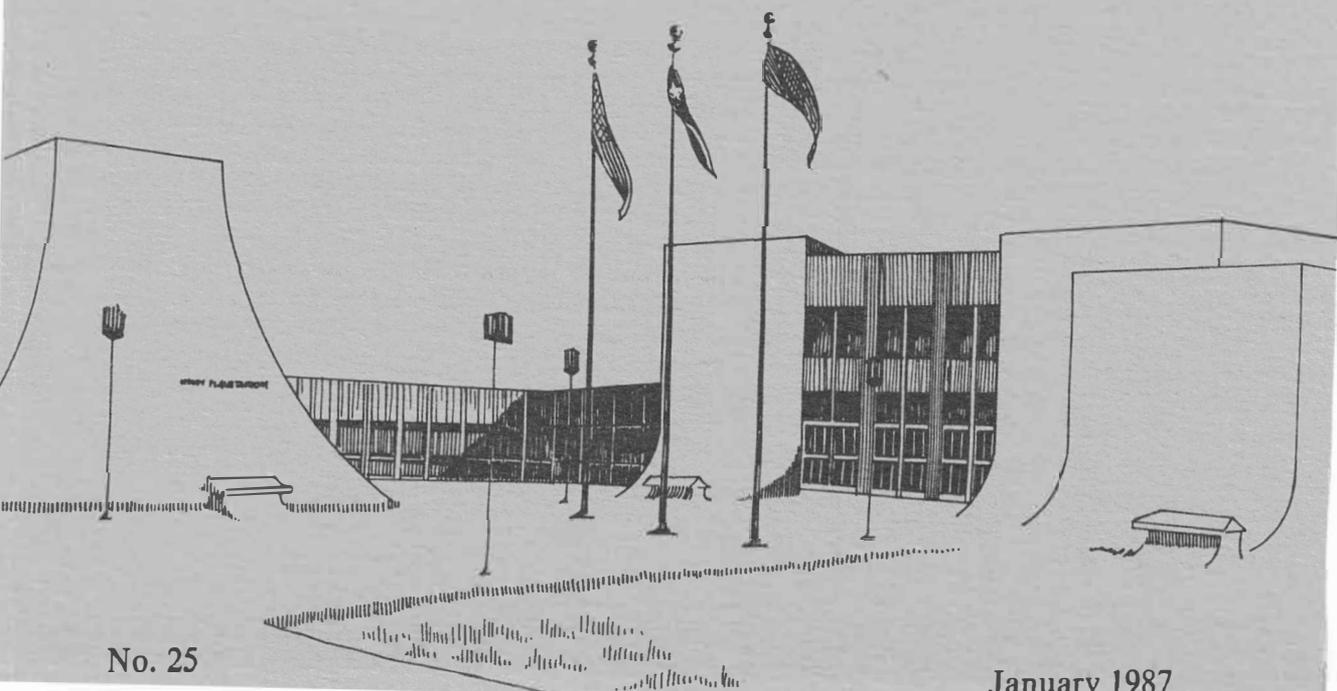


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**Scorpions (Arachnida) from Costa Rica**

*Oscar F. Franke and Scott A. Stockwell*



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## Scorpions (Arachnida) from Costa Rica

*Oscar F. Francke and Scott A. Stockwell*

The scorpion fauna of Costa Rica has received sporadic treatment in the literature. The only comprehensive report is that of Pocock (1902). In *Biologia Centrali-Americana*, he recorded four species of Buthidae from Costa Rica, three in the genus *Centruroides* Marx and one in *Tityus* Koch, based on less than a dozen specimens. Viquez (1935) listed nine species for Costa Rica but, as indicated below, his work is fraught with errors. Our study of hundreds of specimens from Costa Rica indicates that its scorpion fauna is more diverse than previously known. In this contribution, we propose one synonymy, we dismiss reports of six species for Costa Rica, we report for the first time three species for that country, and finally we describe three species new to science.

The fauna of Costa Rica as presently known includes representatives of four of the nine families of Recent scorpions, distributed among 14 species in seven genera. Much has been written about the role of Central America as a biogeographic barrier to marine organisms in the Pacific and Caribbean oceans, and its role as a bridge for the terrestrial biota of North and South America (for example, Marshall *et al.*, 1982). As would be expected, the scorpion fauna of Costa Rica consists of a mixed assemblage of taxa with northern and southern affinities. The genus *Centruroides* (Buthidae) is diverse and abundant in North America and the Caribbean region. The genera *Ananteris* Thorell (Buthidae), *Chactas* Gervais (Chactidae), *Opisthacanthus* Peters (Ischnuridae), and *Tityus* Koch (Buthidae), are clearly South American, and their northern (or northwestern) limits of distribution are in Costa Rica. The genus *Didymocentrus* Kraepelin (Diplocentridae) is a circum-Caribbean element found in Central America and the Antilles. Finally, the species of *Isometrus* Hemprich and Ehrenberg (Buthidae) found in Costa Rica is a pantropical taxon widely dispersed by man.

Aside from isolated taxonomic works, we are unaware of any other publications dealing with the biology or medical significance of scorpions in Costa Rica. Some members of the genera *Centruroides* and *Tityus* have neurotoxic venoms that can cause death in humans. Most of the species from Costa Rica are too rare and poorly known to state definitely their potential medical significance. Others are inferred (based on studies on congeneric species) to have low concentrations of, or altogether lack, neurotoxins and thus are of no medical concern. The venom of *Centruroides margaritatus* (Gervais), the only member of the Costa Rican scorpiofauna studied, has a low mammalian toxicity (Marinkelle and Stahnke, 1965). We hope that the taxonomic and distributional information

presented herein will stimulate further research into the biology of Costa Rican scorpions.

#### LITERATURE REVIEW

In this section we present a chronological review of the taxonomic literature pertinent to the scorpion fauna of Costa Rica. First reports were by Pocock (1898), who described *Centrurus limbatus* and *Centrurus bicolor* as new species from Costa Rica. In the same paper, Pocock described *Centrurus rubricauda* from "Managua in Costa Rica," an error rectified by Kraepelin (1899) [Managua, Nicaragua] but unacknowledged by Pocock (1902). Subsequently, Kraepelin (1901) added *Centrurus margaritatus* (Gervais) to the list of species known from Costa Rica. One year later, Pocock (1902) added *Tityus championi* Pocock, and transferred the species in *Centrurus* to *Centruroides*. Kraepelin (1911) described *Centruroides koesteri* on the basis of one female from Costa Rica, and Francke (1978a) redescribed and illustrated that species based on numerous specimens of both sexes.

Viquez (1935) presented a list of the scorpions from Costa Rica that contains spurious records, misidentifications, and misspellings. He listed *Isometrus maculatus* (Degeer) from Costa Rica for the first time, but gave no specific locality data. We suspect that this pantropical scorpion, predicted by Pocock (1902) to occur in Central America, was included by Viquez in his list without supporting evidence. Also, he used the generic name *Centrurus* rather than *Centruroides*, and reported the following species: *limbatus* Pocock, *maculatus* (a *nomen nudum*), *flavopictus* Pocock (known only from México), *margaritatus* (Gervais), *negrescens* (a *nomen vanum* for *nigrescens* Pocock, known only from México), *bicolor* Pocock, *subgranosus* Kraepelin (an enigmatic species described and known only from "Central America"), and *rubicauda* (a *nomen vanum* for *rubricauda* Pocock). He also cited *Tityus champione* (a *nomen vanum* for *championi* Pocock), and *Ropalurus barythenar* (a *nomen vanum* for *Rhopalurus barythenar* Penther, known only from Brazil).

Werner (1939) described *Iomachus exsul* based on one male from Costa Rica. The genus *Iomachus* Pocock is known only from Africa and India. The type specimen of *Iomachus exsul* Werner was deposited in the Zoologisches Institut und Zoologisches Museum, Hamburg, and was destroyed during World War II (Dr. G. Rack, personal communication). Thus, we could not examine it to investigate the possibility that a labelling error had occurred. However, Werner's brief description agrees with that of a species of *Chactas* found in Costa Rica and Panamá. Furthermore, Werner placed the description of *I. exsul* under the heading of the family Chactidae, even though *Iomachus* has always been referred to the Ischnuridae. Thus, we conclude that an identification error at the supraspecific level occurred, rather than a labelling error. For these reasons we have decided to consider

Werner's name as valid, to transfer it to *Chactas*, and to designate a neotype for the species.

Roewer (1943) reported *Centruroides hasethi* Pocock, a species endemic to Curaçao and Bonaire, from "Hamburg Farm, Costa Rica." We have examined the specimens from Roewer's collection, deposited in the Senckenberg Museum, and concur with his identification; therefore, we conclude that a labelling error, not uncommon among Roewer's material, has occurred.

Francke (1974) reported the first scorpions from Isla del Coco as *Opisthacanthus lepturus* (Palisot de Beauvois), and Lourenço (1983b) recognized the island population as a new species, *Opisthacanthus valerioi* Lourenço, distinct from the isthmian populations.

Wagner's (1977) report of *Centruroides gracilis* (Latreille) from Costa Rica is based on misidentifications. The specimens he studied are actually a darkly pigmented morph of *Centruroides limbatus* (Pocock), and a specimen of *Centruroides margaritatus* (Gervais). We are not aware of any reliable records of *C. gracilis* from Costa Rica, although the species occurs in other areas of Central America.

Finally, Lourenço (1982) added *Ananteris ashmolei* Lourenço, to the list of species known from Costa Rica.

#### MATERIALS AND METHODS

The senior author spent three weeks in Costa Rica during January of 1978 team-teaching a course in arachnid biology co-sponsored by the Organization for Tropical Studies and the Universidad de Costa Rica. The material collected then, plus the relatively large collection of the Escuela de Biología, Universidad de Costa Rica, provided the stimulus and served as a nucleus for this study. In addition, we obtained specimens from numerous other institutions, which are listed in the acknowledgements. The acronyms used in the text to indicate specimen depositories also appear in the acknowledgments.

The taxonomic treatments are applicable only to Central American (Guatemala south to Panamá) scorpions; the species synonymies are complete unless otherwise indicated. New species and species that are poorly known are given full descriptions; species for which modern descriptions are available are merely diagnosed. New species are compared with their nearest relatives, regardless of their geographic origin. No section on comparisons is given for previously known species; they can be distinguished from other Costa Rican scorpions by the characters given under their respective diagnoses, and in the key to scorpion taxa that follows the text.

The measurements (lengths in millimeters, obtained at 10× magnification) and terminology follow essentially those proposed by Stahnke (1970), except for trichobothriotaxy (Vachon 1974, 1975), and carinae of the metasoma and pedipalps (Francke 1977). Data given for material examined were taken directly from information associated with specimens.

## CHECKLIST OF SCORPIONS OF COSTA RICA

Taxa of equal rank are listed alphabetically, and their treatment in the text follows the same sequence. New records are preceded by an asterisk (\*).

## Family BUTHIDAE Simon

Genus *Ananteris* Thorell, 1891

*Ananteris ashmolei* Lourenço, 1981

Genus *Centruroides* Marx in Howard, 1890

*Centruroides bicolor* (Pocock, 1898)

*Centruroides koesteri* Kraepelin, 1911

*Centruroides limbatus* (Pocock, 1898) (= *Centruroides rubricauda* (Pocock, 1898), new synonymy)

*Centruroides margaritatus* (Gervais, 1841)

\**Centruroides thorelli* (Kraepelin, 1891)

\*Genus *Isometrus* Hemprich and Ehrenberg, 1829

\**Isometrus maculatus* (Degeer, 1778)

Genus *Tityus* Koch, 1836

*Tityus championi* Pocock, 1898

\**Tityus dedoslargos*, new species

\**Tityus ocelote*, new species

\**Tityus pachyurus* Pocock, 1897

## Family CHACTIDAE Pocock

\*Genus *Chactas* Gervais in Gervais and Walckenaer, 1844

*Chactas exsul* (Werner, 1939), new combination

## Family DIPLOCENTRIDAE Pocock

\*Genus *Didymocentrus* Kraepelin, 1905

\**Didymocentrus concavimanus*, new species

## Family ISCHNURIDAE Simon

Genus *Opisthacanthus* Peters, 1862

*Opisthacanthus valerioi* Lourenço, 1983

## FAMILY BUTHIDAE

The largest family of scorpions is Buthidae, with 56 currently recognized genera (Francke 1985). Four genera occur in Costa Rica: *Ananteris*, a small, primarily South American genus; *Centruroides*, a large and diverse Meso-American genus; *Isometrus*, a Southeast Asian genus with 14 species, one being pantropical; and *Tityus*, a large and diverse genus found primarily in South America.

Genus *Ananteris* Thorell

The genus *Ananteris* Thorell contains 13 described species, and was recently revised by Lourenço (1982). These are small scorpions, 20 to 40 mm. in length. They have feeble pedipalps, thinner than the metasoma; the chela thinner than the tibia; and the fixed finger about three times as long as the underhand. The lack of fulcra on the pectines is diagnostic (Fig. 9).

*Ananteris ashmolei* Lourenço

Figs. 1, 6-9, Map 3

*Ananteris ashmolei* Lourenço 1981:644-648, figs. 19-27, 1982:138-141, figs. 33-34, 45.

*Type data*.—Holotype female from Los Tayos, Provincia de Morona-Santiago, Ecuador. Deposited in the Muséum National d'Histoire Naturelle, Paris. Not examined.

*Distribution*.—Known from Costa Rica, Panamá, Colombia, and Ecuador.

*Diagnosis*.—Adults 25 to 30 mm. in length. Pale to medium brown; opisthosoma with distinct variegated fuscosity, tergites with submedian chevrons (> <) pointed axially (Fig. 6). Venter a dirty yellow-brown; stigmata small, ellipsoidal; last sternite with weak submedian keels and no lateral keels. Pectines without fulcra (Fig. 9), with 15-21 teeth. Metasomal segments I-III with 10 complete keels, segment IV with eight complete keels, and segment V with five complete keels; all keels moderately strong, finely serrate. Trichobothrial pattern A-beta (Figs. 7, 8). Pedipalp tibia and chela smooth, acarinate; chela with manus light yellow, fingers heavily infuscate. Dentate margin of fixed finger with six rows of granules, basalmost row about three times longer than any other row (Fig. 1). Legs III and IV with distinctive tibial spurs.

*Measurements*.—Adult male: carapace 2.5; metasomal segment V 3.7; pedipalp femur 2.5; tibia 3.0; chela 3.7; fixed finger 2.5. Adult female: carapace 3.5; metasomal segment V 4.8; pedipalp femur 3.3; tibia 4.1; chela 5.1; fixed finger 3.4.

*Variability*.—The specimens from Costa Rica do not differ significantly from Panamanian and Colombian populations. Pectinal tooth counts on the two males are 19-20, on the immature (? female) 17-18.

*Specimens examined*.—*Prov. Limon*: Finca La Lola, near Siquirres, 1 August 1981 (A. Young), one immature (MPM); same locality, 10 August 1984 (A. M. Young), one male (MPM). *Prov. Puntarenas*: Sirena-Corcovado, 2-6 Jul. 1979 (C. E. Valerio), one juvenile male (OFF).

Genus *Centruroides* Marx

*Centruroides* Marx contains about 50 species, and is found between the Equator and 40° north latitude in the New World. It is a taxonomically difficult complex of species in dire need of revision. The best identification keys available for Central American species are those of Pocock (1902) and Stahnke and Calos (1977). The presence of supernumerary granules flanking internally and externally the 8 to 9 primary rows of denticles on the pedipalp chela fingers is diagnostic (Figs. 3, 4).

In species in this genus, there is often considerable sexual dimorphism, with males having proportionately longer pedipalps and cauda than females and juveniles (see Francke and Jones, 1982, for a detailed life history study on one species).

*Centruroides bicolor* (Pocock)

Figs. 4, 10-18, 96, Map 1

*Centrus bicolor* Pocock, 1898:388; Kraepelin, 1899:92; Penther, 1913:240; Viquez, 1935:112, fig. 44.

*Centruroides bicolor*: Pocock, 1902:35, pl.VII, figs. 5, 5a; Stahnke and Calos, 1977:112; Wagner, 1977:45.

*Type data*.—Holotype female was from Poyo Azul de Pirris, Costa Rica (T. Zeledon), presumably deposited in the British Museum (Natural History), but could not be found there. Because the holotype is either lost or destroyed, we hereby designate a neotype: adult male from Panamá (no collector), no date. Deposited in the British Museum (Natural History).

*Distribution*.—Known from Puntarenas Province in Costa Rica, and from neighboring Panamá.

*Diagnosis*.—Adults often more than 100 mm. long. Base color pale yellow; carapace, tergites I-VI, metasomal segment V, and telson, granules on metasomal carinae, apex of pedipalp tibia, and pedipalp chela black (Figs. 10, 11). Carapace and tergites moderately granulose. Pectinal tooth count 25-28 (mode, 26-27). Pedipalp chela fixed finger with nine primary rows of denticles. Digital carina vestigial to obsolete. Metasomal segment V 3 to 3.5 times longer than wide.

*Males*. Large, adults 100-120 mm. long. Carapace, tergites I-VI, metasomal segment V and telson, metasomal carinal granulation, apex of pedipalp tibia, and pedipalp chela densely infuscate, almost black; other body parts pale yellow. Carapace minutely granular throughout, carinae weak to moderate, furnished with moderately spaced granules. Venter of prosoma yellow, with tips of maxillary lobes infuscate, smooth, pitted. Sternum granular, with deep median furrow. Mesosomal tergites infuscate, with pretergites and margins of tergites densely infuscate; shagreened, moderately granulose; median carinae weak to moderately strong, granulose. Tergite VII pentacarinata; median keel present on basal one-half, moderate, granulose; submedian and lateral carinae weak to moderate, granulose. Pectinal tooth counts 27-28 (mode, 27). Sternites lustrous, weakly punctate; margins slightly infuscate. Sternite VII tetracarinata; submedian keels weak, smooth to vestigially granulose; lateral keels weak, weakly granulose.

Mestasoma long and slender, segments II-V at least three times longer than wide. Metasomal carinae moderately granulose. Dorsolateral and lateral suprmedian carinae weak on I-III, moderate on IV. Lateral inframedian carinae weak on I; present as one distal granule on II; obsolete on III and IV. Ventrolateral carinae moderate on I-IV. Ventral submedian carinae weak on I, moderate on II-IV. Segment V cylindrical; dorsolateral and ventrolateral carinae vestigial, vestigially granulose; ventral median carina weak, weakly granulose; anal subterminal keel weak, vestigially granulose; all other keels obsolete. Intercarinal spaces coriaceous to minutely granular. Telson elongate, weakly granulose; subaculear tooth moderately strong.

Chelicera densely infuscate throughout.

Pedipalp slender; femur 4.5 times longer than wide; tibia 3.5 times longer than wide; chela five times longer than wide. All carinae on femur and tibia weak, moderately granulose, their internal faces moderately tuberculate; basal tubercle of tibia fine, moderately developed. Intercarinal spaces minutely granular, internal faces moderately setose. Chela with digital carina vestigial to obsolete, present as a few basal granules; dorsal secondary carina weak, densely granulose; dorsal marginal carina weak, moderately granulose; internal secondary carina vestigial, weakly granulose; ventral external carina weak, smooth to weakly granulose; ventral internal carina vestigial, granular; other carinae obsolete. Trichobothriotaxy (Figs. 12-18) A-alpha (Vachon 1975).

Legs weakly carinate, granulose. Tibia and tarsomeres moderately setose.

Hemispermaphore flagelliform (Fig. 96); trunk and pedicel 9.4 mm. long.

Females. Differ from males as indicated below. Pectinal tooth count 23-28 (mode, 26). Sternites finely granulose. The metasoma and pedipalps are not as elongate as on males, and all the carinae appear more strongly developed. Dorsolateral and lateral supramedian keels on I-III moderately strong, on IV strong; lateral inframedian keel on I moderate; ventrolateral carinae on I-IV strong; ventral submedian carinae on I moderate, on II-IV strong; segment V angular, pentagonal in cross-section, dorsolateral, ventrolateral, and ventromedian keels weak; all carinae on femur and tibia moderately strong, granulose to tuberculate; chela with dorsal secondary, dorsal marginal, and ventral external keels moderate; internal secondary keel weak, moderately granulose. Telson globular.

*Measurements.*—Adult male: carapace 11.6; metasomal segment V 17.9; pedipalp femur 12.9; tibia 13.1; chela 21.0; fixed finger 11.2. No adult females were available from Costa Rica.

*Variability.*—Immatures have a less striking coloration, with diffuse to moderate fuscosity on the pedipalps and metasoma. Pectinal tooth counts varied as follows: on males, 3 combs with 27 teeth, 1 with 28; on females, 2 combs with 26 teeth, 2 with 28; on juveniles, 1 comb with 25, 3 with 26, and 2 with 27 teeth.

*Specimens examined.*—COSTA RICA: no date (Hoffmann), one female (ZMB). *Prov. Puntarenas:* Sandalo, 26 April 1930 (C. R. Dodge), two juveniles (MCZ); Isla del Caño, 26 April-Mayo 1970 (R. Rivera R.), one juvenile (UCR); El General, 18 km. S San Isidro, 2-3 Junio 1972 (J. E. Baldrige), one adult male (UCR); Madrigal, Parque Nacional Corcovado, Mayo 1983 (J. H. Castro), one juvenile male (UCR).

### *Centruroides koesteri* Kraepelin

Figs. 19-27, 97, Map 2

*Centruroides koesteri* Kraepelin, 1911:70-72; Mello-Leitão, 1945:255, Francke, 1978a:65-71.

*Rhopalurus testaceus koesteri*: Meise, 1934:29, 32; Stahnke and Calos, 1977:119 (?).

*Type data.*—Holotype female, adult, from Costa Rica, 10 June 1905 (H. Köster). Deposited in the Zoologisches Institut und Zoologisches Museum, Hamburg Universität. Examined.

*Distribution.*—Known only from Puntarenas and Guanacaste provinces, Costa Rica.

*Diagnosis.*—Adults 65-75 mm. long. Light yellow or yellow-brown with diffuse dark-brown tingeing on carapace, tergites, and metasomal carinae; mesosomal pretergites with moderately dense, uniform, dark-brown bands submedially (Figs. 19, 20). Carapace with superciliary crests smooth to vestigially crenate. Pectinal tooth count 21-26 (mode, 23-24). Metasomal segments I and II with 10 keels, lateral inframedians on II incomplete, present on distal one-half to one-third; III and IV with eight keels each, lateral inframedians obsolete; all metasomal keels moderately strong, with distinct large granules. Segment V 2.1 to 2.4 times longer than wide, in adult males segment V shorter than segment IV. Pedipalp chela somewhat stout, 3.5 to 5 times longer than wide, with granulose carinae, digital carina strong, manus lighter than fingers; dentate margin of fixed finger with eight primary rows of denticles. Inner aspects of pedipalp femur, tibia and chela sparsely hirsute, almost bare. Trichobothriotaxy A-alpha (Figs. 21-27). Hemispermatophore flagelliform (Fig. 97); trunk and pedicel 5.7 mm. long.

*Measurements.*—Holotype female: carapace 6.9; metasomal segment V 7.5; pedipalp femur 6.0; tibia 7.9; chela 12.5; fixed finger 7.1. Adult male: carapace 7.2; metasomal segment V 9.3; pedipalp femur 7.6; tibia 8.0; chela 14.7; fixed finger 8.4.

*Variability.*—Immatures are darker than adults, displaying diffuse brownish tingeing on the legs and posterior submedian areas of the carapace, moderate tingeing on the pedipalps and tergites, and moderately dense tingeing on the ventral areas of the tail. Pectinal tooth counts varied as follows: in males, 4 combs with 22 teeth, 6 combs with 23, 4 combs with 24, and 1 each with 25 and 26 teeth, respectively; in females, 1 comb with 21 teeth, 4 combs with 22, 6 combs with 23, 8 combs with 24, and 1 comb with 25 teeth; in immatures 2 combs with 21 teeth, 2 combs with 22, 5 combs with 23, and 2 combs with 24 teeth.

*Specimens examined.*—COSTA RICA: 10 June 1905 (H. Köster), holotype female (ZMH). *Prov. Guanacaste:* Bebedero (confluence of Rio Tenorio and Rio de las Piedras), 17 June 1930 (E. Reimoser), one female (NHW); El Coco, 23-VII-1965 (F. Coyle), one juvenile (MCZ); Playas del Coco (sea level), 19 August 1965 (R. D. Sage), one male (UCB); Rio Sandillal (sobre Carretera Panamericana), Feb. 1966 (C. E. Valerio), one male (UCR); Finca Palo Verde, 6 km. NE Puerto Humo (on Rio Tempisque), 16-22 January 1978 (C. E. Valerio, W. G. Eberhard and O. F. Francke), two males, four females, four juveniles (OFF), two males, two females (AMNH), one male, one female (FSCA); Parque Nacional Santa Rosa, 25 km. S La Cruz, March 1984 (D. H. Janzen), one male, one female (OFF). *Prov. Puntarenas:* Monteverde, 7-29-63 (C. W. Palmer), one immature (CAS).

### *Centruroides limbatus* (Pocock)

Figs. 28-38, 98, Map 1

*Centruroides limbatus* Pocock, 1898:387-388; Kraepelin, 1899:92; Viquez, 1935:111,112.

*Centruroides limbatus:* Pocock, 1902:35, pl. VIII, figs. 1, 1a; Roewer, 1943:218; Wagner, 1977:45, 46.

*Centruroides rubricauda* Pocock, 1898:389; Kraepelin, 1899:93 (new synonymy).

*Centrurus rubicauda* [sic]: Viquez, 1935:111, 112.

*Centruroides rubicauda*: Pocock, 1902:34; Wagner, 1977:45, 46.

*Centruroides gracilis*: Wagner, 1977:46 (misidentification).

*Type data*.—Holotype male from Sirirea, Talamanca, Costa Rica (H. Pittier). Deposited in the British Museum (Natural History). Examined. The holotype has been labelled "Lectotype (H. L. Stahnke) ♂, *Centruroides limbatus* Pocock." Stahnke's lectotype designation was never published and therefore is not valid. Furthermore, a lectotype designation is not necessary because Pocock (1898) clearly described *C. limbatus* from a single male. The measurements, number of pectinal teeth, and description of this specimen fit Pocock's description exactly, and it therefore must be considered the holotype.

The types of *Centrurus rubicauda* Pocock, 1898, are supposedly from Managua, Nicaragua (Dr. Rothschuh). One specimen, presumably from Pocock's series of four males and four females, was obtained from the British Museum (Natural History). This specimen, a male, has been labelled "Lectotype (H. L. Stahnke), *Centruroides rubicauda* Pocock, ♂, Managua, Nicaragua, coll. Dr. Rothschuh." Stahnke's lectotype designation was never published, and is not valid. However, we hereby designate that specimen as the lectotype of *Centrurus rubicauda* Pocock.

Close examination of the lectotype and other specimens of *Centruroides rubicauda* (Pocock) revealed no significant, consistent morphological differences with *Centruroides limbatus*. The characters used by Pocock to distinguish between the two species, namely color, telson shape, and pectinal tooth counts, are highly variable in both taxa. The two occur sympatrically in Costa Rica, and a number of specimens show intermediate states of the three characters. Therefore, we consider *C. limbatus* to be a senior synonym of *C. rubicauda* by page precedence.

*Distribution*.—Known from throughout Costa Rica, and parts of Honduras and Nicaragua.

*Diagnosis*.—Polymorphic; adults medium to large, up to 110 mm. long. Color variable, ranging from a uniform dark brown to yellow, with the ocular tubercle and margins of the carapace and tergites, pedipalp chela fingers, chelicera, metasomal segment V and telson, and granules on metasomal carinae heavily infuscate, almost black (Figs. 28-31). Pedipalp chela slender, 4.5 to 5 times longer than wide; digital carinae vestigial to obsolete; fixed finger with nine imbricated rows of primary denticles. Carapace, tergites, and carinae with variable, but usually sparse, granulation. Metasomal segment V on males 3 to 3.5 times longer than wide. Pectinal tooth count in males 19-27 (mode, 23), in females 18-26 (mode, 21).

Males. Medium to large, adults 55 to 110 mm. long. Base color yellow to dark brown, heavily infuscate as detailed above. Carapace minutely granular throughout; carinae vestigial to weak, sparsely to moderately granulose. Venter of prosoma yellow to brown, variably infuscate; smooth, pitted. Sternum granular, with moderately deep median furrow. Mesosomal

tergites variably infusate, minutely granular to shagreened, sparsely to moderately granulose; median carina present on all tergites, weak to moderate, granulose. Tergite VII pentacarinata; median keel present on basal one-half, weak to moderate, granular. Pectinal tooth count 18-27 (mode, 23). Sternites lustrous, weakly punctate; variably infusate. Sternite VII tetracarinata; submedian and lateral keels incomplete, weak, feebly granulose.

Metasoma long, segments III-V at least three times longer than wide. Metasomal carinae sparsely granulose. Dorsal lateral carinae weak on I-III, moderate on IV. Lateral suprmedian carinae on I-IV weak. Lateral inframedian carinae on I complete, weak; on II present as one or two distal granules; on III and IV obsolete. Ventral lateral carinae on I-IV weak. Ventral submedian carinae on I and II weak to vestigial; on III and IV weak. Segment V cylindrical, all carinae vestigial, feebly granulose. Intercarinal spaces smooth to shagreened. Telson elongate, vestigially granulose; subaculear tubercle weak, spinoid.

Pedipalps slender; femur 4.7 to 5.2 times longer than wide, tibia 3.5 times longer than wide, chela five times longer than wide. All carinae on femur and tibia weak to extremely weak, feebly granulose. Internal face on femur and tibia weakly tuberculate; basal tubercle on tibia moderate. Intercarinal spaces minutely granular to shagreened, internal faces sparsely setose. Chela with dorsal secondary, dorsal marginal, and ventral external carinae weak, feebly granulose; internal secondary keel vestigial, granular; digital carina vestigial to obsolete, present as a few basal granules; all other carinae obsolete. Trichobothriotaxy A-alpha (Figs. 32-38).

Legs minutely granular, carinae weak, granulose. Tibiae and tarsomeres moderately setose.

Hemispermaphore flagelliform (Fig. 98); trunk and pedicel 8.8 mm. long.

Females. Differ from males as indicated below. Slightly more granulose throughout; median carina on tergites moderate to strong; sternites coriaceous to granular. Metasoma not as long, segments IV and V only two times longer than wide. Metasomal carinae weak to moderate, sparsely to moderately granulose. Segment V subsylindrical, all carinae extremely weak. Telson globular, weakly granulose. Pedipalps not as slender: femur 3.6 to 3.7 times longer than wide, tibia 2.7 to 2.8 times longer than wide, chela 4.6 times longer than wide. Chela with dorsal secondary, dorsal marginal, and ventral external carinae weak; internal secondary keel weak.

*Measurements.*—Holotype male, *Centruroides limbatus*: carapace 9.2; metasomal segment V 12.8; pedipalp femur 9.8; tibia 10.2; chela 18.0; fixed finger 10.0. Lectotype male, *Centruroides rubricauda*: carapace 9.3; metasomal segment V 13.7; pedipalp femur 10.4; tibia 10.7; chela 17.0; fixed finger 8.8. Adult female (from Tilarán, Guanacaste Prov.): carapace 7.6; metasomal segment V 8.9; pedipalp femur 7.4; tibia 7.8; chela 13.0; fixed finger 7.5.

*Variation.*—This species is polymorphic for a number of characteristics, the most confusing being color and granulation. In the typical morph of *C. limbatus*, the pedipalps, legs, and cauda are yellow; the carapace and tergites are olive to yellow-brown, with dense fuscosity on the margins; the chelicera, pedipalp chela fingers, metasomal segment V, and telson are heavily infuscate, almost black, and sharply contrasting with the body (Figs. 28, 29). In the *rubricauda* morph, the entire body and the pedipalps are brown, the males have yellow legs, and the females brown legs (Figs. 30, 31). The fuscous pattern is as in *limbatus* morphs, but because the background is brown there is hardly any contrast. In some forms, notably populations from Monteverde, Prov. Puntarenas, the color is intermediate, with the degree of contrast varying from one individual to another.

The typical morph exhibits weak granulation, with the granules well spaced on the carapace, tergites, pedipalpal and metasomal carinae. Dark morphs, particularly females, exhibit moderate to dense granulation on those areas.

The shape of the telson of males is also variable, being elongate with parallel sides and strong shoulders in some males, elongate and rounded (without shoulders) in other males, and with weak to moderate shoulders in still others.

Pectinal tooth counts varied as follows: in males, 1 comb with 19 teeth, 9 with 20 teeth, 20 with 21 teeth, 29 with 22 teeth, 32 with 23 teeth, 17 with 24 teeth, 10 with 25 teeth, 8 with 26 teeth, and 1 with 27 teeth (3 combs damaged); in females, 2 with 18 teeth, 4 with 19 teeth, 10 with 20 teeth, 28 with 21 teeth, 18 with 22 teeth, 24 with 23 teeth, 16 with 23 teeth, 13 with 25 teeth, and 7 with 26 teeth (2 combs damaged); in immatures, 4 with 19 teeth, 16 with 20 teeth, 41 with 21 teeth, 43 with 22 teeth, 17 with 23 teeth, 7 with 24 teeth, 5 with 25 teeth, 3 with 26 teeth, and 1 with 27 teeth (3 combs damaged).

*Specimens examined.*—NICARAGUA: Managua, no date (Dr. Rothschild), lectotype male of *Centruroides rubricauda* (Pocock) (MNNH). COSTA RICA: no date (no collector), one female (CAS); no date (C. E. Valerio), one female (UCR); no date (C. E. Valerio), one female (UCR); no date (C. E. Valerio), one female (UCR); 4.VII.1899 (Mus. Königsberg), one immature (ZMH). Prov. *Alajuela*: Cariblanco, 1905.3.29.1-3 (C. Lt. Lankester), two females (BMNH); Los Chiles, 24 May 1964 (F. S. Truxal), one male, one female (LACM); Ciudad Quesada, San Carlos, 29 August 1966 (C. E. Valerio), one male (UCR); Muelle de San Carlos, Mayo 1980 (C. E. Valerio), one female (UCR). Prov. *Cartago*: Turrialba, no date (P. Biolley), two males, one immature (BMNH); Juan Viñas, Reventazón Road (from bromeliads), 3.4.X.09 (P. P. Calvert), one immature (USNM). Prov. *Guanacaste*: Tilarán, 14 Julio 1966 (C. E. Valerio), one female (UCR); Arenal, Tilarán, 11 Abril 1968 (C. E. Valerio), one female (UCR); Arenal, Tilarán, 2 Junio 1968 (C. E. Valerio), three males (UCR); San Luis de Tilarán, 18 Abril 1981 (C. E. Valerio), one male (UCR). Prov. *Heredia*: Finca La Selva, no date (W. Bussing), one male (LACM); Puerto Viejo, Sarapiquí, 1-15 Aug. 1965 (C. E. Valerio), three males, five females (UCR); Finca Rio Cuarto, Rio Cuarto, Sarapiquí, 22 Sept. 1974 (A. Guardian), one male (UCR); Finca La Tirimbina, nr. La Virgen, 6 July 1976 (A. Young), one female (MPM); Colegio forest at margin of Puerto Viejo (under bark), 27 January 1977 (MAN ?), one female (MPM); Finca La Tirimbina, La Virgen, 9 February 1977 (A. Young), one female (MPM); Finca La Selva (O.T.S.), 3 km SE Puerto Viejo (U. V. light detection, on tree trunk), 4-11 Jan.

1978 (O. F. Francke), two males, two females, two immatures (OFF); Finca La Tirimbina, nr. La Virgen de Sarapiquí (in field station house), 3 December 1978 (A. Young), one female (MPM); Finca La Tigra, nr. La Virgen, 23 March 1979 (A. Young), two males, one female (MPM); Finca La Tigra (elev. 220 m.), nr. La Virgen (in leaf litter in primary tropical wet forest), February 1980 (A. Young), one female (MPM); Finca La Tigra, nr. La Virgen, 3 Dec. 1982 (A. M. Young), one immature (MPM); Finca La Tirimbina, nr. La Virgen (under boards), July-August 1984 (A. Young), one male (MPM). *Prov. Limón*: Port Limon, no date (Dr. Edw. L. Salisbury), one immature (MCZ); Waldeck, 30 March (C. R. Dodge), one female (MCZ); Pacuarido, Dec. 1904-Febr. 1905 "Scheukgeber: vorlanfig unbekamit. . ." (M. Kayser, D. S. Savoia [H.-A. Linie]), one female (ZMH); Ebene von Limon, farm Hamburg am Reventazón, 12-13 km. von Atlantik, 1923 (Ferd. Nevermann), one male (ZMH); Hamburg Farm, 5-V-(1930) [Hamburg Farm (=Castilla Farm), lower reaches Rio Reventazón, 5 May 1930] (E. Reimoser), two immatures (NMW); Waldeck, 4 VIII '30 [Waldeck Farm, lower reaches of Rio Pacuare, 4 Aug. 1930] (E. Reimoser), one male, one female, one immature (NMW); Parismina 7.9.1930 (unter loser Rinde) (F. Nevermann), one male (NMW); Tortuguero (unter loser Rinde), 22.II.31 (F. Nevermann), one male (ZMH); probably Tortuguero, July or August 1955 (L. Giovannoli), one female (USNM); Punta Cahuita, 8-14 Marzo 1966 (C. E. Valerio), one female (UCR); Puerto Vargas, 24 Sept. 1977 (J. Cortez), four females (UCR); Hdas. La Suerte/Topezco, 29 air km. W Tortuguero (40 m), 13-31 Aug. 1979 (J. P. and K. E. Donahue, C. C. Hair, N. K. Moore, M. A. Hopkins [LACM/Earthwatch Tapezco's Rainforest Expedition]), one male, two females (one with 29 first instars) (LACM); Tortuguero N. P. (send. Nat. wet forest, second growth), 17-23 April 1983 (D. Ubick), one immature (DUC/CAS); Finca La Iola, near Siquirres, 7-13 March 1984 (A. M. Young), one immature (MPM). *Prov. Puntarenas*: "Monteverde," no date (Chas. L. Hogue), one male (LACM); Santa Elena, 14-18 Marzo (C. E. Valerio), three immature (UCR); Golfito, 6 July 1957 (Truxal and Menke), one immature (LACM); Rio Guacimal, Monte Verde, 23 April 1963 (K. A. Arnold), one male (MCZ); Monteverde, rec. 7-29-63 (C. W. Palmer), one female (UCB); Monteverde, rec. 7-29-63 ("probably" Charles W. Palmer), one male (UCB); Monteverde, rec. date 7.29.63 (C. W. Palmer), 29 males, 17 females, 10 immatures (CAS); Monteverde, 13 May 1964 (F. S. Truxal), one female (LACM); Monteverde, 14 May 1964 (F. S. Truxal), one female, one immature (LACM); Monteverde, 15 May 1964 (F. S. Truxal), one male (LACM); Monteverde, 17 May 1964 (F. S. Truxal), one male, two females (LACM); Monteverde (1390 m.), April 1971 (W. Burkirk), three males, two females, three immatures (CAS); Santa Elena, 14-18 Marzo 1977 (C. E. Valerio), four females (one with 42 young) (UCR); Monteverde community, in house on Smith farm (1520 m.), April-Aug. 1977 (C. L. Craig), one male (MCZ); Soda Flor Mar, Monteverde community, July 1978 (C. L. Craig, P. Klass), five males, one immature (MCZ); Manuel N. P. (moist trop. for. 0-50 m.), 24-26 Mar. 1983 (D. Ubick), one immature (DUC/CAS); Monteverde Res. Bosque Nuboso cloudforest (1700 m.), 1-4 April 1983 (D. Ubick), two males, two females, one immature (DUC/CAS); 5 km. antes de Bajo Rodriguez, camino a Santa Clara, Ciudad Quesada, 19.VI.1983 (S. Salas), one male (UCR). *Prov. San Jose*: San Jose, 10 May-10 August 1930 (E. Reimoser), one female (NMW).

### *Centruroides margaritatus* (Gervais)

Figs. 3, 39-47, 99, Map 2

*Scorpio margaritatus* Gervais, 1841:281-282, pl. II, figs. 13-17.

*Centrurus granosus* Thorell, 1877:155; *nec* Kraepelin, 1899:90.

*Centrurus margaritatus*: Pocock, 1893:386-387; Kraepelin, 1895:91, 1901:270; Borelli, 1899:3; Lampe, 1918:197; Viquez, 1935:112.

*Centruroides margaritatus*: Pocock 1902:30-32, pl. VII, figs. 1a-e, 2a-b; Baerg, 1925:472, 1954:275, 1961:24; Roewer, 1943:218; Kraus, 1955:101, 103, figs. 1-3; Bücherl, 1969:767; Armas, 1977:4; Wagner, 1977:42; Lourenço, 1983b:762-763.

*Centruroides gracilis*: Wagner, 1977:45 (in part, misidentification).

The synonymy given for this widespread, polytypic species is restricted to citations pertinent to the nominate subspecies from Central America (Guatemala to Panamá).

*Type data.*—Holotype female from Isla de Puna, Golfo de Guayaquil, Ecuador (Eydoux and Souleyet). Deposited in the Muséum National d' Histoire Naturelle, Paris. Not examined.

*Distribution.*—This abundant, widespread polytypic species is found in vast areas of tropical America, including Cuba and Jamaica, and from México south to Colombia.

*Diagnosis.*—Medium to large scorpions, adults 60-100 mm. long. Color variable; carapace, tergites I-VI, pedipalp chela, metasomal segment V and telson dark red-brown; carinae and larger granulation on body dark red-brown to black; all other regions yellow to yellow-brown (Figs. 39, 40). Carapace and tergites with dense, large granulation. Pectinal tooth counts 26-34 (mode, 30) on males, 24-33 (mode, 28) on females. Metasomal segment V 3 to 3.5 times longer than wide in males, slightly more than two times longer than wide in females. Metasomal carinae moderate to strong, granulose. Pedipalps densely hirsute, particularly internal aspect; all carinae moderate to strong, granulose; chela stout, 3 to 4 times longer than wide; digital carinae strong. Pedipalp chela fixed finger with eight primary rows of denticles. Trichobothriotaxy A-alpha (Figs. 41-47). Hemispermatophore flagelliform (Fig. 99); trunk and pedicel 8.8 mm. long.

*Measurements.*—Adult male: carapace 8.6; metasomal segment V 13.4; pedipalp femur 9.4; tibia 9.7; chela 15.5; fixed finger 8.3. Adult female: carapace 9.4; metasomal segment V 10.2; pedipalp femur 8.4; tibia 9.0; chela 15.0; fixed finger 7.8.

*Variation.*—Tergite VII and metasomal segments I-III are usually paler in color than are the carapace and tergites I-VI, but might be of the same color. Pectinal tooth counts varied as follows: in males, 2 combs with 26 teeth, 9 combs with 27 teeth, 14 combs with 28 teeth, 29 combs with 29 teeth, 47 combs with 30 teeth, 28 combs with 31 teeth, 13 combs with 32 teeth, 4 combs with 33 teeth, and 1 comb with 34 teeth, (3 combs damaged); in females, 7 combs with 24 teeth, 15 combs with 25 teeth, 28 combs with 26 teeth, 32 combs with 27 teeth, 45 combs with 28 teeth, 26 combs with 29 teeth, 7 combs with 30 teeth, 5 combs with 31 teeth, 1 comb with 32 teeth, and 1 comb with 33 teeth (5 combs damaged); in immatures, 2 combs with 24 teeth, 4 combs with 25 teeth, 2 combs with 26 teeth, 4 combs with 27 teeth, 21 combs with 28 teeth, 6 combs with 29 teeth, 10 combs with 30 teeth, 2 combs with 31 teeth, and 1 comb with 33 teeth (2 combs damaged).

*Specimens examined.*—COSTA RICA: no date (C. R. Dodge), one immature (MCZ); no date (C. Burgdorf and P. Schild), two immatures (USNM); no date (no collector), two females, one immature (NMW); no date (no collector), one female (UCR). *Prov. Alajuela:* Nov. 1911 (Wm. M. Wheeler), one immature (MCZ); Finca San Miguel, Estacion Barranca, 10 May 1939 (col. and pres. by Her R. Highness, Princess Sigismund of Prussia), two females (FMNH); San Miguel de Barranca, Pacific Coast, June 1951 (coll. by Carlota Agnes, Princesa Segismundo of Prussia), one male, one immature (MCZ); San Miguel, Tunucares, 19 Enero 1970 (R. Comacho C.), one male (UCR); Orotina, 15 Abril 1981 (G. Umana), one male (UCR). *Prov. Cartago:* Cartago, 6 Dec. 1911 (Wm. M. Wheeler), one immature (MCZ); Cartago, Dec. 1911 (Wm. M. Wheeler), one immature (MCZ); Cartago, 11-VIII-1956 (L. C. Kuitert), one juvenile (FSCA); 1 km. E and 4 km. N Corralillo, 4 August 1965 (S. J. Arnold), one female (UCB);

Tres Rios, 8 July 1966 (F. W. Fisk), one immature (UCR); Tres Rios, 14 March 1983 (W. G. Eberhard), one male (UCR). *Prov. Guanacaste*: Bebedero [confluence of Rio Tenorio and Rio de las Piedras], 17 June 1930 (E. Reimoser), five males, nine females, ten immatures (NMW); El Coco, 19-VII-1962 (F. S. Truxal), one female (LACM); Playa del Coco, 20-VII-1962 (F. S. Truxal), two females (LACM); Tilarán, Dec. 1964 (C. E. Valerio), one male, one female (UCR); Playas del Coco (under bark of fence posts), 9 July 1965 (no collector), three females (UCB); Playas del Coco (elev. sea level), 10 July 1965 (S. J. Arnold), one female, one immature (UCB); Playas del Coco (under bark of fence posts), 16 August 1965 (S. J. Arnold), one male, five females (UCB); Playas del Coco (sea level), 16 August 1965 (R. D. Sage), one immature (UCB); Playas del Coco, 17 August 1965 (S. J. Arnold), one female, one immature (UCB); Playas del Coco, 18 August 1965 (R. D. Sage), one male, two immatures (UCB); Playas del Coco, 19 August 1965 (S. J. Arnold), one male, two females, three immatures (UCB); Playas del Coco, 19 August 1965 (R. D. Sage), four males, three females, one immature (UCB); Playas del Coco (female and young under bark of fence post), 19 August 1965 (S. J. Arnold), one female with 15 first instars (UCB); 5 km. W Liberia, 20 August 1965 (R. D. Sage), one immature (UCB); 5.5 km. SE Desamparados (1260 m.), 29 August 1965 (R. D. Sage), one male (UCB); Finca La Pacifica, Cañas, 7-12 Febrero 1966 (C. E. Valerio), one male, one female, one immature (UCR); Aduana de Peñas Blancas, 15 Junio 1966 (C. E. Valerio), one immature (UCR); Tilarán, 17 Julio 1966 (C. E. Valerio), one immature (UCR); Finca Pacifica, Cañas (tropical dry forest), 2nd week February 1967 (H. L. Heringhi), one immature (UCB); Rio Cocobici, Las Cañas, 15 June 1967 (no collector), one male (USNM); Taboga, 27-29 June 1967 (Flint and Ortiz), one male, one immature (USNM); 6 mi. S. 6 mi. W Cañas, Taboga, 11-3 to 12-1967 (OTS Adv. Zoo. Course), one immature (MCZ); Finca Escuadra, 8.3 km. S Cañas, 2 June 1968 (C. A. Manea), one male, one female (UCR); Puerto Soley, La Cruz, 30 Noviembre 1970 (C. E. Valerio), one male (UCR); Taboga, Cañas (Es/comeca, Hda. ?), 3 Febrero 1971 (M. Marin y Z. Alvarez), one female (UCR); Finca Los Inocentes, Liberia, Volcan Orosi, 2 Nov. 1973 (R. Sotos), one female (UCR); Parque Nacional de Santa Rosa, 3 Agosto 1974 (J. Hidalgo R.), one male (UCR); Tilarán, Feb. 1975 (C. E. Valerio), one male (UCR); Conchal, 14 Julio 1977 (F. Valverde), one female (UCR); Playas del Coco, 28 Julio 1977 (J. Mirande), one female (UCR); Finca Palo Verde, nr. Puerto Humo (ultraviolet detection), 16 January 1978 (O. F. Francke), 14 males, 14 females, 9 immatures (OFF); Palo Verde Field Station-OTS, nr. Nicoya, 1 January 1979 (R. O. Albert), one female (FSCA); Parque Nacional de Santa Rosa, 10 Feb.-2 Mar. 1979 (C. K. Starr), two males (UCR); Playas del Coco, January 1982 (T. Brittain), two males, two females, one immature (MPM); Santa Rosa N. P.—send. Nat. deciduous Forest (250 m.), 5-9 April 1983 (D. Ubick), one female (DUC/CAS); Santa Rosa Parque Nacional, 31 Dec. 1983 (D. H. Janzen), one male (OFF); Liberia, 2 March 1984 (A. M. Young, J. Jass, S. Borkin), one immature (MPM); Parque Nacional Santa Rosa, 25 km. S. La Cruz, March 1984 (D. H. Janzen), 24 males, 8 females (OFF). *Prov. Limón*: Hamburg Farm, [=Castilla Farm]—lower reaches of Rio Reventazón, 4 IX 31, "im Wald" (E. Reimoser), one male (NMW). *Prov. Puntarenas*: Golfito ?, 22 July 1957 (Truxal and Manke), one female (LACM); Camino Monteverde, 23 August 1966 (F. M. Fisk), one female (UCR); Buenos Aires de Osa, 8 Abril 1977 (M. Villalobos), one female (UCR); Playa Jaco, 15 Abril 1977 (R. A. Acuna), one female (UCR); Jesus Ma., Orotina, 7 Mayo 1977 (C. Viscaino G.), one male (UCR); Costa de Pajaros, 5 Abril 1980 (V. E. Castillo), one female (UCR). *Prov. San Jose*: San Jose, Tibas, Guadalupe, no date (Tristan and Bailey), four females (BMNH); San Jose, 1892 (C. Fleischmann), one female (SM); La Caja, 23 Dec. (C. E. Valerio), one male (MCZ); 77 S. Jose, 1930 (M. Valerio), one immature (MCZ); San Jose, 10 July 1930 (E. Reimoser), two males (NMW); Escazu, Septiembre 1963 (C. E. Valerio), two females (UCR); Rio Virilla, carretera a Heredia, Julio 1964 (F. W. Fisk), one female (UCR); 5 km. ESE Desamparados, 31 July 1965 (R. D. Sage), one immature (UCB); 5 km. ESE Desamparados, 1 August 1965 (S. J. Arnold), one male (UCB); 5.5 mi. SE Desamparados (1350 ft.), 3 August 1965 (S. J. Arnold), one female (UCB); 4 km. SE Desamparados (1200 m.) (under rocks), 5 August 1965 (S. J. Arnold), one female, one juvenile (UCB); 5 km. ? S and 6 km. E Desamparados (1420 m.) (under bark), 6 August 1965 (S. J. Arnold), two females (UCB); 3 km. S, 6 km. E Desamparados (1400 m), 6 August

1965 (R. D. Sage), one immature (UCB); Lagos Lindara, Sta. Ana, San Jose, 17 Nov. 1969 (R. Camacho), one female (UCR); Santa Maria de Dota, Dec. 1978 (C. E. Valerio), one male, four females (UCR); Santa Maria de Dota, 4 Set. 1977 (R. Saenz C.), one female, six immatures (UCR); Reserva Biologica Carara, 30 Nov. to 3 Dec. 1982 (A. C. Gomez Ch.), one female (UCR); Escazu (banana-coffee plantation), 29.VII.1983 (H. and L. Levi), one female (MCZ); Lomas de Salitral, Desamparados, 1 Dec. 1983 (E. Mirando), one female (UCR).

*Centruroides thorelli* Kraepelin

Figs. 48-56, 100, Map 1

*Centrurus thorelli* Kraepelin, 1891:124, 1899:89-90.

*Centruroides thorelli*: Pocock, 1902:22; Hoffman, 1932:304-307, figs. 77, 78, 1938:319; *nec* Moreno, 1939a:73,74 (misidentification); Díaz-Nájera, 1966:111, 113, 1975:4, 18.

*Rhopalurus testaceus thorelli*: Meise, 1934:32, 34.

*Type data*.—Lectotype male and five paralectotypes (hereby designated), from Guatemala. Deposited in the Zoologisches Museum, Berlin. Examined.

*Distribution*.—Known from the Isthmus of Tehuantepec, México, south to Costa Rica.

*Diagnosis*.—Small scorpions, adult males rarely attain 50 mm. in length; slender. Base color yellow, with symmetrical infusate marbling producing an overall speckled appearance (Figs. 48, 49). Metasomal segment V and telson uniformly infusate. Pedipalp chela fixed finger with eight primary rows of denticles. Chela thinner than tibia, at least five times longer than wide; with weak digital carina. Metasoma very long and slender in adult males, segment I three times longer than wide, segment V at least five times longer than wide. Pectinal tooth count 12-14.

Males. Slender, 40-50 mm. long. Yellow with symmetrical light infusate marbling, producing a speckled appearance. Metasomal segment V and telson with uniform, light fuscidity. Carapace shagreened; interocular area and posterior submedian region moderately granulate. Prosomal venter yellow, smooth to vestigially granular, pitted; sternum with posteromedian pit. Mesosomal tergites shagreened, sparsely granulate; I-VI weakly monocarinate, VII pentacarpinate with submedian and lateral keels weak and finely granulate; intercarinal spaces coarsely granulate. Pectinal tooth count 14. Sternites smooth to shagreened, lightly punctate posteromedially. Sternite VII tetracarpinate, keels extremely weak to vestigial.

Metasoma long and slender. Segment I decarpinate, II-IV octocarpinate; all carinae weak, subserrate to smooth. Intercarpinal spaces shagreened. Segment V cylindrical, all carinae vestigial to obsolete, smooth. Telson elongate, vesicle longer than aculeus; subaculear tubercle large, strong.

Chelicera weakly infusate.

Pedipalps slender, minutely granular throughout. Femur with dorsal internal and dorsal external carinae weak, moderately granulate; ventral external keel weak, irregularly granulate; ventral internal keel weak, finely granulate. Tibia with all carinae weak to extremely weak, finely granulate. Internal surfaces of femur and tibia coarsely tuberculate. Chela slender, minutely granular throughout; dorsal marginal, dorsal secondary, digital,

external secondary, and ventral external carinae weak, minutely granulose; all other keels obsolete; internal face coarsely granulose. Fixed finger with eight imbricated rows of granules. Trichobothriotaxy A-alpha (Figs. 50-56).

Legs weakly infusate; carinae weak, minutely serrate. Tarsomeres moderately to densely setose.

Hemispermatothore flagelliform (Fig. 100); trunk and pedicel 3.6 mm. long.

Females. Shorter and less slender than males, 30-40 mm. long. Coloration as on males, more densely infusate. Prosomal venter smooth, pitted. Basal piece of pectines produced posteriorly into a large, rounded lobe. Pectinal tooth count 12-13. Mesosomal sterna smooth. Metasoma not very elongate; all carinae weak to moderate, finely serrate. Metasomal segment V pentacarinata, keels weak to moderate, finely serrate. Vesicle of telson subglobular, about as long as aculeus. Pedipalps not as long as on males; all carinae on femur and tibia moderate, minutely and closely granular; internal faces weakly tuberculate. Chelal carinae weak, feebly granular.

*Measurements.*—Adult male: carapace 4.0; metasomal segment V 7.10; pedipalp femur 4.4; tibia 5.0; chela 6.7; fixed finger 3.4. Adult female: carapace 3.2; metasomal segment V 3.8; pedipalp femur 3.0; tibia 3.3; chela 5.1; fixed finger 3.1.

*Variation.*—Specimens from Costa Rica do not differ significantly from those from Belize and from Campeche, México. These lowland scorpions, however, show some differences with the type series, which is probably from the mountainous areas in Guatemala. The examination of additional material from throughout Central America will be necessary to establish the taxonomic significance of these differences. Pectinal tooth counts among the Costa Rican specimens varied as follows: on males, 6 combs with 14 teeth, on females, 2 combs with 12 teeth, 3 combs with 13 teeth (1 comb was damaged).

*Specimens examined.*—Prov. Guanacaste: Tilarán, July 1964 (C. E. Valerio), one immature female (UCR); Tilarán (1 km. W pueblo, bajo cascara seca de un poste de la cereal), 18 Julio 1966 (C. E. Valerio), one adult male (UCR); Tilarán, 1 Junio 1968 (C. E. Valerio), one adult male (UCR); Parque Nacional Santa Rosa, 25 km. S. La Cruz, March 1984 (D. E. Janzen), one adult female (OFF).

### Genus *Isometrus* Hemprich and Erhenberg

The genus *Isometrus* contains 14 species, found in the Oriental and Australian biogeographic regions. One of those species is pantropical, presumably distributed by man in Recent times. The speckled appearance, lack of tibial spurs, presence of fulcra on the pectines (Fig. 61), and lack of supernumerary granules flanking the six primary rows of denticles of the pedipalp chela fingers are diagnostic (Fig. 2).

*Isometrus maculatus* (Degeer)

Figs. 2, 57-61, 101, Map 3

*Scorpio maculatus* Degeer, 1778:346-347, pl. 41, figs. 6, 7, 9, 10; Gervais, 1844a:222, 1844b:57.*Lychas maculatus* Koch, 1845:1-2, fig. 960.*Isometrus maculatus*: Thorell, 1876:8, 1894:369; Karsch, 1879a:18, 1879b:113-114; Pocock, 1890:119, 1893:376, 1897a:360, 1902:38-39; Kraepelin, 1891:103, 1899:66-67, 1901:268; Mello-Campos, 1924a:260-261, 1924b:326-327; Viquez, 1935:111; Moreno, 1939a:63-64, 1939b:121-122; Mello-Leitão, 1945: 241-242; Lamoral and Reynders, 1975:508-509; Koch, 1977:152-155.

We have chosen to present an abbreviated synonymy for this widespread species, as there are dozens of literature citations that merely add distribution records for tropical locations throughout the world.

*Type data.*—Types from "Suriname and Pennsylvania." Deposited in the Naturhistoriska Riksmuseet, Stockholm. Not examined.

*Distribution.*—Pantropical.

*Diagnosis.*—Adult males 70-80 mm. long, females 45-55 mm. long; males with metasoma and pedipalps extremely elongate, metasomal segment V, pedipalp femur, tibia, and chela each at least six times longer than wide. Yellow, with moderately dense, dark-brown to black mottling and spotting, tergites with five interrupted longitudinal dark bands (Figs. 57, 58). Pectinal tooth counts 16-20. Pedipalp chela fingers with six primary rows of denticles, no supernumerary granules (Fig. 2). Trichobothriotaxy A-beta (Figs. 59, 60). Legs with prolateral and retrolateral pedal spurs, no tibial spurs. Hemispermatophore flagelliform (Fig. 101); trunk and pedicel 2.3 mm. long.

*Measurements.*—Adult male (from Hawaii): carapace 4.4; metasomal segment V 7.6; pedipalp femur 6.9; tibia 7.1; chela 9.8; fixed finger 5.8. Adult female (from Hawaii): carapace 5.1; metasomal segment V 5.9; pedipalp femur 5.1; tibia 5.5; chela 8.3; fixed finger 5.1.

*Variability.*—The three females studied from Costa Rica do not differ from specimens collected in Hawaii. Pectinal tooth counts varied as follows: 1 comb with 17 teeth, 3 combs with 18 teeth (2 combs damaged).

*Specimens examined.*—COSTA RICA: Zent, 1915 (H. F. Blair and T. Barbour), one female (MCZ). Prov. Limon: "Port Limon," no date (Dr. Edw. L. Salisbury), two females (MCZ).

Genus *Tityus* Koch

The most diverse genus of scorpions in the world, *Tityus* has more than 100 described species. It occurs from Argentina north to Costa Rica, and on the Caribbean islands north to Cuba. There is no comprehensive revision available: Mello-Leitão's (1945) treatment of the South American species is outdated; various works by Francke, González-Sponga, Lourenço, and Maury have dealt with certain species groups or regional faunas.

The presence of 12 or more imbricated rows of primary denticles, without supernumerary granules, on the fingers of the pedipalp chela is diagnostic (Fig. 5).

*Tityus championi* Pocock

Figs. 5, 62-70, 102, Map 3

*Tityus championi* Pocock, 1898:384-385; Kraepelin, 1899:81.*Tityus cambridgei championi*: Pocock, 1902:40-42; Hirst, 1911:468; Esquivel de Verde, 1968:68; Esquivel de Verde and Machado-Allison, 1969:28.*Tityus asthenes championi*: Mello-Leitão, 1931:135.*Tityus championi* [sic]: Viquez, 1935:111.

*Type data*.—Holotype male (subadult), from Bugaba, Panamá. Deposited in the British Museum (Natural History). Examined.

*Distribution*.—Known from Colombia, Costa Rica and Panamá.

*Diagnosis*.—Member of the *forcipula* group of Mello-Leitão (1945); characterized by large size, uniform dark coloration, paired ventral submedian keels on metasomal segments I-IV, and dilated basal middle lamellae on the pectines of the females. Adults 60-70 mm. long. Medium brown with moderate to dense variegated fuscosity throughout, except pedipalp femur, tibia, and manus (Figs. 62, 63). Metasomal segment V at least twice longer than wide. Underhand shorter than carapace. Pedipalp chela fingers with 14 imbricated rows of denticles. Pectinal tooth counts 16-22.

Males. Carapace medium brown: ocular tubercle and margins densely infusate, disc with moderate variegated fuscosity; submedian keels moderate, granulose; other keels vestigial; disc with sparse, small granules. Prosomal venter moderately infusate. Tegites I-VI with posterior margin densely infusate, other areas with moderate, variegated fuscosity; median keel weak to vestigial, sparsely granulose; disc with sparse, small and medium granules. Tergite VII with moderate, variegated fuscosity throughout; pentacarinat, with median keel weak and subgranulose, submedian and lateral keels weak to moderate and granulose. Mesosomal venter brown, progressively more densely infusate distally. Pectinal tooth count 16-22 (mode, 21). Sternites III-VI smooth; VII tetracarinat, keels weak to moderate, granulose.

Metasoma brown, moderately to densely infusate, progressively darker distally. Dorsal submedian carinae on I-IV moderately strong, granulose. Lateral suprmedian carinae on I-III moderate, granulose; on IV vestigial, feebly granulose. Lateral inframedian carinae on I complete, moderate, granulose; on II present on distal one-fourth, weak, subgranulose; on III and IV obsolete. Ventral lateral and ventral submedian carinae on I-IV moderate, granulose. Segment V pentacarinat; dorsolateral, ventrolateral, and ventral median keels weak, subgranulose; other keels obsolete.

Chelicera pale yellow; chela with moderate, variegated fuscosity; fingers densely, uniformly infusate.

Pedipalps orange-brown; apex of tibia, and chela fingers densely, uniformly infusate. Trichobothriotaxy A-alpha (Figs. 64-70). Fixed finger with 14 imbricated primary rows of denticles, with weak basal notch; movable finger with weak basal lobe.

Legs brown, densely infusate.

Hemispermatothore flagelliform (Fig. 102); trunk and pedicel 9.6 mm. long.

Females. Differ from males as follows: pedipalps not elongate (see measurements); pedipalp chela fingers without basal matching lobe/notch combination; basal middle lamellae of pectines dilated.

*Measurements.*—Adult male: carapace 7.2; metasomal segment V 8.5; pedipalp femur 10.3; tibia 10.5; chela 17.2; fixed finger 9.0. Adult female: carapace 6.8; metasomal segment V 7.2; pedipalp femur 7.2; tibia 7.6; chela 13.2; fixed finger 7.6.

*Variability.*—Immature specimens are yellow, with fuscous marbling throughout. Pectinal tooth counts for the three Costa Rican specimens were as follows: male 16-16, female 18-18, juvenile 18-18.

*Specimens examined.*—*Prov. Puntarenas:* Finca Las Cruces, San Vito, 14 Marzo 1967 (C. E. Valerio), one juvenile (UCR); San Vito, Coto Brus, 29 Aug. 1969 (C. E. Valerio ?), one female (UCR); San Vito de Coto Brus, 9.VII-7.VIII 1982 (B. D. Gill), one male (MIUP).

***Tityus dedoslargos*, new species**

Figs. 71, 73-79, 103, Map 3

*Type data.*—Holotype male (adult) from El General, approx. 18 km. S San Isidro, Provincia Puntarenas, Costa Rica (Jean E. Baldrige). Deposited at the Museo de Zoología, Universidad de Costa Rica.

*Etymology.*—The specific epithet is a Spanish noun in apposition (meaning "long fingers").

*Distribution.*—Known only from the type locality.

*Diagnosis.*—Member of the *nematochirus* group of Mello-Leitão, characterized by relatively large size, uniformly dark color, metasomal segments I-IV with parallel ventral submedian carinae, and elongate pedipalps (Fig. 71). Adult male 67 mm. long. Orange-brown; margins of carapace and tergites uniformly infusate; pedipalp chela fingers, metasomal segment V, and telson dark reddish-brown. Pectinal tooth count 16. Dorsolateral keels on metasomal segments III and IV with distal granule enlarged. Metasomal segment V not conspicuously wider than preceding segments, slightly over two times longer than wide. Pedipalps long and slender; femur, tibia and chela together over six times longer than carapace; femur over five times longer than wide. Underhand longer than carapace. Fixed finger of pedipalp chela with 14 imbricated rows of denticles, movable finger with 15 rows of denticles.

Holotype male. Orange-brown; margins of carapace and tergites infusate; chela fingers, segment V, and telson dark red-brown. Surface of sclerites shagreened to minutely granulate throughout. All keels sparsely granulate. Carapace with superciliary, lateral ocular, anterior submedian, and posterior submedian carinae weak to moderate. Prosomal venter yellow-brown, gnathobases moderately infusate. Tergites I-VI: pretergites moderately infusate medially, posterior margin of tergites moderately

infusate medially and laterally, producing a faint striped aspect; median longitudinal and transverse lateral carinae weak to obsolete. Tergite VII pentacarinata: median keel vestigial, present on anterior one-half; submedian and lateral keels weak. Genital operculi infusate on margins. Pectinal tooth count 16 (right side damaged, with only 8 teeth). Mesosomal sternites lightly to moderately infusate, with posterior margins densely infusate. Sternite III with small, pale, triangular patch posteromedially, sternite V with large triangular patch posteromedially. Sternite VII with submedian carinae vestigial, lateral carinae weak.

Metasoma orange-brown basally, dark red-brown distally. Dorsal lateral carinae on I moderate; on II-IV strong, weakly tuberculate, with an enlarged granule distally. Lateral supramedian carinae on I weak, on II-IV moderate. Lateral inframedian keel on I complete, weak; on II present on distal one-fourth, extremely weak; on III and IV obsolete. Ventral lateral carinae on I and II weak, on III and IV moderate. Ventral submedian carinae on I quite weak, on II-IV weak. Segment V pentacarinata; with keels weak to vestigial. Telson globular, sparsely granulose.

Chelicera yellow-brown, moderately infusate.

Pedipalps long and slender; orange-brown except for dark red-brown fingers. Femur with dorsal internal, dorsal external and ventral external carinae weak; ventral internal keel weak; internal face weakly tuberculate. Tibial carinae weak, basal tubercle moderately strong, spinoid. Chela with dorsal secondary, digital, and ventral external carinae weak to vestigial, sparsely and weakly granulose; external secondary and ventral internal keels vestigial. Trichobothriotaxy A-alpha (Figs. 73-79). Fixed finger with 14 imbricated rows of denticles, movable finger with 15 imbricated rows of denticles.

Legs yellow-brown, moderately infusate.

Hemispermaphore flagelliform (Fig. 103); trunk and pedicel 7.5 mm. long.

Female. Unknown.

*Measurements.*—Holotype male: carapace 7.7; metasomal segment V 9.4; pedipalp femur 12.7; tibia 12.9; chela 20.8; fixed finger 11.1.

*Variability.*—Known only from holotype male.

*Remarks and comparisons.*—To our knowledge, only two species have been referred to the *nematochirus* group of Mello-Leitão (1945)—*Tityus nematochirus* Mello-Leitão, from Colombia and Venezuela, and *Tityus meridanus* González-Sponga, from Venezuela. Mello-Leitão gave, in addition to the characters listed in the diagnosis, one further feature for this species group; namely, the basal middle lamellae on females is not dilated. It is not clear from the original description (Mello-Leitão, 1940), nor from the treatment in his monograph on South American scorpions (Mello-Leitão, 1945), that he ever saw an adult female. González-Sponga (1984) reported the species from Venezuela, but did not mention the basal middle lamellae on females. In addition, González-Sponga (1981) illustrated the

marginal and middle lamellae in *Tityus meridanus*, but it is not clear whether the basal middle lamellae on females is swollen. We have examined one adult female from Colombia (accompanied by an adult male), that has clearly dilated basal marginal lamellae on the pectines.

*Tityus dedoslargos* has the elongate pedipalps which are a diagnostic feature of the *nematochirus* group. It differs from *T. nematochirus* as follows: (1) pectinal teeth 16 rather than 18-22 (mode, 20), (2) fixed finger with 14 rows of granules rather than 15, (3) movable finger with 15 rows of granules rather than 17, (4) body without variegated fuscosity throughout. The new species differs from *T. meridanus* as follows: (1) pectinal tooth count 16 rather than 18-19, (2) fixed finger with 14 rows of granules rather than 15, (3) movable finger with 15 rows of granules rather than 16-17.

*Specimens examined*.—Known only from the holotype.

***Tityus ocelote***, new species

Figs. 80-88, 104, Map 3

*Type data*.—Holotype male from Finca La Selva, Provincia Heredia, Costa Rica, 4-11 January 1978 (O. F. Francke and J. Rodriguez). Deposited in The American Museum of Natural History, New York. Paratypes listed under specimens examined.

*Etymology*.—The specific epithet is a noun in apposition, from the Spanish word for a small, spotted cat found throughout Central America.

*Distribution*.—Known only from three provinces in Costa Rica—Heredia, Limón, and Puntarenas.

*Diagnosis*.—Member of the *clathratus* group of Mello-Leitão (1945), group characterized as follows: small to medium size (always less than 50 mm. long); body, legs, and palps spotted; dorsal lateral keels on segments II-IV with distal tooth enlarged; females with basal middle lamellae on pectines not dilated; male pedipalp chela movable finger without a basal lobe; metasoma parallel-sided, or narrowing posteriorly. Specifically, *Tityus ocelote*, as members of this group, are small scorpions, always less than 30 mm. long. Base color yellow, with dark reddish-brown marbling (Figs. 80, 81). Pedipalp chela and metasomal segment V on males greatly inflated, globular. Pedipalp chela trichobothrium Eb<sub>3</sub> basal to Eb<sub>1</sub> and Eb<sub>2</sub>. Fixed finger with 13 imbricated primary rows of denticles, movable finger with 13 or 14 rows. Metasomal dorsal lateral keels with weakly enlarged distal teeth on segments I-IV. Pectinal tooth count 11-14 (mode, 13). Females with basal middle lamellae on pectines not dilated.

Males. Small, less than 30 mm. long. Base color yellow, symmetrically marbled by dark reddish-brown, producing an overall spotted appearance. Carapace densely granular; all carinae distinct, granular; median eyes relatively large. Tergites densely granular; median, submedian, and transverse keels present, granulose, becoming stronger distally. Tergite VII pentacarinat; keels moderate, granulose. Pectinal tooth count 11-14.

Sternites spotted, rough. Sternite VII with submedian keels vestigial, granular; lateral keels obsolete.

Metasoma granular; all carinae on metasomal segments I-IV granulose. Dorsal lateral carinae on I and II weak, and III and IV very weak; distal tooth weakly enlarged. Lateral suprmedian carinae on I-III weak, and IV vestigial. Lateral infrmedian keels on I weak, on II vestigial, on III and IV obsolete. Ventral lateral carinae on I-IV weak. Ventral submedian carinae on I-IV weak to extremely weak. Metasomal segment V inflated, globular; all carinae vestigial to obsolete; subgranulose. Telson somewhat elongate, granular.

Chelicera marbled.

Pedipalps granular throughout, with fine carinae. Femur with dorsal external keel weak, granulose; ventral external and ventral internal keels moderate, finely tuberculate; dorsal internal keel weak, granular. Tibia with dorsal internal and dorsal median keels weak, granular; dorsal external and ventral external keels weak, granular; ventral internal keel moderate, granular; basal internal tubercle moderately strong. Chela inflated; internal secondary, dorsal marginal, dorsal secondary, digital, external secondary, ventral external, and ventral median carinae weak to vestigial, subgranulose to smooth; all other keels obsolete. Fixed finger with 13 imbricated rows of denticles, movable finger with 13-14 rows of denticles. Trichobothriotaxy A-alpha (Figs. 82-88).

Legs weakly granular, finely carinate.

Hemispermaphore flagelliform (Fig. 104); trunk and pedicel 3.3 mm. long.

Females. Differ from males as indicated below. Pedipalp chela and metasomal segment V not inflated, of same proportions as on immatures. Metasomal dorsal lateral keels on I-IV weak; all keels on segment V weak to extremely weak, granulose.

*Measurements.*—Holotype male: carapace 3.5; metasomal segment V 4.1; pedipalp femur 3.3; tibia 3.6; chela 6.3; fixed finger 3.2. Adult female: carapace 3.4; metasomal segment V 3.8; pedipalp femur 3.2; tibia 3.6; chela 5.6; fixed finger 3.4.

*Variation.*—Pectinal tooth counts do not vary significantly between sexes, and vary only slightly among all specimens: 1 comb had 11 teeth, 31 had 12 teeth, 61 had 13 teeth, and 5 had 14 teeth.

*Comparisons.*—This new species belongs in the *clathratus* group of Mello-Leitão (1945), which was briefly analyzed by Lourenço (1984). *Tityus ocelote* appears to be most closely related to *Tityus columbianus* (Thorell), on morphological and geographical considerations. These two species have the lowest pectinal tooth counts within the *clathratus* group, with a mode of less than 14, as opposed to 14 or more for the other species in the group. *Tityus columbianus*, however, does not have the inflated pedipalp chela and metasomal segment V observed on males of *T. ocelote*, and has only 11 to 12 rows of granules on the pedipalp chela fingers, rather than the 13 to 14 observed in the new taxon.

The new taxon is also similar to *Tityus parvulus* Kraepelin, from which it differs as follows: (1) lower pectinal tooth counts (17-18 in the latter); (2) lateral inframedian keels on metasomal segment II, vestigial on the new species, and well developed on *T. parvulus*; and (3) in pedipalp chela morphometrics, with males of the new species having a proportionately wider chela, and a relatively shorter finger than has the single male of *T. parvulus* available to us.

*Specimens examined* (all designated paratypes).—*Prov. Heredia*: Finca La Selva, 4-11 January 1978 (O. F. Francke and J. Rodriguez), 14 males, 25 females, 12 immatures (AMNH, FSCA, MNHN, OFF); La Selva, February 1981 (W. G. Eberhard), one immature (MCZ); Finca La Tigra, near La Virgen, 3 August 1984 (A. M. Young), one immature (MPM). *Prov. Limón*: Parque Nacional Cahuita, Puerto Cahuita, 25 April 1983 (D. Ubick), one immature (DUC/CAS). *Prov. Puntarenas*: Coto (humus on palm), 11 Sept. 1957 (E. Dixon), one male, one female with seven immatures (2 vials, FSCA); Parque Nacional Manuel Antonio (0-50 m.), 24-26 March 1983 (D. Ubick), one immature (DUC/CAS).

*Tityus pachyurus* Pocock

Figs. 73, 89-95, 105, Map 3

*Tityus pachyurus* Pocock, 1897b:511-512, 516, 518, figs. 2-2b; Kraepelin, 1899:80. 1901:269, 1914:16-17; Mello-Leitão, 1931:135-136, 1932:30, 1945:427-429, figs. 174, 175; Caporiacco, 1951:4; Scorza, 1954a:161, 1954b:206-207; Bücherl, 1969:767; Esquivel de Verde and Machado-Allison, 1969:28.

*Type data*.—Holotype male from Colombia. Deposited in the British Museum (Natural History). Not examined.

*Distribution*.—Known from Costa Rica, Panamá, and Colombia. Several citations of this species for Venezuela appear to be based on Mello-Leitão's (1945) work; however, none mention any specimens or localities from that country. González-Sponga (1981), in his comprehensive review of the scorpions of Venezuela, did not mention it either.

*Diagnosis*.—Member of the *forcipula* group of Mello-Leitão (1945), characterized by large size, uniformly dark color, paired ventral submedian keels on metasomal segments I-IV, and dilated basal middle lamellae on the pectines of females. Adults 60-75 mm. long. Pale to medium brown, with metasomal segments IV, V and telson darker, almost black; without variegated fuscosity on dorsum (Fig. 72). Pectinal tooth counts 16-22 (mode, 21). Metasoma becoming distinctly wider distally, segment V less than twice as long as wide. Pedipalp femur and tibia each shorter than metasomal segment V. Underhand shorter than carapace. Pedipalp chela fixed finger with 14 rows of denticles; on males with strong basal notch; movable finger with 15 rows of denticles; on males with strong basal lobe.

Male. Carapace medium brown; submedian carinae weak, granulose, other keels obsolete; densely, minutely granulose. Prosomal venter medium brown. Tergites medium brown, without traces of fuscosity; densely, minutely granulose; II-VI with median keels present on distal one-half only, weak, granulose; VII tetracarinate, keels weak to moderate, coarsely granulose. Pectinal tooth counts 16-22. Sternites medium brown, with

diffuse fuscidity on disc, moderate fuscidity on margins. Sternite VII with lateral keels vestigial, subserrate; submedian keels obsolete.

Metasomal segments I and II medium brown; III reddish brown; IV, V, and telson very dark red-brown, almost black. Segments become progressively wider distally. Dorsolateral carinae on I-IV weak to moderate, coarsely granulose; distal granules on III and IV slightly larger than preceding granules. Lateral supramedian carinae on I-III weak, coarsely granulose, on IV vestigial to obsolete. Lateral inframedian carinae on I complete, weak, subgranose; on II present on distal one-third, vestigial; on III and IV obsolete. Ventral lateral carinae on I-IV moderate, coarsely granulose. Ventral submedian carinae on I-III weak, subgranose; on IV vestigial to obsolete. Segment V coarsely granulose laterally and ventrally; dorsal lateral and ventral lateral keels moderate, coarsely granulose; other keels indistinct. Telson vestigially granulose.

Chelicera yellow, with faint, finely variegated fuscidity basally, moderately dense, uniform fuscidity distally.

Pedipalp femur and tibia medium brown, chela with manus red-brown, finger dark brown to black. Femur with internal carina moderate, tuberculate; dorsal internal, ventral internal, and dorsal external carinae moderate, finely granulose; ventral external keel obsolete. Tibia with dorsal internal carina moderate, tuberculate, with strong basal tubercle; dorsal median, dorsal external, and external keels weak, finely granulose; ventral external keel obsolete. Chela globose, wider than metasomal segment I; carinae weak to vestigial, subgranose. Fixed finger with strong basal notch, 14 rows of denticles; movable finger with strong basal lobe, 15 rows of denticles. Trichobothriotaxy A-alpha (Figs. 89-95).

Legs medium brown, with weak fuscidity distally.

Hemispermatothore flagelliform (Fig. 105); trunk and pedicel 9.0 mm. long.

*Measurements.*—Adult male: carapace 7.5; metasomal segment V 9.0; pedipalp femur 8.0; tibia 8.4; chela 16.0; fixed finger 9.0.

*Variability.*—Only one adult male from Costa Rica was examined.

*Specimen examined.*—Prov. Limón: Waldeck, 30 March (C. R. Dodge), one male (MCZ).

#### Family CHACTIDAE

The family Chactidae contains 18 genera (Francke, 1985), 16 of which are found in the New World, and two in Europe. Only three genera are found in Central America—*Plesiochactas* Karsch in Guatemala, *Broteochactas* Pocock in Panamá, and *Chactas* Gervais in Costa Rica and Panamá.

#### Genus *Chactas* Gervais

The genus *Chactas* contains about 20 species, variously assigned to five subgenera. They are found from the Amazon basin in Perú and Brazil north to Costa Rica. The presence of only two pair of lateral eyes, prolateral and

retrolateral pedal spurs, and five ventral trichobothria on the tibia are diagnostic. The species found in Costa Rica belongs in the subgenus *Chactas* Gervais, characterized by having tarsomere II on all legs armed ventrally with a longitudinal row of 4 to 8 spines, and the absence of ventral lateral and ventral submedian carinae on metasomal segments I-III.

*Chactas (Chactas) exsul* (Werner, 1939), new combination

Figs. 106, 108-113, Map 4

*Iomachus exsul* Werner, 1939:360, fig. 3.

*Type data*.—Holotype male from Las Mercedes (10-30 m.), plains of Limón, Costa Rica. Originally deposited in the Zoologisches Institut und Zoologisches Museum, Hamburg; destroyed during World War II. Neotype female (hereby designated) from El Valle, Panamá, I-1947 (N. L. H. Kraus). Deposited in the United States National Museum, Smithsonian Institution, Washington.

*Distribution*.—Known only from Panamá and Costa Rica.

*Diagnosis*.—Medium to small scorpions, adult females 30-35 mm. long, males unknown. Body medium brown with diffuse variegated fuscidity throughout, lustruous; pedipalps orange-brown, with sparse to moderate fuscidity; legs and venter yellow-brown, sparsely infuscate. Two pairs of lateral eyes. Pectinal tooth count 5-6 (mode = 6). Stigmata oval. Metasomal segments I-IV with ventral keels obsolete. Bothriotaxia C, tibia with five ventral trichobothria. Tarsomere II on all legs with a ventral median longitudinal row of 3 to 4 sharp, setiform spines.

Males. Unknown.

Females.—Carapace medium brown, with distinct variegated fuscidity; two pairs of lateral eyes, the anterior pair larger in diameter than the median eyes; lustruous and acarinate, furrows shallow; laterally with moderately dense, minute granulation. Venter yellow to orange-brown, sparsely infuscate. Sternum pentagonal, wider than long. Tergites medium brown, with distinct variegated fuscidity; acarinate, smooth and shiny, except for VII with sparse small granulation posterolaterally. Venter yellowish, sternites diffusely infuscate laterally. Pectinal tooth count 5-6. Sternites smooth and shiny, VII acarinate.

Metasomal segments I and II wider than long, III as long as wide, IV and V longer than wide; medium brown with distinct variegated fuscidity; vesicle yellow-brown with diffuse fuscidity; segments I-IV smooth and shiny, V and telson with moderately dense, small granulation. Dorsal lateral carinae on I-III vestigial to obsolete, a few granules indicate their position; on IV weak, sparsely granulose. Lateral supramedian carinae on I and II weak, smooth; on III and IV vestigial, smooth to faintly granular. Lateral inframedian keels on I indicated by a basal granule; on II-IV obsolete. Ventral lateral and ventral submedian carinae on I-IV obsolete. On segment V, dorsal lateral and lateral median keels vestigial, subgranulose; ventral lateral and ventral median keels weak, granulose.

Chelicera yellow-brown, base with diffuse variegated fuscosity, fingers with dense uniform fuscosity. Movable finger with serrula.

Pedipalps medium brown to orange-brown; femur with moderately dense, almost uniform fuscosity; tibia with moderate to sparse variegated fuscosity; manus vestigially infusate, fingers densely infusate appearing black. Femur with dorsal internal, dorsal external and ventral internal keels strong, tuberculate; ventral external keel obsolete; dorsal and ventral faces with dense, small and minute granulation; internal face coarsely granulose. Tibia smooth, lustrous; dorsal internal and ventral internal keels weak to moderate, tuberculate; ventral external and dorsal external keels weak, densely granulose; other keels obsolete. Chela lustrous; dorsal marginal, digital, external secondary, and ventrointernal keels weak, densely granulose; ventral median keel strong, coarsely granulose; other keels vestigial to obsolete, smooth. *Neobothriotaxia* C (Figs. 108-113).

*Measurements.*—Neotype female: carapace 5.9; metasomal segment V 4.3; pedipalp femur 4.9; tibia 5.2; chela 10.2 fixed finger 3.5.

*Variability.*—The only significant variability among the five females studied was in pectinal tooth counts: 1 comb with 5 teeth, and 9 combs with 6 teeth.

*Comparisons.*—This species is most closely related to *Chactas* (*Chactas*) *vanbenedeni* Gervais, from Colombia. The most significant differences between females of these two species are: (1) pectinal tooth counts in *C. exsul* are 5-6 (mode, 6), and in *C. vanbenedeni* are 8-9 (mode, 9); (2) the dorsal face of the pedipalp femur in *C. exsul* is densely, minutely granulose, whereas on *C. vanbenedeni* it is lustrous with a few small granules; and (3) the pedipalp chela on *C. exsul* has four keels (dorsal marginal, digital, external secondary, and ventrointernal) that are weak and densely granulose, whereas on *C. vanbenedeni* the chela is smooth and shiny, and the only prominent keel is the ventral median.

*Specimens examined.*—PANAMA: El Valle, 1-1947 (N. L. H. Kraus), neotype female and one additional female (USNM); Porto Bello, Feb 1911 (Aug. Busck), one female (USNM); Porto Bello, 14 Mar. 1911 (August Busck), one juvenile (USNM). COSTA RICA: *Prov. Limón*: Hamburg Farm, no date (C. R. Dodge), one female (MCZ).

#### Family DIPLOCENTRIDAE

Diplocentridae is a relatively small family with seven genera: one occurs in the Middle East, five occur in the New World, and one genus has a disjunct distribution and occurs in both areas. The New World taxa are found from the United States south to northern Colombia and Venezuela. The diplocentrids from circum-Caribbean regions, including Central America, were revised by Francke (1978b).

#### Genus *Didymocentrus* Kraepelin

The genus *Didymocentrus* contains eight species, six from Caribbean islands, and two from Central America. The lack of retrolateral pedal spurs,

presence of a subaculear tubercle, presence of a strong ventral transverse keel on metasomal segment V, and tarsomere II on all legs armed ventrally with two parallel rows of spines are diagnostic.

*Didymocentrus concavimanus*, new species

Figs. 114-124, Map 4

*Type data*.—Holotype male from Finca Palo Verde (OTS), 6 km. NE Puerto Humo (on Río Tempisque), Provincia Guanacaste, Costa Rica, 16-22 January 1978 (O. F. Francke, J. Rodriguez). Deposited in the American Museum of Natural History, New York. Paratypes listed under specimens examined.

*Etymology*.—Specific epithet derived from a combination of the Latin words *concavus*, or concave, and *manus*, or hand.

*Distribution*.—Known only from Guanacaste Province, Costa Rica.

*Diagnosis*.—Adults 35-40 mm. long (Figs. 114, 115). Adult males yellow-brown, females medium brown, immatures tan. Pectinal tooth counts 11-13 (mode, 12) in males, 9-11 (mode, 10) in females. Metasomal segment II longer than wide; segment V length greater than twice its width in adult males, less than or equal to twice its width in females and immatures. Pedipalp chela fixed finger length greater than femur length in males, less than femur length in females and immatures. Pedipalp chela length greater than twice its width in males, equal to twice its width in females. Inner face of pedipalp chela on adult males with a sharply defined, deep, and broad depression. Tarsomere II spine formula 3/3:4/4:5/5:5/5.

Males. Yellowish brown; carapace, tergites, and metasomal carinae uniformly and weakly infusate. Carapace and tergites acarinate. Carapace lustrous, densely punctate. Mesosomal pretergites lustrous, moderately punctate; tergites weakly shagreened, densely punctate. Tergite VII bilobed posterolaterally, acarinate. Pectinal tooth counts 11-13. Sternites coriaceous, densely punctate; sternite VII acarinate.

Metasomal segments densely punctate, weakly shagreened. Segment II longer than wide, segment V more than twice longer than wide. Dorsal lateral carinae on I-IV weak to vestigial, granulose. Lateral supramedian carinae vestigial on I-IV. Lateral inframedian carinae present as a weak bump on the basal one-fourth of segment I, obsolete on II-IV. Ventral lateral carinae on I-IV weak, smooth. Ventral submedian carinae on I weak, smooth; on II vestigial; on III and IV obsolete. Segment V with ventral median, transverse, and ventral lateral carinae moderately strong, with a single row of medium-sized tubercles (Fig. 121); lateral median carinae obsolete; dorsal carinae weak, granulose; anal subterminal carina moderately strong, tuberculate; and terminal keel obsolete. Telson moderately setate, densely punctate, with several granules basally.

Pedipalps elongate, densely punctate, all internal faces granular. Femur with dorsal external carina weak to vestigial, granulose proximally; ventral external carina vestigial; dorsal internal and ventral internal keels moderate,

tuberculate. Tibia with dorsal internal carina weak proximally, obsolete distally, weakly tuberculate; dorsal median keel weak, smooth to crenulate; dorsal external carina vestigial; ventral external keel weak, smooth; ventral internal keel weak, weakly tuberculate. Chela elongate, angular in appearance. Ventral area of chela broad. Digital carina weak to vestigial, smooth; dorsal marginal carina moderate, granulose; ventral external keel moderate, smooth; ventral median keel moderate, granulose; ventral internal keel weak. Fingers densely setate; inner aspect of base of fixed finger with distinct, deep depression. Trichobothriotaxy C (Figs. 116-120).

Legs yellow, lightly infuscate, sparsely granulose, weakly punctate on all segments except tarsomeres. Tarsomere II spine formula 3/3:4/4:5/5:5/5.

The two adult males available are teneral (not fully sclerotized), and no hemispermaphores were obtained.

Females. Differ from males as follows. Carapace and tergites brown, uniformly infuscate. Mesosomal tergite VII with lateral carinae weak, smooth. Pectinal tooth count 9-11. Metasoma brown to reddish brown distally; carinae and distal margins of each segment infuscate. Dorsal lateral carinae on segment I vestigial, smooth to subcrenulate; on II weak, subcrenulate; on III moderate, crenulate; on IV moderately strong, granulose. Lateral supramedian carinae on I-III weak, smooth to subgranulose; on IV vestigial, subgranulose. Lateral inframedian carinae on I weak to vestigial, smooth; on II-IV obsolete. Ventral lateral carinae on I-IV moderately strong, smooth. Ventral submedian carinae on I moderate, smooth; on II weak, smooth; on III and IV obsolete. Segment V length to width ratio between 1.85 and 2.00; ventral median and ventral lateral carinae moderate, closely tuberculate; lateral median carina present on basal one-half, vestigial, smooth; dorsal lateral keels moderate, crenulate; anal subterminal keel strong, with medium-sized, close tubercles.

Pedipalps brown basally, reddish brown distally. Femur with dorsal external keel weak on basal two-thirds, granulose; vestigial, smooth distally; ventral external carina vestigial, smooth; ventral internal and dorsal internal keels moderate, granulose. Tibia with dorsal internal keel obsolete; dorsal median carina moderate, smooth; dorsal external keel vestigial, smooth; ventral external keel weak, smooth; ventral internal keel weak, granulose. Chela robust, its length equal to twice its width; dorsal and external carinae obsolete; ventral internal and ventral external keels vestigial, smooth; ventral median keel weak, weakly granulose. Inner aspect of base of fixed finger smooth, without depression (Figs. 122-124).

Legs brownish yellow, lustrous, weakly punctate.

*Measurements.*—Holotype male: carapace 5.0; metasomal segment V 4.7; pedipalp femur 4.8; tibia 5.9; chela 10.1; fixed finger 5.0. Adult female: carapace 5.5; metasomal segment V 4.5; pedipalp femur 4.2; tibia 4.5; chela 8.9; fixed finger 3.5.

*Variation.*—Aside from the sexual dimorphism described above, the following characters varied significantly. Pectinal tooth counts: in males, 4

combs with 11 teeth, 30 combs with 12 teeth, and 4 combs with 13 teeth; in females, 2 combs with 9 teeth, 26 combs with 10 teeth, and 18 combs with 11 teeth; in small immatures, 1 comb with 9 teeth, 7 combs with 10 teeth, and 10 combs with 11 teeth. Tarsomere II spine formulae: 32 of 49 specimens studied have the typical formula of 3/3:4/4:5/5:5/5; six have the typical formula on all but one missing tarsus, and 11 have variation in the number of spines on one or two legs.

*Comparisons.*—The pronounced sexual dimorphism in metasomal and pedipalp proportions in the new species has rendered worthless the distinction of the two species groups proposed by Francke (1978b). A given morphometric character tends to ally males with one species group and females with the other group, whereas another character reverses those affinities altogether. Until adult males of the two other Central American species are found it is not practical to attempt any further phylogeny reconstructions.

*Didymocentrus concavimanus* differs from *Didymocentrus nitidus* Hirst, from Nicaragua, in tarsomere II spine formula: 3/3:4/4:5/5:5/5 in the former and 4/4:5/5:6/6:6/6 in the latter. The new species differs from *Didymocentrus krausi* Francke, known only from immatures and found in El Salvador, Honduras, and Nicaragua, in having metasomal segment II longer than wide, metasomal segment V length/width ration greater than 1.85, tergite VII bilobed posterolaterally, and females with a chela width to carapace length ratio greater than 0.75.

*Specimens examined* (all designated paratypes).—*Prov. Guanacaste*: Finca Palo Verde (OTS), 6 km. NE Puerto Humo (on Rio Tempisque), 16-22 January 1978 (O. F. Francke and J. Rodriguez), 17 males, 31 females (AMNH, FSCA, OFF); Elena Bay, 12 January 1938 (no collector), one immature male (AMNH); Finca Los Inocentes, Volcan Orosi, Liberia, 2 Nov. 1973 (R. Sotos), one female (UCR); Parque Nacional Santa Rosa (300 m), 25 km. S La Cruz, 31 Decembe 1983 (D. H. Janzen), one female (OFF).

#### Family ISCHNURIDAE

The family Ischnuridae is a Gondwanan element, as its eight genera are found in South America, Africa, India, Australia, and Southeast Asia. The lack of retrolateral pedal spurs, lack of a subaculear tubercle, and having tarsomere II sides truncate, rather than lobed, are diagnostic.

#### Genus *Opisthacanthus* Peters

The 18 species of the genus *Opisthacanthus* are assigned to two subgenera: *Nepabellus* Francke, which is African and has 12 species, and the nominate subgenus, which has five New World species and one African species. A comprehensive study of the genus was recently completed by Lourenço (1985).

The presence of two parallel rows of denticles on the pedipalp chela fingers is diagnostic.

*Opisthacanthus valerioi* Lourenço

Figs. 107, 125-129, Map 4

*Opisthacanthus valerioi* Lourenço, 1983a [1980]: 180, 1985:76-80, plate XX, figs. 1-12.

*Type data.*—Holotype male from Isla del Coco, Costa Rica. Deposited in the Museo de Zoología, Universidad de Costa Rica. Not examined.

*Distribution.*—Known only from Isla del Coco, Costa Rica.

*Diagnosis.*—Adults 45-55 mm. long (Fig. 107). Body yellow-brown, with diffuse variegated fuscosity; pedipalps reddish brown, femur with diffuse uniform fuscosity, tibia with diffuse variegated fuscosity; venter and legs yellow. Carapace with moderately dense, small granulation; anterior margin deeply notched; median longitudinal furrow distinct and conspicuous on anterior two-thirds. Genital operculi on male ovoid, divided; on females fused into a single, subtriangular plate. Pectinal tooth count in males 9-10, in females 5-7. Metasoma weakly developed, without keels; segment V length less than pedipalp chela width. Pedipalp stout, chela approximately as wide as fixed finger length; orthobothriotaxy C (Figs. 125-129). Tarsomere II with two rows of spines ventrally, usually two spines on prolateral margin, four spines on retrolateral margin.

*Measurements.*—Holotype male: carapace 8.1; metasoma segment V 5.5; pedipalp femur 7.4; tibia 8.1; chela 15.4. Adult female: carapace 9.7; metasomal segment V 6.3; pedipalp chela femur 8.1; tibia 8.8; chela 17.9; fixed finger 7.7.

*Variability.*—The only significant variation encountered among the few specimens examined was in pectinal tooth counts, as follows: in males, 2 combs with 8 teeth, 5 combs with 9 teeth, and 1 comb with 10 teeth; in females, 2 combs with 5 teeth, and 2 combs with 6 teeth.

*Specimens examined.*—COSTA RICA: Isla del Coco, 12-15 Aug. 1973 (D. C. Robinson), one adult female, one juvenile male (UCR); under stone, Aug. 1973 (F. Vollrath), one immature male (MCZ); 12-VII-1978 (Gary Stiles), one juvenile female (UCR); Chatham Bay, Isla del Coco, 8-11 Apr. 1979 (N. Smythe), two juvenile males (MCZ).

## KEY TO SCORPION TAXA FROM COSTA RICA

1. Sternum subtriangular, longer than wide. Cheliceral movable finger with dorsal tine longer than ventral tine; with two ventral teeth. Pedipalps with trichobothrial pattern A: femur with 10 or more trichobothria, of which four or five are on the internal face; tibia without ventral trichobothria..... Buthidae...2
1. Sternum distinctly pentagonal, wider than long. Cheliceral movable finger with dorsal tine shorter than ventral tine; with no ventral teeth. Pedipalps with trichobothrial pattern C: femur with three trichobothria, of which only one is on the internal face; tibia with three or more ventral trichobothria.....12
2. Median granules on dentate margins of pedipalp chelae fingers arranged in one continuous row, which appears subdivided by larger median tubercles (Figs. 1, 2). Dorsal femoral trichobothria in beta configuration (Fig. 8): with five trichobothria on dorsal face.....3
2. Median granules on dentate margins of pedipalp chelae fingers arranged in eight or more oblique rows (Figs. 3-5). Dorsal femoral trichobothria in alpha configuration (Fig. 16): with only four trichobothria on dorsal face.....4
3. Pectines without fulcra (Fig. 9). Tibial spurs present on legs III and IV...*Ananteris ashmolei*

- Pectines with fulcra (Fig. 61). Tibial spurs absent. . . . . *Isometrus maculatus*
4. Dentate margin of fixed finger of pedipalp chela with eight or nine oblique rows of median granules, flanked internally and externally by larger supernumerary granules (Figs. 3, 4). . . . . Genus *Centruroides*. . . 5
- Dentate margin of fixed finger of pedipalp chela with 13 or more oblique rows of median granules, without any supernumerary granules (Fig. 5). . . . . Genus *Tityus*. . . 9
5. Dentate margin of fixed finger of pedipalp chela with eight oblique rows of median granules; digital carinae moderate to strong. . . . . 6
- Dentate margin of fixed finger of pedipalp chela with nine oblique rows of median granules; digital carinae weak to vestigial. . . . . 8
6. Small- to medium-sized scorpions, generally pale in color, with variegations on the carapace or the mesosoma. Pectinal tooth counts 26 or less on males, 24 or less on females. . . 7
- Medium- to large-sized scorpions, generally medium to dark brown, without stripes or variegations on the carapace or the mesosoma. Pectinal tooth counts 26-34 on males (mode, 30), 24-33 on females (mode, 28). . . . . *Centruroides margaritatus*
7. Adults small, less than 55 mm. in length, slender. Pedipalp chelae gracile, telson elongate with long, slender aculeus and well-developed subaculear spine. Entire animal yellow with black marbling, giving a speckled appearance. Pectinal tooth count 12-14. . . . .
- . . . . . *Centruroides thorelli*
- Adults medium, greater than 55 mm. in length. Yellow with a pair of dusky markings submedially on each pretergite, giving a striped appearance. Pectinal tooth count 21-26. . . . . *Centruroides koesteri*
8. Entire chela darker than rest of pedipalp. Chelae, carapace, first six mesosomal tergites, fourth and fifth metasomal segments, and telson of about the same dark brown or black color. Cauda gradually darkening distally. Often more than 100 mm. in length. Pectinal tooth count 25-28. . . . . *Centruroides bicolor*
- Color variable, ranging from uniform brown to having the carapace and mesosoma olive to yellowish brown with margins of carapace and tergites dark brown to black. Only fingers of pedipalp chelae, metasomal segment V, and telson black; rest of pedipalp, cauda, and legs yellow or brown. Rarely more than 100 mm. in length. Pectinal tooth count 18-27. . . . . *Centruroides limbatus*
9. Small scorpions, adults no more than 30 mm. in length; color yellow, speckled throughout. Pectinal tooth count 14 or less. . . . . *Tityus ocelote*
- Medium-sized scorpions, adults greater than 60 mm. in length; color medium to dark brown, not speckled. Pectinal tooth count 16 or more. . . . . 10
10. Pale to medium brown, without fuscosity on carapace and tergites. Pedipalp femur and tibia each shorter than metasomal segment V. Pedipalp chela movable finger on males with a strong basal lobe, fixed finger with a strong basal notch. Metasomal segment V less than twice as long as wide. . . . . *Tityus pachyurus*
- Light to medium brown, with moderate fuscosity on carapace and tergites. Pedipalp femur and tibia each longer than metasomal segment V. Pedipalp chela fingers on males without strong basal lobes or notches. Metasomal segment V more than twice as long as wide. . . . 11
11. Tergites with two light submedian bands, and margins moderately infusate. Underhand longer than carapace. Pedipalp femur, tibia, and chela together more than six times longer than carapace. . . . . *Tityus dedoslargos*
- Tergites with variegated fuscosity throughout. Underhand shorter than carapace. Pedipalp femur, tibia, and chela together only five times longer than carapace. . . . . *Tityus championi*
12. Retrolateral pedal spurs present. Pedipalp tibia with five ventral trichobothria. . . . . Chactidae. . . *Chactas exsul*
- Retrolateral pedal spurs absent. Pedipalp tibia with three ventral trichobothria. . . . . 13
13. Subaculear tubercle present. Dentate margins of pedipalp chela fingers with one median row of granules. . . . . Diplocentridae. . . *Didymocentrus concavimanus*
- Subaculear tubercle absent. Dentate margin of pedipalp chela fingers with two parallel rows of granules. . . . . Ischnuridae. . . *Opisthacanthus valerioi*

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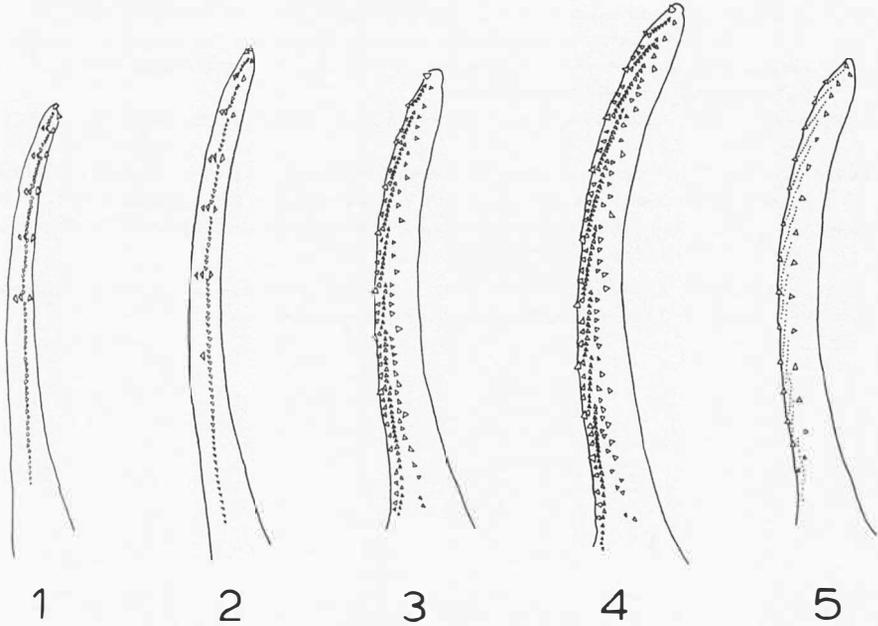
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Address of authors: *Department of Biological Sciences, Texas Tech University, Lubbock, Texas 79409. Received 11 December 1985, accepted 3 January 1986.*

## APPENDIX

Figures and maps have been placed together in an appendix to facilitate use by the reader. Figures are grouped into plates that deal with taxonomically important morphological characteristics for scorpions of Costa Rica. All figures are not drawn to a uniform scale. Maps appear in the order in which they are cited in text.



FIGS 1-5.—Dentation on fixed finger of pedipalp chela: 1, *Ananteris ashmolei* Lourenço; 2, *Isometrus maculatus* (Degeer); 3, *Centruroides margaritatus* (Gervais); 4 *Centruroides bicolor* (Pocock); 5, *Tityus championi* Pocock.

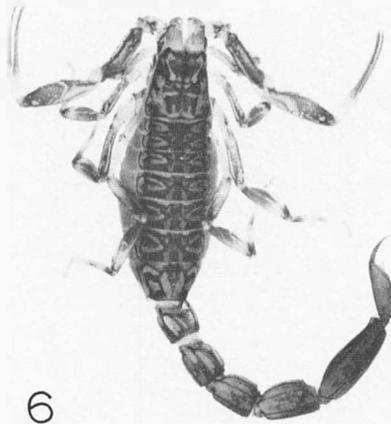
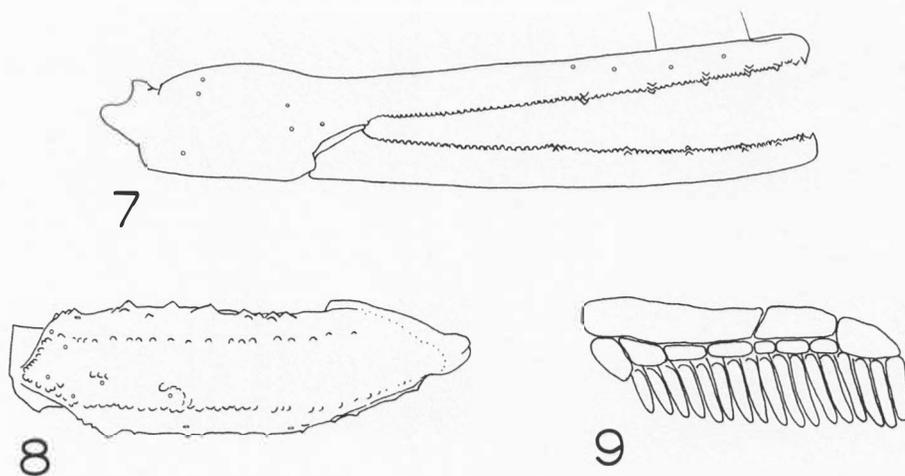
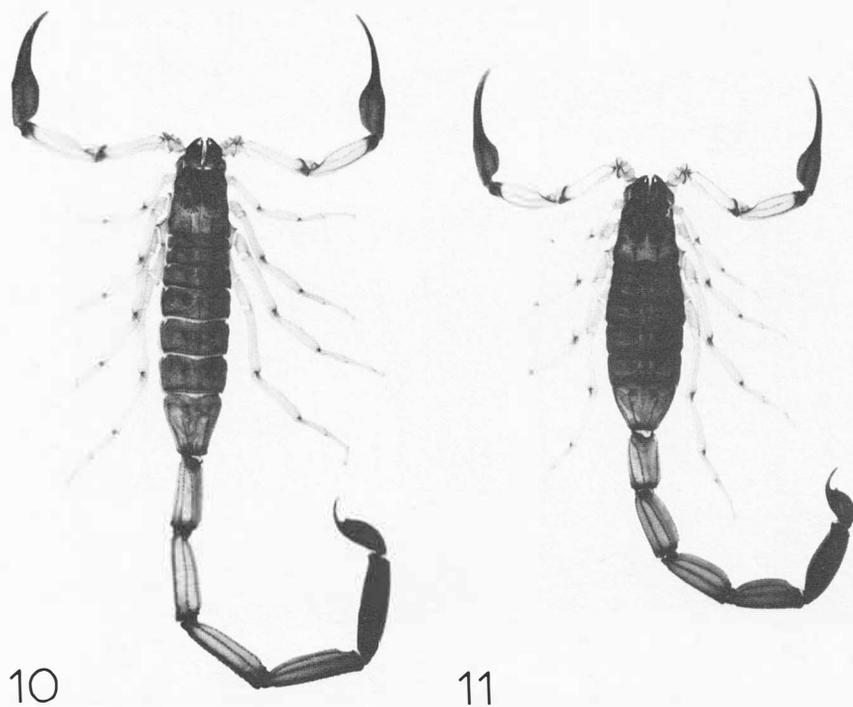


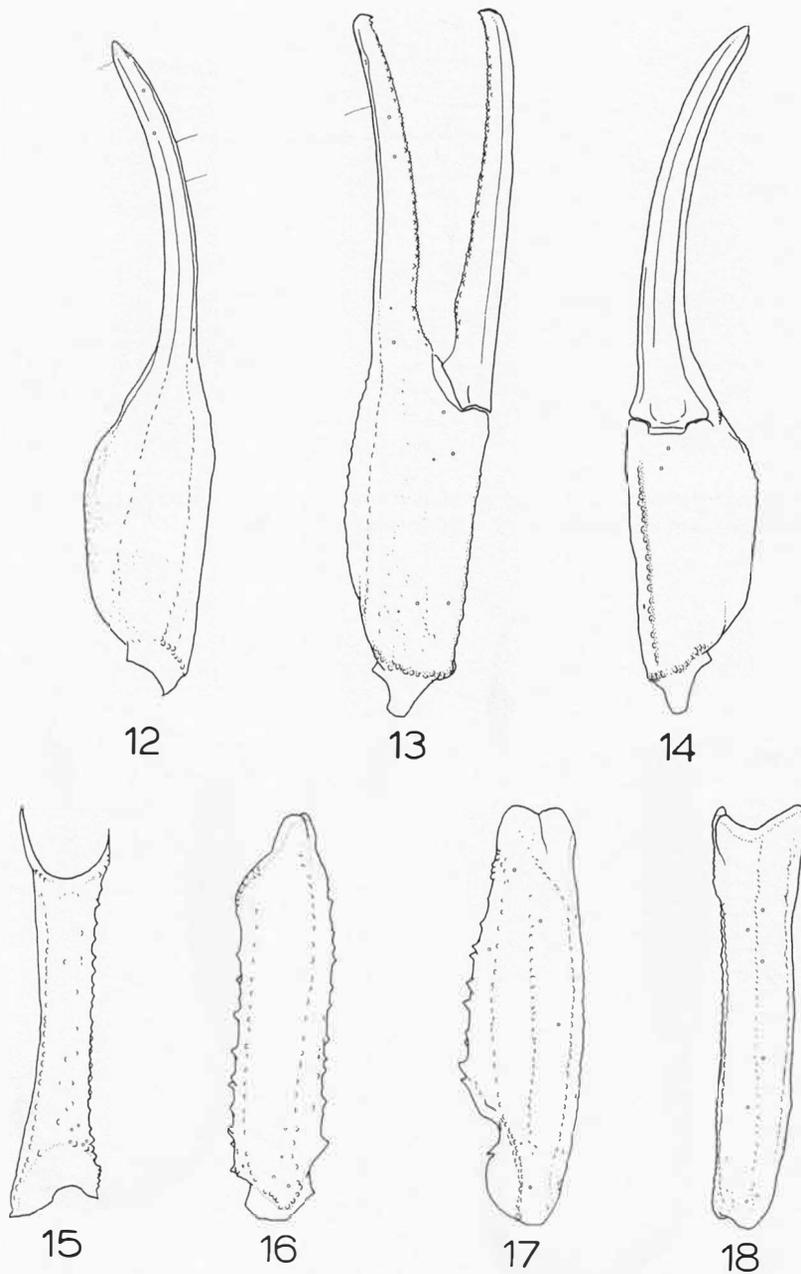
FIG. 6.—Adult female *Ananteris ashmolei* Lourenço.



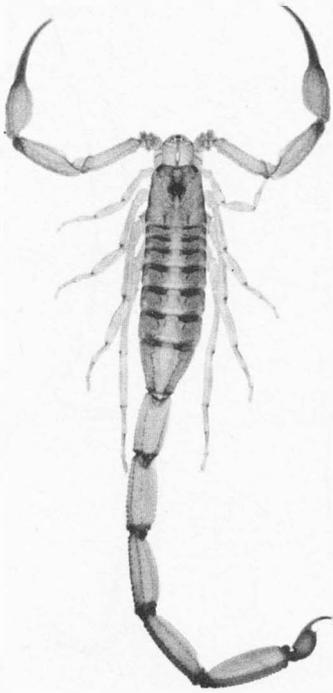
FIGS. 7-9.—*Ananteris ashmolei* Lourenço, adult female: 7, external aspect of right pedipalp chela; 8, dorsal aspect of pedipalp femur; 9, ventral aspect of left pectine.



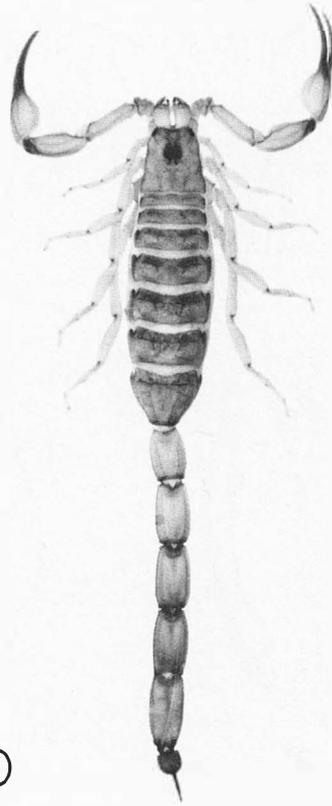
FIGS. 10, 11.—Adult *Centruroides bicolor* (Pocock): 10, male; 11, female.



FIGS. 12-18.—*Centruroides bicolor* (Pocock), trichobothrial pattern on adult male: 12, dorsal aspect of pedipalp chela; 13, external aspect of chela; 14, ventral aspect of chela; 15, internal aspect of pedipalp femur; 16, dorsal aspect of femur; 17, dorsal aspect of pedipalp tibia; 18, external aspect of tibia.

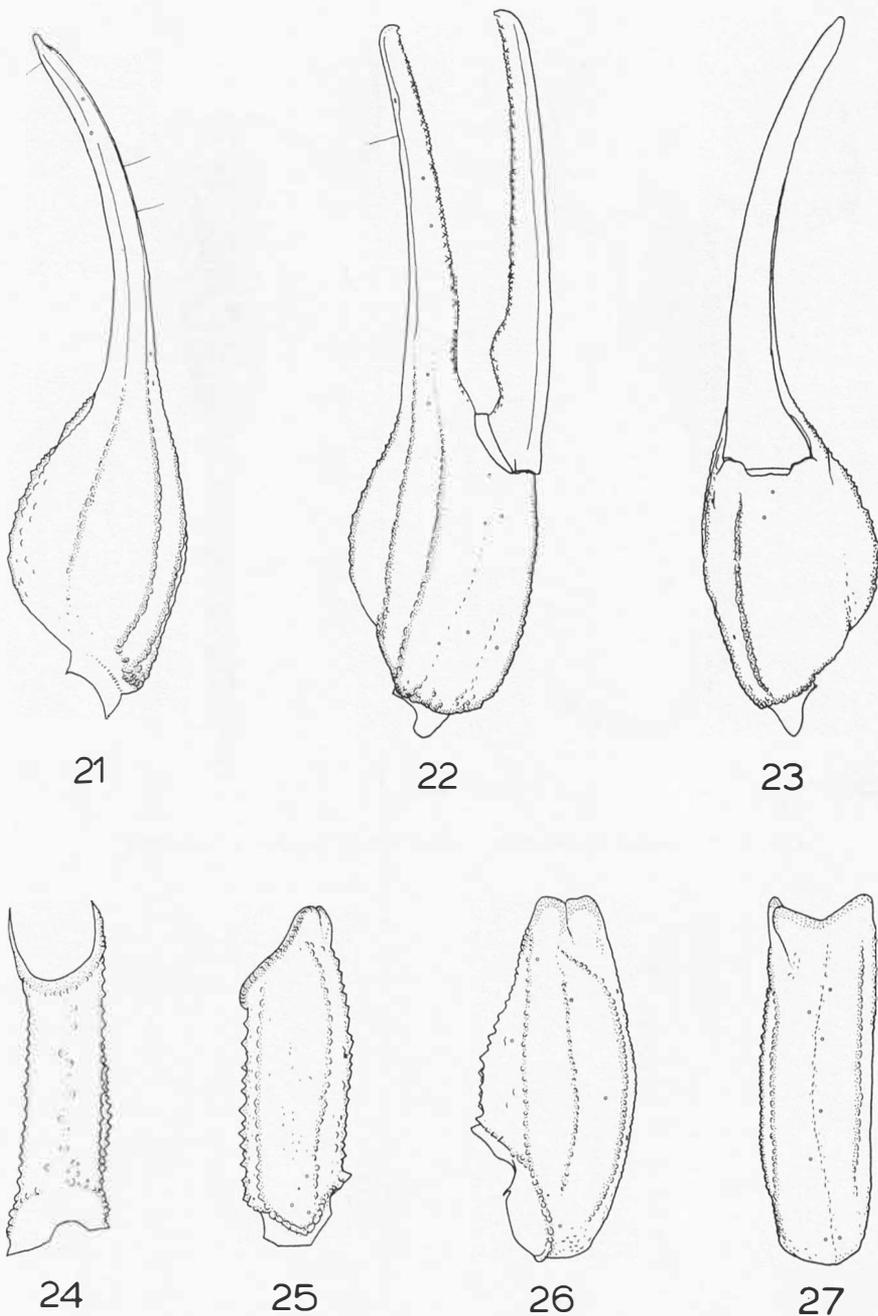


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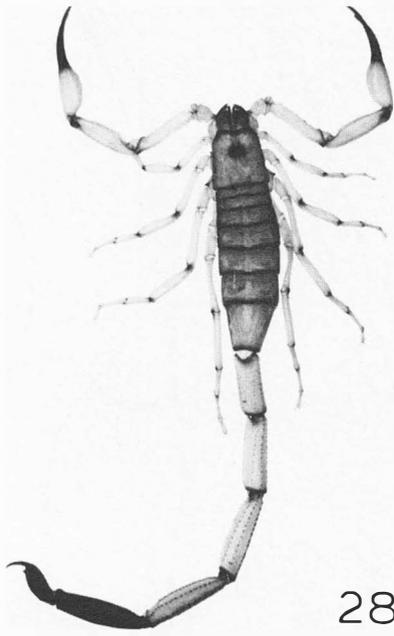


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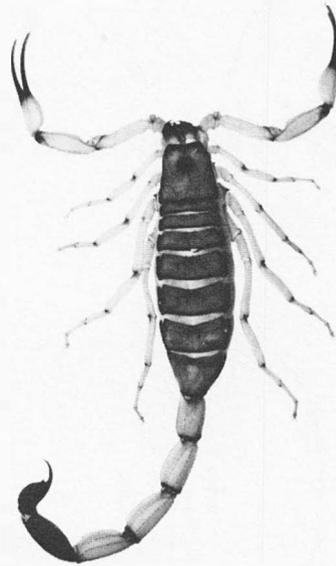
FIGS. 19, 20.—Adult *Centruroides koesteri* Kraepelin: 19, male; 20, female.



FIGS. 21-27.—*Centruroides koesteri* Kraepelin, trichobothrial pattern on adult female: 21, dorsal aspect of chela; 22, external aspect of chela; 23, ventral aspect of chela; 24, internal aspect of femur; 25, dorsal aspect of femur; 26, dorsal aspect of tibia; 27, external aspect of tibia.

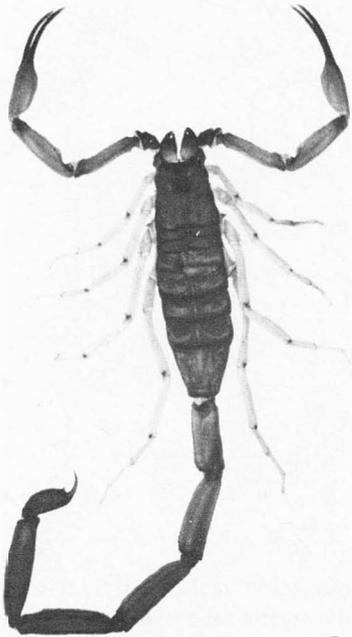


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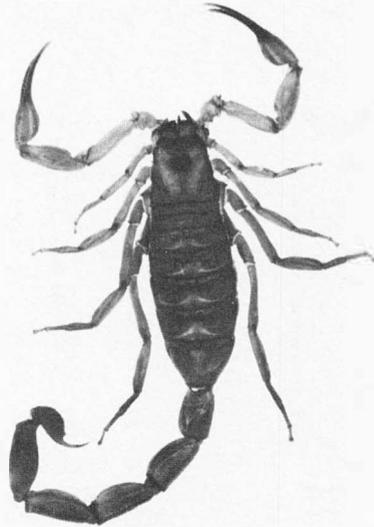


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FIGS. 28, 29.—Adult *Centruroides limbatus* (Pocock): 28, male; 29, female.

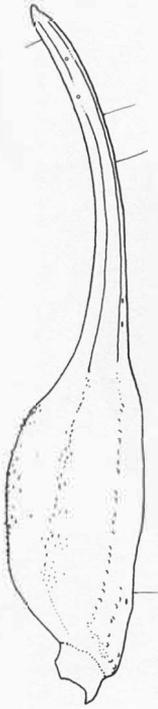


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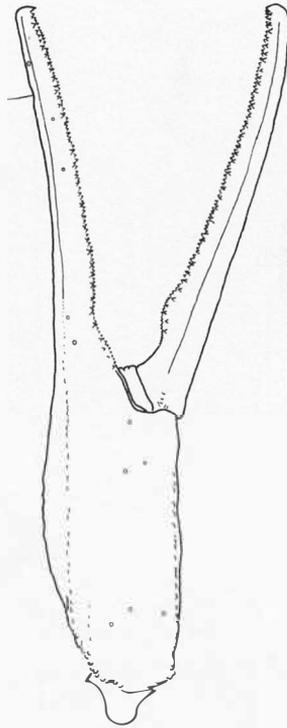


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FIGS. 30, 31.—Adult *Centruroides limbatus* (Pocock), dark morph (= *C. rubricauda*): 30, male; 31, female.



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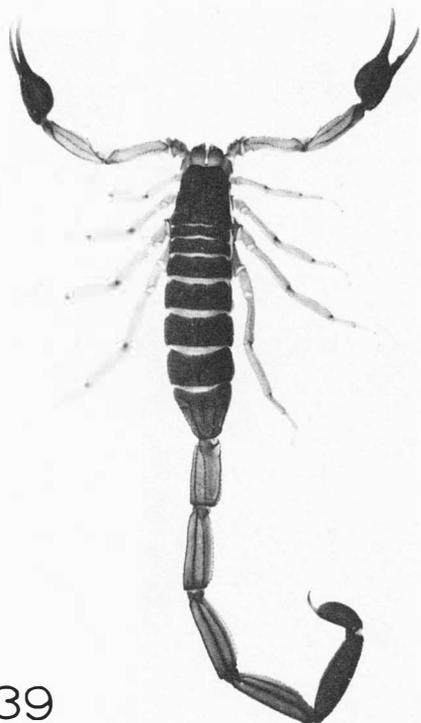


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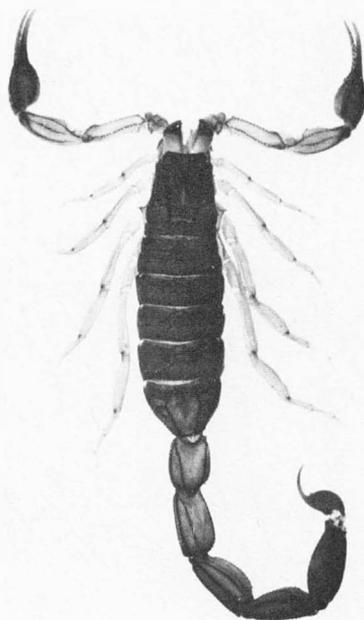


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FIGS. 32-38.—*Centruroides limbatus* (Pocock), trichobothrial pattern on adult male: 32, dorsal aspect of chela; 33, external aspect of chela; 34, ventral aspect of chela; 35, internal aspect of femur; 36, dorsal aspect of femur; 37, dorsal aspect of tibia; 38, external aspect of tibia.

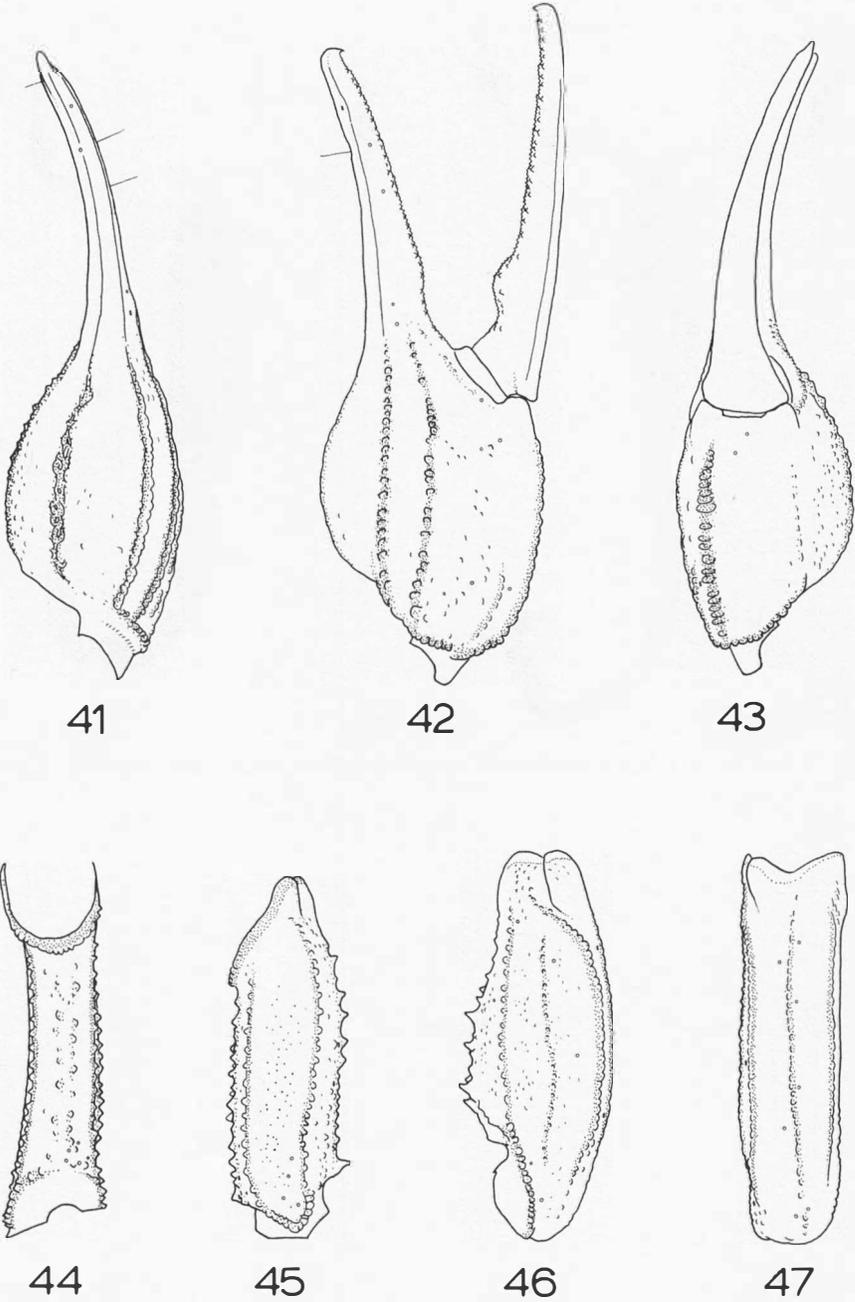


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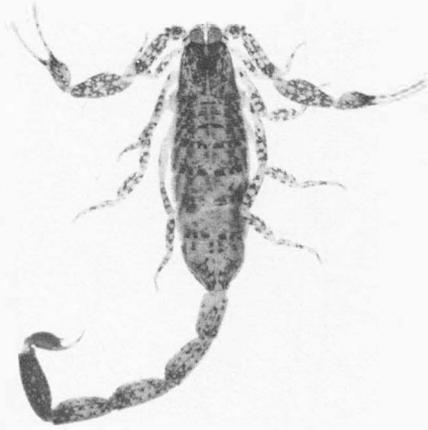
FIGS. 39, 40.—Adult *Centruroides margaritatus* (Gervais): 39, male; 40, female.



FIGS. 41-47.—*Centruroides margaritatus* (Gervais), trichobothrial pattern on adult female: 41, dorsal aspect of chela; 42, external aspect of chela; 43, ventral aspect of chela; 44, internal aspect of femur; 45, dorsal aspect of femur; 46, dorsal aspect of tibia; 47, external aspect of tibia.

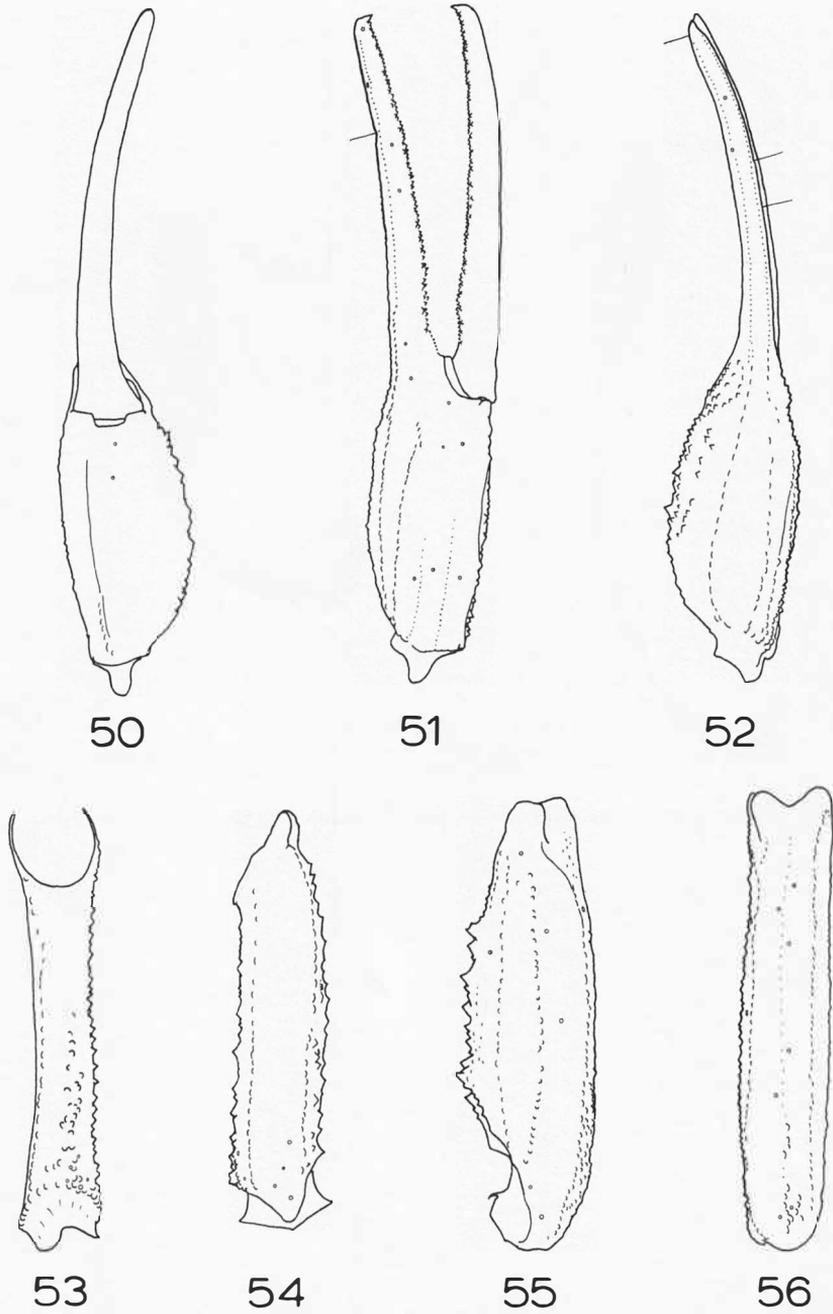


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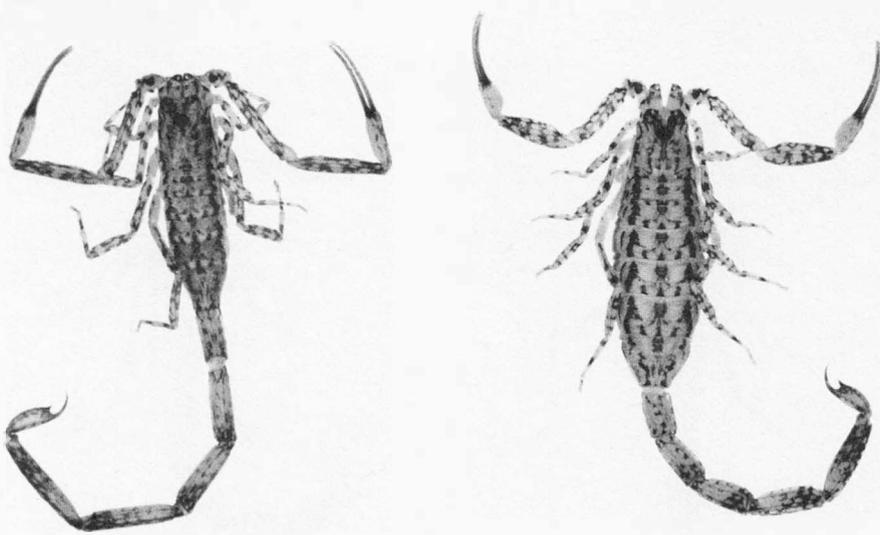


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FIGS. 48, 49.—Adult *Centruroides thorelli* (Kraepelin): 48, male; 49, female.



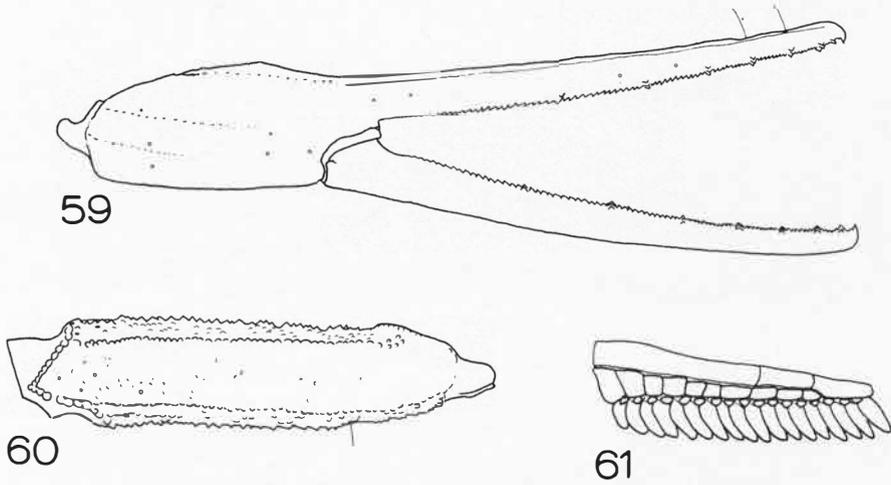
FIGS. 50-56.—*Centruroides thorelli* (Kraepelin), trichobothrial pattern on adult male: 50, dorsal aspect of chela; 51, external aspect of chela; 52, ventral aspect of chela; 53, internal aspect of femur; 54, dorsal aspect of femur; 55, dorsal aspect of tibia; 56, external aspect of tibia.



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FIGS. 57, 58.—Adult *Isometrus maculatus* (Degeer): 57, male; 58, female.

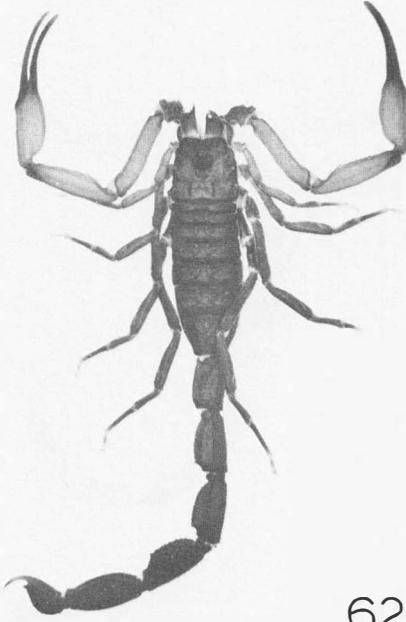


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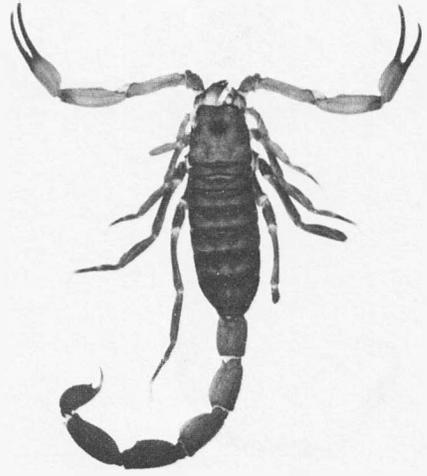
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FIGS. 59-61.—*Isometrus maculatus* (Degeer), adult female: 59, external aspect of right pedipalp chela; 60, dorsal aspect of pedipalp femur; 61, ventral aspect of right pectine.

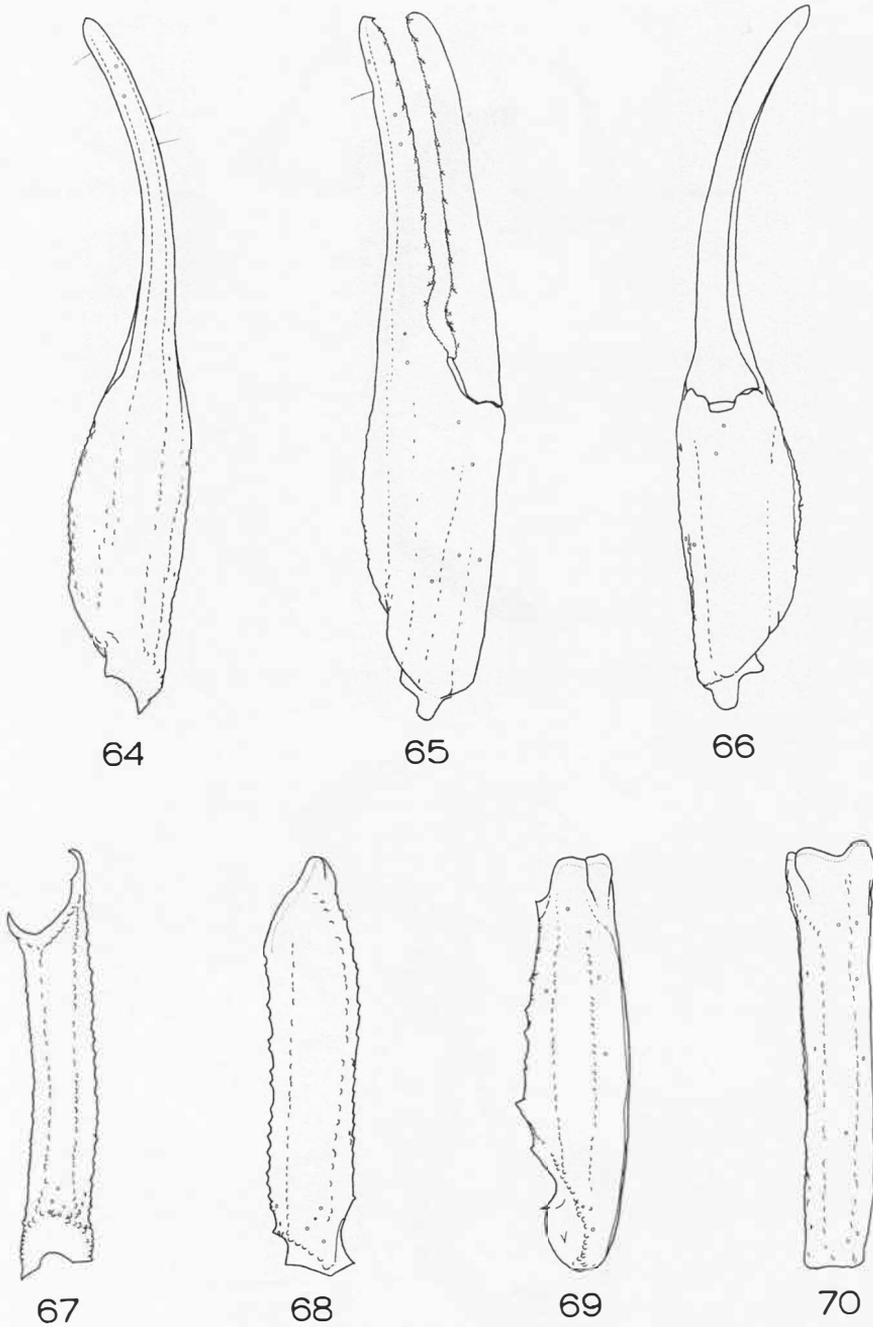


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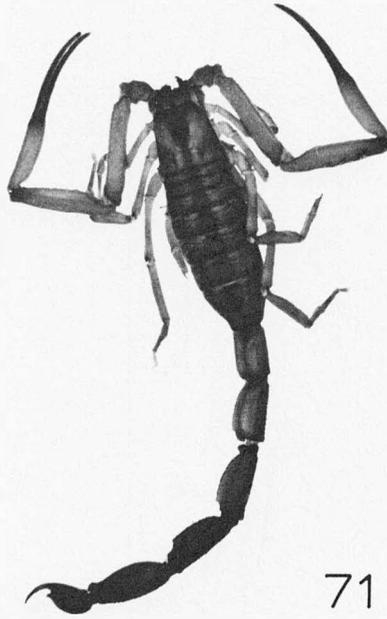


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FIGS. 62, 63.—Adult *Tityus championi* Pocock: 62, male; 63, female.

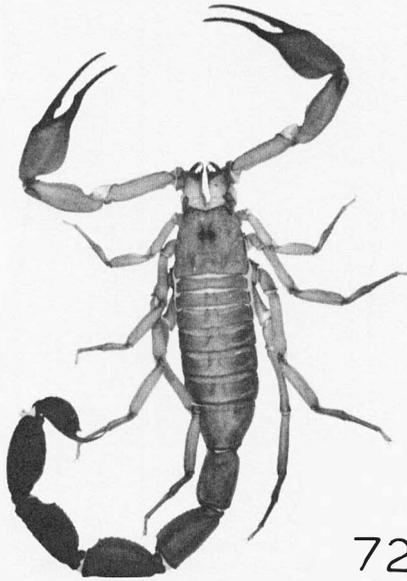


FIGS. 64-70—*Tityus championi* Pocock, trichobothrial pattern on adult male: 64, dorsal aspect of chela; 65, external aspect of chela; 66, ventral aspect of chela; 67, internal aspect of femur; 68, dorsal aspect of femur; 69, dorsal aspect of tibia; 70, external aspect of tibia.



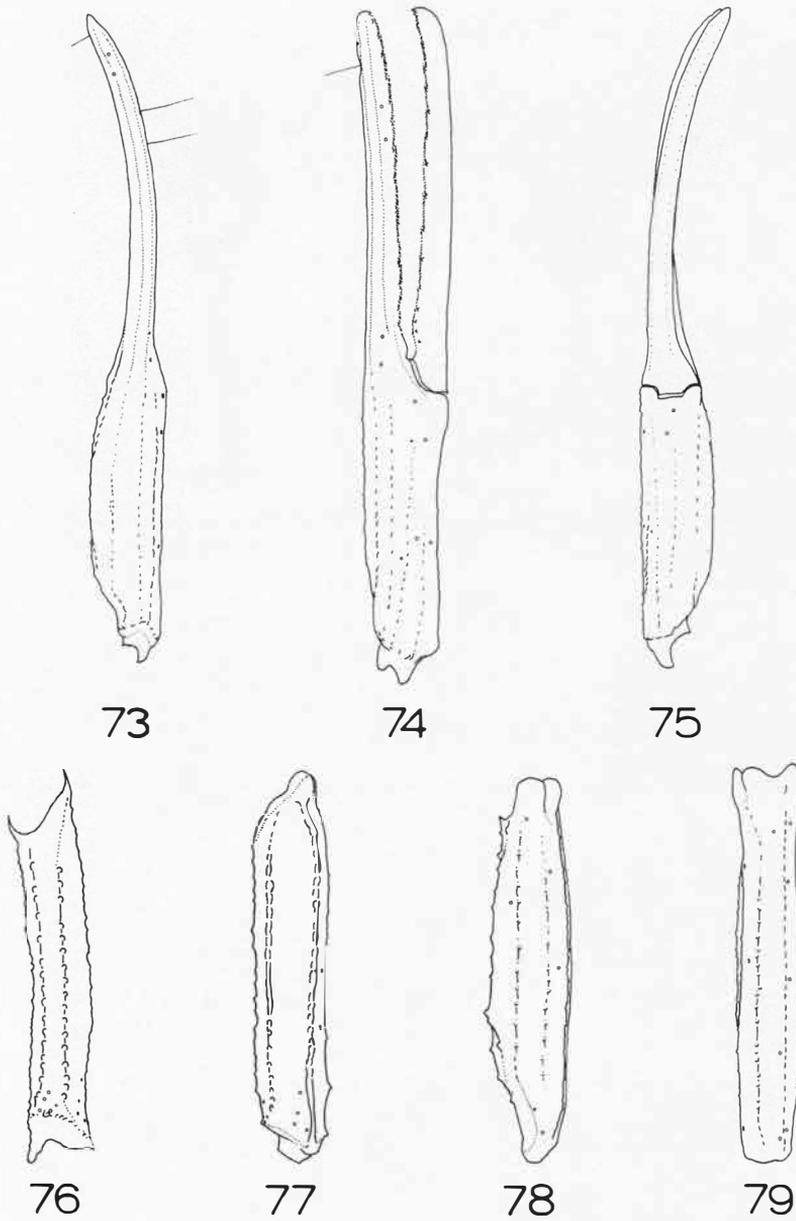
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FIG. 71.—Adult male *Tityus dedoslargos*, new species.

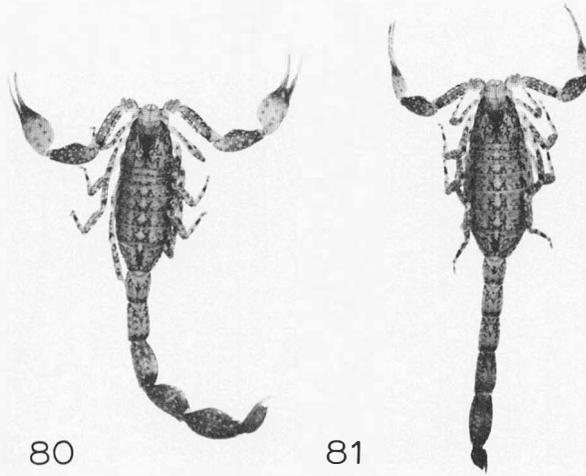


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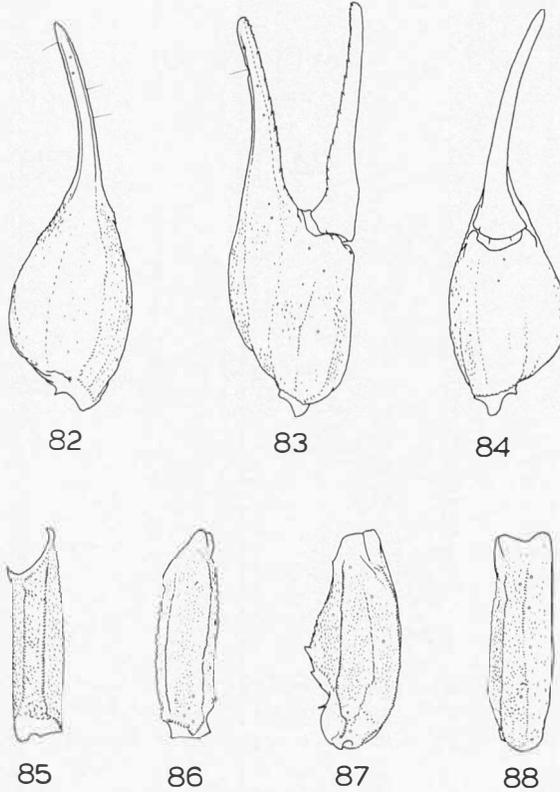
FIG. 72.—Adult male *Tityus pachyurus* Pocock.



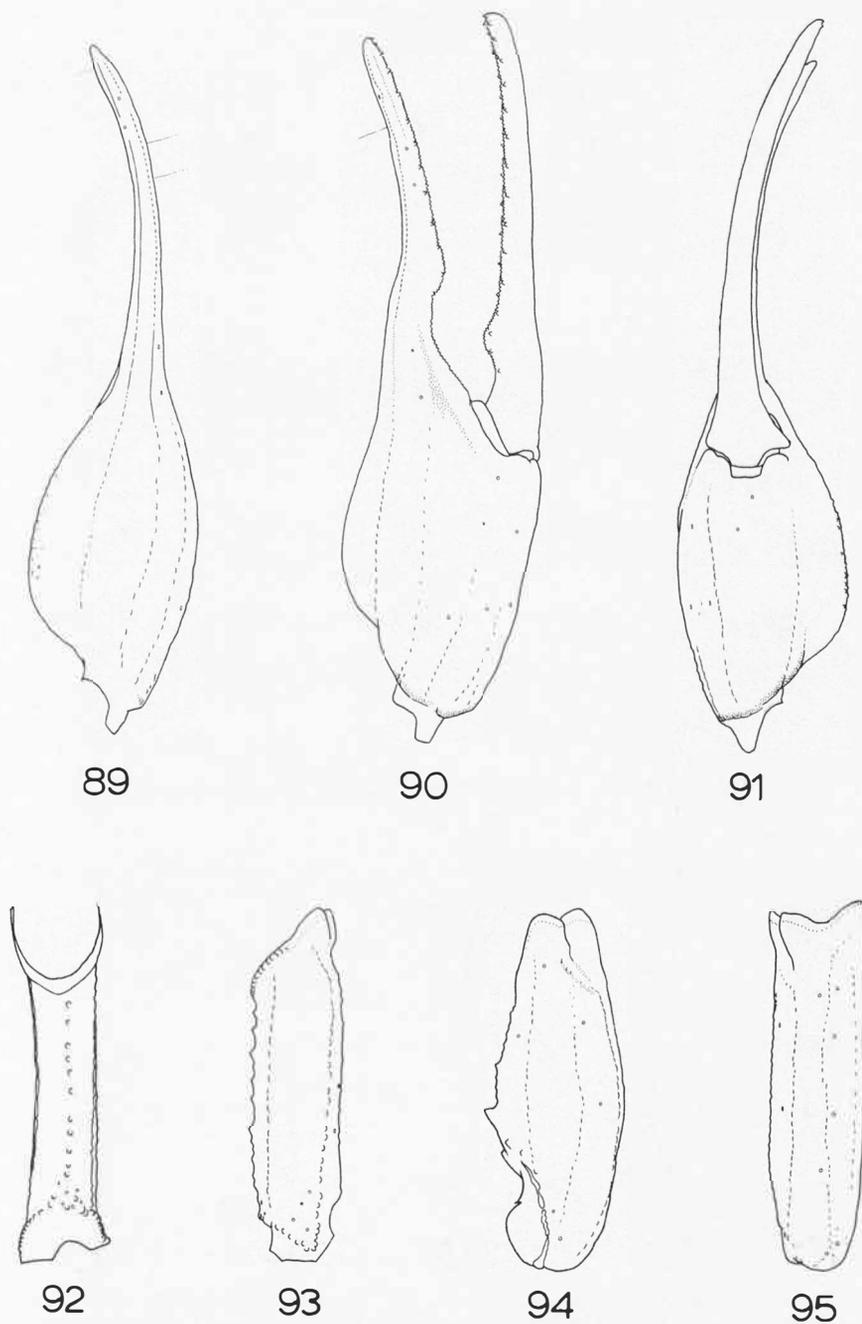
FIGS. 73-79.—*Tityus dedoslargos*, new species, trichobothrial pattern on adult male: 73, dorsal aspect of chela; 74, external aspect of chela; 75, ventral aspect of chela; 76, internal aspect of femur; 77, dorsal aspect of femur; 78, dorsal aspect of tibia; 79, external aspect of tibia.



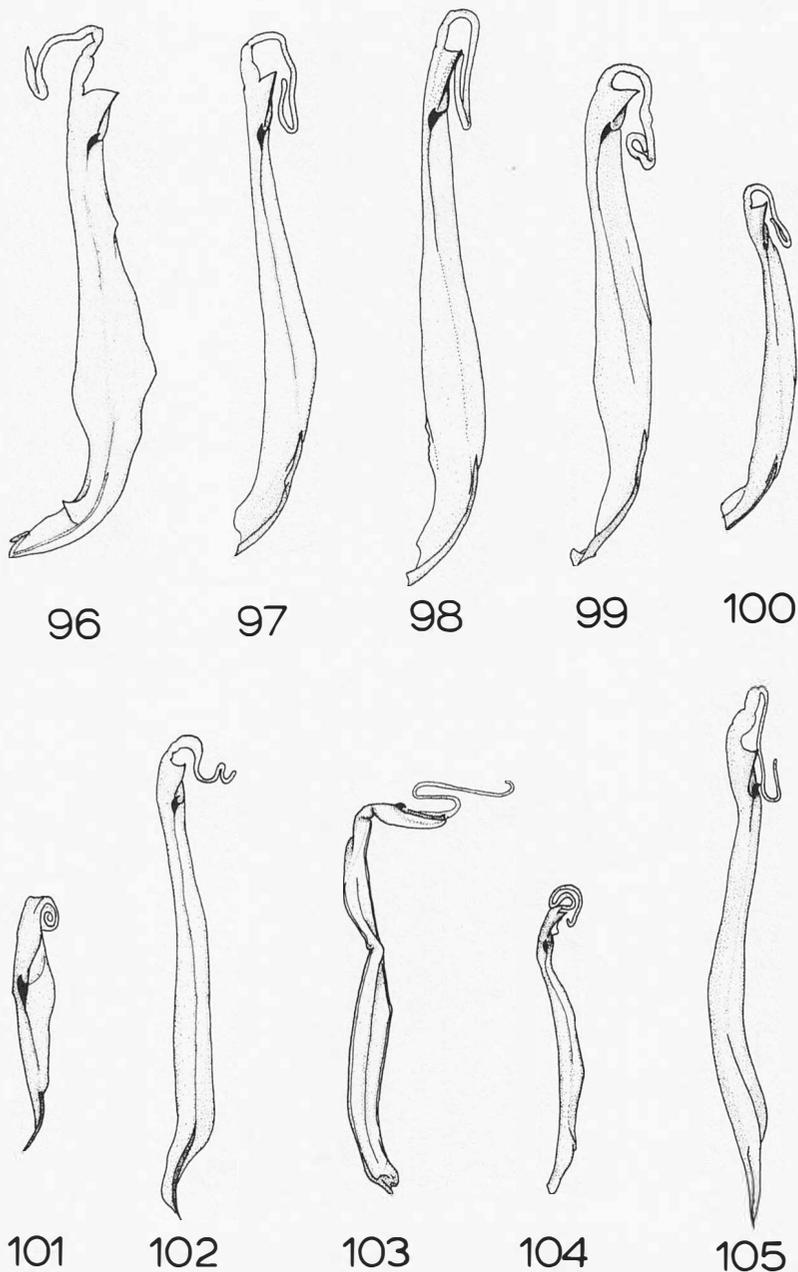
Figs. 80, 81.—Adult *Tityus ocelote*, new species: 80, male; 81, female.



Figs. 82-88.—*Tityus ocelote*, new species, trichobothrial pattern on adult male: 82, dorsal aspect of chela; 83, external aspect of chela; 84, ventral aspect of chela; 85, internal aspect of femur; 86, dorsal aspect of femur; 87, dorsal aspect of tibia; 88, external aspect of tibia.



FIGS. 89-95.—*Tityus pachyurus* Pocock, trichobothrial pattern on adult male: 89, dorsal aspect of chela; 90, external aspect of chela; 91, ventral aspect of chela; 92, internal aspect of femur; 93, dorsal aspect of femur; 94, dorsal aspect of tibia; 95, external aspect of tibia.

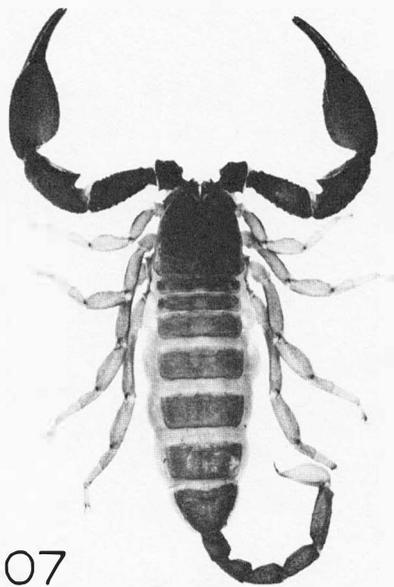


FIGS. 96-105.—Right hemispermatozoa: 96, *Centruroides bicolor* (Pocock); 97, *Centruroides koesteri* Kraepelin; 98, *Centruroides limbatus* (Pocock); 99, *Centruroides margaritatus* (Gervais); 100, *Centruroides thorelli* (Kraepelin); 101, *Isometrus maculatus* (Degeer); 102, *Tityus championi* Pocock; 103, *Tityus dedoslargos*, new species; 104, *Tityus ocelote*, new species; 105, *Tityus pachyurus* Pocock.



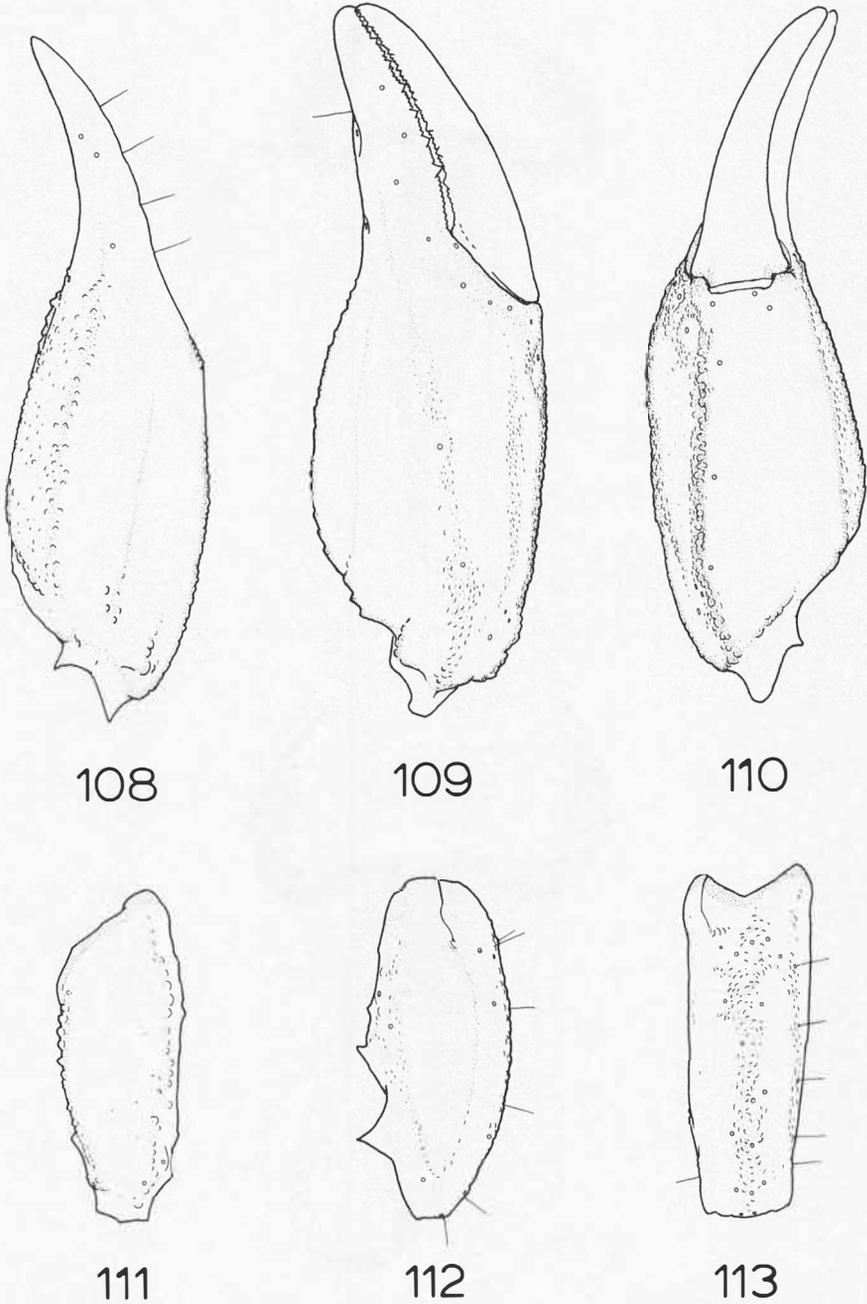
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FIG. 106.—Neotype female *Chactas exsul* (Werner).



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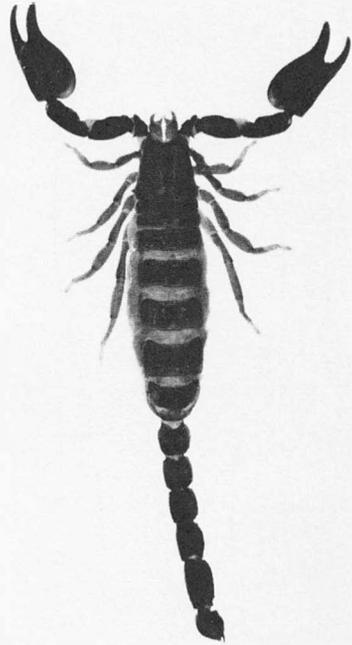
FIG. 107.—Adult female *Opisthacanthus valerioi* Lourenço.



FIGS. 108-113.—*Chactas exsul* (Werner), trichobothrial pattern on neotype female: 108, dorsal aspect of chela; 109, external aspect of chela; 110, ventral aspect of chela; 111, dorsal aspect of femur; 112, dorsal aspect of tibia; 113, external aspect of tibia.

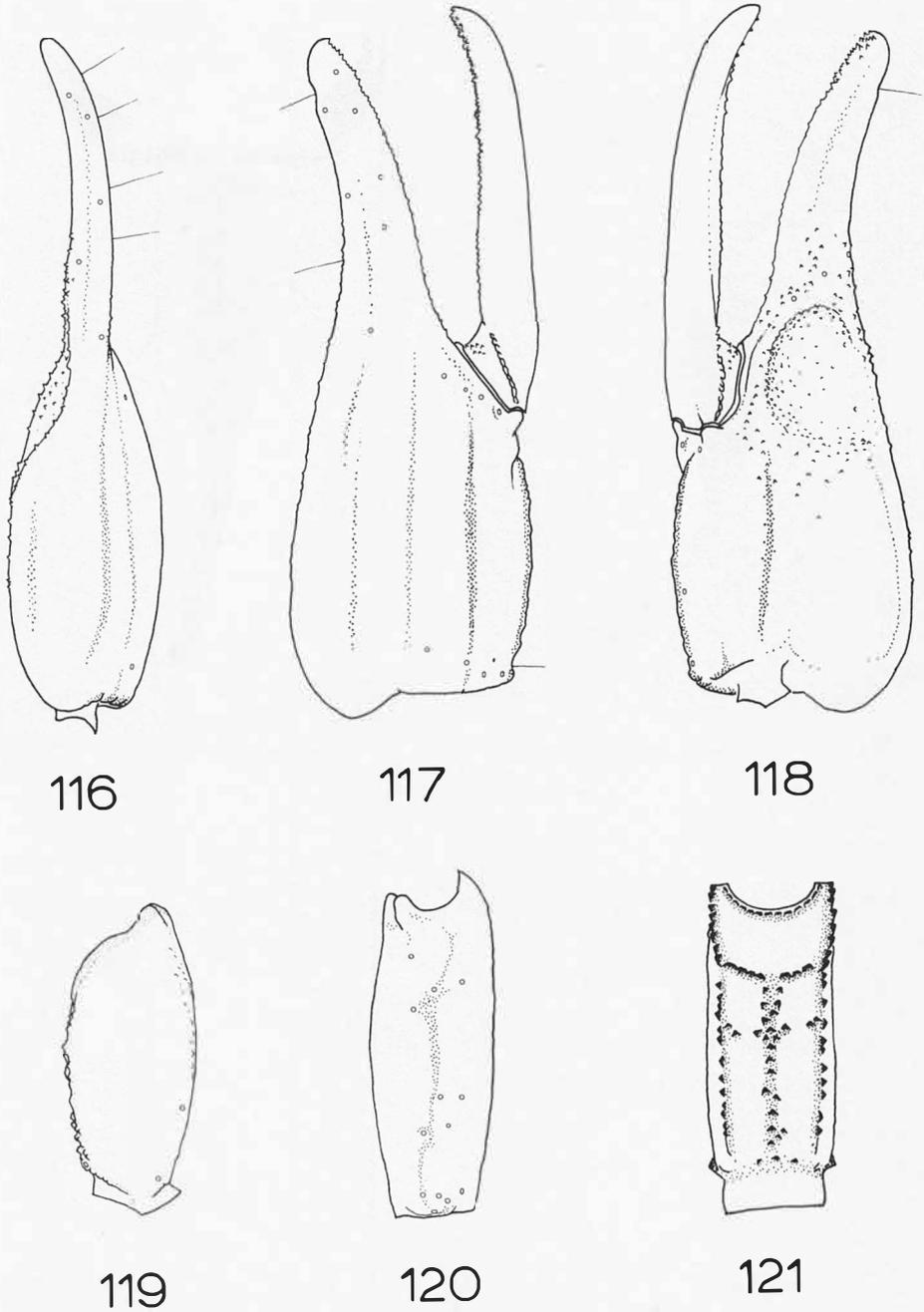


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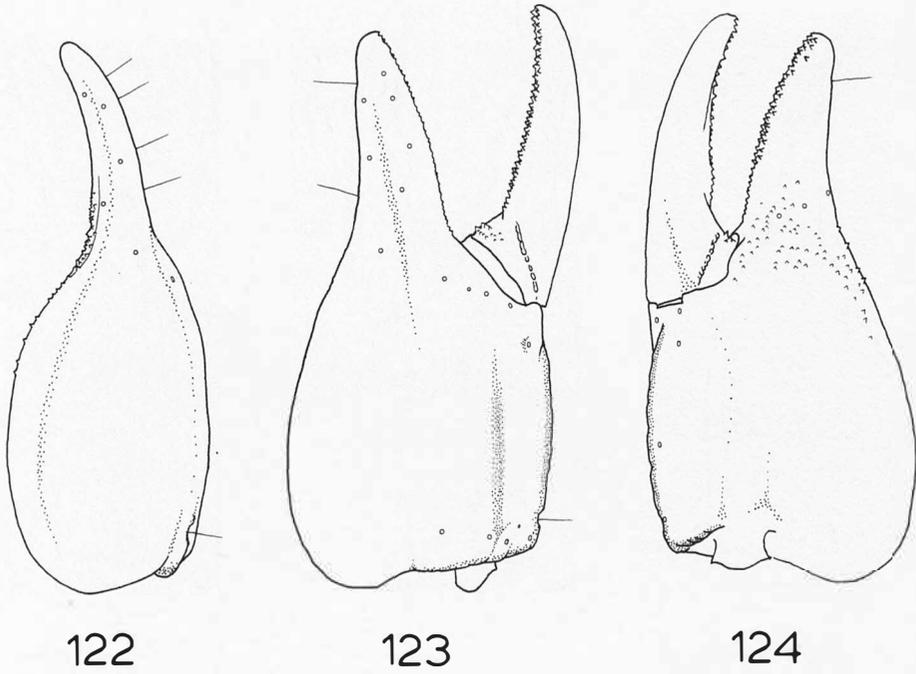


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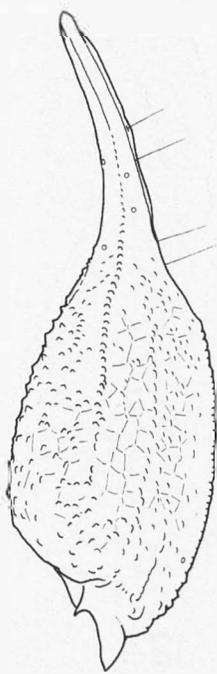
FIGS. 114, 115.—Adult *Didymocentrus concavimanus*, new species: 114, holotype male; 115, female.



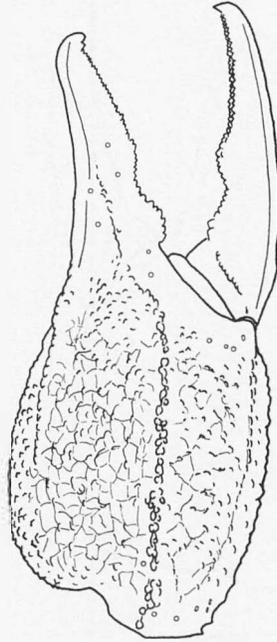
FIGS. 116-121.—*Didymocentrus concavimanus*, new species, holotype male: 116, dorsal aspect of chela; 117, external aspect of chela; 118, internal aspect of chela; 119, dorsal aspect of femur; 120, external aspect of tibia; 121, ventral aspect of metasomal segment V.



FIGS. 122-124.—*Didymocentrus concavimanus*, new species, adult female: 122, dorsal aspect of chela; 123, external aspect of chela; 124, internal aspect of chela.



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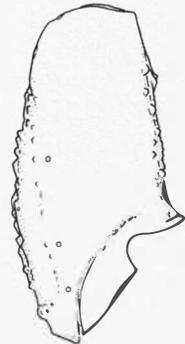
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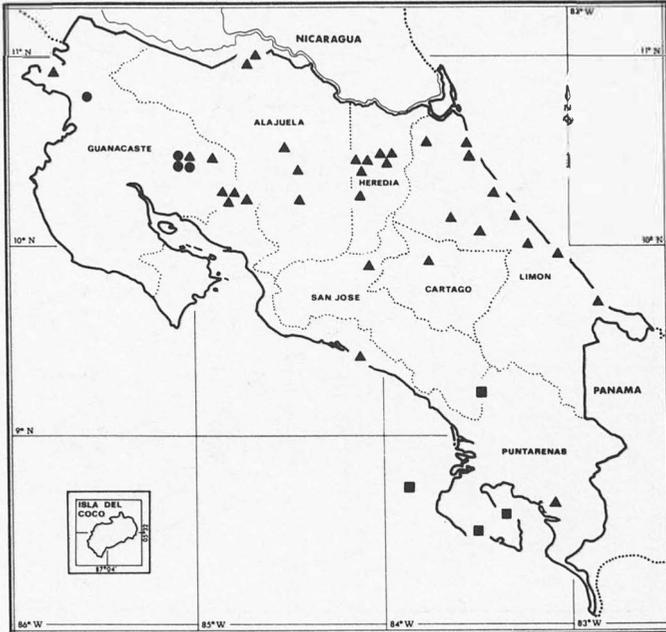


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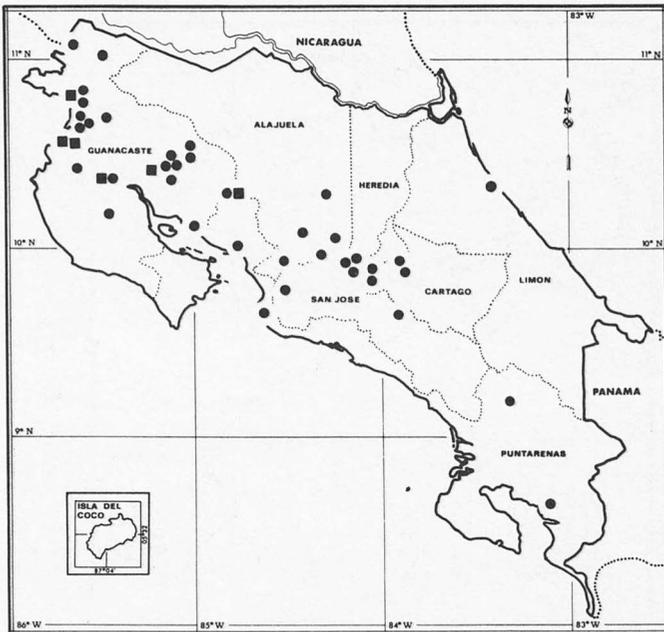


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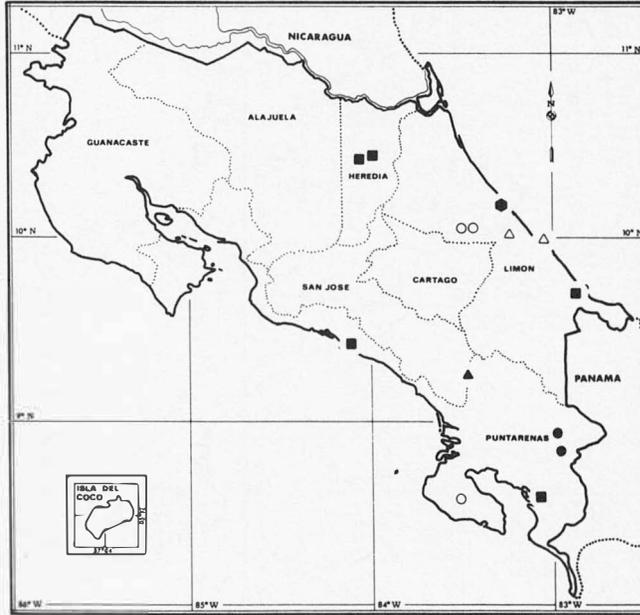
FIGS. 125-130.—*Opisthacanthus valerioi* Lourenço, trichobothrial pattern on adult female: 125, dorsal aspect of chela; 126, external aspect of chela; 127, internal aspect of chela; 128, dorsal aspect of femur; 129, external aspect of tibia; 130, ventral aspect of tibia.



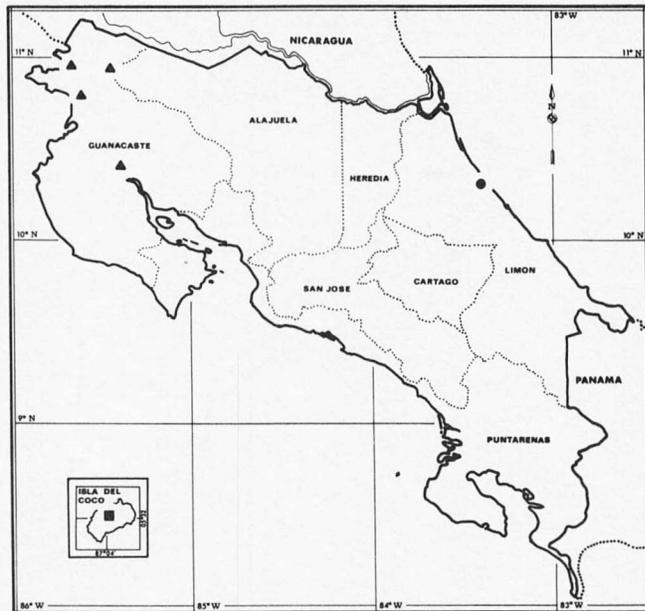
MAP 1.—Distribution of scorpions in Costa Rica: square = *Centruroides bicolor* (Pocock); triangle = *Centruroides limbatus* (Pocock); circle = *Centruroides thorelli* (Kraepelin).



MAP 2.—Distribution of scorpions in Costa Rica: square = *Centruroides koesterei* Kraepelin; circle = *Centruroides margaritatus* (Gervais).



MAP 3.—Distribution of scorpions in Costa Rica: open circle = *Ananteris ashmolei* Lourenço; open triangle = *Isometrus maculatus* (Degeer); solid circle = *Tityus championi* Pocock; solid triangle = *Tityus dedoslargos*, new species; solid square = *Tityus ocelote*, new species; solid hexagon = *Tityus pachyurus* Pocock.



MAP 4.—Distribution of scorpions in Costa Rica: circle = *Chactas exsul* (Werner); triangle = *Didymocentrus concavimanus*, new species; square = *Opisthacanthus valerioi* Lourenço.

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