that have used their urticating hairs extensively may even display bald patches corresponding to the size of the hair field.

TABLE 1  
DISTRIBUTION OF URTICATING HAIR TYPES

Species	Locality	Sex	I	Hair Type				
				II	III	IV	None	

ISCHNOCOLINAE								
<i>Cyrtopholis bartholomaei</i> (Latreille)	Antigua	♂	—	—	+	—	—	
<i>C. jamaicola</i> Strand	Haiti	♂	+	—	—	—	—	
<i>C. longistylus</i> Kraus	El Salvador	♂	+	—	—	—	—	
<i>Hapalopus pentaloris</i> (Simon)	Mexico	♀	—	—	+	—	—	
<i>Metriopelma familiare</i> (Simon)	Venezuela	♂	—	—	—	—	+	
GRAMMOSTOLINAE								
<i>Aphonopelma chalcodes</i> Chamberlin	Arizona	♀, ♂	+	—	—	—	—	
<i>A. eutylenum</i> Chamberlin	California	♂	+	—	—	—	—	
<i>A. moderatum</i> (Chamberlin and Ivie)	Texas	♀, ♂	+	—	—	—	—	
<i>A. reversum</i> Chamberlin	California	♀	+	—	—	—	—	
<i>A. seemanni</i> (F. O. Pickard-Cambridge)	Guatemala	♀	+	—	—	—	—	
<i>Delopelma helluo</i> (Simon)	Mexico	♂	+	—	—	—	—	
<i>D. melania</i> Chamberlin and Ivie	Utah	♂	+	—	—	—	—	
<i>Dugesiella hentzi</i> (Girard)	Texas	♀	+	—	—	—	—	
<i>D. wacona</i> Chamberlin	Texas	♀, ♂	+	—	—	—	—	
<i>D. echina</i> Chamberlin	New Mexico	♂	+	—	—	—	—	
<i>Brachypelma emilia</i> (White)	Mexico	♂	+	—	+	—	—	
<i>B. smithi</i> (F. O. Pickard-Cambridge)	Mexico	♀, ♂	+	—	+	—	—	
<i>Eurypelma caniceps</i> Simon	Mexico	♀	+	—	—	—	—	
<i>E. mesomelas</i> O. Pickard-Cambridge	Mexico	♂	—	—	+	—	—	
<i>Citharacanthus spinicrus</i> (Latreille)	Cuba	♂	+	—	+	—	—	
<i>Grammostola</i> sp.	Uruguay	♂	—	—	+	—	—	
<i>G. actaeon</i> (Pocock)	Brazil	♂	—	—	+	+	—	
<i>G. iheringi</i> (Keyserling)	Brazil	♂	—	—	+	—	—	
<i>Paraphysa manicata</i> Simon	Chile	♀	—	—	+	+	—	
<i>Pterinopelma velutinum</i> Mello-Leitao	Brazil	♀	+	—	+	—	—	
<i>Plesiopelma</i> sp.	Brazil	♀	+	—	—	—	—	
<i>Sphaerobothria hoffmani</i> Karsch	Costa Rica	♀, ♂	+	—	—	—	—	
THERAPHOSINAE								
<i>Acanthoscurria atrox</i> Vellard	Brazil	♂	—	—	+	—	—	
<i>A. rhodothele</i> Mello-Leitao	Brazil	♀	+	—	+	—	—	
<i>A. sternalis</i> Pocock	Brazil	♀	+	—	+	—	—	
<i>A. violacea</i> Mello-Leitao	Brazil	♂	+	—	+	—	—	
<i>Lasiodora klugi</i> (C. L. Koch)	Brazil	♂	+	—	+	—	—	
<i>Pamphobeteus tetracanthus</i> Mello-Leitao	Brazil	♀	+	—	—	—	—	

TABLE 1—(Continued)

Species	Locality	Sex	Hair Type				
			I	II	III	IV	None
<i>Phormictopus cancerides</i> (Latreille)	West Indies	♀	—	—	—	—	+
<i>Sericopelma rubronitens</i> (Ausserer)	Panama	♀	+	—	+	—	—
AVICULARIINAE							
<i>Avicularia avicularia</i> (Linnaeus) <sup>b</sup>	Trinidad	♀	—	+	—	—	—
<i>A. surinamensis</i> Strand	Guyana and Trinidad	♂	—	+	—	—	—
<i>A. laeta</i> (C. L. Koch)	Puerto Rico	♀	—	+	—	—	—
<i>A. velutina</i> Simon	Trinidad	♀	—	—	—	—	+
<i>Psalmopeus reduncus</i> (Karsch)	Costa Rica	♀	—	+	—	—	—
<i>Tapinauchenius plumipes</i> (C. L. Koch)	Guyana	♀	—	—	—	—	+
EUMENOPHORINAE							
<i>Phoneyusa bidentata</i> Pocock	Congo	♀, ♂	—	—	—	—	+
<i>Ephebopus murinus</i> (Walckenaer)	Guyana	♀	—	—	—	—	+
SELENOCOSMIINAE							
<i>Ceratogyrus darlingi</i> Pocock	Central Africa	—	—	—	—	—	+
<i>Selenocosmia</i> sp.	New Guinea	♀, ♂	—	—	—	—	+
ORNITHOCTONINAE							
<i>Ornithoctonus andersoni</i> Pocock	India	♀	—	—	—	—	+

<sup>a</sup> Hairs of two distinct sizes present.

<sup>b</sup> Considerable confusion surrounds the identity of these *Avicularia* species and the specific names must be regarded as tentative.

We recognize in the Theraphosidae four main types of urticating hair, and their distribution among the identified species examined is summarized in table 1. A feature common to all four types, and one that distinguishes urticating hairs immediately from other types of abdominal hair, is the mode of attachment. Whereas other abdominal hairs arise from characteristic cups or sockets (figs. 22–24), the urticating hairs are attached to the cuticle of the spider by a smooth stalk approximately 0.10 mm. in length.

DESCRIPTION OF URTICATING HAIR TYPES: Type I (figs. 4–8, 29): Approximate length 0.2–0.6 mm. These hairs are characterized by a group of barbs at the basal (i. e. functionally rear) end that are reversed in direction. These reversed barbs may be separated from the main set of barbs by a length of bare shaft but not always so. The shaft itself is bent or kinked and the main barbs, which form a single or double row, are arranged helically. In front of the main barbs, the shaft tapers to a sharp point and carries minute backward-pointing denticles.

Type II (figs. 9–12, 20): Approximate length 0.5–1.5 mm. These hairs



FIG. 2. *Brachypelma smithi* (F. O. Pickard-Cambridge), soon after molting. A. Frontal view. B. Dorsolateral view of abdomen, showing pelage largely intact. Guard hairs are conspicuous and several dislodged Type III urticating hairs are also visible. The latter are pale in color, much smaller than guard hairs, and tend to clump together.

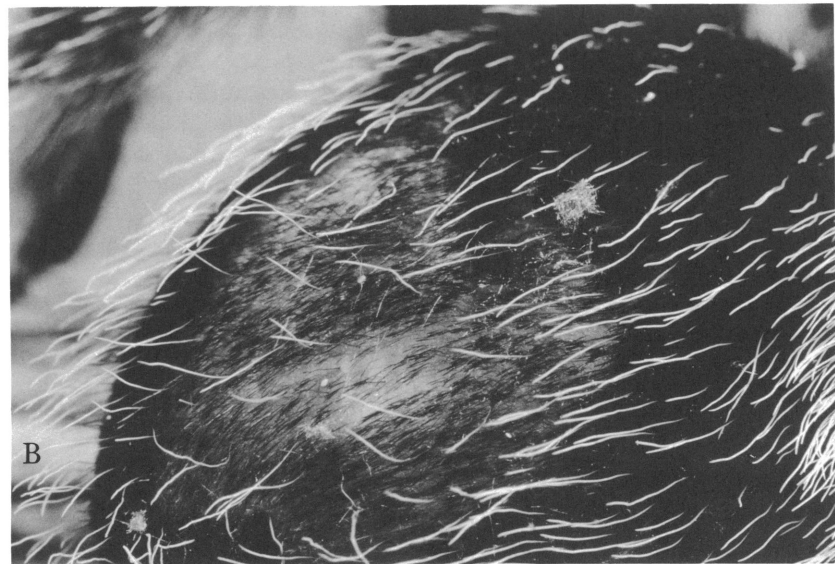


FIG. 3. *Brachypelma smithi* (F. O. Pickard-Cambridge), toward end of intermolt period; as urticating hairs are discharged, hair field becomes rather barren. A. General view of abdomen from behind. B. Detail of the hair field, showing regions of bare cuticle and many loose Type III urticating hairs.

TABLE 2  
RELATIVE PROPORTIONS IN TYPE I URTICATING HAIRS

Species	Sex	Mean Length (in mm.)	Standard Deviation	a/l <sup>a</sup> Mean	Standard Deviation
<b>ISCHNOCOLINAE</b>					
<i>Cyrtopholis jamaicola</i> Strand	♂	0.21	0.013	0.20	0.015
<i>C. longistylus</i> Kraus	♂	0.50	0.018	0.19	0.007
<b>GRAMMOSTOLINAE</b>					
<i>Aphonopelma chalcodes</i> Chamberlin	♂	0.43	0.016	0.42	0.017
<i>A. eutylum</i> Chamberlin	♂	0.40	0.009	0.43	0.014
<i>A. moderatum</i> (Chamberlin and Ivie)	♀	0.46	0.013	0.44	0.010
<i>A. reversum</i> Chamberlin	♀	0.35	0.031	0.36	0.022
<i>A. seemanni</i> (F. O. Pickard-Cambridge)	♀	0.40	0.015	0.19	0.011
<i>Delopelma helluo</i> (Simon)	♂	0.27	0.027	0.34	0.013
<i>D. melania</i> Chamberlin and Ivie	♂	0.27	0.009	0.40	0.020
<i>Dugesia hentzi</i> (Girard)	♀	0.34	0.010	0.29	0.015
<i>D. wacona</i> Chamberlin	♀	0.28	0.011	0.20	0.018
<i>D. echina</i> Chamberlin	♂	0.44	0.021	0.44	0.025
<i>Brachypelma emilia</i> (White)	♂	0.36	0.047	0.25	0.050
<i>B. smithi</i> (F. O. Pickard-Cambridge)	♂	0.38	0.052	0.23	0.019
<i>Eurypelma caniceps</i> Simon	♀	0.41	0.015	0.29	0.019
<i>Citharacanthus spinicrus</i> (Latreille)	♂	0.28	0.020	0.19	0.021
<i>Pterinopelma vellutinum</i> Mello-Leitao	♀	0.50	0.044	0.21	0.032
<i>Plesiopelma</i> sp.	♀	0.28	0.009	0.22	0.005
<i>Sphaerobothria hoffmani</i> Karsch	♂	0.47	0.027	0.25	0.011
<b>THERAPHOSINAE</b>					
<i>Acanthoscurria rhodothele</i> Mello-Leitao	♀	0.45	0.015	0.13	0.017
<i>A. sternalis</i> Pocock	♀	0.42	0.007	0.12	0.000
<i>A. violacea</i> Mello-Leitao	♂	0.22	0.019	0.17	0.016
<i>Lasiodora klugi</i> (C. L. Koch)	♂	0.44	0.034	0.22	0.030
<i>Pamphobeteus tetracanthus</i> Mello-Leitao	♀	0.57	0.011	0.27	0.011
<i>Sericopelma rubronitens</i> (Ausserer)	♀	0.18	0.005	0.39	0.030

<sup>a</sup> See figure 29.



FIG. 4. Type I urticating hair, in silhouette.

TABLE 3  
RELATIVE PROPORTIONS IN TYPE I URTICATING HAIRS

Species	Sex	b/l <sup>a</sup> Mean	Standard Deviation	c/l <sup>a</sup> Mean	Standard Deviation
<b>ISCHNOCOLINAE</b>					
<i>Cyrtopholis jamaicola</i> Strand	♂	0.14	0.029	0.18	0.019
<i>C. longistylus</i> Kraus	♂	0.21	0.04	0.15	0.015
<b>GRAMMOSTOLINAE</b>					
<i>Aphonopelma chalcodes</i> Chamberlin	♂	0.10	0.012	0.10	0.012
<i>A. eutyleneum</i> Chamberlin	♂	0.11	0.013	0.12	0.015
<i>A. moderatum</i> (Chamberlin and Ivie)	♀	0.10	0.022	0.10	0.011
<i>A. reversum</i> Chamberlin	♀	0.11	0.008	0.13	0.029
<i>A. seemanni</i> (F. O. Pickard-Cambridge)	♀	0.19	0.029	0.19	0.008
<i>Delopelma helluo</i> (Simon)	♂	0.12	0.017	0.16	0.025
<i>D. melania</i> Chamberlin and Ivie	♂	0.09	0.020	0.13	0.016
<i>Dugesia hentzi</i> (Girard)	♀	0.12	0.022	0.17	0.012
<i>D. wacona</i> Chamberlin	♀	0.19	0.019	0.23	0.016
<i>D. echina</i> Chamberlin	♂	0.09	0.019	0.11	0.023
<i>Brachypelma emilia</i> (White)	♂	0.15	0.032	0.17	0.032
<i>B. smithi</i> (F. O. Pickard-Cambridge)	♂	0.18	0.029	0.17	0.030
<i>Eurypelma caniceps</i> Simon	♀	0.15	0.011	0.15	0.015
<i>Citharacanthus spinicrus</i> (Latreille)	♂	0.20	0.042	0.17	0.014
<i>Pterinopelma vellutinum</i> Mello-Leitao	♀	0.17	0.054	0.12	0.012
<i>Plesiopelma</i> sp.	♀	0.16	0.020	0.18	0.017
<i>Sphaerobothria hoffmani</i> Karsch	♂	0.18	0.030	0.14	0.014
<b>THERAPHOSINAE</b>					
<i>Acanthoscurria rhodothele</i> Mello-Leitao	♀	0.24	0.026	0.18	0.020
<i>A. sternalis</i> Pocock	♀	0.33	0.015	0.14	0.037
<i>A. violacea</i> Mello-Leitao	♂	0.17	0.041	0.20	0.019
<i>Lasiodora klugi</i> (C. L. Koch)	♂	0.26	0.045	0.12	0.019
<i>Pamphobeteus tetracanthus</i> Mello-Leitao	♀	0.16	0.017	0.12	0.012
<i>Sericopelma rubronitens</i> (Ausserer)	♀	0.10	0.031	0.17	0.030

<sup>a</sup> See figure 29.

are found only on certain members of the subfamily Aviculariinae, particularly the genus *Avicularia*. They take the form of a straight, sometimes rather cigar-like shaft, pointed at both ends. The barbs are small and in *Avicularia surinamensis* (fig. 12) consist only of tiny spatulate denticles restricted to the basal end. In *A. avicularia* (fig. 11), however, the barbs are rather larger and cover all but the distal portion of the shaft.

The most remarkable feature of Type II hairs, and one that sets them quite apart from other spider hairs, is the direction in which the barbs lie. In the other three hair types the barbs are directed in such a way that the penetrating tip of the hair is upward, away from the body, i.e. distal.

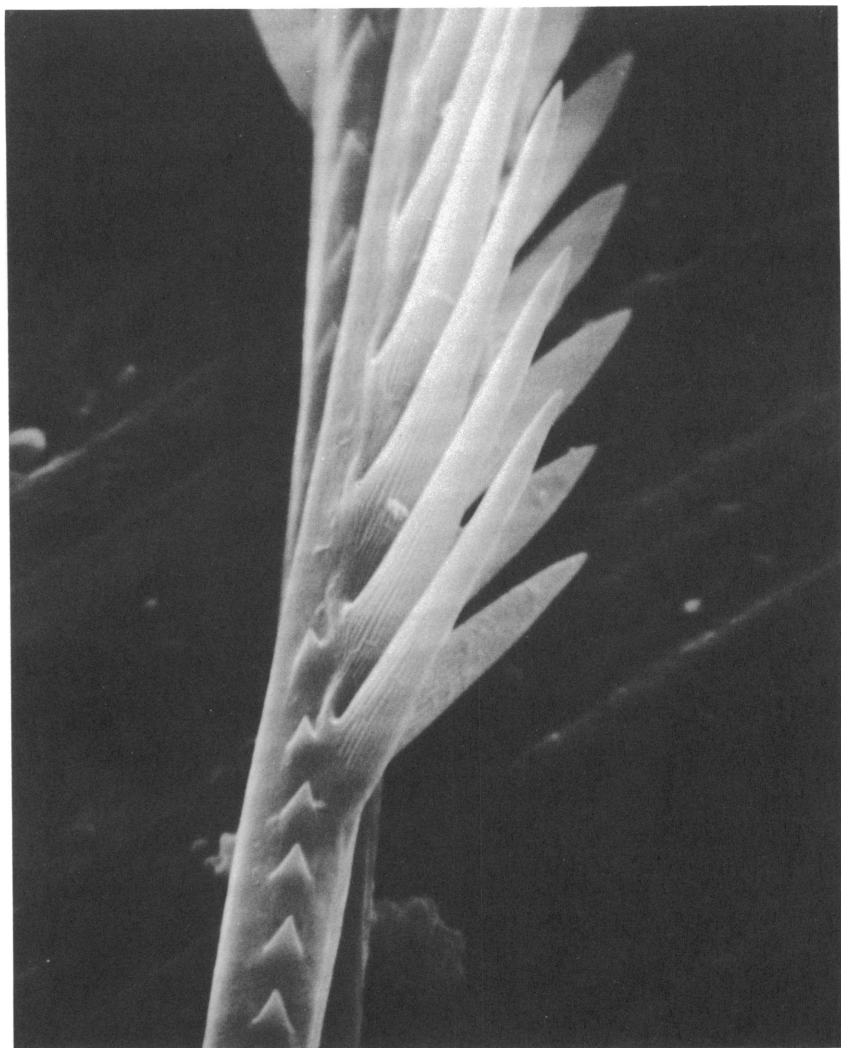


FIG. 5. *Lasiodora klugi* (C. L. Koch). Type I urticating hair, showing main barbs lying in double row distally and small denticles that extend along the shaft from penetrating tip.  $\times 2100$ .

In contrast the Type II hairs lie with the penetrating tip downward (figs. 20, 21). The point at which the hair is attached to its supporting stalk, just distal to the tip, presents after the hair is shed, the appearance



FIG. 6. *Lasiadora klugi* (C. L. Koch). Detail of paired distal main barbs of Type I urticating hair.  $\times 5400$ .

of a small pore, (visible in fig. 12). By analogy with the hairs of Lepidoptera, we suspected that this pore might lead into the lumen of the shaft and that Type II hairs could possess a chemical irritant. The small size of the barbs and the curious orientation of the hairs also lent weight

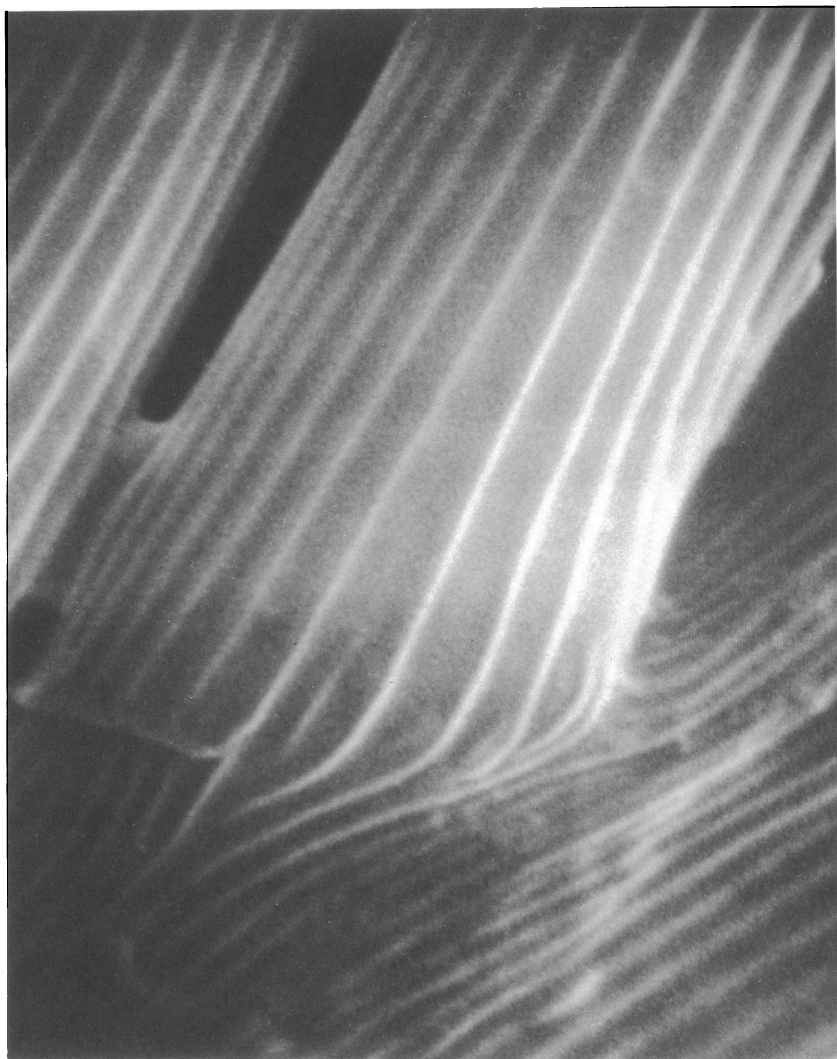


Fig. 7. *Lasiodora klugi* (C. L. Koch). Type I urticating hair. Detail of surface sculpturing at junction between the main barbs and shaft.  $\times 13,000$ .

to this idea. However, sectioning the hairs revealed that the lumen ended some distance from the pore and was not in connection with the outside, making it unlikely that any chemical irritants are actually involved.

Type III (figs. 13-16): Approximate length 0.3-1.2 mm. These long,



FIG. 8. *Lasiodora klugi* (C. L. Koch). Reversed barbs at basal end of Type I urticating hairs.  $\times 780$ .

thin straight-shafted hairs have a fine point and barbs along at least one-half the length. There is considerable variation not only in length but also in the size and density of the barbs among hairs of this type.

Type IV (figs. 17–18): Approximate length 0.06–0.2 mm. These very small dartlike hairs are chiefly characterized by their size and appear to be typical of the genus *Grammostola*. Although the shaft may be either straight or bent, they resemble one another in having the barbs restricted to the posterior end. Nothing is known of the urticating effects of Type IV hairs, but it is possible that they are responsible for the effects reported by Bücherl (1951) in rats and mice (see below).

In those spiders possessing more than one kind of urticating hair it appears that, in some species at least, the different types are segregated into distinct areas of the hair field. However, it is not clear whether all species have the hairs so arranged or whether in some the hair types are mixed randomly over the entire field. Examination of the abdomen under the binocular microscope presents a confused picture because the hairs are so densely packed. However, if the abdominal wall is sectioned (fig. 19) the arrangement of the hairs on their supporting stalks is clearly visible and the question of the distribution of different hair types will probably be resolved by a program of serial sectioning.



FIG. 9. Type II urticating hair, in silhouette.

TABLE 4  
VARIATION IN TYPE III URTICATING HAIRS

Species	Sex	Mean Length (in mm.)	Standard Deviation	a/l <sup>a</sup> Mean	Standard Deviation
ISCHNOCOLINAE					
<i>Cyrtopholis bartholomaei</i> (Latreille)	♂	0.47	0.031	0.30	0.014
<i>Hapalopus pentaloris</i> (Simon)	♀	0.36	0.008	— <sup>b</sup>	—
GRAMMOSTOLINAE					
<i>Brachypelma emilia</i> (White)	♂	0.76	0.060	0.36	0.025
<i>B. smithi</i> (F. O. Pickard-Cambridge)	♀	1.51	0.040	0.19	0.029
<i>Eurypelma mesomelas</i> O. Pickard-Cambridge	♂	1.04	0.037	0.28	0.028
<i>Citharacanthus spinicrus</i> (Latreille)	♂	0.66	0.015	0.33	0.028
<i>Grammostola</i> sp.	♂	0.36	0.037	—	—
<i>G. acteon</i> (Pocock)	♂	1.08	0.084	—	—
<i>G. iheringi</i> (Keyserling)	♂	1.21	0.020	0.15	0.017
<i>Paraphysa manicata</i> Simon	A ♀	0.62	0.025	—	—
	B ♀	0.44	0.049	—	—
<i>Pterinopelma velutinum</i> Mello-Leitao	♀	0.64	0.036	0.32	0.022
THERAPHOSINAE					
<i>Acanthoscurria atrox</i> Vellard	♂	0.84	0.004	—	—
<i>A. rhodothele</i> Mello-Leitao	♀	0.82	0.018	0.27	0.017
<i>A. sternalis</i> Pocock	♀	0.74	0.028	—	—
<i>Lasiodora klugi</i> (C. L. Koch)	♂	0.65	0.049	0.30	0.030
<i>Sericopelma rubronitens</i> (Ausserer)	♀	0.46	0.017	—	—

<sup>a</sup> See figure 29.

<sup>b</sup> In some species, especially those with small barbs, it was not possible to measure the distance "a" with accuracy so the ratio a/l is omitted.

When hairs are removed from spiders by scraping, the supporting stalks are often broken off from the integument but remain attached to the hairs. This happens particularly with Type II hairs and helps confirm their somewhat unexpected orientation with the tip down, as evidenced by the direction of the barbs (figs. 20, 21).

By examining areas from which the hairs have been shed, it is possible to calculate hair density by counting the basal stalks. A series of such counts on *Aphonopelma chalcodes* gave a density of 9800–11,400 Type I hairs per square mm. over most of the area, but toward the edges of the hair field, particularly ventrally where the integument is much folded, the numbers drop off somewhat. Thus a medium-sized spider would have over one million hairs to shed during each intermolt period. In *Avicularia* the number of Type II hairs is substantially less. Under the SEM, patches

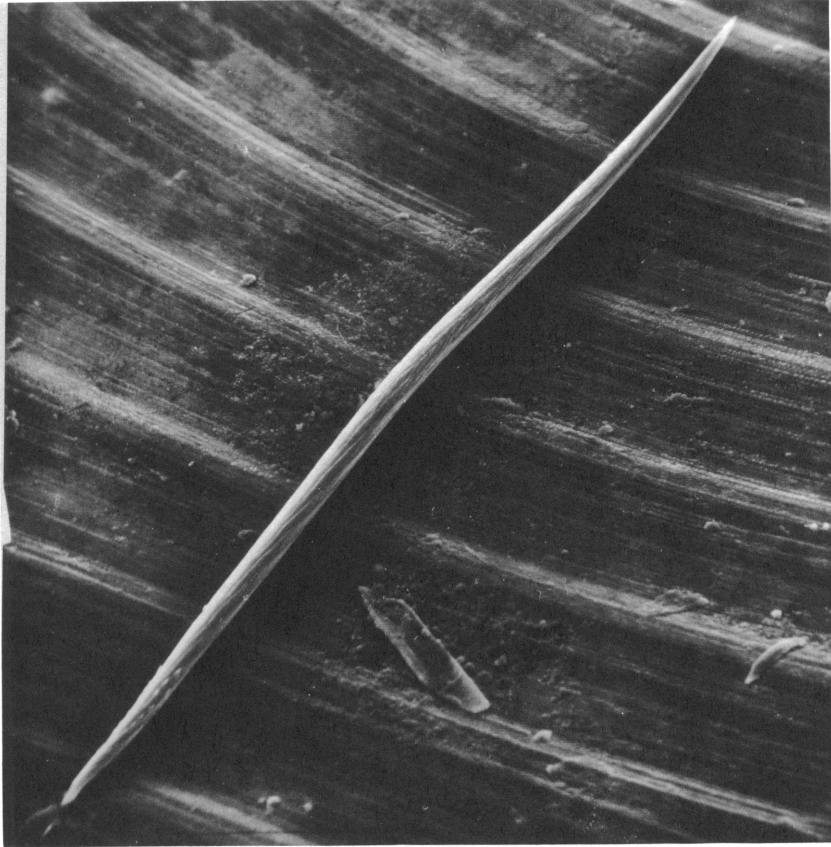


FIG. 10. *Avicularia surinamensis* Strand. Type II urticating hair.  $\times 205$ .

of integument from which the hairs have been removed take on a curiously desolate appearance (figs. 22, 23). Among the forest of stalks may be seen not only the insertion sockets of the ordinary hairs (fig. 24) but hitherto unknown structures, presumably sensilla, that resemble small baskets of eggs (fig. 25). The function of these sensilla is uncertain, but it is possible that they may monitor the turgidity of the abdominal wall.

#### DEFENSIVE BEHAVIOR

The response of theraphosid spiders to attack or the threat of attack is subject to both specific and individual variation. Among species that lack urticating hairs the spiders tend to turn rapidly toward the stimulus and

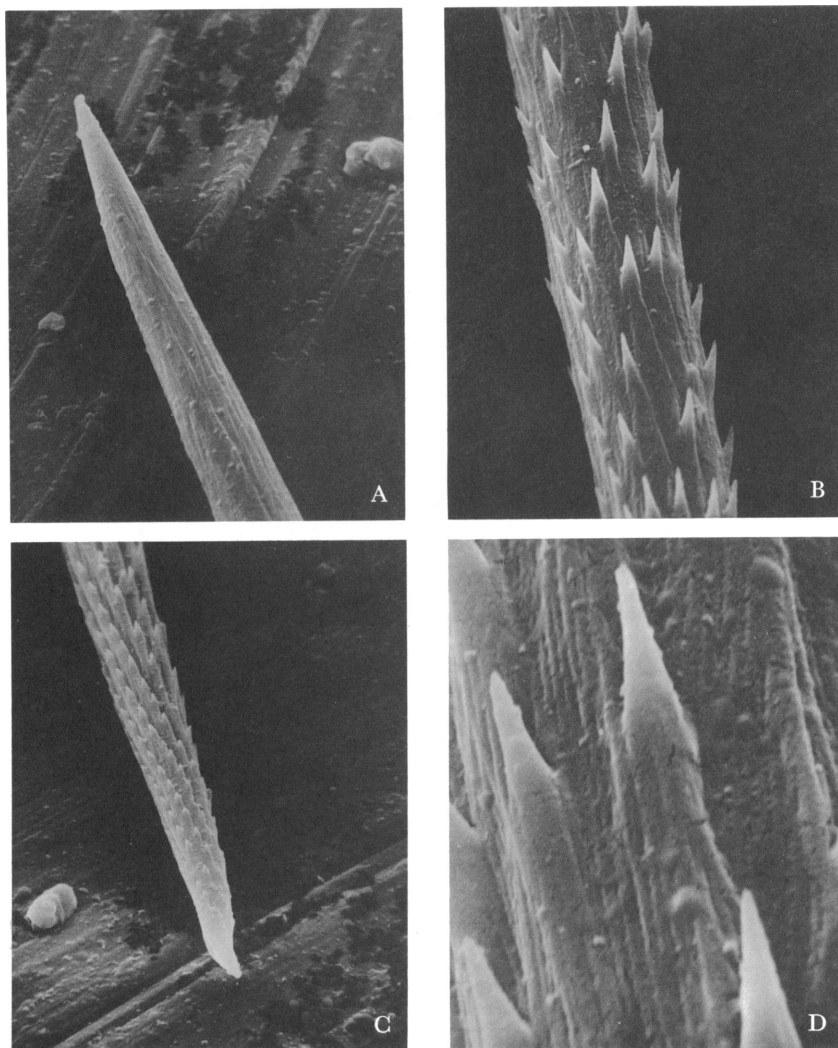


Fig. 11. *Avicularia avicularia* (Linnaeus). Type II urticating hair. A. Smooth distal section.  $\times 510$ . B. Barbed midsection.  $\times 510$ . C. Penetrating basal tip.  $\times 510$ . D. Detail of midsection barbs.  $\times 2550$ .

assume an aggressive stance with the fangs displayed. Thus in the African genera *Citharischius* Pocock and *Pterinochilus* Pocock, for example, even a slight disturbance causes the spider to raise the body almost vertical with the anterior legs stretched out, and to lunge forward repeatedly. The fangs,

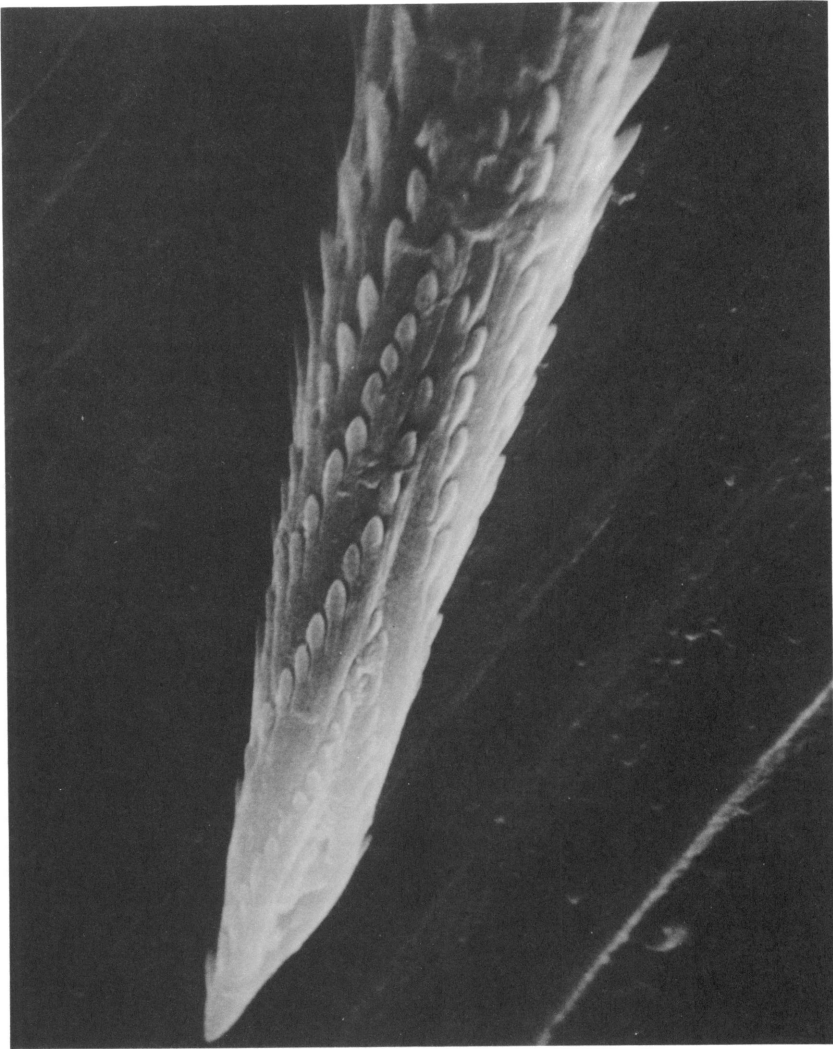


FIG. 12. *Avicularia surinamensis* Strand. Basal tip of Type II urticating hair. Note depression marking point at which supporting stalk was inserted.  $\times 2400$ .

which are surrounded by bright red hairs, are open, and stridulating organs lying between the chelicerae and the maxillae emit a loud hissing sound. Among New World spiders such aggressive behavior is less common. Except when attacked by *Pepsis* wasps, when they often assume a defensive stance at or near the entrance to their burrow (Cazier and Mortenson,



FIG. 13. Type III urticating hair, in silhouette.

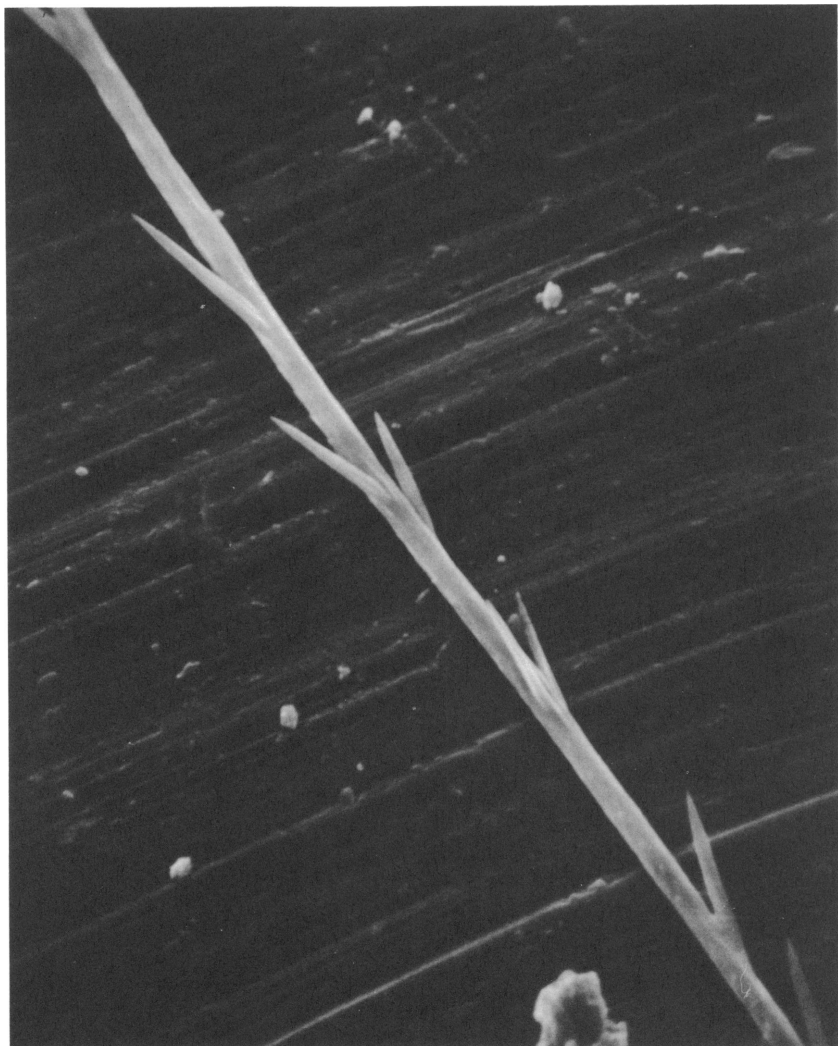


FIG. 14. *Acanthoscurria rhodothele* Mello-Leitao. Midsection of Type III urticating hair, showing massive, well-spaced barbs.  $\times 540$ .



FIG. 15. *Grammostola acteon* (Pocock). Midsection of Type III urticating hair, showing form of barbs.  $\times 2400$ .

1964), American theraphosids slowly retreat from potential predators often laying down an entangling snare of silk at the same time. Usually it is only as a last resort when approached from the front or cornered that spiders such as *Aphonopelma* will use their fangs. The most typical defensive reaction, particularly if attacked from behind, is hair-flicking. The thresh-



FIG. 16. *Brachypelma smithi* (F. O. Pickard-Cambridge). Midsection of Type III urticating hair, showing extremely long barbs.  $\times 2100$ .

old for this release of urticating hairs varies widely not only between species but also between individuals.

The hairs are dislodged from their supporting stalks by rapid vibrations of one or both of the hind legs, which are lifted onto the dorsum of the abdomen. It appears that the ventral metatarsal spines play an important



FIG. 17. Type IV urticating hair, in silhouette.

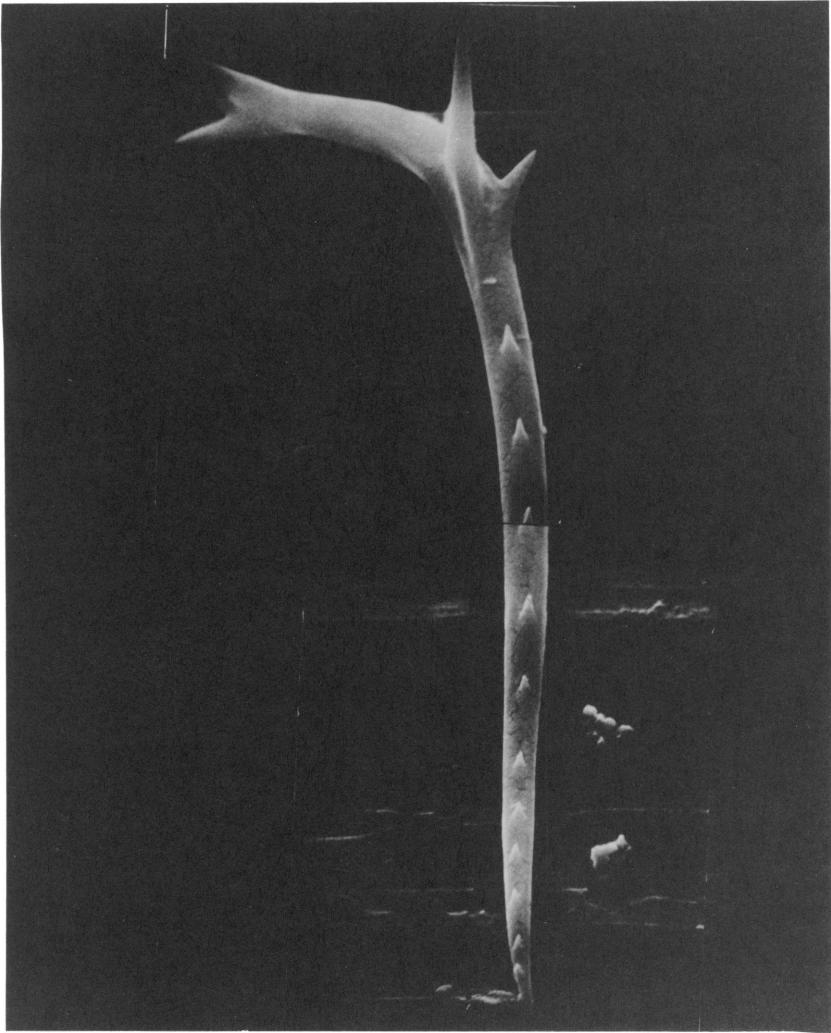


FIG. 18. Mosaic of Type IV urticating hair from unidentified theraphosid from Chile.  $\times 1850$ .

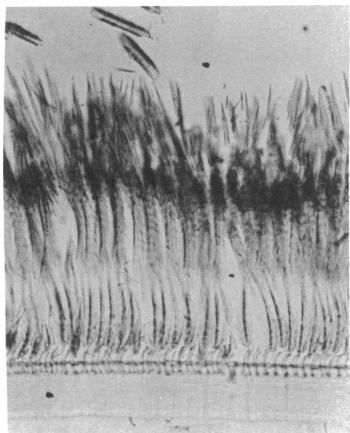


FIG. 19. *Aphonopelma chalcodes* Chamberlin. Section through dorsal abdominal wall, showing alignment of dense layer of Type I urticating hairs on supporting stalks.  $\times 86$ .

role in combing off the hairs, although no comparative study of these structures has yet been made between species possessing urticating hairs and those that do not.

It is doubtful whether the urticating hairs provide any protection against such insect parasites as acrocerid flies or pompilid wasps, and indeed attacks by pompilids, although quite often observed (e.g. Williams, 1956; Cazier and Mortenson, 1964) have never been reported to induce hair flicking. *Aphonopelma* sometimes releases hairs half-heartedly if surrounded by harvester ants (*Pogonomyrmex* sp.) in experimental conditions but this is probably a generalized response indicating irritability and does not appear to have the least effect on the ants. Thus the role of the spider hairs contrasts markedly with that of the highly specialized hastate hairs

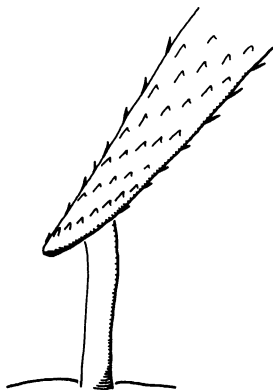


FIG. 20. Diagram of Type II urticating hair to show way in which supporting stalk is attached.



FIG. 21. Distal tip of Type II urticating hair from *Avicularia surinamensis* Strand, showing supporting stalk still attached.  $\times 2400$ .

of dermestid beetle larvae (Nutting and Spangler, 1969) whose prime role is defense against arthropod predators. The dermestid hairs function by entangling their arthropod victims and have no immediate effect against vertebrate predators. However, it should be added that many people suffer quite severe allergic reactions to contact with the accumulations of hastate hairs associated with *Dermestes* infestations.

Little is known of the natural predators of theraphosid spiders, which are seldom recorded from the stomach contents of birds and mammals and never from reptiles or amphibia. It is possible, of course, that the absence of theraphosids from the known diet of snakes and lizards reflects the effectiveness of the defense system of the spider, but as yet we have no data on the reactions of these animals to theraphosid urticating hairs.

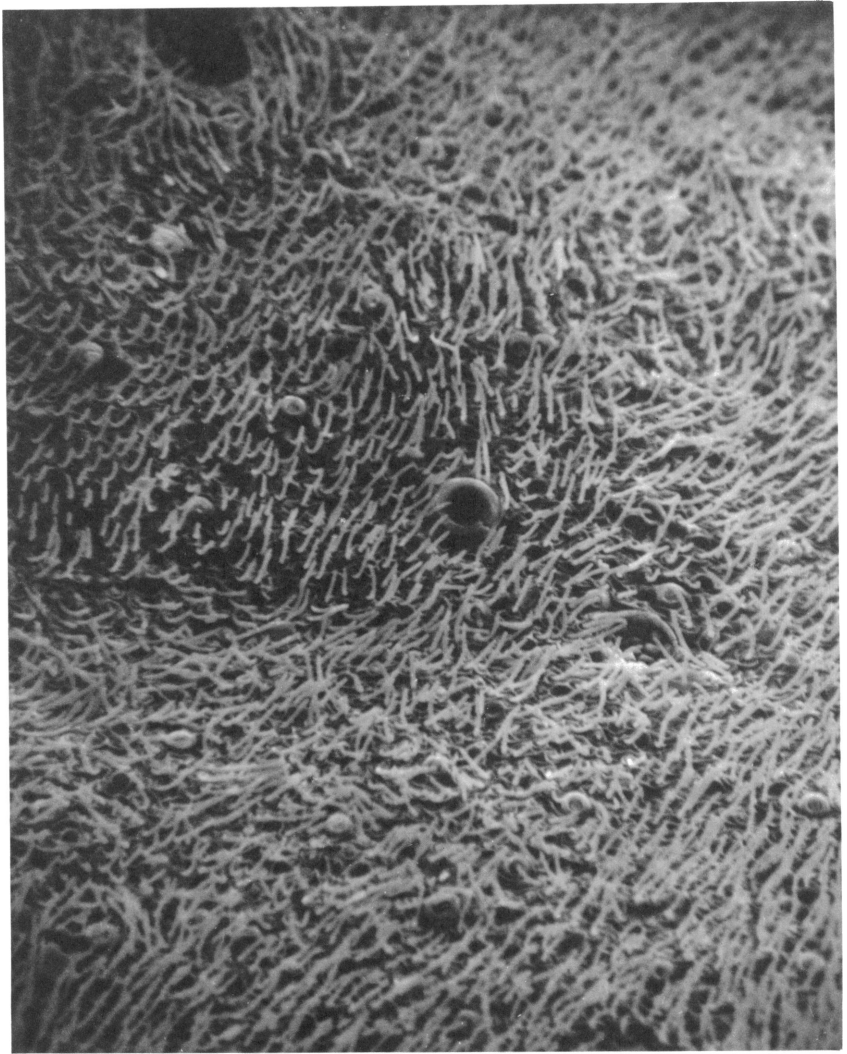


FIG. 22. *Aphonopelma chalcodes* Chamberlin. Dorsal abdominal surface showing stalks that supported urticating hairs and insertion sockets of other types of abdominal hairs. Large socket of a long guard hair is visible near center of picture.  $\times 210$ .

Theraphosids are cryptic animals and seldom leave their burrows except in the mating season, when adult males may sometimes be found in quite large numbers at dusk. Despite their crepuscular activity, they are ap-



FIG. 23. *Aphonopelma chalcodes* Chamberlin. Dorsal abdominal surface, showing supporting stalks in area where Type I urticating hairs have been discharged. Also visible are insertion sockets of two of the hairs that make up basic abdominal pelage.  $\times 1200$ .

parently not normally preyed upon by the insectivorous owls (Bent, 1938; Ligon, 1968; Ross, 1969) even though the latter do eat Araneomorph spiders, scorpions, and centipedes. However, Ohlendorf (1971) cited a

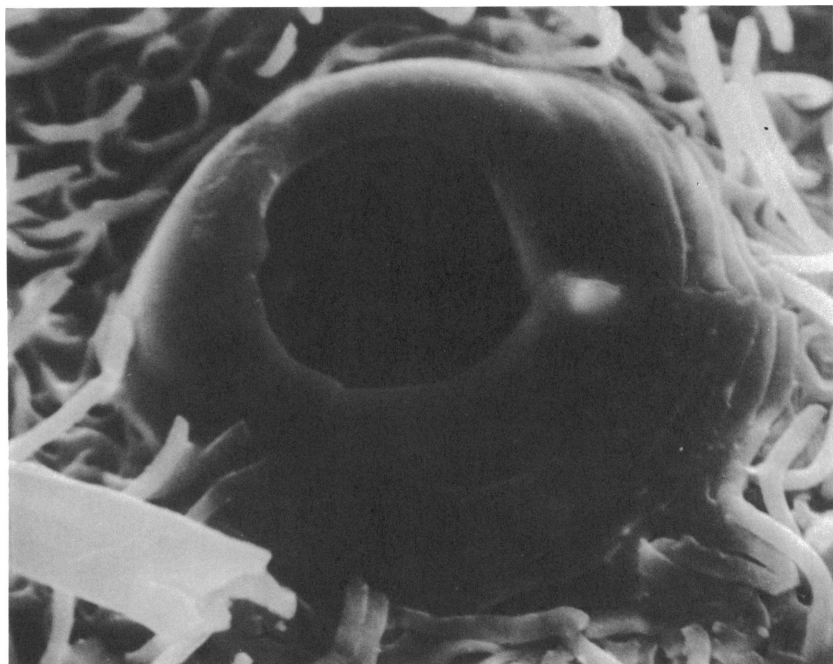


FIG. 24. *Aphonopelma chalcodes* Chamberlin. Insertion socket of abdominal guard hair, surrounded by supporting stalks of Type I urticating hairs.  $\times 950$ .

Western Horned Owl [*Bubo virginianus* (Gmelin)] in Texas as having fed upon *Dugesia*. Similarly theraphosids are not recorded among the prey of the roadrunner [*Geococcyx californianus* (Lesson)] (Bryant, 1916; McAtee, 1931), which is an omnivorous predator. The record quoted by Sutton (1940) clearly refers to a lycosid spider and not to a theraphosid. Out of more than 11,000 coyote (*Canis latrans* Say) stomachs and scats examined (Sperry, 1941; Ferrel, Leach, and Tillotson, 1953; Korschgen, 1957) only three contained theraphosid remains. Korschgen (1957) also found one specimen among 352 stomachs of the Gray Fox [*Urocyon cinereoargenteus* (Schreber)] in Missouri, but he found none in the stomachs of Red Fox (*Vulpes vulpes* Linnaeus) in Kansas. Cutler (1958) found none in the food of the Swift Fox [*Vulpes velox* (Say)] in northern Texas and Stains (1956) found none in raccoon [*Procyon lotor* (Linnaeus)] scats in Kansas. The only published accounts of theraphosids defending themselves against vertebrates are those of Bücherl (1951) and Torres (1921). Bücherl described how rats and mice provoke the release of urticating hairs from *Grammostola*



FIG. 25. *Aphonopelma chalcodes* Chamberlin. Surface view of abdominal structure of unknown function, presumed to be a sense organ.  $\times 1200$ .

and *Lasiodora*. The rodents are immediately affected and show increasing discomfort until some two hours later the mucosa of the respiratory tract is so inflamed that they may die from asphyxia. In a later work Bücherl (1962) stated that the spiders make use of the hairs to drive rodents from

TABLE 5  
REACTION OF CAGED MAMMALS TO EDIBLE GRASSHOPPERS AND SPIDERS

Species	Individual Test Animals	Reaction <sup>a</sup> to:	
		Grasshopper	<i>Aphonopelma</i> sp.
Coyote, <i>Canis latrans</i> Say	A and B	2	2
Bobcat, <i>Felis rufus</i> (Schreber)	A	2	2
Mountain Lion, <i>Felis concolor</i> Linnaeus	A	2	2
Javelina, <i>Tayassu tajacu</i> (Linnaeus)	A	3, 4, 5	2
	B	2	3, 1
Striped Skunk, <i>Mephitis</i> <i>mephitis</i> (Schreber)	A and B	2	2
	C	4, 5	4
Hooded Skunk, <i>Mephitis</i> <i>macroura</i> Lichtenstein	A and B	4	3, 0 <sup>b</sup>
Kit Fox, <i>Vulpes macrotis</i> Merriam	A and B	4	3 <sup>b</sup>
Raccoon, <i>Procyon lotor</i> (Linnaeus)	A	4	3
	B and C	4, 6	3, 0 <sup>b</sup>
Coati Mundi, <i>Nasua narica</i> (Linnaeus)	A-F	6	6
Badger, <i>Taxidea taxus</i> (Schreber)	A	4, 6	3
	B	4, 6	3, 0 <sup>b</sup>
Ring-tailed Cat, <i>Bassariscus</i> <i>astatus</i> (Lichtenstein)	A	4, 6	3, 5
	B	4, 6	3, 0 <sup>b</sup>
Grasshopper Mouse, <i>Onychomys</i> <i>torridus</i> (Coues)	A and B	6	4, 6
	C and D	6	3, 0 <sup>b</sup>
Domestic Dog, <i>Canis familiaris</i> Linnaeus	A	—	3, 4 <sup>b</sup>

<sup>a</sup> Reactions are rated as follows: 0, retreat; 1, fear; 2, indifference; 3, curiosity; 4, maul and sometimes kill; 5, eats daintly; 6, eats voraciously.

<sup>b</sup> Tarantula gave hair-flicking response.

their burrows, which the spiders then take over. Torres, working with spiders doubtfully attributed to the genus *Theraphosa*, observed symptoms of distress in mice and birds but clearly not so extreme as those reported by Bücherl. In addition, Baerg (1938) attributed the death of white rats under experimental conditions to the hairs of *Brachypelma emilia*.

In order to test further the defensive value of urticating hairs to spiders a number of potential predators were presented with adult males of an undescribed *Aphonopelma* species from southeastern Arizona. The tests were artificial in that the spiders were not within their burrows and the predators were well-fed captive animals lent by local zoos. In order to

test the willingness of the predators to feed each was first offered an edible grasshopper. The results of these tests, each with a different animal, are summarized in table 5. The dog and foxes did not appear to be affected by the hairs and one fox ate a spider without any apparent irritation. The badger, raccoons, hooded skunks, and ring-tailed cat backed off immediately after the spider started hair-flicking and except for the hooded skunks, all showed discomfort with eye-blinking and mouth-licking. The coati mundi attacked so rapidly that it did not give the spider time to discharge hairs. Coati mundi are voracious feeders that even eat lubber grasshoppers [*Taeniopoda eques* (Burmeister)] which are normally rejected by other animals.

The grasshopper mice belonging to the genus *Onychomys* Baird are important predators of invertebrates and readily attacked the spiders offered. However, the latter proved to be formidable opponents. Although two spiders were killed in four tests, the mice all appeared to be affected by hairs in their eyes. In two cases it was interesting to note that the mice ate the spider abdomen from beneath, leaving the area of urticating hair intact. Several exotic mammals, including a stump-tailed macaque (*Macaca speciosa* Cuvier), three squirrel monkeys [*Saimiri sciureus* (Linnaeus)] and two tayras [*Eira barbara* (Linnaeus)] were frightened by spiders and would not attack even though they fed ravenously on grasshoppers.

It should be noted that members of the genus *Aphonopelma* have only Type I hairs, which produce almost no urticaria in man (see below).

#### URTICATING HAIR FUNCTION

What slight attention the urticating hairs of spiders have attracted in the past has, to a large extent, been due to their effects on man, and their true defensive role in nature has not really been studied.

A large proportion of the New World theraphosids are comparatively docile and may be handled without difficulty or danger. This is particularly true of the species occurring in the United States. However, even a spider that does not object to being handled, may, if hurt or agitated, throw off hairs. Most people who handle theraphosids are familiar with the urtication that can result. It can range from a mild, short-lived pricking sensation to intense discomfort, with extensive inflammation that may persist intermittently for several weeks. It appears that Type I hairs have little effect on man for we have never experienced any marked discomfort when handling spiders possessing only these hairs. Moreover, we have applied Type I hairs to various sensitive areas such as lips and eyelids of volunteers both young and old without eliciting more than the mildest reaction. So far as man is concerned, it is mainly the Type III hairs that

cause trouble. Reliable reports in the literature (e.g. Vellard, 1936; Bücherl, 1951) mention the genera *Lasiodora*, *Grammostola*, and *Acanthoscurria* as being particularly urticarious and to this list we can add *Brachypelma smithi*, a distinctively marked species of considerable size from Colima in Mexico (fig. 2). The effects generally follow the handling of live spiders, but systematists are all too familiar with the equally unpleasant response that can result from wetting the skin with alcohol in which one of these spiders has been preserved. This conflicts with the statement by Torres (1921), who claimed that hairs from spiders that had been dead for a few hours produced no irritation. It is conceivable that Torres was experimenting with spiders whose hairs contained a toxin of some sort, and this would also explain his observation that the irritation ceased with the application of ammonia or alcohol. Unfortunately it is not possible to determine what hair types were present on the spiders that Torres used in his experiments.

In 1951, Dr. R. E. Wheeler, then Professor of Bacteriology at Tufts College Medical School, Boston, made patch tests on 27 subjects using the sediment from the bottom of jars in which specimens of *Aphonopelma* had been stored. The results of these tests, which have not been published, were:

NEGATIVE		POSITIVE		TOTAL
	Slight	Moderate	Marked	
5	6	13	3	27

The usual reaction was a raised red papular area limited to the size of the patch (about 1 cm. square). A few showed vesicles. Some showed quite a persistent reaction, lasting up to two weeks and nearly all those who reacted complained of itching, which was sometimes intense.

In Dr. Wheeler's view too many subjects reacted to justify an allergic interpretation, thus implicating the hair themselves. Microscopical examination confirmed the presence of urticating hairs in the sediment used.

The question of whether spider hairs produce their urticaria mechanically or by means of chemical irritants has hitherto been almost wholly ignored in the literature. Marx (quoted by Schwarz, 1890) believed the irritation to be mechanical and suggested (quite correctly) that the hairs might be barbed. In view of the size of the hairs it is indeed extraordinary that neither Marx nor any other arachnologist has apparently thought to look at them under the microscope, where barbs are clearly visible even at low magnifications. Savory (1928), on the other hand, assumed without evidence that spider hairs function similarly to the hairs of some Lepidoptera and were both hollow and associated with glands producing a chemical irritant.

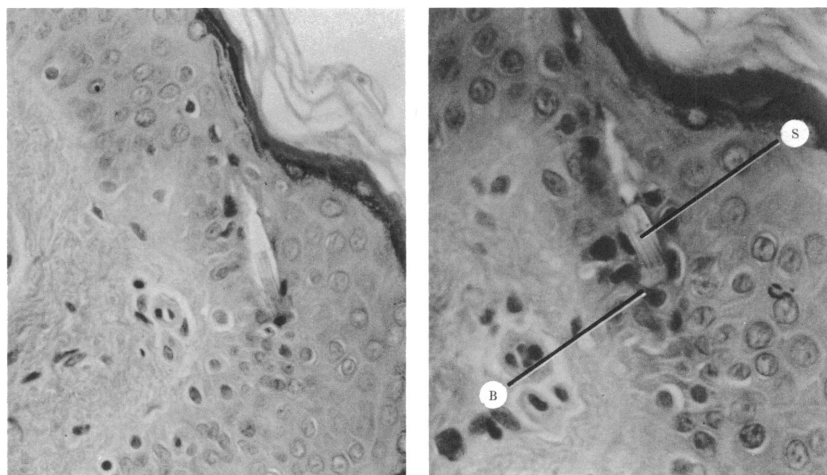


FIG. 26. Adjacent sections of human skin (different magnifications) with embedded fragments of Type III urticating hairs from *Brachypelma smithi* (F. O. Pickard-Cambridge).

Abbreviations: B, barb; S, shaft.

A third possibility is that the hairs, being protein, might provoke an antibody response. Although this would provide no protection to the individual spider, it would, of course, be advantageous to the species. If the reaction were in the nature of a protein allergic response, then it would not be necessary for the hairs to penetrate the skin deeply, but simply remain snagged on the surface, as indeed is the case with Type I hairs. Alternatively they might penetrate the sweat pores as has been postulated may happen with the highly urticarious East African "Buffalo Bean" (*Mucuna* sp.).

In order to examine these various possibilities, hairs from a live female *Brachypelma smithi* were applied to several regions of the body of a volunteer (Cooke). After some 20 to 30 minutes, an area of skin about 20 mm. across on the inner side of the arm just above the elbow, which had become inflamed and extremely itchy was excised under local anesthesia and fixed for both histological and electron microscopical examination. It was found that Type III hairs had penetrated extremely rapidly and in some cases had reached a depth of 2 mm. or more. None was found associated with sweat pores. A careful examination of the sections (fig. 26) by John L. Duffy, Associate Chairman of the Department of Pathology, Nassau County Medical Center, disclosed no indication of any reaction other than the minimal edema caused by straightforward mechanical

irritation, and nothing to suggest the presence of a chemical irritant.

*Brachypelma smithi* possess both Type I and Type III hairs but in the sections of human skin only the larger Type III hairs were found. This observation, coupled with the fact that in *Aphonopelma* and *Dugesiella* (which possess only Type I hairs) the effect on man is minimal, prompted us to investigate the function of Type I hairs further. Since it appears that the urticating hairs are of use primarily against small mammal predators it was decided to use laboratory white mice in our experiments. Because of Bücherl's (1951) report on the drastic effects of *Grammostola* hairs on the respiratory mucosa of rats and mice we initially assumed that they had to be inhaled to produce their effect. Early attempts to introduce hairs into the nose and mouth of anesthetized mice had only limited success. The hairs had been removed from *Aphonopelma chalcodes* some time prior to the experiments and had become compacted into a ball. Despite attempts to loosen the hairs and "spray" them in, none penetrated the respiratory mucosa. The majority were carried in the mucous stream into the stomach, where they did no damage and only a few became embedded in the tongue. On regaining consciousness the mice exhibited only very mild, short-lived symptoms of discomfort. In subsequent experiments the hairs were brushed directly off the spider into the nose and mouth of the anesthetized mouse. When applied in this way, the mice soon exhibited symptoms indicative of distress on recovery from anesthesia, and in some cases it appeared that hairs had entered the eyes.

However, even in mice subjected to this treatment no trace of hairs was found in sections of the lungs and tracheae. Several haemorrhagic areas were observed in the lungs, but we do not believe they were the direct result of hair trauma but more probably due to post-mortem damage when the respiratory tract was removed for fixation. In a later series of experiments we attempted to replicate more closely the natural circumstances in which the hairs would be used. The mice, which were not anesthetized, were held with their noses close to the hind end of females of *Aphonopelma chalcodes*, *Brachypelma smithi*, and *Dugesiella* sp. which were goaded into hair flicking. In this way the mice received dosages of the kind they might encounter in the wild. In these experiments the reactions of the mice were more immediate and dramatic. Both eyes and nose were clearly affected and more than half an hour later the eyes remained closed, with the mice suffering obvious distress. Because of the greatly improved effectiveness of the hairs when discharged by the spider, we suggest that they may be oriented toward the stimulus due to their arrow-like form, with the result that they penetrate more efficiently.

It was originally thought that the Type I hairs would break off at the

point at which the direction of the barbs reversed. However, when it became apparent that the break came below the point of reversal at the junction with the stalk, it seemed likely that the hairs would penetrate only as far as the reversed barbs. This would then localize the site of irritation in the surface layers and presumably enhance the effect considerably. In order to see if this were indeed the case, we took a series of experimental mice that had been exposed to hair-flicking spiders and killed them at intervals during the day. Histological serial sectioning again failed to reveal the presence of hairs embedded in the wall of the respiratory tract. However, examination of the nose, eyelids, and other exposed skin areas showed many Type I hairs present. Unlike the Type III hairs, which penetrate deeply (fig. 19), the Type I hairs go in more or less horizontally and lie snagged in the outer layers of skin. The reversed barbs clearly ensure that the hairs do not work themselves out of the skin once they have become embedded.

As the manuscript of this paper was nearing completion, we received living specimens apparently of *Avicularia surinamensis* from Trinidad through the kindness of Mr. A. L. Bordes. This has enabled us to make a preliminary study of the way in which Type II hairs function. In view of the unusual nature of these hairs, this was most valuable. Although agile, *A. surinamensis* is a very docile spider and will not throw hairs like other theraphosids, even when goaded. However, there is no doubt about the urticarious effects of the hairs, which were amply demonstrated under experimental conditions with hairs scraped off the abdomen of the spider. Type II hairs do not produce the same kind of general itchiness as Type III hairs but rather each hair causes a discrete pricking sensation. This did not persist for long and did not cause inflammation, applied in small doses. The clue to the role of Type II hairs in nature comes from Mr. Bordes's field observations. *Avicularia surinamensis* is an arboreal spider and constructs extensive silken nests high up in trees. Any attempt to extract the spider from its retreat results in immediate and painful urticaria that can leave small sores on the skin. This urticaria is caused by the deep penetration (fig. 27) of numerous Type II hairs incorporated into the silk walls of the retreat. It is not known whether the spider deliberately sheds hairs for incorporation into the retreat, as seems likely, or whether the presence of hairs is fortuitous.

Thus it seems that theraphosid spiders in the New World have evolved a unique, rapid-acting, short-term defense system against potential predators. Although we do not yet know anything about the function of Type IV hairs, it is apparent that the different hair types each have a specific role to play. It is interesting to compare the successful exploitation of this

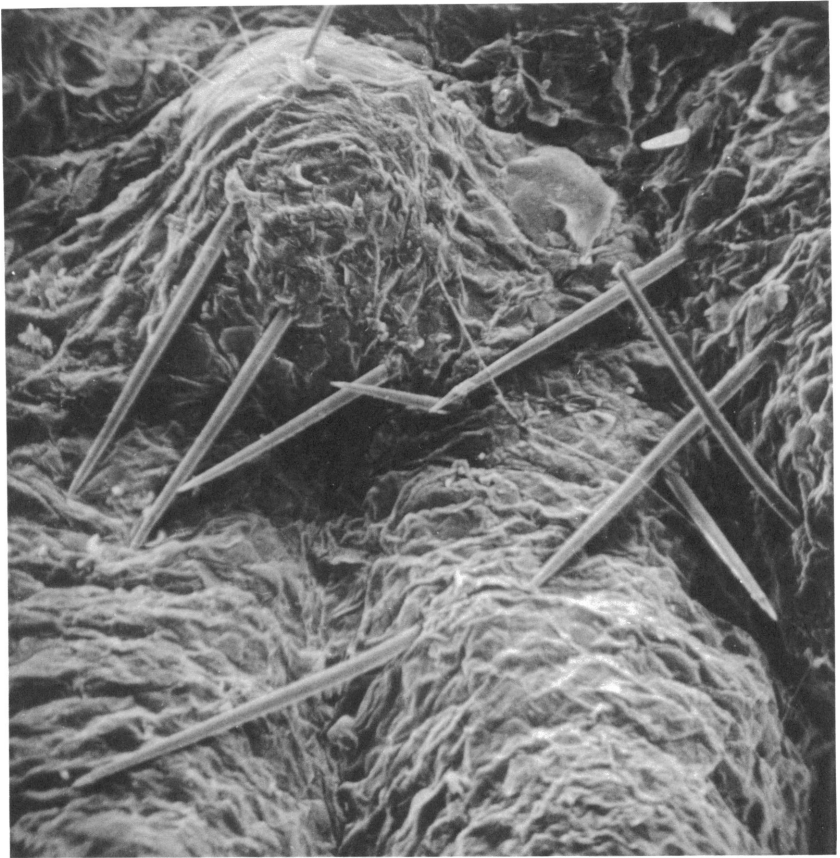


FIG. 27. Surface view of Type II urticating hairs from *Avicularia surinamensis* Strand embedded in skin of young mouse.  $\times 92$ .

fundamentally simple mechanical defense system with the many sophisticated chemical systems evolved in other arthropod groups, which have been reviewed by Eisner (1970).

Attention has already been drawn above to the relative docility of most New World theraphosids and the aggressiveness of African and Oriental species. Unfortunately very little is known about the relative toxicity of theraphosid venoms, but one is led to speculate that an inverse correlation exists between the possession of urticating hairs and the possession of a high-toxicity venom coupled with aggressive behavior. Thus spiders of the Far Eastern genus *Selenocosmia* (fig. 28) lack urticating hairs and are reputed to be both aggressive and particularly venomous. Similarly

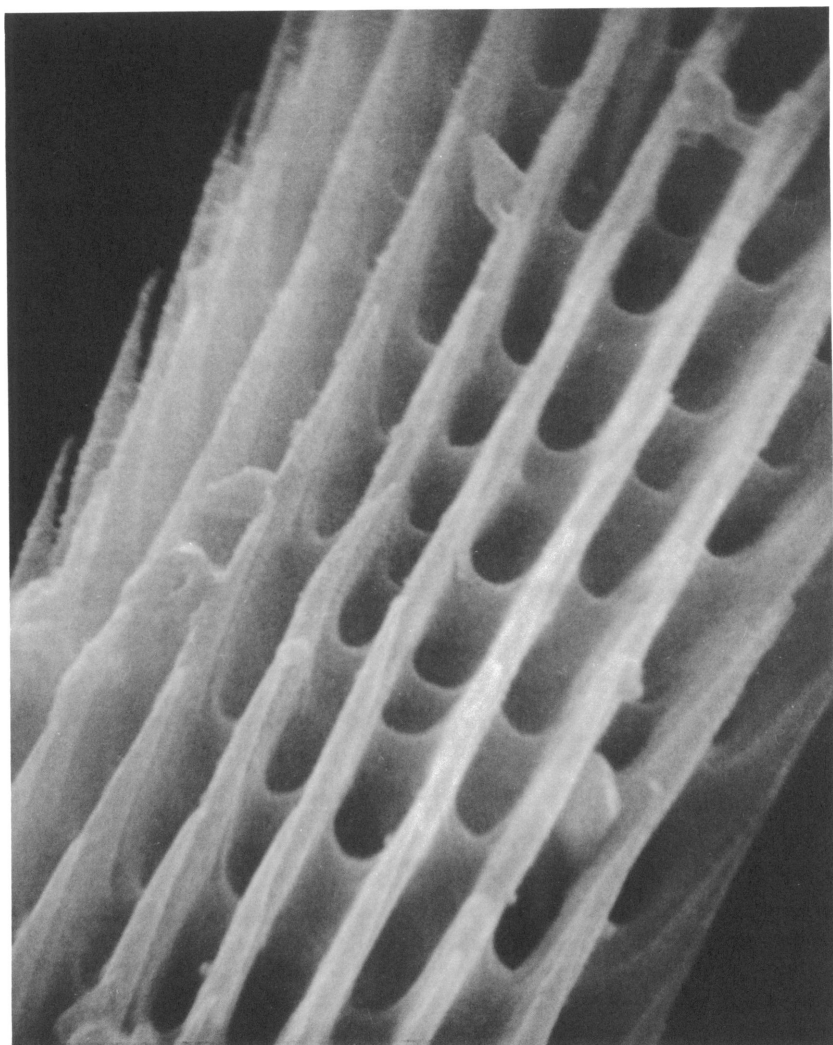


FIG. 28. *Selenocosmia* sp. Detail of surface of finely pilose non-urticating abdominal hair.  $\times 5900$ .

*Phormictopus cancerides* from Brazil and the Caribbean, which is the one New World theraphosid alleged to be highly venomous, also lacks urticating hairs although belonging to a subfamily (Theraphosinae) whose other members appear well endowed.

## SYSTEMATIC ASPECTS

In the course of this study abdominal hairs from more than 60 spiders were examined. It became apparent at an early stage that these hairs, especially the urticating hairs, exhibited considerable diversity, even within genera, and there seems no doubt that a valuable systematic character has been discovered. The exploitation of urticating hairs as a systematic character is beyond the scope of this paper, but in order to emphasize the potential value of urticating hairs in this field we present a summary of our relevant observations.

A major difficulty for those wishing to study theraphosid taxonomy is in gaining access to reliably named material. The systematics of the family is notoriously confused, and the significance of many characters utilized is uncertain. Thus most identifications tend to be highly suspect. The American Museum of Natural History is fortunate in possessing a substantial number of theraphosids identified by such specialists as Gertsch, Schiapelli and Gerschman de Pikelin, and Bücherl, and wherever possible we have utilized this material in our studies. However, it should be noted that for a number of reasons we have followed the generic placings and nomenclature adopted by Bonnet (1955-1959). At this somewhat preliminary stage we have not thought it right to examine hairs from type specimens,<sup>1</sup> although this is clearly an essential prerequisite for any serious systematic investigation.

Within a species the hairs appear fairly constant both in size and proportion, although there is a slight sexual dimorphism that does not appear to be entirely related to difference in size. Both sexes possess hairs of the same type or types, however. Clearly before hair characters are utilized practically the nature and extent of such intraspecific variation must be quantified, but we have not yet attempted to do this.

The distribution of hair types in the identified spiders examined is summarized in table 1. It is immediately apparent that little in the way of overall pattern exists in the distribution of the various types of hair and that there is considerable diversity even within a single genus. However, in view of the uncertainty surrounding the delimitation of genera, it may well be that the apparent lack of order reflects the confusion of the present classification rather than a true state of randomness. There is also the ever-present possibility of misidentification to further confound the picture when studying hairs from non-type material.

Within each hair type interspecific variation includes differences in overall size, differences in the proportion of the barbed and unbarbed

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<sup>1</sup> A survey of the urticating hairs of theraphosid type specimens is now in progress.

parts of the shaft, and also the size of the barbs themselves. Tables 2 and 3 and figure 30 show the sort of diversity observed in Type I hairs. The hairs of *Cyrtopholis jamaicola*, *Acanthoscurria violacea*, and *Sericopelma rubronitens* are notable for their small size, whereas those of *Cyrtopholis longistylus*, *Pterinopelma vellutinum*, and *Pamphobeteus tetracanthus* are conspicuously large. *Aphonopelma moderatum* and *Dugesiella echina*, both with the unbarbed tip extended to nearly half the total length of the hair, stand out markedly in contrast to those of *Acanthoscurria rhodothele*, *A. sternalis*, *Aphonopelma seemanni*, *Citharacanthus spinicrus*, and *Cyrtopholis jamaicola*, in

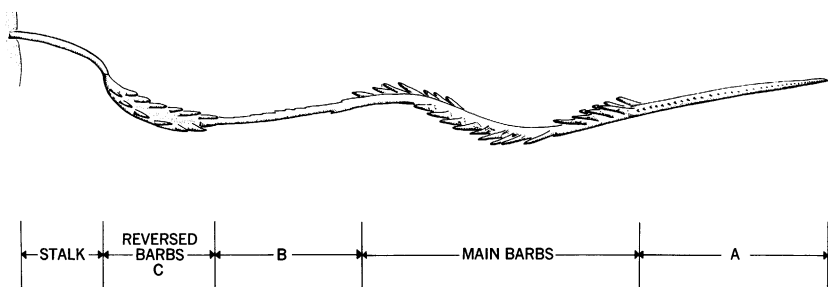


FIG. 29. Drawing of typical Type I urticating hair attached to abdominal cuticle, showing characteristic arrangement of barbs. Sections "A," "B," and "C" refer to the measurements in tables 2-4.

which the barbs start much nearer the tip. The unbarbed mid-portion of the shaft is usually quite short, but in species such as *Lasiodora klugi* and *Acanthoscurria sternalis* it may occupy a quarter of the total length. The length of the shaft occupied by the rear (basal) reversed barbs is usually small, as in *Aphonopelma chalcodes* and *Dugesiella echina* but in *Acanthoscurria violacea* and *Aphonopelma seemanni* they occupy almost a fifth of the total shaft length.

Although we have made no measurements on the size of the barbs themselves, it is clear that considerable variation exists between species. This particularly is noticeable among Type III hairs, with species such as *Brachypelma smithi*, *B. emilia*, and *Acanthoscurria rhodothele* possessing massive barbs, whereas *Cyrtopholis bartholomaei* and *Citharacanthus spinicrus* have only small, fine barbs.

In addition to the types of variation outlined above, the hairs of some species show other distinguishing features. Thus the Type III hairs of *Pterinopelma velutina* are not easily distinguished at first sight from the Type I hairs as both are of similar size and possess a kinked shaft. In a

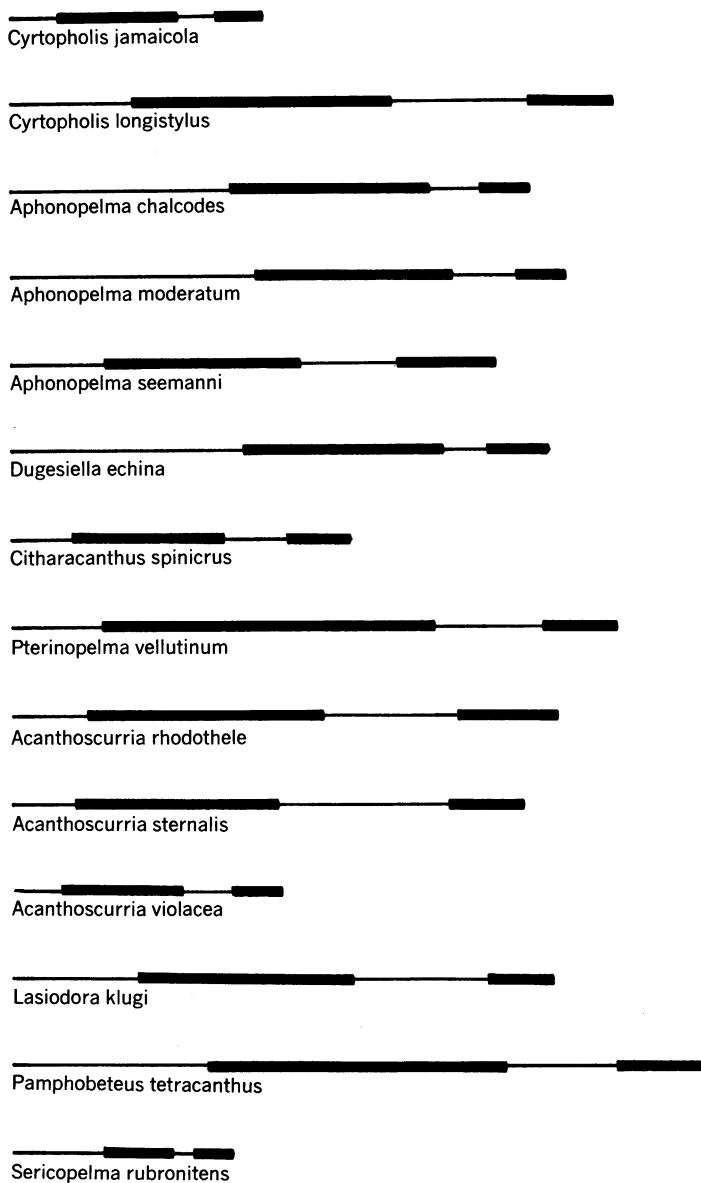


FIG. 30. Schematic representation of relative sizes and proportions of Type I urticating hairs of 14 species discussed in text. Thickened parts indicate the extent of the barbs.

species of *Plesiopelma* and an unidentified theraphosid from the British Virgin Islands, Type I hairs are present in two quite distinct lengths (0.62 mm. and 0.44 mm.; 0.50 mm. and 0.25 mm. respectively). These are the only spiders at present known to possess two kinds of Type I urticating hair. Similarly *Paraphysa manicata* possesses Type III hairs of two different lengths (0.62 mm. and 0.44 mm.) in addition to Type IV hairs, and is thus the only species at present known to us with three separate kinds of urticating hair.

Clearly there is much work to be done on the urticating hairs of the Theraphosidae and many questions still remain unanswered. Do any urticating hairs possess chemical irritants? Why are there several different hair types, even on a single species, and how did they evolve? If there is any phylogenetic basis for the present division of the Theraphosidae into subfamilies, why is it apparently only the New World species that have evolved such hairs? In this paper we are fully conscious that we have done little more than whet the appetite.

#### LITERATURE CITED

- BAERG, W. J.  
1938. The poisons of scorpions and spiders, their effect and treatment. Nat. Hist., New York, vol. 42, pp. 42, 45-51.  
1958. The tarantula. Lawrence, Kansas, Univ. Kansas Press, 88 pp.
- BATES, H. W.  
1863. The naturalist on the River Amazons. London, 2 vols.
- BENT, A. C.  
1938. Life histories of North American birds of prey. U. S. Natl. Mus., Bull. 170, pt. 2, 482 pp.
- BERLAND, L.  
1932. Les Arachnides. Encyclop. Ent., vol. 16, pp. 1-485.
- BONNET, P.  
1955-1959. Bibliographia Araneorum. Toulouse, vol. 2, pp. 1-5058.
- BRISTOWE, W. S.  
1941. The comity of spiders. London, vol. 2, pp. 229-560.
- BRYANT, H. C.  
1916. Food habit studies in roadrunners. Univ. California Publ. Zool., vol. 17, pp. 21-58.
- BÜCHERL, W.  
1951. Estudos sobre a biologia e a sistematica do genero *Grammostola* Simon, 1892. Monogr. Inst. Butantan, vol. 1, pp. 1-203.  
1962. Sudamerikanische Vogelspinnen. Wittenberg, Neue Brehmbuch., vol. 302, pp. 1-92.
- CAZIER, M. A., AND M. A. MORTENSON  
1964. Bionomical observations on tarantula-hawks and their prey (Hymenoptera: Pompilidae: *Pepsis*). Ann. Ent. Soc. Amer., vol. 57, pp. 533-541.
- COOKE, J. A. L.  
1970. Mounting and clearing: notes on some useful arachnological techniques.

- Bull. Brit. Arachnological Soc., vol. 1, pp. 92-95.
- CUTLER, W. L.  
1958. Food habits of the Swift Fox in northern Texas. Jour. Mammal., vol. 39, pp. 527-532.
- DISTANT, W. L.  
1898. Zoological rambles in the Transvaal. Zoologist, vol. 4, ser. 2, pp. 249-260.
- EISNER, T.  
1970. Chemical defense against predation in arthropods. In Sondheimer, E., and J. B. Simone (eds.), Chemical ecology. London, Academic Press, pp. 157-217.
- FERREL, C. M., H. R. LEACH, AND D. F. TILLOTSON  
1953. Food habits of the coyote in California. California Fish and Game, vol. 39, pp. 301-341.
- GERTSCH, W. J.  
1949. American Spiders. New York, D. Van Nostrand Co., 285 pp.
- KAESTNER, A.  
1968. Invertebrate zoology. New York, Interscience, vol. 2, 472 pp.
- KORSCHGEN, L. J.  
1957. Food habits of coyotes, foxes, house cats and bobcats in Missouri. Missouri Conserv. Comm., P-R. ser. 15, ii+64 pp.
- LANGSDORFF, G. H. VON  
1812. Bemerkungen auf einer Reise um die Welt. Frankfurt. (Not seen.)  
1813. Voyages and travels in various parts of the world. London, vol. 1.
- LIGON, J. D.  
1968. The biology of the Elf Owl, *Micrathene whitneyi*. Misc. Publ. Mus. Zool., Univ. Michigan, vol. 136, pp. 1-70.
- MCATEE, W. L.  
1931. A little essay on vermin. Bird Lore, vol. 33, pp. 381-384.
- NUTTING, W. L., AND SPANGLER, H. G.  
1969. The hastate setae of certain dermestid larvae: an entangling defense mechanism. Ann. Ent. Soc. Amer., vol. 62, pp. 763-769.
- OHLENDORF, H. M.  
1971. Arthropod diet of a Western Horned Owl. Southwestern Nat., vol. 16, pp. 124-125.
- ROSS, A.  
1969. Ecological aspects of the food habits of insectivorous screech-owls. Proc. Western Found. Vertebrate Zool., vol. 1, pp. 301-344.
- ROTHSCHILD, M., T. REICHSTEIN, J. VON EUW, R. APLIN, AND R. R. M. HARMAN  
1970. Toxic Lepidoptera. Toxicon, vol. 8, pp. 293-299.
- SAVORY, T. H.  
1928. The biology of spiders. London, Sidgwick & Jackson, pp. 1-376.
- SCHWARTZ, E. A.  
1890. Poisonous insects in Central Africa. Proc. Ent. Soc. Washington, vol. 1, pp. 228-230.
- SHEAR, W. A., AND W. H. LEVI  
1970. Cleaning museum specimens of spiders and myriapods with ultrasonics. Bull. Brit. Arachnological Soc., vol. 1, p. 117.
- SPERRY, C. C.  
1941. Food habits of the coyote. U. S. Fish Wildlife Serv. Wildlife Res. Bull.,

vol. 4, pp. 1-70.

STAINS, H. J.

1956. The raccoon in Kansas, natural history, management and economic importance. Univ. Kansas Misc. Publ., vol. 10, pp. 1-76.

SUTTON, G. M.

1940. Roadrunner. In Bent, A. C. Life histories of North American cuckoos, goatsuckers, hummingbirds and their allies. U. S. Nat. Mus. Bull., vol. 176, pp. 1-506.

TORRES, O.

1921. Algumas observacoes sobre a biologia das Aranhas do genero Theraphosa. Rev. Sci., Soc. Brasileira Sci., annos 5, pp 181-185.

VELLARD, J.

1936. Le Venin des Araignées. Paris, Masson, 311 pp.

WILLIAMS, F.

1956. Life history studies of *Pepsis* and *Hemipepsis* wasps in California, (Hymenoptera, Pompilidae). Ann. Ent. Soc. Amer., vol. 49, pp 447-466.

