REVISION OF THE GENUS *HETEROMETRUS* HEMPRICH & EHRENBERG (SCORPIONIDAE, ARACHNIDEA)

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With 71 figures and 14 tables

Contents

Abstract

The author deals with taxonomy, character variation, phylogeny and biogeography of *Heterometrus*, a scorpion genus occurring in Southeast Asia. The taxonomic value of 131 characters is studied, including 75 biometric ones; 72 characters are selected to be used in the present revision for purposes of classification. In the numerical analysis and in the study of descriptive characters, specimens are clustered polythetically; this method allows variation as observed in the taxa, the sharing of the total set of taxon characteristics not being absolutely required. A total of 21 species (4 new) and 31 subspecies (16 new) are discriminated, classified in five subgenera, two of which are new. The African genus *Pandinus* Thorell is found to be the sistergroup of *Heterometrus*.

Résumé

L'auteur a fait une étude de la taxonomie, la variation des caractères, la phylogénèse et la biogéographie du genre *Heterometrus*, scorpions du Sud-Est asiatique. On a étudié la valeur taxonomique de 131 caractères, y compris 75 caractères biométriques; on a fait, dans le cadre de la révision, une sélection de 72 caractères à l'usage de la classification. Dans l'analyse numérique et dans l'étude des caractères descriptives, on a groupé les exemplaires selon une méthode polythétique; cette méthode permet la variation observée dans les taxa, n'exigeant pas strictement le partage de la série complète de caractères des taxa. On a distingué un total de 21 espèces (4 espèces nouvelles) et 31 sous-espèces (16 sous-espèces nouvelles), réparties en cinq sous-genres (parmi lesquels il y a deux sous-genres nouveaux). Le genre africain *Pandinus* Thorell est considéré comme le genre le plus proche parent du genre *Heterometrus*.

I. Introduction

Within the Chelicerata, the order Scorpionida has an isolated position. This is demonstrated, e.g., by the distinct trunk segmentation and shape, the large pincers (pedipalps), the ventral comb-like organs (pectines), the pivot joint between patella and tibia of the walking-legs, and the characteristic intra-maternal development of the eggs. For this reason, in a recent classification of the Chelicerata (Van der Hammen, 1977: 316, 317, table 3), the order Scorpionida is the only representative of the new class Scorpionidea. It contains six well-separated families. The members of the family Scorpionidae occurring in the jungles of Southeast Asia are classified with the genus *Heterometrus* Hemprich & Ehrenberg, 1828. As to their conspicuous size (trunk length up to 16 cm) they are a good match for the closely related African genus *Pandinus* Thorell: they are among the world's largest scorpions. The stout metasoma and impressive pedipalps form their most striking features. These scorpions inhabit natural holes or quite deep burrows which they dig themselves in loamy riverbanks, other sloping grounds, or vertically into the forest soil, partly under a stone or at the roots of a tree. They seem to prefer forests as their habitat, while many other scorpion genera can be found in open country and sometimes in caves. Like other scorpions, *Heterometrus* is nocturnal; by its nightly activities in lodgings and tents (warning by its sinister hissing stridulation when disturbed), it has terrified many a westerner in the Southeast Asiatic territories. Man's fear of scorpions, which has led him to a regular inspection of bed and boots, is well understandable because of the stories about deadly poisonous "bites" by scorpions. The venom of *Heterometrus*, a poisonous protein, causes temporary paralysis and irregularities in breathing, but there are no reliable reports on deaths of healthy persons caused by scorpions of this genus (there are, on the contrary, fatal incidences in the cases of the South American *Centrurus noxius* and the North African *Androctonus australis*, which seem to be as dangerous as a cobra). Invertebrate preys, however, for which *Heterometrus* is waiting in his lair or is searching by night, will not stand a chance against the fatal sting. The life-habits of these scorpions present also many harmless and interesting aspects, e.g., their remarkable courtship, by which these solitary animals manage a safe mutual approach. The partners seize each other's pedipalp hands (large pincers) and chelicerae (small pincer-like mouthparts), and stay in this position for hours, while occasionally one of them forces its partner to walk back or aside. During this "dance" the male adheres a spermatophore to the substrate and guides the female over it: she takes it into her genital orifice. The intra-maternal development of the embryos inside the egg-shell, with the aid of special nourishing organs, is another peculiarity, as is the ovoviviparity. The first days after their birth the young scorpions still cling to their mother's trunk, as in some spiders. They are not fed by the mother, but they digest the embryonic yolk which is left in their midgut. For this reason, this instar is called an elattostasic larva (Van der Hammen, 1978: 56). This larva moults into a more active nymph with a body almost like that of an adult, only on a small scale. Now the stock of embryonic yolk has run out and the nymphs leave their mother, since they are now able to look for their own prey. They disperse and start a hermit's life, although in several instances the dwellings of scorpions are found associated in colonies. This applies especially to desert scorpions, e.g., the scorpionid genus *Opisthophthalmus* Koch (see Lamoral, 1978). Probably such distribution patterns are more easily discovered in deserts than in luxuriant tropical forests, but it is possible that forest scorpions like *Heterometrus* also live in colonies. I deduce this from the fact that a group of live specimens of *H.* (*Javanimetrus*) *c. cyaneus* (Koch), which I have kept for a study of their behaviour, were caught from burrows situated close to each other in a river bank near Bogor.

Representatives of the genus *Heterometrus* are known from an area extending from India eastward up to and including Java, Borneo and the Philippines. From this vast and, by its many islands, discontinuous area, about sixty species and subspecies have been described in the literature. These "species" are of different taxonomic value; they have been described or criticized by various authors, according to different characters and taxonomic criteria. This has led to intricate distortion of simple correlations and to complex synonymies. For this reason, a revision of the genus as a whole is badly needed. In systematic treatises on, and faunistic reviews of Arachnidea, Scorpionida or the family Scorpionidae in particular, much attention was paid to *Heterometrus*, although mostly under different names: *Buthus*, *Scorpio*, *Palamnaeus* and *Pandinus*. Here I mention the important works by Koch (1836-1842), Simon (1872-1905), Thorell (1876-1889), Karsch (1885-1887), Pocock (1893-1900), Kraepelin (1894-1904), Kopstein (1921-1923), Giltay (1931) and Takashima (1945). Studies on certain species of this genus have been made by Schultze (1927) and Meise (1932). Many of these authors noticed the variability of characters used in descriptions, and the numerous complications in the taxonomy of the genus resulting from these variations. Simon (1872: 52), for instance, remarked that "chez les *heterometrus*, les caractères semblent s'effacer, et les organes, qui, dans les autres genres de l'ordre des Scorpionidae, peuvent être utilement employés, présentent dans les espèces de ce groupe une similitude parfaite." Thorell (1889: 590) also complained that "res ardua sane est, species generis *Palamnaei* distinguere, quum non parum variare videantur, et mares saepe magnopere a feminis differant". This sexual dimorphism is indeed a striking character of many *Heterometrus* species. Giltay (1931: 5, 6) found that "caractères sexuels secondaires montrent un maximum de variabilité. Ils ne peuvent être, par conséquent, que d'un assez faible secours au point de vue taxonomique. Leur usage inconsidéré conduit à la création de nouvelles formes n'ayant en réalité aucun caractère spécifique particulier. (...) il n'est pas étonnant voir qu'un certain nombre de ♂ de *Heterometrus longimanus longimanus* (Herbst), pris à des stades différents, ont été décrits comme espèces distinctes." He illustrated this with the curious remark by Schultze (1927), made in his study on the Philippine *Heterometrus longimanus*, that he could not find any male of this species. Giltay rightly concluded that the usual strong sexual dimorphism in this species, well-known already from *Heterometrus* on the Larger Sundas and the Indochinese peninsulas, is absent in material from the Philippines. He stated that this geographic variation of sexual dimorphism could, in fact, constitute an important taxonomic character. This theory was further developed by Meise (1932) for *Heterometrus* species in this eastern part of the area of distribution of the genus. Kraepelin (1899: 107) wrote at the start of his chapter on *Heterometrus*: "Die sichere Trennung der Arten dieser Gattung bietet nicht unerhebliche Schwierigkeiten, da augenscheinlich Uebergangsformen existieren und die ohnehin ziemlich geringfügigen Unterscheidungsmerkmale nicht immer konstant sind. Die nachfolgende Bestimmungstabelle enthält daher nur die besser gekannten und charakterisierten Arten."

The above clearly demonstrates that a revision of this genus should start with a character analysis. The correlations of the characters with a given taxon are listed in table 1, where these characters are classified in one of the following six categories (partly after Vachon, 1952: 45-47).

1. Characters independent of sex and age, and stable within the taxon. — These characters are the most valuable, generally exhibiting geographic variation only. In this paper the variation studied is restricted to locations, because old labels rarely give data with reference to altitude and habitat (seasonal variation has never been observed in scorpions).

2. Characters independent of age and stable within the taxon in question, but exhibiting sexual dimorphism. — These characters can be useful to the taxonomist, provided that mention is made of the sex.

3. Characters independent of sex and stable within the taxon in question, but changing with age. — These characters can be useful too, provided that age (juvenile or (sub)adult stase) is mentioned. In practice age-dependent characters can be used with reasonable certainty only when applied to adults. This instar can easily be recognized by the characters of sexual maturity. Age-dependent characters are fairly constant in this instar, although even adult scorpions could moult (Vachon, Roy & Condamin, 1970: 427).

TABLE I

Classification of characters according to their relation to a certain taxon.

character category	taxonomic stability	sexual dimorphism	age dependence
1	+	-	-
2	+	+	-
3	+	-	+
4	+	+	+
5	-	+/-	+/-
6	+ for a taxon of higher rank, including the taxon studied		

4. Characters dependent on sex and age, but stable within the taxon in question. — These characters can be used in taxonomy less easily than those of the previous categories, because sex and age concerned (generally the adult stase) must be known.

5. Characters variable within the taxon in question. — These characters are of no use to the taxonomist, because of their wide variability. Many characters used in older descriptions, such as microsculpture of the cuticle, colour and other strongly variable characters, belong to this category.

6. Characters stable in the taxon in question, with the same state in related taxa. — Many of these characters can be used to define higher taxa, but not the taxon concerned.

Within the scope of a general revision, a thorough analysis of numerous characters of many species is an obvious starting point. A fairly representative collection of specimens from the whole area of distribution was made available to me, thanks to the cooperation of the curators of the collections listed below (with the abbreviations with reference to the collections, as used in the present paper): BM, British Museum (Natural History), London; CFB, Coll. Dr. E. I. Fuhn, Bucuresti; CKL, Coll. P. Kuyten, Department of Systematics and Evolutionary Biology at Leiden University, Leiden; CLC, Coll. Prof. Dr. Lahiri, Calcutta; MCG, Museo Civico di Storia Naturale "Giacomo Doria", Genova; MCZ, Museum of Comparative Zoology (the Agassiz Museum), Cambridge (Mass.); MHG, Muséum d'Histoire naturelle, Genève; NMG, Naturhistoriska Museet, Göteborg; NRS, Naturhistoriska Riksmuseet (Sektionen för entomologi), Stockholm; RMNH, Rijksmuseum van Natuurlijke Historie, Leiden; RS, Muséum nationale d'Histoire naturelle (Laboratoire de Zoologie, Arthropodes), Paris; SMF, Forschungsinstitut Senckenberg, Frankfurt am Main; UZM, Universitetets Zoologiske Museum, København; ZIU, Zoologiska Institutionen, Uppsala; ZMA, Instituut voor taxonomische Zoologie (Zoologisch Museum), Amsterdam; ZMB, Zoologisches Museum, Berlin; ZSI, Zoological Survey of India, Calcutta.

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II. Methods

General remarks. — From the literature on scorpion systematics a number of characters have been selected of which a precise definition is possible. Several new characters have been added, most of which are biometric and consequently little dependent on the author's interpretation.

Nobody can be absolutely sure about the meaning of "rather sharp denticles" in a description of some part of an animal; it is impossible to draw a line between faint, obtuse, rather sharp, sharp and acuminated denticles in a continuous range of variation, and it is difficult to choose one of these terms when comparing a single specimen with a description. Variations in descriptive characters are often difficult to define. On the other hand, every biologist is able to count or can make use of compasses and ruler; hardly any difference of opinion can, for instance, exist in the case of pedipalp hand width or the number of pectinal teeth. In the present paper, figures illustrate my methods of measurement, so as to exclude any doubts that could still arise. Several biometric characters are taken from Vachon's extensive comments on taxonomically valuable characters in the study of scorpions (Vachon, 1952: 44-70; Vachon & Stockmann, 1968: 81-93). Besides a strong restriction of arbitrariness, the use of biometry in taxonomic problems offers the advantage of an easy measurement of variations, and the possibility of demonstrating variations by graphs. These are the reasons why, besides many descriptive characters, biometric characters play an important role in the present study.

Some measurements can be expected to depend on age, because they are direct results of growth. If these measurements are to be involved in comparisons between specimens, it is preferable to relate them to other age-dependent measurements in the form of ratios. A disadvantage of a ratio is the loss of original information; in order to avoid this loss, in some cases, the components of such a ratio were used also. A second disadvantage, which cannot be avoided, refers to the possibility of an increase of errors in ratios as a result of combination of the errors in both components. In table 2 all characters are listed that have been thoroughly examined during the study of population-samples; in the table the taxonomic value of each character is indicated. In several cases the publications are mentioned from which the characters were taken and further explanation (besides the illustration in the present paper) can be found in the literature cited. Measurements were taken by means of compasses and ruler, except for very small distances, which were measured with the use of an ocular micrometer mounted in a Wild M-5 stereomicroscope. A camera lucida adapted to this microscope was used in making numerous drawings according to which angles and ratios of

Table 2

General list of characters investigated

The character numbers correspond with the numbers used in the present paper. Indications in the right columns contain the following information: A — biometric character: absolute measure (A) (distances in tenths of mm, angles in degrees) or ratio (R); B — descriptive character; C — differential value demonstrated in the present study; some of these characters were rejected later on because of practical difficulties in large-scale screening of samples; D — differential value demonstrated in the introductory study of three population samples, as described in chapter II; E — applied to the systematic study of the genus; F — number of category in table 1 (uncertain conclusions in parentheses); G — originally (in the introductory study of three population samples) selected as possibly valuable, but rejected after application to the genus; H — rejected: category 5 or 6 of table 1, or application or definition difficult. A cross (X) in one of the right columns indicates that the respective information applies to the character in question; for further explanation, see p. 16.

no.	definition	A	B	C	D	E	F	G	H
1	Carapace (cp): median length	A	.	x	x	x	4	.	.
2	cp: maximum width	A	.	x	x	.	(4)	.	.
3	cp: number of granules on frontal lobes per square mm (fig. 1a: *flc*)	A	.	.	.	.	5	.	x
4	cp: depth of frontal median incision (fig. 1a: *fic*)	A	.	.	.	.	6	.	x
5	cp: number and arrangement of macrosetae (Scheuring, 1912: 371-374; Vachon, 1952: 52, 53)	A	x	.	.	.	5	.	x
6	cp: distance from foremost edge of frontal lobes to centre of median oculiferous tubercle, expressed as a ratio to the distance from tubercle to hindmost edge of carapace (fig. 2a)	R	.	x	.	x	1	.	.
7	cp: type of superciliary crests (fig. 2a: *sc*; table 3)	.	x	x	.	x	1	.	.
8	cp: presence of two small areas with distinct colour (*c*) and/or relief (*m*, *s*), in some cases represented by bulges (*b*), each paraxially flanking a lateral eye-group (fig. 2b; table 9)	.	x	x	.	x	1	.	.
9	cp: presence of a straight-sided and brightly coloured triangle formed by the medioposterior transverse ridge and the pair of protuberances flanking the median furrow posteriorly of the oculiferous tubercle (figs. 2a, 39a)	.	x	x	.	x	1	.	.
10	cp: absence of smooth areas	.	x	x	.	x	1	.	.
11	cp: presence of granulation on the medioposterior border	.	x	x	.	x	1	.	.
12	cp: smoothness, or sparse granulation of all areas	.	x	x	.	x	1	.	.
13	cp: large median area smooth and flat, only the utmost lateral and frontal areas finely granulated	.	x	x	.	x	1	.	.

(no.	definition)	(A	B	C	D	E	F	G	H)
14	cp: presence of a depression in the median furrow, deeper than the medioposterior T-shaped furrows and situated between these furrows and the median oculiferous tubercle (fig. 31)	.	x	x	.	x	1	.	.
15	cp: presence of sharp, heart-shaped incision in the medioposterior border (fig. 50a)	.	x	x	.	x	1	.	.
16	Chelicerae (ch): length of *de* expressed as a ratio to length of *di* (terminal teeth of movable digit: external, *de*, and internal, *di*; cf. figs. 1a, b: *Lde*, *Ldi*) as measured from the insertion of the terminal macroseta on this digit	R	.	x	x	.	2	.	.
17	ch: idem, improved by measuring from the conjunction of these teeth	R	.	x	.	x	2	.	.
18	ch: hand: number of dorsal macrosetae (fig. 1a)	A	.	.	.	.	.	.	x
19	ch: hand: number of dorsal microsetae (fig. 1a)	A	.	.	.	.	.	.	x
20	ch: hand: presence of reticulate colour pattern	.	x	.	.	.	5	.	x
21	Pedipalps: segment 3 (p3): number of granules on dorsal surface (rounded off in multiples of five)	A	.	x	x	x	2	.	.
22	p3: angle *ma.d.b* — *d* — *ma.de.b* (fig. 3a)	A	.	x	x	.	2	.	.
23	p3: angle *ma.d.b.* — *ma.de.b* — *d* (fig. 3a)	A	.	.	.	.	1	.	x
24	p3: number of terminal lyrifissures (Hansen, 1894: 143) near the dorsal condyle	A	.	.	.	.	6	.	x
25	p3: idem, near the ventral condyle	A	.	.	.	.	6	.	x
26	p3: presence of stout and sharp teeth on the internodorsal keel (fig. 3a)	.	x	x	.	x	1	.	.
27	p3: presence of sharper denticulation on the externodorsal keel than on the internodorsal keel	.	x	x	.	x	1	.	.
28	p3: presence of stouter denticulation on the externodorsal keel than on the internodorsal keel	.	x	x	.	x	1	.	.
29	pedipalp segment 4 (p4): length of internal side (fig. 3c; Vachon, 1952: 60, fig. 66: *Li*)	A	.	x	x	x	4	.	.
30	p4: angle formed by the longitudinal axis of the segment and the line *esb1* — *esb2* (fig. 3d, e)	A	.	x	x	x	1	.	.
31	p4: angle *em1* — *em2* — *em3* (fig. 3d, e)	A	.	.	.	.	.	x	x
32	p4: angle *t1* — *t2* — *t3* (fig. 3d, e)	A	.	.	.	.	1	.	x
33	p4: shortest distance between trichobothria *t* and *t* (fig. 3d, e) / shortest distance between trichobothria *em* and *t* (fig. 3d, e)	R	.	x	x	.	1	.	.
34	p4: idem, numerator measured between trichobothria *eb* and *t*	R	.	x	.	x	1	.	.

(no.	definition)	(A	B	C	D	E	F	G	H)
35	p4: position of trichobothria *sb* with regard to *eb* and *em* (fig. 3d)	R	.	.	.	.	1	.	x
36	p4: reduction of *esb2* (fig. 3d)	.	x	.	.	.	6	.	x
37	p4: presence of distinct (coarse) granulation on external surface	.	x	x	.	x	1	.	.
38	p4: presence of only one prominent tooth, accompanied by smaller teeth or granules, on the internal surface (fig. 3b, c)	.	x	x	.	x	1	.	.
39	p4: idem, two prominent teeth	.	x	x	.	x	1	.	.
40	p4: idem, more than two prominent teeth	.	x	x	.	x	1	.	.
41	p4: absence of prominent teeth (merely granules or very low teeth) on internal surface	.	x	x	.	x	1	.	.
42	pedipalp hand (ph): length of ventral side (Vachon, 1952: 62, fig. 70: *Lm*)	A	.	x	x	x	4	.	.
43	ph: maximum width (fig. 3h; Vachon, 1952: 62, fig. 70: *lm*)	A	.	x	x	x	4	.	.
44	ph: ventral length as a ratio to maximum width	R	.	x	x	x	2	.	.
45	ph: mean value of character no. 44 in the ♂♂ (including neotenic ♂♂) of a population, as a ratio to that in the ♀♀	R	.	x	.	x	1	.	.
46	ph: length of dorsal side, the fixed digit included (fig. 3k; Vachon, 1952: 62, fig. 70: *LP*)	A	.	x	x	.	3	.	.
47	ph: angle *Eb1* — *Esb* — *Eb2* (fig. 3i, j)	A	.	x	x	x	3	.	.
48	ph: distance between *Db* and *Eb3* added to the distance *Eb3* — *Eb1*, as a ratio to the distance *Db* — *Eb3* (fig. 3h, i)	R	.	.	.	.	1	.	x
49	ph: angle *eb* — *Dt* — *Et5* (fig. 3h)	A	.	.	.	.	1	.	x
50	ph: distance between *Et2* and *Dt*, as a ratio to the distance between *Et2* and *Et5* (fig. 3h)	R	.	.	.	.	1	.	x
51	ph: distance between *Et2* and *Dt*, as a ratio to length of the continuation of *Et2* — *Dt* till dorsal keel *cd* (fig. 3h)	R	.	x	x	x	1	.	.
52	ph: distance between *V1* and *V4*, as a ratio to distance *V3* — *V4* (fig. 3j, k)	R	.	x	x	x	4	.	.
53	ph: presence of reticulate pattern of confluent granules on external surface (fig. 4b)	.	x	x	.	x	1	.	.
54	ph: external keels completely visible in microsculpture (figs. 3h; 4b, e)	.	x	x	.	x	1	.	.
55	ph: arrangement of trichobothria *Eb1*, *Eb2* and *Eb3* along a more or less straight line (fig. 3i, j)	.	x	.	.	.	1	.	x
56	ph: angle *Eb1* — *Esb* — *Eb2* (fig. 3j)	A	.	.	.	.	1	x	x
57	ph: the distance *Esb* — *Eb1* as a ratio to the distance *Esb* — *Eb2*	.	x	.	.	.	1	.	x
58	ph: reduction of trichobothrium *Esb* (fig. 3j)	.	x	.	.	.	6	.	x
59	ph: reduction of trichobothrium *Et4* (fig. 3h)	.	x	.	.	.	6	.	x
60	ph: large hand (width mostly exceeding 17 mm in adults) with almost straight dorsal keel and large proximal lobe, external surface coarsely granulated, unkeeled or faintly keeled	.	x	x	.	x	1	.	.

no.	definition	A	B	C	D	E	F	G	H
61	ph: microsculpture of external surface (extension of characters nos. 53 and 54; figs. 4a-f; table 4)	.	x	x	.	x	1	.	.
62	pedipalp fixed digit (pf): number of ordinary teeth (*do*) per series, counted in the terminal three series (figs. 5a-d; Vachon, 1952: 62, figs. 71-74)	A	.	x	x	.	1	.	.
63	pf: distance between *eb* and digit apex, as a ratio to distance between *et* and apex (fig. 3h)	R	.	.	.	x	1	.	.
64	pf: angle *dt* — *dst* — *dsb* (fig. 3h)	A	.	.	.	.	5	.	x
65	pf: angle *dst* — *dsb* — *db* (fig. 3h)	A	.	.	.	.	5	.	x
66	pf: position of *ib* and *it* (fig. 3k; Vachon, 1967: 1535-1537)	.	x	.	.	.	6	.	x
67	pedipalp: movable digit (pm): number of ordinary teeth (*do*) per series, counted in the terminal three series (figs. 6a-d; Vachon, 1952: 62, figs. 71-74)	A	.	x	x	.	1	.	.
68	pm: length of ventral side (Vachon, 1952: 62, fig. 70: *Ld*)	A	.	x	x	x	3	.	.
69	pm: width of ventral base	A	.	x	x	x	3	.	.
70	pm: length of ventral side, as a ratio to char. no. 29	R	.	x	x	x	2	.	.
71	pm: char. no. 68 as a ratio to char. no. 42 (Vachon, 1952: 63)	R	.	x	x	x	3	.	.
72	pm: idem, as a ratio to char. no. 43	R	.	x	x	.	3	.	.
73	pm: idem, as a ratio to char. no. 46	R	.	.	.	.	3	.	x
74	pm: idem, as a ratio to char. no. 69	R	.	x	x	x	2	.	.
75	Walking-legs (wl): granulation on inferior keels of femora II-IV is faint	.	x	x	.	x.	1	.	.
76	wl: granulation of inferior keels of femur IV is faint and/or sparse [1]	.	x	x	.	x.	1	.	.
77	wl: presence of setae on basitarsal calcars ("spurs"; Vachon, 1952: 65)	.	x	.	.	.	.	.	x
78	wl: shape and position of telotarsal dorsal organ (Hansen, 1894: 148-149, figs. II 4a, b)	.	x	.	.	.	6	.	x
79	wl: number of telotarsal spines on legs III and IV (fig. 1c; Kraepelin, 1899; Vachon, 1952: 65; 1967: 1534, 1535): antero-inferior spines	A	.	x	x	x	1	.	.
80	wl: idem, postero-inferior spines	A	.	x	x	x	1	.	.
81	Pectines (pc): distance from base of shaft to basal tooth (fig. 1d)	A	.	.	.	.	3	.	x
82	pc: total length of shaft (fig. 1d; Vachon, 1952: 66: "manche")	A	.	x	x	x	4	.	.
83	pc: number of teeth per pecten (left, right) (fig. 1d)	A	.	x	x	x	2	.	.

[1]) The significance of this specification of char. no. 75 was demonstrated later on during the study of the genus.

(no.	definition)	(A	B	C	D	E	F	G	H)
84	ps: maximum number of setae per external fulcral plate (figs. 1e, f: *fe*)	A	.	.	.	.	4	x	x
85	pc: shape of pectiniferous plate (fig. 1d: *pp*)	.	x	.	.	.	6	.	x
86	pc: ornamentation of internal fulcral plates (Vachon, 1952: 66-68, fig. 81-84): *fr* (without protuberance), *fma* (with macroseta) or *fmi* (with microseta)	.	x	x	x	x	1	.	.
87	Paraxial organ (po): distance from terminal end of cylindrical gland (*gc*) to articular suture (*sa*) of the hemispermatophore (fig. 7d; Vachon, 1952: 69-70, fig. 85: *d*)	A	.	.	.	.	5	.	x
88	po: hemispermatophore: length of distal part (fig. 7a: *Ld*; Vachon, 1952: 69-70, fig. 85: *r* + *rf*)	A	.	.	.	.	5	x	x
89	po: idem: shape of terminal end of distal part	.	x	.	.	.	5	.	x
90	Mesosoma (ms): number of tergal and sternal macrosetae, per segment (Vachon, 1952: 53)	A	.	.	.	.	5	.	x
91	ms: medioposterior borders of tergites 1-6 granulated	.	x	x	.	x	1	.	.
92	ms: lateroposterior denticulated protuberances on tergite 7 inconspicuous	.	x	x	.	x	1	.	.
93	ms: presence of bright spot-pairs on the anterior part of the tergites	.	x	x	.	x	1	.	.
94	ms: presence of fine granulation or denticulation on lateral borders of sternites 2-4	.	x	x	.	x	1	.	.
95	ms: presence of a pair of contiguous longitudinal furrows in sternite 5	.	x	.	.	.	6	.	x
96	ms: presence of fine granulation or denticulation on the (latero)posterior border of sternite 4	.	x	x	.	x	1	.	.
97	Metasoma (mt): number of dorsal, dorsolateral, ventrolateral and ventral macrosetae per segment (Vachon, 1952: 54-56)	A	.	.	.	.	5	.	x
98	mt: sum of lengths of segments 1-5 (Vachon, 1952: 54, fig. 50, 51: *L*)	A	.	x	x	x	4	.	.
99	mt: char. no. 98 as a ratio to char. no. 1	R	.	x	x	x	4	.	.
100	mt: sum of lengths of segments 3 and 4, as a ratio to char. no. 1	R	.	x	.	x	1	.	.
101	metasomatic segment 5 (m5): length (fig. 8b; Vachon, 1952: 54, fig. 53: *L*)	A	.	x	x	x	3	.	.
102	m5: char. no. 98 as a ratio to char. no. 101	R	.	x	x	x	2	.	.
103	m5: mid-width (Vachon, 1952: 54, figs. 51-53: *l*)	A	.	x	x	.	3	.	.
104	m5: mid-height (fig. 8c; Vachon, 1952: 54, fig. 50, 54: *h*)	A	.	x	x	x	3	.	.
105	m5: char. no. 101 as a ratio to char. no. 104	R	.	x	.	x	4	.	.
106	m5: terminal width as a ratio to basal width (Vachon & Stockmann, 1968: 92: *k*, *lb*; 141: fig. 68D)	R	.	.	.	.	1	.	x
107	m5: length of lateral keel (fig. 8a: *lc*; Vachon, 1952: 54; figs. 50, 51: *3*)	A	.	.	.	.	5	.	x

(no.	definition)	(A	B	C	D	E	F	G	H)
108	m5: char. no. 101 as a ratio to char. no. 107	R	.	x	x	x	1	.	.
109	m5: number of macrosetae surrounding the anal region (Vachon, 1952: 56)	A	.	.	.	.	5	.	x
110	mt: presence of median longitudinal furrow in dorsal surfaces of segments 1-5	.	x	.	.	.	6	.	x
111	mt: very poorly developed denticulation on dorsal keels (fig. 35c)	.	x	x	.	x	1	.	.
112	mt: idem, lateral keels (fig. 49c)	.	x	x	.	x	1	.	.
113	m5: about equal size of terminal tooth and remaining teeth of ventrolateral keels of segment 5 (fig. 8c)	.	x	x	.	x	1	.	.
114	mt: smoothness of dorsal surface (absence of any granules)	.	x	x	.	x	1	.	.
115	m5: presence of dorsal granules	.	x	.	.	.	5	x	x
116	m5: smoothness of ventral intercarinal areas (except for a pair of teeth halfway on the segment) (Vachon & Stockmann, 1968: 92: *lc, lb*; 141: fig. 68D)	.	x	x	x	x	1	.	.
117	m5: shape of anal region (Vachon, 1952: 56, figs. 56-58: "cadre anal")	.	x	.	.	.	6	.	x
118	mt: denticulation on lateral keels of the metasoma, from its basal to its terminal end, gradually less pronounced (reduced to fine granulation or denticulation series on segment 5)	.	x	x	.	x	1	.	.
119	mt: idem, this phenomenon being distinct only on segments 4 and 5	.	x	x	.	x	1	.	.
120	metasoma: telson (te): width of vesicular pedicel (Vachon, 1952: 56-57, fig. 59-61: *lp*)	A	.	.	.	.	3	x	x
121	te: maximum width of vesicle (Vachon, 1952: 57, fig. 59: *lv*)	A	.	.	.	.	3	x	x
122	te: length of aculeus (Vachon, 1952: 57, fig. 59: *La*)	A	.	.	.	.	3	x	x
123	te: curvature of aculeus (Sergent, 1941: 449, pl. XL)	A	.	.	.	.	.	.	x
124	te: presence of ventral median granules on vesicle	.	x	.	.	.	6	.	x
125	te: presence of ventral tooth at base of aculeus	.	x	.	.	.	6	.	x
126	te: presence of granules at the border of the pedicular plate of the vesicle	.	x	.	.	.	6	.	x
127	Total median length of the trunk	A	.	.	.	x	3	.	.
128	Colour pattern of the body (in relative grades of lightness: bright, medium and dark; fig. 9)	.	x	.	.	.	5	x	x
129	Carapace *): lateral eye-groups (cl): the distance between the edges of anterior and medial eyes, as a ratio to the shortest distance between medial and posterior eyes (fig. 2b; cf. Simon, 1872: 53)	R	.	x	.	x	(1)	.	.

*) Three characters added later during the revisional studies.

(no.	definition)	(A	B	C	D	E	F	G	H)
130	cl: sum of three eye diameters, as a ratio to the sum of shortest distances between anterior and medial eyes, and between medial and posterior eyes (fig. 2c; cf. Simon, 1884: 361)	R	.	x	.	x	(1)	.	.
131	carapace: shape of rostrolateral edge, particularly the presence of an incision next to the posterior eye of the lateral eye-group (fig. 2b)	.	x	x	.	x	1	.	.

small distances were measured. Of these drawings only a few were selected to be published in the present paper. Presence and absence of elements regarded here as descriptive characters, are indicated mostly by + and — signs (tables 9, 11 and 13). If the character is hardly developed, but not completely absent, this is indicated by (—); if the character is distinctly present, but sub-optimal, this condition is listed as (+); for intermediate cases a ± sign is used. In a few cases (characters numbers 6, 7, 8, 61, 68, 128) several possibilities are indicated by codes, as mentioned in table 2. Some descriptive characters, that appeared to be differential for small sections of the genus, are used in the descriptions and in the keys only (not in the general tables). Generally, the descriptive characters used in the generic analysis are independent of sex and age, although in some populations slight correlations with sex were found in the case of characters numbers 10, 26, 27, 37, 38, 40, 76, 94 and 114, and slight correlation with age in the case of the characters numbers 112 and 113 (in only one sample of *H. wroughtoni*). More deviations are to be expected in juvenile specimens.

TABLE 3

Classification of types of superciliary crests.

Types of superciliary crests			type nos. 1	2	3	4	5	6
anteocular part	absent		x					
	present	continuous ridges		x				
		discontinuous ridges			x		x	
		series of granules				x		x
postocular part	absent		x	x	x	x		
	present	discontinuous ridges					x	
		series of granules						x

Trichobothriotaxy gave rise to some new characters. The trichobothrial names and sigla were chosen in consultation with Prof. Dr. M. Vachon, who introduced the application of trichobothriotaxy and biometry in scorpion systematics (Vachon, 1973). Some trichobothriotactic characters are expressed

TABLE 4

Classification of types of microsculpture on the external surface of the pedipalp hand.

microsculpture	type numbers 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
granulation present	+	+	+	+	+	+	-(±*)	±	-	-	-	-	-	-	-
reticulation present	-	-	+	±	±	+	+	+	+	+/±	±	±	±	-	±
keels absent (or hardly recognizable)	+	-	+	+	+	-	+	-	-	±	-	±	-	+	+
keels recognizable only in granulation pattern)	(±*)	+	-	±	-	-	-	-	-	-	-	-	-	-	-
keels prominent and contiguous	-	-	-	-	-	+	-	+	+	±	-	±	+	-	-
hand surface smooth (or almost smooth)	-	-	-	-	-	-	-(±*)	-	-	+	±	±	-	+	+

* possible variation

in ratios and angles; since the relative positions of trichobothria with respect to each other are studied, the proportions of the pedipalp segments in question are not used in the ratios. In the literature on systematics and morphology of Arthropoda, the terminology with reference to segments of the appendages shows much variation. I paid attention to this problem in an earlier publication (Couzijn, 1976: 456-461, 490-498) referring mainly to the walking-legs of Scorpionida. The terms, proposed in that paper, are also used for the

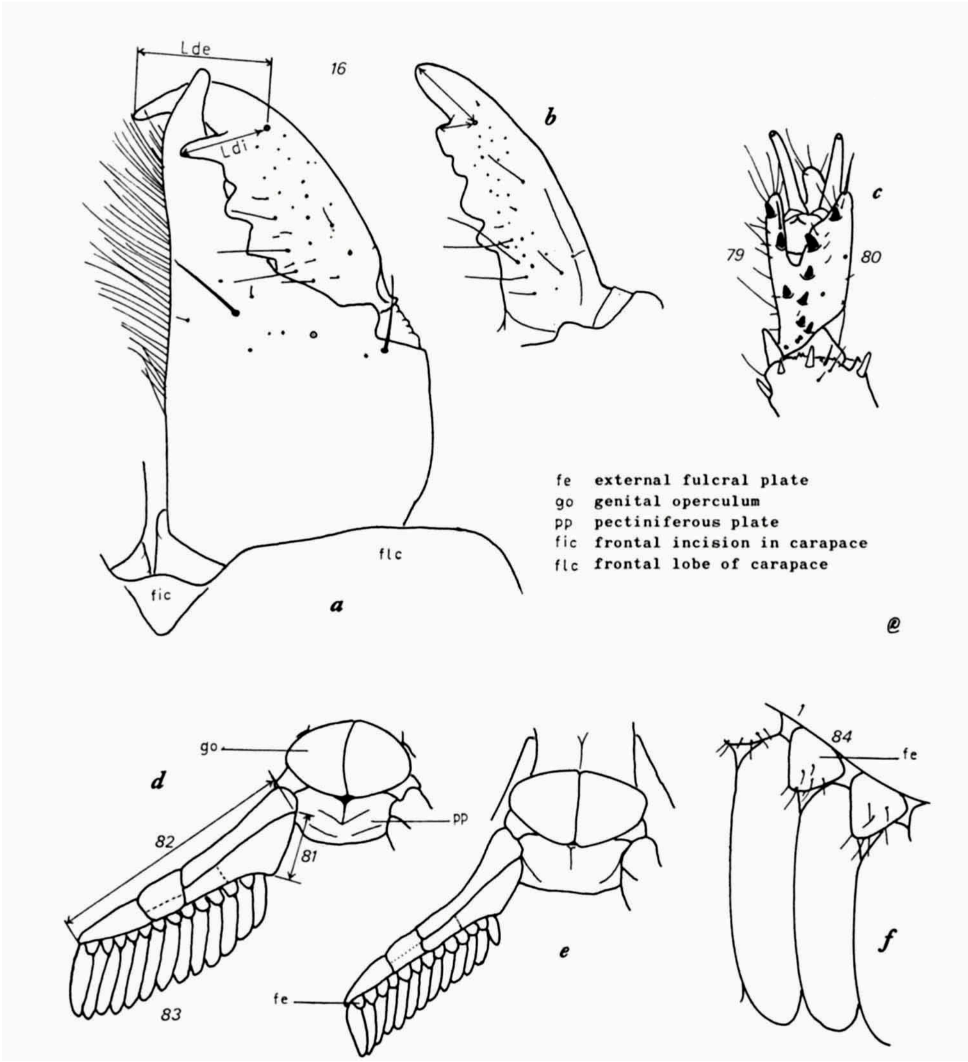

Fig. 1. a, *Heterometrus c. cyaneus* (Koch), dorsal view of right chelicera and carapace front; b-f, *H. fulvipes* (Koch); b, dorsal view of right cheliceral movable digit; c, inferior view of right telotarsus III with antero-inferior (left) and postero-inferior spines (right) in black; d-e, external view of right pecten: d, ♂; e, ♀; f, detail of external surface of left pecten in ♂; a-c, × 6.7; d-e, × 3.7; f, × 14.

description of walking-legs in the present paper. In comparison with the walking-legs, the pedipalps present considerable torsion: the plane of pseudo-symmetry is horizontal. That is why most readers — not familiar with these matters — would be confused if the same topographical terminology would be applied consistently to the segments of these appendages too. Therefore Vachon's topographical indications used with reference to the position of

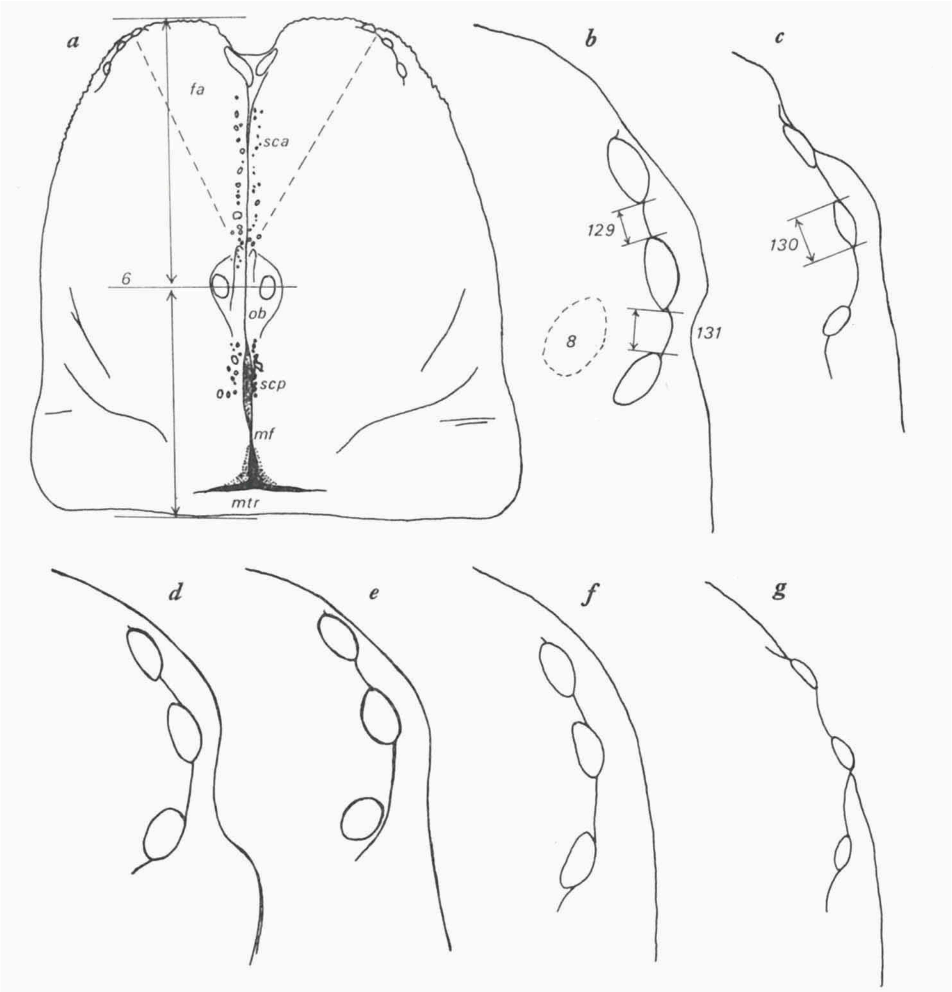

Fig. 2. a, carapace of *Heterometrus swammerdami flavimanus* (Pocock); b-g, region of the right lateral eye-group; b, *H. s. spinifer* (H. & E.); c, *H. petersii mindanaensis* subsp. nov.; d, *H. l. longimanus* (Herbst); e, *H. longimanus paris* subsp. nov.; f, *H. pelekomanus* sp. nov.; g, *H. granulomanus* sp. nov.; a, × 3.7; b-g, × 14. Explanation of sigla: *fa*, frontal area; *mf*, median furrow; *mtr*, medioposterior transverse furrow; *ob*, oculiferous tubercle; *sca*, antocular part of superciliary crests; *scp*, idem, postocular part.

trichobothria on the pedipalp (fig. 3) are applied also to the surfaces and keels on this organ. For the terminology of parts of the hemispermatophore counsel was taken with Dr. R. Stockmann, who made extensive studies of these organs in other scorpionid genera, the species *Pandinus imperator* Koch in particular (Garnier & Stockmann, 1972). As to characters concerning the telson, the border between vesicle and aculeus has been defined

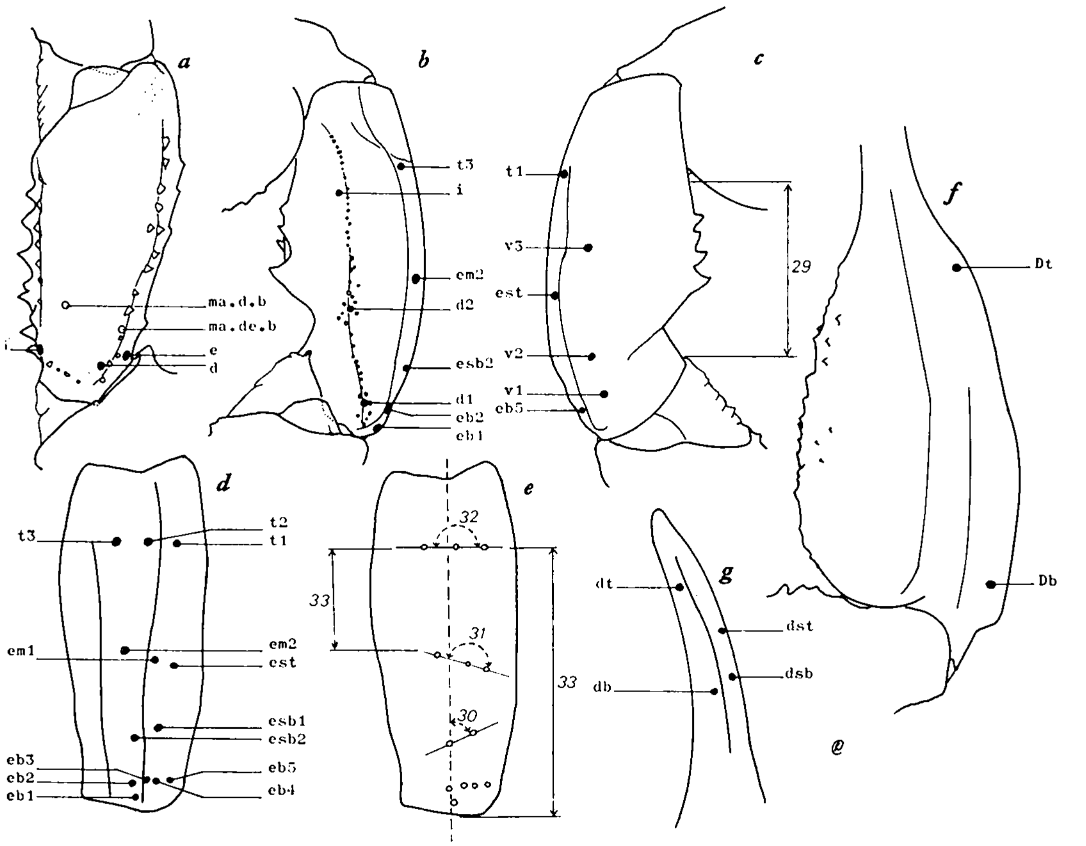

Fig. 3. Shape, keels and chaetotaxy of pedipalp segments; a, dorsal view of segment 3; b-e, segment 4; b, dorsal view; c, ventral view; d-e, external views; f-k, hand and digits; f, dorsal view of hand; g, dorsal view of fixed digit; h, external view; i, dorso-external view of joint region; j, ventral view of hand; k, internal view; a-k, × 3.7. Explanation of sigla (for trichobothria of the hand, capitals are used): *b*, basal; *D*, *d*, dorsal; *c*, carina, keel; *cmd*, dorsal external keel; *cie*, intermediate external keel; *cmv*, subventral external keel; *cp*, median external keel; *E*, *e*, external; *i*, internal; *m*, median; *ma*, macroseta; *sb*, subbasal; *st*, subterminal; *t*, terminal; *V*, *v*, ventral.

(after Vachon, 1952: 57, figs. 59-62) as the place of insertion of a pair of conspicuous ventral macrosetae at the base of the aculeus (in some genera a tubercle is found between these macrosetae, but this structure is lacking in the genera of Scorpionidae). Many characters are found, which cannot be easily expressed in measurements. In these cases series of drawings or descriptions facilitate comparative studies. This concerns the microsculpture of the integument (granules, tubercles, denticles), the position of lobes of

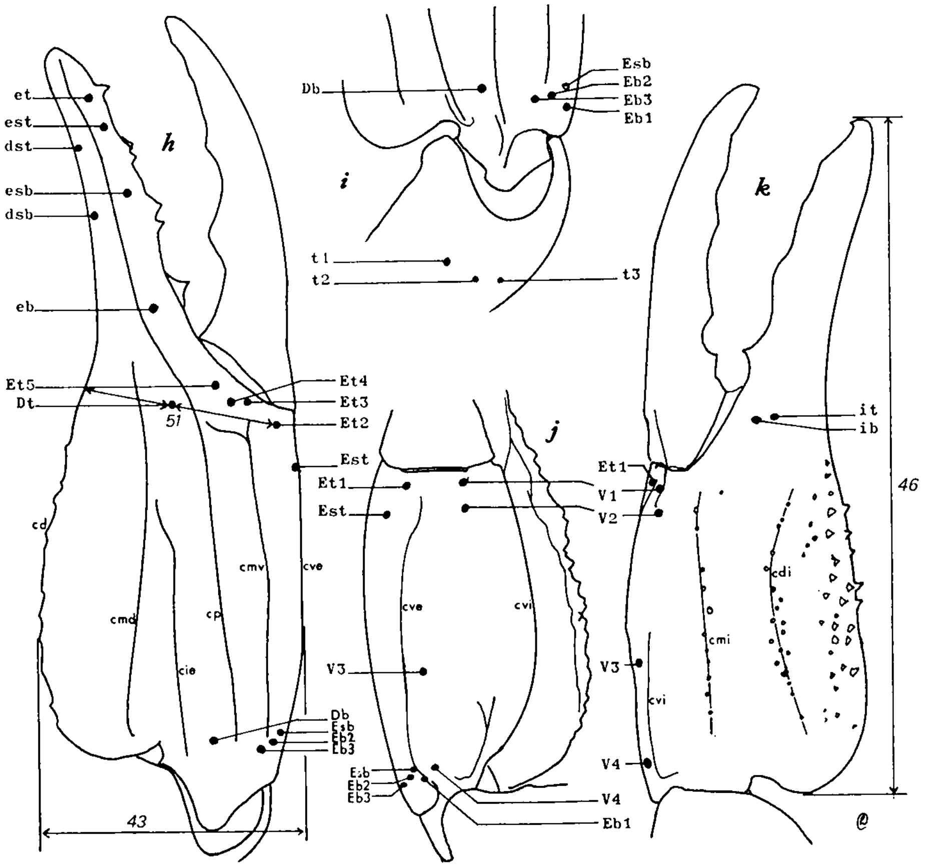

Fig. 3 (2)

the hemispermatophore, the dentition of the pedipalp digits, several trichobothriotactic characters, etc.

Age- end sex-dependent characters. — The differential value of each character was established in a study of three samples taken from well separated populations:

RMNH 87: *H* (*H.*) *l. longimanus* (Herbst), 8 ♂ and 5 ♀ from Deli (Bekri), Sumatra; leg. H. M. Pantekoek, 1892;

RS 3486: *H.* (*Javanimetrus*) *c. cyaneus* (Koch), 7 ♂ and 17 ♀ from Sukabumi, Java; leg. E. Cordier, Comtesse de Béarn, 1909;

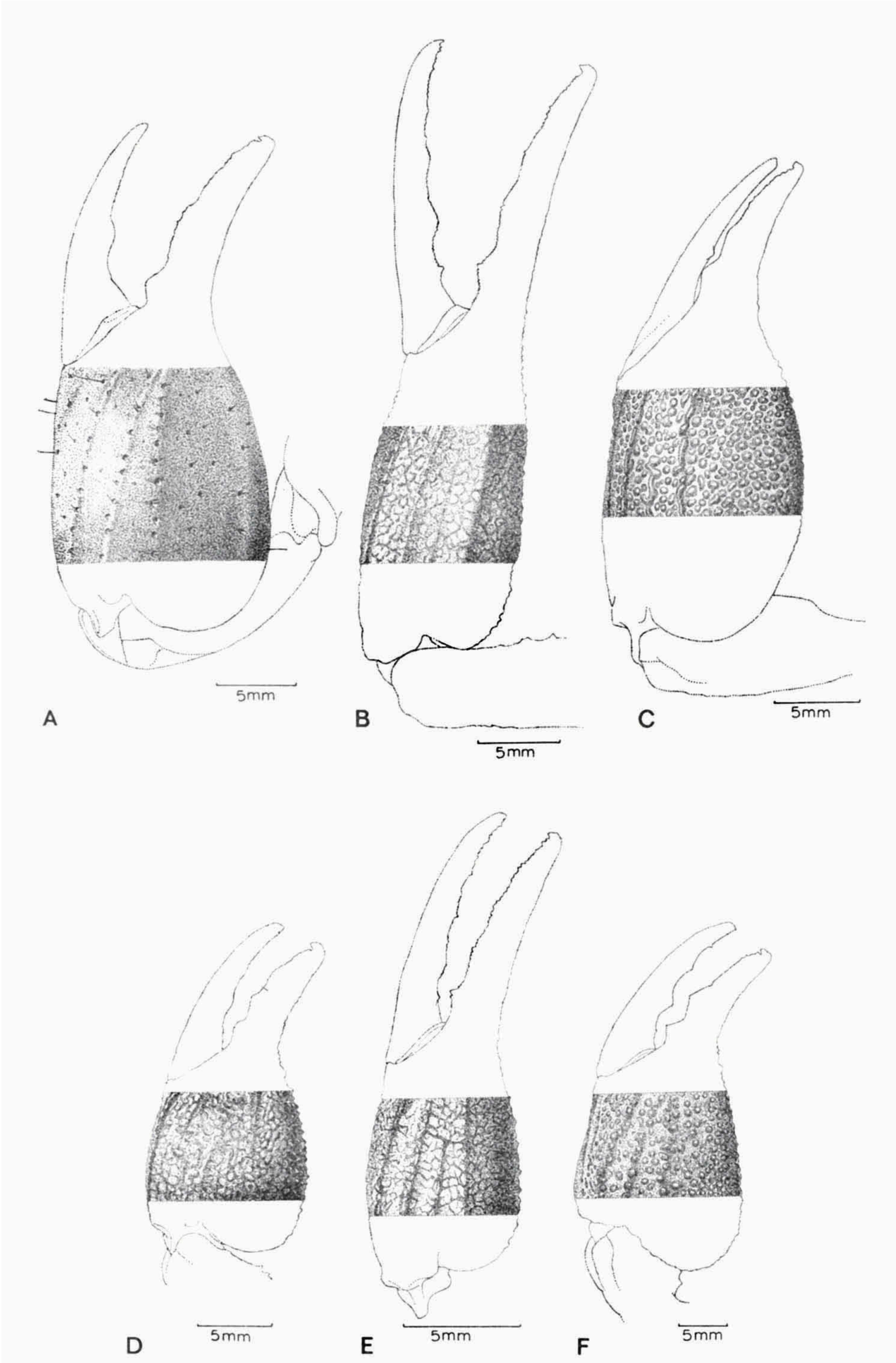

Fig. 4. Dorso-external views of left pedipalp hand; a, *Heterometrus laoticus* sp. nov., ♂ holotype (RS 0030); b, *H. liophysa separatus* subsp. nov., ♂ holotype (RMNH 185); c, *H. granulomanus* sp. nov., ♀ holotype (RS 0087); d, *H. fastigiosus* sp. nov., ♀ (RS 0123); e, *H. madoerensis* Kopstein, ♀ subad. holotype (RMNH 188); f, *H. swammerdami titanicus* subsp. nov., ♀ holotype (RS 0084).

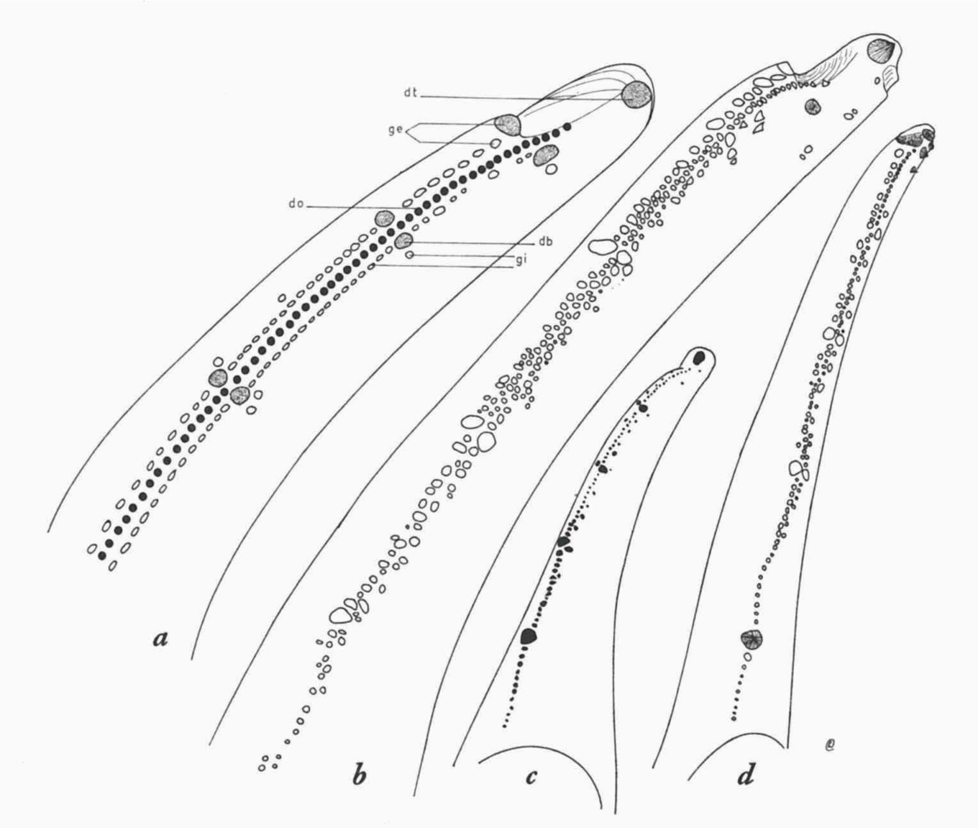

Fig. 5. Dentition of the fixed digit of the right pedipalp; a-b, *Heterometrus c. cyaneus* (Koch): a, schematic interpretation; b, actual aspect; c, *H. fulvipes* (Koch); d, *H. l. longimanus* (Herbst); a-d, × 14. Explanation in fig. 6.

RS 6168: *H.* (*Chersonesometrus*) *fulvipes* (Koch), 8 ♂ and 20 ♀ from Puttuchcherri (Pondichéry), India; leg. Maurice Maindron, August 1901 (several specimens in bad condition; still, this sample is useful to the character analysis, since it is the largest sample available to me).

Each population-sample was differentiated in male and female specimens. This is never a problem in scorpions preserved in liquid, as the male genital papillae are easily discovered under the bivalved genital operculum, the two valves of this operculum being fused into one valve in the female (fig. 1d: *go*).

Within the group of equal sex the different developmental stages had to be discriminated. Each ♂ was sectioned, according to the method recommended by Vachon (1952: 69-70), by incision of a few mesosomatic pleura

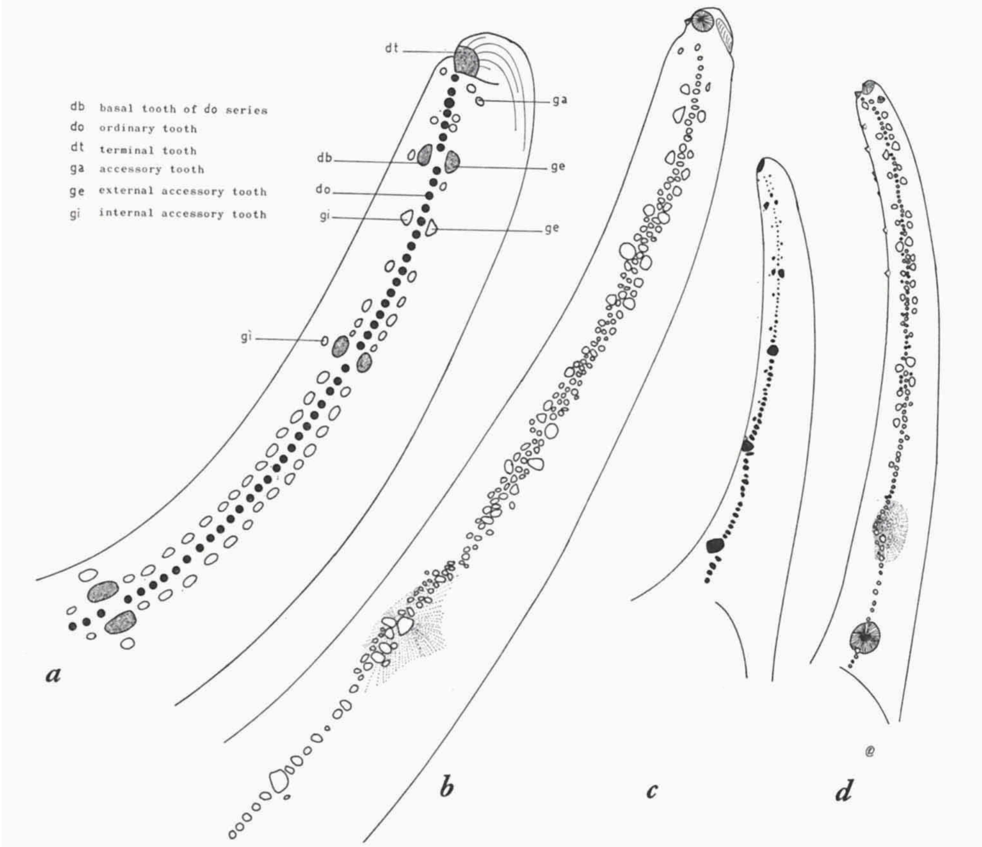

Fig. 6. Dentition of the movable digit of the right pedipalp; a-b, *Heterometrus c. cyaneus* (Koch): a, schematic interpretation; b, actual aspect; c, *H. fulvipes* (Koch); d, *H. l. longimanus* (Herbst); a-d, × 14.

on one side of the animal. In the case of an adult male a paraxial organ (in most cases the left one) was obtained for closer study. This organ is an oblong, membraneous bag in which a chitinous, lamelliform hemispermatophore is developed, that, in mating, will adhere to its counterpart to form a single spermathophore. In some genera the chitinous parts of this organ can show specific characters (these were frequently used by Maury, Stockmann, Vachon and others); consequently, the soft membraneous cover was removed and a drawing was made of the hemispermatophore. As the removal of the membrane is difficult, whilst there is a risk of tearing the fragile lobes of the hemispermatophore, an alternative method was tested, by which the membrane must be dissolved in hot lactic acid (80%). This method was rejected after the thin chitinous parts appeared not to be resistant to this acid. Vachon,

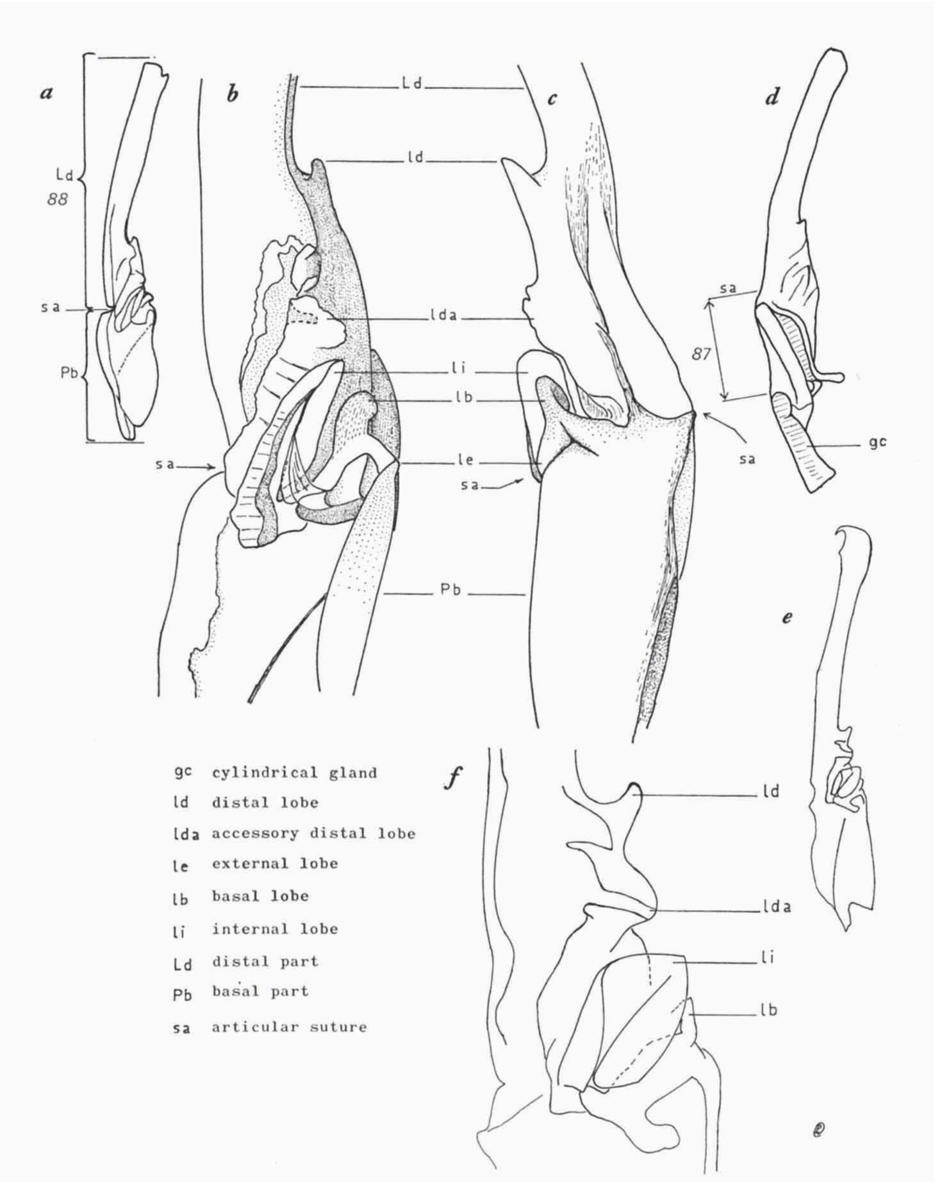

Fig. 7. Left paraxial organ; a-d, *Heterometrus l. longimanus* (Herbst); a-c, hemispermatophore; a-b, internal view; c, external view; d, internal view of paraxial organ; e-f, *H. c. cyaneus* (Koch), internal view of hemispermatophore; a, d, e, × 3.7; b, c, f, × 14.

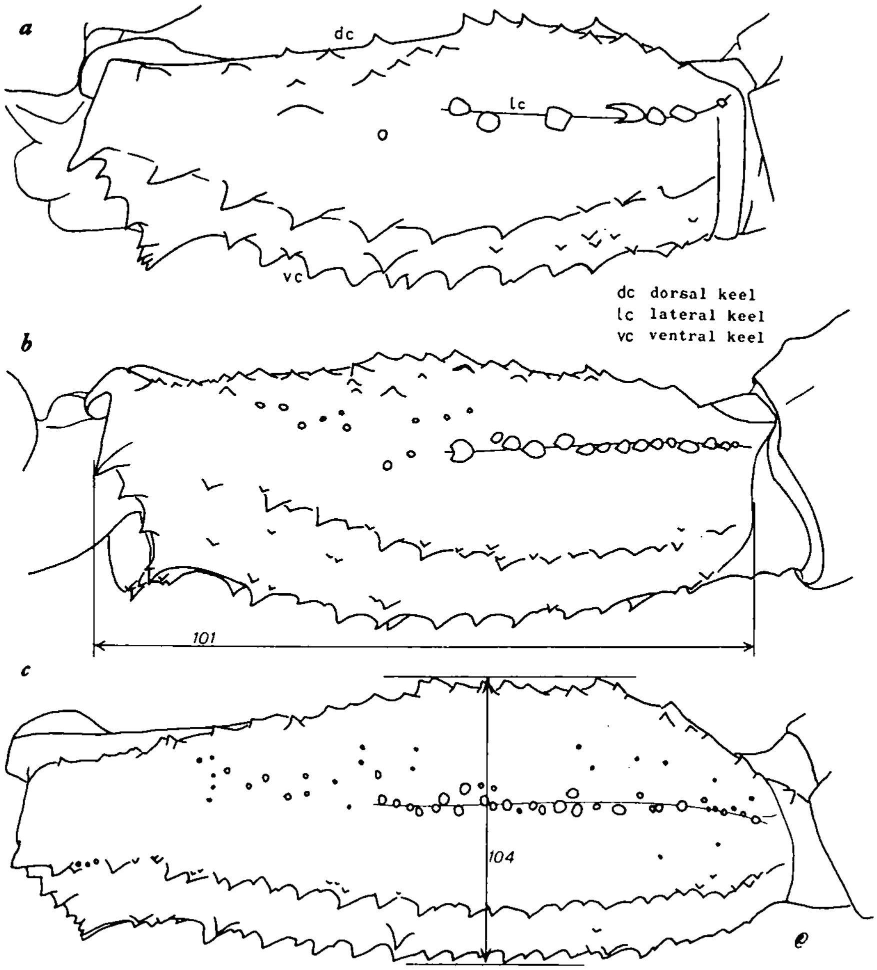

Fig. 8. Right view of metasomatic segment 5; a, *Heterometrus c. cyaneus* (Koch); b, *H. fulvipes* (Koch); c, *H. l. longimanus* (Herbst); a-c, × 6.7.

Roy & Condamin (1970) did find sexually mature males of *Pandinus gambiensis* Pocock, which nevertheless appeared to belong to different levels of postembryonic development. Vachon & Stockmann (1968: 88) used the terms "individus adultes" and "individus pubères" in this connection, but the expression "neotenic male" is to be preferred here (Van der Hammen, 1978: 52, 56). In order to study this phenomenon in *Heterometrus*, each male (except for the very young ones, less than about 4 cm in total length) was examined according to the method described above. One has to take into account that a male that has mated shortly before capture does not possess

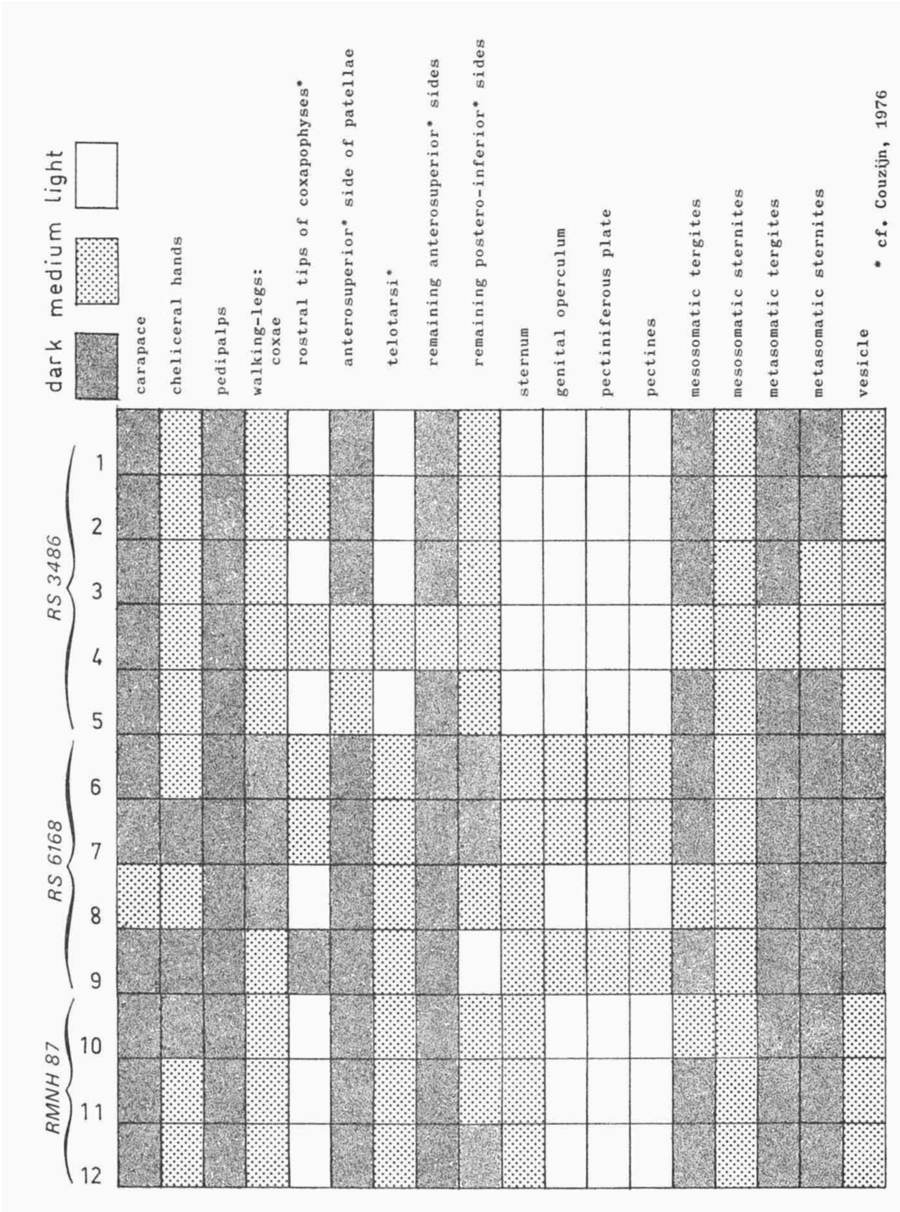

Fig. 9. Colour patterns, in relative grades of lightness, with code numbers.

hemispermatophores. The development of the complete organ takes about 10 to 11 days. Thus adult males can be found without hemispermatophores or with poorly developed ones; still these specimens will generally exhibit many other unmistakable characters of adult age. Recognition of adult females is more difficult. After mating the genital orifice of a female is closed by a plug, the so-called spermatocleuthrum. This structure can serve as an auxiliary criterion for sexual maturity (Vachon, Roy & Condamin, 1970: 427). In this way, adult females which did not yet mate will not be recognized as adults. Besides, the orifice is often polluted with sand, dust etc., so in some cases it can be difficult to decide whether a spermatocleuthrum is present or not. In case of uncertainty other characters (proportions) can facilitate a decision, but possible neotenic females can not be recognized in that way.

Table 5

Analysis of sample RMNH 87: sequences of specimens (nos.) according to the values of 9 age-dependent characters. Underlining indicates equality in size.

character nos.	specimen numbers arranged according to increase (character number 72 excepted) ♂♂								♀♀				
1	3	6	1	2	5	7	8	4	11	9	10	12	13
2	3	2	6	1	8	4	5	7	11	9	10	13	12
29	6	3	2	1	7	8	5	4	11	9	12	13	10
42	6	3	2	1	8	7	5	4	11	10	12	9	13
52	1	4	6	8	7	2	3	5	11	12	9	13	10
72	6	3	2	7	1	8	4	5	12	10	13	9	11
81	1	3	6	8	2	4	5	7	11	10	12	9	13
82	1	3	4	2	8	5	6	7	11	9	10	12	13
127	6	1	2	3	8	4	5	7	11	10	12	9	13

For a classification of the specimens according to age, the males and females of each population sample were arranged according to size. For each of a number of absolute measures (proportions of carapace, pedipalps, pectines, metasomatic segments 1-5 and telson, total trunk length) the animals were arranged in order of increasing values. Thereupon, the sequences for each character were compared, and the place in a general sequence was attributed to the specimens most frequently taking this place in the character-sequences. After such a classification the increase in size appeared to be discontinuous and the population sample could be divided in groups of animals called instars in this paper. As the number of instars preceding sexual maturity is unknown in the species studied here, the adult has served as a starting-point and the two preceding instars discriminated in these samples are called subadult and juvenile. This method is demonstrated here for the sample from Deli, Sumatra. The sequence of individuals according to the respective absolute measures is given in table 5; equality in size is indicated by underlining. Except for character number 72, the specimens are arranged according to increasing values. The frequencies, for each specimen, of taking a certain place in a sequence, are listed in table 6. The final sequence of specimens (numbers) is a follows:

♂: 6, 3, 2, 1, 8, 7, 5, 4;
♀: 11, 9, 10, 12, 13.

TABLE 6

Frequency of taking a certain position in the sequences of table 5 by each specimen of sample RMNH 87.

specimen nos.	ranks in sequences (ascending progression) 1	2	3	4	5	6	7	8
♂♂ 1	3	3	2	3	1	0	0	0
2	0	1	4	3	2	2	1	0
3	4	5	2	1	0	0	0	0
4	0	1	1	0	1	3	2	4
5	0	0	0	0	2	2	6	2
6	5	2	3	0	0	0	1	1
7	0	0	0	1	2	3	2	4
8	0	0	0	3	5	3	1	0
♀♀ 9	0	4	2	4	0			
10	0	4	5	2	1			
11	8	0	0	0	1			
12	1	3	5	2	1			
13	0	1	1	3	5			

When comparing the results of the measurements (in the final sequence) one can notice discontinuity by which specimen no. 11 can be discriminated by its small size (e.g., fig. 12). This specimen was called subadult and this was confirmed by the absence of a spermatocleuthrum. Specimen no. 6 also attracted attention by its small size (though less distinctly); because fully developed hemispermatophores were found in this male, it was classified with the adults as a neotenic male. The sexes and instars being discriminated, they were compared for each character. In this way the status of each character, indicated in table 1, was found. During further research some of the conclusions had to be adjusted to results of a similar comparison in several other samples. Neotenic males appeared to occur also in other samples used for the study of the whole genus, but they represent at most about 5% of the (mainly adult) males examined. As to the establishing of the age of the pre-adult instars, the subadults could be easily recognized, since a comparison with adults is possible in most samples. The identification of different levels of development in the younger instars, however, is hardly possible, because they merely differ in proportions and a complete series of instars is never present in the samples examined here; moreover, age-dependent trichobothriotactic characters, useful in other orders of Arachnidea, are lacking in Scorpionida.

Character-clustering. — The survey of the whole genus was executed in geographic order, from the Indonesian archipelago northward and westward. Of almost every specimen available, a selected set of biometric and descriptive characters regarded as probably useful were examined. Later on, some of these were rejected, because they appeared to be unpractical or to refer to differentially valueless characters; the definitive set is indicated in column E of table 2. In the case of paired organs, many measurements were taken at the left as well as at the right side of the specimens.

Agglomerative methods in taxonomy can be divided into monothetic and polythetic methods. One of the principles of monothetic clustering is constituted by the requisite that all representatives of a certain taxon share one (or a few) special character(s). The data of the specimens examined were subjected to polythetic clustering, which does not make this strict demand. A system built up on this basis will approximate more closely to the natural interrelations of specimens than a monothetic system, because sufficient space is left for the natural pluriformity in a gene pool. Moreover, in a study of biometric characters the meeting of fixed requirements by a specimen is often difficult to admit or deny when the characters have a rather wide range of variation. Decisions about presence or absence of certain descriptive characters can be rather doubtful too, if one wants to register that such a character is more or less pronounced in different specimens. The method used here also implies that those two specimens, which show the closest resemblance in a number of characters, are clustered. The third specimen (from the total group), which shows the closest resemblance to this pair, is then added to it to form a cluster of three, and so on. This clustering does not require a perfect resemblance in every character involved, though the majority of specimens will approximate this ideal situation. There would be little sense in using a computer program for the clustering in small and diverse samples of scattered origin. Computer treatment of such small samples will suffer from the conspicuous statistic errors in at least the same rate as any other method and one has to keep an eye on this work sharply enough. Thus a manual method was considered more satisfactory for the analysis of such data and only the really large and visually unsurveyable groups of specimens were handled by computer in order to discover any resemblance patterns.

Computerized elaboration. The use of this method was restricted to the specimens from Java and the Southeast Asiatic peninsula (Burma, Malacca, Cambodia, Thailand, Laos and Vietnam), including a few neighbouring islands. Several programs were tested, that form part of the program system for biological pattern analysis "Biopat" (cf. Hogeweg & Hesper, 1972). The clearest results were obtained by application of the principal components cluster analysis (in R-mode) to log-normalized data or log-standardized absolute measures. Also useful was the dendrogram resulting from Ward's averaging of correlation coefficients (in Q-mode) from log-normalized (standardized) data.

Manual elaboration. As the data were collected in a geographic order, a visual survey of such limited groups of data was mostly practicable. After extensive comparison, in some cases after repeated recombination of individual lists of biometric and descriptive characters, clusters could be formed between which more or less clear discrepancies were noticeable. For each cluster a list was composed of the characters and their variation. The biometric data were given as means, standard deviations, minimum and maximum values observed, whilst mention was made of the number of measurements involved. After elaboration of data from specimens of a different origin, close resemblance could often be noticed between some newly found clusters and previously discerned ones; these similar clusters could then be fused. At the end of the survey of the genus numerous definitive clusters were formed, which demonstrated various degrees of mutual resemblance (table 7: lists 1-43).

The interrelations of this multitude of clusters had to be assembled in a clear survey. For this purpose the exact data themselves could not be used because one would not see the wood for the trees. Biometric data of clusters must be simplified to short indications. Each character was studied for all clusters and the data were divided into a series of classes separated by more or less distinct discontinuities. For character number 83 (number of pectinal teeth) the original arrangement of cluster data and the classification deduced from it are illustrated in figs. 10a and b. The classes were numbered (figs. 11 a-f) and these numbers were indicated in a surveying table (table 8). This classification was carried out also with the descriptive characters, for which also a survey was made (table 9). Here almost none of the characters could be subdivided easily into a series of classes. In many cases presence or absence

TABLE 7

char.	1. H.s.spinifer					2. H.laoticus					3. H.p.petersii				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	99	14	58	128	119	65	9	52	102	48	62	9	44	87	115
34	2.5	.2	2.0	3.1	120	2.6	.1	2.1	3.2	24	2.3	.2	1.9	3.1	115
45	1.15					.97					.96				
51	1.5	.4	.8	2.6	119	1.3	.3	.8	2.1	49	1.2	.2	.8	1.7	115
57	1.0	.2	.6	1.8	117	1.2	.2	.8	1.9	49	1.0	.1	.7	1.5	116
63	4.2	.4	3.2	5.6	119	4.7	.4	3.8	5.8	50	4.4	.3	3.7	5.3	109
100	1.19	.05	1.04	1.31	60	1.19	.12	1.07	1.23	25	1.13	.05	1.04	1.26	59
108	1.9	.2	1.5	2.3	60	1.8	.2	1.6	2.2	24	1.9	.2	1.6	2.4	59
B 56	89	13	61	121	97	84	7	67	101	41	85	11	65	125	108
71	1.20	.06	.98	1.30	49	1.24	.05	1.16	1.37	21	1.27	.07	1.01	1.40	56
C 17	1.7	.3	1.2	2.6	67	1.9	.2	1.6	2.4	28	1.9	.3	1.5	2.4	49
21	10	11	1	35	34	11	7	1	25	16	8	5	2	20	25
31	121	28	68	188	69	164	34	92	234	30	161	29	103	222	48
44	1.3	.2	.9	1.6	35	1.0	.1	1.0	1.3	14	.9	.0	.8	1.0	25
70	1.8	.3	1.1	2.3	35	2.2	.1	2.0	2.4	15	2.3	.1	2.1	2.5	25
74	3.5	.3	3.3	4.0	35	3.1	.2	2.7	3.5	15	2.9	.2	2.7	3.3	25
83	16.71	.89	15	19	63	16.67	.99	14	18	30	16.35	.93	13	18	48
102	3.3	.1	3.2	3.5	35	3.4	.1	3.3	3.5	14	3.3	.1	3.2	3.5	25
D 29	103	19	70	130	30	80	9	60	99	13	63	5	53	72	24
42	159	20	130	200	30	146	14	110	161	13	114	10	90	142	24
43	127	19	95	170	30	144	17	108	168	13	126	11	97	161	24
52	3.3	.6	2.1	5.2	60	3.8	.8	2.7	5.1	25	4.0	.4	3.3	4.9	47
82	90	10	75	110	30	90	9	70	100	24	75	6	63	91	24
98	476	50	379	589	30	479	44	376	532	12	392	28	321	477	24
99	3.1	.1	2.7	3.4	30	3.0	.1	2.9	3.1	12	3.0	.1	2.8	3.1	24
105	2.6	.1	2.3	2.7	30	2.5	.1	2.2	2.7	12	2.4	.1	2.3	2.6	24
E 17	1.6	.3	1.2	2.5	50	2.0	.5	1.7	2.6	20	2.0	.4	1.5	3.5	67
21	30	30	2	95	26	27	15	3	55	11	12	16	2	55	35
31	124	29	80	185	49	155	32	73	198	18	166	26	100	218	66
44	1.1	.1	.9	1.6	19	1.1	.1	1.0	1.2	10	1.0	.1	.8	1.0	35
70	2.2	.1	1.9	2.4	25	2.3	.2	2.1	2.6	10	2.3	.1	1.8	2.5	34
74	3.3	.2	3.0	3.6	25	3.0	.2	2.9	3.3	10	2.9	.1	2.5	3.2	34
83	15.36	1.69	13	18	50	15.30	.80	12	16	20	15.24	1.07	12	17	67
102	3.3	.1	3.0	3.5	25	3.3	.1	3.2	3.4	10	3.3	.1	3.2	3.5	34
F 29	82	9	71	101	19	76	7	63	87	8	68	6	51	79	31
42	143	15	127	175	19	142	14	117	160	8	122	10	94	137	32
43	129	15	104	162	19	134	14	111	153	8	130	12	98	151	32
52	3.5	.5	2.7	5.2	42	3.9	.8	2.4	5.1	15	3.9	.4	3.2	5.1	62
82	77	7	70	91	19	80	6	69	91	8	73	7	60	85	31
98	464	47	408	571	19	470	46	385	527	8	423	37	339	484	31
99	3.0	.1	2.8	3.2	19	2.9	.1	2.8	3.1	8	2.9	.1	2.7	3.1	31
105	2.6	.1	2.4	2.8	19	2.6	.1	2.4	2.7	8	2.5	.1	2.3	2.6	30

Lists of biometric data for the 43 taxa discriminated in the genus *Heterometrus*: mean values, standard deviations (s), minimum and maximum values, number of measurements (n). The characters are numbered according to table 2 and classified (A-F) according to table 1: A, category 1; B, category 3, data stated for adults; C, category 2, data stated for ♂♂; D, category 4, data stated for adult ♂♂; E, category 2, data stated for ♀♀; F, category 4, data stated for adult ♀♀.

TABLE 7 (continued)

char.	4. H.p.mindanaensis					5. H.p.luzonensis					6. H.s.solitarius				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	38				1	59	14	46	75	4	90				1
34	2.1				1	2.2	.4	1.9	2.8	4	2.4				1
45															
51	1.1				1	1.2	.1	1.1	1.3	4	.7				1
57	1.0				1	1.0	.1	.9	1.1	3	.9				1
63	4.4				1	3.9	.2	3.7	4.1	4	4.3				1
100	1.13				1	1.17	.01	1.16	1.18	2	1.44				1
108	1.8				1	1.8	.1	1.7	1.9	2	1.9				1
B 56	88				1	66	5	61	70	3	75				1
71	1.28				1	1.33	.04	1.30	1.35	2	1.26				1
C 17	1.5				1										
21	5				1										
31	156				1										
44	.9				1										
70	2.3				1										
74	3.0				1										
83	16.00	0			2										
102	3.2				1										
D 29	66				1										
42	118				1										
43	136				1										
52	3.9				1										
82	73				1										
98	402				1										
99	2.9				1										
105	2.4				1										
E 17						3.1	.1	3.0	3.3	4	1.7				1
21						60	28	40	80	2	0				1
31						114	12	102	130	4	146				1
44						.9	.1	.8	1.0	2	1.1				1
70						2.3	.0	2.3	2.4	2	2.3				1
74						3.1	.0	3.1	3.2	2	3.1				1
83						12.25	.96	11	13	4	15.50	.71	15	16	2
102						3.4	.0	3.4	3.5	2	3.3				1
F 29						64	3	62	66	2	80				1
42						113	4	110	115	2	148				1
43						129	23	113	145	2	131				1
52						3.6	.7	3.1	4.6	4	5.3				1
82						66	6	61	70	2	80				1
98						399	22	383	414	2	492				1
99						3.0	.0	3.0	3.1	2	3.3				1
105						2.4	.2	2.2	2.5	2	2.8				1

TABLE 7 (continued)

char.		7. H.l.angustimanus					8. H.l.longimanus					9. H.l.borneensis				
no.		mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A	30	87	10	74	111	10	84	11	61	107	119	83	12	57	105	73
	34	2.5	.1	2.2	2.7	10	2.5	.3	2.1	2.9	118	2.4	.2	2.1	3.1	74
	45	1.33					1.36					1.28				
	51	1.5	.4	1.0	2.1	10	1.6	.4	.8	3.3	106	1.5	.3	1.0	2.5	73
	57	1.2	.2	.7	1.6	10	1.2	.2	.8	1.9	105	1.2	.2	.7	1.6	74
	63	4.1	.3	3.7	4.7	10	4.4	.4	3.3	5.9	118	4.4	.4	3.3	5.1	70
	100	1.17	.07	1.12	1.26	10	1.20	.09	1.07	1.26	53	1.20	.05	1.09	1.32	35
	108	1.9	.1	1.7	2.1	10	1.9	.1	1.6	2.3	66	1.9	.1	1.8	2.2	34
B	56	101	8	88	109	7	95	11	65	120	94	88	11	67	112	58
	71	1.15	.06	1.00	1.22	7	1.11	.07	.96	1.24	59	1.15	.05	1.07	1.25	27
C	17	1.7	.3	1.4	1.9	3	1.5	.2	1.1	2.0	64	1.5	.3	1.2	1.7	36
	21	2	3	5	20	3	6	8	0	15	41	9	7	2	70	19
	31	113	35	80	150	3	118	38	55	183	59	146	24	86	212	48
	44	1.8	.2	1.5	2.0	3	1.8	.2	1.3	2.0	37	1.6	.1	1.4	1.8	24
	70	1.7	.3	1.3	1.9	3	1.5	.2	1.3	1.9	37	1.6	.2	1.4	2.0	23
	74	3.9	.4	3.9	4.1	3	3.8	.2	3.5	4.2	36	3.8	.2	3.5	4.2	23
	83	16.80	.45	15	17	5	16.38	.87	15	18	71	16.18	.89	15	18	45
	102	3.0	.1	2.8	3.1	3	3.3	.1	3.0	3.5	37	3.3	.1	3.2	3.4	22
D	29	158				1	124	17	90	160	33	135	16	110	160	18
	42	200				1	169	20	136	215	33	183	19	152	210	18
	43	100				1	98	19	88	151	33	111	13	90	130	18
	52	4.1				1	3.9	.6	2.2	5.3	50	3.6	.7	2.8	4.2	37
	82	96				1	84	7	70	103	33	95	11	75	116	18
	98	500				1	445	37	386	517	25	496	44	423	566	16
	99	3.3				1	3.2	.1	2.9	3.4	33	3.2	.1	2.9	3.3	16
	105	2.9				1	2.6	.1	2.4	2.8	25	2.6	.2	2.5	2.8	16
E	17	1.4	.2	1.3	1.7	7	1.4	.1	1.1	1.7	53	1.5	.2	1.2	1.9	26
	21	31	26	5	105	7	47	29	15	145	30	52	23	30	65	15
	31	118	21	98	164	7	126	32	55	183	53	152	28	99	198	26
	44	1.3	.1	1.1	1.5	7	1.3	.1	1.1	1.4	29	1.3	.1	1.2	1.4	13
	70	1.9	.1	1.8	2.1	7	2.0	.1	1.8	2.6	28	2.0	.1	1.8	2.2	12
	74	3.5	.2	3.2	3.8	7	3.3	.2	3.0	3.5	29	3.4	.2	3.2	3.8	12
	83	15.07	.47	14	16	14	14.97	.65	14	17	58	14.52	.59	14	15	25
	102	3.1	.1	3.0	3.4	7	3.3	.1	2.9	3.5	29	3.3	.1	3.2	3.4	12
F	29	87	13	62	100	6	88	7	75	119	26	89	8	70	100	11
	42	141	19	102	152	6	149	14	122	175	26	147	12	123	165	11
	43	110	20	70	128	6	118	17	88	151	26	119	12	100	137	11
	52	3.4	.5	2.6	3.9	6	3.8	.6	2.9	5.1	48	3.2	.7	2.9	3.8	22
	82	70	10	51	80	6	78	9	62	98	26	77	8	60	88	11
	98	444	52	340	482	6	457	44	382	531	22	469	38	383	518	10
	99	3.1	.1	3.0	3.2	6	3.0	.1	2.7	3.3	26	3.1	.1	3.0	3.2	10
	105	2.6	.2	2.4	2.9	6	2.6	.1	2.4	2.9	22	2.6	.1	2.4	2.7	10

TABLE 7 (continued)

char.		10. H.l.belitungensis					11. H.l.paris					12. H.l.bengkalitensis				
no.		mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A	30	86	10	58	105	34	81	17	64	115	12	87	13	62	111	13
	34	2.4	.2	2.1	2.4	34	2.4	.1	2.1	2.6	11	2.3	.2	2.1	2.6	13
	45	1.39					1.22					1.30				
	51	1.3	.4	.4	2.3	37	1.9	.5	1.0	2.6	12	1.7	.4	.9	2.6	13
	57	1.4	.2	1.3	1.6	36	1.4	.2	1.0	1.7	12	1.2	.2	.9	1.5	13
	63	4.0	.4	3.4	4.8	31	4.3	.5	3.7	5.1	12	4.2	.3	3.7	4.7	13
	100	1.24	.05	1.09	1.34	25	1.16	.08	1.04	1.25	6	1.20	.03	1.14	1.25	13
	108	1.8	.1	1.7	2.0	25	1.9	.1	1.9	2.0	6	1.9	.1	1.8	2.1	13
B	56	93	12	71	**133**	34	94	7	80	102	8	94	12	73	114	11
	71	1.13	.07	1.00	1.25	25	1.13	.06	1.06	1.20	4	1.14	.06	1.05	1.22	11
C	17	1.5	.1	1.4	1.8	12	1.4	.1	1.3	1.6	6	1.5	.2	1.3	1.7	6
	21	3	3	0	5	12	3	3	0	5	3	16	30	0	75	6
	31	135	25	81	169	16	160	14	132	180	6	140	24	99	170	6
	44	1.7	.1	1.6	1.9	11	1.6	.0	1.6	1.6	4	1.6	.1	1.6	1.8	6
	70	1.5	.1	1.4	1.6	11	1.5	.1	1.4	1.6	3	1.6	.2	1.4	1.5	6
	74	3.8	.2	3.3	4.0	11	3.8	.0	3.7	3.8	3	3.8	.3	3.5	4.3	6
	83	15.86	.71	14	17	22	15.50	.84	15	17	6	15.83	.58	15	17	12
	102	3.3	.0	3.2	3.4	11	3.3	.0	3.3	3.4	3	3.3	.2	3.2	3.3	6
D	29	126	9	107	141	11	130	11	118	138	3	113	13	94	121	4
	42	170	15	139	189	11	174	10	162	180	3	150	13	130	160	4
	43	99	9	79	111	11	108	8	100	115	3	90	8	78	97	4
	52	4.0	.5	3.2	4.7	14	3.8	.2	3.7	4.1	6	3.4	.3	3.0	3.8	4
	82	90	7	75	99	11	89	4	85	92	3	75	7	65	81	4
	98	440	34	377	488	11	470	14	456	484	3	396	30	352	418	4
	99	3.3	.1	3.1	3.4	11	3.2	.1	3.1	3.2	3	3.2	.1	3.1	3.3	4
	105	2.8	.2	2.3	3.0	11	2.6	.2	2.5	2.8	3	2.9	.3	2.5	2.7	4
E	17	1.5	.2	1.2	1.8	16	1.8	.2	1.6	2.0	3	1.5	.1	1.4	1.6	7
	21	72	39	30	185	14	65				1	64	9	50	70	7
	31	170	17	136	201	20	167	37	125	180	3	138	41	74	186	7
	44	1.2	.1	1.2	1.4	14	1.3	.1	1.2	1.4	2	1.2	.1	1.1	1.3	7
	70	2.0	.2	1.5	2.4	14	2.0	.2	1.8	2.1	2	2.0	.1	1.9	2.1	7
	74	3.3	.2	2.7	3.5	14	3.4	.3	3.2	3.6	2	3.4	.2	3.3	3.6	7
	83	14.26	.86	12	16	27	14.75	.96	14	16	4	14.64	.63	14	16	14
	102	3.3	.1	3.2	3.4	14	3.4	.2	3.2	3.5	2	3.2	.1	3.1	3.4	7
F	29	84	4	81	90	14	72				1	74	7	64	84	7
	42	140	9	120	155	14	128				1	124	9	108	133	7
	43	114	10	98	131	14	103				1	101	11	81	117	7
	52	4.5	.7	3.5	6.8	17	4.2	.3	4.0	4.4	2	3.3	.3	2.8	3.7	7
	82	75	5	63	83	14	66				1	64	4	56	70	7
	98	442	29	394	498	14	391				1	400	28	357	431	7
	99	3.1	.1	2.9	3.2	14	3.0				1	3.1	.1	3.1	3.2	7
	105	2.6	.1	2.4	2.9	14	2.6				1	2.5	.2	2.3	2.7	7

TABLE 7 (continued)

char.	13. H.l.tarawakanensis					14. H.l.marmoratus					15. H.l.humilis				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	82	12	70	105	6	80	11	71	81	10	96	15	82	126	7
34	2.4	.1	2.3	2.5	5	2.4	.1	2.2	2.6	10	2.3	.2	1.8	2.5	7
45	1.10					1.32					1.01				
51	1.6	.3	1.3	2.1	6	1.4	.2	.9	1.7	10	1.6	.4	.9	2.2	7
57	1.0	.1	.9	1.1	6	1.2	.2	.9	1.5	10	1.0	.1	.8	1.2	7
63	4.6	.4	4.0	5.1	6	3.9	.3	3.4	4.1	9	3.9	.5	2.9	4.3	7
100	1.10	.02	1.08	1.11	3	1.17	.05	1.09	1.20	5	1.16	.02	1.12	1.18	7
108	1.8	.1	1.7	1.9	3	1.9	.1	1.9	2.0	5	2.0	.1	1.9	2.2	7
B 56	90	1	89	90	2	101	8	90	107	8	112	15	101	129	3
71	1.30				1	1.16	.07	1.14	1.22	4	1.28	.07	1.22	1.36	3
C 17	1.6	.0	1.6	1.6	2	1.5	.0	1.5	1.6	2	1.5				1
21	50				1	5				1	0				1
31	129	18	116	141	2	115	21	100	129	2	80				1
44	1.4				1	1.7				1	1.2				1
70	2.1				1	1.5				1	1.9				1
74	3.8				1	3.9				1	3.3				1
83	15.50	.71	15	16	2	16.00	.00	16	16	2	17.00	.00	17	17	2
102	3.3				1	3.3				1	3.3				1
D 29						109				1	87				1
42						149				1	129				1
43						90				1	112				1
52						3.0	.1	2.9	3.0	2	3.5				1
82						80				1	83				1
98						395				1	427				1
99						3.0				1	3.1				1
105						2.6				1	2.6				1
E 17	1.5	.0	1.5	1.5	4	1.4	.2	1.2	1.5	7	1.4	.2	1.2	1.8	6
21	∞		100	∞	2	30*	14	20	50*	4	7	3	5	10	6
31	131	41	70	155	4	156	21	141	180	8	137	26	100	174	6
44	1.3	.1	1.2	1.4	2	1.3	.0	1.2	1.3	3	1.1	.1	1.1	1.2	2
70	2.1	.0	2.1	2.1	2	2.1	.1	2.0	2.2	4	2.0	.2	1.8	2.4	6
74	3.7	.4	3.4	4.0	2	3.3	.1	3.2	3.6	3	3.5	.1	3.3	3.6	6
83	14.50	.58	14	15	4	15.00	.76	14	16	8	14.42	.67	13	15	12
102	3.3	.1	3.2	3.3	2	3.3	.1	3.3	3.4	4	3.4	.1	3.2	3.5	6
F 29	80				1	83	4	79	87	3	81	13	72	90	2
42	130				1	146	14	130	158	3	138	18	125	150	2
43	111				1	116	15	100	129	3	121	6	116	125	2
52	3.6				1	3.2	.2	2.9	3.4	6	3.3	.3	3.0	3.5	2
82	68				1	78	8	69	85	3	75	0	75	75	2
98	403				1	450	39	409	486	3	448	16	436	459	2
99	2.9				1	3.1	.0	3.0	3.1	3	3.0	.0	3.0	3.0	2
105	2.5				1	2.6	.1	2.5	2.8	3	2.7	.2	2.5	2.8	2

*in some specimens
+ ∞ very fine granules

TABLE 7 (continued)

char.	16. H.l.liophysa					17. H.l.laevifrons					18. H.l.spartanicus				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	114	13	89	135	18	101	14	81	135	29	93				1
34	2.5	.2	2.0	2.8	18	2.5	.2	2.1	3.0	29	2.0				1
45	1.19					1.29									
51	1.5	.4	1.0	2.4	18	1.3	.3	.7	2.1	29	1.3				1
57	1.1	.1	.9	1.2	18	1.1	.1	.9	1.4	29	1.2				1
63	5.0	.4	4.3	5.8	18	4.6	.6	3.1	5.4	29	3.3				1
100	1.18	.06	1.08	1.26	9	1.15	.05	1.07	1.24	16	1.05				1
108	2.2	.3	1.6	2.6	9	1.9	.3	1.6	2.4	16	2.5				1
B 56	68	7	56	79	12	72	8	58	86	25	77				1
71	1.27	.04	1.20	1.31	6	1.27	.07	1.16	1.40	14	1.34				1
C 17	1.6	.1	1.4	1.7	14	1.6	.2	1.4	2.1	13	1.6				1
21	16	12	5	35	7	9	8	5	25	7	15				1
31	112	16	100	142	13	91	26	50	134	13	123				1
44	1.5	.1	1.4	1.6	7	1.5	.1	1.3	1.6	7	1.4				1
70	1.7	.2	1.5	2.0	7	1.6	.2	1.4	2.0	7	1.9				1
74	4.2	.2	4.0	4.5	7	4.3	.2	3.9	4.6	7	4.1				1
83	14.38	.87	13	16	13	13.86	.53	13	15	14	14.00	.00	14	14	2
102	3.3	.1	3.2	3.4	7	3.3	.1	3.1	3.5	7	3.2				1
D 29	128	18	111	154	5	129	16	111	148	6	88				1
42	168	9	161	182	5	159	18	138	180	6	125				1
43	108	7	101	119	5	103	12	88	119	6	87				1
52	3.8	.3	3.4	4.3	10	4.0	.4	3.5	4.6	11	3.5				1
82	92	2	91	95	5	88	10	76	100	6	79				1
98	483	24	464	524	5	446	30	412	488	6	388				1
99	3.2	.1	3.1	3.3	5	3.2	.1	3.1	3.3	6	2.8				1
105	2.9	.1	2.8	3.1	5	3.1	.2	2.8	3.4	6	2.9				1
E 17	1.6	.0	1.5	1.6	4	1.6	.2	1.3	1.8	13					
21	100	113	20	180	2	115	54	45	250	9					
31	121	48	85	192	4	117	17	85	143	16					
44	1.3	.1	1.2	1.4	2	1.2	.1	1.1	1.3	9					
70	2.1	.0	2.1	2.1	2	2.0	.1	1.9	2.2	9					
74	3.8	.3	3.6	4.0	2	3.5	.2	3.3	3.9	9					
83	12.75	.50	12	13	4	12.56	.86	11	14	18					
102	3.3	.1	3.3	3.4	2	3.2	.1	3.1	3.3	9					
F 29	99				1	88	7	78	95	8					
42	159				1	139	12	122	154	8					
43	130				1	121	12	102	138	8					
52	3.2	.1	3.1	3.3	2	3.9	.4	3.4	4.5	14					
82	82				1	71	8	59	80	8					
98	487				1	437	37	372	483	8					
99	3.0				1	2.9	.1	2.8	3.1	8					
105	2.7				1	2.8	.3	2.7	3.4	7					

TABLE 7 (continued)

char.	19. H.l.separatus					20. H.madocrensis					21. H.bengalensis				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	90	31	61	139	5	102				1	70	12	50	98	26
34	2.5	.1	2.5	2.6	5	2.7				1	2.7	.2	2.3	3.0	26
45	1.49										1.47				
51	1.2	.1	1.1	1.2	5	1.6				1	1.5	.3	1.1	2.4	26
57	1.2	.1	1.1	1.3	5	1.3				1	1.3	.2	1.0	1.7	25
63	5.3	.5	4.8	6.1	5	4.8				1	4.6	.5	3.2	5.2	24
100	1.12	.07	1.04	1.20	5	1.04				1	1.10	.03	1.04	1.14	13
108	2.1	.2	1.9	2.3	5	3.6*				1	1.9	.2	1.7	2.3	13
B 56	71	8	60	80	5						62	9	42	78	25
71	1.17	.11	1.04	1.29	5						1.15	.08	1.03	1.26	13
C 17	1.8	.1	1.7	2.0	3						1.9	.2	1.6	2.1	16
21	7	3	5	10	3						31	9	15	45	10
31	117	59	65	181	3						116	29	75	180	16
44	1.9	.1	1.8	1.9	3						1.7	.1	1.6	1.7	8
70	1.4	.0	1.4	1.5	3						1.6	.1	1.5	1.7	8
74	4.5	.0	4.5	4.6	3						3.8	.1	3.6	3.9	8
83	14.50	.55	14	15	6						16.20	.56	15	17	15
102	3.2	.0	3.2	3.3	3						3.3	.1	3.3	3.4	8
D 29	134	16	122	152	3						99	8	89	109	8
42	173	19	152	190	3						144	11	129	155	8
43	94	7	87	100	3						87	4	80	91	8
52	5.2	.8	4.4	6.0	3						4.3	.5	3.5	5.2	16
82	75	5	70	80	3						74	5	67	80	8
98	427	43	380	464	3						388	20	354	409	8
99	3.0	.1	3.0	3.1	3						2.9	.1	2.7	2.9	8
105	2.9	.2	2.7	3.0	3						2.6	.1	2.5	2.8	8
E 17	1.8	.0	1.8	1.8	2	1.4				1	1.9	.2	1.5	2.2	10
21	70	14	60	80	2	15				1	59	19	35	90	6
31	122	7	117	127	2	171				1	143	13	121	159	10
44	1.2	.0	1.2	1.2	2	1.3				1	1.1	.0	1.1	1.2	5
70	2.1	.1	2.0	2.1	2	2.0				1	2.1	.1	2.0	2.1	5
74	3.8	.0	3.8	3.8	2	3.8				1	3.1	.2	2.9	3.4	5
83	14.25	.96	13	15	4	14.50	.71	14	15	2	14.78	.44	14	15	9
102	3.2	.0	3.2	3.2	2	3.2				1	3.4	.1	3.3	3.4	5
F 29	94	2	92	95	2						70	4	64	76	5
42	150	2	148	151	2						119	6	109	123	5
43	121	3	119	123	2						105	8	91	111	5
52	5.2	.3	4.9	5.4	2						3.9	.3	3.5	4.4	10
82	78	1	77	78	2						63	3	59	65	5
98	437	6	432	441	2						373	15	347	387	5
99	2.8	.0	2.7	2.8	2						2.8	.1	2.7	2.9	5
105	3.1	.1	3.1	3.2	2						2.5	.1	2.3	2.6	5

* keel hardly present

TABLE 7 (continued)

char.	22. H.i.indus					23. H.i.laevitensus					24. H.s.scaber				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	44	9	29	64	20	45	6	40	53	4	59	8	44	72	16
34	2.3	.2	2.0	2.7	19	2.3	.2	2.2	2.6	4	2.1	.1	1.9	2.4	16
45	.93										1.02				
51	1.1	.2	.8	1.5	19	1.2	.1	1.0	1.3	4	1.3	.1	1.1	1.6	16
57	1.3	.3	.9	1.8	19	1.2	.1	1.1	1.4	4	1.0	.2	.6	1.4	16
63	3.7	.4	3.4	4.7	19	4.0	.4	3.5	4.4	4	4.3	.2	4.0	4.7	14
100	1.39	.23	1.19	1.58	16	1.11	.04	1.08	1.14	2	1.42	.21	1.21	1.92	8
108	2.0	.3	1.7	2.8	15	2.2	.1	2.1	2.3	2	1.6	.2	1.4	1.9	8
B 56	90	10	70	108	11	83	3	80	87	4	93	20	57	133	16
71	1.25	.12	1.01	1.36	9	1.31	.04	1.28	1.34	2	1.49	.06	1.42	1.56	8
C 17	3.7	.9	2.5	5.0	10	3.7	.4	3.2	4.1	4	2.7	.5	2.2	3.6	12
21	18	9	5	30	8	18	11	10	25	2	31	5	25	35	7
31	123	34	70	163	11	103	17	78	113	4	128	18	99	155	11
44	.9	.1	.8	.9	8	.9	.0	.9	.9	2	.9	.0	.9	.9	6
70	2.2	.3	1.8	2.7	8	2.3	.0	2.3	2.3	2	2.1	.1	2.0	2.2	6
74	3.0	.3	2.4	3.3	8	3.1	.0	3.0	3.1	2	3.4	.1	3.3	3.5	6
83	12.93	1.39	10	15	15						11.83	.72	11	13	12
102	3.3	.1	3.2	3.4	8	3.3	.0	3.3	3.4	2	3.5	.1	3.4	3.6	6
D 29	73	8	66	89	7	75	7	70	80	2	80	5	73	87	6
42	126	7	117	137	7	130	17	118	142	2	111	8	102	125	6
43	148	15	136	180	7	147	21	132	161	2	124	9	111	137	6
52	2.4	.6	1.6	3.3	7	2.6	.1	2.4	2.7	4	3.1	.2	2.8	3.4	12
82	87	9	78	106	7						59	7	49	70	6
98	427	30	391	485	7	428	51	392	464	2	512	31	475	554	6
99	2.9	.1	2.8	3.0	7	2.9	.1	2.8	2.9	2	3.5	.1	3.4	3.6	6
105	2.6	.1	2.4	2.8	7	2.7	.3	2.5	2.8	2	2.5	.2	2.3	2.7	6
E 17	3.2	.4	2.2	3.4	9						3.7	.1	3.6	3.9	4
21	18	18	0	40	4						30	7	25	35	2
31	121	19	115	156	9						140	13	125	153	4
44	.9	.2	.8	1.1	3						.9	.0	.9	.9	2
70	2.8	.6	2.0	3.9	8						2.3	.0	2.3	2.3	2
74	3.0	.2	2.8	3.3	8						3.2	.0	3.2	3.2	2
83	11.81	1.56	10	13	16						11.75	.96	11	13	4
102	3.3	.1	3.1	3.3	8						3.5	.0	3.5	3.5	2
F 29	71	1	70	72	2						65	6	60	69	2
42	139	1	138	140	2						104	8	98	110	2
43	177	1	176	178	2						120	15	109	130	2
52	2.2	.8	1.7	2.8	2						3.3	.4	2.9	3.7	2
82	84	5	80	87	2						55	7	50	60	2
98	461	4	458	463	2						457	50	422	492	2
99	2.7	.0	2.7	2.7	2						3.2	.1	3.1	3.3	2
105	2.6	.2	2.5	3.1	2						2.6	.1	2.5	2.7	2

TABLE 7 (continued)

char.	25. H.s.rugosus					26. H.s.obscurus					27. H.fulvipes				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	59	5	55	62	2	54	7	49	59	2	57	12	35	86	50
34	2.0	.0	2.0	2.0	2	2.0	.0	2.0	2.0	2	2.1	.2	1.9	2.7	48
45											1.18				
51	1.4	.3	1.2	1.5	2	1.0	.2	.9	1.1	2	.8	.2	.5	1.3	47
57	1.0	.1	.9	1.0	2	1.2	.1	1.1	1.2	2	1.2	.2	.7	1.5	49
63	4.0	.1	4.0	4.1	2	4.3				1	3.5	.4	2.6	4.3	50
100	1.13				1	1.11				1	1.21	.08	1.08	1.36	25
108	2.5				1	1.7				1	1.7	.1	1.4	2.0	25
B 56	86	4	83	89	2	63	4	60	66	2	69	8	56	92	45
71	1.24				1	1.18				1	1.29	.07	1.13	1.42	23
C 17											3.1	.4	2.3	3.9	19
21											29	10	15	45	10
31											122	28	68	171	19
44											.9	.1	.8	1.0	10
70											1.8	.1	1.7	2.0	9
74											3.1	.1	2.8	3.3	9
83											15.95	.97	14	17	19
102											3.5	.1	3.4	3.7	10
D 29											83	5	77	89	9
42											112	6	101	120	9
43											123	11	105	140	9
52											3.1	.5	2.4	4.0	18
82											84	6	72	91	9
98											430	21	392	463	9
99											3.3	.1	3.1	3.4	9
105											2.4	.2	2.1	2.7	9
E 17	2.3	.1	2.2	2.4	2	2.8	.1	2.8	2.9	2	3.2	.7	1.6	4.5	30
21	80				1	60				1	38	14	20	75	15
31	165	22	149	180	2	125	11	117	133	2	147	28	101	202	30
44	1.1				1	.9				1	.8	.1	.8	.9	14
70	2.1				1	2.1				1	2.3	.2	2.1	2.8	15
74	3.5				1	2.7				1	2.7	.2	2.4	3.2	14
83	10.50	.71	10	11	2	12.00	.00	12	12	2	14.10	.82	12	15	29
102	3.5				1	3.3				1	3.6	.1	3.0	3.8	15
F 29	90				1	78				1	51	5	41	61	14
42	150				1	137				1	94	7	82	108	14
43	132				1	150				1	123	11	111	149	14
52	3.6	.2	3.5	3.8	2	3.2	.1	3.1	3.3	2	2.9	.4	2.2	3.7	27
82	70				1	77				1	65	5	60	78	14
98	450				1	423				1	364	20	325	401	14
99	2.9				1	2.7				1	3.0	.1	2.8	3.3	14
105	2.3				1	2.3				1	2.3	.1	2.2	2.6	14

TABLE 7 (continued)

char.	28. H.xanthopus					29. H.pelekomanus					30. H.fastigiosus				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	55	15	33	75	6	58	16	40	88	14	64	16	43	86	12
34	2.7	.8	2.0	4.4	6	2.1	.3	1.9	2.9	14	2.1	.1	1.9	2.2	12
45	1.15					1.13					1.26				
51	.8	.1	.7	.9	6	.9	.1	.7	1.1	14	1.1	.2	.9	1.5	12
57	1.2	.2	1.0	1.4	6	1.1	.1	.9	1.3	14	1.1	.1	.9	1.3	12
63	2.7	.2	2.4	2.9	6	3.5	.3	3.1	4.0	13	3.7	.2	3.4	4.2	10
100	1.04	.04	1.01	1.06	2	1.15	.11	1.00	1.29	7	1.14	.06	1.04	1.23	6
108	1.5	.1	1.5	1.6	2	1.4	.2	1.3	1.7	7	1.6	.1	1.5	1.7	6
B 56	70	10	62	83	4	73	5	65	77	8	69	14	48	95	10
71	1.21	.06	1.17	1.25	2	1.13	.04	1.09	1.18	4	1.35	.06	1.32	1.40	5
C 17	5.2	1.1	4.2	7.0	6	2.6	.7	1.8	3.6	6	3.1	.2	2.9	3.3	3
21	62	8	55	70	3	52	29	30	85	3	48	32	25	70	2
31	120	7	111	126	4	123	24	92	153	6	114	18	100	140	4
44	.9	.1	.9	1.0	3	.9	.0	.9	.9	2	1.2	.0	1.1	1.2	2
70	2.2	.4	1.8	2.5	3	1.7	.1	1.7	1.8	3	1.6	.0	1.6	1.6	2
74	2.9	.1	2.8	3.0	3	3.1	.0	3.1	3.2	3	3.1	.3	2.9	3.3	2
83	16.00	1.90	13	18	6	18.67	.52	18	19	6	15.25	.96	14	16	4
102	3.5				1	3.5	.1	3.4	3.5	3	3.5	.1	3.5	3.6	2
D 29	57				1	106	8	100	112	2	80				1
42	87				1	169	9	162	175	2	103				1
43	87				1	179	10	172	186	2	90				1
52	3.0	.1	3.0	3.1	2	2.8	.1	2.8	3.0	4	3.2	.0	3.2	3.2	2
82	72				1	106	8	100	112	2	63				1
98						539	26	520	557	2	373				1
99						3.3	.0	3.3	3.3	2	3.1				1
105						2.6	.2	2.4	2.7	2	2.4				1
E 17	6.2	1.5	5.0	8.4	4	2.0	.2	1.7	2.2	8	3.4	.7	2.5	4.6	8
21	35	7	30	40	2	96	53	65	175	4	89	22	60	110	4
31	109	48	75	143	2	123	20	90	152	8	133	22	103	166	8
44	.8	.0	.8	.8	2	.9	.0	.8	.9	2	.9	.0	.9	.9	4
70	2.4	.0	2.4	2.4	2	2.1	.1	1.9	2.2	4	2.3	.1	2.2	2.3	4
74	2.6	.1	2.6	2.7	2	2.8	.0	2.8	2.9	2	3.2	.2	3.1	3.4	4
83	14.50	.71	14	15	2	15.75	1.16	14	17	8	13.25	.46	13	14	8
102	3.6				1	3.5	.1	3.4	3.6	4	3.5	.1	3.5	3.6	4
F 29	38				1	78	8	72	83	2	59	5	53	64	4
42	72				1	143	11	135	150	2	98	5	90	101	4
43	91				1	167	16	155	178	2	107	3	103	109	4
52	2.6	.2	2.5	2.8	2	3.1	.1	3.0	3.1	4	2.9	.3	2.6	3.3	8
82	50				1	89	5	85	92	2	62	4	58	67	4
98	267				1	483	17	471	495	2	375	23	346	396	4
99	2.7				1	3.0	.1	2.9	3.0	2	2.9	.1	2.7	3.0	4
105	2.3				1	2.4	.0	2.4	2.4	2	2.3	.1	2.2	2.4	4

TABLE 7 (continued)

char.	31. H.liurus					32. H.collinus					33. H.tristis				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	47	8	38	60	12	40	16	28	66	8	49	23	30	80	4
34	2.3	.2	2.1	2.8	10	2.2	.1	2.0	2.5	8	2.1	.1	2.0	2.3	4
45	1.12					1.21					1.36				
51	1.0	.1	.7	1.1	12	1.1	.2	.9	1.3	8	1.1	.1	1.0	1.2	4
57	1.0	.3	.7	1.5	12	1.1	.1	.9	1.3	8	1.3	.3	.9	1.6	4
63	3.4	.3	3.0	3.9	12	3.6	.3	3.3	4.2	7	3.7	.2	3.4	4.0	4
100	.98	.05	.93	1.05	6	.95	.04	.90	1.00	4	1.12	.02	1.10	1.13	2
108						1.9	.2	1.6	2.1	4	1.5	.1	1.4	1.6	2
B 56	69	5	61	72	4	81	11	66	98	6	68	25	45	99	4
71	1.3	.2	1.2	1.4	2	1.1	.0	1.1	1.2	3	1.0	.0	1.0	1.0	2
C 17	3.2	.4	2.7	3.6	4	2.6	.2	2.3	3.0	6	1.9	.0	1.9	2.0	4
21	58	25	40	75	2	45	17	35	65	3	80	21	65	95	2
31	124	10	110	132	4	112	34	78	172	6	124	28	100	153	4
44	1.1	.1	1.0	1.1	2	1.2	.1	1.2	1.3	3	1.5	.0	1.5	1.5	2
70	1.8	.2	1.6	1.9	2	1.6	.0	1.6	1.6	2	1.5	.0	1.4	1.5	2
74	3.2	.2	3.1	3.3	2	3.3	.2	3.1	3.5	3	3.5	.1	3.4	3.5	2
83	14.50	.58	14	15	4	12.67	.52	12	13	6	17.67	.58	17	18	3
102	3.5	.1	3.4	3.5	2	3.5	.0	3.5	3.5	3	3.4	.0	3.4	3.4	2
D 29	80	0			2	115	8	109	120	2	127	16	115	138	2
42	112				1	164	9	157	170	2	182	21	167	196	2
43	87				1	130	10	123	137	2	122	14	112	132	2
52	3.8	.1	3.7	3.9	2	2.4	.3	2.1	2.7	4	2.9	.3	2.6	3.3	4
82	68				1	86	5	82	89	2	88	13	79	97	2
98	306				1	393	5	389	396	2	445	46	412	477	2
99	2.6				1	2.5	.1	2.4	2.6	2	2.9	.1	2.8	2.9	2
105	2.7				1	2.2	.0	2.1	2.2	2	2.4	.5	2.1	2.7	2
E 17	3.0	.2	2.8	3.5	7	2.7	.2	2.6	2.9	2	1.8				1
21	43	6	35	50	4	80				1	150	0			2
31	131	23	108	167	8	139	5	135	142	2	144	6	140	148	2
44	1.0	.0	1.0	1.1	4	1.0				1	1.1				1
70	2.0	.1	2.0	2.1	4	2.2				1	2.1	.1	2.1	2.2	2
74	3.1	.1	3.0	3.1	4	3.0				1	3.1				1
83	11.63	1.19	10	13	8	11.50	.71	11	12	2	14.50	.71	14	15	2
102	3.5	.0	3.4	3.5	4	3.5				1	3.5				1
F 29	60	0			2	70				1	86	4	83	88	2
42	95				1	130				1	167				1
43	95				1	132				1	159				1
52	3.3	.3	3.1	3.5	2	1.9	.0	1.9	1.9	2	2.9	.2	2.7	3.0	2
82	49				1	62				1	80				1
98	275				1	343				1	463				1
99	2.4				1	2.5				1	2.8				1
105	2.4				1	2.1				1	2.6				1

TABLE 7 (continued)

char.		34. H.p.phipsoni					35. H.p.kanarensis					36. H.granulomanus				
no.		mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A	30	58	16	30	88	30	54	17	32	82	6	42	14	22	69	20
	34	2.2	.2	1.9	2.6	30	2.1	.2	2.0	2.3	6	2.1	.2	1.8	2.5	20
	45	1.26					1.19					1.21				
	51	1.0	.2	.6	1.4	30	1.3	.3	.9	1.6	6	.9	.2	.6	1.1	19
	57	1.2	.2	.9	1.9	29	1.1	.1	1.0	1.2	5	1.1	.2	.8	1.4	20
	63	3.6	.3	3.1	4.4	29	3.8	.2	3.5	4.0	5	3.8	.3	3.2	4.3	20
	100	1.14	.07	1.01	1.26	15	1.15	.05	1.10	1.20	3	1.07	.05	1.00	1.16	10
	108	1.7	.2	1.5	2.1	15	2.0	.1	1.8	2.1	3	1.7	.1	1.5	2.0	10
B	56	73	7	58	88	27	68	7	57	73	5	72	13	45	87	12
	71	1.22	.06	1.10	1.29	14	1.16	.06	1.09	1.20	3	1.12	.05	1.06	1.21	6
C	17	2.3	.4	1.9	2.9	6	3.0	.4	2.7	3.2	2	2.5	.6	1.9	5.7	8
	21	25	19	10	50	4	10				1	21	12	10	40	5
	31	110	7	102	123	6	114	37	87	140	2	125	22	73	166	10
	44	1.2	.0	1.1	1.2	3	1.2				1	1.0	.1	1.0	1.1	5
	70	1.6	.0	1.6	1.6	3	1.5				1	2.0	.1	1.8	2.1	5
	74	3.4	.2	3.2	3.5	3	3.2				1	3.0	.0	3.0	3.2	5
	83	14.40	.89	13	15	5	13.00	.00	13	13	2	13.70	.48	13	14	10
	102	3.5	.2	3.3	3.6	3	3.4				1	3.5	.1	3.5	3.6	5
D	29	105	5	100	110	3	110				1	91	6	87	98	3
	42	148	7	140	153	3	153				1	153	12	140	161	3
	43	126	5	121	131	3	130				1	154	17	135	165	3
	52	2.8	.2	2.6	3.0	6	3.7				1	2.0	.2	1.8	2.3	6
	82	87	6	80	91	3	77				1	99	2	97	100	3
	98	442	29	408	461	3	485				1	451	35	411	478	3
	99	3.1	.1	3.0	3.2	3	3.0				1	2.9	.0	2.9	2.9	3
	105	2.4	.1	2.4	2.5	3	2.6				1	2.5	.1	2.4	2.6	3
E	17	2.2	.3	1.6	2.7	23	2.4	.2	2.2	2.5	4	2.9	.7	1.8	5.0	8
	21	51	23	25	100	13	28	18	15	40	2	26	10	15	40	5
	31	109	22	82	155	24	157	20	134	179	4	140	30	86	191	10
	44	.9	.1	.9	1.0	12	1.0	.0	1.0	1.0	2	.8	.1	.7	1.0	5
	70	2.1	.1	2.0	2.3	12	2.0	.0	2.0	2.0	2	2.5	.3	2.2	2.8	5
	74	2.9	.1	2.6	3.1	12	3.1	.2	2.9	3.2	2	2.9	.2	2.7	3.2	5
	83	13.08	1.28	11	16	24	11.00	2.00	9	13	3	13.00	.47	12	14	10
	102	3.5	.1	3.4	3.7	12	3.5	.1	3.4	3.6	2	3.5	.1	3.5	3.6	5
F	29	71	5	64	82	11	85	6	80	89	2	62	7	53	69	4
	42	122	10	111	140	11	143	10	136	150	2	134	8	124	143	4
	43	133	13	119	161	11	146	16	135	157	2	168	10	154	178	4
	52	2.7	.3	2.1	3.2	22	3.6	.2	3.4	3.7	4	2.0	.2	1.8	2.3	8
	82	74	7	69	86	11	69	2	67	70	2	80	1	79	82	4
	98	406	31	374	466	11	479	23	463	495	2	406	19	378	421	4
	99	2.9	.1	2.7	3.0	11	2.9	.1	2.8	3.0	2	2.6	.0	2.5	2.6	4
	105	2.3	.2	2.1	2.6	11	2.7	.1	2.6	2.8	2	2.5	.1	2.3	2.6	4

TABLE 7 (continued)

char.	37. H.wroughtoni					38. H.c.cyaneus					39. H.c.sumatrensis				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	85	19	67	115	8	50	10	32	92	188	54	15	41	78	8
34	2.3	.1	2.2	2.5	8	2.1	.1	1.7	2.6	190	2.2	.2	1.8	2.5	8
45	1.08					1.09					1.02				
51	.7	.1	.6	.8	8	1.1	.2	.7	2.6	189	1.1	.1	.9	1.3	8
57	1.0	.1	.9	1.2	8	.9	.1	.5	1.4	188	.8	.1	.7	1.0	8
63	3.2	.1	3.0	3.3	8	3.6	.3	2.9	5.0	188	3.7	.2	3.5	4.0	8
100	1.15	.02	1.14	1.17	4	1.08	.06	1.01	1.26	96	1.14	.08	1.04	1.23	4
108	1.8	.2	1.6	2.1	4	2.0	.2	1.6	2.6	94	2.5	.1	2.4	2.6	4
B 56	75	6	69	84	8	106	11	60	141	141	89	6	75	93	8
71	1.17	.02	1.16	1.19	4	1.31	.06	1.18	1.54	68	1.23	.02	1.21	1.24	4
C 17	3.0	.5	2.5	3.7	6	2.9	.4	1.7	4.3	75	2.8	.7	2.3	3.5	4
21	37	3	35	40	3	31	15	10	75	35	40	21	25	55	2
31						127	30	75	200	73	119	22	99	149	4
41	1.0	.0	1.0	1.0	3	.9	.1	.8	1.1	37	.9	.0	.9	.9	2
70	2.2	.1	2.1	2.2	3	2.0	.2	1.7	3.7	23	2.0	.2	1.8	2.1	2
74	3.0	.1	2.9	3.1	3	3.3	.2	3.0	3.6	37	3.2	.2	3.1	3.3	2
83	16.83	.41	16	17	6	13.80	.86	12	16	71	13.50	.58	13	14	4
102						3.5	.1	3.4	4.0	37	3.5	.1	3.4	3.5	2
D 29						82	10	61	103	23	97	0	97	97	2
42						130	12	100	152	23	154	10	147	161	2
43						143	13	109	164	23	166	8	160	172	2
52						4.4	.5	3.4	5.3	46	3.4	.2	3.2	3.6	4
82						79	7	64	92	23	93	7	88	98	2
98						426	32	358	481	23	498	14	483	508	2
99						2.9	.1	2.7	3.3	23	3.0	.1	2.9	3.1	2
105						2.3	.1	2.1	2.7	23	2.5	.2	2.4	2.6	2
E 17	3.4	.4	2.9	4.2	10	3.2	.6	2.1	4.8	113	3.2	.7	3.2	4.1	4
21	43	4	35	45	5	68	27	20	135	57	65	0	65	65	2
31	131	20	97	159	8	131	25	80	212	116	160	36	128	199	4
44	.9	.0	.9	.9	5	.9	.0	.8	1.0	46	.9	.0	.9	.9	2
70	2.1	.0	2.0	2.3	5	2.3	.2	2.1	4.9	58	2.2	.1	2.1	2.2	2
74	2.9	.1	2.8	3.2	5	3.1	.2	2.8	3.5	58	3.1	.1	3.0	3.2	2
83	15.00	.94	14	17	10	13.31	.71	11	15	110	12.75	.50	12	13	4
102	3.6	.0	3.6	3.7	4	3.5	.1	3.3	3.7	58	3.6	.0	3.6	3.6	2
F 29	65	3	61	68	4	66	6	51	125	45	74				1
42	115	4	110	120	4	114	10	99	137	45	131				1
43	127	5	120	132	4	134	14	101	163	46	148				1
52	2.6	.2	2.2	2.9	7	4.4	.7	3.0	6.2	90	3.9	.6	3.5	4.3	2
82	70	3	67	74	4	69	6	57	83	45	72				1
98	399	3	395	4.2	4	401	31	351	471	45	429				1
99	2.9	.0	2.9	2.9	4	2.7	.1	2.6	3.0	45	2.6				1
105	2.5	.0	2.4	2.5	3	2.3	.1	2.1	2.9	45	2.2				1

TABLE 7 (continued)

char.	40. H.c.insulanus					41. H.s.swammerdami					42. H.s.flavimanus				
no.	mean	s	min.	max.	n	mean	s	min.	max.	n	mean	s	min.	max.	n
A 30	52	11	44	66	2	64	8	51	80	28	80	4	76	85	4
34	2.2	.1	2.1	2.2	2	2.1	.2	1.9	2.4	28	2.1	.1	2.1	2.3	4
45	1.01					.97					.96				
51	1.0	.0	1.0	1.0	2	.9	.1	.7	1.2	28	.7	.1	.6	.9	4
57	1.3	.1	1.2	1.3	2	1.3	.2	.9	1.8	27	1.2	.3	.8	1.5	4
63	3.6	.2	3.4	3.7	2	3.4	.4	2.6	4.1	27	3.5	.1	3.4	3.7	4
100	1.19	.03	1.17	1.21	2	1.56	.12	1.38	1.75	14	1.58	.06	1.54	1.62	2
108	1.8	.1	1.7	1.9	2	1.6	.1	1.4	1.7	14	1.5	.0	1.5	1.5	2
B 56	128	8	122	133	2	80	13	56	106	23	82	8	69	87	4
71	1.30	.06	1.25	1.34	2	1.39	.03	1.35	1.45	12	1.45	.08	1.39	1.50	2
C 17	2.3				1	2.1	.3	1.8	2.5	10	2.7				1
21	20				1	63	14	45	80	5	50				1
31	135				1	143	21	113	170	10	111	7	106	116	2
44	.8				1	.8	.1	.7	.8	5	.7				1
70	2.2				1	2.6	.1	2.5	2.7	5	2.5				1
74	3.0				1	3.0	.1	2.8	3.2	5	2.9				1
83	14.50	.71	14	15	2	18.22	.44	18	19	9	20.50	.71	20	21	2
102	3.5				1	3.6	.1	3.6	3.7	5	3.6				1
D 29	69				1	68	10	55	79	4	73				1
42	113				1	128	16	109	142	4	132				1
43	140				1	173	24	139	194	4	200				1
52	4.1				1	2.8	.2	2.6	3.1	8	3.0	.0	3.0	3.0	2
82	82				1	105	13	89	120	4	113				1
98	431				1	670	118	537	796	4	682				1
99	3.1				1	4.1	.4	3.6	4.3	4	4.0				1
105	2.4				1	2.7	.1	2.6	2.8	4	2.8				1
E 17	2.9				1	1.9	.2	1.7	2.4	18	2.4	.1	2.3	2.4	2
21	80				1	77	16	55	110	9	60				1
31	150				1	134	23	101	170	18	116	13	107	125	2
44	.8				1	.8	.0	.7	.8	9	.7				1
70	2.0				1	2.6	.1	2.4	2.8	9	2.7				1
74	2.8				1	3.0	.2	2.8	3.2	9	3.1				1
83	13.00	.00	13	13	2	16.71	.77	16	18	17	18.00	.00	18	18	2
102	3.5				1	3.7	.1	3.5	3.8	9	3.6				1
F 29	65				1	70	11	58	88	8	68				1
42	128				1	129	16	110	151	8	122				1
43	161				1	171	25	140	202	8	177				1
52	5.0				1	3.0	.2	2.7	3.3	16	2.5	.2	2.3	2.6	2
82	72				1	97	10	83	109	8	95				1
98	464				1	664	97	546	801	8	619				1
99	2.9				1	3.9	.3	3.5	4.2	8	3.8				1
105	2.3				1	2.8	.2	2.6	3.0	8	2.6				1

TABLE 7 (continued)

char. no.	43. H.s.titanicus mean	s	min.	max.	n
A 30	76	4	71	79	3
34	1.9	.1	1.9	2.0	3
45	.97				
51	1.0	.1	.9	1.1	3
57	1.1	.1	1.0	1.2	3
63	3.4	.6	3.0	4.1	3
100	1.68	.06	1.72	1.29	2
108	1.5	.1	1.4	1.5	2
B 56	71	5	66	74	3
71	1.38	.08	1.32	1.44	2
C 17	2.0	.0	2.0	2.0	2
21	75				1
31	135	5	131	138	2
44	.8				1
70	2.6				1
74	3.0				1
83	16.50	.71	16	17	2
102	3.8				1
D 29	70				1
42	137				1
43	182				1
52	2.3	.0	2.3	2.3	2
82	101				1
98	744				1
99	4.2				1
105	2.8				1
E 17	1.9				1
21	85				1
31	162				1
44	.8				1
70	2.5				1
74	3.1				1
83	16.50	.71	16	17	2
102	3.7				1
F 29	89				1
42	153				1
43	200				1
52	1.7				1
82	111				1
98	809				1
99	4.1				1
105	3.1				1

of a certain character were indicated; faintness or variation within a cluster were expressed in ± signs or in a notation in parentheses. For the variations in superciliary crests (character number 7) and in the microsculpture of pedipalp hands (character number 61) code numbers were used; their explanation can be found in tables 3 and 4.

Taxonomic evaluation. — Not every resemblance between two clusters can be interpreted as an indication of systematic affinity, for such value can only be attributed to similarity in derived character-states. So the next step had to be the distinction between primitive and derived character-states; for that purpose a comparative study was made of closely related genera, viz., *Pandinus* Thorell, *Ischnurus* Koch, *Opisthophthalmus* Koch, *Opisthacanthus* Peters and *Scorpio* Linnaeus. It was expected that such a study would also result in the discovery of several generic characters of *Heterometrus* not cited before in the literature. Several specimens of species of these related genera were examined in the same way as *Heterometrus* specimens. These data were included in the surveys (tables 8 and 9); they constitute the base of judgements on character-states (either derived or primitive). Such judgements were difficult in a few cases, because of the small number of data and the variability of the characters. A list was composed in which the correlations of the clusters (including those discerned by computer treatment) with regard to the derived character-states were assembled (table 10). As several incertainties are involved in delimitation of value classes within biometric data and in designation of derived character-states, the correlations were established roughly. This implies that, in many pairs of taxa, the place of their character values in adjacent derived value classes was often interpreted as a correlation, in the same way as a place in identical classes would be interpreted.

A thorough study of the correlations of the clusters resulted in a general view of affinities. Thereupon decisions had to be made concerning the systematic status of the clusters. The information available on allopatry and sympatry was considered, as the subspecies of a scorpion species are allopatric. At higher levels judgements on the systematic status can be difficult, but the data on distribution and the experience with the degree of infraspecific difference could help to discern these relations from interspecific ones. Consequently, some of the clusters were called subspecies or species, while other clusters (just slightly different, and not mentioned separately in tables) were united to form a single cluster with subspecific or specific status. In this comparison also the results of computer elaborations were involved.

TABLE 8

Char. nos.		Taxon nos. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
A	30	5*	2	2	1*	2	4*	4*	4*	4*	4*	4*	4*	4*	4*	5*	6*	5*	4*	4*	5*	2	1*	1*	2	2	1*	2
	34	4*	5*	3*	2*	3*	3*	4*	4*	3*	3*	3*	3*	3*	3*	3*	4*	4*	1*	5*	6	6	3*	3*	2*	1*	1*	2*
	45	2	1	1				4*	4*	4*	4*	3*	4*	2	4*	1	3*	4*		5*		5*	1		1			3*
	51	6*	6*	5	5	6*	3	6*	7*	6*	6*	8*	8*	7*	6*	7*	6*	6*	6*	5	7*	6*	5	5	6*	6*	5	4
	57	2*	3	2*	2*	2*	2*	3	3	3	4*	4*	3	2*	3	2*	3	3	3	3	3	3	3	3	2*	2*	3	3
	63	5*	6*	5*	5*	4*	5*	5*	5*	5*	4*	5*	5*	6*	3	3	7*	6*	2	8*	6*	6*	3	4*	5*	4*	5*	3
	100	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3	2	2	2
	108	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	4	3		2	3	3	1	4	2	2
B	56	4	4	4	4	5*	3*	4	4	4	4	4	4	4	4	4	2*	2*	3*	2*		2*	4	3*	4	4	2*	2*
	71	3*	3*	4*	4*	4*	3*	2*	2*	2*	2*	2*	2*	4*	2*	4*	4*	4*	4*	3*		2*	3*	4*	5	3*	3*	4*
C	17	1*	2*	2*	1*			1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	2*		2*	6*	6*	4			5
	21	2	2	2	2			1*	2	2	2	2	3	4	2	1*	3	2	3	2		4	3	3	4			4
	44	6*	4*	3*	3*			7*	7*	6*	6*	6*	6*	6*	6*	5*	6*	6*	6*	7*		6*	3*	3*	3*			3*
	70	3*	4*	4*	4*			2*	2*	2*	2*	2*	2*	3*	2*	3*	2*	2*	3*	1*		2*	4*	4*	3*			2*
	74	2	1	1	1			3*	3*	3*	3*	3*	3*	3*	3*	2	4*	4*	4*	5*		3*	1	1	2			1
	83	3	3	3	3			3	3	3	3	3	3	3	3	3	2*	2*	2*	2*		3	1*		1*			3
	102	2*	2*	2*	2*			1*	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*		2*	2*	2*	3			3
D	29	2*	1	1	1			5*	4*	4*	4*	4*	3*		2*	1	4*	4*	1	4*		2*	1	1	1			1
	42	5*	4*	2	2			7*	6*	6*	6*	6*	4*		4*	6*	3	5*	3	6*		4*	3	3	2			2
	43	2	2	2	2			1*	1*	1*	1*	1*	1*		1*	1*	1*	1*	1*	1*		1*	2	2	2			2
	52	4*	5*	5*	5*			5*	5*	5*	5*	5*	4*		3	5*	5*	5*	5*	7*		6*	2	2	3			3
	82	3*	3*	1*	1*			4	3*	4	3*	3*	2*		3*	3*	3*	3*	3*	2*		2*	3*		1*			3*
	98	2*	2*	1*	1*			2*	1*	2*	1*	2*	1*		1*	1*	2*	1*	1*	1*		1*	1*	1*	2*			1*
	99	3*	2*	2*	2*			3*	3*	3*	3*	3*	3*		2*	2*	3*	3*	2*	2*		2*	2*	2*	3*			3*
	105	3	3	2*	2*			4*	3	3	3	3	4*		3	3	4*	5*	4*	4*		3	3	3	3			2*
E	17	3*	2*	2*		6	3*	2*	2*	2*	3*	3*	3*	2*	3*	2*	3*	2*		4	2*	4	6		7*	4	6	6
	21	2	2	2		3	1*	2	3	3	3	3	3	5*	2	1*	5*	5*		3	2	3	2		2	4*	3	3
	44	5*	5*	3*		2	5*	6*	6*	6*	6*	6*	6*	6*	6*	6*	6*	5*		6*	6*	5*	3*		2	5*	3*	2
	70	1*	2	2		2	2	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*		1*	1*	1*	3		2	1*	1*	2
	74	3	3	3		3	3	4*	4*	4*	3	4*	4*	5*	4*	4*	5*	4*		5*	5*	3	3		3	4*	2	2
	83	3	3	3		2*	3	3	3	3	3	3	3	3	3	3	2*	2*		3	3	3	2*		2*	2*	2*	3
	102	3*	3*	3*		4	3*	1*	3*	3*	3*	3*	3*	3*	3*	3*	3*	3*		2*	3*	3*	3*		4	4	4	4
F	29	5*	4*	4*		3	5*	5*	5*	5*	5*	4*	4*	5*	5*	5*	5*	5*		5*		4*	4*		3	5*	4*	2*
	42	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3	3		3		3	3		2	3	3	2
	43	3*	3*	3*		3*	3*	2*	3*	3*	2*	2*	2*	2*	3*	3*	3*	3*		3*		2*	5		3*	3*	4*	3*
	52	5	6*	6*		5	8*	5	6*	4	7*	7*	4	5	4	4	4	6*		8*		6*	3		4	5	4	4
	82	4	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4		4		3*	4		2*	4	4	3*
	98	4*	4*	4*		4*	5*	4*	4*	4*	4*	4*	4*	4*	4*	4*	5*	4*		4*		3*	4*		4*	4*	4*	3*
	99	2	2	2		2	2	2	2	2	2	2	2	2	2	2	2	2		2		2	2		2	2	2	2
	105	2	2	2		2	2	2	2	2	2	2	2	2	2	2	2	2		3*		2	2		2	2	2	2

Survey of biometric data of the taxa nos. 1-43 discriminated in the genus *Heterometrus*, and of the related genera *Pandinus, Ischnurus, Opisthophthalmus* and *Scorpio* (taxa nos. 44-47, respectively). The characters are arranged as in table 7. Character values are represented by class numbers as established in figs. 11a-f. The last column states the value classes which are considered primitive; in the table, derived value classes are indicated by an asterisk. In column X, characters are indicated in which adjacent derived value classes were counted also in establishing correlations between taxa (as used in table 10).

TABLE 8 (continued)

Char.	nos.	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	X	prim.
A	30	1*	2	2	1*	1*	1*	2	1*	1*	4*	1*	1*	1*	2	4*	3		3	5*	2	x	2,3
	34	6	2*	2*	3*	3*	2*	2*	2*	2*	3*	2*	2*	2*	2*	2*	1*		7	8	7	x	6-8
	45	2	2	3*	2	3*	4*	3*	3*	3*	1	2	1	1	1	1	1	1	1				1,2
	51	4	5	5	5	5	5	5	6*	5	4	5	5	5	5	3	5	2	5		1	x	1-5
	57	3	3	3	2*	3	3	3	3	3	2*	2*	1*	3	3	3	3	3	3	3	2*		3
	63	1	3	3	2	3	3	3	3	3	2	3	3	3	2	3	2	1	3		2	x	1-3
	100	2	2	2	1	1	2	2	2	2	2	2	2	2	3	3	4*	3	1	2	2		1-3
	108	2	1	2		2	2	2	2	2	2	2	4	2	1	1	1	1	3		4		1-4
B	56	2*	2*	3*	2*	3*	2*	2*	2*	2*	3*	4	4	5*	3*	3*	2*	4	1*	2*	4		4
	71	3*	2*	4*	4*	2*	1*	3*	3*	2*	3*	4*	3*	4*	4*	5	4*	6	6	2*	5		5-6
C	17	7*	4	5	5	4	2*	3	5	4	5	4	4	3	3	4	3	4				x	3-5
	21	5	4	4	5	4	5	3	2	3	4	4	4	3	5	4	5	3	5				3-5
	44	3*	3*	5*	5*	5*	6*	5*	5*	4*	4*	3*	3*	3*	2	1	2	1	2			x	1,2
	70	4*	2*	2*	3*	2*	1*	2*	2*	3*	4*	3*	3*	4*	5	5	5	6	5			x	5,6
	74	1	1	1	1	2	2	2	1	1	1	2	2	1	1	1	1	1	2				1,2
	83	3	4	3	2*	1*	4	2*	4	1*	2*	2*	2*	2*	4	5*	3	3	4				3,4
	102	3	3	3	3	3	3	3	3	3		3	3	3	3	3	4	4	2*				3,4
D	29	1	2*	1	1	3*	4*	2*	2*	2*		1	2*	1	1	1	1	1				x	1
	42	1*	6*	2	2	5*	6*	4*	5*	5*		5*	2	2	3	3	3	2				x	2,3
	43	1*	3	1*	1*	2	2	2	2	3		2	3	2	3	4	3	3					2-4
	52	3	2	3	5*	2	2	2	5*	1*		6*	4*	5*	2	3	2					x	2,3
	82	2*	4	1*	1*	3*	3*	3*	3*	4		3*	3*	3*	4	5*	4	4				x	4
	98		3*	1*	1*	1*	1*	1*	2*	2*		1*	2*	1*	4	4	4	4				x	4
	99		3*	3*	1*	1*	2*	3*	1*	2*		2*	2*	2*	4	4	5*	4					4
	105		3	2*	3	1*	2*	2*	3	3		1*	3	2*	3	3	4*	3				x	3
E	17	9*	4	6	6	6	2*	4	5	6	6	6	6	6	4	6	4	4	8*	1*	8*	x	4-6
	21	3	5*	4*	3	4*	5*	3	2	2	3	3	3	4*	4*	3	4*	2	3	3	5*	x	2,3
	44	2	2	3*	4*	4*	5*	3*	4*	2	3*	2	2	2	2	1	2	1	1	5*	1	x	1,2
	70	2	1*	2	1*	1*	1*	1*	1*	2	1*	2	1*	1*	2	2	2	3	4	1*	1*		2-4
	74	2	2	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2	4*	3	1	x	1-3
	83	3	3	3	2*	2*	3	3	2*	3	3	3	3	3	4*	5*	4*	3	3	1*	1*		3
	102	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5*	4	4	3*	4	4		4
F	29	1*	4*	2*	2*	4*	5*	4*	5*	3	3	3	4*	3	4*	4*	5*	3	3	5*	1*	x	3
	42	1	3	2	2	3	3	3	3	3	3	3	3	3	3	3	3	2	2	3	1		1-3
	43	1*	5	2*	1*	3*	5	3*	4*	5	3*	3*	4*	5	5	5	6	6	5	3*	1*	x	5,6
	52	4	4	4	4	2*	4	4	5	2*	4	7*	7*	8*	4	3	1*		4	9*	4	x	3-5
	82	2*	4	3*	1*	3*	4	4	4	4	4	4	4	4	5*	5*	6*	4	4	2*	1*	x	4
	98	1*	5*	3*	1*	2*	4*	4*	5*	4*	4*	4*	4*	4*	6	6	6	6	4*	4*	1*	x	6
	99	2	2	2	1	1	2	2	2	1	2	2	2	2	4	4	4	3	1	2	1		1-4
	105	2	2	2	2	1*	2	2	2	2	2	2	2	2	2	2	3*	2	2	2	1*		2

TABLE 9

Survey of descriptive data of the taxa nos. 1-43 discriminated in the genus *Heterometrus*, and of the related genera *Pandinus*, *Opisthophthalmus*, *Scorpio* and *Opisthacanthus* (taxa nos. 44 and 46-48, respectively). The last line gives the character states which are considered primitive in this study. Abbreviations: *b*, low protuberance; *c*, distinct colour; *m*, *s*, distinct microsculpture; *ma*, macroseta; *mi*, microseta; *p*, partly, viz., faint and/or variable within the taxon, *r*, smooth; *s.s.*, sensu stricto, viz., without variations. Error: taxon no. 5, char. no. 7: type 4 (instead of 6).

taxon	nos. of descriptive characters																											
nos.	7	8	9	10	11	14	26	27	28	37	38	40	41	60	61	75	76	86	91	92	93	94	111	112	113	114	116	118
1	5	+	-	-	-	-	+	-	-	-	+	-	-	-	10	-	+	ma(-r/+mi)	-	-	-	+	-	-	p	+	p	+
2	2	-	-	-	-	-	+	-	-	-	+	-	-	-	14	-	+	ma	-	-	-	+	-	-	-	-	-	p
3	5/3	-	-	-	-	+	+	-	-	-	-	-	+	-	14	-	-	ma	-	+	-	+	-	-	-	p	-	p
4	6		-	-	-	-	+	-	-	-	♂+	-	-	-	11	-	-	ma	-	+		+	-	-	+	-	-	-
5	6		-	-	-	+	+	-	-	p	-	-	+	-	7	-	-	ma-r	-	+		p	-	-	-	-	-	-
6	5		-	-	-	-	+	-	-		+	-	-	-	15	-	-	ma	-	-		-	-	-	+	+	-	+
7	6	s, pc	-	-	-	-	+	-	-	-	+	-	-	-	13	-	+	ma+mi	-	-	p	-	-	-	+	-	-	+
8	6	s, pc	-	-	-	-	+	-	-	-	+	-	-	-	13	-	-	ma	-	-	p	-	-	-	+	-	-	+
9	6	s, pc	-	+	-	-	+	-	-	-	+	-	-	-	11	-	-	ma(-r)	-	-	+	-	-	-	+	-	-	+
10	6	p	-	-	-	-	+	-	-	-	+	-	-	-	11	-	-	ma(+mi)	-	-	p	-	-	-	+	-	-	+
11	6	p	-	-	-	-	+	-	-	-	+	-	-	-	11	-	-	ma	-	-	+	-	-	-	+	-	-	+
12	6	-	-	-	-	-	+	-	-	-	+	-	-	-	11	-	-	ma+mi	-	-	p	-	-	-	+	-	-	+
13	6		-	+	+	-	+	-	-		+	-	-	-	12	-	-	r-mi-ma	-	-		-	-	-	-	-	-	-
14	6	+	-	+	-	-	+	-	-	-	+	♀+	-	-	11/12	-	-	ma	-	-		-	-	-	+	-	-	+
15	6	p	-	-	-	+	+	-	-	-	♀+	♀+	-	-	11	-	-	ma+mi	-	+	+	-	-	-	+	♂+	-	+
16	6	+	-	+	+	-	+	-	-	-	-	+	-	-	9	-	-	r	+	-	p	+	-	-	-	-	p	+
17	6	+	-	+	+	-	+	p	p	-	-	+	-	-	8	-	-	r	+	-	p	♂+	-	-	-	-	-	+
18	6	+	-	+	+	-	+	-	-	p	-	+	-	-	8	-	+	r	+	-	+	-	-	-	-	-	-	+
19	6	+	-	+	+	-	+	-	-	-	+	-	-	-	9	-	-	r	+	-		+	-	-	-	-	-	+
20	6	+	-	+	+	-	-	-	-	p	+	-	-	-	6	-	-	r	+	-	-	-	+	+	-	+	+	-
21	6	-	-	-	+	-	+	-	-	-	+	-	-	-	9	-	-	r(-ma)	+	+	p	-	-	-	+	-	-	-
22	1	p	-	-	-	+	-	-	-	-	-	-	+	-	4	+	+	r(-ma)	-	+	p	♂p	+	+	-	p	-	-
23	1	pb	-	-	-	+	-	-	-	+	-	-	+	-	2	+	+		-	+	-	+	+	+	-	+	+	-
24	4	-	-	+	-	-	-	-	-	-	-	+	-	-	7	+	+	r-ma	+	+	-	-	-	-	-	-	-	-
25	4	m	-	-	-	+	-	-	-	+	-	-	+	-	5	-	+	ma	-	+	+	-	-	-	-	-	-	-
26	4	-	+	-	-	-	-	-	+	+	-	+	-	-	1	-	-	ma	-	+	+	-	+	+	-	-	-	-
27	4	-	+	-	-	p	-	+	-	♀+	-	p	p	-	1	-	-	r-ma	+	+	+	+	p	+	-	-	-	-
28	4		-	♂p	-	-	-	-	+	+	-	+	-	-	5	-	+	ma	-	+	+	+	+	+	+	-	-	-

TABLE 9 (continued)

taxon nos.	nos. of descriptive characters 77	8	9	10	11	14	26	27	28	37	38	40	41	60	61	75	76	86	91	92	93	94	111	112	113	114	116	118
29	2/3/4	-	-	-	-	+	-	-	-	+	-	-	+	-	2	-	-	ma(+mi)	+	+	p	+	+	+	p	-	-	-
30	3	pc	-	-	-	-	-	-	-	+	-	+	-	-	3	-	-	r(-mi)	p	+	+	+	-	-	-	-	-	-
31	3		-	-	-	+	-	-	-	-	-	-	+	-	7 s.s.	-	+	r		+		-	+	+	-	+	-	-
32	4	pc	-	-	-	+	-	-	-	+	-	-	+	-	1	-	-	r(-ma)	-	+	+	+	-	-	-	+	-	-
33	4	c	p	-	-	-	-	+	+	+	-	+	-	-	2	-	p	ma	-	+	+	+	+	+	-	-	-	-
34	4	c	-	-	-	-	-	♂+	+	+	-	+	-	-	1	-	♂p	r-mi-ma	-	+	+	p	-	-	p	-	+	-
35	3		-	-	-	-	-	♂+	+	-	-	+	-	-	7	+	+	r	-	+	+	p	-	+	-	-	+	-
36	3	pc	-	-	-	+	-	-	-	-	-	-	+	-	2	+	+	r-mi	+	+	-	+	-	-	-	-	-	-
37	3/4		-	-	-	+	-	-	-	+	-	-	+	-	1/2	-	+	r	-	+	p	+	p	adult +	adult +	-	-	-
38	4	-	-	-	-	-	+	-	-	♀+	p	p	-	-	7	-	-	r	+	+	+	+	-	-	-	-	-	-
39	4	-	-	-	-	p	+	-	-	-	p	p	p	-	7	-	-	r	+	+	-	+	-	-	-	-	-	-
40	4	-	-	-	-	-	♂+	-	-	-	+	-	-	-	7	+	-	r(-ma)	-	+	+	+	-	-	-	-	-	-
41	6	pc	-	-	+	+	-	-	-	+	-	-	+	+	1	-	-	r(-ma)	+	+	+	+.	-	-	-	-	-	-
42	6		-	-	+	+	-	-	-	+	-	-	+	+	1	-	-	r-ma	+	+	+	+	-	-	-	-	-	-
43	6	pc	-	+	+	+	+	-	-	-	-	-	+	+	1	-	-	r	+	-	+	+	-	-	-	-	-	-
44	4	m,(b)	-	-	-	-	-	-	+	(+)	-	+	-	(+)	1	-	+	ma	-	-	-	+	-	-	-	-	-	-
46	1	-	-	-	-	-	-	-	+	+	-	-	+	-	2	-	+	r	(+)	+	-	(-)	-	-	(-)	-	-	-
47	1/2	(b)	-	-	-	-	-	+	+	-	-	-	+	-	2	+	+	r	+	+	-	-	-	-	+	-	-	-
48	(1)	+	-	+	-	-	-	-	-	+	-	+	-	(-)	(5)	-	+	r	-	+	-	-	+	+	+	(-)	-	-
prim.	1	m	-	-	-	-	-	-	+	+	-	-	+	p	2	-	+	r	+	+	-	+	-	-	-	-	-	-

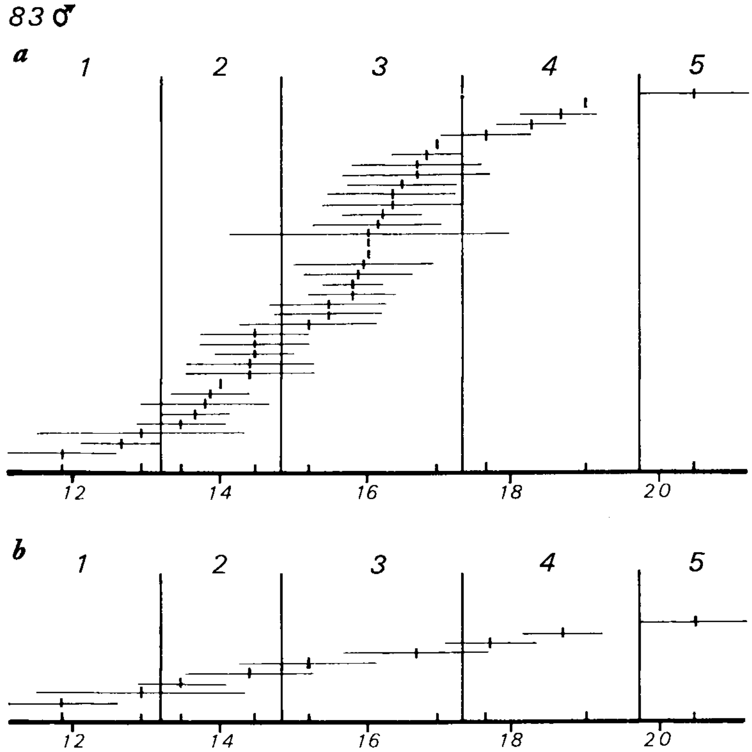

Fig. 10. Distribution of measurements for the number of pectinal teeth (character number 83) in the ♂♂ (class numbers indicated above, number of teeth below); a, complete survey of mean values and standard deviations in all taxa, with indication of discontinuities used as class limits; b, simplified scheme of class distinction (as applied in figs. 11), with indication of extreme mean values (on the axis) and extreme standard deviations for each value class.

Identification. Finally, in order to avoid a preconceived opinion, identification with taxa previously described had to take place after the clusters had been rearranged and a rank had been attributed to them. For that purpose a comparative study has been made of all *Heterometrus* (sub)species described in the literature and of all type-specimens (if still available). These type-specimens were subject of the normal measurements and investigation of descriptive characters (as in other *Heterometrus* samples), by which method identification of clusters became possible. As a rule data from descriptions were incomplete and indistinct; often only a small number of these data could be adapted to the set used for the present study. This applies especially to biometric data, which as yet have been little used. In some cases drawings were available, but these are quite unreliable as to most biometric

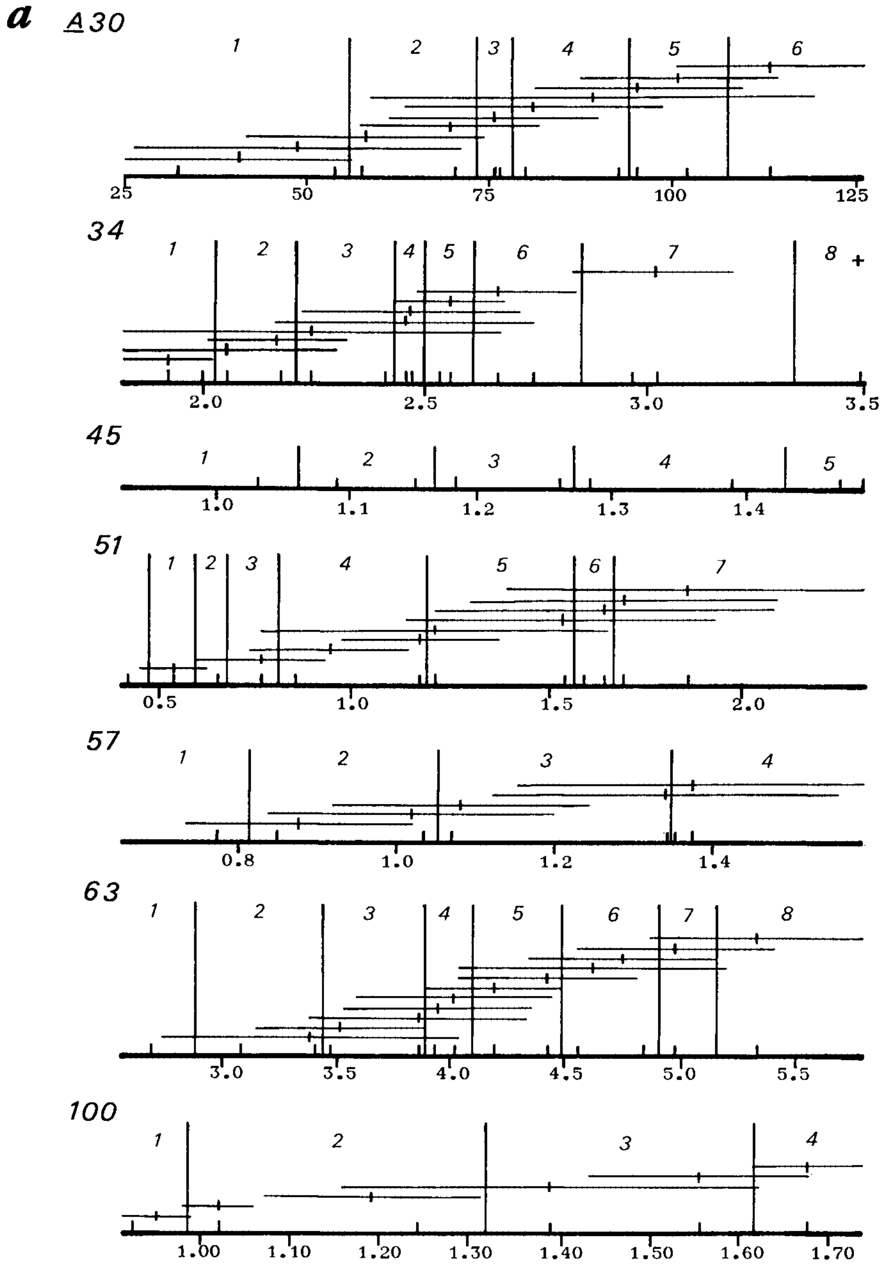

Fig. 11a-f. Distinction of classes in the distribution of measurements for the biometric characters, used in tables 8 and 10. The sequence of characters is according to table 7. Class numbers and limits are indicated, as well as extreme mean values (on the axis) and extreme standard deviations for each class.

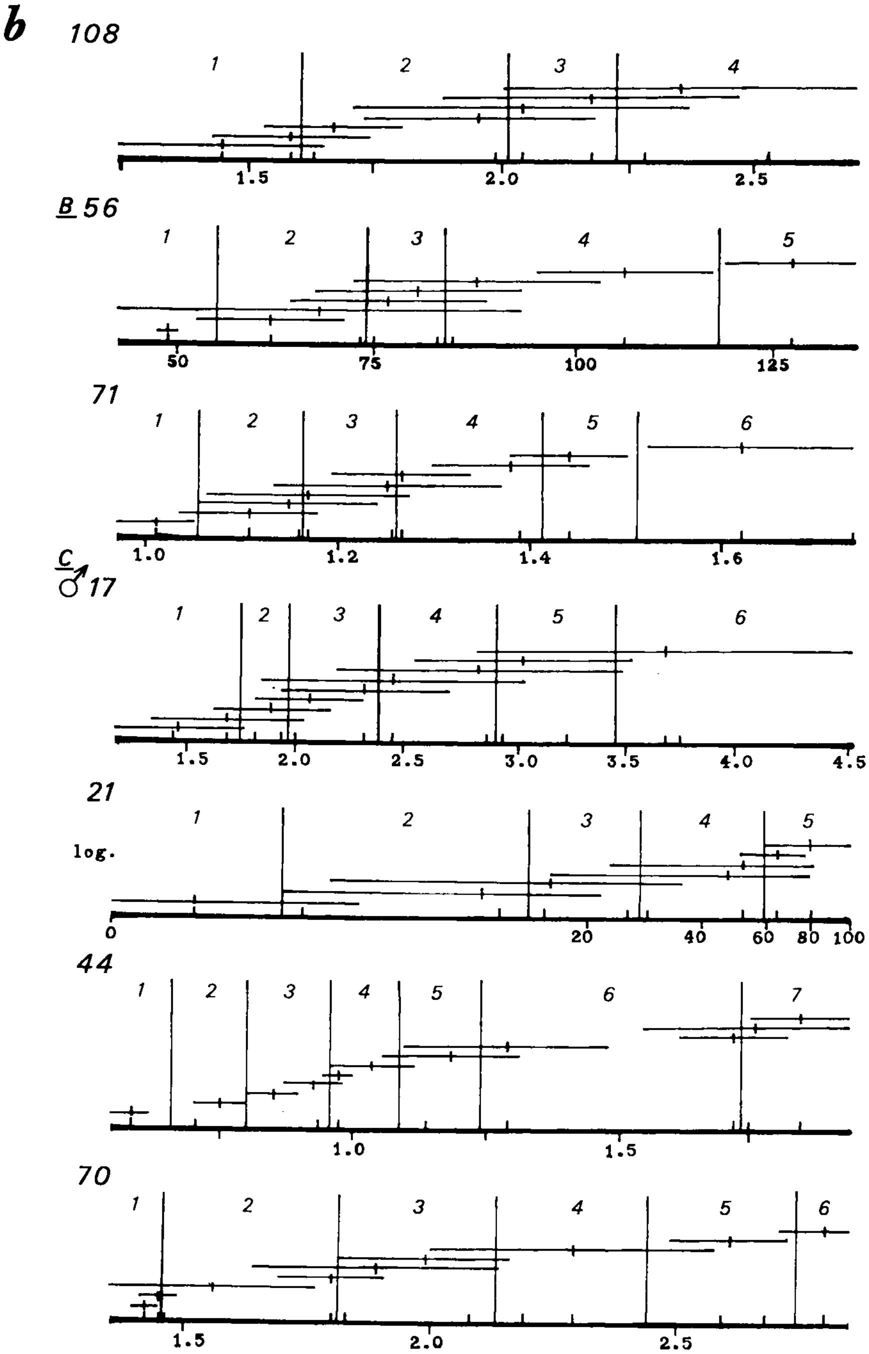
b
108
1
2
3
4
1.5
2.0
2.5
B 56
1
2
3
4
5
50
75
100
125
71
1
2
3
4
5
6
1.0
1.2
1.4
1.6
C
♂ 17
1
2
3
4
5
6
1.5
2.0
2.5
3.0
3.5
4.0
4.5
21
log.
1
2
3
4
5
0
20
40
60
80
100
44
1
2
3
4
5
6
7
1.0
1.5
70
1
2
3
4
5
6
1.5
2.0
2.5

Fig. b

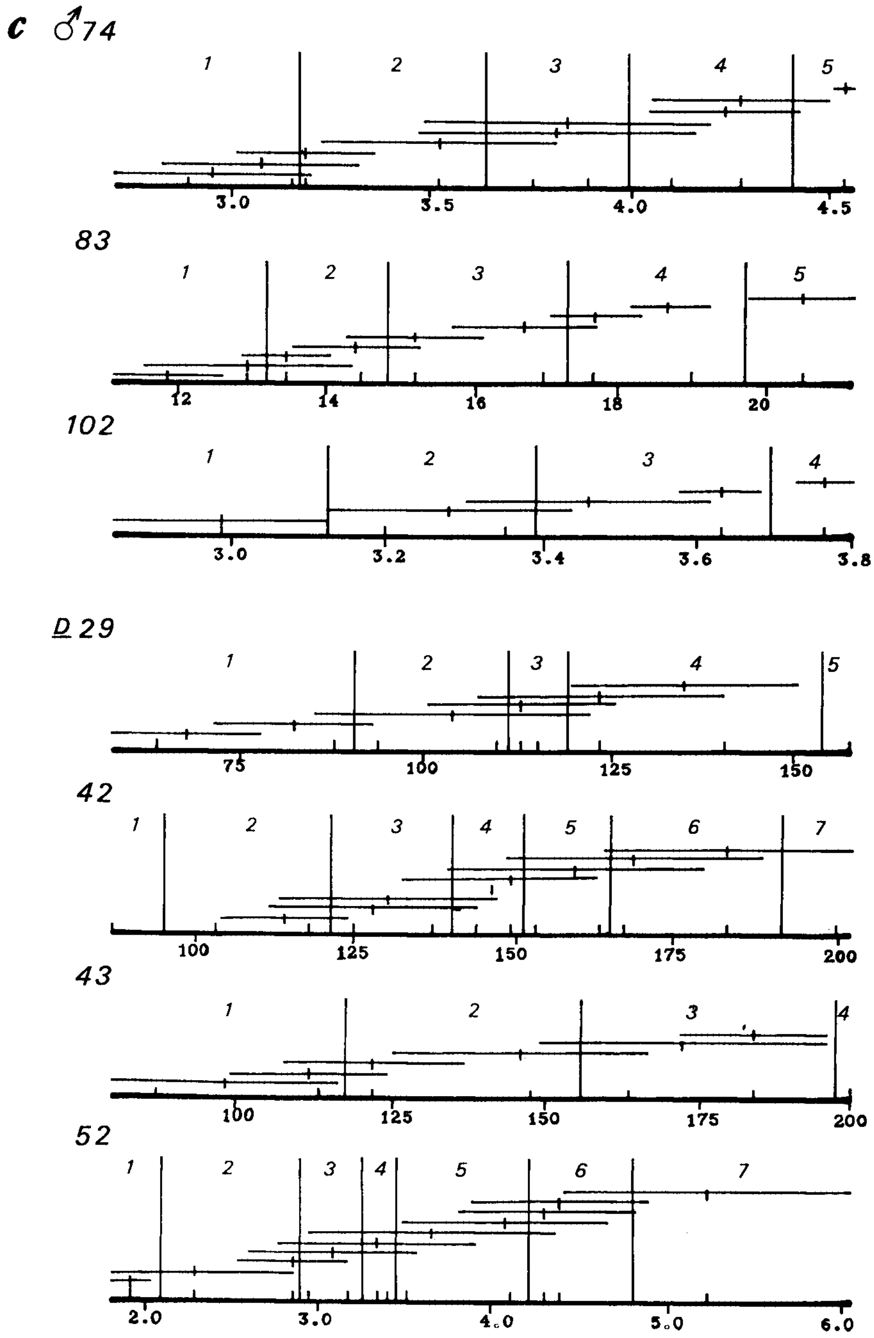
C ♂74
1
2
3
4
5
3.0
3.5
4.0
4.5
83
1
2
3
4
5
12
14
16
18
20
102
1
2
3
4
3.0
3.2
3.4
3.6
3.8
D 29
1
2
3
4
5
75
100
125
150
42
1
2
3
4
5
6
7
100
125
150
175
200
43
1
2
3
4
100
125
150
175
200
52
1
2
3
4
5
6
7
2.0
3.0
4.0
5.0
6.0

Fig. c

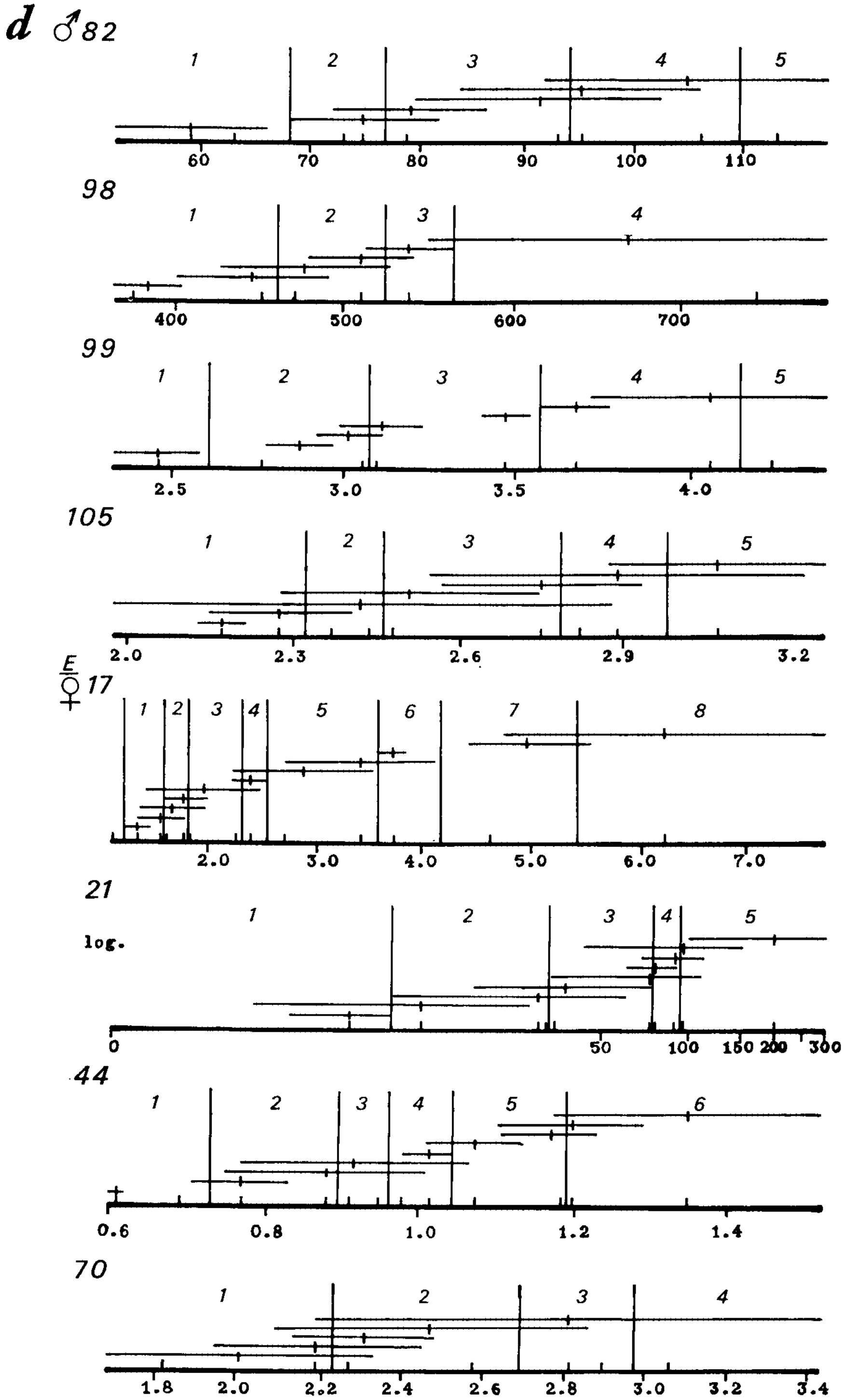
d ♂82
1
2
3
4
5
60
70
80
90
100
110
98
1
2
3
4
400
500
600
700
99
1
2
3
4
5
2.5
3.0
3.5
4.0
105
1
2
3
4
5
2.0
2.3
2.6
2.9
3.2
E
♀17
1
2
3
4
5
6
7
8
2.0
3.0
4.0
5.0
6.0
7.0
21
log.
1
2
3
4
5
0
50
100
150
200
300
44
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
70
1
2
3
4
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4

Fig. d

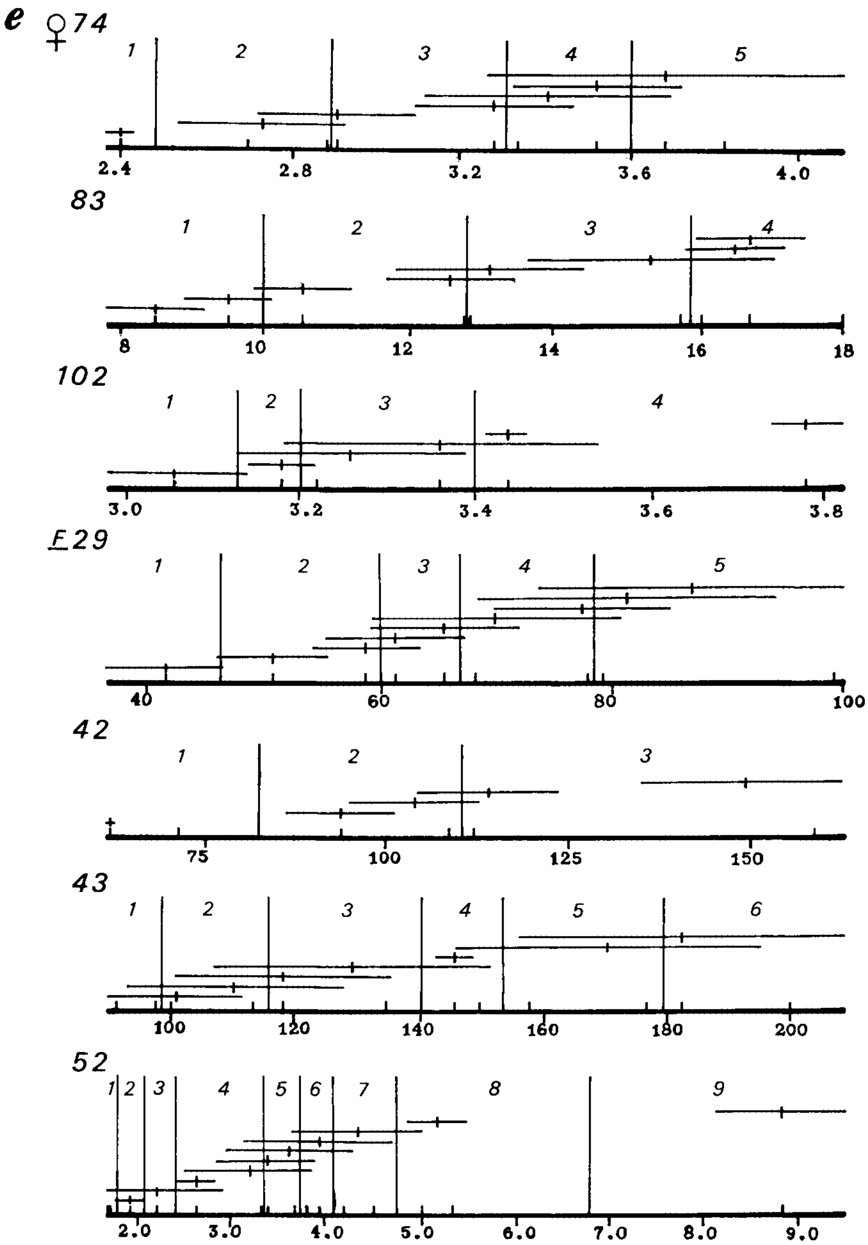
e ♀74
1 2 3 4 5
2.4 2.8 3.2 3.6 4.0
83
1 2 3 4
8 10 12 14 16 18
102
1 2 3 4
3.0 3.2 3.4 3.6 3.8
E29
1 2 3 4 5
40 60 80 100
42
1 2 3
75 100 125 150
43
1 2 3 4 5 6
100 120 140 160 180 200
52
1 2 3 4 5 6 7 8 9
2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0

Fig. e

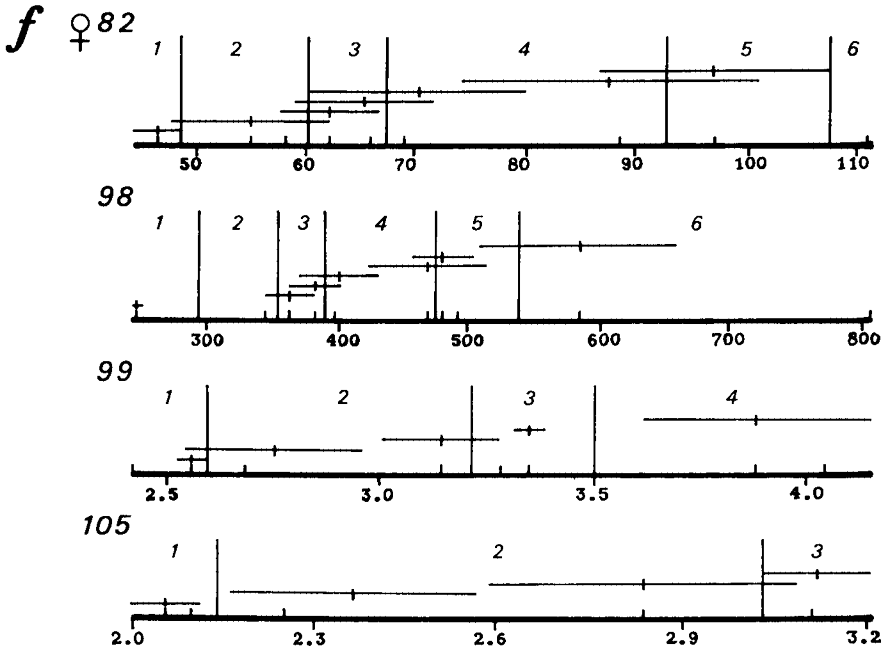

Fig. f

aspects. A great deal of the characters mentioned in older descriptions refer to variable aspects like colour, whilst some of the oldest descriptions are almost useless. The identification of some clusters was subject to further complications by the existence of complicated synonymy, which had first to be solved.

III. Species inquirenda

The following old descriptions could not be identified with one of the species or subspecies here distinguished.

Scorpio indicus Linnaeus, 1748: 68 (cf. Thorell, 1877: 208).

Scorpio leioderma Dufour, 1856: 571 (cf. Pocock, 1900b: 99; Takashima, 1945: 94).

Centrurus galbineus Koch, 1838: 110.

Buthus setosus Koch, 1841: 87.

Buthus ceylonicus Koch, 1842: 9 (non Herbst, 1800: 38, 83).

IV. Results

Character analysis. — In column F of table 2 the status of the characters examined according to table 1 can be found. Biometric characters and those

Table 10

Survey of correlations between taxa, with reference to the derived biometric characters in table 8. For each taxon, the number of derived biometric character states can be found on the diagonal of this table. For each pair of taxa, the number of correlations is indicated at the point of intersection of their correlation lists. In case the list of biometric data (table 7) is incomplete for a certain taxon, its correlation list is accompanied by a line: at the diagonal the categories (A-F, as in table 7) of characters are indicated, of which the data were available.

taxon nos.	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24
1	5	12	11	11	1	2	1	6	10	7	8	5	14	12	10	11	9	6	8	3	6	6	9	8
2	3	12	15	14	1	1	1	7	11	10	5	6	11	8	8	7	5	4	4	4	5	5	6	7
3	4	10	14	13	2	2	3	9	10	12	7	6	7	7	8	6	9	8	4	3	7	5	5	9
4	4	1	4	6	2	1	2	9	7	10	4	6	4	3	6	4	9	5	2	4	5	3	3	7
5	5	9	11	7	1	1	2	4	3	5	4	2	5	3	2	3	5	4	2	0	4	4	6	7
6	1	9	7	9	1	4	3	3	6	5	7	2	6	5	5	5	3	3	3	1	2	5	7	5
7	5	15	10	9	2	2	1	4	6	5	5	4	7	7	12	7	8	6	8	2	5	4	8	7
8	3	15	10	9	1	2	1	5	9	8	5	5	10	8	13	10	6	6	7	2	6	5	8	7
9	4	15	12	9	1	3	2	5	8	7	5	6	11	9	13	10	7	8	9	1	6	5	8	8
10	4	13	11	10	1	3	2	7	9	9	5	6	11	10	13	11	8	8	8	3	7	4	7	8
11	4	13	10	10	1	3	2	7	9	9	5	7	11	11	14	12	8	9	9	3	8	4	7	7
12	5	14	12	10	2	3	2	6	9	7	5	7	11	12	13	11	10	9	8	3	7	4	7	8
13	7	11	9	5	3	3	4	6	5	6	7	3	7	7	9	7	7	7	6	2	5	4	9	7
14	5	14	13	11	1	3	2	6	10	8	5	8	12	11	13	11	7	7	7	2	6	4	7	6
15	6	12	11	10	2	3	3	9	10	11	8	7	12	9	13	9	9	8	6	3	7	4	8	7
16	4	12	10	9	5	1	3	8	9	8	5	5	13	12	13	12	12	9	8	3	8	6	9	7
17	3	14	8	4	5	2	3	8	10	10	6	5	14	12	15	13	12	9	8	3	8	7	9	8
18	3	3	5	7	3	3	3	8	7	8	4	4	7	6	6	5	8	7	2	3	5	1	2	4
19	2	13	10	6	4	2	1	7	10	9	6	5	10	10	13	8	7	6	6	4	6	6	7	4
20	3	7	6	3	0	1	0	1	1	0	2	0	2	1	3	1	1	0	1	0	0	2	4	2
21	5	15	13	11	2	1	2	6	6	9	3	8	12	11	12	13	11	8	6	5	7	5	6	8
22	4	8	17	17	1	1	2	8	10	8	6	8	9	7	7	8	6	4	4	6	5	6	4	7
23	2	2	7	6	1	2	3	6	6	7	4	6	3	2	4	4	5	4	2	4	4	2	1	5
24	9	8	14	15	1	1	1	5	6	7	6	6	7	6	3	7	8	8	6	4	8	5	7	15
25	9	12	9	4	3	2	3	4	6	4	5	2	9	6	8	6	5	4	5	2	3	8	13 ABEF	
26	6	13	9	7	3	2	3	4	7	4	5	4	10	8	8	6	5	3	5	3	4	11 ABEF		
27	8	11	14	17	3	1	2	7	7	9	4	7	7	10	8	9	7	11	5	5	14			
28	14	9	12	12	1	0	0	3	3	4	3	4	4	3	3	4	10	5	2	14				
29	9	12	14	19	4	2	3	5	9	5	4	9	9	8	8	8	5	4	13					
30	8	10	13	14	3	2	4	6	4	7	6	6	6	10	8	12	11	17						
31	11	8	11	12	3	1	2	9	8	8	7	8	12	10	8	10	20							
32	8	11	10	7	3	3	4	7	10	8	6	11	15	13	14	24								
33	5	8	8	3	4	3	4	9	9	8	3	7	13	10	19									
34	6	13	13	14	3	2	2	7	11	9	8	9	15	18										
35	6	14	11	13	3	2	2	7	12	9	7	10	20											
36	6	10	13	17	3	1	1	7	8	8	4	15												
37	6	11	13	11	0	3	2	6	8	7	11 ABCEF													
38	7	9	12	12	2	1	2	13	11	16														
39	8	11	14	16	2	2	2	12	17															
40	8	11	14	17	3	1	3	16																
41	6	7	17	25	6	4	7																	
42	4	7	14	23	3	8																		
43	5	7	12	22	12																			
44	6	5	13	36																				
45	7	6	31 ABCEF																					
46	6	21 ABEF																						
47	24 ABEF																							

TABLE 10 (continued)

taxon nos.	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	5	9	16	7	14	9	20	18	19	18	16	20	19	20	19	20	16	11	6	7	13	17	23
2	5	10	15	5	11	8	16	14	15	13	11	13	13	13	12	15	11	8	3	8	14	20	
3	8	10	12	3	8	7	13	11	14	10	12	12	12	12	11	12	9	8	6	13	20		
4	9	7	7	1	5	8	6	5	9	5	7	7	6	6	6	5	4	3	4	14			
5	3	3	3	1	2	2	6	6	6	4	6	4	4	5	5	5	5	5	9			ABCD	
6	3	5	5	5	7	2	9	7	10	8	10	9	10	10	9	9	8	14			ABEF		
7	3	4	15	7	16	9	20	18	17	18	15	21	21	22	23	23	27		ABEF				
8	4	6	19	8	17	10	24	20	19	21	17	25	26	26	25	27							
9	4	6	17	8	15	9	22	19	19	20	17	23	23	24	25								
10	4	7	18	6	16	10	22	19	19	20	15	23	25	27									
11	4	7	18	8	17	9	23	20	20	19	17	24	28										
12	4	7	18	8	16	10	23	20	19	22	17	27											
13	4	6	13	8	10	7	18	17	17	16	20												
14	4	8	19	7	15	10	19	17	19	24		ABCEF											
15	6	9	16	7	14	12	21	20	25														
16	4	8	16	8	19	13	29	30															
17	4	8	19	8	20	14	31																
18	6	5	10	2	10	17																	
19	3	7	16	4	28		ABCD																
20	0	1	5	8																			
21	3	7	25		AE																		
22	8	16																					
23	11																						
		ABCD																					

descriptive characters which lend themselves to simple indication, are arranged in tables 11-13 (with reference to their variation). Table 11 represents the characters which appeared to be sex-dependent in at least one population sample. If age-dependence occurred too, the data refer to the adults only. Sexual dimorphism can also become evident from graphs (fig. 12). Table 12 represents the characters which appeared to be age-dependent in at least one population sample. If sex-dependence also occurred, the data refer to the females only, as in females a larger number of instars were found in these samples. In graphs (fig. 13) the discontinuity in size-sequences is evident, just as it is obvious in the length of the movable digit of the pedipalp (fig. 14). Exclusion of the characters mentioned in tables 11 and 12 from those mentioned in the general list (table 2: columns D and E) results in a series of characters that are, in *Heterometrus*, independent of sex and age. Among these, several characters useful for the differentiation of *Heterometrus* taxa can be distinguished by judgement of their variation (table 13; 2: D). Those characters which proved to be dependent on sex and/or age can be useful too, provided the data refer to a given sex and/or age, respectively.

TABLE II

Data of 16 sex-dependent characters in three population samples: mean values are given (in most cases with mention of standard deviation, in some cases with frequencies of character states).

char. nos.	remarks	RS 3486 ♂♂	RS 3486 ♀♀	RS 6168 ♂♂	RS 6168 ♀♀	RMNH 87 ♂♂	RMNH 87 ♀♀
1	adults	144	150	145	158	139	156
	only	1	6	10	6	8	3
2	adults	157	168	148	158	152	171
	only	3	6	12	6	6	5
21		40	74	34	31	4	17
		22	17	11	10	2	9
22		49	52	41	50	43	62
		4	5	8	9	8	4
43	adults	140	139	148	168	93	126
	only	0	7	10	7	6	5
44		1.0	.9	.9	.9	1.8	1.3
		.0	.1	.0	.1	.2	.1
52	adults	4.3	4.6	2.0	1.9	4.2	3.8
	only	.1	.4	.1	.2	.5	.3
54	% +	0	6	13	10	100	0
	% ±	0	0	13	25	0	60
	% -	100	94	74	65	0	40
70		3.4	3.8	2.1	2.7	1.4	2.0
		.2	.5	.2	.3	.2	.1
74		3.4	3.1	3.2	3.0	4.0	3.6
		.1	.1	.2	.2	.2	.2
82	adults	82	71	93	80	85	77
	only	5	3	4	4	3	5
83	% 12	0	18	0	28	0	0
	% 13	21	67	19	60	0	0
	% 14	72	15	75	13	0	10
	% 15	7	0	6	0	6	60
	% 16	0	0	0	0	56	30
	% 17	0	0	0	0	32	0
	% 18	0	0	0	0	6	0
84	adults	6	4	7	4	7	7
	only	0	0	1	1	1	1
98'	segm. 1-4	332	293	309	287	311	320
	ad. only	24	11	8	13	18	34
99	adults	3.1	2.8	2.9	2.5	3.2	3.0
	only	.2	.1	.0	.1	.1	.2
116	% +	43	94	100	75	100	100
	% -	57	6	0	25	0	0

TABLE 12

Data of 24 age-dependent characters in three population samples: mean values and, in case of more than one measurement, standard deviations.

char.	remarks	RS 3486			RS 6168			RMNH 87	
nos		sa I	sa II	adult	sa I	sa II	adult	sa	adult
1	♀♀ only	100	122	150	106	127	158	110	156
				6	2	10	6		3
2	♀♀ only	98	124	168	102	115	158	108	171
				6	8	6	6		5
29		29	38	43	34	48	64	62	115
		4	4	5	2	7	12		22
42		74	94	123	81	99	136	98	165
		6	4	8	1	6	9		17
43	♀♀ only	69	97	139	84	112	168	65	126
				7	4	10	7		5
46		152	201	268	164	208	280	197	322
		7	5	12	6	13	16		26
52	♀♀ only	3.8	4.1	4.6	2.0	2.0	1.9	2.9	3.8
				.4	.3	.2	.2		.3
68		99	126	160	100	120	156	118	180
		3	4	6	4	8	12		11
69		31	39	50	30	39	52	30	48
		1	2	2	3	3	3		4

Their differential value must also be established by a study of their variation; the results of this study are given in table 2: D, and figs. 13-16 (ratios and absolute measurements). In a graph, the presence of a cluster for certain populations demonstrates probable differential value (figs. 13-15). In fig. 16 the variation of character no. 33 is shown: within sample RS 3486 the range is somewhat wider than within sample RS 6168, but they have a common average. The average of sample RMNH 87 strongly deviates from the other two, but its range shows some overlap.

The remaining, more complex, descriptive characters need more space to be demonstrated and discussed. In figs. 5 and 6 the dentitions on the digits of the pedipalps are given. The number of accessory teeth (*ga*, *ge*, *gi*) appear to be different in the three populations. On the movable finger it increases from about 20 in RS 6168 to about 50 in RMNH 87 and further to about 95 in RS 3486. In the last mentioned sample these accessory teeth complicate the pattern of dentition. In many other genera of Scorpionida each basal tooth is accompanied by a stout accessory tooth (Vachon, 1952:

TABLE 12 (continued)

char. nos.	remarks	RS 3486 sa I	sa II	adult	RS 6168 sa I	sa II	adult	RMNH 87 sa	adult
71	RNH 87:	1.34	1.34	1.30	1.24	1.20	1.17	1.20	1.17
	♀♀ only	.08	.02	.06	.04	.06	.04		.03
72	RNH 87:	1.37	1.26	1.15	1.20	1.07	.99	1.82	1.44
	♀♀ only	.04	.00	.04	.00	.05	.08		.03
73		.65	.62	.60	.61	.58	.57	.60	.56
		.01	.01	.02	.00	.02	.01		.03
81		15	19	21	17	21	27	16	21
		2	2	2	2	2	2		1
82	♀♀ only	46	58	71	53	63	80	55	77
				3	4	5	4		5
84	♀♀ only	3	3	4	3	3	4	5	7
				0	0	1	1		1
99	♀♀ only	2.4	2.6	2.8	2.5	2.5	2.5	3.0	3.0
				.1	.1	.1	.1		.2
101		74	91	120	77	91	117	97	141
		4	4	6	5	5	8		9
103		31	40	52	31	38	51	30	52
		3	4	3	1	3	4		3
104		29	38	47	31	36	45	35	51
		3	3	3	1	3	3		3
107		34	38	52	42	48	63	52	76
		2	2	5	1	5	5		7
120		21	25	32					
		3	2	2					
121		29	37	54					
		1	5	3					
122		41	50	58					
		2	1	4					
127		718	880	1006	647	796	939	833	1056
		39	23	45	54	75	58		90

figs. 71-72). Such pairs are distinct in RS 3486; the basic row of teeth and the numerous, internal and external, accessory teeth are, however, irregularly arranged, thwarting a discrimination of basic and accessory teeth. Schematic drawings can simplify the situation, but (in this interpretation) arbitrariness cannot be avoided. The absence of the stout external accessory tooth near the third basal tooth of the movable digit (in sample RS 6168) constitutes, however, a distinct character (figs. 3c, 4c). The shape of the digit-apex

seems to vary between the three samples; the number of accessory teeth at the base of the terminal tooth is, however, individually variable. Consequently, the character-value of the pattern of dentition in *Heterometrus* is less than in other genera (Vachon, 1952: 63, figs. 71-74).

The hemispermatophores are figured in figs. 7a-f. The relative position of the accessory distal lobe (*lda*) with regard to the distal lobe (*dl*) and the other lobes (*li, lb, le*) is different in RMNH 87 and RS 3486. In further studies the lobes of a hemispermatophore of every adult ♂ were examined in order to look for constant differences between taxa. Within the three population samples used in the character analysis the material was too scarce for a thorough study of the variation in characters of the hemispermatophore; during the survey of the genus this variation appeared to be too strong for any differential use.

Fig. 8 represents lateral views of the fifth metasomatic segment; it demonstrates the different denticulations of the keels (carinae, crests), especially the dorsal and lateral ones (*dc, lc*). This denticulation is interrupted and coarse in RS 3486 but continuous and fine in RS 6168 and RMNH 87. Other differences are evident at the ventrocaudal border of this segment: attention should be paid to the length of the teeth at the angular points, and also to the size of the teeth situated between them.

The colour of the *Heterometrus* specimens is difficult to describe in a simple and concise way. A scheme (fig. 9) was drafted, in which the degrees of lightness are mentioned for different parts of the body. The code numbers of the colour patterns correspond with those used in table 13. Within a population sample a pattern shows variations but none of the patterns was found in more than one sample. The differential value, provisionally attributed to this character, was lost when further studies of other samples revealed its large variability. As several characters of table 13, it presents variation to such a degree that the samples of different taxa are often hardly distinguishable. Such characters lack differential value and are listed in column E of table 2, together with those which appeared to be stable for the whole genus.

At the end of the revisional studies it was discovered that the two distances used in the ratio of character number 6 are dependent on each other. On the carapace, an increasing distance from the foremost edge of the frontal lobes to the centre of the median oculiferous tubercle goes with a decreasing distance from this tubercle to the hindmost edge of the carapace (fig. 2a). This ratio would be more reliable, if, for instance, the maximum length of the carapace would be used as denominator. Since important parts of the examined material were, at this phase, no longer easily available to me, I could

TABLE 13

Data of 29 characters, independent of sex and age, in three population samples: mean values and standard deviations, or frequencies of character states.

char. nos.	remarks	RS 3486	RS 6168	RMNH 87
16	♀♀ only	1.9	2.1	1.3
		.1	.3	.1
23		83	83	93
		6	16	12
29	adults	43	64	115
	only	5	12	22
30		53	35	87
		11	7	12
32		162	176	161
		11	11	15
33		2.3	2.3	2.7
		.2	.1	.1
42	adults	123	136	165
	only	8	9	17
49		81	68	72
		9	9	7
50		1.3	1.2	1.4
		.1	.1	.1
51		1.1	.8	1.5
		.1	.1	.4
53	% +	100	0	0
	% -	0	100	100
55	% +	59	100	61
	% ±	33	0	8
	% -	8	0	31
56	% +	96	54	39
	% ±	0	0	23
	% -	4	46	38
57	% +	92	21	15
	% -	8	79	85

char. nos.	remarks	RS 3486	RS 6168	RMNH 87
62	series 1	3.9	3.0	5.1
		.7	.3	1.3
	series 2	12.9	10.8	12.2
		2.3	1.1	2.0
	series 3	17.3	12.8	18.0
		1.9	1.2	1.1
67	series 1	7.0	5.7	9.2
		1.1	.7	.7
	series 2	17.5	12.5	14.9
		1.9	1.3	1.1
	series 3	21.4	13.0	20.2
		2.3	1.3	.9
71	adults	1.30	1.17	1.10
	only	.06	.04	.08
73	adults	.60	.57	.56
	only	.02	.01	.03
79	% 3	100	96	0
	% 4	0	4	100
80	% 5	100	82	0
	% 6	0	18	38
	% 7	0	0	62
81	adults	21	27	21
	only	2	2	1
86	% fr	100	4	0
	% fr(+ma)	0	18	0
	% fma	0	78	84
	%fma(+mi)	0	0	8
	% fmi	0	0	8
88	adults	9.7	8.4	9.5
	only	.5	.4	.8

not correct this in the present paper. The character in question is, however, of minor importance in the taxonomy of *Heterometrus*.

The shape of the apex of the movable digit of the chelicera demonstrates striking differences between the three samples (figs. 1a, b). It was tested, if this shape could be well expressed in the ratio of character no. 16. In this computation of the relative length of the terminal teeth on the digit in

TABLE 13 (continued)

char. nos	remarks	RS 3486	RS 6168	RMNH 87
98	adults only	418 23	408 23	454 30
106		1.5 .1	1.3 .1	1.3 .1
108		2.3 .2	1.9 .1	1.9 .1
114	% + % -	100 0	0 100	15 85
127	adults only	1006 45	939 58	1056 90
128	% no.1	67	0	0
	% no.2	17	0	0
	% no.3	83	0	0
	% no.4	4	0	0
	% no.5	4	0	0
	% no.6	0	18	0
	% no.7	0	71	0
	% no.8	0	7	0
	% no.9	0	4	0
	% no.10	0	0	15
	% no.11	0	0	77
	% no.12	0	0	8

question, the striking differences observed at first became much less manifest. The ratio depends not only on the lengths of the teeth, but also on the position of the macroseta from which point the measurement was taken. In later measurements, I preferred to start from a common basal point, in the incision between the two teeth (character no. 17).

A comparative study of trichobothriotaxy revealed the generic constancy of the number of trichobothria, though in abnormal cases one or more of these setae are lacking, or additional setae are present (the possible evolutionary significance of the absences and presences has not been studied by me). The position of several trichobothria is rather variable, e.g., in the groups *esb*, *em* and *t* on the external surface of pedipalp segment 4 (see table 13: nos. 30-33). This applies also to the macrosetae *ma.d.b* and *ma.de.b* on the dorsal and dorso-external keels of pedipalp segment 3 (see tables 11 and 13). Even in a single animal the variation in the relative position of these hairs, on the left and on the right side, can be strong. This is demonstrated in the angles of characters nos. 22 and 23, e.g., in one specimen of sample RS 6168:

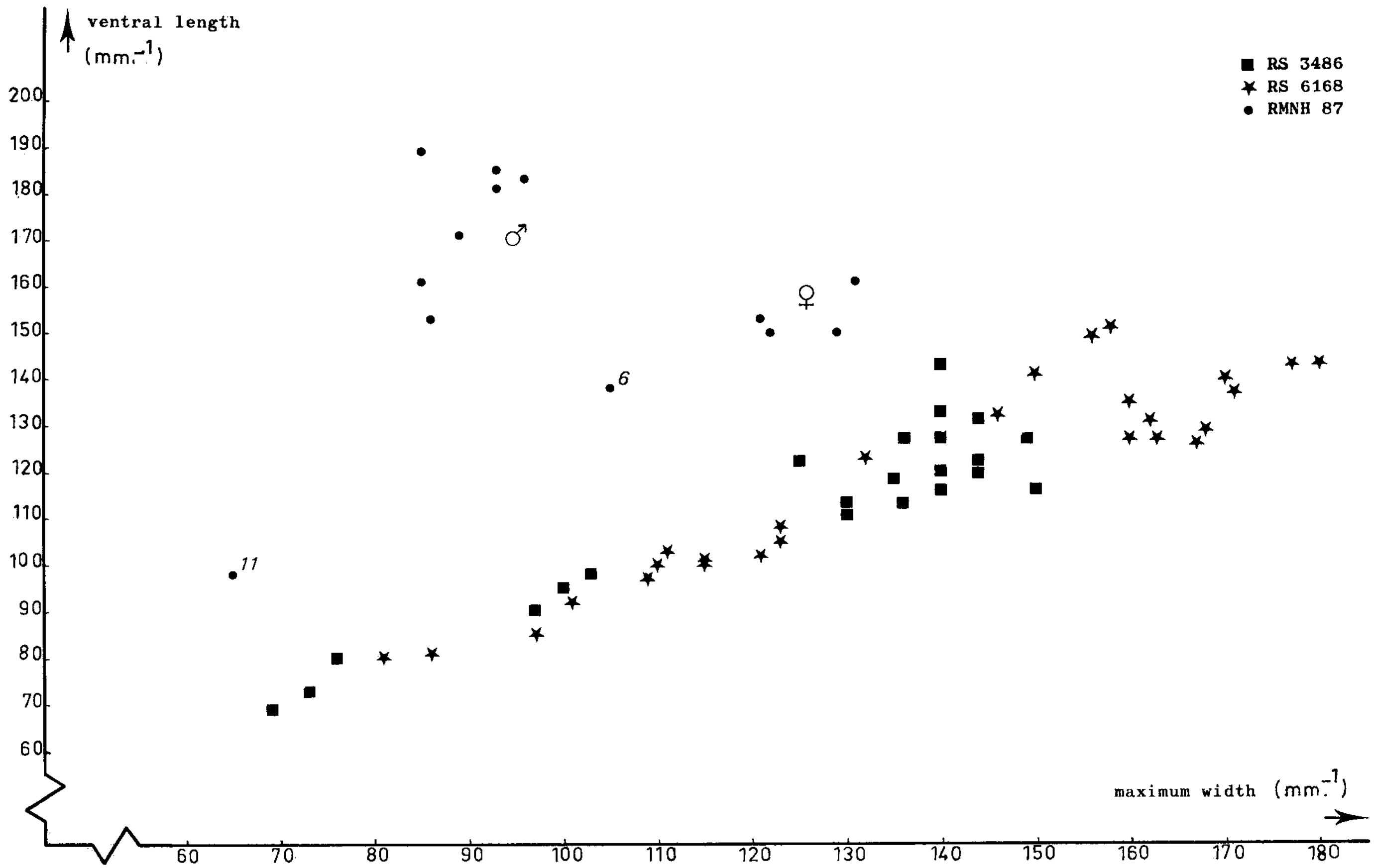

Fig. 12. Measurements of the pedipalp hand in three population-samples. Sexual dimorphism is distinct in sample RMNH 87 (*Heterometrus l. longimanus*); two particular specimens in this sample are indicated.

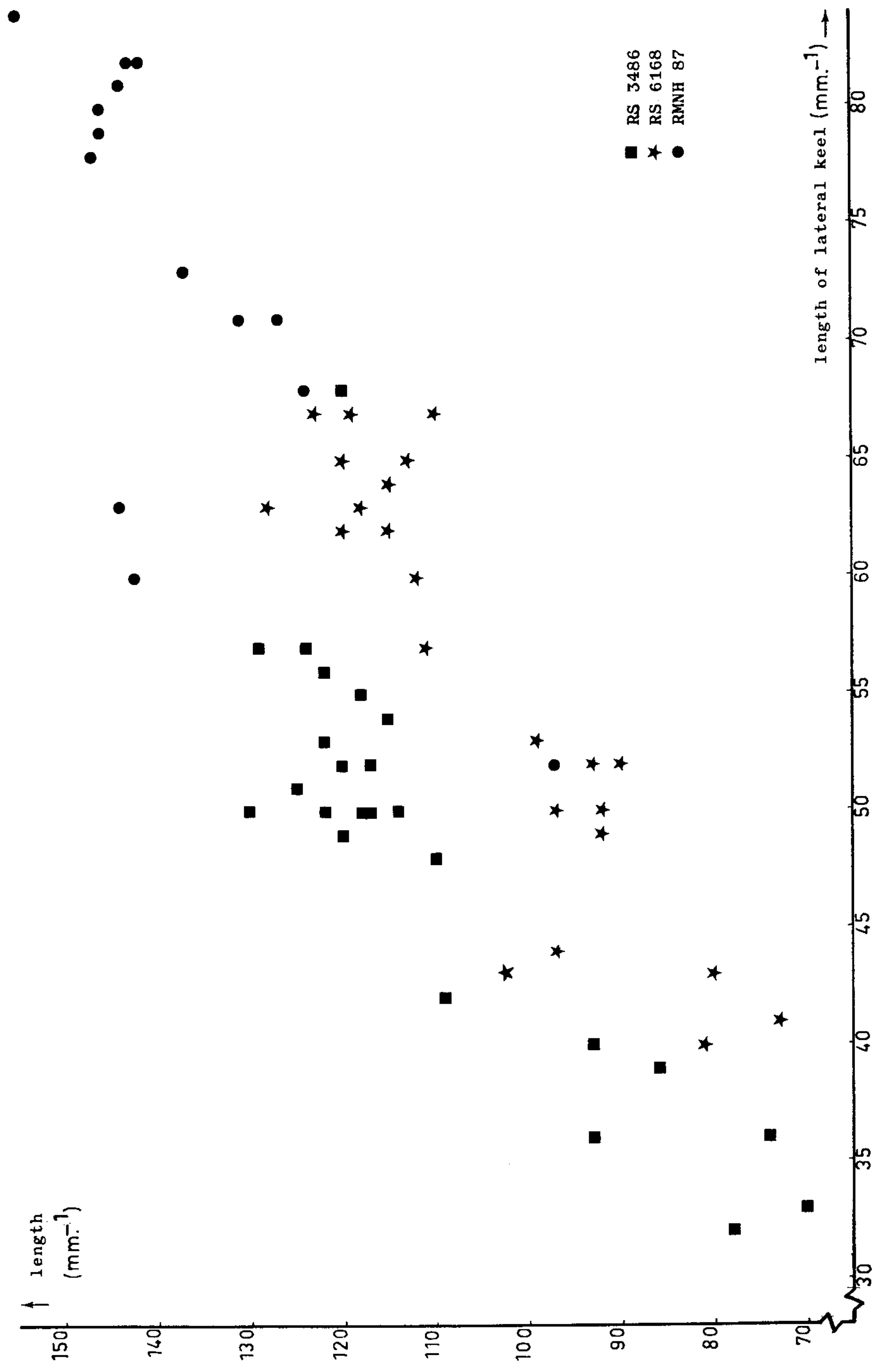

Fig. 13. Measurements of metasomatic segment 5 in three population-samples.

char. no. 22: left side 76 degrees, right side 49 degrees;
char. no. 23: left side 49 degrees, right side 86 degrees.
It will be clear that these characters have no taxonomic value.

Kraepelin (1908) produced a list of differences between the two sexes in the various scorpionid families, i.a. Scorpionidae. Comparison of his results with those mentioned in the present paper demonstrates many deviations, at least as far as *Heterometrus* is considered. Indeed the genital valve parts are fused in females, the number of pectinal teeth in males is (mostly!) larger than in females and the hand of females is often broader than that of males, just as Kraepelin has mentioned. But according to my observations the digits of the pedipalp of males are neither absolutely shorter than those of females (age-dependence) nor relatively shorter when compared with the width of the hand or digit base, or with the length of the internal side of pedipalp segment 4. No sexual dimorphism was discovered in the furrows of the pectiniferous plate, in the sum of lengths of carapace and metasoma, expressed as a ratio to the length of the mesosoma, nor in the setosity of hand and metasoma. The mean width of the vesicle in adult males of sample RS 3486 is not smaller, but even larger than that in adult females and is also age-dependent. Giltay (1931) mentioned that the third pedipalp segment ("fémur") is relatively larger and less granulated in males than in females of *Heterometrus cyaneus* (Koch) from Java. This difference was observed in the samples RS 3486 and RMNH 87 also. Giltay (1931: 5) remarked that in *Heterometrus l. longimanus* (Herbst) the pectinal teeth of males are longer than those of females; this is shown clearly in figs. 1d and e (sample RS 6168). This author also made mention of sexual dimorphism in the ratio of length and width of the hands (character no. 45 in this paper). Meise (1932: 660-661, 670) stated that in *Heterometrus longimanus* (Herbst) two groups of subspecies can be discerned, based upon the presence of certain phenomena of sexual dimorphism (viz., the width of the pedipalp hand). Representatives of the first group, displaying strong sexual dimorphism, he localised in Burma, Salanga (an island off the north Malayan west coast), Sumatra, Java, Celebes, Borneo and perhaps the southern Philippines. The second group, hardly showing sexual dimorphism of the hand width, was said to inhabit Malacca, South Vietnam, Thailand and perhaps more westward regions. Meise's ideas emphasize the value of sex-dependent characters frequently used in the present paper and find a response in the results of my revisional studies.

Revision of the genus *Heterometrus*. — Clustering and nomenclature. The results of the principal components cluster analysis are visible in figs. 17, 18 and 20. The clustering exists in a multi-dimensional space with as

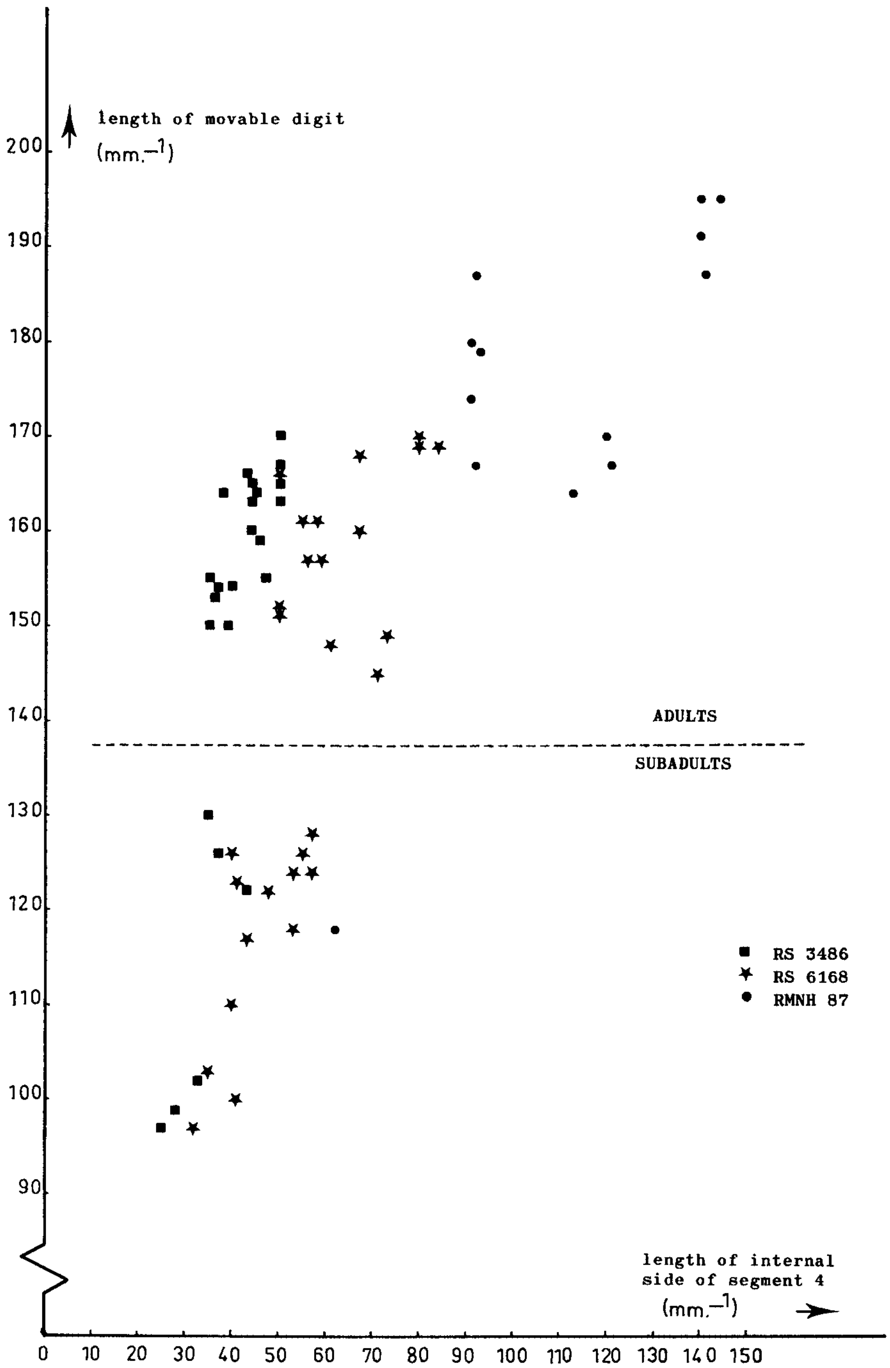

Fig. 14. Measurements of the pedipalp in three population-samples. Age-dependence can be observed.

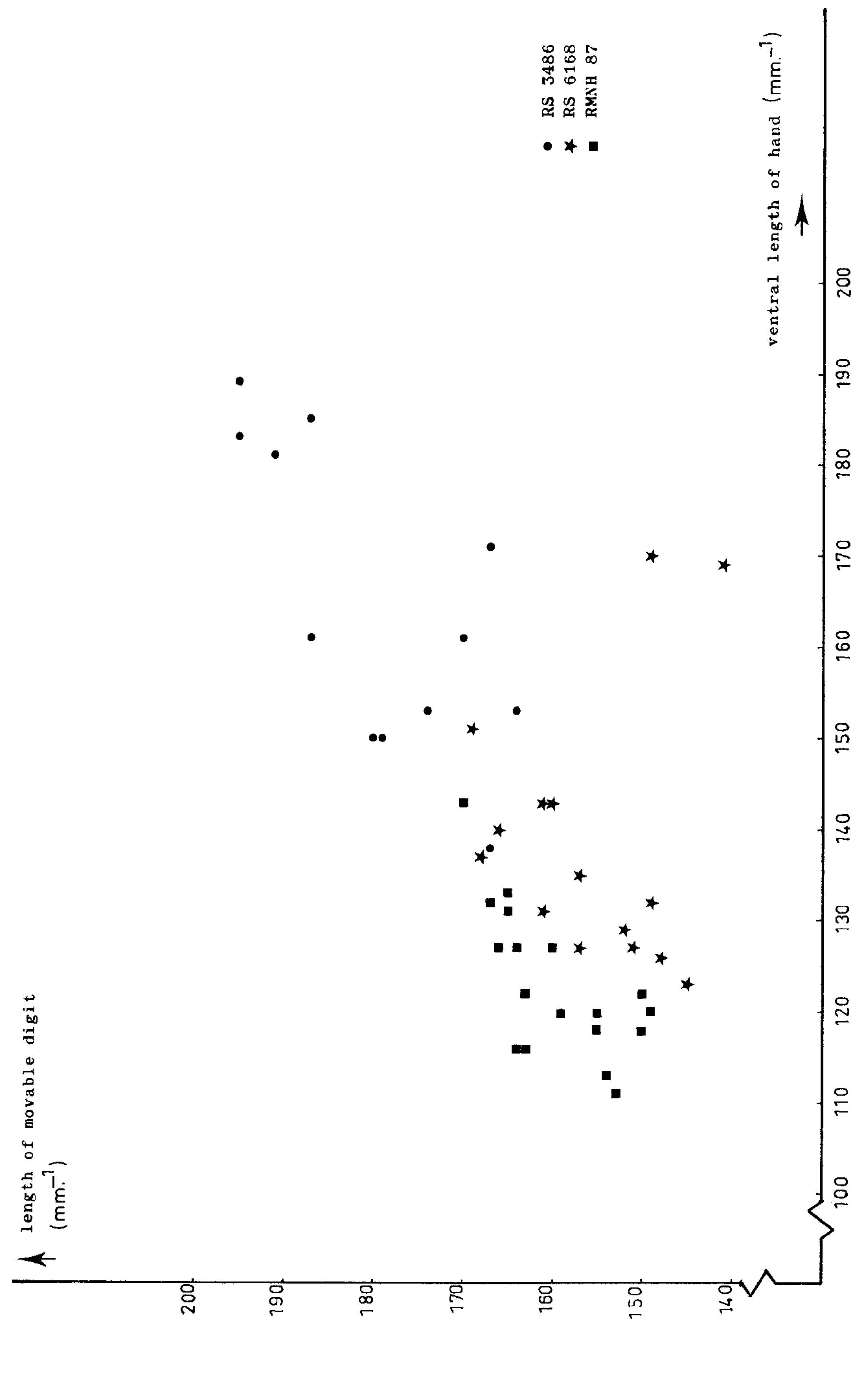

Fig. 15. Measurements of the pedipalp hand of adults in three population-samples.

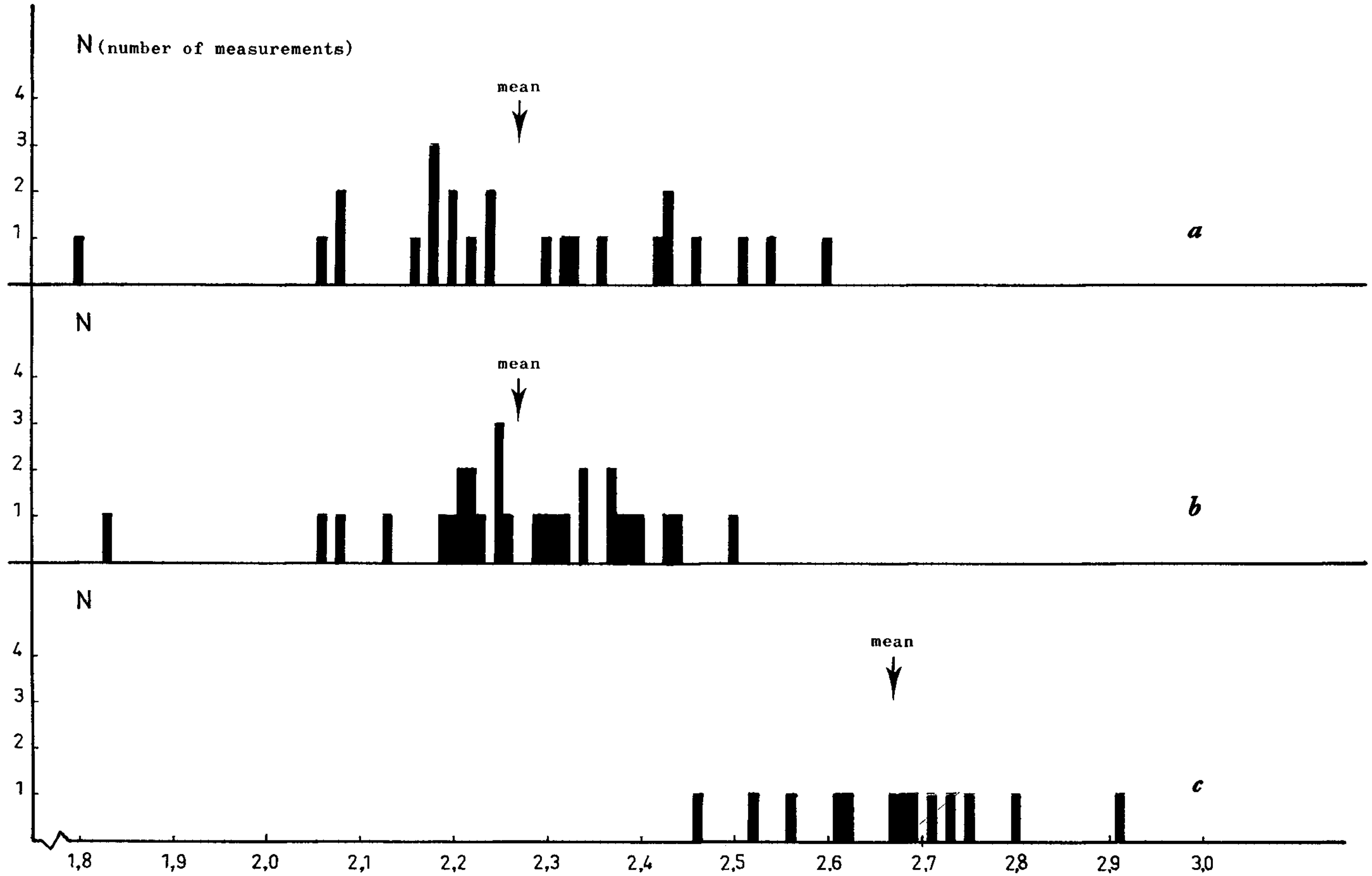

Fig. 16. Distribution of measurements for character number 33 (shortest distance between trichobothria *t* and the base of pedipalp segment 4, as a ratio to the shortest distance between trichobothria *em* and *t*), in three population-samples; a, *Heterometrus c. cyaneus* (Koch), RS 3486; b, *H. fulvipes* (Koch), RS 6168; c, *H. l. longimanus* (Herbst), RMNH 87.

many axes ("columns") as characters; along the first three axes, differentiation is the most distinct. Members of the different clusters were listed according to the original computer plots and to a dendrogram (simplified in fig. 18), and their characters were investigated. After this the clusters were identified and supplemented with some remaining, slightly aberrant, specimens. These interpretations of the original plots (not suited for print) are represented in figs. 17a and b. Specimens from the south-east Asiatic peninsulas are differentiated into three groups (taxa), which is apparent also from graphs of certain biometric characters (fig. 19). These continental taxa are strongly different from the Javanese specimens, as appeared from a separate cluster analysis (plots not suited for print). In the dendrogram of fig. 18 the stray positions of specimens of *H. laoticus* are striking, but here it seems probable that this species is related more closely to *H. petersii* than to *H. spinifer* or *H. bengalensis*. The last-mentioned two species appear to be closely related, while *H. petersii* has a separate position, together with *H. laoticus*. In separate analysis of Javanese specimens, there was no proof of any geographic variation on Java. In the principal components cluster analysis (fig. 20) applied to these specimens, the cumulated explained variance along the first three columns is 33%, viz. 15%, 10% and 8%, respectively, a percentage which is too low for clear differentiation. A few characters, however, show some east-west variation, as will be explained in the description of the taxon concerned (p. 128). The complete survey of the genus resulted from the further manual elaboration of data. The affinities between the *Heterometrus* taxa, as they could be derived from tables 8-10 and the computer output, are represented as diagrams in figs. 21 and 66 (see chapter VII). This survey and the identification with existing descriptions and types of species and subspecies resulted in the revision below. The taxon numbers used in this paper had been chosen (for practical reasons) before the study of the interrelations of the taxa. This implies that the definitive classification is not in accordance with the original numbering. This is also evident from the systematic list of taxa (p. 191) and in the sequence of descriptions below.

V. Classification of the genus Heterometrus

(see also chapter VIII)

Heterometrus Hemprich & Ehrenberg

Heterometrus Hemprich & Ehrenberg, 1828: Anim. Evert., ...: Scorp.; Tab. 1, fig. 2 (the paper has no pagination). Description of adult ♂, 2 species included: *Buthus* (*H.*)

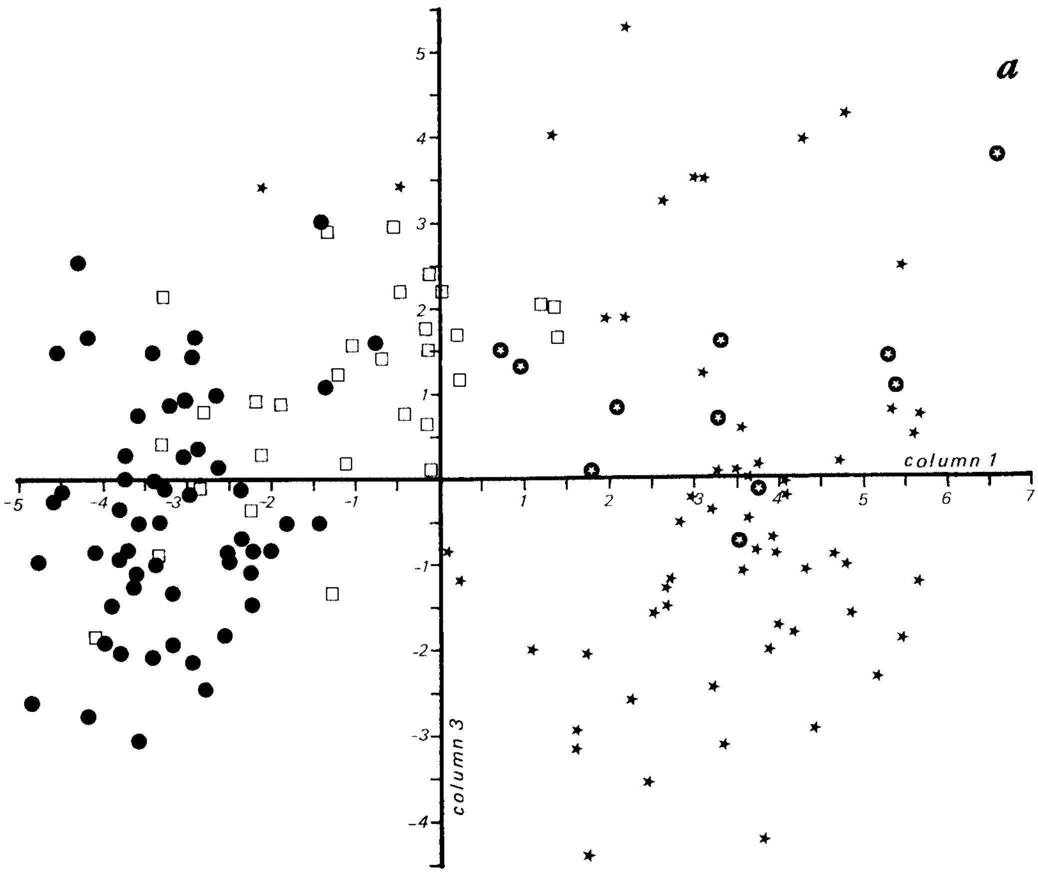

Fig. 17. Interpretation of the computer plot resulting from a principal components cluster analysis (in R-mode) of log-normalized biometric data from samples collected on the mainland of south-east Asia; a, distribution with respect to columns 1 and 3; b, distribution with respect to columns 2 and 3; final identifications and taxon numbers are indicated.

palmatus (= *Scorpio maurus* L., 1758), and *Buthus* (*H.*) *spinifer*, respectively. To stabilize the current use of *Heterometrus*, I designate *Buthus* (*H.*) *spinifer* H. & E., 1828, as the type-species of the genus *Heterometrus* H. & E., 1828.

Heterometrus sensu Pocock (1900a: 362) does not belong to this genus, but to *Scorpio* Linnaeus (1758: 624).

Several authors have classified *Heterometrus* species with other genera, viz., sub *Scorpio* (part.) sensu Dufour (1856: 571), Becker (1880: 140), Simon (1885: 38); *Buthus* (part.) sensu Koch (1836: 9);

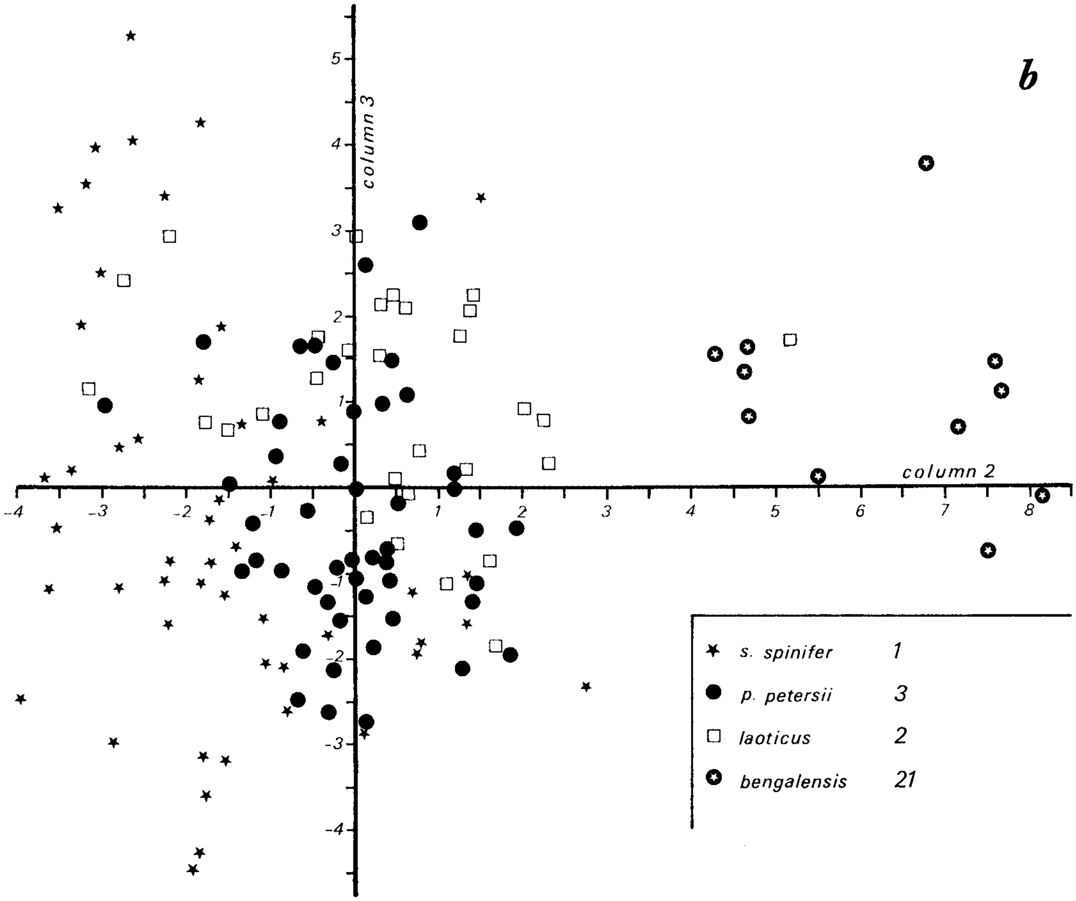

Fig. 17 (b)

Palamnaeus Thorell, 1876; Pocock (1897: 114; 1900b: 84);
Pandinus Thorell, 1876 (Indian spp.; application of this name critisized by Pocock, 1896b: 75); Karsch (1879b: 127), Simon (1905: 160).

Diagnosis. — Large scorpionids, the median length of the adults exceeding 8½ cm (mostly even exceeding 10 cm), with an area of distribution comprising the tropical south and south-east Asiatic mainland and archipelagos, from India and Sri Lanka as far as Wallace's line. Body and pedipalp hands slightly convex (with exception of the Indian species *H. collinus* and *H. pelekomanus* with a flat carapace and, in *H. pelekomanus*, with depressed, in males even concave, pedipalp hands). The carapace has a deep mediorostral incision. The ventral surface of the pedipalp hand is furnished with only

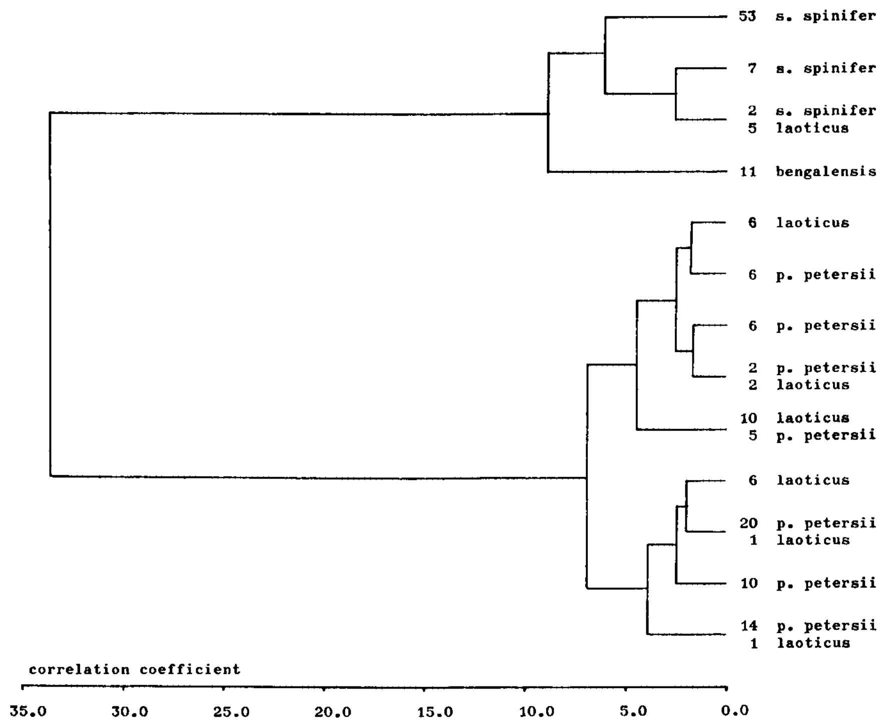

Fig. 18. Simplification of the dendrogram resulting from Ward's averaging of correlation coefficients (in Q-mode) from log-normalized (standardized) biometric data from samples collected on the mainland of south-east Asia; the number of specimens included in each cluster is indicated, with their final identifications.

four trichobothria. The telotarsus of the walking-leg is terminally produced into two lobes, which flank the two claws of the apotele. These telotarsal lobes each bear two stout spines, while two rows of 1-6 spines occur on the inferior surface of the telotarsus. The metasoma is long and stout (only in juvenile specimens it is short and slender).

Description. — As many new characters were studied extensively, the original generic description by Hemprich & Ehrenberg can be supplemented and more precisely defined.

Carapace. A deep mediorostral incision is present. The superciliary crests are present in nearly all species and are generally granular; in many species they are continued posteriorly of the median eyes. The median oculiferous tubercle has a central position on the carapace. The second of the three lateral eyes at the border of each frontal lobe (in almost every species) is closer to the first than to the third.

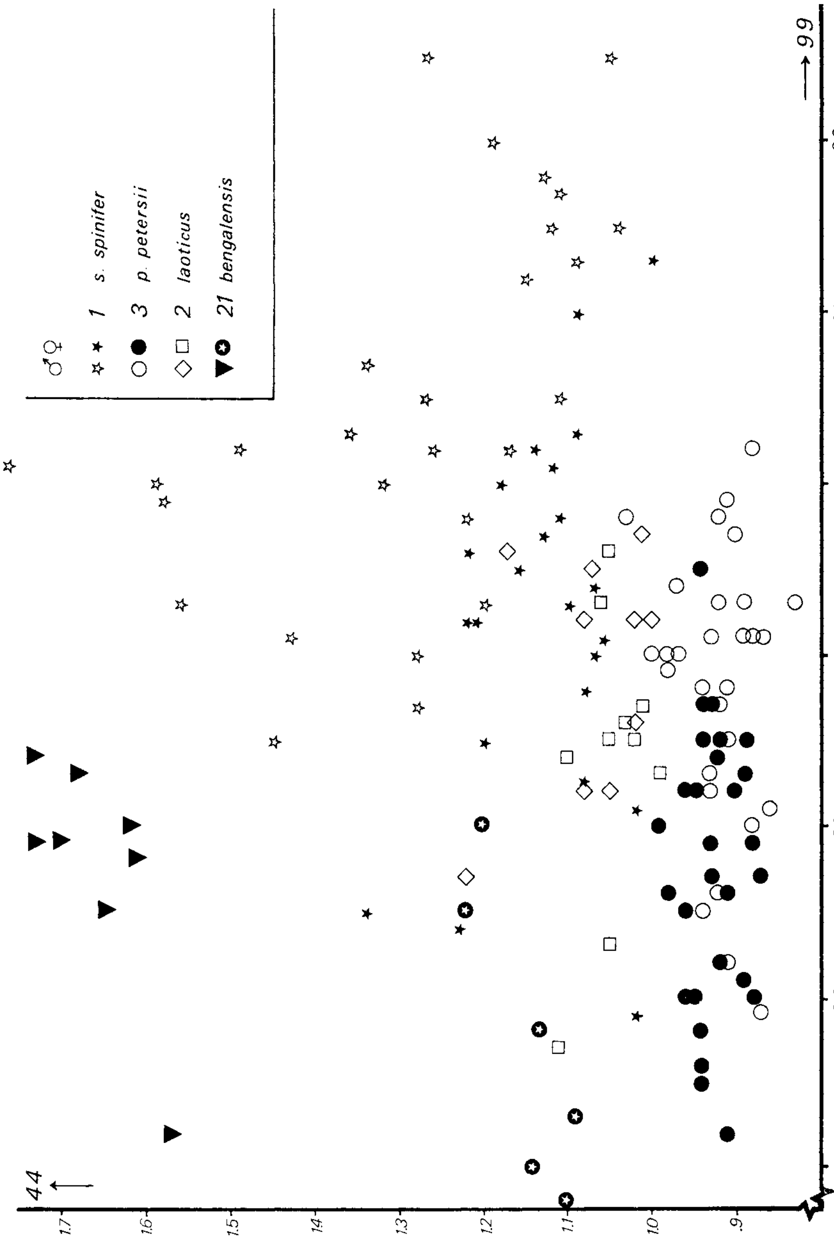

Fig. 19. Variation of two biometric characters (nos 44 and 99) in the samples collected on the mainland of south-east Asia, differentiated according to sex; final identifications are indicated, with the respective taxon numbers.

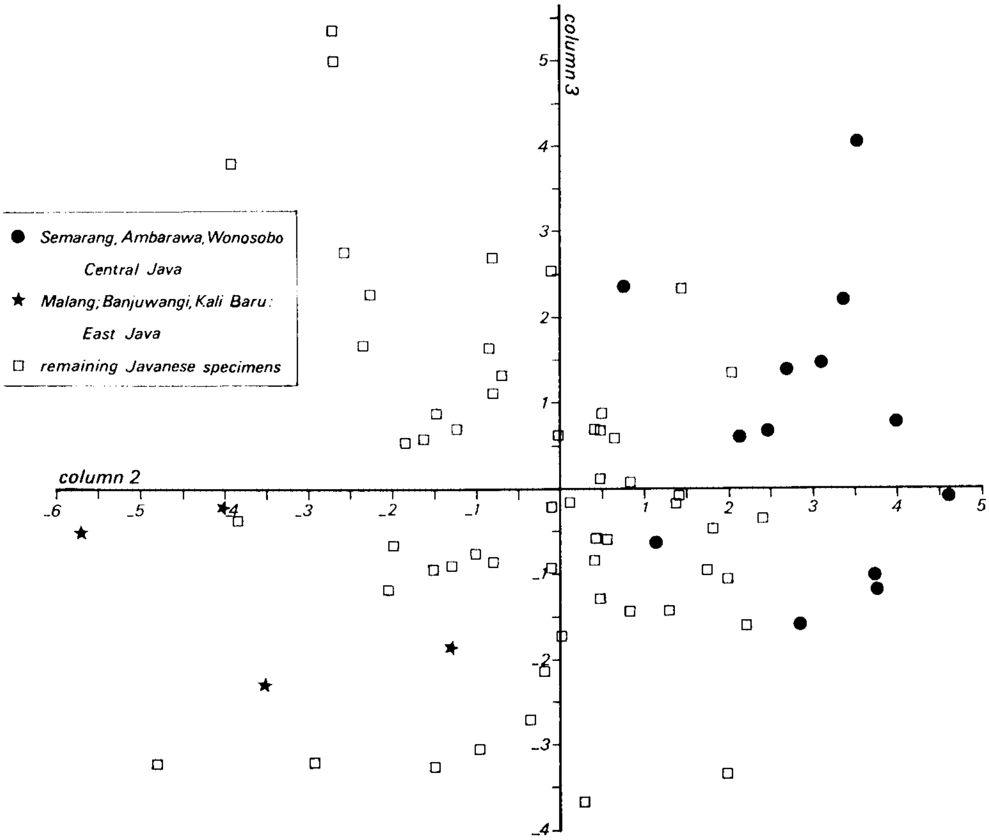

Fig. 20. Plot resulting from a principal components cluster analysis of characters, applied to the Javanese samples of *Heterometrus c. cyaneus* (Koch); some particular localities are indicated.

Stridulation organ. This is composed of those faces of the coxae of pedipalp and anterior walking-leg, which are in mutual contact. The pedipalpal component of the organ presents numerous tiny denticles with fine, curved, setae. The leg component of the organ presents a granulate microsculpture.

Trichobothriotaxy. The distribution of trichobothria on the external surface of the fourth pedipalp segment is characteristic (figs. 3b-e). There are: five basal trichobothria, of which *eb1* is close to the basal border and *eb2-5* are inserted according to a more or less transverse line; two subbasal trichobothria (*esb1, 2*); two median trichobothria (*em1, 2*); one subterminal trichobothrium (*est*) of which the position, in comparison with *em2*, is more proximal and closer to *em1*; and three terminal trichobothria (*t1-3*). The external surface of the pedipalp hand shows the following characteristic trichobothriotaxy (figs. 3f-k): three external basal trichobothria (*Eb1-3*), more or less constituting a file, the position of *Eb1* being very close to keel *cve*; one external subbasal trichobothrium (*Esb*) close to *Eb1* and *Eb2*; one dorsal basal trichobothrium (*Db*) close to *Eb3*, these two being separated by keel *cp*; one external subterminal trichobothrium (*Est*); five external terminal trichobothria (*Et1-5*) parallel to the terminal border, *Et1* situated close to *Est*; one dorsal terminal trichobothrium (*Dt*) as far removed from the base as *Et1-5*, close to *Et5* and just dorsal of keel *cp*. The ventral surface of the hand shows only four ventral trichobothria (fig. 3j) of which *V1*, *V2* and *V4* are situated as far from the base as are *Et1*, *Est* and *Esb*, respectively.

Pedipalp hand. The microsculpture of the external surface of the pedipalp hand is seldom represented by mere granulation (without keels, as in *Pandinus* Thorell); in many species a reticulate sculpture and/or keels (generally not very distinct) are found, in some cases combined with granulation. Keels, if present, are characterized by a more or less equal microsculpture: the keel continuing on the fixed digit (*cp*) is not developed into a distinctly stronger ridge dividing a dorsal from an external part of the surface (as is the case in *Ischnurus* Koch). The dentition of the digits is complex in many species (figs. 5, 6: a-d). Generally, it presents a row of ordinary teeth (*do*), interrupted at regular distances, or (if contiguous) flanked by pairs of stout basal teeth (*db*), and in many species moreover flanked by an internal (*gi*) and an external (*ge*) series of accessory teeth. This fundamental arrangement is often much obscured by irregularly denticulate edges.

Walking-legs. The inferior surface of the telotarsus shows two rows of spines: an anterior row containing 3-6 spines and a posterior row containing 4-7 spines. Of each series two spines are inserted on a telotarsal lobe projecting from the terminal end (fig. 1c).

Paraxial organ. The hemispermatophore has a well-developed accessory distal lobe (*lda*) protruding between the articular suture and the distal lobe (fig. 7).

Mesosoma. The two longitudinal furrows in sternite 5 are incomplete and not continued to the posterior border.

Metasoma. Distinct dorsal keels are present, all denticulated in most species. The venom vesicle bears seriate granulation.

Biometric characters (general values; to the values indicated with an asterisk there are a few exceptions mentioned with the respective descriptions):

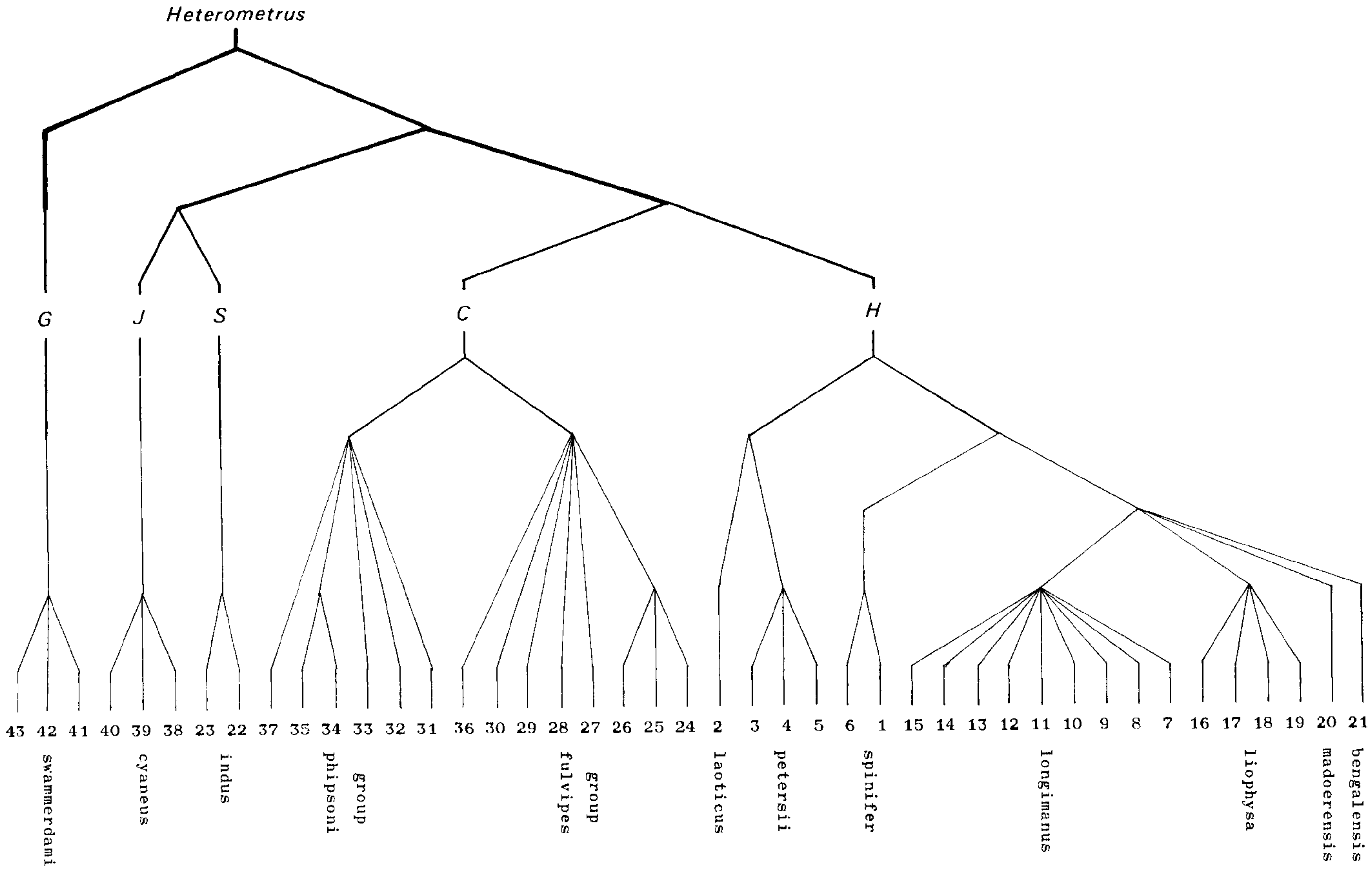

Fig. 21. Diagram of hypothetical affinities between *Heterometrus* taxa, with indications of particular species, species-groups and subgenera: *G*, *Gigantometrus*; *J*, *Javanimetrus*; *S*, *Srilankametrus*; *C*, *Chersonesometrus*; *H*, *Heterometrus*.

	char. no. 34: <2.9		char. no. 71: means $<1.30^*(-1.50)$
	51: $>.63$		
♂,	char. no. 70: $\leqslant 2.7$		
♀,	char. no. 42: $\geqslant 11$ mm*		char. no. 70: $<2.75^*$
	44: $>.7^*$		99: 2.55-3.30 or 3.65-4.15*

KEY TO THE SPECIES AND SUBSPECIES

As a result of taxonomic methods applied in the present study, the key presents polythetic features, by which the use of the key is complicated. In almost every couplet several characters are involved, many of which are biometric. In some cases quite a number of measurements have to be taken and a (small) series of specimens should preferably be studied (premised that the specimens represent only one subspecies or species). Lists of characters used are given in tables 7 and 9. Except for those taxa based on subadult specimens, only adult specimens can be identified by this key, but subadults of *Heterometrus* species do not differ from adults to such a degree, that the construction of a separate key for the subadults would be necessary. For biometric characters, the mean value is given; in parentheses the observed limits of variation are mentioned, with addition of the standard deviation (s) of the distribution of measurements.

1. Very large animal (trunk length in most specimens 11-15 cm); pedipalp hand with almost straight dorsal keel and large proximal lobe, its external surface coarsely granulate, not or fainty keeled; teeth of dorsal and lateral metasomatic keels numerous, uniform and in a regular line. (sum of the lengths of segments 1-5 of metasoma) : (median length of carapace) $\geqslant 3.6$ in ♂, $\geqslant 3.5$ in ♀. (India, Sri Lanka; (*Gigantometrus*) *swammerdami*) 2
— Character combination given above does not fit 4
2. Fine granulation or denticulation present on the (latero)posterior border of mesosomatic sternite 4. Number of teeth per pecten in ♂: $\geqslant 20$. (India) . . . . *swammerdami flavimanus* (p. 164)
— (Latero)posterior border of mesosomatic sternite 4 smooth. Number of teeth per pecten in ♂ not exceeding 19 3
3. External surface of pedipalp segment 4 coarsely granulated. (distance between hand trichobothria *V1* and *V4*) : (distance between *V3* and *V4*) in ♀ $\geqslant 2.7$; number of teeth per pecten in ♂: 18. (India) . . . . *s. swammerdami* (p. 162)

— External surface of pedipalp segment 4 smooth or uneven. (distance between hand trichobothria $V1$ and $V4$) : (distance between $V3$ and $V4$) in ♀ = 1.7; number of teeth per pecten in ♂ not exceeding 17. (Sri Lanka) . . . . *swammerdami titanicus* (p. 165)

4. Superciliary crests type 4 (table 3; fig. 2a); pedipalp hand microsculpture type 7 (table 4; fig. 4); size of teeth on lateral metasomatic keels increasing from the basal to the terminal end of the metasoma. Number of postero-inferior telotarsal spines: 4 (leg III; in some specimens 5 spines) and 5 (leg IV) respectively. (Indonesia; (*Javanimetrus*) *cyaneus*). 5

— Mostly none of the above characters, but certainly not the combination of these 7

5. Medioposterior borders of mesosomatic tergites 1-6 smooth. (Madura) . . . . *cyaneus insulanus* (p. 131)

— Medioposterior borders of mesosomatic tergites 1-6 granulated . 6

6. Median and posterior areas of the carapace punctate, as are the mesosomatic tergites; dorsal surface of metasomatic segment 5 smooth. (length of this segment) : (length of its lateral keel) = 2.0 (1.6-2.6; s = .2); ventral length of the pedipalp hand in ♂: 13.0 mm (10.0-15.2; s = 1.2); slight sexual dimorphism in the ratio of ventral length and maximum width of pedipalp hand (char. no. 45: 1.09). (Java, Borneo) . . . . *c. cyaneus* (p. 126)

— No punctation on carapace and tergites; dorsal surface of metasomatic segment 5 mostly furnished with granules. (length of this segment): (length of its lateral keel) = 2.5 (2.4-2.6; s = .1); ventral length of pedipalp hand in ♂: 15.4 mm (14.7-16.1; s = 1.0); no sexual dimorphism in the ratio of ventral length and maximum width of the pedipalp hand (char. no. 45: 1.02). (Sumatra, Nicobar Islands) . . . . *cyaneus sumatrensis* (p. 130)

7. Superciliary crests type 1; pedipalp hand microsculpture type 2 or 4; denticulation of lateral metasomatic keels strongly reduced. (Sri Lanka; south-east India: Madras; (*Srilankametrus*) *indus*) 8

— No combination of the characters mentioned above 9

8. Pedipalp hand microsculpture type 4; no distinct (coarse) granulation on the external surface of pedipalp segment 4; ventral intercarinal areas on metasomatic segment 5 not smooth (there are not only a pair of teeth halfway the segment, but also granulation is present). (Sri Lanka) . . . . *i. indus* (p. 121)

— Pedipalp hand microsculpture type 2; coarse granulation on external surface of pedipalp segment 4; smooth ventral intercarinal areas on metasomatic segment 5 (except for a pair of teeth halfway the segment). (India) . . . . *indus laevitensus* (p. 124)

9. Superciliary crests type 5 or 6 (except for material from Laos, some Vietnamese and some Philippine specimens: types 2, 3 and 4 respectively; these have stout and sharp internal teeth on pedipalp segment 3); these specimens, however, show pedipalp hand microsculpture type 14); rostrolateral edge of the carapace has an (in most cases distinct) incision next to the lateral eyes; pedipalp hand microsculpture types 6 to and including 15 are possible. (Regions eastward from Bangladesh; (*Heterometrus*)) 10

— Superciliary crests type 1, 2, 3 or 4; no incision in the rostrolateral edge of the carapace next to the lateral eyes; pedipalp hand microsculpture types 1, 2, 3, 5 and 7 are possible. (India, (*Chersonesometrus*)) 30

10. Superciliary crests type 2, 3 or 5 11

— Superciliary crests type 4 or 6 14

11. Superciliary crests type 2 . . . . *laoticus* (p. 94)

— Superciliary crests type 3 or 5 12

12. (distance between hand trichobothria *Et2* and *Dt*) : (length of the continuation of *Et2*-*Dt* till the dorsal keel) $\geqslant$.8; (distance between *V1* and *V4*) : (distance between *V3* and *V4*) in ♀ $\leqslant$5.2. (Burma or more eastward) 13

— (distance between hand trichobothria *Et2* and *Dt*) : (length of the continuation of *Et2*-*Dt* till the dorsal keel) = .7; (distance between *V1* and *V4*) : (distance between *V3* and *V4*) in ♀ = 5.3. (Sri Lanka) . . . . *spinifer solitarius* (p. 93)

13. Pedipalp hand microsculpture type 14; distinct incision in rostrolateral edge of carapace next to the lateral eyes. Angle formed by the longitudinal axis of pedipalp segment 4 and the line *esb1*-*esb2* on its external surface: 99° (58-128; s = 14). (Malacca, Thailand, Cambodia, sporadically Vietnam) . . . . *s. spinifer* (p. 89)

— Pedipalp hand microsculpture type 10; very faint incision in rostrolateral edge of carapace next to the lateral eyes. Angle formed by the longitudinal axis of pedipalp segment 4 and the line *esb1*-*esb2* on its external surface: 62° (44-87; s = 9). (Vietnam, sporadically in Laos, Cambodia, Thailand) . . . . *p. petersii* (p. 96)

14. Pedipalp hand microsculpture type 7; superciliary crests type 4 (Luzon) . . . . *petersii luzonensis* (p. 99)

— Pedipalp hand microsculpture type not 7; superciliary crests type 6 15

15. Pedipalp hand microsculpture type 11 or 12 16

— Pedipalp hand microsculpture type not 11 nor 12 23

16. Lateral borders of mesosomatic sternites 2-4 finely granulated or denticulated. Angle formed by the longitudinal axis of pedipalp segment 4 and the line *esb1-esb2* on its external surface: 38°. (Mindanao) . . . . *petersii mindanaensis* (p. 97)

— Lateral borders of mesosomatic sternites 2-4 smooth. Angle formed by the longitudinal axis of pedipalp segment 4 and the line *esb1-esb2* on its external surface: 80°-96° (57-126; s = 11 and 15 respectively). 17

17. Length of ventral side of movable pedipalp digit, as a ratio to that of the hand: 1.28 (1.22-1.36; s = .07). (Philippine islands: Tarawakan, Luzon) 18

— Length of ventral side of movable pedipalp digit, as a ratio to that of the hand: 1.13-1.16 (1.00-1.25; s = .07 for both means) . . . 19

18. Carapace granulated all over, as is its medioposterior border; pedipalp hand relief type 12; distinct denticulated protuberances on mesosomatic tergite 7. (distance between *eb* and apex of fixed pedipalp digit): (distance between *et* and apex) = 4.6 (4.0-5.1; s = .04). (Tarawakan) . . . . *longimanus tarawakanensis* (p. 108)

— Carapace with smooth areas or smooth medioposterior border; pedipalp hand relief type 11; lateroposterior denticulated protuberances on mesosomatic tergite 7 are indistinct. (distance between *eb* and apex of immovable pedipalp digit) : (distance between *et* and apex) = 3.9 (2.9-4.3; s = .5). (Luzon) . . . . *longimanus humilis* (p. 109)

19. In ♀ (distance between hand trichobothria *V1* and *V4*) : (distance between *V3* and *V4*) = 4.2-4.5 (3.5-6.8; s = .3 and .7 respectively); in ♂ the length of the ventral side of the hand: 17.0-17.4 mm (13.9-18.9; s = 1.5 and 1.0 respectively) and total length of pectinal shaft: 8.9-9.0 mm (7.5-9.9; s = .4 and .7 respectively). (Belitung, Bangka, Riau archipelago) 20

— In ♀ (distance between hand trichobothria *V1* and *V4*) : (distance between *V3* and *V4*) = 3.2-3.3 (2.8-3.8; s = .7 and .3 respectively); in ♂ not a combination of the above-mentioned values for ventral hand length and total length of the pectinal shaft. (Philippines, Borneo, Bengkalis island near Sumatra) 21

20. Distinct incision in the rostrolateral edge of the carapace next to the lateral eyes. (distance between hand trichobothria *Et2* and *Dt*) : (length of the continuation of *Et2-Dt* till the dorsal keel) = 1.3 (.4-2.3; s = .4). (Belitung, Bangka) . . *longimanus belitungensis* (p. 105)

— Very faint incision in the rostrolateral edge of the carapace next to the lateral eyes. (distance between hand trichobothria *Et2* and *Dt*) : (length of the continuation of *Et2-Dt* till the dorsal keel) = 1.9 (1.0-2.6; s = .3). (Riau archipelago) . . . . . *longimanus paris* (p. 106)

21. Carapace with smooth areas. (distance between *Et2* and *Dt*) : (length of the continuation of *Et2-Dt* till the dorsal keel) = 1.7 (.9-2.6; s = .4). (Bengkalis island near Sumatra) . . . . *longimanus bengkalitensis* (p. 106)
— Carapace granulated all over. (distance between *Et2* and *Dt*) : (length of the continuation of *Et2-Dt* till the dorsal keel) = 1.4-1.5 (.9-2.5; s = .2 and .3 respectively). (Borneo, Philippines) 22
22. Carapace with marbled colour-pattern. (Palawan, Balabac) . . . . *longimanus marmoratus* (p. 109)
— Carapace without marbled colour-pattern. (Borneo) . . . . *longimanus borneensis* (p. 104)
23. Pedipalp hand microsculpture type 13. (Java, Sumatra) . . 24
— Pedipalp hand microsculpture type not 13, but 6, 8 or 9 . . 25
24. Distinct incision in the rostrolateral edge of the carapace next to the lateral eyes. In ♀ (sum of lengths of metasomatic segments 1-5): (length of segment 5) = 3.3 (2.9-3.5; s = .1), in ♂ idem: 3.3 (3.0-3.5; s = .1); in ♂ the length of the internal side of pedipalp segment 4: 12.4 mm (9.0-16.0; s = 1.7). (Sumatra) . *l. longimanus* (p. 100)
— Very faint incision in the rostrolateral edge of the carapace next to the lateral eyes. In ♀ (sum of lengths of metasomatic segments 1-5) : (length of segment 5) = 3.1 (3.0-3.4; s = .1), in ♂ idem: 3.0 (2.8-3.1; s = .1); in ♂ the length of the internal side of pedipalp segment 4: about 16 mm (Java) . . . . . *longimanus angustimanus* (p. 103)
25. Pedipalp hand microsculpture type 6. (Madura) . *madoerensis* (p. 116)
— Pedipalp hand microsculpture type not 6, but 8 or 9 . . . 26
26. Pedipalp hand microsculpture type 9 27
— Pedipalp hand microsculpture type 8 29
27. Very faint incision in the rostrolateral edge of the carapace next to the lateral eyes; relatively small lateral eyes (ratio of the sum of diameters and the sum of mutual distances (character number 130): 1.5). Length of ventral side of movable pedipalp digit, as a ratio to that of the hand: 1.15 (1.03-1.26; s = .08); angle formed by the longitudinal axis of pedipalp segment 4 and the line *esb1-esb2* on its external surface: 70° (50-98; s = 12). (Burma). . . . . . *bengalensis* (p. 117)
— Distinct incision in the rostrolateral edge of the carapace next to the lateral eyes; lateral eyes relatively large (ratio of sum of diameters and the sum of mutual distances (character number 130): 2.0-3.6). Length of the ventral side of the movable pedipalp digit, as a ratio to that of the hand: 1.17-1.27 (1.04-1.31; s = .11 and .04 respectively); angle formed by the longitudinal axis of pedipalp segment 4 and the line

esbi-esb2 on its external surface: 90°-114° (61-139; s = 31 and 13, respectively). (Indonesia) 28

28. More than two prominent teeth on the internal surface of pedipalp segment 4. Length of the ventral side of the movable pedipalp digit, as a ratio to that of the hand: 1.27 (1.20-1.31; s = .04). (Sumatra) . . . . *l. liophysa* (p. 111)
— Only one prominent tooth on the internal surface of pedipalp segment 4. Length of the ventral side of the movable pedipalp digit, as a ratio to that of the hand: 1.17 (1.04-1.27; s = .11). (Weh island near Sumatra) . . . . *liophysa separatus* (p. 115)
29. Granulation on inferior keels of walking-leg femur IV faint and/or sparse. (shortest distance between trichobothria *t* and *b* on pedipalp segment 4) : (shortest distance between trichobothria *m* and *t*) = 2.0; (distance between *eb* and apex of immovable pedipalp digit) : (distance between *et* and apex) = 3.3; length of metasomatic segment 5, as a ratio to the length of its lateral keel: 2.5. (Babi island near Sumatra) . . . . *liophysa spartanicus* (p. 115)
— Inferior keel of walking-leg femur IV densely granulated. (shortest distance between *t* and *b* on pedipalp segment 4) : (shortest distance between *m* and *t*) = 2.5 (2.1-3.0; s = .2); (distance between *eb* and apex of immovable pedipalp digit) : (distance between *et* and apex) = 4.6 (3.1-5.4; s = .6); length of metasomatic segment 5, as a ratio to the length of its lateral keel: 1.9 (1.6-2.4; s = .3). (Nias island, Mentawei and Batu archipelagos) . . . *liophysa laevifrons* (p. 114)
30. Dorsal surface of metasoma smooth (no granules). (sum of lengths of metasomatic segments 3 and 4) : (median length of carapace) = .95 (.90-1.00; s = .04) 31
— Dorsal surface of the metasoma with granules. (sum of lengths of metasomatic segments 3 and 4) : (median length of carapace) = 1.04-1.42 (1.00-1.92; s = .04 and .21, respectively) 32
31. Pedipalp hand relief type 7 (without variations); superciliary crests type 3; frontal areas of carapace with numerous, partly confluent, granules; no lateral keels on metasomatic segment 5 . . . *liurus* (p. 153)
— Pedipalp hand relief type 1; superciliary crests type 4; frontal areas of carapace finely granulated, these granules being separate, not confluent; lateral keels on metasomatic segment 5 present . *collinus* (p. 155)
32. Pedipalp hand very flattened and broad, in ♂ even with concave external surface; large species: sum of lengths of metasomatic segments 1-5 in ♂: 53.9 mm (52.0-55.7; s = 2.6), in ♀: 48.3 mm (47.1-49.5; s = 1.7) . . . . *pelekomanus* (p. 137)

— Pedipalp hand not very flattened and/or broad, certainly not concave on the external side; species smaller than indicated above . . 33
33. Pedipalp hand relief type 2 34
— Pedipalp hand relief type not 2 35
34. Superciliary crests type 3; 3 antero-inferior spines on telotarsi III, 4 on telotarsi IV; 5 postero-inferior spines on telotarsi III, 6 on telotarsi IV . . . . *granulomanus* (p. 142)
— Superciliary crests type 4; 5 antero-inferior spines on telotarsi III and IV; 6 postero-inferior spines on telotarsi III, 7 on telotarsi IV . . . . *tristis* (p. 157)
35. Pedipalp hand microsculpture type 3 . . . *fastigiosus* (p. 140)
— Pedipalp hand microsculpture type not 3 36
36. Ventral intercarinal areas of metasomatic segment 5 smooth (except for a pair of teeth halfway the segment) 37
— Ventral intercarinal areas of metasomatic segment 5 granulated . 38
37. Superciliary crests type 4; pedipalp hand microsculpture type 1 . . . . *p. phipsoni* (p. 149)
— Superciliary crests type 3; pedipalp hand microsculpture type 7 . . . . *phipsoni kanarensis* (p. 151)
38. No fine granulation or denticulation on the lateral borders of mesosomatic sternites 2-4 39
— Fine granulation or denticulation on the lateral borders of mesosomatic sternites 2-4 41
39. Pedipalp hand microsculpture type 7. Length of ventral side of movable pedipalp digit, as a ratio to that of the hand: 1.49 (1.42-1.56; s = .06) . . . . *s. scaber* (p. 144)
— Pedipalp hand microsculpture type 1 or 5. Length of ventral side of movable pedipalp digit, as a ratio to that of the hand: 1.18-1.24 . 40
40. Pedipalp hand microsculpture type 5. Angle *Eb1-Esb-Eb2*: 86° (83-89; s = 4); length of metasomatic segment 5, as a ratio to the length of its lateral keel: 2.5 . . . . *scaber rugosus* (p. 146)
— Pedipalp hand microsculpture type 1. Angle *Eb1-Esb-Eb2*: 63° (60-66; s = 4); length of metasomatic segment 5, as a ratio to the length of its lateral keel: 1.7 . . . . *scaber obscurus* (p. 147)
41. The size of the terminal tooth of the ventrolateral keels of metasomatic segment 5 equals the size of preceding teeth. (distance between *eb* and apex of fixed pedipalp digit) : (distance between *et* and the apex) = 2.7 (2.4-2.9; s = .2) . . . . . . *xanthopus* (p. 136)
— Terminal tooth of the ventrolateral keels of metasomatic segment 5 distinctly stouter than preceding teeth. (distance between *eb* and apex

of fixed pedipalp digit) : (distance between *et* and apex) = 3.2-3.5 (2.6-4.3; s = .1 and .4 respectively) 42

42. No straight-sided, brightly coloured, triangle on the medioposterior part of the carapace; granulation of inferior keels of walking-leg femur IV is faint and/or sparse (basal part smooth); medioposterior borders of mesosomatic tergites 1-6 smooth; slight sexual dimorphism in the pedipalp hand shape (char. no. 45: 1.08) . . . *wroughtoni* (p. 158)

— Straight-sided, brightly coloured, triangle on the medioposterior part of the carapace present in most specimens; granulation of inferior keels of walking-leg femur IV is dense and complete; medioposterior borders of mesosomatic tergites 1-6 granular; distinct sexual dimorphism in the pedipalp hand shape (char. no. 45: 1.18) . . *fulvipes* (p. 133)

Subgenus **Heterometrus** Hemprich & Ehrenberg

Synonymy. — Greater part of the species classified by Thorell with *Palamnaeus* Thorell, 1876: 12; this classification was used also by Simon (1884: 360), Pocock (1892a: 38; 1900b: 84) and Henderson (1919: 380).
Heterometrus longimanus group of races Meise, 1932.
Heterometrus, group *spinifer*, Couzijn, 1978: 331 and table 1.
The synonymies mentioned in this paper are restricted to those most relevant to systematic purposes.

Description. — Carapace. The rostrolateral edge has an incision near the posterior lateral eyes (faint in *H.* (*H.*) *p. petersii*, *H.* (*H.*) *petersii mindanaensis*, *H.* (*H.*) *longimanus angustimanus*, *H.* (*H.*) *longimanus paris* and *H.* (*H.*) *bengalensis*). Superciliary crests types 2, 3, 5 or 6. No straight-sided and brightly coloured triangle formed by the medioposterior transverse ridge and the pair of bulges flanking the median furrows posteriorly of the oculiferous bulge.

Pedipalps. The externodorsal keel of segment 3 bears stout and sharp teeth (not in *H.* (*H.*) *madoerensis*). The internal surface of segment 4 bears one prominent tooth (and smaller teeth or granules), except for *H.* (*H.*) *petersii luzonensis* and *H.* (*H.*) *p. petersii*, bearing merely granules or very low teeth, and *H.* (*H.*) *l. liophysa*, *H.* (*H.*) *liophysa laevifrons* and *H.* (*H.*) *liophysa spartanicus*, bearing more than two prominent teeth. Hand relief types 6-15, whilst *H.* (*H.*) *petersii luzonensis* only presents type 7. — Walking-legs. Granulation on inferior keels of femora II-IV is well-developed.

Metasoma. No general reduction of the denticulation on the dorsal and lateral keels (such reduction in *H.* (*H.*) *madoerensis* only), though there is a distinct gradual reduction of the denticulation of the lateral keels, to very fine granulation/denticulation series, from basal to terminal end of the metasoma (this gradual reduction being absent in *H.* (*H.*) *petersii mindanaensis, H.* (*H.*) *petersii luzonensis, H.* (*H.*) *longimanus tarawakanensis, H.* (*H.*) *madoerensis* and *H.* (*H.*) *bengalensis*, partly so in *H.* (*H.*) *laoticus* and *H.* (*H.*) *p. petersii*).

Biometric characters (mean values):

char. nos. and values			taxa (nos.) excepted, with their values	
♂,	17:	1.4-1.7	2, 3, 19, 21:	1.8-1.9
	43:	87-112	1-4:	126-144
	52:	3.5-5.2	1, 12, 14:	3.0-3.4
	83:	15.50-17.00	16-19 (*H. liophysa*):	13.86-14.50
	102:	3.2-3.4	7:	3.0
♀,	17:	1.4-1.7	2, 3, 11, 19, 21:	1.8-2.0
			5:	3.1
	44:	1.1-1.4	3, 5:	.9-1.0
	102:	3.1-3.3	5, 11, 15:	3.4

Distribution (fig. 62). — Eastward from Bangladesh.

1. Heterometrus (Heterometrus) spinifer spinifer
(Hemprich & Ehrenberg)
(figs. 2b, 22, 63)

Buthus (Heterometrus) spinifer Hemprich & Ehrenberg, 1828: Anim. Evert., ...; Scorp.; Tab. I, fig. 2; description of ♂ adult, type-locality "India".
Palamnaeus petersii sensu Thorell, 1877: 214 (non Thorell, 1876: 13; nec *Heterometrus megacephalus* Simon, 1872: 97); Thorell, 1889: 588.
Palamnaeus laevigatus Thorell, 1877: 221.
Heterometrus longimanus (part.) sensu Kraepelin, 1894: 41; 1899: 111; Giltay, 1931: 4; Takashima, 1945: 90.
Palamnaeus oatesii Pocock, 1900b: 98; Giltay, 1931: 4; Takashima, 1945: 94.

Material. — Malacca: Singapore (1 ♂ adult, 1 ♀ ad., RS 0001; 1 ♀ ad., RS 0042; 1 ♂ ad., MCZ (no number); 1 ♀ ad., NMG Scorp. 91 (*P. petersii* sensu Thorell, 1877; non Thorell, 1876!)), Lima Blas (Estate), Malaysia (1 ♂ ad., RS 0028; 1 ♂ ad., 1 ♀ ad., RS 0035), Penang (1 ♂ ad., 1 ♀ ad., RS 0037; 2 ♂ ad., RS 0065; 2 ♂ ad., 2 ♀ ad., RS 0072; 1 ♂ ad., 1 ♀ ad., MCZ 78, 534), Tapah Perak (1 ♂ ad., RS 0038), Perlis (1 ♂ juv., RS 0146), Johore Baru, palm garden (1 ♂ ad., 3 ♀ ad., RS 4559), Kota Tinggi, Johore (1 ♂ ad., 1 ♀ juv., RS 6164; 1 ♂ juv., RS 6166), Kedah (4 ♂ ad. (including neotype), 4 ♀ ad., 2 ♀ subad., leg. Jhr. v. d. Does de Bye 1900, RMNH 290; 1 ♂ juv., 1 ♀ juv., RMNH 295), Malaysia, 5 kms. from Ular, Kuatan (Kuantan), Pahang state (1 ♀ juv., RS 6167), Malaysia, 20 kms. N. of Kuala Lumpur (1 ♂ ad., 1 ♀ ad., CFB, no number), Port Dickson (1 ♀ ad., RMNH 439; 1 ♀ subad., RMNH

499; 1 ♂ ad., RMNH 502), Malacca (1 ♂ ad., RS 0010; 3 ♂ ad., 1 ♀ ad., 1 ♂ juv., RS 0067; 3 ♂ ad., 2 ♀ ad., RS 0073).

Thailand: Pa Rou near Bangtaphan (1 ♂ ad., RS 0016), Bangkok (1 ♀ subad., RS 0024; 1 ♂ ad., 1 ♀ subad., RS 0052; 1 ♂ ad., RS 0396), Thailand (Siam) (1 ♀ ad., RS 0057; 1 ♂ ad., RS 6578; 1 ♀ ad., RS 6579), Ban Lem Ngob (1 ♂ juv., leg. Dr. Th. Mortensen 2-1-1900, UZM, no number), Koh Chang (1 ♂ juv., leg. Dr. Th. Mortensen, UZM, no number).

Cambodia: Houi-Tabo-Phu-Dinh (right bank of the river Sé San in central northern Cambodia) (1 ♂ ad., RS 0132).

South Vietnam: Budop, Cochinchina (1 ♂ subad., RS 0036), Cochinchina (1 ♂ ad., 1 ♀ ad., RS 0115).

Doubtful records: "Nya Hollandia, Melbourne" (1 ♀ ad., type of *P. laevigatus* Thorell, 1877, NMG Scorp. 90), "India" (1 ♂ ad., leg. Biedermann, SMD, no number).

Description. — Carapace. Superciliary crests smooth between the median eyes and (almost) smooth in the rostralmost parts, the remaining parts sparsely and finely granulated (type 5, see table 3, fig. 22a). Lateral eyes relatively large (fig. 2b). Lateroposterior furrows deep. Mediolateral and lateroposterior areas granulated, frontal lobes faintly so, remaining areas smooth (fig. 22b). Medioposterior border smooth, remaining parts of the border granulated.

Pedipalps. Externodorsal keel of segment 3 with stout and sharp denticles, its internodorsal keel with more slender denticles. Internal surface of segment 4 has one very stout and sharp tooth, accompanied by a few (3-5) much smaller and blunter teeth; the external surface of this segment uneven (or reticulated) with smooth, well-developed, keels. External surface of the hand very faintly reticulated (almost smooth) with hardly visible keels (relief type 10, see table 4); its dorsal keel sparsely furnished with stout and sharp teeth. — Walking-legs. Inferior keels on femora I and IV with a few granules, those on femora II and III more densely granulated. Anterior surface of femur I smooth, that of femur II sparsely and finely granulated, those of femora III and IV densely so. Four antero-inferior and seven (occasionally six) postero-inferior spines on telotarsi III and IV. — Pectines. Internal fulcral plates bearing a macroseta, in a few cases a microseta or no seta.

Mesomatic tergites. Lateralmost areas and adjacent parts of the posterior border finely granulated in tergite 1, these granulated areas extended medially on the following tergites, the two granulated areas continuous in tergites 6, or 5 and 6. Median area of tergite 7 almost smooth, furnished with a median tubercle flanked by two pairs of denticulated lateroposterior tubercles. The small median tubercles of the other tergites are flanked by faint, oblong and transverse tubercles which are laterally bordered by furrows running parallel to the finely and densely granulated lateral margins. Lateral borders of tergite 7 granulated, its posterior border smooth except for a few small granules on its median part. — Mesosomatic sternites. Smooth surface with two longitudinal furrows in sternites 1-4 and two quite short ones in sternite 5. Lateral borders finely granulated, though faintly and sparsely so on sternites 1 and 2 or 1-3.

Metasoma (fig. 22c). Dorsal surface smooth except for some plication on segments 1-3. Dorsal keels with stout and sharp denticles, just as the lateral keels on segment 1, but on the following segments the lateral keels show gradual reduction to series of (very) fine teeth or granules on segment 5. Ventrolateral keels smooth on segments 1 and 2, uneven on segment 3, distinctly denticulated on segment 4, stoutly and sharply so on segment 5, its terminal tooth being hardly stouter than the preceding teeth. Ventral keels smooth on segments 1-3, very finely denticulated on segment 4, distinctly and sharply so on segment 5. Fine and very sparse granulations are present on some lateral, ventrolateral and ventral intercarinal areas.

Biometric characters (see table 7: list 1):

char. no.	45: 1.15	char. no.	129: ± .80
	51: 1.5 (s = .4)		130: 2.60-2.70

♂, total median length of neotype: 111 mm

char. no.	17: 1.7 (s = .3)	char. no.	83: 16.71 (s .89)
	43: 127 (s = 19)		102: 3.3 (s = .1)
	52: 3.3 (s = .6)		

♀, total median length of ♀ specimen from sample RMNH 290: 125 mm

char. no.	43: 129 (s = 15)	char. no.	70: 2.2 (s = .1)
	52: 3.5 (s = .5)		102: 3.3 (s = .1)

Distribution (fig. 63). — Regions bordering the Gulf of Siam, viz., mainly in Malacca, more rare in Thailand, Cambodia and South Vietnam; also found on islands along the coast. Type-locality "India" in the original description must be erroneous, because no other records of specimens from India exist (with the exception of another old label mentioning "India", in SMD).

Neotype designation. — Hemprich & Ehrenberg (1828) described an adult ♂ from "India", leg. Morpurgo (an Alexandrian physician). This specimen was donated to the ZMB. It could not be found in this collection nor in several other German museums; it was probably lost during the Second World War. The SMD possesses an old, dried and damaged, ♂ specimen of respectable size (126 mm in total length), showing similarity

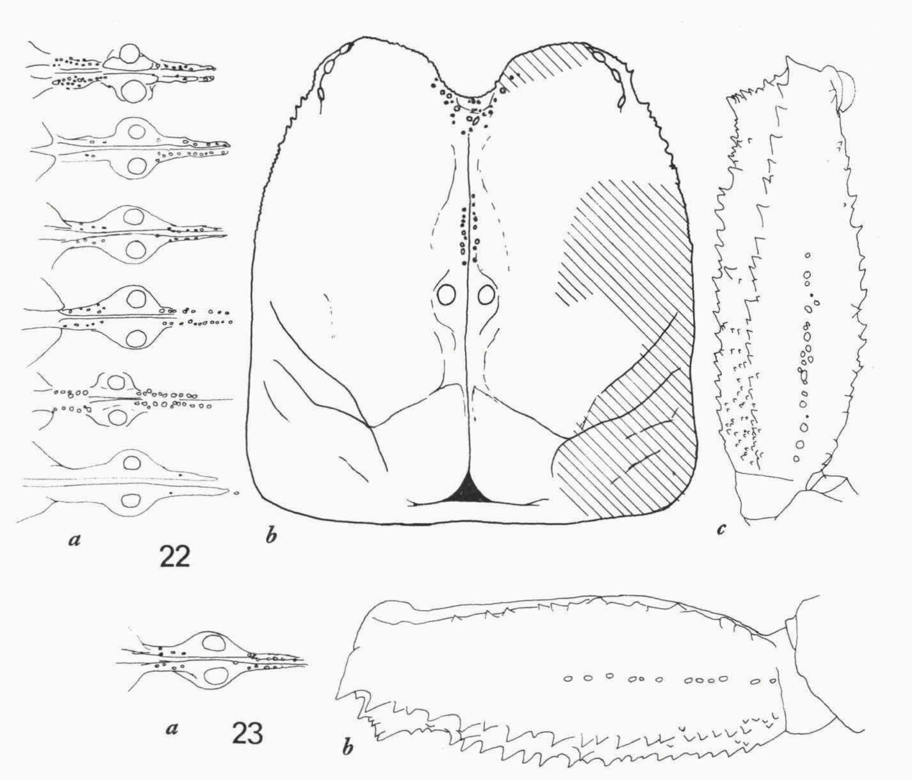

Fig. 22. *Heterometrus* (*H.*) *s. spinifer* (H. & E.); a, observed types of superciliary crests (in order of frequency; antocular parts right); b, carapace (on the right half, granulated areas are shaded); c, right view of metasomatic segment 5 of neotype; a-c, × 3.7.

Fig. 23. *Heterometrus* (*H.*) *spinifer solitarius* subsp. nov., holotype; a, superciliary crests (antocular parts right); b, right view of metasomatic segment 5; a-b, × 3.7.

with the figure and description of the holotype, which, probably, was also a dried specimen. Its label mentions the same (erroneous) locality "India", but no further indication than "*B.*" for *Buthus*. Nevertheless I am sure that this specimen is not the holotype, as it was collected by Biedermann and not by Morpurgo, while its left chelicera is wide open (it was closed in the holotype) and the positions of the left pedipalp hand, the hand and fourth segment of the right pedipalp, and the metasoma (straight instead of slightly curved to the left) are different. A type-specimen should, however, be available because the variability of characters in this genus complicates its taxonomy, as is explained in the first chapter. Such a type should preferably be selected from a large population sample, well-preserved and accurately labelled, and originating from the centre of the distributional area. RMNH 290 is such a large and undamaged sample from Kadeh. The adult ♂ designated as a neotype is complete and identical with the original description.

Remark. — The animal described as *P. laevigatus* Thorell (1877: 221) seems to belong to this species though its hand surface is coarsely reticulated and characters nos. 86 (*r*), 52 and 98 differ somewhat from the typical values. In the description and on the label of this ♀ (kept in NMG) "Melbourne" is indicated as the type-locality, but this probably refers to transportation.

6. **Heterometrus (Heterometrus) spinifer solitarius** subsp. nov.

(figs. 23, 62)

Material. — Sri Lanka: Peradeniya (1 ♀ ad., holotype, leg. unknown, RS 2866).

Description of the adult ♀. — This subspecies differs from the nominal subspecies *H.* (*H.*) *s. spinifer* H. & E. in the following characters.

Carapace. Second lateral eye much closer to the first than to the third. Superciliary crests: see fig. 23a. — Pedipalps. There are 7-10 small teeth (besides the stout and sharp tooth) on the internal surface of segment 4. Dorsal keel of the hand almost straight and sparsely furnished with teeth. Pedipalp hand relief type 15. — Walking-legs. Anterior surfaces of femora finely granulated. Inferior keels on femora regularly denticulated. Four antero-inferior spines on telotarsi III, five on telotarsi IV.

Mesosomatic tergites. On each tergite the posterior half is densely and finely granulated, except for the smooth (or almost smooth) median part. Tergite 7 bears 10-15 stout teeth on its lateroposterior part, its borders are furnished with low and obtuse teeth. — Mesosomatic sternites. Very fine denticulations on the lateral borders of sternite 5 only. — Metasoma (fig. 23b). Dorsal surface smooth. Lateral keels on segments 1-4 strongly denticulated (± 10 teeth per keel), those on segment 5 with slender and pointed teeth (± 25 per keel) the stoutest of which are situated halfway the length of the segment. Anterior third part of the ventral areas of segment 5 granulated, as is the dorsoterminal part of its lateral intercarinal area.

Biometric characters (see also table 7: list 6):

char. no.	51: .7	char. no. 130: 2.31
	129: .64	

♀, total median length of holotype: 109 mm

char. no. 52: 5.3

Distribution (fig. 62). — Only one specimen was found in Peradeniya, Sri Lanka.

Remark. — According to Pocock (1892b: 312), the BM possesses a specimen of *H. "cyaneus"* from Sri Lanka. This could be another representative of *H. spinifer solitarius* or a specimen of *H. indus* (de Geer); the last-mentioned species superficially looks like *H. cyaneus* (Koch). In the collection this specimen could not be found.

2. **Heterometrus (Heterometrus) laoticus** spec. nov.

(figs. 4a, 24, 63)

Material. — Laos: Lakhone (Muang Lakhonphéng?) 1 ♂ ad., 1 ♀ ad., 1 ♂ juv., 1 ♀ juv., RS 0014), Savannachet (1 ♀ ad., 1 of 4 specimens, RS 0050), Luang Prabang (1 ♀ ad., RS 0060; 1 ♀ ad., RS 0066; 1 ♂ ad., 1 ♂ subad., 2 of 6 specimens, RS 0074), Thaxhex (Takhek) (2 ♂ ad., 2 ♀ ad., 4 of 6 specimens, RS 0074), Vientiane (1 ♂ ad., RS 0124), province of Cammon (Khouèng Khammouan), near Kouan Pha Vang, 140 m altitude (1 ♂ ad., 1 ♀ subad., RS 3468), Tathom (Muang Thathôm), river Pakoane (1 ♂ ad., 1 ♀ ad., RS 5272), Laos (3 ♂ ad. including holotype, 1 ♀ ad. allotype, leg. Neïs 1884-1899, RS 0030; 2 ♀ ad., RS 0069).

South Vietnam: Saigon (Ho-Tsji-Minh-city) (1 ♂ ad., RS 0005), Tayninch, Indochina (1 ♂ ad., 1 ♀ ad., 1 ♂ subad., 1 ♂ juv., RS 0075).

Cambodia: Pnom Penh (2 ♂ ad., RS 0130).

Thailand: Siam (1 ♂ ad., RS 0049).

Description. — This species closely resembles *H.* (*H.*) *spinifer* H. & E., but is different by the following characters.

Carapace (fig. 24a). Superciliary crests smooth, their antocular parts quite short, their postocular parts short or even almost absent (type 2; see fig. 24b). All areas smooth. The posterior border smooth or sparsely granulated. — Pedipalps. Internodorsal keel of segment 3 granulated and accompanied by low teeth on the internal surface. External surface of segment 4 almost smooth with very faint reticulation and smooth, hardly developed, keels. The dorsal keel of the hand uneven or faintly denticulated. Hand relief type 14 (fig. 4a). — Walking-legs. Inferior keels on femora I-III granulated, those on femur IV almost smooth (only a few faint granules present near its distal end).

Mesosomatic tergites 1 and 2 (or 1-3) smooth. Posterior borders smooth. — Metasoma (fig. 24c). Dorsal and lateral keels with low and relatively fine denticulation. Ventrolateral keels on segments 1 and 2 faintly and finely denticulated or uneven.

Biometric characters (see also table 7: list 2):

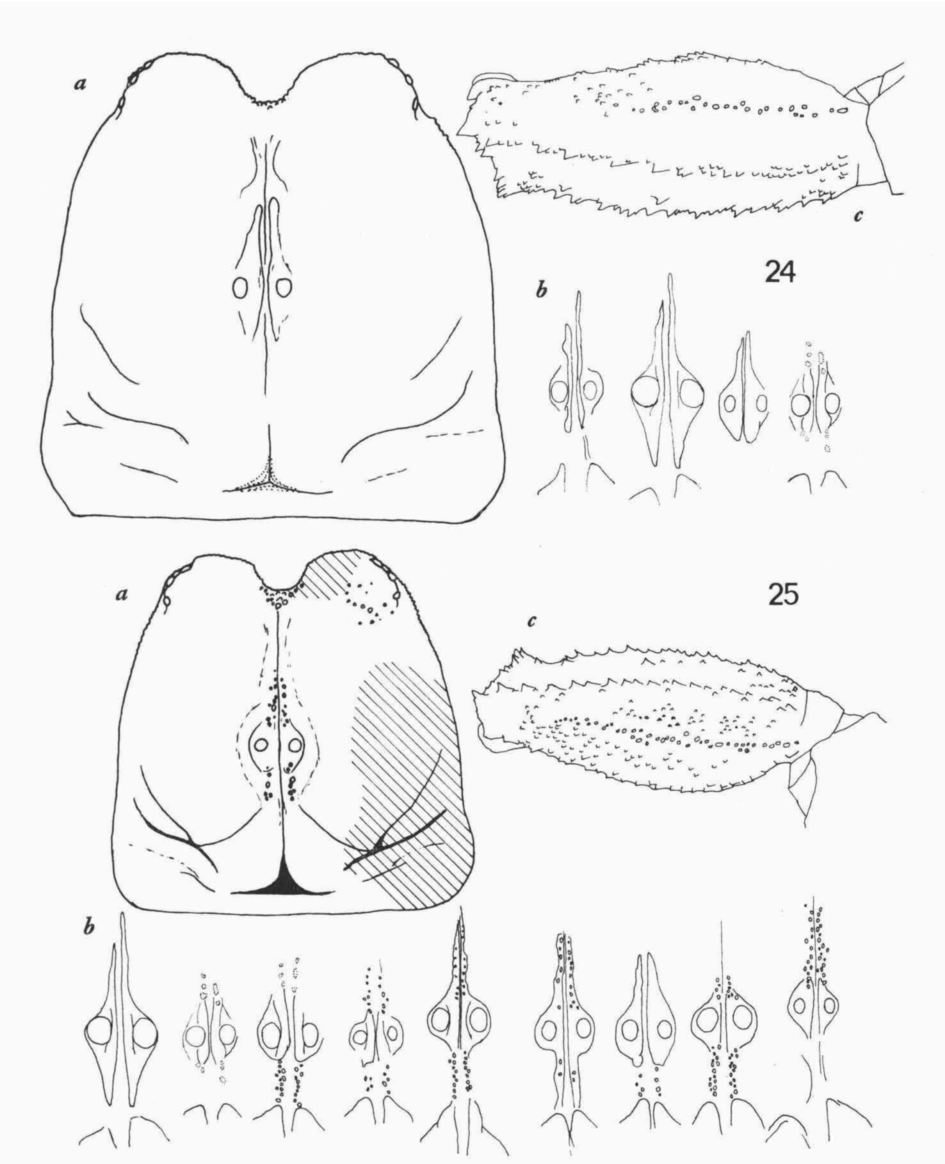

Fig. 24. *Heterometrus* (*H.*) *laoticus* sp. nov.; a, carapace; b, observed types of superciliary crests (most common type left; antocular parts above); c, right lateral view of metasomatic segment 5 of holotype; a-c, × 3.7.

Fig. 25. *Heterometrus* (*H.*) *p. petersii* (Thorell); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (in order of frequency; antocular parts above); c, left view of metasomatic segment 5 of holotype; a-c, × 3.7.

char. no. 30: 65 (s = 9) char. no. 45: .97

♂, total median length of holotype: 117 mm

char. no. 44: 1.0 (s = .1)

♀, total median length of allotype: 117 mm

Distribution (fig. 63). Mainly Laos, more rare in Thailand, Cambodia and South Vietnam.

3. **Heterometrus (Heterometrus) petersii petersii** (Thorell) (figs. 25, 63)

Heterometrus megacephalus sensu Simon, 1872: 97 (non Koch, 1836: 73); description of adult ♂, type-locality Cochinchina.
Palamnaeus petersii Thorell, 1876: 13 (new name for *H. megacephalus* sensu Simon).
Palamnaeus silenus Simon, 1884: 361; Kraepelin, 1894: 41; 1899: 111; Meise, 1932: 666.
Heterometrus longimanus petersi Kraepelin, 1904: 199 (nom. imperf.); Giltay, 1931: 4.

Material. — South Vietnam: Saigon (Ho-Tsji-Minh-city) (1 ♀ ad., RS 0032; 2 ♂ ad., RS 0039; 1 ♀ ad., RS 0137; 1 ♂ ad., 3 ♀ ad., RS 3456), environs of Saigon (1 ♀ ad., RS 3457), Bung Binh, Saigon (2 ♀ ad., 1 ♂ subad., 1 ♀ subad., RS 0026), Ba-Ngoï, Southern Annam (1 ♀ ad., RS 0047), Plateau of Kontoum (1 ♀ ad., 1 of 4 specimens sharing number RS 0050), post of Baria, eastern Cochinchina (3 ♂ ad., 3 ♀ ad., RS 3454), province of Bien-Hoa (1 ♀ ad., RS 3455; 1 ♂ ad., 3 ♀ ad., RS 3458), Giadinh (1 ♂ ad., RS 3459), central Annam (2 ♂ ad., 2 ♀ ad., RS 0053), Cochinchina (1 ♂ ad., RS 0012; 2 ♂ ad., holotype and paratype, leg. Germain, RS 0020; 2 ♀ ad., RS 0033; 2 ♀ ad., 1 ♂ juv., 3 of 4 specimens sharing number RS 0155), Krong Pha (Thôn Sông Pha), at the foot of the Plateau of Lang Biang (Cao Nguyên Lâm Viên) (1 ♀ ad., 1 of 4 specimens, RS 0050), Caúda (Thôn Câu Dá), Vhatrang (1 ♀ ad., RS 0075).
North Vietnam: Tonkin (Gulf of Tongking) (2 ♂ ad., 2 ♀ ad., RS 0051), Bachien (2 ♂ ad., RS 0055).
Cambodia: Kratié (1 ♂ ad., 1 ♀ juv., RS 0041), Angkor (1 ♀ ad., 1 of 4 specimens, RS 0050: 1 ♂ ad., RS 0029).
Laos: Kieng (1 ♀ subad., RS 0061).
Uncertain locality: Indochina (6 ♂ ad., 1 ♀ ad., RS 0029).

Description. — This species resembles *H.* (*H.*) *spinifer* H. & E., but it is different by the following characters.

Carapace. Superciliary crests short, their postocular parts hardly present in some specimens (type 5 or 3; see figs. 25a, b). Second lateral eye much closer to the first than to the third. — Pedipalps. Internal surface of segment 3 with three small teeth. Reticulation on the external surface of segment 4 hardly visible. Dorsal keel of the hand sparsely furnished with small, low and rather obtuse teeth; hand microsculpture type 14. — Walking-legs. Inferior keels on femur I coarsely and sparsely granulated, those on femora II-IV finely and densely so. Anterior surfaces of femora I and II smooth, those of femora III and IV finely and densely granulated. Six (rarely seven) postero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. The almost smooth median areas are rather small. Lateral and posterior borders granulated. The tubercles on tergites 1-6 indistinct, as are the median and lateroposterior tubercles on tergite 7. In the ♂ two distinct macrosetae are inserted in the posterior border of tergites 1-6. — Mesosomatic sternites. Two longitudinal furrows present in sternites 1-4, no furrows in sternite 5. — Metasoma (fig. 25c). Dorsal and lateral keels of segments 1-4 regularly denticulated; these regular denticulations on segment 5 finer. Terminal tooth of the ventrolateral keels of segment 5 stouter than the preceding teeth. Ventrolateral and ventral keels almost smooth or uneven on segment 1, uneven or faintly granulated on segment 2.

Biometric characters (see also table 7: list 3):

char. no. 30: 62 (s = 9)	char. no. 129: ± .65
45: .96	130: ± 2.05
80: 6 (rarely 7)	

♂, total median length of holotype: 103 mm

char. no. 42: 114 (s = 10) char. no. 44: .9 (s = .0)

♀, total median length of ♀ specimen in sample RS 0053: 104 mm

char. no. 44: 1.0 (s = .1)

Distribution (fig. 63). — Mainly Vietnam, more rare in Laos and Cambodia.

Remark. — Takashima (1941: 281) mentioned this form from Hainan, though he admitted that Wu Hsien Wen (1936) denied this and only reported the occurrence of three species of other genera on this island. Kishida (1939: 45) stated that *H.* "*silenus*" occurs in the Chinese province Manchoukuo, but, taking in consideration the far northern position of this locality and the complete absence of preserved specimens from this region (also in Japanese museums), the data are here regarded as doubtful.

4. **Heterometrus (Heterometrus) petersii mindanaensis** subsp. nov.

(figs. 2c, 26, 62)

Material. — Mindanao (1 ♂ ad., holotype, leg. Mantano & Rey, RS 0023).

Description of the adult ♂. — This subspecies differs from the nominal subspecies *H.* (*H.*) *p. petersii* (Thorell) in the following characters.

Carapace. Superciliary crests granulated (except for the smooth interocular part) (type 6; fig. 26a). Lateral eyes relatively small (fig. 2c).

26 a b

27 a b

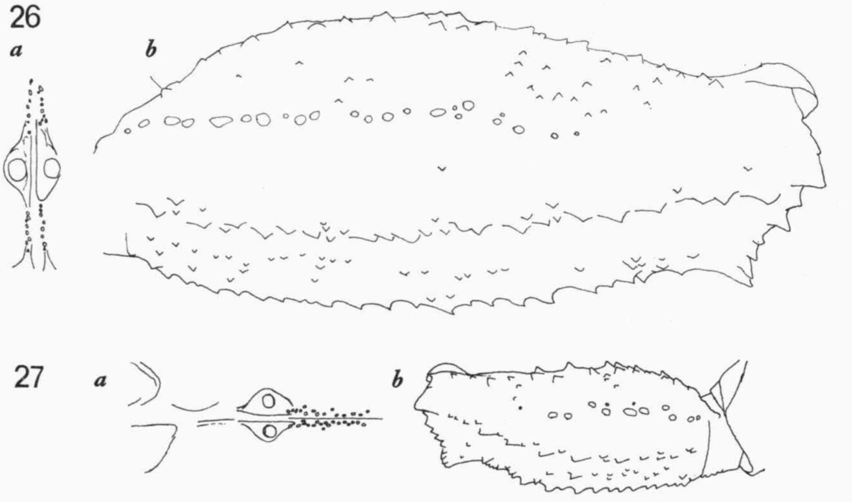

Fig. 26. *Heterometrus* (*H.*) *petersii mindanaensis* subsp. nov., holotype; a, superciliary crests (antocular parts above); b, left view of metasomatic segment 5; a, × 3.7; b, × 6.7.

Fig. 27. *Heterometrus* (*H.*) *petersii luzonensis* subsp. nov.; a, superciliary crests (antocular parts right); b, right view of metasomatic segment 5; a-b, × 3.7.

Posterior border smooth; lateral and rostral borders finely granulated, but smooth in front of the lateral eye-groups. Frontal lobes granulated; lateral areas furnished with a granulation which extends towards the median eyes. — Pedipalps. Three internal teeth on segment 4 somewhat stouter than in *H.* (*H.*) *p. petersii*, accompanied by a few low and small teeth. Dorsal keel of the hand sparsely furnished with low pointed teeth. Hand microsculpture type 11. — Walking-legs. Anterior surface of femur II sparsely and finely granulated.

Mesosomatic tergites. Median part of the posterior border smooth in the case of tergite 1; this smooth part is also present, but very small, in tergites 2 and 3; in tergites 4-7 the corresponding part of the posterior border is faintly granulated; the remaining parts of the posterior border, and the lateral borders, are granulated. Tergites 3-6 with small median tubercle; tergite 7 with large, low, finely granulated tubercle, surrounded by a smooth circular depression; lateroposterior tubercles of tergite 7 distinct and denticulated. Bases of caudal pair of macrosetae swollen and distinct on tergites 5-7. — Metasoma (fig. 26b). Dorsal surface of segments 1-4 finely and sparsely granulated, smooth in the case of segment 5. The teeth of the dorsal keels on segments 2 and 3 stouter than those on the other segments. Ventrolateral intercarinal areas of segments 3 and 4 almost smooth; lateral areas of segment 5 with granulated dorsal part.

Biometric characters (see also table 7: list 4):

char. no. 30: 38 char. no. 130: 1.29
34: 2.1

♂, total median length of holotype: 100 mm

char. no. 42: 118 char. no. 44: .9

Distribution (fig. 62). — Only a single specimen from Mindanao (Philippines) is known.

5. **Heterometrus (Heterometrus) petersii luzonensis** subsp. nov. (figs. 27, 62)

Material. — Mt. Maquiling, Luzon (1 ♀ ad. holotype, 1 ♀ ad. paratype, collector unknown, SMF II/8882/224).

Description of the adult ♀. — This subspecies differs from the nominal subspecies *H. p. petersii* (Thorell) in the following characters.

Carapace. Superciliary crests granulated anteriorly (with smooth postocular part) (type 4; fig. 27a). Frontal lobes granulated; the granulation of the lateral areas extends to the antocular parts of the superciliary crests; remaining areas faintly granulated. — Pedipalps. Internal surface of segment 4 furnished with 5-8 stout (though rather low) teeth, dorsally accompanied by a group of small teeth or granules; its external surface rather smooth with uneven keels, or reticulate-granulate with granulated keels. External surface of the hand distinctly reticulated, without keels (relief type 7); denticulation of its dorsal keel rather variable, sparse and low in one specimen, dense and stout in another. — Walking-legs. Anterior surfaces of femora II-IV densely granulated, that of femur I sparsely so.

Mesosomatic sternites. Borders smooth in one of the specimens. — Metasoma (fig. 27b). Dorsal surface coarsely granulated on segments 1-4, more sparsely so on segment 5. The teeth of the dorsal keels of segments 1-3 smooth or uneven; the terminal ventrolateral tooth on segment 5 distinctly stouter than the preceding teeth. Ventrolateral intercarinal areas of segments 1(-3) smooth and those of segments (2-)4 and 5 granulated.

Biometric characters (see also table 7: list 5):

char. no. 30: 59 (s = 14) char. no. 56: 66 (s = 5)

♀, total median length of holotype: 100 mm

char. no. 29: 64 (s = 3) char. no. 44: .9 (s = .1)

Distribution (fig. 62). — Only two specimens from Mt. Maquiling, Luzon (Philippines) are known.

8. **Heterometrus (Heterometrus) longimanus longimanus** (Herbst) (figs. 2d, 28, 64)

Scorpio longimanus Herbst, 1800: (4) 42, description of adult ♂, type-locality "Africa".
Buthus costimanus Koch, 1838: 27.

Material. — Sumatra: Gunung Leuser Reserve, N. Sumatra, ladang near Ketambe (1 ♂ ad., RMNH, no number), Deli (Bekri) (8 ♂ ad., 4 ♀ ad., 1 ♀ subad., RMNH 87; 1 ♂ ad., 3 ♀ ad., RMNH 122; 3 ♂ ad., 2 ♀ ad., 1 ♂ subad., RMNH 128), Deli, N. Sumatra (2 ♂ ad., 1 ♀ ad., 1 sp. without metasoma, RS 0027; 1 ♀ ad., RS 0043), Gedong Djohore, Deli (1 ♀ ad., RMNH 294; 1 ♂ ad., RMNH 296; 1 ♂ ad., RMNH 297), river Bedagnok, Deli (2 ♂ ad., RS 0068), Tandjong, Deli (3 ♂ ad., 1 ♀ ad., RS 0397), environs of Medan, E. coast of Sumatra (2 ♀ ad., RMNH 288), Tandjong Morawa (4 ♂ ad., 3 ♀ ad., RMNH 88), Serdang (2 ♂ ad., RMNH 84), Tanah-Gambus (1 ♂ ad., RS 0044), Solok (1 ♂ ad., 1 ♀ ad., RMNH 125), Gunung Talang, 1000 m (1 ♂ ad. neotype, 2 ♀ ad., leg. v. Duivenbode & E. Jacobson 1926, RMNH 291), Lahat (2 ♂ ad., 2 ♀ ad., 1 ♂ subad., 1 ♀ subad., RMNH 79), Palembang (1 ♀ ad., RMNH 77), Palembang, Nirou forest, E. coast of Sumatra (2 ♂ subad., RS 3475; 1 ♀ juv., RS 5270).

Description. — Carapace (fig. 28a). Superciliary crests complete and granulated (except for the smooth interocular part), confluent with the medioposterior pair of tubercles (type 6; fig. 28b). Second lateral eye much closer to the first than to the third (fig. 2d); lateral eyes relatively large. Rostral border granulated except for a smooth part in front of the lateral eyes; posterolateral and lateral borders bearing fine granules (obtuse teeth next to the lateral eyes); medioposterior border smooth. Frontal area faintly granulated; frontal lobes granulated in the ♀, faintly granulated in the ♂; small area around the median eyes smooth; lateral areas granulated, posterolateral areas almost smooth (rarely granulated).

Pedipalps. Dorsal keels of segment 3 strongly denticulated. The internal surface of segment 4 bears one stout, pointed tooth and 8-12 smaller teeth; the external surface with reticulated intercarinal areas and prominent, smooth keels. Hand slightly dilated in the male, considerably dilated in the female. External surface of hand faintly reticulated; keels smooth and clearly visible (♂) or very faint (♀) (relief type 13); its dorsal keel slightly curved and furnished with low and sharp teeth. — Walkings-legs. Anterior surfaces of femora granulated. Inferior keels of femora II-IV distinctly granulated; keel of femur I granulated in the terminal part only, while the basal part is uneven. — Pectines. The internal fulcral plates each bear a macroseta.

Mesosomatic tergites. Tergite 1 bears some granules on the most lateroposterior part of its surface; this granulation extends on the following tergites. The adjacent part of the borders also granulated; on tergite 7 only the two parts of the posterior border at both sides of the median part are smooth. The granulation on tergites 1-6 is fainter in the ♂ than in the ♀. Every tergite has a distinct median bulge. — Mesosomatic sternites. Smooth surface; sternites 1-4 with clearly visible pairs of longitudinal furrows, which in sternite 5 are short (♂) or faint (♀). Borders smooth except for the uneven lateral borders of sternite 5 in the ♀.

Metasoma (fig. 28c). Dorsal surface granulated on segment 1, furnished with only a few, very small, granules on the following segments; segments 1-3 with a plicate or reticulated aspect. All metasomatic keels (if denticulated) have fine and very regular dentition (more or less in a line). The teeth on the dorsal keels of segment 1 are obtuse; they become gradually sharper on the following segments and are somewhat smaller on segment 5. The teeth of the lateral keels have the same size as the dorsal teeth in the case of segment 1; they gradually become smaller on the following segments, till on segment 5 they are similar to the granules of the dorsolateral surfaces. Ventral and ventrolateral keels smooth on segments 1 and 2, faintly denticulated on segment 3, distinctly denticulated on segment 4, whilst the teeth on segment 5 resemble the dorsal teeth on segments 1-4; the terminal ventrolateral tooth of segment 5 resembles the preceding teeth. Intercarinal areas of the laterodorsal, lateroventral and ventral surfaces of segments 1-4 granulated except for the smooth areas flanking the medioventral area on segment 1; the ventral areas of segment 5 granulated.

Biometric characters (see table 7: list 8):

char. no. 45: 1.36 char. no. 129: .53-.62
71: 1.11 (s = .07) 130: ± 2.35

♂, median length of the neotype: 100 mm

char. no. 29: 124 (s =17) char. no. 102: 3.3 (s = .1)

♀, total median length of ♀ specimen from sample RMNH 291: 130 mm

char. no. 52: 3.8 (s = .6) char. no. 102: 3.3 (s = .1)

Distribution (fig. 64). — Sumatra. The original record of the type-locality "Africa" must be erroneous, since no other *Heterometrus* specimens have ever been found in that continent.

Remark. — According to handwritten personal notes by Kopstein in a copy of his 1921 paper (now in the library of the RMNH), this form was found also on the Sula islands (coll. Denin, Buitenzorg Museum, not examined in the present study). This is, however, not mentioned in a later publication (1923) on the Buitenzorg collection. It is possibe that he meant the Sulu islands (see subspecies *H. longimanus tarawakanensis* below).

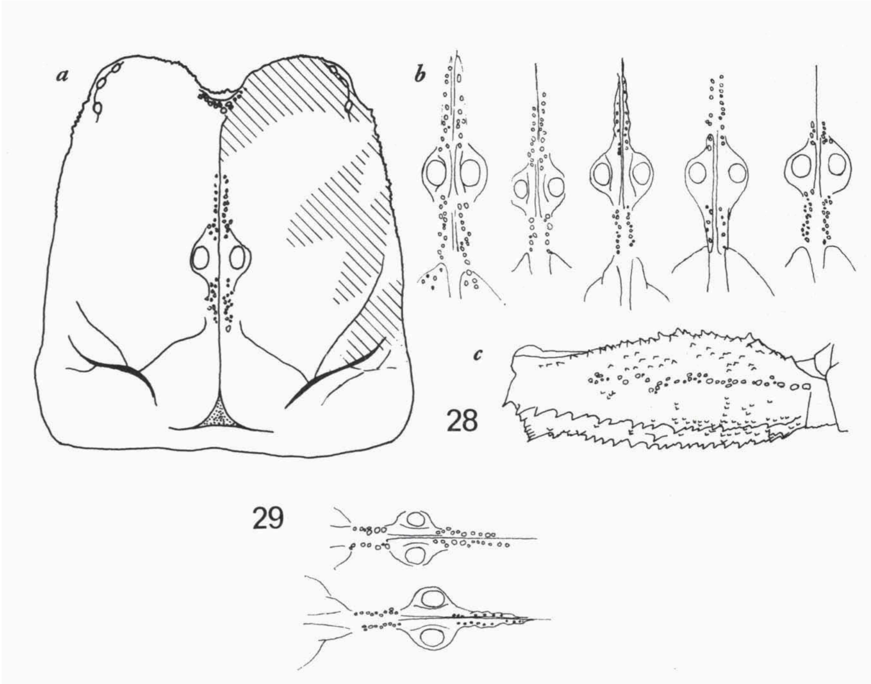

Fig. 28. *Heterometrus* (*H.*) *l. longimanus* (Herbst); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (most common type left; antocular parts above); c, right view of metasomatic segment 5 of neotype; a-c, × 3.7.

Fig. 29. *Heterometrus* (*H.*) *longimanus angustimanus* (Thorell): observed types of superciliary crests (antocular parts right), × 3.7.

Neotype-designation. — Herbst (1800: 42) described an adult ♂ from "Africa"; this specimen belonged to the Museum of Baron de Block. This collection could not be traced, though several arachnologists and German museums were consulted. The variability of characters in this genus and, consequently, the taxonomic difficulties (as explained in the first chapter) necessitate the availability of a well-preserved and accurately labelled specimen for reference, preferably forming part of a large sample. RMNH 291 (leg. van Duivenbode & E. Jacobson 1926) is an undamaged and accurately labelled sample containing specimens of both sexes. They are collected on the Gunung Talang (1000 m altitude) in the centre of the distribution area. From the original (erroneous) locality "Africa" no specimens exist. The adult male designated as a neotype is complete and fits well with the original description.

7. **Heterometrus (Heterometrus) longimanus angustimanus** (Thorell) (figs. 29, 64)

Palamnaeus angustimanus Thorell, 1877: 211, description of adult ♂, original locality: East Indies.

Material. — Krapjak, Java (1 ♂ ad., 6 ♀ ad., 1 ♀ ad./subad.?, 2 ♂ juv., leg. Kannegieter 1892, RMNH 85), East Indies (1 ♂ ad. holotype, NMG Scorp. 87).

Description. — This subspecies differs from the nominal subspecies *H. l. longimanus* (Herbst) in the following characters.

Carapace. Second lateral eye less close to the first eye. Frontal lobes faintly granulated. Superciliary crests: see fig. 29. — Pedipalps. External surface of segment 4 with uneven intercarinal areas (faintly reticulated in the ♀). The hand of the ♂ very slender and elongate, that of the ♀ slightly dilated; the keels on the external surface smooth and clearly visible; its dorsal keel almost straight in the ♂, slightly curved in the ♀, provided with sharp teeth. — Walking-legs. Anterior surfaces of the femora finely granulated in the ♀, this granulation restricted to femur IV and (and less on femur III) in the ♂. Inferior keels of femora II and III in most specimens entirely granulated; those of femora I and IV granulated in their terminal part only, while their basal part is uneven. — Pectines. Internal fulcral plates furnished with a macro- or microseta.

Mesosomatic tergites. Posterolateral areas of tergites 1-5 faintly and finely granulated. Tergites 3-7 provided with a median tubercle flanked by two lateral tubercles. Lateral margins of tergites 1-6 densely and finely granulated. Lateral borders of tergite 7 obtusely denticulated; posterior borders faintly granulated except for the smooth median parts of tergites 1-6 (♂) or 1-5 (♀). The posterolateral area of tergite 7 bears a few prominent teeth. — Mesosomatic sternites. Lateral borders smooth or uneven.

Biometric characters (see table 7: list 7):

char. no. 129: ± .70 char. no. 130: ± 3.00

♂, total median length of holotype: 114 mm

char. no. 29: 158 char. no. 102: 3.0 (s = .1)

♀, total median length of ♀ specimen from sample RMNH 85: 105 mm

char. no. 102: 3.1 (s = .1)

Distribution (fig. 64). — Krapjak (Java); also recorded from Salak, Taluk and Sukabumi (Java) by Kopstein (1921: 129).

9. **Heterometrus (Heterometrus) longimanus borneensis** (Thorell) (figs. 30, 64)

Palamnaeus costimanus var. *β, borneensis* Thorell, 1877: 217, description of adult ♂ and ♀, type-locality Sarawak.

Material. — Borneo: Sandakan (1 ♂ ad., RS 0006), Sandakan Bay (1 ♂ ad., RMNH 76), Mahakkan (Mahakam river) (2 ♂ ad., RMNH 131), Long Bloe-oe (Longbluu), Mahakkan (2 ♂ ad., RMNH 118; 1 ♂ juv., RMNH 299), river Bahau, north-east Borneo (1 ♀ ad., RS 0139), Barau fleet (= river Berau or river Bahau?) (1 ♂ ad., MCZ, no number), Sarawak (1 ♂ ad. holotype, leg. Doria & Beccari 1865, MCG, no number), Smitau (Semitau) (1 ♂ ad., 1 ♂ subad., RMNH 114; 3 ♂ ad., RMNH 116), Landak (1 ♀ ad., RMNH 115), Sintang (3 ♀ ad., RMNH 126; 1 ♂ ad., RMNH 293; 1 ♀ subad., RMNH 300), Sanggau, Kapuas river (1 ♀ ad., 1 ♂ subad., RMNH 129), Ketoongau and Kenepai region (= region of the rivers Sungai Ketungau and Sungai Kenepai) (1 ♂ ad., exp. Moret, RMNH 130), Balik Papan, E. Borneo (2 ♀ ad., RMNH 292), Kina Balu (1 ♀ ad./subad., 1 ♂ juv., RS 0011), Long Peso, E. Borneo (1 ♂ ad., RS 0147), Brunei (1 ♂ ad., RS 4537; 1 ♂ ad., RS 4538), Tapanoeli, Borneo (?, certainly not Tapanoeli on Sumatra!) (2 ♂ ad., RMNH 123), Noenoekan (Nunukan) island, "near Java" (err., near Borneo!) (1 ♀ ad., NMG 62-498; 1 ♀ ad., NMG 62-499), Borneo (2 ♀ ad., RS 0040; 1 ♂ ad., 1 ♀ ad., 1 ♂ juv., RS 0062; 1 ♂ subad./juv., RS 0063).

Description. — This subspecies differs from the nominal subspecies *H. l. longimanus* (Herbst) in the following characters.

Carapace. Lateral eyes smaller; second lateral eye less close to the first eye. The rostral end of the median furrow bears a small group of granules or teeth, which is often protuberant. Frontal area sparsely granulated (most granules on the rostral part), remaining areas more densely granulated. Posterior border smooth. Superciliary crests: see fig. 30. — Pedipalps. External surface of segment 4 with uneven and faintly reticulated intercarinal areas. The hand somewhat dilated; its external keels smooth and distinctly visible (microsculpture type 11). — Walking-legs. Anterior surface of femur I hardly granulated, its inferior keels with a few small tubercles.

Mesosomatic tergites. Median bulge of each tergite (1-6) flanked by two longitudinally plicate areas; on the densely granulated tergite 7 the median tubercle is flanked by two denticulated tubercles and (next to these) two groups of teeth. Lateral borders of tergite 7 granulated, just as its medio-posterior border, the lateroposterior borders being smooth. — Mesosomatic sternites. Lateral borders uneven.

Metasoma. Dorsal surface granulated, except for the terminal part of segment 5. Lateral keels of segment 5 short but sharply denticulated; ventrolateral keels of segment 2 faintly denticulated; ventral keels of segment 2 uneven, those of segment 3 with low and obtuse teeth; on segment 5 the teeth of the ventrolateral keels are stouter than those of the dorsal keels, the teeth of the ventral keel being as stout as the dorsal ones. All intercarinal areas in the ♀ (except for the medioventral areas) granulated; in the ♂ the dorsolateral areas of segments 1-4 hardly granulated, its lateral areas on segments 1 and 2 smooth, remaining areas as in the ♀.

Biometric characters (see table 7: list 9):

char. 34: 2.4 (s = .2) char. no. 129: .85-.92
51: 1.5 (s = .3) 130: 1.8-1.9

♂, total median length of ♂ specimen from sample RMNH 130: 121 mm

char. no. 44: 1.6 (s = .1) char. no. 98: 496 (s = 44)
82: 95 (s = 11)

♀, total median length of ♀ specimen from sample RMNH 126: 120 mm

char. no. 52: 3.2 (s = .7)

Distribution (fig. 64). — Borneo.

Remark. — I did not examine the holotype kept in MCG, though its presence and good condition was checked. The original description by Thorell (1877: 217) is extensive and sufficiently precise to be sure about the identification of the specimens available to me.

10. **Heterometrus (Heterometrus) longimanus belitungensis** subspec. nov. (fig. 64)

Material. — Bangka (3 ♀ ad., RMNH 80; 11 ♂ ad. including holotype, 6 ♀ ad. including allotype, leg. Vosmaer & Budding, RMNH 86; 2 ♀ ad., 2 juv., SMF 5330), Belitung (Billiton) (2 ♀ ad., RMNH 81; 2 ♀ ad., RS 0002; 1 ♀ ad., ZMA, no number).

Description. — This subspecies differs from the closely resembling subspecies *H. longimanus borneensis* (Thorell) in the following characters (see also remark below).

Carapace. — Granulation on frontal lobes hardly developed; medioposterior and lateroposterior areas often smooth, as are the areas between median and lateral eye-groups. Lateroposterior border granulated in the ♀. — Mesosomatic tergites. Longitudinally plicate areas not present; on tergites 3-6 low, transversely oblong, protuberances are present instead.

Biometric characters (see table 7: list 10):

char. no. 63: 4.0 (s = .4) char. no. 130: ± 2.30

♂, total median length of holotype: 106 mm
♀, total median length of allotype: 107 mm

char. no. 17: 1.5 (s = .2) char. no. 52: 4.5 (s = .7)

Distribution (fig. 64). — Bangka, Belitung (Billiton).

Remark. — In the Senckenberg collection (Frankfurt), specimens from Bangka are present (SMF 5330: 2 ♀ ad., 2 juv.), which show a rather well developed granulation on the frontal lobes, very sparse granulation on the dorsal surface of the metasoma (in one specimen segments 4 and 5 are smooth), and faint reticulation on the external surface of pedipalp segment 4 (keels smooth). Since many other specimens from Bangka (and Belitung) do show the characters mentioned in the description, I still consider the distinction of a separate subspecies justified.

11. **Heterometrus (Heterometrus) longimanus paris** subspec. nov. (figs. 2e, 64)

Material. — Riau (3 ♂ ad. including holotype, 1 ♀ ad. allotype, leg. A. H. G. Blokzeyl, RMNH 83), Karimau, Riau (1 ♂ juv., 1 ♀ juv., RMNH 302).

Description. — This subspecies differs from the closely resembling subspecies *H. longimanus borneensis* (Thorell) in the following characters.

Carapace. Lateral eyes relatively smaller (fig. 2e). Frontal lobes with hardly developed granulation; lateroposterior borders granulated in the ♀. — Mesosomatic tergites. Plicate areas with few, sparsely developed folds (no oblong protuberances instead, as is the case in *H. longimanus belitungensis*). — Metasoma. Dorsal plication present (reticulation almost absent) on segment 1 (♀) or 1-3 (♂).

Biometric characters (see table 7: list 11):

char. no.	45: 1.22	char. no.	57: 1.4 (s = .2)
	51: 1.9 (s = .5)		130: 1.90

♂, total median length of holotype: 111 mm
♀, total median length of allotype: 89 mm

char. no.	17: 1.8 (s = .2)	char. no.	52: 4.2 (s = .3)
	29: 72		

Distribution (fig. 64). — Riau archipelago.

12. **Heterometrus (Heterometrus) longimanus bengkalitensis** subspec. nov. (fig. 64)

Material. — Bengkalis (1 ♂ ad. holotype, 3 ♀ ad. including allotype, 1 ♂ juv., leg. M. Maindron, RS 0048; 3 ♂ ad., 4 ♀ ad., 1 ♂ subad., RMNH 82).

Description. — This subspecies differs from the closely resembling subspecies *H. longimanus borneensis* (Thorell) in the following characters.

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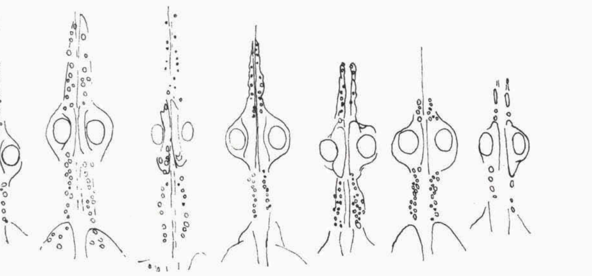

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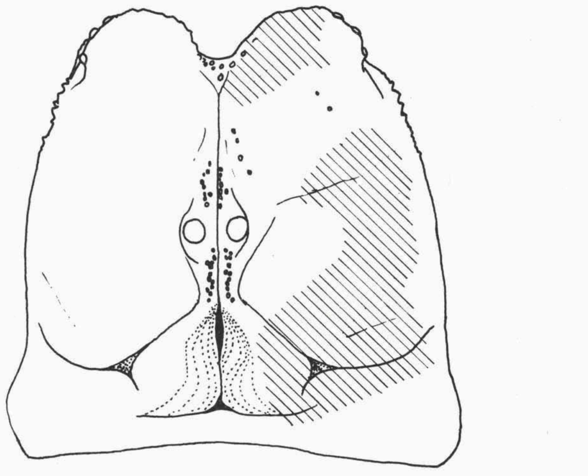

Fig. 30. ***Heterometrus (H.) longimanus borneensis*** (Thorell): observed types of superciliary crests (in order of frequency; antocular parts above), × 3.7.

Fig. 31. *Heterometrus (H.) longimanus humilis* (Simon): carapace (on the right half, granulated areas are shaded), × 3.7.

Carapace. Lateral eyes very large when compared with their mutual distances. Frontal lobes smooth. — Mesosomatic tergites. Longitudinal plication of areas flanking the median tubercles is very faint; they are replaced by low, tranversely oblong, protuberances in tergites 3-6. — Metasoma. Granulation of the dorsal surface in the ♂ restricted to segments 1 and 2.

Biometric characters (see table 7: list 12):

char. no 130: ± 3.55-3.60

♂, total median length of holotype: 93 mm

char. no.	21: 16 (0-75; s = 30)	char. no.	52: 3.4 (s = .3)
	29: 113 (s = 13)		82: 75 (s = 7)
	42: 150 (s = 13)		

♀, total median length of allotype: 100 mm

char. no. 29: 74 (s = 7)   char. no. 82: 64 (s = 4)

Distribution (fig. 64). — Bengkalis island, Indonesia (near Sumatra).

13. **Heterometrus (Heterometrus) longimanus tarawakanensis** subspec. nov.

(fig. 64)

Material. — Tawi Tawi, Tarawakan, Philippines (Sulu islands) (1 ♀ ad. holotype, 1 ♂ subad. allotype, 1 ♀ juv., Noona Dan Expedition, UZM, no number).

Description of the adult ♀ and subadult ♂. — This subspecies differs from the closely resembling subspecies *H. longimanus borneensis* (Thorell) in the following characters.

Carapace. Posterior border finely granulated. — Pedipalps. Internal surface of segment 4 bears one stout, pointed tooth and 3-5 other teeth (besides some granules). The external keels of the hand smooth and distinctly visible (♂) or faint (♀) (relief type 12).

Mesosomatic tergites. Median areas of all tergites uneven; plicate areas nearly completely absent. — Metasoma. Dorsal surface sparsely and finely granulated. The size of the teeth of the lateral keels hardly decreasing from segment 1 to segment 5. In the male, the ventrolateral areas of segment 1 are smooth, while in segments 2-5 these areas are granulated.

Biometric characters (see table 7: list 13):

char. no. 45: 1.10   char. no. 57: 1.0 (s = .1)
51: 1.6 (s = .3)   71: 1.30

♂, total median length of (subadult) allotype: 83 mm

char no. 21: 50   char. no. 70: 2.1

♀, total median length of holotype: 101 mm

char. no. 21: ∞ (100-∞)   char. no. 72: 3.7 (s = .4)
52: 3.6

Distribution (fig. 64). — Tawi Tawi, Tarawakan, (Sulu islands, Philippines).

Remark. — The *H. longimanus* specimens from the "Sula islands", mentioned by Kopstein (handwritten note), possibly belong to this subspecies (see *H. l. longimanus* above).

14. **Heterometrus (Heterometrus) longimanus marmoratus** subspec. nov. (fig. 64)

Material. — Palawan, Uring Uring near Brooke's Point (1 ♀ ad., Noona Dan Expedition, UZM, no number), Palawan, "Emnurumsena to Taukidu" (1 ♀ ad., 1 ♀ juv., Noona Dan Expedition, UZM, no number), Balabac, Dalawan Bay (1 ♂ ad. holotype, 1 ♀ ad. allotype, Noona Dan Expedition 9-X-1961, UZM, no number).

Description. — This subspecies differs from the closely resembling subspecies *H. longimanus borneensis* (Thorell) in the following characters.

Carapace. Variegated (marbled). Lateral parts of the posterior border granulated. — Pedipalps. Rostral surface of segment 4 bears one stout and pointed tooth, 3-5 other teeth and some granules. The external keels of the hand are smooth and distinctly visible (♂) or faint (♀); its dorsal keel sparsely denticulated (♀) or stoutly and sharply denticulated (♂). — Walking-legs. Inferior keels of femora I-IV denticulated.

Mesosomatic tergites. Variegated. Plicate areas nearly absent. — Metasoma. Dorsal surface of segments 2-5 sparsely granulated. In the ♀, the teeth on the ventrolateral keels of segment 5 are as stout as those on the dorsal keels. In both sexes the size of the terminal ventrolateral tooth equals that of the preceding teeth. In the ♀, the teeth of the ventral keel of segment 5 are stouter than the dorsal teeth. Ventrolateral intercarinal areas smooth on segments 1 and 2 of the ♀; in the ♂ the dorsolateral areas of segments 1-4 are reticulated, whilst the ventrolateral areas are smooth in the case of segment 1, granulated in the case of segments 2-5.

Biometric characters (see table 7: list 14):

char. no. 51: 1.4 (s = .2) char. no. 63: 3.9 (s = .3)

♂, total median length of holotype: 98 mm

char. no. 29: 109 char. no. 52: 3.0 (s = .1)
42: 149 99: 3.0

♀, total median length of allotype: 86 mm (in a specimen from Uring Uring, Palawan (UZM): 102 mm).

Distribution (fig. 64). — Palawan, Balabac (Philippines).

15. **Heterometrus (Heterometrus) longimanus humilis** (Simon) (figs. 31, 64)

Pandinus humilis Simon, 1877: 94, description of juvenile ♀, type-locality Manila.

Material. — Manila (1 ♀ juv. holotype, 2 ♀ juv. paratypes, leg. Laglaise, Simon's no. 2499, RS 0021), Philippines (2 ♀ ad., leg. M. Marche, RS 0054; 1 ♂ ad., 1 ♀ juv., Simon's no. 2499, RS 0153).

Description of adults. — This subspecies differs from the nominal subspecies *H. l. longimanus* (Herbst) in the following characters.

Carapace (fig. 31). Second lateral eye less close to the first eye. Posterior border smooth. Lateral areas with a granulation extending to the median eyes. — Pedipalps. In the ♀ the internal surface of segment 4 bears three stout teeth and a few small, obtuse, teeth. Its external surface has uneven and faintly reticulated intercarinal areas and smooth or uneven keels. The hand is somewhat dilated in both sexes; external keels smooth and hardly prominent (relief type 11); the dorsal keel bears a few pointed teeth. — Walking-legs. Anterior surfaces of femora smooth; inferior keels of femora with small teeth.

Mesosomatic tergites 1-6 smooth or finely punctate, their lateral margins finely granulated, their lateroposterior margins faintly and finely granulated; median areas of tergite 7 finely granulated, its remaining areas distinctly granulated, with a few pointed teeth on its lateroposterior parts. Medio-posterior borders of tergites 1-6 smooth, their remaining borders finely granulated; lateral borders of tergite 7 denticulated. In some cases a pair of bright spots is present near the anterior border of each tergite.

Metasoma. Dorsal surface smooth in the ♂; in the ♀ it shows fine granules (on segments 2-5 in two small groups). Dorsal keels with a regular series of uniform, pointed teeth; lateral keels with smaller, more obtuse teeth (on segments 1-4, the lateral keels present one or two terminal teeth as stout as the teeth of the dorsal keels).

Biometric characters (see table 7: list 15):

char. no.	30: 96 (s = 15)	char. no.	71: 1.28 (s = .07)
	45: 1.01		129: .80
	57: 1.0 (s = .1)		130: ± 2.40-2.45
	63: 3.9 (s = .5)		

♂, total median length of the described adult from sample RS 0153: 100 mm

char. no.	29: 87	char. no.	70: 1.9
	42: 129		74: 3.3
	44: 1.2		99: 3.1

♀, total median length of the described adult from sample RS 0054: 110 mm (juvenile holotype: 59 mm).

char. no.	21: 7 (s = 3)	char. no.	52: 3.3 (s =.3)

Distribution (fig. 64). — Philippines, particularly Manila on Luzon.

Type-specimens. — The holotype, described by Simon, is a juvenile ♀

from Manila (RS 0021, leg. Laglaise; Simon's collection number 2499). Therefore I have used an adult ♂ (RS 0153, also no. 2499 in Simon's collection) and an adult ♀ (RS 0054, leg. M. Marche), both from the Philippines, for the preparation of the present description. It is strange that Simon described a juvenile specimen, while an adult was present in his collection under the same number. Possibly he did not notice the difference between this adult and *H. l. longimanus* (Herbst); the specimen in question has, however, no separate label confirming this assumption.

Remark. — Schultze (1927: 375-389) mentions that this subspecies has not been collected on Luzon for several decades. I do not know whether thorough searching for this subspecies did recently take place. In the Paris Museum several old specimens, including the types from Luzon, are preserved.

16. **Heterometrus (Heterometrus) liophysa liophysa** (Thorell) (figs. 32, 65)

Palamnaeus liophysa Thorell, 1888: 415, description of adult ♂, type-locality Ajer Mancior (Sumatra).

Material. — Sumatra: Padang (1 ♂ ad. neotype, leg. J. v. d. Hoeven, RMNH 78; 1 ♀ subad./juv., RMNH 264; 1 ♂ ad., RMNH 289), Kayoutanam, Padang Highlands (1 ♂ ad., 2 ♂ subad., RMNH 184), Kayoutanam, Central Sumatra (1 ♂ ad., ZMA, no number), Kenkandam (1 ♂ ad., RS 0034), Bunga-Bondar, W. Sumatra (2 ♂ ad., SMF 18158/2; 2 ♂ ad., SMF 5323), W. coast Sumatra (1 ♀ ad., RS 3460).

Description. — Carapace. Superciliary crests (fig. 32b) complete and granulated (type 6), linking up with the faint granulation of the medio-posterior pair of tubercles. Second lateral eye much closer to the first than to the third; lateral eyes somewhat smaller (with respect to their mutual distances) than in *H. longimanus*. Dorsal surface granulated (fig. 32a), faintly so on the frontal area and the parts directly next to the superciliary crests; the granules can be dark and contrasting with the rest of the carapace. Medioposterior and lateroposterior furrows very deep. The border finely and densely granulated.

Pedipalps. Dorsal keels of segment 3 strongly denticulated. Internal surface of segment 4 bears 5-9 stout and pointed teeth (in most specimens one tooth is distinctly larger); external surface coarsely reticulated, with almost smooth (somewhat uneven) keels in the ♂, distinct, uneven keels in the ♀; external surface strongly reticulated with clearly visible and smooth keels in the ♂, a little less distinct keels in the ♀ (relief type 9); dorsal keel slightly curved, with low and sharp teeth. — Walking-legs. Anterior surfaces of femora I and II scarcely and finely granulated, those of femora III and IV densely so. Inferior keels of femur I somewhat uneven, those of femora II-IV densely granulated. — Pectines. Internal fulcral plates smooth, without setae.

Mesosomatic tergites. Entire surface and borders finely granulated, except for the smooth anterior margins. Inconspicuous tubercles on tergites 1-6. The pair of macrosetae at the posterior border of tergites 1-6 and near this border on tergite 7 (here on well-developed denticulated tubercles) are in some cases very distinct. — Mesosomatic sternites. Lateral margins of sternites 1-4 finely granulated, lateral margins of sternite 5 in some specimens granulated with additional small tubercles; the remaining surface smooth. Longitudinal furrows distinct in sternites 1-4, in sternite 5 short (♂) or faint (♀). Lateral borders finely granulated, posterior borders smooth.

Metasoma (fig. 32c). Dorsal surface reticulated (very faintly in the case of segment 5); segments 1-3 (♀) or 1-4 (♂) dorsally also granulated. Dorsal keels with obtuse teeth which, on segment 1, are lower and, on segment 5, finer, lower and sharper than on the remaining segments. The lateral keels of segment 1 with obtuse and low denticulation, on the following segments gradually replaced by faint granulation on segment 5, this phenomenon being clear especially in the anterior part of these keels. Ventrolateral and ventral keels of segments 1 and 2 (in some specimens 1-3) smooth, on segment 3 uneven, on segment 4 finely denticulated or (faintly, in some specimens distinctly) granulated, in segment 5 furnished with fine and pointed teeth of which the lateroterminal one is somewhat stouter than the other teeth. Dorsolateral intercarinal areas reticulated and finely granulated; lateral areas of segments 1-4 bear a few fine granules (in most specimens the granulation is restricted to the posterior parts); ventrolateral areas of segments 1-4 smooth and those of segment 5 with a few very fine granules (though in some specimens segments 3 and 4 with some fine granules on their posterior parts and segment 5 smooth); ventral areas of segments 1-4 smooth.

Biometric characters (see table 7: list 16):

char. no.	30: 114 (s = 13)	char. no.	108: 2.2 (s = .3)
	56: 68 (s = 7)		129: .60-.65
	63: 5.0 (s = .4)		130: ± 2.00
	71: 1.27 (s = .04)		

♂, total median length of neotype: 109 mm (in a specimen from Bunga-Bondar, W. Sumatra (SMF 5323): 120 mm).

char. no.	21: 16 (s = 12)	char. no.	83: 14.38 (s = .87)
	74: 4.2 (s = .2)		

♀, total median length of ♀ specimen from sample RS 3460: 115 mm

char. no. 21: 100 (20-180; s = 113) char. no. 74: 3.8 (s = .3)
52: 3.2 (s = .1) 83: 12.75 (s = .50)

Distribution (fig. 65). — West coast of Sumatra.

Neotype-designation. — Thorell (1888: 415) described an adult ♂ and two further specimens from Ajer Mancior, Sumatra (leg. Beccari); these specimens belonged to the collection of the MCG. They could not be recovered, and are apparently lost. The variability of characters in this genus and, consequently, the taxonomic difficulties (as explained in the first chapter) necessitate the availability of a well-preserved and accurately-labelled specimen for reference. RMNH 78 (leg. J. v. d. Hoeven) constitutes an undamaged and accurately labelled sample from Padang, the centre of the distributional area. No specimens from the type-locality (Ajermantsjur, at

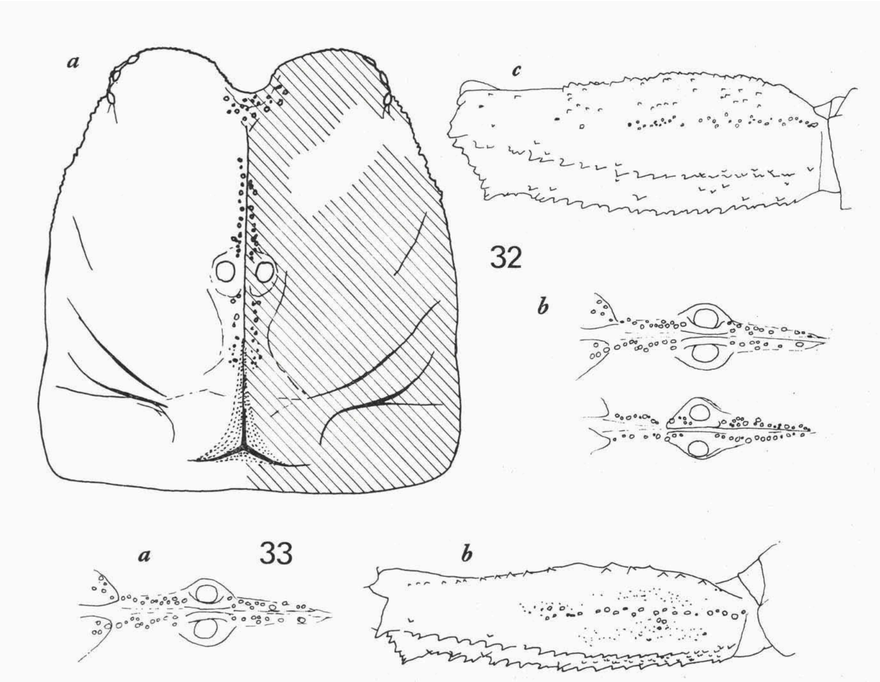

Fig. 32. *Heterometrus* (*H.*) *l. liophysa* (Thorell); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (antocular parts right); c, right view of metasomatic segment 5 (RS 3460); a-c, × 3.7.

Fig. 33. *Heterometrus* (*H.*) *liophysa laevifrons* Roewer; a, superciliary crests (antocular parts right); b, right view of metasomatic segment 5 of ♂ adult (RMNH 265); a-b, × 3.7.

a small distance from Padang at the N.W.) are available. The adult ♂ designated as a neotype is complete and well identical with the original description.

17. **Heterometrus (Heterometrus) liophysa laevifrons** Roewer (figs. 33, 65)

Heterometrus laevifrons Roewer, 1943: 229, description of juveniles; type-locality: Siberut island, Mentawei islands, Indonesia.

Material. — Mentawei islands, Siberut (1 ♀ juv. holotype, 1 ♂ juv. allotype, leg. unknown, SMF II/883/225), Saibi (place on Siberut), Mentawei islands (1 ♂ ad., 1 ♀ ad., leg. E. Jacobson 1912, RMNH 265), Nias (1 ♀ ad., RMNH 186; 2 ♀ ad., ZMA, no number; 1 ♂ ad., 2 ♀ ad., BM 1950.2.20.1-10), Lalanaca, Nias (3 ♂ ad., ZMA, no number), Pulau Tello (1 ♀ ad./subad., RMNH 266; 1 ♀ ad., RMNH 267), Batu (1 ♂ ad., 1 ♀ ad., 1 ♂ subad., ZMA, no number).

Description of adults. — This subspecies differs from the nominal subspecies *H. l. liophysa* (Thorell) in the following characters.

Carapace. Relatively larger eyes. — Pedipalps. Hand relief type 8. — Mesosomatic sternites. Lateral borders smooth in most ♀♀. — Metasoma. Reticulations faint and for most areas restricted to the ♀; ventral and ventrolateral areas of segments (1-)3-5 granulated (fig. 33b).

Specimens originating from different islands along the west coast of Sumatra show some particular differences:

Mentawei archipelago: reticulation of metasoma clearly visible only in the ventrolateral intercarinal areas of segments 2-4;

Nias: fine granulation of tergites in ♀♀ present only on the lateral areas (leaving a smooth median area even on tergite 7);

Batu archipelago: lateral margins of sternites smooth; near the dorsal keel of the pedipalp hand, the reticulation of the external surface is accompanied by some granulation.

These differences are considered too small for subspecific differentiation.

Biometric characters (see table 7: list 17):

char. no. 130: ± 2.75

♂, total median length of adult specimen (RMNH 265): 106 mm (juvenile allotype: 65 mm).

char. no. 105: 3.1 (s = .2)

♀, total median length of adult specimen (RMNH 265): 96 mm (juvenile holotype: 54 mm).

char. no. 43: 121 (s = 12)

Distribution (fig. 65). — Mentawei archipelago, Nias, Batu archipelago.

18. **Heterometrus (Heterometrus) liophysa spartanicus** subspec. nov. (fig. 65)

Material. — Babi (1 ♂ ad. holotype, leg. Dr. Buitendijk 1908, RMNH 187).

Description of the adult ♂. — This subspecies differs from the nominal subspecies *H. l. liophysa* (Thorell) in the following characters.

Carapace. Second lateral eye less close to the first eye; lateral eyes relatively larger. Frontal area and areas directly flanking the superciliary crests granulated. — Pedipalps. External surface of segment 4 bears finely granulated keels. Hand with granulated external keels, also some of the intercarinal areas on its reticulated surface are granulated (relief type 8). — Walking-legs. Anterior surfaces of femora II-IV finely granulated, that of femur I smooth. Inferior keels on femora I and IV granulated only in their terminal part, their basal part being uneven.

Mesosomatic tergites 3-7 bear a median tubercle flanked by two lateral tubercles. — Mesosomatic sternites. Lateral borders smooth or uneven. Surface smooth. — Metasoma. Dorsolateral areas of segments 1-4 granulated, but smooth on segment 5; ventrolateral areas of segments 1-3 smooth, but granulated on segments 4 and 5.

Biometric characters (see table 7: list 18):

char. no.	34: 2.0	char. no.	108: 2.5
	56: 77		129: .80
	63: 3.3		130: 2.57

♂, total median length of holotype: 91 mm

char. no.	29: 88	char. no.	70: 1.9
	42: 125		

Distribution (fig. 65). — Babi (island near the west coast of Sumatra).

19. **Heterometrus (Heterometrus) liophysa separatus** subspec. nov. (figs. 4b, 65)

Material. — Weh (3 ♂ ad. including holotype, 2 ♀ ad. including allotype, leg. Dr. Buitendijk 1919, RMNH 185).

Description. — This subspecies differs from the nominal subspecies *H. l. liophysa* (Thorell) in the following characters.

Pedipalps. Internal surface of segment 4 bears one stout tooth and 12-14 (♂) or 4 (♀) smaller teeth, in the ♀ this surface somewhat uneven; its external surface shows distinct uneven keels in both sexes.

Mesosomatic tergites. Median tubercles, and the oblong low protuberances flanking these, are prominent on all tergites. — Mesosomatic sternites. Lateral margins of sternite 1 smooth; the additional small tubercles are lacking on sternite 5. — Metasoma. Ventrolateral areas of segments 3 and 4 bear a few granules (these could easily be confounded with carinal teeth); those of segments 1 and 2 smooth, just as the ventral areas of segments 1-4; ventral areas of segment 5 with a few very fine granules.

Biometric characters (see table 7: list 19):

char. no.	45: 1.49	char. no.	63: 5.3 (s = .5)
	51: 1.2 (s = .1)		71: 1.17 (s = .11)

♂, total median length of holotype: 119 mm

char. no.	17: 1.8 (s = .1)	char. no.	70: 1.4 (s = .0)
	44: 1.9 (s = .1)		82: 75 (s = 5)
	52: 5.2 (s = .8)		

♀, total median length of allotype: 121 mm

char. no.	17: 1.8 (s = .0)	char. no.	102: 3.2 (s = .0)
	21: 70 (s = 14)		105: 3.1 (s = .1)
	52: 5.2 (s = .3)		

Distribution (fig. 65). — Pulu Weh (island near the north-western point of Sumatra).

20. **Heterometrus (Heterometrus) madoerensis** Kopstein (figs. 4e, 62)

Heterometrus liophysa var. *madoerensis* Kopstein, 1921: 132; description of subadult ♀, type-locality Madura.

Material. — Madura (1 ♀ subad. holotype, leg. Dr. Buitendijk Mai 1910, RMNH 188).

Description of the subadult ♀. — This species differs from the closely resembling species *H. liophysa* (Thorell) in the following characters.

Carapace. Granulation at the posterior border faint and sparse. Rostral border faintly granulated. — Pedipalps. Dorsal keels of segment 3 with blunt teeth. External surface of segment 4 almost smooth with granulated middle keel flanked by two sparsely granulated or uneven keels. External hand surface (fig. 4e) with numerous granules and clearly visible prominent keels (relief type 6). — Walking-legs. Anterior surfaces of femora I-III densely and finely granulated. Inferior keels on femur I bear a few small granules.

Mesosomatic tergites. Median area smooth. — Mesosomatic sternites. Smooth surface. Lateral borders uneven. — Metasoma. Dorsal surface smooth.

Biometric characters (see table 7: list 20):

char. no. 34: 2.7 char. no. 51: 1.6

♀, total median length of subadult holotype: 77 mm

char. no. 21: 15 char. no. 83: 14.50 (s = .71)

Distribution (fig. 62). — Madura.

Remark. — Kopstein (1921: 132) described this form as a subspecies of *H. liophysa* (Thorell). In the present paper it is regarded as a species, because in my opinion *H. madoerensis* differs more widely from *H. l. liophysa* than the other subspecies of *H. liophysa* (for instance in its granulation in the hand microsculpture and the high number of pectinal teeth). I consider the long distance between Madura and the distributional area of *H. liophysa* on W. Sumatra and the islands along the coast to be another support for this taxonomic status. Because only one subadult specimen is known, the label of which could be erroneous, it could represent a rare variety of *H. liophysa* (to which it is rather like).

21. **Heterometrus (Heterometrus) bengalensis** (Koch)

(figs. 34, 63)

Buthus bengalensis Koch, 1842: 3, description of adult ♂ and ♀, type-locality Bengal, East Indies.
Palamnaeus costimanus var. *γ glaucus* Thorell, 1877: 219.
Palamnaeus petersii Thorell, 1889: 588, non Thorell, 1876: 13, nec Thorell, 1877: 210.
Palamnaeus thorellii Pocock, 1892a: 40; Meise, 1932: 666.
Heterometrus l. longimanus (part.) Kraepelin, 1899: 111; Giltay, 1931: 3; Meise, 1932: 661.
Heterometrus (spinifer) longimanus aurulentus Stahnke (nom. nud., unpublished).

Material. — Burma: Rangoon (2 ♂ ad., 2 ♀ ad., RS 3447; several specimens, leg. J. Thomsen, NRS, no number), Irouaddy (5 ♂ ad. including neotype, 1 ♀ ad., leg. Vossion, RS 0045), Tharrawaddy (1 ♀ ad., BM 1912.8.26.18), Prome (1 ♀ ad., SMF II/7986/160).

India (W. Bengal): Calcutta, "Ambala" (second locality probably erroneous) (1 ♂ ad., 2 ♀ ad., RS 0122).

Uncertain localities and doubtful records: Bengal (2 ♀ ad. including type of *P.*

costimanus glaucus Thorell, NMG Scorp. 88), "Cochinchina" (label probably refers to 3 other specimens in the same sample) (1 ♀ ad., 1 of 4 specimens sharing number RS 0155), East Indies? (1 ♀ ad. type of *H. (spinifer) longimanus aurulentus* Stahnke, nom. nud., 3 ♂ juv., 1 ♀ juv., NMG Scorp. 86, nos. 63-073, 067, 071, 072 and 068 respectively), Lavanono ("Lavonono"), Madagascar (1 ♂ ad., BM, no number).

Description. — This species differs from the closely resembling species *H. liophysa* (Thorell) in the following characters.

Carapace (fig. 34a). Second lateral eye less close to the first eye; lateral eyes somewhat smaller. Frontal area granulated, just as the lateral areas; sparse granulation close to the antocular parts of the superciliary crests (fig. 34b); remaining areas smooth.

Pedipalps. Internal surface of segment 4 bears one stout and pointed tooth and 4 or 5 smaller blunt teeth; its external surface reticulated, with smooth keels. Hand relief type 9. — Walking-legs. Anterior surface of femur I smooth in the ♂, sparsely and finely granulated in the ♀, just as in the case of femur II of the ♂; anterior surface of femora III and IV (♂) or II-IV (♀) densely and finely granulated. Inferior keels on femur I sparsely granulated. Six postero-inferior spines on telotarsus III, seven (in one specimen six) on telotarsus IV. — Pectines. Internal fulcral plates smooth, rarely bearing a macroseta.

Mesosomatic tergites. Lateral areas of tergites 1-6 sparsely granulated, those of tergite 7 densely so; median areas of tergites 1-6 smooth, that of tergite 7 sparsely granulated. Lateroposterior borders of tergite 7 smooth. Posterior pairs of macrosetae indistinct. — Mesosomatic sternites. Smooth surface. Longitudinal furrows in sternite 5 reduced (small and superficial).

Biometric characters (see table 7: list 21):

char. no.	30: 70 (s = 12)	char. no.	71: 1.15 (s = .08)
	34: 2.7 (s = .2)		129: ± .80
	45: 1.47		130: ± 1.50
	63: 4.6 (s = .5)		

♂, total median length of neotype: 89 mm

char. no.	21: 31 (s = 9)	char. no.	105: 2.6 (s = .1)
	83: 16.20 (s = .56)		

♀, total median length of ♀ specimen from sample RS 0045: 89 mm

char. no.	21: 59 (s = 19)	char. no.	82: 63 (s = 3)
	43: 105 (s = 8)		83: 14.78 (s = .44)
	52: 3.9 (s = .3)		98: 373 (s = 15)

Distribution (fig. 63). — Burma and Bengal.

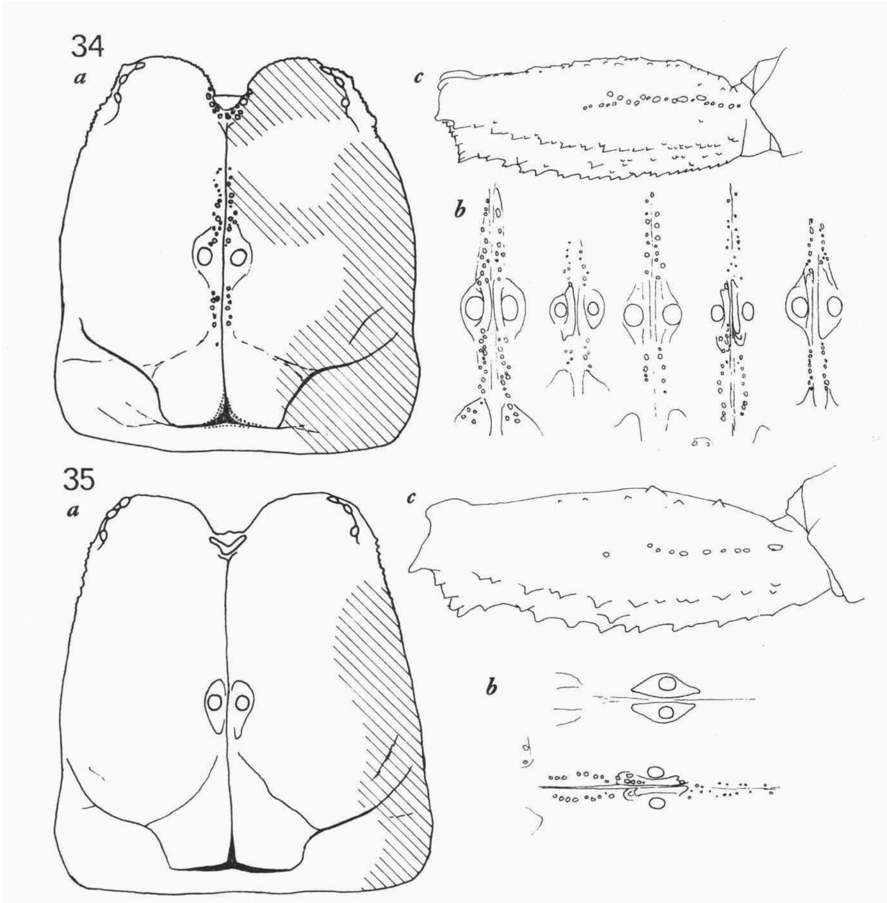

Fig. 34. *Heterometrus* (*H.*) *bengalensis* (Koch); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (in order of frequency; antocular parts above); c, right view of metasomatic segment 5 of neotype; a-c, × 3.7.

Fig. 35. *Heterometrus* (*Srilankametrus*) *i. indus* (de Geer); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (most common type above; antocular parts right); c, right view of metasomatic segment 5 of ♂ adult (RMNH 501); a-c, × 3.7.

Remark. — This species was also recorded from Lavanono (south point of Madagascar); this probably concerns a specimen transported by man. The specimen in question, an adult ♂, was examined by G. Newlands and identified with *Opisthacanthus madagascariensis* Kraepelin. The high number of pectinal teeth (16-17, while *Opisthacanthus madagascariensis* possesses 7-9) and the large size of the specimen demonstrate, that this identification is erroneous.

Neotype-designation. — Koch (1842: 3) described an adult ♂ (and a ♀) from Bengal, East Indies; they belonged to the ZMB. These specimens could not be recovered; they were probably lost during the Second World War. The "syntypes" still kept in Berlin do not belong to this species, but to *H. fastigiosus* spec. nov. (see below), as can easily be established on differences in the superciliary crests, the external keels of the pedipalp hand, the denticulation on the internal surface of the fourth pedipalp segment, etc. The variability of characters in this genus and, consequently, the taxonomic difficulties (as explained in chapter I) require the availability of a well preserved and precisely labelled specimen for reference, if possible forming part of a larger sample. RS 0045 (leg. Vossion) is a well labelled, undamaged and relatively large sample of 6 adults, in which both sexes are represented. This sample was collected in Irouaddy, Burma, in which country this species seems to be the most abundant. The original type-locality "Bengal" is a rather vague indication; no ♂ adult specimens with this indication were available during my studies. The ♂ adult contained in sample RS 0122 has the disadvantages of a probable error in its label and its unknown collector. The adult ♂ designated as a neotype in sample RS 0045 is complete and fits well with the original description.

Srilankametrus subg. nov.

(fig. 60)

Heterometrus (*H.*) group *indus*, Couzijn, 1978: 331 and table 1.

Description. — The following combination of characters separates *Srilankametrus* from the related subgenus *Javanimetrus* and other subgenera.

Carapace. Rostrolateral edge continuously curved (without incision next to the lateral eyes). Second lateral eye much closer to the first than to the third; lateral eyes relatively large. Superciliary crests type 1. In the median furrow there is a depression, deeper than the medioposterior T-shaped furrows and situated between these furrows and the median oculiferous tubercle. Pedipalps. Neither stout nor sharp teeth on the dorsal keels of segment 3. No prominent teeth on the internal surface of segment 4, only 5-8 small and low teeth. Hand relief type 2 or 4. — Walking-legs. The granulation of the inferior keels of femora II-IV is faint, in the case of femur IV it is also sparse. — Pectines. Internal fulcral plates smooth, rarely bearing a macroseta.

Mesosomatic tergites. Medioposterior borders of tergites 1-6 are smooth. — Metasoma. Dorsal surface smooth. Strong general reduction of the denticulation of dorsal and lateral keels; no gradual reduction from anterior to posterior end of the metasoma (as in the subgenus *Heterometrus*) but from posterior to anterior. Terminal lateroposterior tooth on segment 5 much stouter than the preceding teeth.

Biometric characters (mean values):

char. no.	45:	.93	char. no.	129:	.44-.60
	108:	2.0-2.2		130:	2.4
♂, char. no.	17:	3.7	♂, char. no.	83:	12.93
	52:	2.4-2.6		102:	3.3
♀, char. no.	17:	3.2	♀, char. no.	52:	2.2
	43:	177		70:	2.8
	44:	.9		102:	3.3

Distribution (fig. 60). — Sri Lanka and the extreme south-eastern part of India.

Type-species: *H. indus* (de Geer, 1778).

Name. — Sri Lanka is now the official name of Ceylon; to this name the suffix "-metrus" (m.) is added.

22. **Heterometrus (Srilankametrus) indus indus** (de Geer) (figs. 35, 60)

Scorpio indus de Geer, 1778: 341, description of adult ♀, type-locality "India".
Scorpio indicus Linnaeus, 1748: 68; 1754; 84; Thorell, 1877: 208; 1888: 412; 1894: 25; Kraepelin, 1894: 53.
Scorpio afer (part.) Linnaeus, 1758: 624; Herbst, 1800: 38, 83.
Scorpio ceylonicus Herbst, 1800: 38, 83; Karsch, 1884: 69; Kraepelin, 1894: 46.
Buthus megacephalus Koch, 1836: 73; Thorell, 1877: 203; Karsch, 1884: 69.
Buthus caesar Koch, 1842: 6; Pocock, 1892b: 311; 1894a: 73.
Scorpio crassimanus Becker, 1880: 140.
Scorpio gravimanus Pocock, 1894a: 75; Simon, 1905: 161; Takashima, 1945: 94.
Scorpio latimanus Pocock, 1894a: 74; 1900b: 90; Kraepelin, 1899: 113; Takashima, 1945: 92.
Palamnaeus serratus Pocock, 1900b: 97; Takashima, 1945: 94.

Material. — Sri Lanka: Peradeniya (2 ♂ ad., 1 ♀ ad., 1 ♂ subad., 1 ♀ juv., RS 0081; BM 1898.4.21.1), Peradeniya, botanical garden (1 ♀ ad./subad., 1 ♀ juv., CKL, no number), Gannuruwa, Peradeniya, under a stone (1 ♀ ad./subad., RS 6165 = VA 1912 in collection Vachon), Kandy, station 71, wooded hills South of the lake, under bark (2 ♀ ad., RS 6169 = VA 1915 in collection Vachon), Kandy (1 ♂ ad., RS 3263), Negombo, W. coast, N. of Colombo (1 ♂ ad., the smallest of two specimens, RS 7759), Colombo (1 ♂ ad., RMNH 501), Ceylon (1 ♂ ad., RS 3245; 3 ♀ ad., SMF 5318; 1 ♂ ad., type *P. serratus* Pocock, BM 88.55).

Uncertain localities: "India?" (1 ♀ ad./subad., type *S. latimanus* Pocock, BM 1979.7.3.1), "India" (mentioned in description only) (1 ♀ ?, ad. holotype, NRS, coll. de Geer, no number), unknown locality (1 ♂ ? ad., "*afer α*; *ceylonicus*; *Pandinus indus*", ZMU, Thunberg's collection, no number); all these specimens doubtless originated from Sri Lanka.

Description. — This subspecies shows many variations, which has been the cause of the extensive synonymic list; it can be characterized as follows.

Carapace (fig. 35a). Superciliary crests reduced to the smooth part on the median oculiferous tubercle (type 1; see fig. 35b). Lateral areas granulated; lateroposterior areas faintly granulated in the ♀; frontal lobes faintly granulated, and uneven in some ♂♂; remaining areas smooth and shining. Rostral and posterior borders smooth; lateral borders finely granulated.

Pedipalps. Dorsal keels on segment 3 with stout and obtuse teeth. Internal surface of segment 4 with 5-8 small and low teeth, which are blunt in the ♀♀ and some ♂♂, pointed in most ♂♂; its external surface with reticulated intercarinal areas and with smooth keels (though 3 adult ♀♀ kept in SMF 5318 have uneven keels). The hand rather dilated, its external surface covered with large and low granules, in most specimens partly confluent; the keels almost indistinguishable, but in some places in the ♂ indicated by regular series of larger granules (relief type 4); dorsal keel slightly curved, the terminal third part almost straight in the ♀; this keel bears low and obtuse teeth in its terminal part, often fused to form a crest, but it bears small tubercles on its basal part. — Walking-legs. Anterior surfaces of femora I and II sparsely and finely granulated, those of femora III and IV more densely so (though in some specimens faintly granulated and even partly smooth). Inferior keels on the femora smooth (in some specimens faintly and sparsely granulated). The telotarsi III and IV bear four (in some cases three) antero-inferior spines and five (in some cases six) postero-inferior spines. — Pectines. Internal fulcral plates smooth, though in some specimens a macroseta was observed.

Mesosomatic tergites. Lateral areas of tergites 1-6 faintly granulated, their median areas smooth and shining (though uneven in some ♂♂); lateral margins of tergites 1-3 very finely granulated, those of the other tergites almost smooth; the uneven tergite 7 bears a few low and blunt teeth on its lateroposterior areas and it has uneven lateral borders. All posterior borders smooth. — Mesosomatic sternites. Smooth surface. Longitudinal furrows distinct in sternites 1-4, absent in sternite 5. Borders smooth, though in some ♂♂ the lateral borders of sternites 1-4 (or even all sternites) are finely granulated.

Metasoma (fig. 35c). Dorsal surface smooth in most specimens; the following variations are, however, known: uneven aspect or faint granulation (or plication) on segments 1(-3 or 1-4), with small tubercles and a few granules on the remaining segment(s). Dorsal keels of segment 1 smooth, with one terminal tooth, though in some ♂♂ they bear low and obtuse teeth of which several are fused; dorsal keels of segment 5 distinctly denticulated with small, slender and irregularly situated teeth; remaining segments represent a gradual transition between segments 1 and 5: segment 2 faintly denticulated (more distinctly so on its posterior half), segments 3 and 4 with low, but clearly visible teeth. Lateral keels uneven or (♀) faintly denticulated on segments 1-4, distinctly denticulated on segment 5. Ventrolateral and ventral keels of segments 1-3 smooth, on segment 4 uneven, on segment 5 furnished with pointed teeth (stouter and sharper near the posterior border, while the terminal ventrolateral tooth is much stouter than the preceding teeth). Dorsolateral intercarinal areas of segments 2-4 with a few small tubercles, all remaining areas of the metasoma smooth; as a variation, in some ♂♂ the dorsolateral or lateral areas bear granules, while the basal parts of the ventral areas on segments 4 and 5 are granulated.

Biometric characters (see table 7: list 22):

char. no. 30: 44 (s = 9)
45: .93

char. no. 63: 3.7 (s = .4)
108: 2.0 (s = .3)

♂, total median length of ♂ specimen from sample RS 0081: 111 mm

char. no. 17: 3.7 (s = .9)
29: 73 (s = 8)
42: 126 (s = 7)
44: .9 (s = .1)

char. no. 52: 2.4 (s = .6)
74: 3.0 (s = .3)
83: 12.93 (s = 1.39)

♀, total median length of ♀ specimen from sample RS 0081: 114 mm (the holotype (NRS), which lacks its metasomatic segments 3-5 and telson, reaches 54 mm)

char. no. 17: 3.2 (s = .4)
43: 177 (s = 1)
44: .9 (s = .2)

char. no. 52: 2.2 (s = .8)
70: 2.8 (s = .6)
83: 11.81 (s = 1.56)

Distribution (fig. 60). — Sri Lanka. The record of the type-locality ("India") is inaccurate.

Remarks. — The holotype is a dried and incomplete (♀?) adult from "India" (NRS); for this reason the present description was based upon additional complete adults (♂ and ♀) from Peradeniya (leg. B. H. Buxton, RS 0081). A "syntype of *B. caesar* (Koch)" from "India Orientalis" kept in Berlin (ZMB) evidently belongs to *H. fulvipes* (Koch) and not to *H. indus* (de Geer), nor to *B. caesar* (Koch).

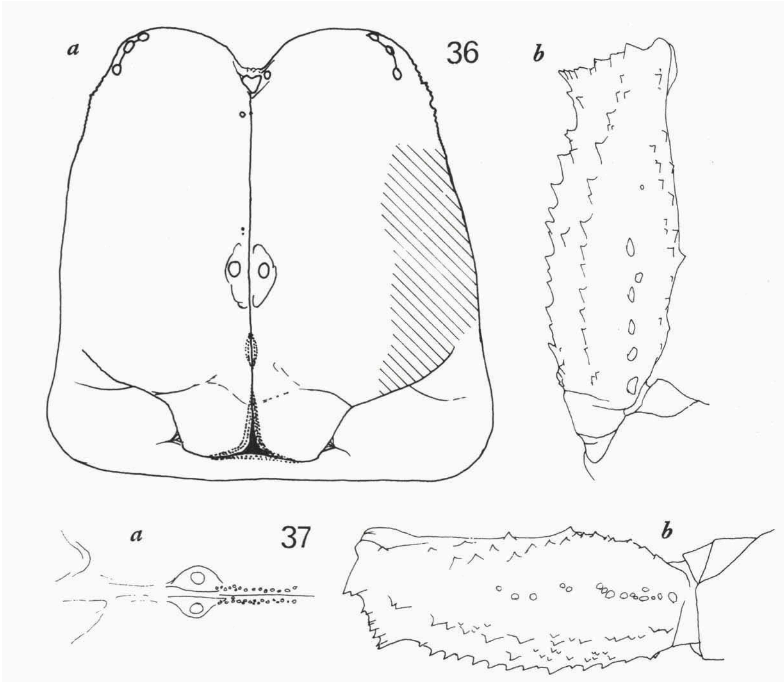

Fig. 36. *Heterometrus* (*Srilankametrus*) *indus laevitensus* subsp. nov.; a, carapace (on the right half, granulated areas are shaded); b, right view of metasomatic segment 5 of holotype; a-b, × 3.7.

Fig. 37. *Heterometrus* (*Javanimetrus*) *c. cyaneus* (Koch); a, superciliary crests (antocular parts right); b, right view of metasomatic segment 5 of neotype; a-b, × 3.7.

23. Heterometrus (Srilankametrus) indus laevitensus subspec. nov. (figs. 36, 60)

Material. — Madras (1 ♂ ad. holotype, RS 0089; 1 ♂ ad., RS 0092).

Description of the adult ♂. — This subspecies differs from the nominal subspecies *H. i. indus* (de Geer) in the following characters.

Carapace (fig. 36a). Lateral eyes much smaller (in proportion to their mutual distances). Frontal areas smooth. — Pedipalps. External surface of segment 4 granulated, particularly its keels. Hand microsculpture type 2. — Walking-legs. Anterior surfaces of femora I and II smooth, those of femora III and IV finely granulated. Four antero-inferior and five postero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. Lateral margins of tergites 1-6 finely granulated. — Mesosomatic sternites. Lateral borders of sternites 1-4 uneven and finely denticulated or granulated. — Metasoma (fig. 36b). Dorsal keels of segments 1-4 almost smooth (uneven, with a small tooth at the posterior end, on segments 3 and 4); lateral keels of segments 1-3 smooth or uneven, two small teeth at the posterior end on segment 4, a few small teeth on segment 5. All intercarinal areas smooth.

Biometric characters (see table 7: list 23):

char. no. 56:	83 (s = 3)	char. no. 100:	1.11 (s = .04)
63:	4.0 (s = .4)	130:	1.57
71:	1.31 (s = .04)		

♂, total median length of holotype: 110 mm

Distribution (fig. 60). — Madras (Chennapattanam) in Tamil Nadu. Pocock (1900b: 91) mentioned *Scorpio gravimanus* (Pocock) from Southern India, Tanjore; this probably refers to *H. indus laevitensus*.

Javanimetrus subg. nov.

(fig. 61)

Heterometrus (*H.*), group *cyaneus*, Couzijn, 1978: 331 and table 1.

Description. — The following combination of characters separates *Javanimetrus* from the related subgenus *Srilankametrus* and other subgenera.

Carapace. Rostrolateral edge continuously curved (without incision next to the lateral eyes). Relatively small lateral eyes. Superciliary crests type 4. — Pedipalps. Stout and sharp teeth on the externodorsal keel of segment 3. One or two stout teeth on the internal surface of segment 4. Hand microsculpture type 7. — Walking-legs. Granulation of inferior keels of femur IV is well developed. — Pectines. Internal fulcral plates smooth, in *H. cyaneus insulanus* rarely bearing a macroseta.

Mesosomatic tergites. Lateroposterior denticulated tubercles on tergite 7 inconspicuous. — Mesosomatic sternites. Lateral borders of sternites 2-4 bear fine granulation or denticulation. — Metasoma. No general reduction of the denticulation of dorsal and lateral keels. The denticulation of lateral keels, when compared with the subgenus *Heterometrus*, shows a reverse reduction, i.e. the size of the teeth decreases from the terminal end to the base of the metasoma. The terminal lateroventral tooth of segment 5 is much stouter than the preceding teeth.

Biometric characters (mean values):

char. no. 34:	2.1-2.2	char. no. 63:	3.6-3.7
45:	1.01-1.09	129:	± .8
56:	56-106	130:	1.30-1.65

♂, char. no. 17: 2.3-2.9	♂, char. no. 102: 3.5
44: .8-.9	
♀, char. no. 17: 2.9-3.2	♀, char. no. 52: 3.9-5.0
44: .8-.9	102: 3.5-3.6

Distribution (fig. 61). — Nicobar islands, Sumatra, Java, Madura and Borneo.

Type-species: *H. cyaneus* (Koch, 1836).

Name. — Composition of an adjective, pertaining to Java, and the suffix "-metrus" (m.).

38. **Heterometrus (Javanimetrus) cyaneus cyaneus** (Koch) (figs. 37, 61)

Buthus cyaneus Koch, 1836: 75; description of adult, type-locality Java. The sex of the described specimen cannot be inferred from the description, because of the very faintly developed sexual dimorphism in this species.
Scorpio afer (part.) Linnaeus 1758: 624; Lönnberg, 1897: 178.
Buthus defensor Koch, 1838: 3; Karsch, 1884: 68.
Buthus heros Koch, 1838: 1.
Buthus reticulatus Koch, 1838: 25; Doleschall, 1857: 494.
Pandinus indicus Thorell, 1877: 209; 1888: 413; 1894: 25; Karsch, 1884: 69; Pocock, 1892b: 312; 1894b: 95.

Material. — Java: Wijnkoopsbaai (1 ♀ ad., RMNH 190), Bogor (Buitenzorg) (1 ♂ ad., 1 ♀ ad., 1 ♀ subad./juv., RMNH 91; 2 ♂ subad., 1 ♀ subad., RMNH 140; 1 ♀ ad., 9 juv., RMNH 142; 1 ♀ ad., 1 ♂ subad./juv., 2 ♂ juv., 2 ♀ juv., RMNH 144; 4 ♂ ad., 1 ♀ ad., RMNH 270; 1 ♂ juv., RMNH 271; 1 ♂ ad., 1 ♂ subad., RMNH 274; 1 ♀ juv., RMNH 301; 4 ♀ ad., 1 ♀ juv., RS 3469; 1 ♂ ad., 6 ♀ ad., 1 ♀ subad., 1 ♂ subad./juv., 1 ♂ juv., RS 3470; 1 ♂ ad., 1 ♀ ad., BM 1901.7.15.1-6), Sindanglaja, Preanger reg. (1 ♀ ad., RMNH 95), Sukabumi (3 ♂ ad., 15 ♀ ad., 2 ♂ subad., 1 ♀ subad., 2 ♂ juv., 1 ♀ juv., RS 3486; 2 ♂ ad., 4 ♀ ad., 1 ♂ subad./juv., RS 3488), Jakarta (Batavia) (2 ♂ ad., RMNH 189; 1 ♂ ad., RS 0091; 1 ♂ ad., RS 0131; 1 ♂ ad., RS 3480; 1 ♀ ad., RS 3483), Siti Ardea (Sitiardjo) (several specimens, NRS, no number, leg. Curt Jaederfeldt), Preanger Regencies (RMNH 143; 1 juv., RMNH 275), Palabuan (2 ♂ ad., 2 ♀ ad., 1 ♂ juv./subad., 2 ♂ juv., 1 ♀ juv., RS 3478; 1 ♂ ad., 5 ♀ ad., 1 ♂ juv., 2 ♀ juv., RS 3485), W. Java (2 ♀ ad., RS 0143; 1 ♀ ad., RS 0393), Wonosobo (2 ♀ ad., RMNH 138; 3 ♀ ad., RMNH 145), Ambarawa (5 ♀ ad., 1 ♀ subad., RMNH 93), Srondol, Semarang (1 ♀ ad., RMNH 147), Semarang (2 ad., RMNH 269), Tjepu (1 ♂ ad., CFB, no number), Malang (2 ♂ ad., RMNH 276), Kali Baru, Banjuwangi (1 ♂ ad. neotype, 1 ♀ ad., leg. M. A. J. Fokker, RMNH 139), Java (1 ♀ ad., RMNH 117; 5 ♂ ad., RMNH 124; 1 ♂ ad., RMNH 132).

Borneo: Sandakan (1 ♀ ad., RS 0003), Kina Balu, N. Borneo (1 ♀ ad., RS 0136), Dutch region, Borneo (1 ♀ subad., 1 ♀ juv., RS 0150).

Uncertain localities and doubtful records: Xuân Long, Vietnam (near Hué) (1 ♀ ad., RS 0126), "Africa" (1 ♀ ad., MCZ 97), "Victoria" (1 ♀ ad., 1 ♂ subad., leg. Haüschild., UZM, no number), ? Java (1 ad., "typus *afer α. Scorpio afer* (= *Sc. indicus* auct.)", ZMU, Linnean collection: no location on label, most probably Java, according to the remark "*javanicus*" in an early publication by Linnaeus (1746: 45), which referred to the same species; cf. Thorell, 1877: 205-211).

Description. — Carapace. Postocular parts of the superciliary crests (fig. 37a) absent, interocular parts smooth, antocular parts granulated (type 4). Frontal and lateral areas granulated; frontal lobes granulated in the ♀, faintly so in the ♂ (see fig. 38a); other areas punctate. No prominent teeth in the mediodorsal incision. Border finely and densely granulated, except for the smooth mediodorsal part and the smooth (♂) or almost smooth (♀) medioposterior part.

Pedipalps. Dorsal keels on segment 3 strongly denticulated. Internal surface of segment 4 bears one or two stout and pointed teeth accompanied by 4-5 (♂) or 6-9 (♀) low and obtuse teeth (in some specimens from Borneo all these teeth are acuminate); external surface in the ♂ reticulated with smooth keels (or median keel granulated), in the ♀ granulo-reticulated with sparsely granulated keels. The hand much dilated; its external surface strongly reticulated, in some specimens bearing small granules on a reticulated pattern or showing superficial microsculpture (almost smooth surface); its keels recognizable merely as smooth streaks (relief type 7); its dorsal keel curved, with low teeth (or, in specimens from Borneo, almost straight and with small bulges or with a few low and acuminate teeth). — Walking-legs. Anterior surfaces of femora II-IV densely granulated, that of femur I sparsely so. Inferior keels on femur I somewhat uneven, those on femora II-IV with granules or low and obtuse teeth. Three antero-inferior spines on telotarsi III and IV; four postero-inferior spines on telotarsus III, five on telotarsus IV. — Pectines. Internal fulcral plates smooth.

Mesosomatic tergites. Surface punctuated. Tergites 1-6 with faintly granulated lateral areas and finely granulated borders. Tergite 7 bears a median tubercle, its lateroposterior areas are uneven, with fine granulation and a few low and obtuse teeth, its posterior border smooth and its lateral borders finely denticulated. — Mesosomatic sternites. Surface smooth. Lateral borders of sternites 2-4 in many specimens finely granulated, the other borders smooth or uneven. Longitudinal furrows distinct in sternites 1-4 (1-5 in some specimens), in sternite 5 rarely more than slight impressions.

Metasoma (fig. 37b). Dorsal surfaces of segments 1-3 faintly plicate, also granulated on segments 1 and 2; often some granules occur on segments 3 and 4 (absent in specimens from central and south-east Java). The dorsal keels bear stouter teeth than the lateral keels, in both there is low dentition on segment 1 with gradual transition to the pointed teeth on segment 5. Ventrolateral and ventral keels smooth on segments 1 and 2, almost smooth or uneven on segment 3, with low and obtuse teeth on segment 4, on segment 5 provided with pointed teeth (as stout as the dorsal ones), the stouter as they stand closer to the posterior border, the terminal ventrolateral tooth being far stouter than the preceding teeth. A few granules occur on the dorsolateral intercarinal areas of segments 1 and 2 (or, in some ♀♀, 1-3), on the lateral areas of segments 1-4 (2-4 in some ♂♂), and on the ventrolateral areas of segments 3-5 (rarely 4 and 5) in the ♂, segments 2-5 (Borneo: 3-5) in the ♀.

Biometric characters (see table 7: list 38):

char. no.	30: 50 (s = 10)	char. no.	63: 3.6 (s = .3)
	45: 1.09		71: 1.31 (s = .06)
	51: 1.1 (s = .2)		129: .75-.83

♂, total median length of neotype: 111 mm

char. no.	17: 2.9 (s = .4)	char. no.	102: 3.5 (s = .1)
	44: .9 (s = .1)		

♀, total median length of ♀ specimen from sample RMNH 139: 111 mm

char. no.	17: 3.2 (s = .6)	char. no.	102: 3.5 (s = .1)
	44: .9 (s = .0)		

Distribution (fig. 61). — Mainly Java, more rare on Borneo.

Remarks. — The presence of *H. c. cyaneus* on Mount Kina Balu is worth to be mentioned. One specimen of *H. c. cyaneus* was, according to its label, collected in Xuân Long, a place on the latitude of Hué in Vietnam (RS 0126); this record is probably erroneous (caused by the hardly decipherable label). According to handwritten notes by Kopstein in a copy of his 1921 paper (now in the library of the RMNH), this species was found also on Irian Jaya (former Dutch New Guinea). Two ♀ and one ♂ from Merauke (New Guinea Expedition 1920, leg. Branderhorst) and 6 ♀ and 3 ♂ from Hollandia (Jayapura) (leg. Gjellerup 1911) are mentioned. These data are also mentioned in Kopstein's paper (1923: 185) on the Buitenzorg collection. I have not yet examined the specimens in question.

A graded series of slightly different forms of this subspecies can be distinguished from west to east Java. In this direction, colour darkens from brown to black (especially distinct in the case of the vesicle). The number of animals, in which the dorsal surface of the fifth metasomatic segment is granulated, increases also. The populations in central Java and Kali Baru (Banjuwangi) in east Java lack the granulation on the dorsal surfaces of metasomatic segments 3 and 4. In central Java the average number of granules on the external surface of pedipalp segment 4 in ♀ is higher than in the other parts of Java. A plot resulting from a principal components analysis on 44 log-normalized data of biometric characters in 73 specimens (fig. 20), shows a certain clustering of specimens from central Java and those from east Java. On the other hand, as for all Javanese specimens the variation appeared to be small (see p. 73) and it is impossible to define good characters by which a specimen can be determined with reasonable certainty, there is insufficient reason to discriminate subspecies within the Javanese *H. cyaneus*.

Nomenclature. — The name *S. afer* (Linnaeus, 1758: 624) was published as a substitute for earlier names used by Linnaeus (1746: 45): *S. javanicus* (= *B. cyaneus* Koch), *S. indicus* and *S. ceylonicus* (= *S. indus* de Geer). Many nomenclatorial problems resulted from Linnaeus' simplification and discord existed among later authors about the validity of names, the interpretation of descriptions and type-localities, etc. An important factor in the confusion is constituted by the (probable) loss of holotypes. The two "Linnean types" of *S. afer* kept in the ZMU were examined by me and identified as *H. i. indus* (de Geer) and *H. c. cyaneus* (Koch), in accordance with Thorell (1877: 205-211), in his profound study on the validity of these names. It is probable, however, that these specimens are younger than the true type-specimens described by Linnaeus: they could have been replaced later by Thunberg. As the nomenclatorial position of *afer* (Linnaeus) is not clear, and as this name has not been used since Lönnberg (1897: 178) in his study on the same problem, I here prefer the undoubted, although younger name *H. cyaneus* (Koch), frequently used in publications since Kraepelin (1899: 115).

Neotype-designation. — Koch (1836: 75) described an adult from Java. It formed part of the collection of J. Sturm in Nürnberg, but it could not be found in Nürnberg, nor in museums elsewhere. From the description it is impossible to deduce the sex of the holotype, because sexual dimorphism is hardly developed in this species, whilst the primary sexual characters were not yet known in the 19th century. The variability of characters in this genus and, consequently, the difficulties concerning its taxonomy (as explained in the first chapter) necessitate the availability of a type specimen for reference, preferably a well-preserved and accurately labelled specimen from a large sample. One of the dried "Linnean types" of *S. afer* Linnaeus, kept in the ZMU and identified as *H. c. cyaneus* (Koch), does not meet these conditions; it is, moreover, difficult or impossible to check certain characters in dried specimens (even its sex could not be established). Its systematic status is doubtful; after all it could be no Linnean type. For these reasons I have selected a specimen from sample RMNH 139 as a neotype. This sample from Kali Baru, Banjuwangi (Java), collected by M. A. J. Fokker, is accurately labelled and undamaged; it represents both sexes, of which I selected the ♂ as a neotype, because in most descriptions of *Heterometrus* species the holotype is a ♂ and by this selection interspecific comparison is made easier. The specimen selected as a neotype fits well with the description of *B. cyaneus* Koch; it also originates from the type-locality Java.

39. **Heterometrus (Javanimetrus) cyaneus sumatrensis** subspec. nov. (figs. 38, 61)

Material. — Sumatra: Padang (2 ♂ ad. including holotype, 1 ♀ ad. allotype, leg. Muller, RMNH 267), Bekri Deli (1 ♀ ad., RMNH 90).
Lesser Nicobar Islands: (1 ♀ ad., exp. S. Galathea, UZM, no number).

Description. — This subspecies differs from the nominal subspecies *H. c. cyaneus* (Koch) in the following characters.

Carapace (fig. 38a). The areas flanking the superciliary crests (fig. 38b) almost smooth (with a few faint and sparse granules), remaining areas granulated. — Pedipalps. Teeth of the dorsal keels on segment 3 stouter in the ♂ than in the ♀. Internal surface of segment 4 bears one large acuminate tooth and 4-6 smaller teeth, or it bears 3 stout and 4-5 smaller teeth (Nicobar islands), or it bears 4-7 low and obtuse teeth (Bekri Deli); external surface distinctly reticulated, its median keel uneven. External hand surface reticulated (faintly so in the ♂), its keels almost invisible, its dorsal keel almost straight with a few low and pointed teeth. — Walking-legs. Anterior surfaces of femora II-IV finely (and those of femora III and IV densely) granulated.

Mesosomatic tergites. Not punctate; median parts of tergites 1-6 smooth in the ♂, those of tergites 5 and 6 in the ♀ granulated; the median tubercles on tergites 1-6 faint, except for the distinct tubercle on tergites 3-6 in the specimen from the Nicobar islands. Medioposterior area of tergite 7 with distinct small tubercles and low granulation; lateral areas and borders finely granulated; lateral areas of tergite 7 also bear low and obtuse teeth, its lateral borders somewhat uneven or granulated. — Mesosomatic sternites. Longitudinal furrows well developed in sternites 1-4, reduced to series of slight impressions in sternite 5.

Metasoma. Although, in some specimens, the dorsal surface lacks a plicate aspect, it always shows granules on segments 1-4 and mostly also on segment 5. The teeth of the lateral keels of segments 1-4 are low and obtuse. Ventrolateral and ventral keels smooth on segments 1-3. Dorsolateral intercarinal areas of segment 1 (in some specimens 1-4) granulated in the ♀, those of segments 1-3 granulated in the ♂; ventrolateral areas of segments (2-)3-5 granulated, in the specimen from the Nicobar islands also reticulated on segments 1-3.

Biometric characters (see table 7: list 39):

char. no. 45: 1.02 char. no. 108: 2.5 (s = .1)

♂, total median length of holotype: 125 mm

char. no. 42: 154 (s = 10) char. no. 105: 2.5 (s = .2)
52: 3.4 (s = .2)

♀, total median length of allotype: 87 mm (in ♀ specimen from the Lesser Nicobar islands (UZM): 109 mm).

Distribution (fig. 61). — Sumatra (Deli, Padang) and (Lesser) Nicobar islands.

40. **Heterometrus (Javanimetrus) cyaneus insulanus** subspec. nov.

(fig. 61)

Material. — Central Madura (1 ♂ ad. holotype, 1 ♀ ad. allotype, leg. Mr. G. J. A. Steen Oct. 1903, RMNH 272).

Description. — This subspecies differs from the nominal subspecies *H. c. cyaneus* (Koch) in the following characters.

Carapace. Antocular part of superciliary crests sparsely granulated in the ♂ (rather smooth ridges). Posterior border smooth. — Pedipalps. External surface of segment 4 reticulated, with smooth keels. External surface of the hand reticulated by confluent low granules; the keels invisible in the ♂. — Walking-legs. Four antero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. Posterior borders smooth. — Mesosomatic sternites. Sternite 5 smooth or, in one specimen, with slight impressions.

Biometric characters (see table 7: list 40):

char. no. 56: 128(s = 8)

♂, total median length of holotype: 98 mm
♀, total median length of allotype: 105 mm

Distribution (fig. 61). — Central Madura.

Subgenus **Chersonesometrus** Couzijn

(figs. 57-59)

Chersonesometrus Couzijn, 1978: 331 and table 1 (brief introduction).

Description. — The following characters are found in the majority of (sub)species.

Carapace. Rostrolateral edge continuously curved (without incision next

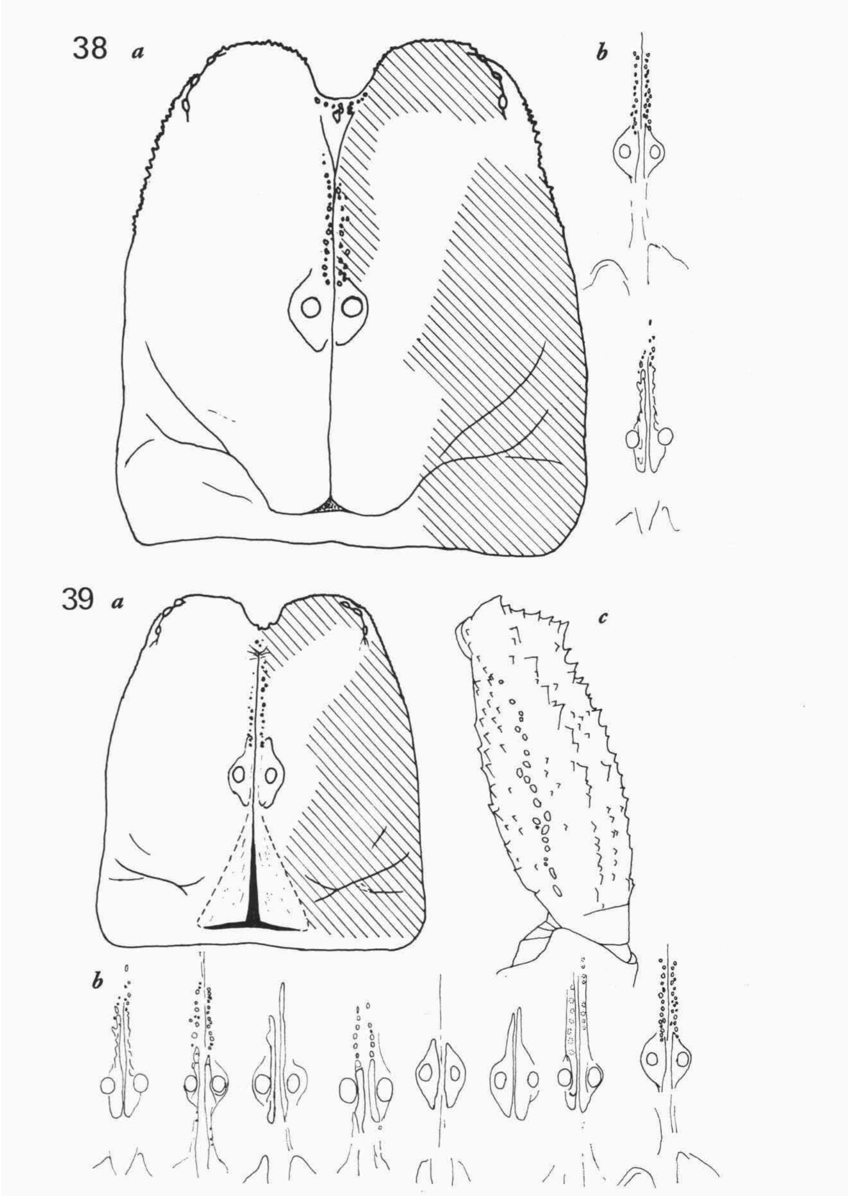

Fig. 38. *Heterometrus (Javanimetrus) cyaneus sumatrensis* subspec. nov.; a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (antocular parts above); a-b, × 3.7.

Fig. 39. *Heterometrus (Chersonesometrus) fulvipes* (Koch); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (most common type left; antocular parts above); c, left view of metasomatic segment 5 of ♂ adult (RS 0085); a-c, × 3.7.

to the lateral eyes). Medioposterior border not granulated but smooth. — Pedipalps. The externodorsal keel of segment 3 does not bear stout and sharp teeth, as in *Javanimetrus* and most representatives of the subgenus *Heterometrus*, though these teeth can be stout or sharp (mostly small and obtuse). External surface of segment 4 coarsely granulated (not in *H. s. scaber, H. liurus, H. phipsoni kanarensis* and *H. granulomanus*). Internal surface of segment 4 bears more than two prominent teeth (and smaller teeth or granules or very low teeth). External hand surface granulated and in most species without keels; some of the species show reticulation, or keels which are recognizable in the granulation pattern. — Pectines. Internal fulcral plates in some taxa smooth, in other taxa bearing a macro- or microseta, or variable.

Mesosomatic tergites. Lateroposterior denticulated tubercles of tergite 7 inconspicuous. — Metasoma. No gradual reduction of the lateral keels from stout and sharp teeth to very fine granulation or denticulation series from basal to terminal end, as can be observed indeed in the subgenus *Heterometrus*.

Biometric characters (mean values):

♂, char. no.	52:	2.4-3.2	except for *H. phipsoni kanarensis*:	3.7
			and *H. granulomanus*:	2.0
	74:	2.9-3.5		
♀, char. no.	17:	2.0-3.7	except for *H. xanthopus*:	6.2
	44:	.8-1.0	except for *H. scaber rugosus*:	1.1
	102:	3.3-3.6		

Distribution (figs. 57-59). — All over India, but not on Sri Lanka.

Type-species: *Buthus fulvipes* Koch, 1838.

Name. — Derived from the Greek word for "peninsula" (referring to the distributional area of the representatives of this subgenus on the Indian peninsula) and the suffix "-metrus" (m.).

Species-group *fulvipes*

This species-group was introduced by Couzijn, 1978: 331 and table 1.

27. **Heterometrus (Chersonesometrus) fulvipes** (Koch)

(figs. 39, 57)

Buthus fulvipes Koch, 1838: 45, description of adult ♀ ?, type-locality "Java".
Palamnaeus fulvipes madraspatensis Pocock, 1900b: 88.
Palamnaeus fulvipes bombayensis Pocock, 1900b: 89.

Material. — Rajasthan: Genji (2 ♂ ad., 3 ♀ ad., RS 0085; 2 ♂ ad., 4 ♀ ad., RS 0113), Beawar, Rajputana (4 ♂ ad., 1 ♀ ad., RS 0157).

Madhya Pradesh: "central province" (1 ♀ ad., 1 of 5 specimens sharing number RS 0109).

Maharashtra: Násik (1 ♀ ad., one of the syntypes of *P. fulvipes bombayensis* Pocock, neotype *H. fulvipes* (Koch), BM 1913.1.6.2).

Orissa: Balasore district (1 ♀ juv., RS 0121).

Bihar: Kathikund, direct surroundings of forest Shorea (1 ♂ ad., RS 5325).

Andhra Pradesh: Secunderabad (1 ♀ ad., 1 ♂ juv., BM 1893.3.16.9.10), Cuddapah (1 ♀ ad., BM 1896.7.30.99).

Karnataka: Mysore, environs of Bangalore (1 ♀ ad., RS 7798; 1 ♀ ad., RS 7799; 1 ♀ ad., RS 7800; 1 ♀ ad., RS 7801; 1 ♀ ad., RS 7802; 1 ♂ juv., RS 7803).

Tamil Nadu: Madras (2 ♂ ad., "brought from Res. College Madras Oct. 1910", BM, no number), Shevaroy Hills (1 ♂ juv./subad., 1 of 2 specimens, "type *Scorpio phipsoni* Pocock: ♀", BM 1979.7.3.2-3), Pondicherry (Puduchcheri) (5 ♂ ad., 10 ♀ ad., 2 ♀ subad., 3 ♂ juv., 8 ♀ juv., RS 6168).

Uncertain locality: India Orientalis (1 ♀ ad., "syntype *Pandinus caesar* Koch" err. non *H. i. indus* (de Geer), ZMB 63).

Description. — Carapace (fig. 39a). Postocular parts of the superciliary crests absent, the interocular parts smooth, the antocular parts granulated (type 4; see fig. 39b). Second lateral eye much closer to the first than to the third; lateral eyes relatively large. Frontal and lateral (in some specimens also lateroposterior) areas granulated, areas flanking the median eyes (in most cases sparsely) granulated, remaining areas smooth. Medioposterior border smooth, remaining borders (finely) granulated.

Pedipalps. Externodorsal keel of segment 3 with blunt teeth; denticles on internodorsal keel sharper. Internal surface of segment 4 with 5-10 (mostly blunt) teeth or granules; its external surface granulated in the ♀, sparsely granulated and uneven in the ♂. The hand rather dilated in both sexes; its external surface covered with granules, the keels partly constituted by series of stout granules, but for the most part not distinguishable (relief type 1); the dorsal keel of the short hand of the ♀ more strongly curved than that in the ♂, furnished with blunt (♀) or pointed (♂) teeth. — Walking-legs. Anterior surface of femur I smooth, that of femur II sparsely and finely granulated, those of femora III and IV densely so. Inferior keels on femur I with a few granules, those of femora II-IV densely granulated. Four (in one specimen five) antero-inferior spines and five or six postero-inferior spines on telotarsi III and IV. — Pectines. Internal fulcral plates without setae or with a macroseta.

Mesosomatic tergites. Rather small smooth median areas with faint tubercles, sparsely granulated on tergite 7 only; remaining areas granulated, just like all borders. The two inconspicuous tubercles near the posterior border of tergite 7 (flanking the median area) granulated. — Mesosomatic sternites.

Surface smooth, with longitudinal furrows in sternites 1-4; lateral borders very finely (in some places faintly) denticulated. — Metasoma (fig. 39c). Dorsal surface sparsely granulated. Dorsal keels with low and blunt teeth on segments 1-4, low and sharp teeth on segment 5, just like its lateral keels, which, on the preceding segments, bear blunter and fainter denticulation (in some places the keels constitute almost smooth ridges). Ventrolateral and ventral keels of segments 1 and 2 smooth, those of segment 3 uneven, those of segment 4 with low and blunt denticulation, on segment 5 bearing sharp teeth of which the size increases in terminal direction, the terminal ventrolateral tooth much stouter than the preceding teeth. Dorsolateral intercarinal areas granulated on segments 1 and 2, this aspect variable on segments 3-5; lateral areas granulated; ventrolateral areas smooth on segments 1 and 2, granulated on segments 3-5; ventral areas smooth.

Colour pattern. In specimens from Genji, Secunderabad, Cuddapah and Beawar, the legs and vesicle are distinctly bright-coloured (yellowish-brown), whilst the remaining part of the body is dark. This character mentioned already by Koch (1838: 45) does, however, not apply to all representatives of this rather variable species.

Biometric characters (see table 7: list 27):

char. no.	30: 57 (s = 12)	char. no.	63: 3.5 (s = .4)
	51: .8 (s = .2)		129: ± .45
	56: 69 (s = 8)		130: ± 2.25

♂, total median length of ♂ from sample RS 0085: 96 mm

char. no.	17: 3.1 (s = .4)	char. no.	44: .9 (.8-1.1; s = .1)
	29: 83 (s = 5)		52: 3.1 (s = .5)
	42: 112 (s = 6)		74: 3.1 (s = .1)

♀, total median length of ♀ specimen from sample RS 0085: 95 mm

char. no.	17: 3.2 (s = .7)	char. no.	52: 2.9 (s = .4)
	29: 51 (s = 5)		74: 2.7 (s = .2)
	44: .8 (s = .1)		

Distribution (fig. 57). — Various places in India. Pocock (1900b: 89) recorded this species (under the subspecific name of *Palamnaeus fulvipes bombayensis* Pocock) also from several other places in central and northwestern India, viz., Ajmeer, Pánch Máhals, Karaghora, W. Kandesh, E. Satpura Hills, Talgaon, Chalisgaon, Niphad, Chandor, Sinnar, Yeola, Malegaon, Nandgaon and Kalwan.

Remarks on synonymy. — The subspecies *P. fulvipes madraspatensis* (of which the holotype could not be found in the BM) and *P. f. bombayensis* described by Pocock (1900b: 88-89, fig. 25) do not show other differences from *B. fulvipes* Koch than the larger or smaller ratio of length and width of the male's pedipalp hand. The range of variation of this character (no. 44 in this paper), measured also in part of Pocock's type series, includes high and low extremes, but without distinct discontinuity. These values appear to me to be less extreme than those mentioned and figured by Pocock.

Neotype-designation. — Koch (1838: 45) described an adult (♀?) from "Java" (the difficult establishing of the sex in this case largely depends on the number of pectinal teeth). It formed part of the collection of J. Sturm in Nürnberg, but it could not be found there, nor in museums elsewhere. The variability of characters in this genus and, consequently, the taxonomic difficulties (as explained in the first chapter) necessitate the availability of a well-preserved and accurately labeled specimen for reference. The specimen indicated as one of the syntypes of *Palamnaeus fulvipes bombayensis* Pocock (leg. Duxbury, BM 1913.1.6.2) can serve as a good neotype of *H. fulvipes* (Koch); its origin is Násik (Maharashtra state), a proper type locality. The original type-locality "Java" must be erroneous, as *H. fulvipes* was never found on this island (cf. Pocock, 1892b: 307; Giltay, 1931: 9). The designated ♀ adult neotype is well identical with the description of *B. fulvipes* Koch.

28. **Heterometrus (Chersonesometrus) xanthopus** (Pocock)

(figs. 40, 57)

Palamnaeus xanthopus Pocock, 1897: 116, description of adult ♀ and ♂, type-locality Kadao Tal (Satara).

Material. — Maharashtra: Kadao Tal (Satara), S. Deccan, Bombay (1 ♂ ad. allotype, 1 ♀ ad. holotype, 2 ♂ juv., 1 ♀ juv., leg. A. D. Wilkins, BM 1896.9.26).

Description. — This species differs from the similar species *H. fulvipes* (Koch) in the following characters.

Carapace (fig. 40a, b). The area closely around the median oculiferous tubercle, and the triangular medioposterior area are faintly or sparsely granulated or smooth, though in one ♂ granulated just like the remaining areas of the carapace.

Pedipalps. Dorsal keels of segment 3 with rather small and mostly blunt teeth, somewhat lower on the externodorsal keel than on the internodorsal keel. Internal surface of segment 4 with 2-5 low granules, dorsally accompanied by many smaller granules; its external surface, including the keels, coarsely granulated. Keels of external hand surface absent (microsculpture type 5); its dorsal keel slightly curved, with blunt teeth. — Walking-legs. Anterior surface of femur I very sparsely and finely granulated. In most specimens only the terminal part of the inferior keels on femur IV is granulated. Four antero-inferior spines on telotarsi III and IV; five postero-inferior spines on telotarsus III, six on telotarsus IV. — Pectines. Internal fulcral plates with a macroseta.

Mesosomatic tergites. Covered with granules (fine on tergites 1-6) in the ♂; smooth median areas and lateroposterior granulation (fine on tergites 1-6) in the ♀. In most ♂ the posterior border of tergite 7 is smooth, just as in all ♀; remaining borders granulated so far as they are limiting granulated areas. Numerous brightly coloured impressions in every tergite. — Mesosomatic sternites. Lateral borders finely granulated. — Metasoma (fig. 40c). In most specimens not every segment has dorsal granulation, though reticulation can occur. Teeth of dorsal keels somewhat more pronounced starting from segment 4. Lateral keels faintly denticulated. Dorsolateral intercarinal areas of segment 2 smooth or reticulated in many specimens, these areas smooth on the other segments; ventrolateral areas of segment 3 smooth.

Biometric characters (see table 7: list 28):

char. no. 34: 2.7 (s = .8) char. no. 63: 2.7 (s = .2)

♂, total median length of allotype: exact length unknown (incomplete metasoma), but estimated length ± 77 mm

char. no. 17: 5.2 (s = 1.1) char. no. 70: 2.2 (s = .4)
42: 87

♀, total median length of holotype: 74 mm

char. no. 17: 6.2 (s = 1.5) char. no. 43: 91
29: 38 98: 267
42: 72

Distribution (fig. 57). — Kadao Tal (Satara, S. Deccan, Maharashtra).

29. **Heterometrus (Chersonesometrus) pelekomanus** spec. nov.

(figs. 2f, 41, 58)

Material. — Maharashtra: Nilgiris, Deccan (2 ♂ ad. including holotype, leg. unknown, SMF II/1088/19), Bombay, Deccan (1 ♂ ad., 2 ♀ ad. including allotype, 10 ♂ juv., 8 ♀ juv., SMF II/329/3).
Karnataka: Mysore, environs of Bangalore (1 ♀ juv., RS 7804).
Andhra Pradesh: Tirumalai Hills, Tirupati (1 ♂ juv., 1 ♀ juv., RS 4499).

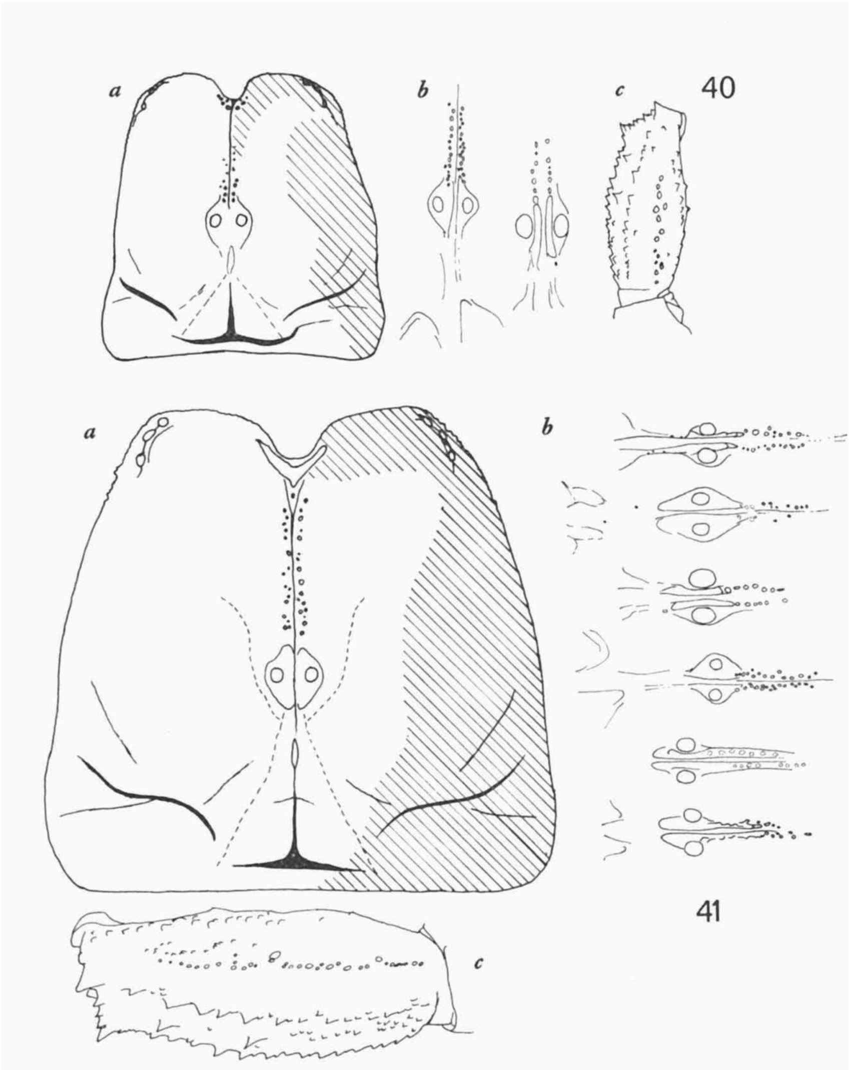

Fig. 40. *Heterometrus (Chersonesometrus) xanthopus* (Pocock); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (antocular parts above); c, right view of metasomatic segment 5 of holotype; a-c, × 3.7.

Fig. 41. *Heterometrus (Chersonesometrus) pelekomanus* sp. nov.; a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (in order of frequency; antocular parts right); c, right view of metasomatic segment 5 of allotype; a-c, × 3.7.

Description. — This species differs from the similar species *H. fulvipes* (Koch) in the following characters.

Carapace (figs. 2f, 41a). Postocular parts of superciliary crests hardly developed, the antocular parts variable: strongly reduced and almost smooth, or uneven, or finely granulated, in some specimens even densely so (type nos. 2, 3 and 4; see fig. 41b). Frontal area in some ♂♂ smooth. Smooth median area rather wide. Rostral border smooth.

Pedipalps. Dorsal keels of segment 3 with rather small and obtuse teeth, hardly contrasting with the granulation of the dorsal surface. Hand much flattened, especially in the ♂♂ in which the, proximally expanded, large inner lobe is sharply edged and mostly bent in such a way that the external surface of this lobe has a concave aspect; the keels recognizable by series of stout granules, which are fused in several places in these series (microsculpture type 2); its dorsal keel with small and blunt teeth. — Walking-legs. Anterior surfaces of femora I and II finely granulated. Inferior keels on femora densely granulated. Five antero-inferior and seven postero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. Median areas rather smooth but very finely granulated, just as the borders. — Metasoma. All dorsal keels with faint, low and obtuse denticulation. Lateral keels of segments 1-3 smooth (in some cases uneven in the posterior part of segment 3), those of segments 4 and 5 faintly and obtusely denticulated. Dorsolateral intercarinal areas sparsely granulated (in some specimens smooth on segment 5). Lateral areas granulated, though mostly smooth on segment 5. Ventrolateral areas granulated (in some specimens smooth on segments 1 and 2). Medioventral areas of segments 1-4 can be sparsely granulated in some ♂.

Biometric characters (see table 7: list 29):

char. no. 71: 1.13 (s = .04)	char. no. 130: ± 2.25-2.30

♂, total median length of holotype: 129 mm

char. no. 42: 169 (s = 9)	char. no. 98: 539 (s = 26)
83: 18.67 (s = .52)	

♀, total median length of allotype: 111 mm

char. no. 21: 96 (65-175; s = 53)	char. no. 43: 167 (s = 16)
29: 78 (s = 8)	98: 483 (s = 17)

Distribution (fig. 58). — Various localities in southern India and near Bombay.

30. **Heterometrus (Chersonesometrus) fastigiosus** spec. nov.

(figs. 4d, 42, 57)

Material. — Uttar Pradesh: Kulu ("Kooloo"), Himalaya (1 ♀ ad., Simon's collection no. 5771, RS 0123), Amballa (1 ♀ ad., Simon's collection no. 2571, RS 0145), Dehra Dún (1 ♂ ad., 1 ♀ ad., 1 ♂ juv., BM 1896.2.2.1-2), Gwalior (1 ♂ ad., BM 1896.12.15-19), Allahabad (2 ♂ ad., 2 ♀ ad., BM 1897.5.10.218-221).

Assam: Assam (1 ♂ ad. holotype, 1 ♀ ad. allotype, 1 ♂ juv./subad., SMF II/8886/228).

Madhya Pradesh: Satna (1 ♂ ad., 1 ♀ ad., 1 ♀ subad., BM 1896.8.15.4), Chota Nagpur (Madhya Pradesh/Bihar) (1 ♂ ad., BM 1896.9.26.92).

Uncertain localities: Himalaya (1 ♀ ad., ZMA, no number), Bengal (1 ♂ ad., 1 ♀ ad., "syntypes of *B. bengalensis* Koch", ZMB, no number).

Description. — This species differs from the similar species *H. fulvipes* (Koch) in the following characters.

Carapace (fig. 42a, b). Postocular parts of the superciliary crests sparsely granulated or hardly present, though there is a distinct and deep postocular furrow with smooth borders (type 3; see fig. 42c); antocular parts sparsely granulated or smooth. Rostral lobes and frontal, lateral and lateroposterior areas granulated; remaining areas very faintly granulated (almost smooth). Borders of rostral lobes smooth or uneven.

Pedipalps. Dorsal keels of segment 3 with rather small and blunt teeth. Internal surface of segment 4 with ± 5 teeth (blunt in the ♀), a few granules (in some ♂♂ many uniform teeth) and dorsally many small granules; its external surface and keels granulated. The hand (fig. 4d) hardly dilated in the ♂, distinctly more dilated in the ♀; its external surface reticulated and (externoventrally) granuloreticulated in the ♂, granuloreticulated and (externoventrally) granulated in the ♀; in a few samples originating from Satna, Allahabad and Chota Nagpur, the reticulation is (almost) absent even in ♂ specimens: here the hand is just granulated, while in ♂♂ from Satna and Allahabad a very small externodorsal area only shows reticulation. External keels of the hand absent (microsculpture type 3); its dorsal keel denticulated. — Walking-legs. Anterior surface of femur I sparsely and finely granulated, those of femora II-IV more densely so; those of femora I and II nearly smooth in specimens from Assam. Inferior keels on femora granulated. Four (to five) antero-inferior spines on telotarsi III and IV; five (to six) postero-inferior spines on telotarsi III, (five to) six on telotarsi IV. — Pectines. Internal fulcral plates smooth, in some cases with a microseta.

Mesosomatic tergites. Surface finely granulated, but the median part of tergite 2(-4) sparsely so. Median tubercles distinct on tergites 3-7. In some specimens the medioposterior border of tergites 1-6 is smooth. — Mesosomatic sternites. Lateral borders finely granulated. — Metasoma (fig. 42d).

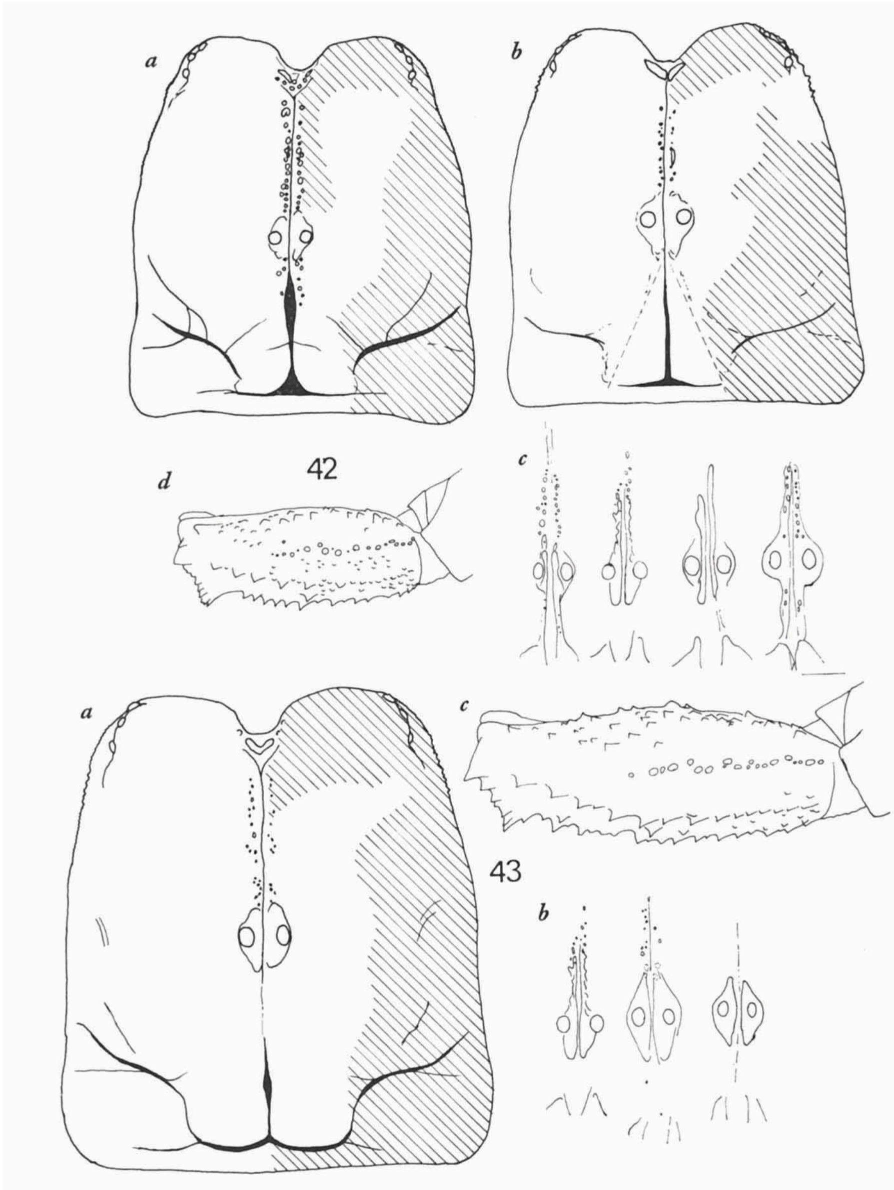

Fig. 42 *Heterometrus* (*Chersonesometrus*) *fastigiosus* sp. nov.; a, b, carapace (on the right half, granulated areas are shaded); c, observed types of superciliary crests (in order of frequency; antocular parts above); d, right view of metasomatic segment 5 of ♀ adult (RS 0123); a-d, × 3.7.

Fig. 43. *Heterometrus* (*Chersonesometrus*) *granulomanus* sp. nov.; a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (in order of frequency; antocular parts above); c, right view of metasomatic segment 5 of holotype; a-c, × 3.7.

Dorsal granulation coarse on segments 1-4, fine and sparse in segment 5. Dorsal keels with stouter and sharper teeth on segments 2-5. Teeth of lateral keels low and blunt on segments 1-4, fine and sharp on segment 5, this transition from segment 1 to segment 5 being more gradual in specimens from Assam. Ventrolateral and ventral keels smooth on segments 1-3. Granulation of dorsolateral and lateral intercarinal areas coarse on segments 1-4, fine and sparse on segment 5. Ventrolateral areas of segments 1-3 smooth (or locally reticulated).

Biometric characters (see table 7: list 30):

♂, total median length of holotype: 93 mm

char. no. 44: 1.2 (s = .0) char. no. 82: 63

♀, total median length of allotype: 88 mm

Distribution (fig. 57). — Ganges plains and southern slopes of the Himalaya Mts., from Punjab to Assam.

Remarks. — The "syntypes" of *B. bengalensis* Koch from Bengal, preserved in the ZMB, evidently belong to this species; they do not fit Koch's description of *B. bengalensis*, i.a., by the absence of external keels on the pedipalp hands and the different internal denticulation on the fourth pedipalp segment. Some geographic (East-West) variation is apparent from the description above, i.a., in the pedipalp hand microsculpture, the granulation of walking-leg femora and the denticulation of lateral metasomatic keels. Within the type series three slightly different groups of specimens can be distinguished, viz., the specimens from Assam, those from eastern Hindostan (Chota Nagpur, Satna, Allahabad) and the animals from western Hindostan (Gwalior, Dehra Dún, Kulu, Amballa). This geographic variation is shared with other faunal and floral elements occurring along the slopes of the Himalaya Mts. (Mani, 1974b: 631; 1974c: 651). I consider these differences in *H. fastigiosus* too small for subspecific differentiation.

36. **Heterometrus (Chersonesometrus) granulomanus** spec. nov. (figs. 2g, 4c, 43, 58)

Material. — Tamil Nadu: Pondicherry (Puduchcheri) (1 ♂ ad., 1 ♀ ad., RS 0079; 1 ♂ ad. holotype, 2 ♀ ad. including allotype, leg. unknown, RS 0087; 1 ♀ ad., RS 3246), Palni Hills ("Pullney-Hills"), Kadai-canal (1 ♂ ad., SMF 5332).

Madhya Pradesh: Central province (2 ♂ subad., 2 of 5 specimens sharing number RS 0109).

Description. — This species differs from the similar species *H. fulvipes* (Koch) in the following characters.

Carapace (fig. 43a). Antocular parts of superciliary crests strongly reduced and only sparsely granulated (fig. 43b). Second lateral eye less close to the first; lateral eyes very small with respect to their mutual distances (fig. 2g). A granulated triangular area extends from the lateroposterior transverse furrow unto the lateral eyes; frontal areas and lateroposterior areas (behind the above-mentioned furrows) faintly granulated (in some ♀♀ distinctly so); remaining areas smooth.

Pedipalps. Dorsal keels of segment 3 with small but sharp teeth. Internal surface of segment 4 with 3-6 low and fine teeth, dorsally accompanied by a group of fine granules; its external surface with faintly reticulated areas and smooth keels (♂) or with sparsely granulated areas and keels (♀). The hand (fig. 4c) in the ♀ strongly dilated, with large proximal lobe, less dilated in the ♂; large and confluent granules indicate the keels (microsculpture type 2); dorsal keel with rather small, low and locally obtuse teeth. — Walking-legs. Anterior surfaces of femora I and II almost smooth (very sparsely and finely granulated). Inferior keels on femora I and II sparsely granulated, those on femora III and IV uneven or smooth. Four (in some specimens three) antero-inferior and five or six postero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. Median areas of tergites 1-7 (or, in some ♀♀, 1 and 2) smooth or faintly granulated; remaining areas finely granulated. Median tubercles distinct on tergites 3-7. Medioposterior borders of tergites 1-6 and posterior border of tergite 7 smooth. — Mesosomatic sternites. Lateral borders of sternites 1-4 finely granulated, uneven on sternite 5.

Metasoma (fig. 43c). Dorsal keels finely denticulated. Lateral keels of segments 1-3 with low and blunt denticles, those of segments 4 and 5 with fine and sharp denticles. Ventrolateral and ventral keels of segments 1-3 smooth. Dorsolateral and lateral intercarinal areas finely granulated on segments 1-4, smooth on segment 5. Ventrolateral areas of segments 1-3 (in some ♀♀ 1 and 2) smooth, those of the other segments sparsely granulated.

Biometric characters (see table 7: list 36):

char. no. 63:	3.8 (s = .3)	char. no. 129:	± .80
71:	1.12 (s = .05)	130:	± .95

♂, total median length of holotype: 98 mm

char. no. 42:	153 (s = 12)	char. no. 52:	2.0 (s = .2)

♀, total median length of allotype: 84 mm (other paratype in sample RS 0087: 98 mm)

char. no. 43:	168 (s = 10)	char. no. 52:	2.0 (s = .2)

Distribution (fig. 58). — Various localities in south-east and central India.

24. **Heterometrus (Chersonesometrus) scaber scaber** (Thorell) (figs. 44, 58)

Pandinus scaber Thorell, 1877: 202; new name for *H. afer* sensu Simon, 1872: 99, non Linnaeus, 1758: 624; type-locality "Bengal". The sex of the holotype cannot be concluded from the description; sexual dimorphism is only slightly developed in this species, and the holotype is, moreover, lost.

Material. — Kerala: Malabar coast (1 ♂ ad., RS 0095), Mahé (1 ♂ ad., RS 0096; 1 ♀ ad. neotype, leg. Deschamps, RS 0098; 1 ♀ ad., RS 3264).
Goa: Goa (1 ♂ ad., RS 0100).
Karnataka: Mangalore Ghâts, 2000'-2500' (2 ♂ ad., 3 ♀ ad., BM 1896.7.30.139-142), Dharwar (1 ♂ ad., 1 ♀ ad., 1 subad., 1 juv., BM 1897.9.17.9.14), Jelgit, Mangalore (6 juv., BM 1896.7.30.143-144), Jedkal, Mangalore (1 ♂ ad., 1 ♀ ad., 1 ♂ subad., 1 ♀ subad., BM 1896.7.30.145-148).
Tamil Nadu: Pondicherry (Puduchcheri) (1 ♂ ad., RS 0099), Coimbatur, Pondicherry (2 ♂ ad., RS 0101).
Kerala: Travandore (? = Travancore or Trivandrum?) (1 ♂ ad., 1 ♀ ad., 3 juv., BM 1896.10.20.65-67).

Description. — Carapace (fig. 44a). Postocular parts of the superciliary crests absent or, in some specimens, hardly recognizable by a few small granules; interocular parts smooth; rostral parts coarsely granulated (type 4; see fig. 44b) just as the whole surface of the carapace. Medioposterior border smooth, lateral borders finely granulated, remaining parts of the border more coarsely granulated.

Pedipalps. Dorsal keels of segment 3 with stout and blunt teeth. Internal surface of segment 4 with 6-9 stout and blunt teeth and a few granules; its external surface uneven, with a plicate aspect in some places. The hand dilated in both sexes, its external surface reticulated but in some areas furnished with faint granulation; its external keels almost completely indistinguishable (relief type 7); its dorsal keel slightly curved and furnished with low and often blunt teeth. — Walking-legs. Anterior surface of femur I smooth, those of femora II-IV granulated. Inferior keels on femur I uneven, those on femora II and III faintly granulated (almost smooth), those on femur IV smooth. Four (in some specimens three) antero-inferior, five or six postero-inferior spines on telotarsi III and IV. — Pectines. Internal fulcral plates smooth or with a macroseta.

Mesosomatic tergites coarsely granulated, the tubercles thus disguised by the large granules. Lateral margins of tergites 1-6 finely granulated, those of tergite 7 furnished with small teeth; posterior borders of tergites 1-6 coarsely granulated, that of tergite 7 smoothly edged, but lined with a few granules. Low and blunt teeth on the low tubercles of tergite 7. — Mesosomatic sternites. Smooth surface, with short longitudinal furrows in sternites 1-4. Borders uneven or smooth (in a few specimens the lateral borders of sternites 2-4 are sparsely and finely denticulated).

Metasoma (fig. 44c). Dorsal surface coarsely granulated. Dorsal keels with pointed teeth. Lateral keels with slightly lower teeth, blunt on segment 1, slightly more pronounced on the last segments. Ventrolateral and ventral keels smooth on segments 1-3, uneven or faintly denticulated on segment 4, distinctly and sharply denticulated on segment 5, the terminal ventrolateral tooth being much stouter than the preceding teeth. Dorsolateral intercarinal areas granulated on segments 1-3, sparsely and finely so on segments 4 and 5; lateral areas densely granulated on segments 1-4, sparsely so on segment 5; ventrolateral areas smooth on segments 1 and 2, more or less granulated on segments 3-5; ventral areas smooth. Intercarinal areas often with series of granulations.

Biometric characters (see table 7: list 24):

char. no. 45:	1.02	char. no. 108:	1.6 (s = .2)
51:	1.3 (s = .1)	129:	± .80
56:	93 (s = 20)	130:	± 1.90
63:	4.3 (s = .2)		

♂, total median length of ♂ specimen from sample RS 0101: 112 mm

char. no. 17:	2.7 (s = .5)	char. no. 82:	59 (s = 7)
44:	.9 (s = .0)	83:	11.83 (s = .72)
52:	3.1 (s = .2)		

♀, total median length of neotype: 103 mm

char. no. 17:	3.7 (s = .1)	char. no. 82:	55 (s = 7)
44:	.9 (s = .0)	83:	11.75 (s = .96)
52:	3.3 (s = .4)		

Distribution (fig. 58). — Southern India: Coromandel coast, Coimbatur and the western Ghâts up to Goa.

Neotype-designation. — Simon (1872: 99) described an adult, of which the sex cannot be concluded from the description, under the erroneous name of *Heterometrus afer* (Linnaeus). Simon mentioned that it "paraît commun au Bengale". He added a few measurements of his largest specimen; none of the specimens of *H. s. scaber* (Thorell) (new name for *H. afer* sensu Simon) that were once parts of Simon's personal collection (now kept in the Paris museum) does fit these measures. No corresponding specimens from Bengal are present in this or other collections. The type-locality is most probably erroneous (cf. Pocock, 1900b: 93, footnote). The variability of characters in *Heterometrus* and, consequently, the taxonomic difficulties (as explained in the first chapter) necessitate the availability of a well-preserved and

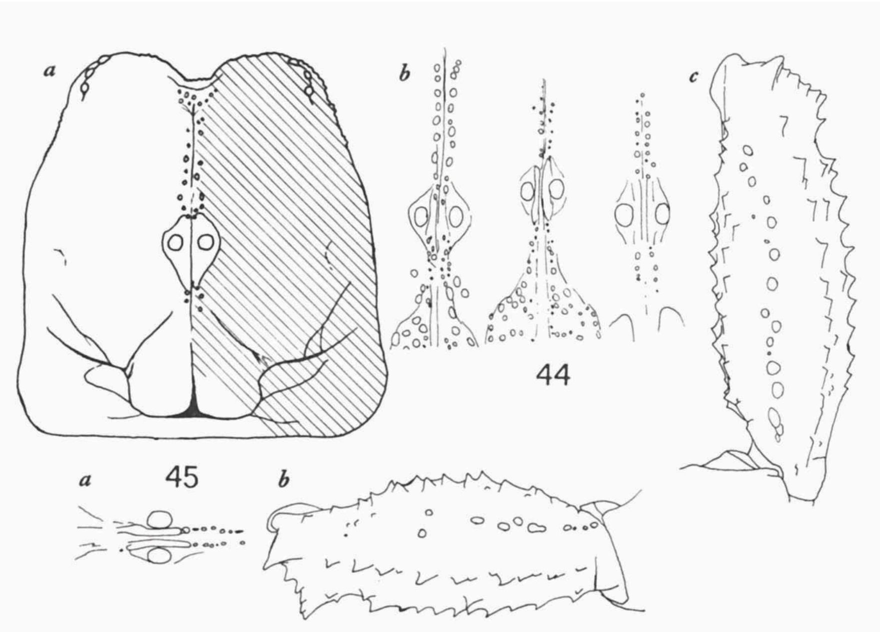

Fig. 44. *Heterometrus* (*Chersonesometrus*) *s. scaber* (Thorell); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (in order of frequency; antocular parts above); c, left view of metasomatic segment 5 of ♂ adult (RS 0101); a-c, × 3.7.

Fig. 45. *Heterometrus* (*Chersonesometrus*) *scaber rugosus* subsp. nov.; a, holotype; a, superciliary crests (antocular parts right); b, right view of metasomatic segment 5; a-b, × 3.7.

accurately labelled specimen for reference. The adult ♀ (sample RS 0098, leg. Deschamps) from Mahé, designated here as a neotype, is complete and well comparable with the holotype. I selected a ♀ as neotype, because the holotypes of the subspecies *H. scaber rugosus* and *H. scaber obscurus* (see below) are ♀, no ♂ being available; by the choice of a ♀ neotype for *H. s. scaber* comparison with these subspecies is facilitated.

25. **Heterometrus (Chersonesometrus) scaber rugosus** subspec. nov.

(figs. 45, 58)

Material. — Kerala: Malabar coast (1 ♀ ad. holotype, leg. E. Pougnet, Simon's personal collection no. 17340, RS 0082).

Description of the adult ♀. — This subspecies differs from the nominal subspecies *H. s. scaber* (Thorell) in the following characters.

Carapace. Postocular parts of superciliary crests absent (fig. 45a). Lateral and posterolateral areas and frontal margin granulated; remaining areas smooth, though locally faint granules occur and a few sparse and fine granules can be found near the superciliary crests.

Pedipalps. Teeth of dorsal keels on segment 3 hardly contrasting with its dense and coarse dorsal granulation. External surface of segment 4 (including its keels) coarsely granulated. The hand slender; its external surface covered with granules, partly fused to form faint reticulation (relief type 5); its dorsal keel almost straight and denticulated. — Walking-legs. Anterior surface of femur I sparsely and finely granulated. Inferior keels on femora I-III granulated, sparsely so on femur IV. Four antero-inferior and five postero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. Tergites 1 and 2 smooth and without median tubercles; lateral areas of tergites 3-6 furnished only with a transverse series of fine granules. Lateral borders of tergite 7 notched, its posterior borders smooth. — Mesosomatic sternites. Longitudinal furrows distinct in every sternite.

Metasoma (fig. 45b). Dorsal surface sparsely granulated on segments 2-4, smooth on segment 5. Dorsal keels of segment 1 with low and obtuse teeth. Ventrolateral keels of segments 2 and 3 uneven. Dorsolateral intercarinal areas of segments 4 and 5 smooth. Ventrolateral areas of segments 2-4 granulated.

Biometric characters (see table 7: list 25):

char. no.	71: 1.24	char. no.	129: .75
	108: 2.5		130: 1.69

♀, total median length of holotype: 112 mm

char. no.	17: 2.3 (s = .1)	char. no.	44: 1.1
	21: 80		82: 70
	29: 90		

Distribution (fig. 58). — Malabar coast.

26. **Heterometrus (Chersonesometrus) scaber obscurus** subspec. nov. (figs. 46, 58)

Material. — Maharashtra: Mathéran, near Bombay (1 ♀ ad. holotype, leg. M. Maindron, RS 0107).

Description of the adult ♀. — This subspecies differs from the nominal subspecies *H. s. scaber* (Thorell) in the following characters.

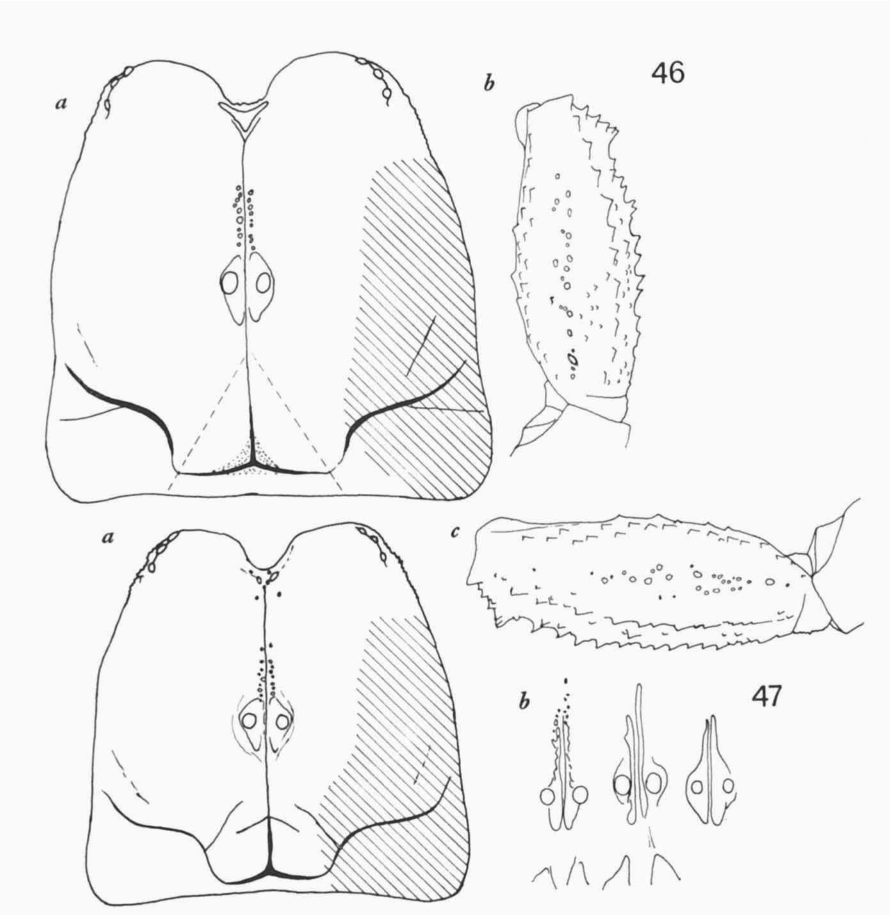

Fig. 46. *Heterometrus (Chersonesometrus) scaber obscurus* subsp. nov., holotype; a. carapace (on the right half, granulated areas are shaded); b, left view of metasomatic segment 5; a-b, × 3.7.

Fig. 47. *Heterometrus (Chersonesometrus) p. phipsoni* (Pocock); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (in order of frequency; antocular parts above; c, right view of metasomatic segment 5 of holotype; a-c, × 3.7.

Carapace (fig. 46a). Postocular parts of superciliary crests absent. Posterior triangular area (including the posterolateral areas and reaching unto the lateral eyes) finely granulated; frontal and medioposterior areas very faintly and finely granulated, remaining areas smooth and shining.

Pedipalps. Teeth of the dorsal keels of segment 3 rather small, most of them blunt, on the externodorsal keel slightly lower than the teeth on the internodorsal keel. Internal surface of segment 4 bears ± 5 blunt teeth and some granules, dorsally accompanied by very fine granules; its external surface (including its keels) coarsely granulated. The external hand surface covered with low and stout granules, no keels present; its dorsal keel with blunt teeth. — Walking-legs. Inferior keels on femur I sparsely granulated, those on femora II-IV more densely so. Five antero-inferior and six postero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. Lateroposterior areas and borders of tergites 1-6 finely granulated; their remaining areas smooth and shining; on tergites 3-7 there is a distinct median tubercle. Median part of the borders of tergites 1-6 and posterior border of tergite 7 smooth; lateral areas and borders of tergite 7 coarsely granulated, its remaining areas smooth and shining; its lateral tubercles hardly developed.

Metasoma (fig. 46b). Dorsal surface sparsely granulated. Dorsal keels with low and blunt teeth (though slightly more pronounced on segments 4 and 5). Lateral keels faintly denticulated. Dorsolateral intercarinal areas of segments 1 and 2 with a few granules, those of the other segments smooth. Lateral areas of segment 5 smooth. Ventrolateral areas of segments 1-3 smooth or faintly reticulated.

Biometric characters (see table 7: list 26):

char. no. 56:	63 (s = 4)	char. no. 129:	.70
71:	1.18	130:	1.70

♀, total median length of holotype: 109 mm

char. no. 82: 77

Distribution (fig. 58). — Mathéran, near Bombay.

Species-group *phipsoni*

This species-group was introduced by Couzijn, 1978: 331 and table 1.

34. **Heterometrus (Chersonesometrus) phipsoni phipsoni** (Pocock) (figs. 47, 59)

Scorpio phipsoni Pocock, 1892b: 307, description of adult ♂ and ♀, type-locality Madras.
Palamnaeus barberi Pocock, 1900b: 95; Takashima, 1945: 94.

Material. — Tamil Nadu: Madras (1 ♂ ad. holotype, 1 ("♂") of 2 specimens (see *H. fulvipes* above) sharing number BM 1979.7.3.2-3), Kannikatti, Tinnevelly (Tirunelveli) district, evergreen forest, 2500 ft. in the western Ghâts (1 ♀ ad., type *P. barberi* Pocock, BM 1899.9.24.1), Pondicherri (1 ♀ ad., 1 ♂ juv., RS 0141).

Kerala: Malabar coast (1 ♀ ad., Simon's collection no. 3737, RS 0125).

Madhya Pradesh: Rajadhar (1 ♀ juv., RS 0111), central province, India (2 ♀ ad., 2 of 5 specimens, RS 0109; 2 ♂ ad., 6 ♀ ad., 8 of 10 specimens, RS 0080).
West Bengal: Talpata, village near Saktigarh, ± 100 km W. of Calcutta, India (1 ♀ ad., 2 ♂ juv., CLC, specimens A, B, C).

Description. — Carapace (fig. 47a). Postocular parts of superciliary crests absent, interocular parts smooth, antocular parts granulated (type 4; see fig. 47b). Second lateral eye much closer to the first than to the third. Large median area almost smooth, except for a few sparse and fine granules at each side of the antocular parts of the superciliary crests; lateral areas granulated behind the lateral eye-groups; faint granulation on the frontal lobes of the ♀ and some ♂. Lateral, laterorostral and lateroposterior borders granulated, remaining parts of the borders smooth.

Pedipalps. Externodorsal keel on segment 3 with blunt teeth, internodorsal keel with stouter (in ♂ pointed) teeth. Internal surface of segment 4 with 5-10 teeth, dorsally accompanied by many small granules; external surface with distinct small tubercles (♂) or granules (♀), especially its keels. Hand slightly dilated in the ♂, somewhat broader in the ♀, its external surface covered with granules *), without keels (microsculpture type 1); its dorsal keel slightly curved, with many acuminate teeth. — Walking-legs. Anterior surface of femur I (in some specimens I and II) smooth, that of femur II mostly sparsely and finely granulated, more densely so on femora III and IV. Inferior keels on femur I sparsely granulated, more densely so on femora II-IV, though the basal part is almost smooth on femur IV in some ♂. Four (occasionally five) antero-inferior and six (in some specimens seven) postero-inferior spines on telotarsi III and IV. — Pectines. Internal fulcral plates smooth, though a microseta can be found on some of these.

Mesosomatic tergites. Median tubercles distinct (only in a few specimens faint) in a smooth median area (though on tergite 7 of some specimens this area is very sparsely, faintly and finely granulated), on the rostral tergites flanked by plicate areas. Lateral areas, lateral margins and lateroposterior borders granulated; medioposterior borders of tergites 1-6 smooth, that of tergite 7 granulated. Lateral tubercles on tergite 7 inconspicuous, with low and blunt teeth. — Mesosomatic sternites. Smooth surface, with distinct longitudinal furrows in sternites 1-4 (absent in sternite 5). Borders smooth, though in some specimens finely denticulated.

Metasoma (fig. 47c). Dorsal surface sparsely granulated, but in many ♂♂ segment 5 is smooth and in some ♂♂ only segments 1 and 2 are sparsely granulated and segments 3 and 4 are smooth or faintly plicate. Dorsal and

*) This is not in accordance with Pocock's description of the ♀ type of *P. barberi* (see Pocock, 1900b: 95), though this specimen does show the other characters mentioned above.

lateral keels with low and blunt teeth on segment 1, their sharpness increased on the following segments. Ventrolateral and ventral keels of segments 1 and 2 smooth, those of segment 3 uneven, those of segment 4 with low denticulation, on segment 5 the teeth being stouter than the dorsal and lateral teeth, the terminal ventrolateral tooth of the same size as the preceding teeth (in some specimens slightly stouter). Dorsolateral and lateral intercarinal areas of segments 1-5 sparsely granulated, though in some ♂♂ one or more areas of segments 2-5 are smooth; ventrolateral areas smooth, but on segment 5 (in some ♂♂: 4 and 5) small granules can occur. Medioventral areas smooth on segments 1-3; in the ♂, segment 4 can show a few fine granules here.

Biometric characters (see table 7: list 34):

char. no.	30: 58 (s = 16)	char. no.	129: ± .58
	51: 1.0 (s = .2)		130: ± 1.75

♂, total median length of holotype: 97 mm

char. no.	17: 2.3 (s = .4)	char. no.	52: 2.8 (s = .2)
	42: 148 (s = 7)		102: 3.5 (s = .2)
	44: 1.2 (s = .0)		

♀, total median length of ♀ specimen from sample RS 0125: 94 mm

char. no.	17: 2.2 (s = .3)	char. no.	102: 3.5 (s = .1)
	44: .9 (s = .1)		

Distribution (fig. 59). — South and central India. Pocock (1900b: 95) recorded this species from Bombay, Mathéran, Kolata, Tanna, Ratnagiri, northern and central and southern Peint, Nàsik Ghâts, Dindori, Lena, Bhudhargarh and Panhâla.

35. **Heterometrus (Chersonesometrus) phipsoni kanarensis** (Pocock) (figs. 48, 59)

Palamnaeus scaber kanarensis Pocock, 1900b: 93, sex not mentioned (description probably based on both sexes), type-locality Kanara, Bombay.

Material. — Maharashtra: Kanara, Bombay (1 ♂ ad. "hololectotype", 2 ♀ ad. paralectotypes, leg. T. R. D. Bell, BM 1897.11.5.29-30).

Description. — This subspecies differs from the nominal subspecies *H. p. phipsoni* (Pocock) in the following characters.

Carapace (fig. 48a). Mediorostral border granulated. Superciliary crests type 3 (fig. 48b). — Pedipalps. External surface of segment 4 uneven, in

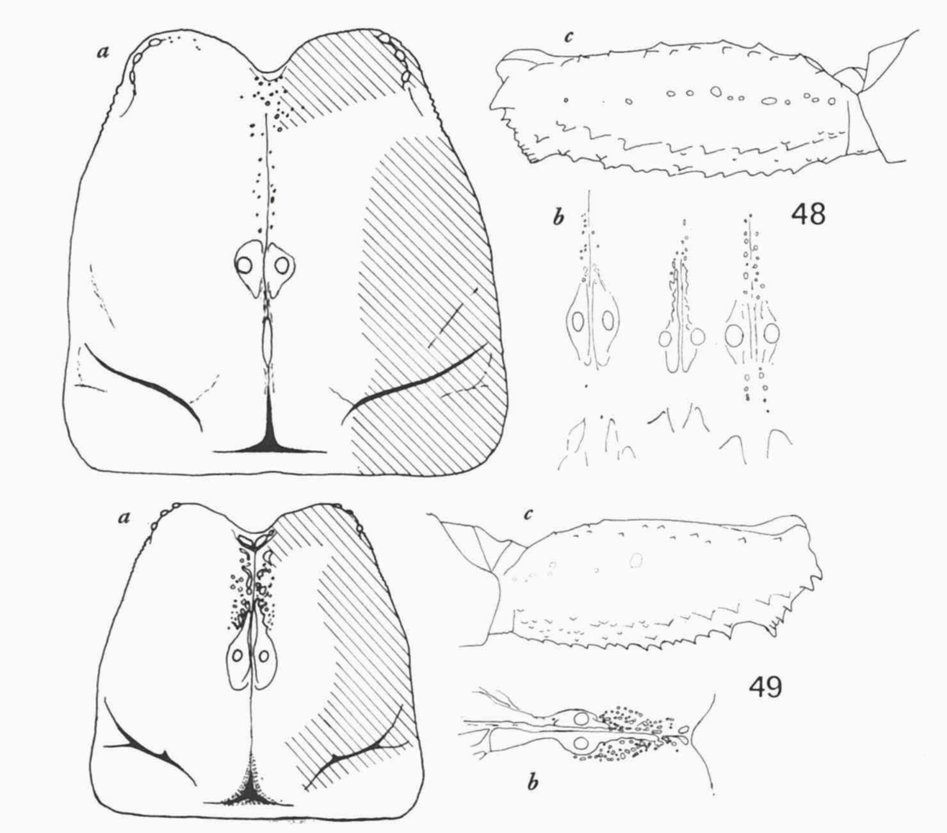

Fig. 48. *Heterometrus (Chersonesometrus) phipsoni kanarensis* (Pocock); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (in order of frequency; antocular parts above); c, right view of metasomatic segment 5 of lectotype; a-c, × 3.7.

Fig. 49. *Heterometrus (Chersonesometrus) liurus* (Pocock); a, carapace (on the right granulated areas are shaded); b, superciliary crests (antocular parts right); c, left view of metasomatic segment 5 of ♂ paralectotype; a-c, × 3.7.

some ♀♀ with faintly reticulated intercarinal areas. External surface of the hand reticulated (faintly so in the ♂); microsculpture type 7. — Walking-legs. Anterior surface of femur I sparsely granulated. Inferior keels on femora I-IV faintly and sparsely granulated. Four antero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. Granules on the lateral areas faint, or large and low, in many parts lacking; granules at the medioposterior border of tergite 7 sparse and in some cases very faint. — Mesosomatic sternites. Lateral borders finely granulated, though (almost) smooth in some specimens. — Metasoma (fig. 48c). Medially, the dorsal keels are flanked by a few low teeth of which it is not clear if these form parts of the carinal denticulation or if they are developed from a dorsal granulation. Lateral keels with low and blunt teeth on segments 1-4, sharp denticulation on segment 5 but on this segment the number or prominence of the teeth can be strongly reduced. Terminal latero-ventral tooth on segment 5 much stouter than the preceding teeth. Dorso-lateral and lateral areas smooth in most specimens; some of these areas can bear one or a few granules or have a reticulated aspect. Ventrolateral areas of segments 1-3 are reticulated in some specimens, those of segment 4 being reticulate granulate and those of segment 5 granulated.

Biometric characters (see table 7: list 35):

char. no. 51: 1.3 (s = .3)

♂, total median length of lectotype: 111 mm

char. no. 17:	3.0 (s =.4)	char. no. 83:	13.00 (s = .00)
52:	3.7	99:	3.0

♀, total median length of paralectotype: 120 mm

char. no. 83: 11.00 (9-13; s = 2.00)

Distribution (fig. 59). — Kanara (Bombay).

Lectotype. — In his description, Pocock (1900b: 93) did not indicate the holotype nor the typical sex in the described sample. As the holotype of the nominal subspecies *H. p. phipsoni* (Pocock) is a ♂, I chose the adult ♂ in the sample to be the lectotype, leaving two adult ♀ paralectotypes.

31. **Heterometrus (Chersonesometrus) liurus** (Pocock)

(figs. 49, 59)

Palamnaeus liurus Pocock, 1897: 114, description of adult ♂ and ♀, type-locality Gwalior, central India.

Material. — Madhya Pradesh: Gwalior, central India (1 ♀ ad. "hololectotype" (no. 995), 1 ♂ ad. "allolectotype" (no. 987), 2 ♀ ad. paralectotypes (nos. 992, 944), leg. Dane, BM 1896.12.15.20-25), Bhopal, central India (1 ♂ ad., 1 ♀ ad., leg. Dane, BM 1896.9.26.87).

Description. — This species of small size differs from the similar species *H. phipsoni* (Pocock) in the following characters.

Carapace (fig. 49a). Antocular parts of superciliary crests are uneven (almost smooth) ridges accompanied by numerous, locally fused, granules (fig. 49b). Frontal areas finely granulated; smooth median area rather small. Rostral border smooth. — Pedipalps. Dorsal keels of segment 3 with rather small and obtuse teeth; its external surface smooth. External surface of the hand reticulated by confluent granules, of which only a few are isolated (microsculpture type 7); its dorsal keel with small teeth. — Walking-legs. Anterior surfaces of femora I and II smooth or sparsely and finely granulated. Basal part of inferior keels on femur IV smooth. Four antero-inferior spines on telotarsi III and IV, though in some specimens three spines on telotarsus III; five postero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. Lateral areas very finely granulated. In some specimens tergites 1-6 merely have finely granulated lateral margins and the lateral areas of tergite 7 are not granulated but merely uneven, while in some other specimens (from Bhopal) the whole surface of all tergites is densely and finely granulated. Hardly any median or lateral tubercles present. — Mesosomatic sternites. Merely slight impressions in sternite 5. Lateral borders smooth; in some specimens (from Bhopal) they are densely and finely granulated in sternites 1-4 and those of sternite 5 more coarsely so.

Metasoma (fig. 49c). Dorsal surface smooth, in most cases slightly plicate. Dorsal keels on segments 1-3 and lateral keels smooth or uneven; dorsal keels on segments 4 and 5 with faint, sparse and obtuse denticulation; lateral keels on segment 5 absent in one specimen (♀ from Bhopal). Lateroventral and ventral keels on segment 4 sharply denticulated, the terminal lateroventral tooth being the stoutest. Ventrolateral intercarinal areas of segments 4 and 5 sparsely granulated, remaining areas smooth or slightly uneven, in one specimen (♀ from Bhopal) all areas smooth.

Biometric characters (see table 7: list 31):

char. no. 100: .95 (s = .02)

♂, total median length of paralectotype: 62 mm

char. no.	17: 3.2 (s = .4)	char. no.	52: 3.8 (s = .1)
	21: 58 (s = 25)		70: 1.8 (s = .2)
	42: 3.8 (s = .1)		74: 3.2 (s = .2)

♀, total median length of lectotype: 76 mm

char. no.	17: 3.0 (s = .2)	char. no.	83: 11.63 (s = 1.19)
	44: 1.0 (s = .0)		

Distribution (fig. 59). — Gwalior and Bhopal in central India.

Lectotype. — In his description Pocock (1897: 114) indicated the holotype by mentioning a few measurements of a specimen in a sample from Gwalior. All ♀ in this sample are, however, slightly smaller. I assume the holotype being the largest of these ♀, approximating the described measurements most closely.

32. **Heterometrus (Chersonesometrus) collinus** (Pocock)

(figs. 50, 59)

Palamnaeus phipsoni collinus Pocock, 1900b: 95, description of adult ♀ and ♂, type-locality Nilgiri Hills.
Palamnaeus phipsoni carnaticus Pocock, 1900b: 95 (nom. null.).

Material. — Tamil Nadu / Andhra Pradesh: Nilgiri Hills (1 ♀ ad. holotype, 1 ♀ ad. paratype, leg. W. M. Daly, BM 1894.8.21.4-7), Yercaud, Shevaroy Hills (2 ♂ ad., 1 ♀ ad., 1 ♂ subad., leg. Dr. K. Lindberg, RS 3267).

Description. — This species differs from the species *H. phipsoni* (Pocock) in the following characters.

Carapace (fig. 50a). Postocular parts of superciliary crests hardly developed; antocular parts densely and finely granulated (fig. 50b). Second lateral eye closer to the third than to the first; lateral eyes larger than in *H. phipsoni*. Frontal areas finely granulated; large median area smooth and very flat. Rostral border finely granulated; heart-shaped median incision in the posterior border.

Pedipalps. Dorsal keels of segment 3 with rather small and obtuse teeth. Internal surface of segment 4 with 6-10 small and obtuse teeth; its externo-dorsal surface granulated. Hand microsculpture type 1. — Walking-legs. Anterior surfaces of femora smooth or on femora III and IV sparsely and finely granulated or uneven. Inferior keels on femur IV densely granulated. Four antero-inferior spines on telotarsi III and IV; five postero-inferior spines on telotarsus III, six on telotarsus IV.

Mesosomatic tergites. Lateral areas of tergites 1-6 rather smooth; no plicate areas; hardly any tubercles. The fine, marginal lateroposterior granulations of the anterior-most tergites are medially extended on the more posterior tergites; a rather smooth medioposterior border remains even on tergite 7. — Mesosomatic sternites. Longitudinal furrows in sternite 5 quite short. Lateral borders faintly denticulated.

Metasoma (fig. 50c). Dorsal surface smooth, often slightly plicate. Ventrolateral and ventral keels of segment 3 smooth; terminal ventrolateral tooth on segment 5 stouter than the preceding teeth. Dorsolateral intercarinal areas sparsely (or not: segment 4) granulated; lateral areas granulated, though on segment 5 mostly smooth; ventral areas of segments 3-5 with sparsely granulated parts.

Biometric characters (see table 7: list 32):

char. no.	71: 1.1 (s = .0)	char. no.	129: ± 1.30
	100: .95 (s = .04)		130: ± 2.25-2.30

♂, total median length of ♂ from sample RS 3267: 102 mm

char. no.	42: 164 (s = 9)	char. no.	99: 2.5 (s = .1)
	83: 12.67 (s = .52)		

♀, total median length of holotype: 84 mm

char. no.	44: 1.0	char. no.	98: 343
	52: 1.9 (s = .0)		105: 2.1
	83: 11.50 (s = .71)		

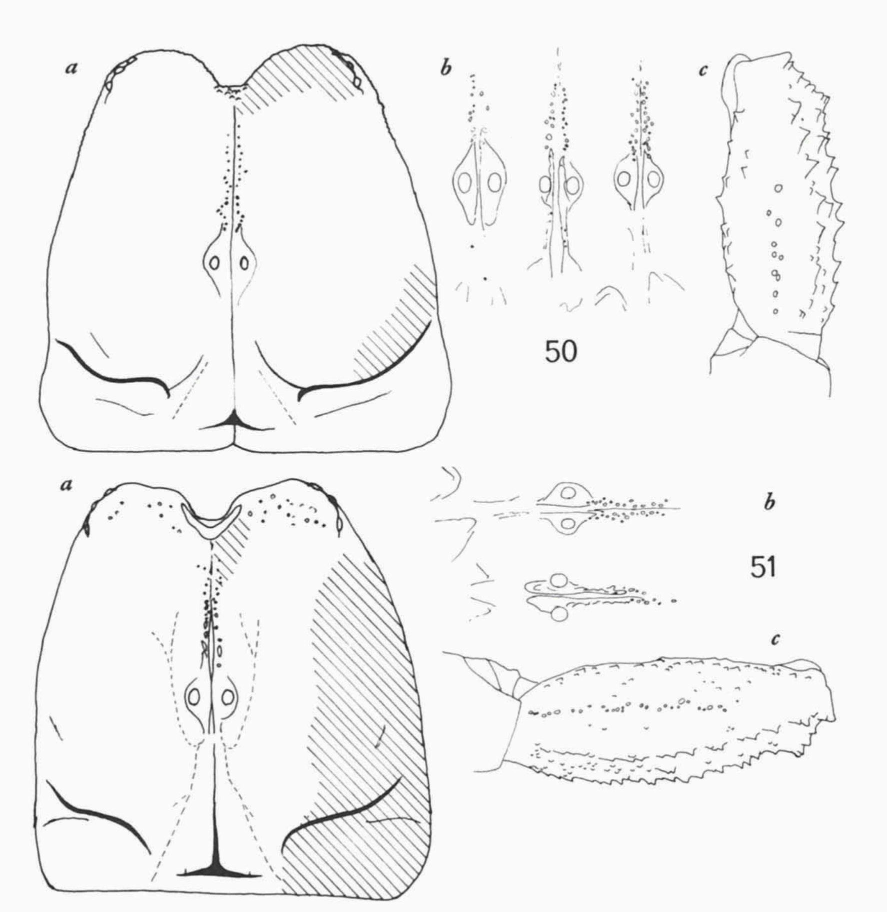

Fig. 50. *Heterometrus (Chersonesometrus) collinus* (Pocock); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (in order of frequency; antocular parts above); c, left view of metasomatic segment 5 of ♂ adult (RS 3267); a-c, × 3.7.

Fig. 51. *Heterometrus (Chersonesometrus) tristis* (Henderson); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (antocular parts right); c, left view of metasomatic segment 5 of paratype; a-c, × 3.7.

Distribution (fig. 59). — Nilgiri Hills and Yercaud (Shevaroy Hills). Also Pocock (1900b: 95) recorded a sample from Yercaud (leg. Henderson).

Holotype. — In his description, Pocock (1900b: 95) mentioned three measures of the ♀ holotype; in the ♀ concerned, these measures appeared to be smaller, but since the sample contains only one ♀ and such difference between the absolute measures and those mentioned by Pocock was noticed before in the case of other species (cf. *H. liurus* above), I am convinced that this is the holotype.

33. **Heterometrus (Chersonesometrus) tristis** (Henderson) (figs. 51, 59)

Palamnaeus tristis Henderson, 1919: 380, description of adult ♂ and ♀, type-locality Tirupati Hills, southern India.

Material. — Tamil Nadu: Tirupati Hills, southern India (1 ♂ ad. holotype, 1 ♂ ad. paratype, leg. S. K. Sundaracharlu, ZSI 2160/18).

Andhra Pradesh: Venkatagiri Hills, Nellore district, southern India (1 ♀ ad. allotype, leg. S. K. Sundaracharlu, ZSI 2160/18).

Description. — This species differs from the similar species *H. phipsoni* (Pocock) in the following characters.

Carapace (fig. 51a). Antocular parts of superciliary crests irregularly granulated and uneven (as a result of fusion of some granules; type 4; see fig. 51b). Frontal areas granulated, but less pronounced than on the lateral areas. Large median area smooth.

Pedipalps. Internal surface of segment 4 furnished with ± 10 stout and sharp teeth and many smaller teeth and granules; its external surface with smooth keels and faintly reticulated areas. The hand slender in the ♂, in the ♀ much broader; its external surface more finely granulated; its external keels are recognizable by series of stout granules, which are often confluent in such a series; microsculpture type 2. — Walking-legs. Inferior keels on femora I-III (♂ paratype: I-IV) densely granulated, on femur IV of the holotype granulated only in the terminal part, the basal part faintly so. Five antero-inferior spines on telotarsi III and IV; six postero-inferior spines on telotarsus III, seven on telotarsus IV. — Pectines. Internal fulcral plates furnished with a macroseta.

Mesosomatic tergites. Median areas smooth, rather wide on tergites 1-6, small on tergite 7. Hardly any tubercles, no plicate areas. Borders very finely granulated. — Mesosomatic sternites. Lateral borders finely denticulated. — Metasoma (fig. 51c). Dorsal surface granulated. Holotype: the dorsal and lateral keels of segments 1-4 almost smooth, somewhat uneven; segment 5 with finely and obtusely denticulated dorsal keels and granulated lateral keels. ♂ paratype: dorsal keels with low denticulation, much finer on segment 5 than on the other segments; lateral keels of segments 1-4 with faint, low and obtuse teeth, slightly sharper and finer on segment 5. Ventrolateral and lateral keels of segment 3 smooth, those of segment 4 faintly denticulated. Dorsolateral intercarinal areas granulated, but sparsely so on segment 5 (or, in the ♂ paratype, 3-5); ventrolateral areas reticulated on segments 1 and 2, granulated on segments 3-5; medioventral areas smooth.

Biometric characters (see table 7: list 33):

char. no. 71: 1.0 (s = .0)	char. no. 45: 1.36

♂, total median length of holotype: 120 mm

char. no. 21: 80 (s = 21)	char. no. 44: 1.5 (s = .0)
29: 127 (s = 16)	83: 17.67 (s = .58)
42: 182 (s = 21)	

♀, total median length of allotype: 110 mm

char. no. 17: 1.8	char. no. 43: 159
21: 150	44: 1.1

Distribution (fig. 59). — Tirupati Hills (N. Arcot district); Venkatagiri Hills (Nellore district).

37. **Heterometrus (Chersonesometrus) wroughtoni** (Pocock) (figs. 52, 59)

Palamnaeus wroughtoni Pocock, 1899: 745; description of adult ♀ and juv. (♂ ?); type-locality Gadingal (Gad-Hinglaj), Belgaum.

Material. — Maharashtra: Gadingal (Gad-Hinglaj), Belgaum (1 ♀ ad. holotype, 3 ♂ juv., 4 ♀ juv., leg. W. A. Talbot, BM 1897.9.17.1-4.11.20).

Description of the adult ♀ and juvenile ♂. — This species differs from the similar species *H. phipsoni* (Pocock) in the following characters.

Carapace (fig. 52a, b). Parts of the border next to the lateral eyes granulated. — Pedipalps. Teeth of dorsal keels of segment 3 low and blunt. Internal surface of segment 4 with 5-10 granules, dorsally accompanied by many small granules; its external surface granulated (especially its keels) in both sexes. Hand rather broad in both sexes, its external keels partly visible by local fusion of granules (microsculpture type 1 or 2), its dorsal keel with many low and blunt teeth. — Walking-legs. Basal part of inferior keels on femur IV almost smooth in both sexes. Four antero-inferior spines on telotarsi III and IV; six postero-inferior spines on telotarsus III, seven on telotarsus IV.

Mesosomatic tergites. Median tubercles small or very faint. In the medio-anterior area of each tergite a pair of small, smooth and brightly coloured spots occur, on tergites 1-6 located behind the transverse ridge, on tergite 7 before this ridge. — Mesosomatic sternites. Lateral borders finely granulated (in some cases sternite 5 shows this granulation only on its anterior part); sternite 5 has a pair of small and slight impressions in the places where the preceding sternites show longitudinal furrows.

Metasoma (fig. 52c). Dorsal surface granulated in the ♂; in the ♀, segment 5 (and often also segment 1) with smooth dorsal surface. Dorsal keels with obtuse and low teeth. Lateral keels strongly reduced and uneven. In juveniles, however, dorsal and lateral keels are distinctly denticulated, the more sharply so on the more terminal segments (similar to *H. phipsoni*). Terminal ventrolateral tooth blunt and hardly different from the preceding teeth, though in juveniles this tooth is sharp and stouter than the preceding teeth. Some of the dorsolateral and/or lateral areas smooth (in both sexes); ventrolateral areas of segment 4 very sparsely granulated in the ♀, those of segments (1-)2-4 granulated in the (juvenile) allotype; ventrolateral areas of segment 5 granulated; medioventral area of segment 4 with just a few granules.

Biometric characters (see table 7: list 37):

char. no.	30: 85 (s = 19)	char. no.	51: .7 (s = .1)
	45: 1.08		

♂, total median length of juvenile allotype: 58 mm

char. no.	17: 3.0 (s = .5)	char. no.	70: 2.2 (s = .1)
	44: 1.0 (s = .1)		83: 16.83 (s = .41)

♀, total median length of holotype: 94 mm

char. no. 17: 3.4 (s = .4)

Distribution (fig. 59). — Belgaum; Gad-Hinglaj.

Subgenus **Gigantometrus** Couzijn

(fig. 56)

Gigantometrus Couzijn, 1978: 331 and table 1 (brief introduction).

Description. — Carapace. Rostrolateral edge entire (without incision next to the lateral eyes); second lateral eye not distinctly closer to the first than

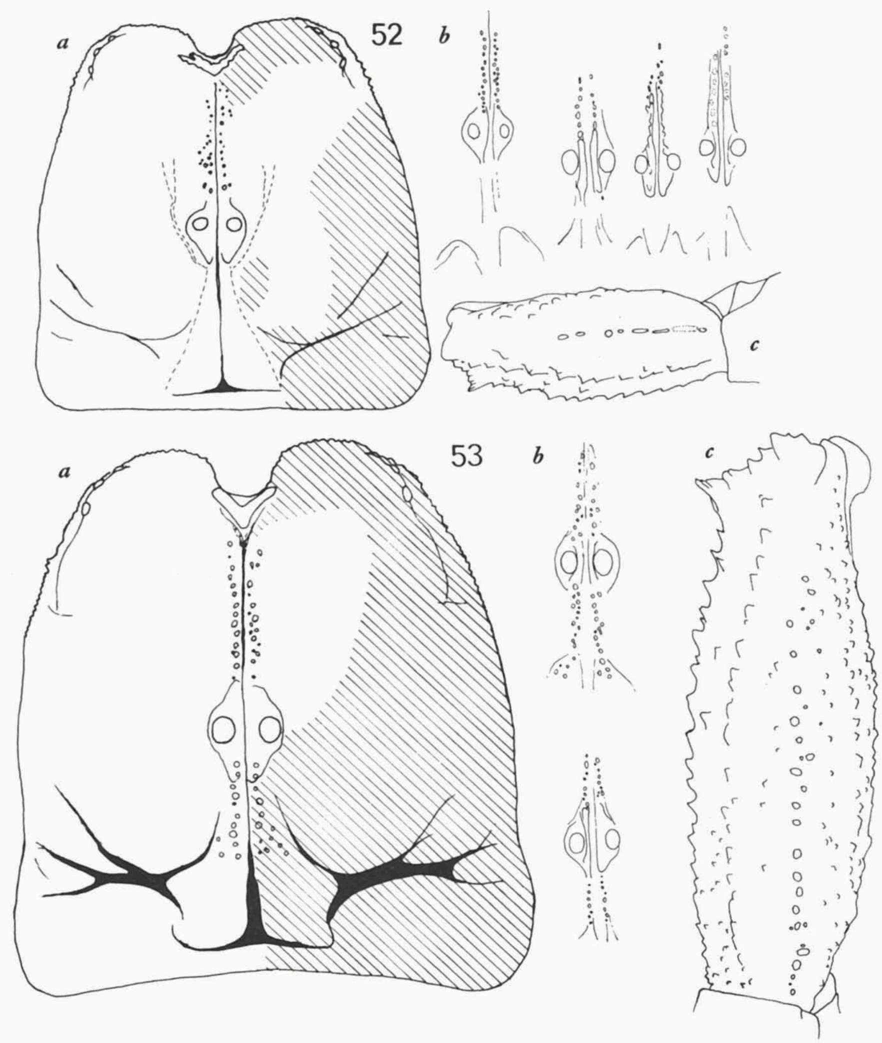

Fig. 52. *Heterometrus (Chersonesometrus) wroughtoni* (Pocock); a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (in order of frequency; antocular parts above); c, right view of metasomatic segment 5 of holotype; a-c, × 3.7.

Fig. 53. *Heterometrus (Gigantometrus) s. swammerdami* Simon; a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (antocular parts above); c, right view of metasomatic segment 5 of holotype; a-c, × 3.7.

to the third. Superciliary crests type 6. There are no absolutely smooth areas, except the frontal area in some specimens of *H.* (*Gigantometrus*) *s. swammerdami*. In the median furrow there is an excavation, more profound than the medioposterior T-shaped furrows and situated between these furrows and the median oculiferous tubercle. Medioposterior border granulated.

Pedipalps. Segment 4 does not bear prominent teeth on its internal surface (prominent teeth occur in the case of the subgenera *Heterometrus, Javanimetrus* and in part of *Chersonesometrus*), merely granules or very low teeth. Dorsal keel of the broad hand almost straight, bearing a large lobe expanding at its proximal end; the external surface coarsely granulated with very faint keels or without any traces of keels: relief type 1 (fig. 4f). — Walking-legs. Granulation of inferior keels on femur IV well developed. — Pectines. Internal fulcral plates smooth or (less frequently) bearing a macroseta.

Metasoma long and stout. The teeth of dorsal and lateral keels are numerous, uniform and arranged in a regular line (no reduction of their denticulation, neither generally, nor gradually; reduction of denticulation occurs in other subgenera).

Biometric characters (mean values):

char. no.	45:	.96-.97	char. no.	108:	1.5-1.6
	63:	3.4-3.5		129:	.81-.83
	100:	1.56-1.68		130:	± 1.8
♂, char. no.	43:	173-200	char. no.	98:	670-744
	44:	.7-.8		99:	4.0-4.2
	70:	2.5-2.6		102:	3.6-3.8
	82:	101-113			
♀, char. no.	43:	171-200	char. no.	98:	619-809
	82:	95-111		99:	3.8-4.1
	83:	16.50-18.00			

Distribution (fig. 56). — Sri Lanka; southern, eastern and central northern parts of India.

Type-species: *H. swammerdami* Simon, 1872.

Name. — Composed of the Greek equivalent of "gigantic", referring to the large size of these scorpions, and the suffix "-metrus" (m.).

41. **Heterometrus (Gigantometrus) swammerdami swammerdami** Simon (figs. 53, 56)

Heterometrus swammerdami Simon, 1872: 56, description of adult ♀, type-locality East Indies.
Buthus afer sensu Koch, 1836: 17 (non Linnaeus, 1758: 624).
Pandinus asper Thorell, 1877: 199.
Pandinus kochi Karsch, 1879b: 127 (*P. kochii*); 1884: 68.
Scorpio lucidipes Simon, 1885: 38; 1905: 161; Pocock, 1900b: 87.

Material. — Tamil Nadu: Madras (1 ♀ ad., RS 0078), Pondicherry (Puduchcheri) (1 ♂ ad., RS 0102; 1 ♀ ad., RS 0104; 1 ♀ ad., RS 0105; 1 ♂ ad., 1 ♂ juv./subad., RS 0106; 2 ♀ ad., RS 0108; 1 ♂ ad., RS 3166), Pondicherry, colonial gaden (2 ♀ ad., RS 0148), Ramnad (Ramanthapuram) (1 ♂ ad. allotype, type of *Scorpio lucidipes* Simon, Simon's personal collection no. 1542, leg. unknown, RS 0112).
Karnataka: Shahabad, Deccan (1 ♀ ad., BM 1897.9.5.1), Dharwar (2 ♀ ad., BM 1897.9.17.14.1).
Madhya Pradesh: Raipur, central province (1 ♂ juv.?, BM 1896.9.26.95), Chota Nagpur (Madhya Pradesh/Bihar) (1 ♀ ad., leg. F. Dundas, BM 1896.9).
Andhra Pradesh: Dowlaishwaram, Godavari (1 ♀ ad., BM 1893.5.15.1).
Uttar Pradesh: Dehra Dún (1 ♂ ad., BM 1896.2.2.1).
Uncertain localities: Lanooli, India (1 ad., 1 juv., SMF 5320), East Indies (1 ♀ ad. incomplete holotype, 1 ♀ ad. complete paratype, Simon's personal collection no. 1500, leg. unknown, RS 0110), unknown locality (1 ♂ ad.?, holotype *Pandinus asper* Thorell, det. Thorell, leg. N. Westring 16.4.75, NMG Scorp. 92).

Description. — Carapace (fig. 53a). Superciliary crests granulated, except for the smooth interocular parts (type no. 6; fig. 53b). Triangular frontal area smooth (in some specimens a rather small area midway between median and lateral eye-groups is faintly granulated); remaining areas granulated just as the borders; rarely the whole carapace is granulated.

Pedipalps. Dorsal keels of segment 3 with blunt teeth. Internal surface of segment 4 with ± 10 granules, dorsally accompanied by many much smaller ones; its external surface granulated. Hand much dilated, with a large lobe at its proximal end; its external surface covered with large and low granules, without keels or with hardly recognizable keels (relief type 1, see also fig. 4f); its dorsal keel almost straight, with low teeth. — Walking-legs. Anterior surface and inferior keels of femur I sparsely and finely granulated, those of femora II-IV densely so. Four antero-inferior spines on telotarsi III and IV, six postero-inferior spines (rarely five on telotarsus III). — Pectines. Internal fulcral plates smooth or some of them bearing a macroseta.

Mesosomatic tergites. Surface granulated, but faintly so on the medio-anterior parts (the more faintly on the more posterior tergites). Borders granulated but the posterior border of tergite 7 smooth (with a few granules near it). Denticulated tubercles on tergite 7 inconspicuous. Rarely bright spots occur on the tergites as described in *H. swammerdami flavimanus* below. — Mesosomatic sternites. Smooth surface, with longitudinal furrows in sternites 1-4. Lateral borders finely denticulated or very finely and densely granulated; posterior borders smooth in some specimens, but often their lateroposterior parts are granulated on sternites 1-4.

Metasoma (fig. 53c). Dorsal surface granulated. Dorsal and lateral keels regularly denticulated with low teeth of equal size, the dorsal ones often obtuse on segment 1, often sharp on the following segments. Ventrolateral and ventral keels of segments 1 and 2 (1-3 in many ♂♂) smooth, mostly uneven or faintly denticulated on segment 3 (rarely smooth or distinctly denticulated), with low teeth on segment 4, while on segment 5 these keels bear teeth, which are stouter than the dorsal teeth, the terminal ventrolateral tooth being the stoutest. Dorsolateral areas of segments 4 and 5 smooth in the ♂. Ventrolateral areas of segments 1 and 2 (♀) or 1-3 (♂) smooth, but in some specimens reticulated on segment 1 and also sparsely and finely granulated on segment 2. Medioventral areas of segments 1-4 smooth. Remaining areas granulated, though on some areas very sparsely so; rarely a reticulated pattern occurs on ventrolateral areas of segments 1-3.

Biometric characters (see table 7: list 41):

char. no. 30: 64 (s = 8)
51: .9 (s = .1)
char. no. 71: 1.39 (s = .03)
100: 1.56 (s = .12)

♂, total median length of allotype: 118 mm

char. no. 43: 173 (s = 24)
44: .8 (s = .1)
char. no. 83: 18.22 (s = .44)
102: 3.6 (s = .1)

♀, total median length of paratype in sample RS 0110: 159 mm (holotype is incomplete)

char. no. 44: .8 (s = .0)
52: 3.0 (s = .2)
82: 97 (s = 10)
char. no. 83: 16.71 (s = .77)
102: 3.7 (s = .1)

Distribution (fig. 56). — Southern, eastern and central northern parts of India. The locality "Madura" mentioned by Simon (1905: 161) probably refers to Madurai in southern India. Pocock (1900b: 87) recorded the subspecies (i.a. under the name of *Palamnaeus swammerdami lucidipes*) from Burdwan (Bengal), Satna (central India), Tanjore and Tiruchirapalli (Trichinopoly; southern India).

42. **Heterometrus (Gigantometrus) swammerdami flavimanus** Pocock (figs. 2a, 54, 56)

Palamnaeus swammerdami flavimanus Pocock, 1900b: 87, type-locality Coimbatore; the sex described cannot be concluded from the description (sexual dimorphism being almost absent).

Material. — Tamil Nadu: Coimbatore (1 ♂ ad. "allolectotype", 1 ♀ ad. "hololectotype", leg. W. Brady, BM 1899.11.2.292-3).

Description. — This subspecies differs from the nominal subspecies *H. s. swammerdami* Simon in the following characters.

Pedipalps. Internal surface of segment 4 with ± 6 granules, dorsally accompanied by numerous much smaller ones. — Walking-legs. Five antero-inferior spines on telotarsi III and IV.

Mesosomatic tergites. In the medio-anterior area of each tergite a pair of small, smooth and brightly coloured spots occur, on tergites 1-6 located behind the transverse ridge, on tergite 7 before this ridge. — Metasoma (fig. 54b). Ventrolateral and ventral keels of segments 1-3 smooth. Dorsolateral intercarinal areas of segment 5 smooth in the ♀. Ventrolateral areas of segments 1 and 2 faintly reticulated, reticulate granulate on segment 3, granulated on segments 4 and 5.

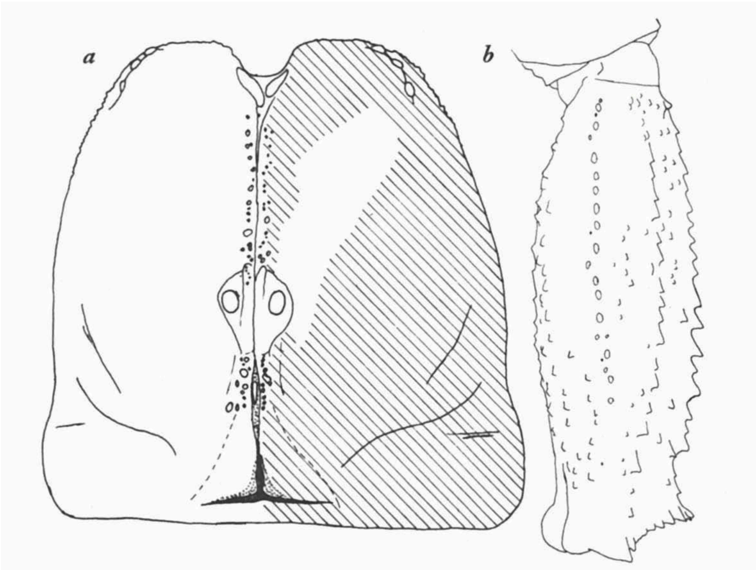

Fig. 54. *Heterometrus (Gigantometrus) swammerdami flavimanus* (Pocock); a, carapace (on the right half, granulated areas are shaded); b, right view of metasomatic segment 5 of ♂ paralectotype; a-b, × 3.7.

Biometric characters (see table 7: list 42):

char. no. 30: 80 (s = 4) char. no. 71: 1.45 (s = .08)
51: .7 (s = .1)

♂, total median length of paralectotype: 150 mm

char. no. 83: 16.50 (16-17; s = .71)
102: 3.8

♀, total median length of lectotype: 168 mm

char. no. 44: .7 char. no. 83: 18.00 (s = .00)
52: 2.5 (s = .2) 102: 3.6

Distribution (fig. 56). — Coimbatore in Tamil Nadu. According to Pocock (1900b: 87), this subspecies was also collected in Coonoor, an adjacent locality.

Lectotype. — The selection of the lectotype in the type-sample is in accordance with Pocock's habit (in the paper concerned) to describe females first. Comparison with the ♀ holotypes of the other subspecies is, moreover, easier by the choice of a female lectotype.

43. **Heterometrus (Gigantometrus) swammerdami titanicus** subspec. nov. (figs. 4f, 55, 56)

Material. — Sri Lanka: Colombo (1 ♀ adult holotype, leg. Errington de la Croix 1900, RS 0084), Negombo, West coast, North of Colombo (1 ♂ ad. allotype, leg. Dr. J. Balazuc, the largest of two specimens, sharing number RS 7759), Trincomali (1 ♂ juv., BM 1898.4.203), Ceylon (1 ♀ ad., 1 ♀ juv., SMF 5319).

Description. — This subspecies differs from the nominal subspecies *H. s. swammerdami* Simon in the following characters.

Carapace (figs. 55a and b). The whole surface covered with numerous granules, faintly so in the areas between median and lateral eye-groups. A small part of the border just in front of the lateral eyes smooth in some ♂. — Pedipalps. External surface of segment 4 smooth or faintly uneven, in some ♂ granulated. External surface of hand: see fig. 4f. — Pectines. Internal fulcral plates smooth.

Mesosomatic tergites. Anterior margins punctate. Pairs of bright spots can occur on tergites 1-6. — Mesosomatic sternites. Granulation of lateral areas faint on sternite 4 and absent on sternite 5. — Metasoma (figs. 55c and d). Dorsal and lateral teeth blunt, though sharp on segments 3-5 of

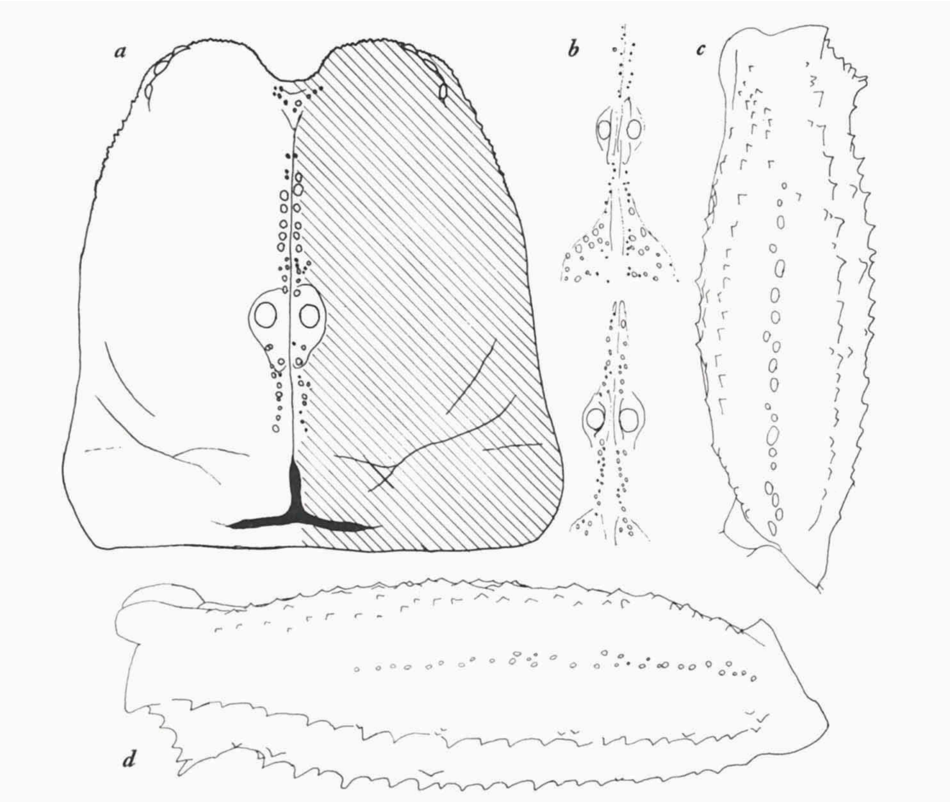

Fig. 55. *Heterometrus (Gigantometrus) swammerdami titanicus* subsp. nov.; a, carapace (on the right half, granulated areas are shaded); b, observed types of superciliary crests (antocular parts above); c, d, metasomatic segment 5: c, left view in allotype; d, right view in holotype; a-d, × 3.7.

some ♂♂. Dorsolateral intercarinal areas of segment 1 granulated, this granulation present also on the terminal part of segment 2 and 3 of the ♀ and some ♂. Lateral areas granulated (faintly so on segment 4). Ventrolateral areas of segment 4 (♀) or 3 and 4 (♂) faintly granulated.

Biometric characters (see table 7: list 43):

char. no. 30: 76 (s = 4) char. no. 100: 1.68 (s = .06)

♂, total median length of allotype: 150 mm

char. no. 83: 16.50 (16-17; s = .71)
102: 3.8

♀, total median length of holotype : 168 mm

char. no. 52: 1.7 char. no. 82: 111

Distribution (fig. 56). — Coastal areas of Sri Lanka (Negombo, Colombo, Trincomali). Pocock (1900b: 87) recorded *H. s. swammerdami* Simon from Chilaw ("Chilan") in the plains of Ceylon; without doubt this refers to *H. swammerdami titanicus*.

VI. Biogeography

The distribution of the genus is limited to the tropical and subtropical forests of the Indian peninsula (including Sri Lanka), its eastern borderlands (as defined by Mani, 1974c: 658) Bangladesh, Assam and Burma, and the Southeast Asiatic peninsulas (Malacca, Indochina) and archipelagos (Philippines, Borneo, Sumatra, Java) unto Wallace's line. According to labels or records in Museum collections, however, a few specimens have been collected outside these boundaries. In four cases (Victoria, Melbourne, Africa, Mexico) the mentioned locality is without doubt erroneous and possibly refers to transportation by man. Some other records could also refer to the results of transportation, viz., *H. bengalensis* being found in Lavanono, southern Madagascar (BM, unnumbered), *H. cyaneus* on Irian Jaya (former Dutch New Guinea: Hollandia (Jayapura) and Merauke; see Kopstein, 1923: 185), and *H. longimanus* on the Sula islands (coll. Denin, Buitenzorg Museum; see p. 101, 108). This applies also to records of a *Heterometrus* species collected on Halmahera (SMF 5350: lost specimen, leg. Kükenthal) and on Sulawesi (Makasar (Ujung Pandang); see Takashima, 1945: 90). It is possible that the type-specimen of the subspecies *H. spinifer solitarius* (the description was based on one specimen from Peradeniya; it closely resembles the Malayan nominal subspecies) was also transported from Malacca to Sri Lanka (though its locality, far from a port, is problematic. Here a decision to define a separate subspecies was difficult, because its differential characters could be mere variations within *H. s. spinifer*.

The distributional pattern of the subgenera and species-groups (see chapter VIII) are interesting. The subgenus *Gigantometrus* inhabits the coasts of Sri Lanka and various places in the Indian peninsula, mainly along the south-eastern (Coromandel) coast (fig. 56). The same distribution can be found in other groups of animals: it is typical for supposed Gondwana relics (Mani, 1974b: 620, 637). Localities of the species of the subgenus *Chersonesometrus* are scattered over the Indian peninsula and its eastern borderlands Bangladesh and Assam (figs. 57-59). This discontinuous distribution is also characteristic for many other Indian faunal elements (Mani, 1974b: 630). A remarkable aspect is constituted by the concentration of many different species and subspecies in southern India and its western coastal region

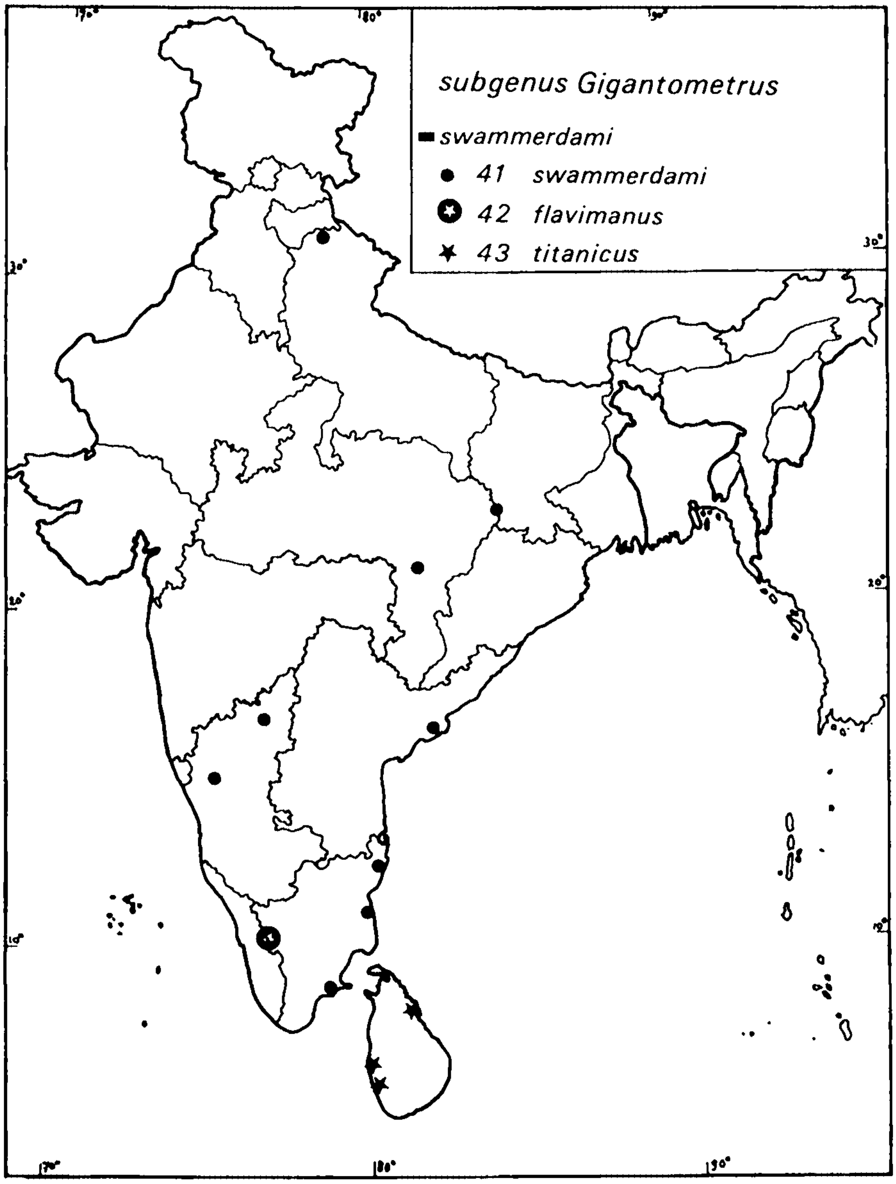

Fig. 56. Distribution of samples of *Heterometrus* (*Gigantometrus*) *swammerdami* Simon.

where some of the original forests still remain (Mani, 1974b: 637), contrasting with their absence on Sri Lanka. Although records on life-habits are scarce and not detailed, it is likely that most of these species are inhabiting (at least originally, i.e. before the recent deforestation) tropical rain-forests.

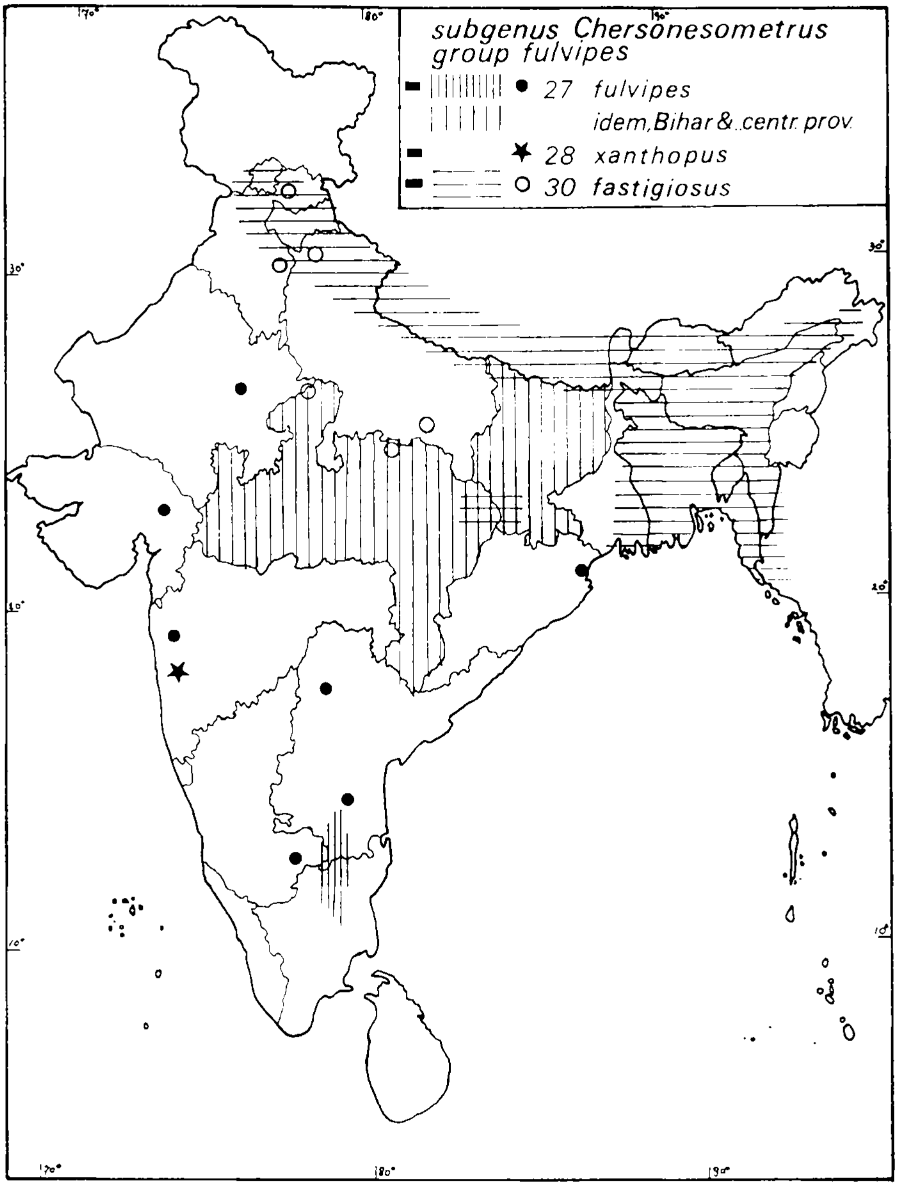

Fig. 57. Distribution of samples of three species of the *Heterometrus fulvipes* group; for remaining species see fig. 58.

A few species have probably been collected in tropical thorn forests (*H. pelekomanus, H. fulvipes, H. liurus*), dry tropical deciduous forests (*H. fulvipes, H. phipsoni, H. collinus, H. tristis*) or even subtropical forests

(*H. fastigiosus*; probably inhabiting also moist tropical deciduous forests). This can be deduced from the localities of the samples and the vegetation map of India published by Mani (1974a: 172, fig. 25). Within the subgenus *Chersonesometrus* two, largely sympatric, groups of species can be distinguished. The species-group *phipsoni* (fig. 59) was found in southern India and along the western coast, with the exception of *H. liurus* which seems to occur in the thorn forests near the northwestern desert, and possibly also with the exception of a few samples of *H. p. phipsoni* collected in Madhya Pradesh. Many species of the *fulvipes* group were also collected in southern India and along the western coast, but the nominate species is wide-spread as it was found in many other places south of the Ganges (figs. 57, 58). The species *H. fastigiosus* shows a remarkable east-west distribution in Assam and the Ganges plains and along the southern slopes of the Himalayas. In this area of distribution specimens of this species exhibit slight differences which could form part of a graded series of varieties; the number of available specimens and of precise localities is, however, too small for a further investigation of this hypothesis.

The subgenus *Srilankametrus* was found on Sri Lanka only, where it represents the main group of Scorpionidae, and on the south-eastern coast

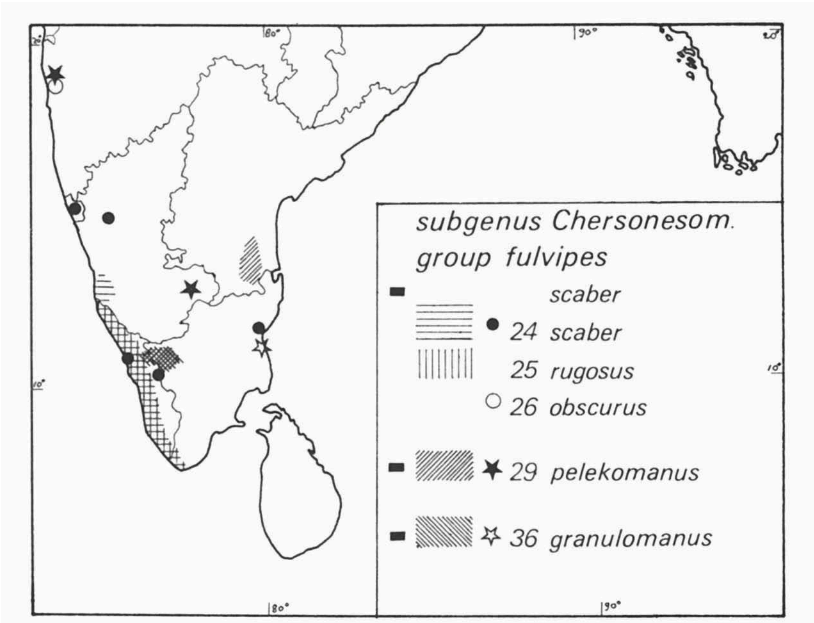

Fig. 58. Distribution of samples of three species of the *Heterometrus fulvipes* group; for remaining species see fig. 57.

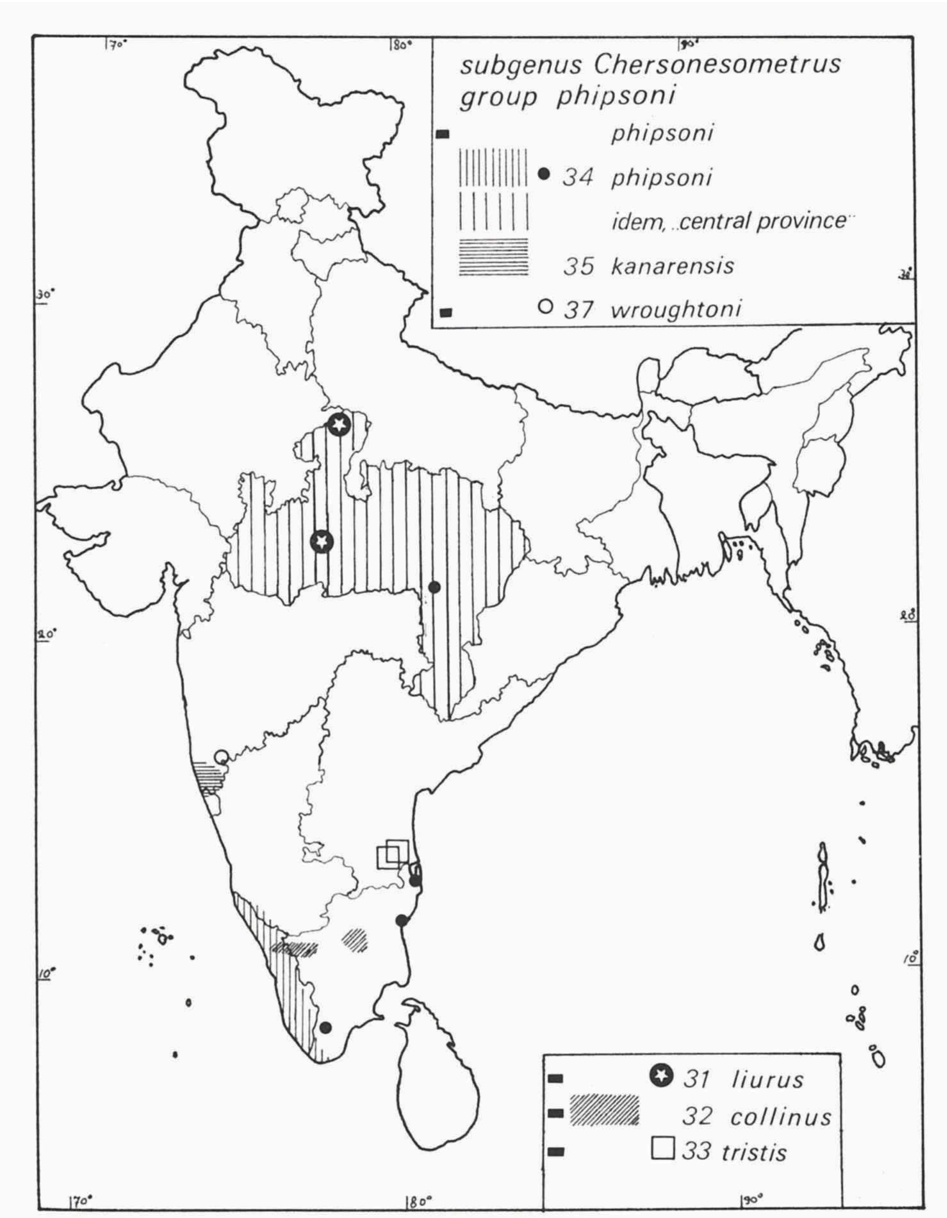

Fig. 59. Distribution of localities of the *Heterometrus phipsoni* group.

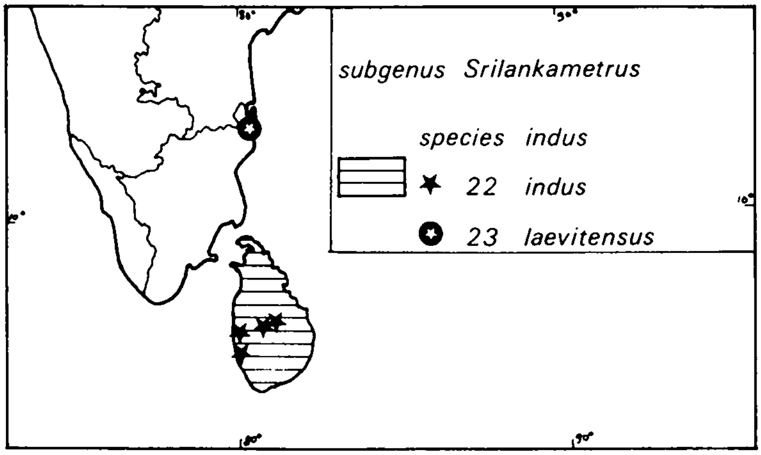

Fig. 60. Distribution of localities of *Heterometrus* (*Srilankametrus*) *indus* (de Geer).

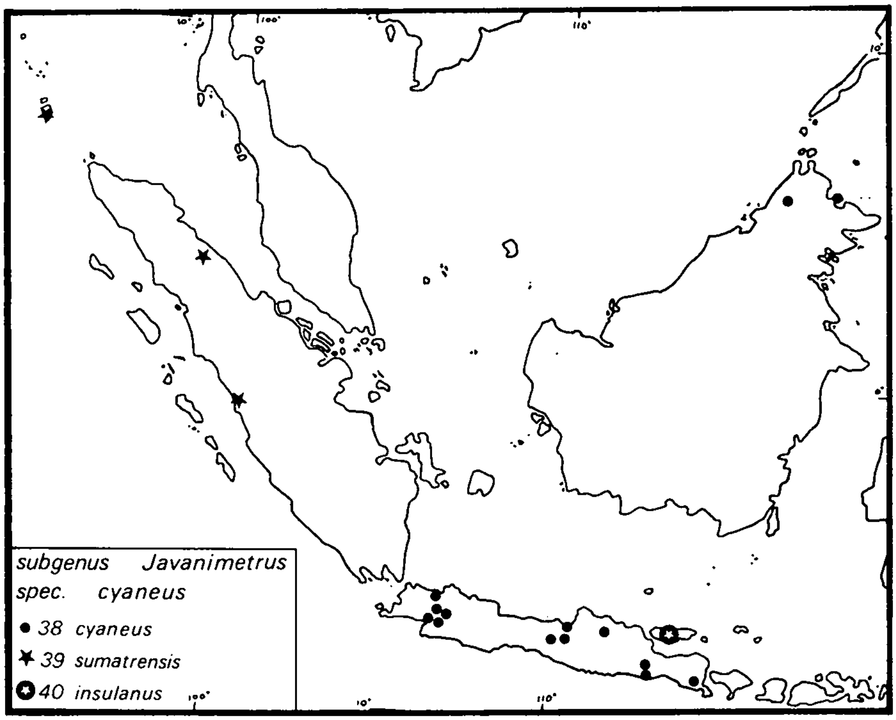

Fig. 61. Distribution of localities of samples of *Heterometrus* (*Javanimetrus*) *cyaneus* (Koch). Doubtful or unprecise localities of *H.* (*J.*) *c. cyaneus* omitted: Dutch Borneo, Java, W. Java, Preanger Regencies, Wijnkoopsbaai, Xuân Long, "Africa", "Victoria".

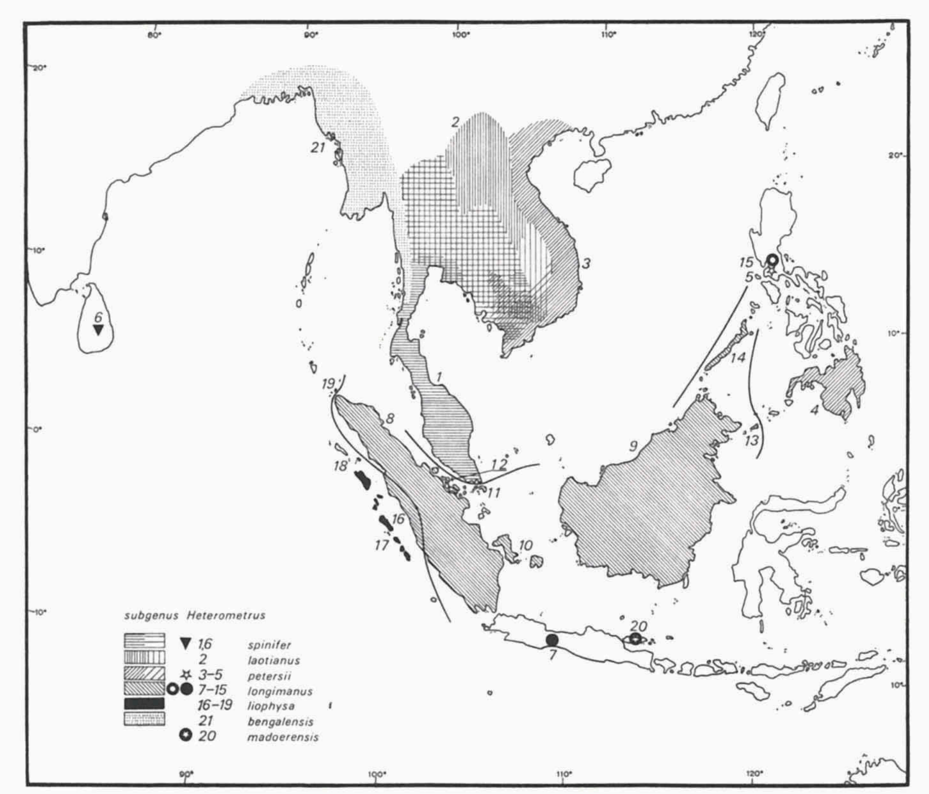

Fig. 62. Probable distribution of the subgenus *Heterometrus*, as can be deduced from the localities of the samples (see figs. 63-65). Shading differentiated on the species level, with more detailed indications by taxon numbers. Areas from which undetailed geographic information only refers to a certain species, are indicated by open shading (parts of the south-east Asiatic peninsula).

of India (fig. 60). This distribution coincides for the greater part with that of *Gigantometrus*. The third small subgenus *Javanimetrus* (fig. 61) comprises nearly all the Scorpionidae occurring on Java and Madura (see *H. longimanus angustimanus* and *H. madoerensis* below). On Java it shows a graded series of slightly different forms from the western to the eastern end of this elongate island (see p. 128). This subgenus occurs locally on Borneo (i.a., on Mount Kinabalu), Sumatra and the Nicobar islands. According to Mani (1974c: 662), the fauna of the Nicobar islands has several Sumatran elements. It is, however, remarkable that the main scorpionid fauna of Sumatra consists of *H. longimanus* and *H. liophysa*, members of the subgenus *Heterometrus*, while *Javanimetrus* is restricted to parts of Deli and the region near Padang.

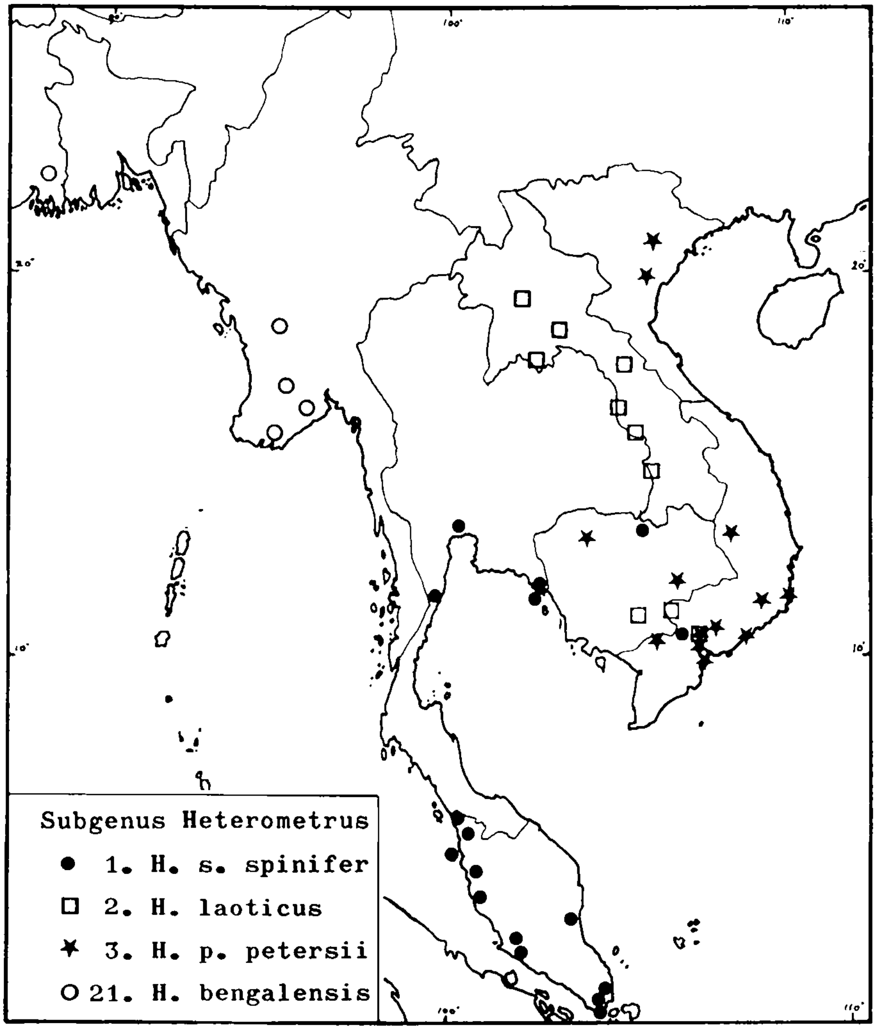

Fig. 63. Distribution of localities of *Heterometrus* (*H.*) *s. spinifer* (doubtful or unprecise localities omitted: Lima Blas, Malaysia; Malacca; Thailand (Siam); Cochinchina; "India"; "Nya Hollandia, Melbourne"), *H.* (*H.*) *laoticus* (unprecise localities omitted: Laos, Siam), *H.* (*H.*) *p. petersii* (doubtful or unprecise localities omitted: Kieng, Laos; Central Annam; Cochinchina; Indochina), and *H.* (*H.*) *bengalensis* (doubtful or unprecise localities omitted: Bengal; East Indies?; Lavanono, Madagascar; "Cochinchina").

Since the subgenera *Srilankametrus* and *Javanimetrus* appear to be rather closely related (see chapter VII), it is interesting to observe that their total distribution is disjunct; this phenomenon is, however, not unique. Similar distributional patterns (Sri Lanka, southern India and the Malayan and

Sunda regions) have been noticed for the Diplopod genera *Anoplodesmus* and *Pratinus* (Jeekel, 1965: 111; 1968: 135), for the wasp *Eumenes flavopictus* (Van der Vecht, 1959: map 7) and for many other groups of animals and plants (Mani, 1974b: 627-634).

The pluriform typical subgenus *Heterometrus* (figs. 62-65) has a vast area of distribution covering Bangladesh (Bengal; possibly also Northeastern India) and Burma, the Indochinese and Malayan peninsulas, the Philippines, Borneo, Sumatra and Java with adjacent archipelagos. A few records refer to localities across Wallace's line, but the occurrence of *Heterometrus* there still needs proof. The type-species *H. spinifer* (fig. 63) occurs in Malaya, the southern parts of Thailand, Cambodia and South Vietnam, where it is locally sympatric with *H. petersii* and *H. laoticus*. No records exist from the more northern adjacent parts in this region, although the species could occur there too. In Laos the distinct species *H. laoticus* occurs, at least in the central and northern parts, as well as in various localities in central Cambodia, Thailand and South Vietnam, where it is locally sympatric with *H. spinifer* and *H. petersii*. Its distribution seems to be discontinuous, but could be indeed continuous. On the eastern margin of the Indochinese peninsula (eastern Cambodia, South and North Vietnam) the species *H. petersii* is found. According to some records (i.a., Takashima, 1941: 281), it should also occur in southern China, on Hainan in particular, but this has not yet been confirmed. Two subspecies, *H. petersii luzonensis* and *H. petersii mindanaensis*, occur respectively on the Philippine islands of which their names are derived (they could also occur on the islands in between). Very interesting in this connection are the reports on *Heterometrus* specimens found on Halmahera and Sulawesi (Meise, 1932: 662; Takashima, 1945: 90); I regret that none of these specimens could be found in collections. In case these animals were not transported by man, but are found there as a result of normal dispersal, they probably belong to the species *H. petersii* or *H. longimanus*. The last-mentioned species is the most probable, because Meise (1932: 662), who apparently examined the specimen from Makasar (Sulawesi), used the name of *H. l. longimanus* for this sample.

The well-known species *H. longimanus* (fig. 64), a close relative of *H. spinifer*, has its main area of distribution on Sumatra (typical form) and Borneo, but is also found on some islands in between, on a restricted part of Java, on the islands linking Borneo with Luzon and Mindanao, and even on Luzon itself. Within this species subspecific variations can be recognized. In a small area (Krapjak, Salak, Taluk, Sukabumi) on Java, in the typical distributional area of *H. cyaneus*, the subspecies *H. longimanus angustimanus* can be found. On Borneo the subspecies *H. longimanus borneensis*

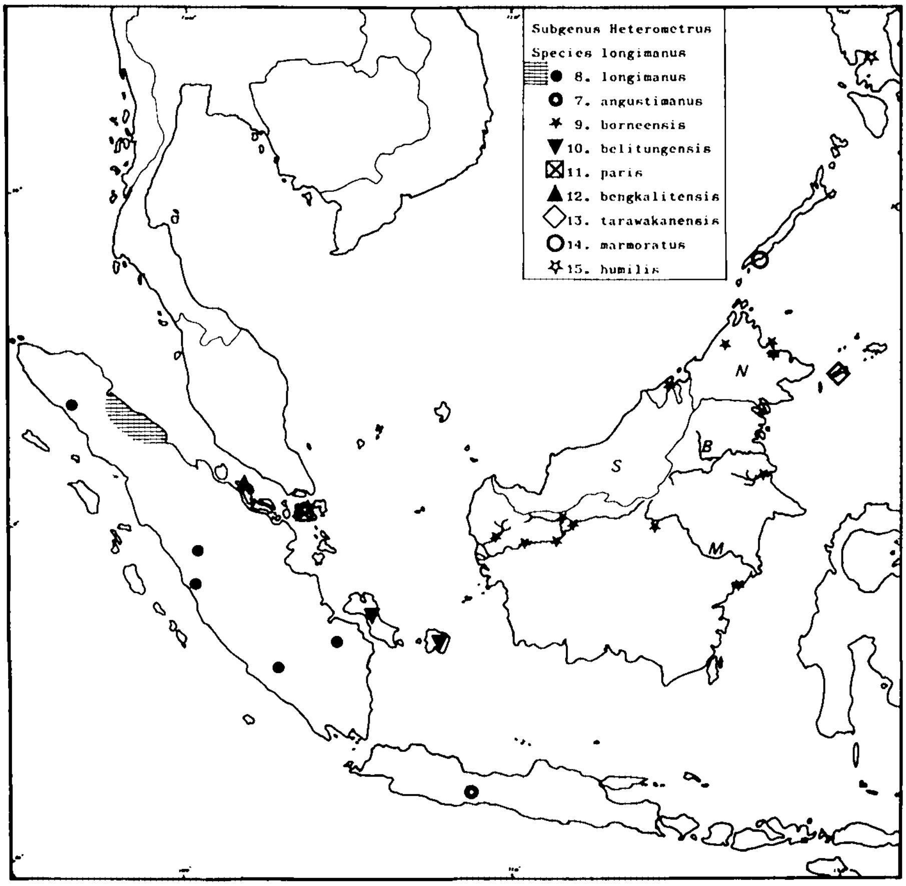

Fig. 64. Distribution of localities of the subspecies of *Heterometrus* (*H.*) *longimanus*. The numerous localities of the nominal subspecies in and near Deli, Sumatra, are represented by horizontal shading (this refers to Deli, Gedong Djohore, river Bedagnok, Tandjong, environs of Medan, Tandjong Morawa, Serdang and Tanah-Gambus). Doubtful or unprecise localities omitted: for *H.* (*H.*) *longimanus humilis*: Philippines; for *H.* (*H.*) *longimanus borneensis*: Long Peso, E. Borneo; Tapanoeli, Borneo; Borneo. For the last-mentioned subspecies are roughly indicated by capitals: *M*, river Mahakkan (Mahakam); *B*, river Bahau; *N*, N. E. Borneo; *S*, Serawak.

occurs; the interjacent islands also have their own representatives, but these differ only slightly from both the typical form and *H. longimanus borneensis*: *H. l. bengkalitensis* on Bengkalis, *H. l. paris* on the Riau archipelago and *H. l. belitungensis* on Bangka and Belitung. Such variation was also found on the two rows of islands (Sulu archipelago and Palawan Passage) between Borneo and the larger Philippine islands (on which the subspecies *H. l.*

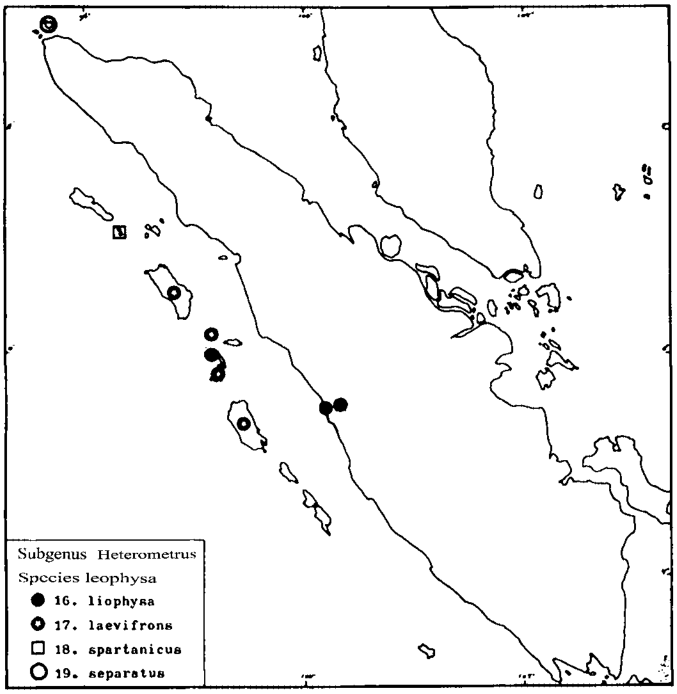

Fig. 65. Distribution of localities of the subspecies of *Heterometrus* (*H.*) *liophysa*. Doubtful or unprecise localities of the nominal subspecies, which are omitted: Kenkandam; Bunga-Bondar, W. Sumatra; W. coast of Sumatra. Error: instead of a black dot, a white star should be indicated on Palau Tello.

humilis occurs), viz., *H. l. tarawakanensis* on Tarawakan and *H. l. marmoratus* on Balabac and Palawan.

A direct neighbour of *H. longimanus*, and sympatric with it on Sumatra, is *H. liophysa* (fig. 65). On the islands off Sumatra's south-western coast slightly different forms occur, which almost range within the variability of the typical form on Sumatra, although they are clearly differentiated by their distribution. It concerns *H. liophysa laevifrons* on the Mentawei islands, Nias and the Batu archipelago, *H. l. spartanicus* on Babi and *H. l. separatus* on Weh. According to scarce information, a close relative of *H. liophysa* was found on Madura, thus living sympatric with *H. cyaneus insulanus*. This concerns the species *H. madoerensis*, of which only a single specimen, a subadult female, was collected. The disadvantage of founding the description of a species on one (immature) specimen is neutralized by the distinct age-independent differences with its relatives and by the disjunct locality (although the label could be erroneous). Another close relative of *H. liophysa*, viz., *H. bengalensis*, is found in Burma, Assam and Bangladesh, and possibly occurs further to the north-east in India. Records of *H. longimanus* specimens found on the Andaman islands (Pocock, 1900b: 98; Kopstein, 1921: 129; Meise, 1932: 662) most probably refer to *H. bengalensis*, a species which occurs also on the Mergui islands; the specimens must have been easily distinguishable from the well-known and strongly different species *H. cyaneus* found on the adjacent Nicobars.

The distribution of the *H. longimanus, H. liophysa, H. madoerensis* and *H. bengalensis* species-complex shows a close resemblance to that of other taxa, such as *Ficus glaberrima* (see Croizat, 1968: 222, fig. 27B). In the light of these facts, Kopstein's note on the occurrence of *H. longimanus* on the Sula islands appears less improbable (the *Ficus* species in question also passes Wallace's line). On the other hand, as already mentioned above, Kopstein could have meant the Sulu archipelago, a series of islands between north-eastern Borneo and Mindanao, on which indeed a *H. longimanus* subspecies was found. For the time being, it seems sensible to regard the natural distribution of the genus *Heterometrus* as bordered by Wallace's line, as is the traditional concept (Vachon, 1953: 8, 9).

VII. Phylogenetic relationships

(see also chapter VIII)

By comparing *Heterometrus* and the genera *Pandinus* Thorell, *Ischnurus* Koch, *Scorpio* Linnaeus, *Opisthophthalmus* Koch and *Opisthacanthus* Peters, and noting the correspondence in primitive and derived character-states (tables 8 and 9), some intergeneric relationships become apparent. Evidently, there is some affinity between *Heterometrus* and *Pandinus* (from Africa), especially between *Pandinus* and *H.* (*Gigantometrus*) *swammerdami*. There remains, of course, the generic difference in the construction of the stridulation organs: the area with fine, setose, teeth on the coxa of the anterior walking-leg and the densely granulated area on the pedipalp coxa of *Pandinus* have the reverse position in *Heterometrus* (cf. Pocock, 1896a: 23). Since the absence of stridulation organs is primitive, *Heterometrus* and *Pandinus* show different specialisation (derivation) on this point. As for other generic characters, the distinction between primitive and derived states is more difficult. It really requires a thorough study of the family and this could not be performed within the scope of the present revision. The judgements on the character states are, therefore, less reliable (more arbitrary) if they apply to intergeneric differences than in the case of relations between subgenera, species-groups and species. In order to recognize the sister-genus of *Heterometrus*, it would, however, be sufficient to distinguish alternative character states, the distinction between primitive and derived states thus being left an open question. In general and as a hypothesis, I here consider a character state primitive, if it occurs in the majority of genera examined, and derived, (in *Heterometrus*), if it is aberrant from most other genera examined. In the text of this chapter, descriptive characters have an important place, because these characters lend themselves better to usage in this text than biometric characters. Both groups of characters are, however, represented in the cladogram composed of figs. 66a and b. Trichobothriotaxy, i.a., clearly demonstrates the distinction between *Heterometrus* and *Pandinus*. Vachon (1973: 916) considered *Heterometrus*, as well as *Ischnurus*, *Opisthacanthus* and *Scorpio*, scorpionid genera with orthobothriotaxy (type C of Vachon), a character state that is supposed to be primitive. *Pandinus* exhibits neobothriotaxy (a character state that is supposed to be derived), in which the number of trichobothria is increased ("néobothriotaxie majorante"): the fourth pedipalp segment bears 30 ventral trichobothria (Vachon, 1973: 919, fig. 96), which implies addition of 27 accessory trichobothria to the orthobothriotactic number of 3. A derived character state in *Heterometrus* is constituted by the pairs of more or less bright spots on its tergites, absent in *Pandinus*. Derived character states for *Pandinus* are the presence of more than two prominent internal teeth on the fourth pedipalp segment, the macroseta on the internal fulcral plates, the smooth medioposterior borders of the tergites and the conspicuous denticulated tubercles on tergite 7. The primitive state of these characters is found in *Heterometrus* (in particular its most primitive subgenus *Gigantometrus*), viz., the absence of prominent internal teeth on the fourth pedipalp segment, the bare internal fulcral plates, the continuous granulation on the tergite borders and the inconspicuous lateroposterior tubercles on tergite 7. These alternative states I consider arguments to conclude that these two genera stand in a sistergroup relation. Even a superficial look demonstrates the striking resemblance between *Pandinus* and *H.* (*Gigantometrus*) *swammerdami*. Without a thorough study of the family, this resemblance does not yet prove affinity on this level, because it could be based on primitive character-states. The joining of *Heterometrus* with *Pandinus* by earlier authors (Thorell, 1876; Karsch, 1879b; Simon, 1905) is, however, well understandable: these two genera resemble each other much more than any other genus of Scorpionidae.

The distinctly primitive state and separate position of *Gigantometrus* within *Heterometrus* is also apparent from table 10 (and its comprised variant, table 14; cf. Couzijn, 1978: table 1: *D. B.*), where the derived character-states are counted, which the various taxa of *Heterometrus* have in common. These tables are less useful than tables 8 and 9, since the involved characters are not discriminated and so there is no differentiation possible between earlier and later derivations. Still they demonstrate that the high rate of derivation in the subgenus *Heterometrus* is striking, while it is somewhat lower in the *phipsoni* group of the subgenus *Chersonesometrus* and moderate in the remaining groups. This is one of the aspects of the groups *indus* and *cyaneus* as former members of the subgenus *Heterometrus* (cf. Couzijn, 1978) that made them problematic from a historical point of view and for these reasons the same rank was given to these taxa i. e., they were considered subgenera. From table 14 one might easily conclude that the subgenus *Chersonesometrus* is an artificial combination of two strongly different groups, merely because of their roughly common distribution area,

TABLE 14

					25.8 ± 3.2	Heterometrus
				16	7.5	Srilankametrus
			16.3 ± .6	8.7 ± 1.2	8.7 ± 3.5	Javanimetrus
		14.7 ± 1.4	6.2 ± 1.7	5.7 ± 1.6	6.9 ± 5.0	gr. fulvipes
	20.2 ± 2.3	7.5 ± 2.5	8.7 ± 1.4	7.4 ± 1.1	10.4 ± 2.1	gr. phipsoni
9.0 ± 2.7	2.7 ± .7	1.8 ± 1.3	2.0 ± .7	1.3 ± .6	2.1 ± 1.0	Gigantometrus
Gigantometrus	gr. phipsoni	gr. fulvipes	Javanimetrus	Srilankam.	Heterom.	subgenus/group

Survey of correlations between subgenera and species-groups of the genus *Heterometrus*, with reference to the derived biometric characters (summarized version of table 10): for each pair of taxa, the mean number of correlations is given, with the standard deviation, as can be calculated from table 10.

and that the group of *H. phipsoni* would be more closely related to the strongly derived subgenus *Heterometrus* than to the more primitive *fulvipes* group. Careful interpretation of this table is necessary, for the high rate of derivation in the *phipsoni* group and in the subgenus *Heterometrus* is certainly not in all instances based on the same derived characters, as is shown in figs. 66a and b. On the other hand, table 14 demonstrates that the *phipsoni* group shares a higher percentage (52%) of its derived biometric character states with *Heterometrus* than with the *fulvipes* group (38%). The *fulvipes* group shows more correlation, in this repect, with the *phipsoni* group (52%) than with the subgenus *Heterometrus* (47%: still fairly high), so it is likely that the *phipsoni* group is a result of further development and specialisation of the ancestors of the *fulvipes* group, while these have evolved from a stock they have in common with the subgenus *Heterometrus*.

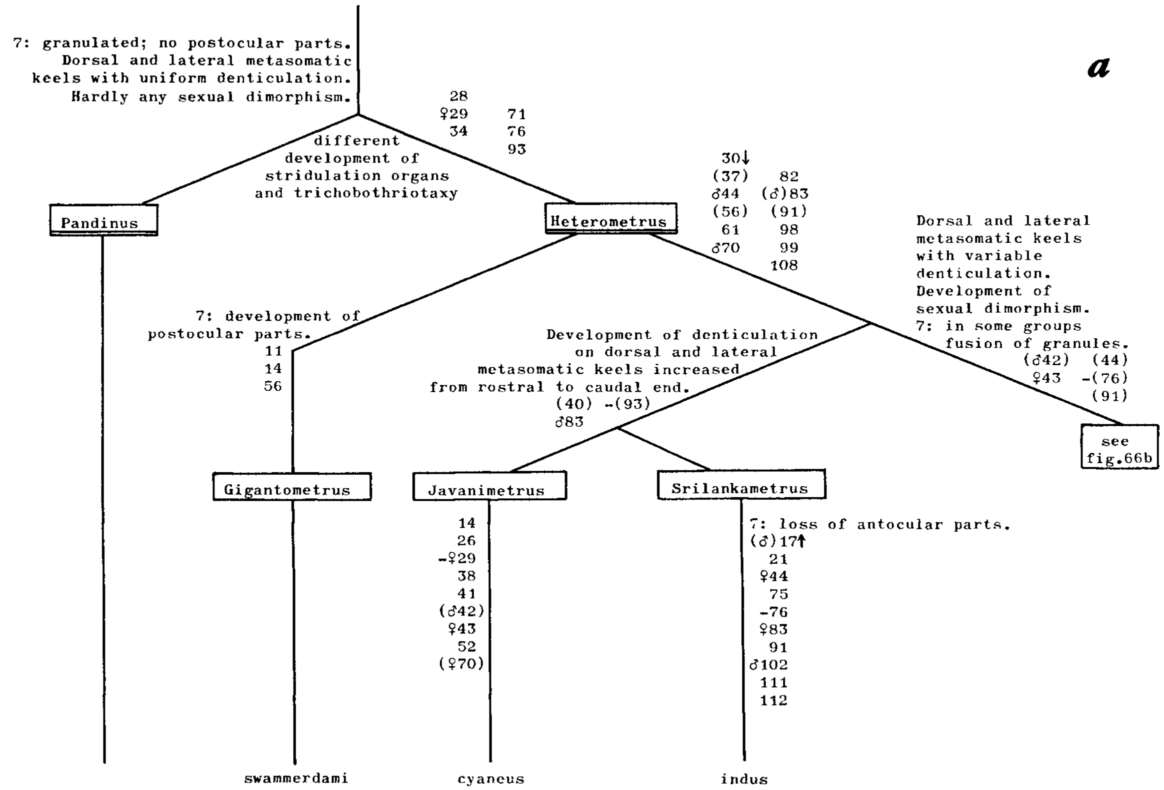

Fig. 66. Cladogram (composed of figs. 66a and b) demonstrating the hypothetical phylogenetic relationships between *Heterometrus* taxa, with addition of the sistergenus *Pandinus*. Beside each "branch" the new derived character states (or their numbers) are indicated; the sistergroup implicitly demonstrates the corresponding primitive character states. A — sign indicates a "secondary primitive" character state. If a character state is found in part (the majority) of the taxa of a "branch", this is placed in parentheses. If derivation can imply both increase and decrease of the value of a biometric character, the direction of derivation is indicated by an arrow.

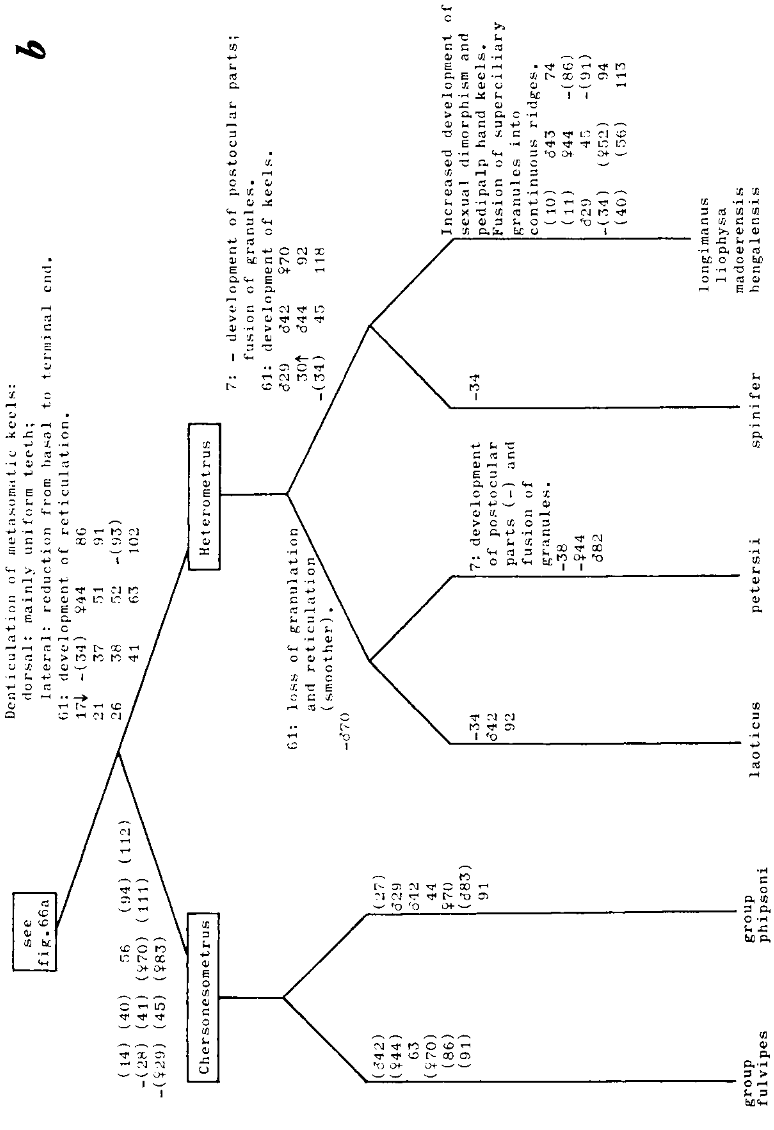
b
see fig.66a
Denticulation of metasomatic keels:
dorsal: mainly uniform teeth;
lateral: reduction from basal to terminal end.
61: development of reticulation.
17↓ -(34) ♀44 86
21 37 51 91
26 38 52 -(93)
41 63 102
(14) (40) 56 (94) (112)
-(28) (41) (♀70) (111)
-(♀29) (45) (♀83)
Chersonesometrus
Heterometrus
61: loss of granulation
and reticulation
(smoother).
-♂70
7: - development of postocular parts;
fusion of granules.
61: development of keels.
♂29 ♂42 ♀70
30↑ ♂44 92
-(34) 45 118
(♂42)
(♀44)
63
(♀70)
(86)
(91)
(27)
♂29
♂42
44
♀70
(♂83)
91
-34
♂42
92
7: development
of postocular
parts (-) and
fusion of
granules.
-38
-♀44
♂82
-34
Increased development of
sexual dimorphism and
pedipalp hand keels.
Fusion of superciliary
granules into
continuous ridges.
(10) ♂43 74
(11) ♀44 -(86)
♂29 45 -(91)
-(34) (♀52) 94
(40) (56) 113
group fulvipes
group phipsoni
laoticus
petersii
spinifer
longimanus
liophysa
madoerensis
bengalensis

Fig. 66 (b)

Another interesting aspect is formed by the two small, moderately derived, subgenera *Srilankametrus* and *Javanimetrus* with their remarkable distribution and their more or less equidistant connections (in common derived character states) with the highly plastic and derived subgenus *Heterometrus*. Further, within this subgenus it must attract our attention that the three species occupying the continental part of the distribution area (*H.* (*H.*) *bengalensis* excepted) are less derived than the species on the archipelagos.

The development of derived character-states in different taxa is made clear in the cladogram composed of figs. 66a and b. It is possible to construct alternative cladograms, but the direction of changes in character-states is less consistent and the increased number of parallel developments and "secondary primitive" states one has to assume, make such alternatives less probable. These alternative cladograms are not included in this paper, because they are not really worth the large space which they would take up. In the figured cladogram, at each bifurcation the newly evolved character-states are indicated (by their character numbers or a short explanation) next to the "branch" that is characterized by these derived states. The sistergroup consequently retains the ancestral state. Some of the changes which lead to the formation of the larger taxa within the genus *Heterometrus* are explained below.

The differentiation in the genus *Heterometrus*, by which its subgenus *Gigantometrus* can be distinguished, is indicated by the development of the postocular parts of the superciliary crests, the deep postocular median impression and the granulation on the medioposterior border of the carapace in *Gigantometrus*, while the sistergroup shows a decrease in several measures, viz., the length of the pectinal shaft and of the metasoma (also as a ratio to the carapace length), the length of the male's pedipalp hand as a ratio to the internal length of its fourth segment, and the number of pectinal teeth, the change in the positions of trichobothria *esb1* and *esb2*, and (in the male) the increase of the ventral hand length as a ratio to the hand width. The last-mentioned character change can be considered the start for the development of sexual dimorphism; also new types of hand microsculpture appear in this sistergroup.

The separation of the ancestor of *Javanimetrus* and *Srilankametrus* from this branch is characterized by the differentiation in denticulation of the dorsal and lateral metasomatic keels (only one of the variants which occur in the sistergroup) and a further decrease of the number of pectinal teeth, while the sistergroup developed stronger sexual dimorphism and shows a tendency to the fusion of superciliary granules to constitute more continuous ridges.

In *Javanimetrus* the deep impression closely behind the median eyes is lost, while the denticulation on the internodorsal keel of the third pedipalp segment and on the internal surface of its fourth segment are more strongly developed; a change in the distances between the ventral hand trichobothria (*V1, V3, V4*) is also distinct. The sistergroup *Srilankametrus* is characterized by the loss of the antocular parts of the superciliary crests, the reduction of granulation on the dorsal surface of the third pedipalp segment, on walking-leg femora and on medioposterior tergite borders, and the reduction of denticulation on dorsal and lateral metasomatic keels. In this subgenus the length of the external cheliceral tooth *de*, when compared with the internal tooth *di*, is increased. In the male, the fifth metasomatic segment takes a larger part in the length of the metasoma; in the female, the ratio of hand length and width has increased, while the number of pectinal teeth has decreased.

The derivation leading to *Chersonesometrus* is obscured by the mosaic development of many of the derived character states, in such a way that no single character is indicative for the whole group. Some of the characters are the disappearance of the deep impression behind the median eyes, the development of internal teeth on pedipalp segment 4, the strong reduction of dorsal and lateral metasomatic keels, the increase of sexual dimorphism and the change in the positions of *Eb1, Eb2* and *Esb*. In its strongly derived sistergroup, the subgenus *Heterometrus*, derived states are the decreased difference between external (*de*) and internal (*di*) cheliceral teeth, the reduction of the dorsal granulation on pedipalp segment 3, a change in the positions of hand trichobothria (*Et2, Dt, V1, V3, V4, eb* and *et*), the development of more slender pedipalp hands in the female and the greater part taken by segment 5 in the total length of the metasoma. On the hand of the pedipalp, reticulation appears, the denticulation of dorsal keels on its third segment is more pronounced, the granulation on the external surface of its fourth segment is reduced, while on the internal surface of this segment one tooth is accentuated. The internal fulcral plates have got a macroseta, the medioposterior tergite borders have lost their granulation.

Within the subgenera *Chersonesometrus* and *Heterometrus* further differentiation is indicated. The high rate of derivation in *Heterometrus* is remarkable particularly in its Indonesian and Burmese species, viz., *H. longimanus, H. liophysa, H. madoerensis* and *H. bengalensis*. These seem to have evolved rather fast. The results of the computer treatment of data from Southeast Asiatic *Heterometrus* species, represented by the dendrogram of fig. 18, find support in this part of the cladogram by the consistent development of various derived character states. The position of *H. laoticus* is somewhat problematic (as in the dendrogram). Its relation with *H. petersii* is demonstrated in the smooth aspect of the pedipalp hand and the increased value of character no. 70 in the male. On the other hand, it shows a few developments parallel with the Malayan and Indonesian sistergroup. But it does not share with these species several other derived character-states (the changed position of trichobothria *esb1* and *esb2*, the longer fourth segment and hand of the pedipalp in the ♂, the increased sexual dimorphism in the hand proportions, etc. These character-states are reasons enough to me to maintain *H. laoticus*' position as I suggested earlier (p. 73).

On the basis of the classification of the species of *Heterometrus*, as suggested above, an attempt can now be made at a coherent narrative (hypothetic) explanation of the distribution observed. On the Triassic continent of Gondwana (fig. 67), representatives of *Heterometrus* may have existed, sharing a common ancestor with African *Pandinus*. Part of these ancient

a

b

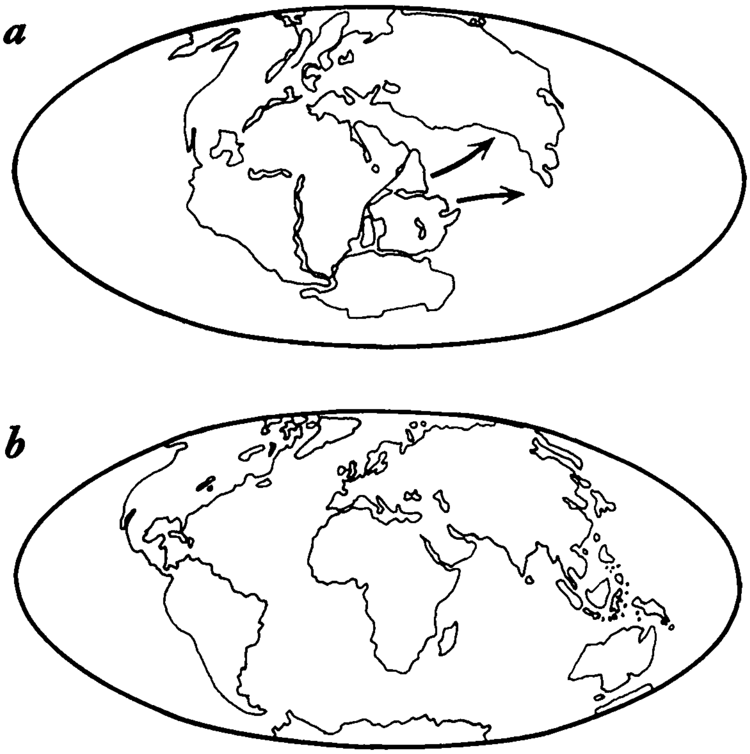

Fig. 67. Fragmentation of Gondwana; a, Triassic situation, with indication of the directions of movement of the shelves, which produced India and the Australian region; b, recent situation.

Heterometrus would stay very conservative until now, producing the present *Gigantometrus*. New forms, probably isolated ecologically from the first one, deviated more from their common ancestor, maybe already while Gondwana was approaching Laurasia across the Thetys Sea, but certainly during the Cretaceous period. In the meantime, Gondwana had split up into four shelves drifting apart (Krishnan, 1974: 87; Croizat, 1968: 151-154): the later Indian peninsula (including Assam), carrying *Gigantometrus* and part of its more derived sistergroup, which would develop, i. a., Indian *Chersonesometrus*, and three shelves, which would fuse in the Upper Cretaceous to form the later Indochinese peninsula (sensu lato) and the Chinese Sea basin (fig. 68). On this Indochinese shelf complex, another part of the more derived *Heterometrus* group occurred, which is the ancestor of groups such as *Javanimetrus*, now found in this region. When the Cretaceous period drew to its end, the shelves collided with Laurasia, this collision causing the large-scale Tertiary orogenesis by which most of the present mountain systems arose (fig. 69). The Assam gateway (Mani, 1974d: 705, fig. 158) enabled various Indian endemic plants and animals to enter the Malayan and Indochinese peninsula, which then still formed a unit including the Sunda shelf. But also in reverse direction these migrations took place. While the

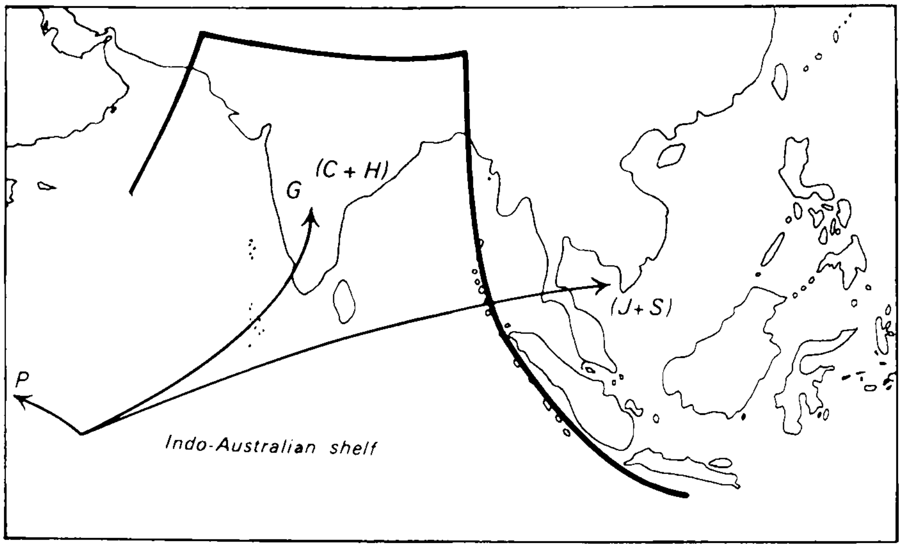

Fig. 68. Hypothetical differentiation of the ancestors of the genera *Pandinus* (*P*) and *Heterometrus*, in connection with the fragmentation of Gondwana. Within *Heterometrus*, specification is given for the ancestors of the subgenus *Gigantometrus* (*G*), of the sugenera *Chersonesometrus* and *Heterometrus* s.s. (*C*+*H*), and of the subgenera *Javanimetrus* and *Srilankametrus* (*J*+*S*).

oriental form of *Heterometrus* populated the Sunda shelf and evolved into the present *Javanimetrus*, part of this group invaded India and produced the subgenus *Srilankametrus*. From the other side, the more advanced and rapidly evolving ancestor of *Chersonesometrus* in India also took part in these migrations (fig. 69): in its new oriental territory, the invader got involved in the accelerated development of the oriental faunal radiation centre (Mani, 1974d: 703-704) and produced the subgenus *Heterometrus*. Because Sulawesi, the Moluccas and other parts of the large Sunda shelf East of Wallace's line separated in this period, these invaders could not cross this line (Vachon, 1953: 8, 9). This boundary held also for *Javanimetrus* already present in this region; the greater part of the Sunda shelf and the new-born Sunda mountain system (Croizat, 1968: 155) cleared the way for this subgenus (before the immigrants) to populate Borneo, Java and Madura, Sumatra and the Nicobars.

According to Mani (1974b: 631), the Pleistocene climate, dry and chilly as it was in the ice-ages, had forced the humid tropical Gondwana relics and Indian endemic species to retreat into the far southern corners of the peninsula, followed by the oriental invaders, and the old territories of the endemics were never re-occupied by them during the milder Holocene (fig. 71). It appears that *Gigantometrus* (a Gondwana relic) and several species of *Chersonesometrus* (endemics) do not fit this rule completely, since they are now found in certain central and northern parts of the peninsula. Further, *Srilankametrus* (an invader) seems, against expectation, to be confined to a small southern refuge. Apparently the plastic, rapidly evolving, *Chersonesometrus* successfully competed with the more conservative immigrant (which, as a result, now has a reduced area of distribution), while *Gigantometrus* did refill some special ecological niche, which seems not to have been occupied by any of the other *Heterometrus* species. The presence on Sri Lanka of a member of the subgenus *Heterometrus*, viz., *H. spinifer solitarius*, does not fit at all in my historical view, leaving as the only interpretation an allochthone if more specimens will be found, or an explanation involving an erroneous label and a wider variation in *H. spinifer*.

The important Tertiary orogenetic metamorphosis in the Indochinese landscape (sensu lato) not only made possible dispersal of *Javanimetrus*. An island chain arose in part of the Sulu basin (fig. 70): Taiwan, northern and central Philippines and, connected by series of small islands, northern Borneo (Croizat, 1968: 155-156). Along this chain, called the Luzon track (Holloway, 1974: 491; Van Steenis, 1934), representatives of the fast evolving Indochinese fauna (the species *H. petersii)* advanced to reach the central Philippines, establishing there the populations *H. petersii mindanaen-*

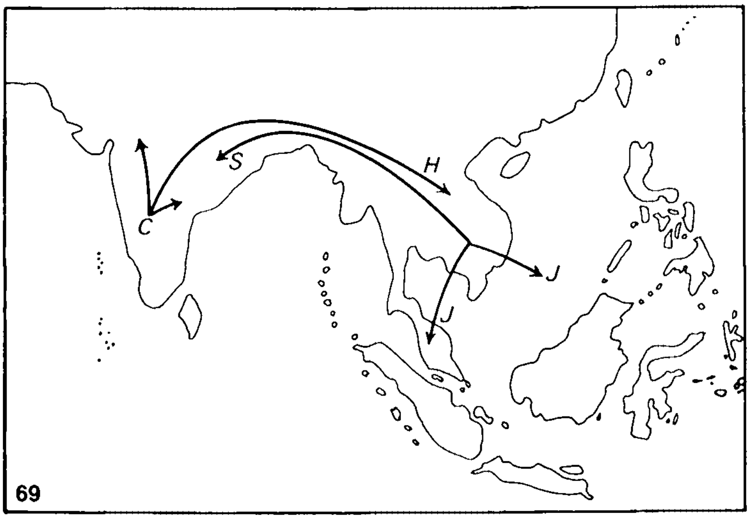

Fig. 69. Migrations via the "Assam gateway" and dispersal of endemic subgenera in India and the Indomalayan region; *C*, *Chersonesometrus*; *H*, *Heterometrus* s.s.; *J*, *Javanimetrus*; *S*, *Srilankametrus*.

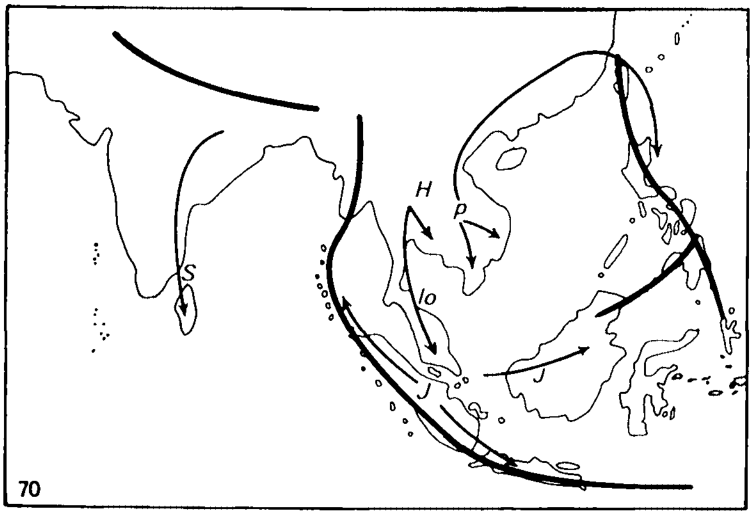

Fig. 70. Dispersal of *Heterometrus* groups in connection with the Tertiary orogenetic metamorphosis (indicated by bold lines); *H*, *Heterometrus* s.s.; *J*, *Javanimetrus*; *lo*, *H. longimanus*; *p*, *H. petersii*; *S*, *Srilankametrus*.

sis and *H. p. luzonensis*. From the other side, *H. longimanus* spreaded from the Malayan part of the radiation centre eastward reaching as far as the Philippines (Luzon) to meet *H. petersii*, but also southward invading Sumatra and Java. On Java it obtained hardly a foothold (*H. longimanus angustimanus*) possibly because this island was hardly connected to the continent in spite of the sea regressions of the Pleistocene ice-ages (fig. 71) during which the dispersal of *H. petersii* and *H. longimanus* did take place. Conservative *Javanimetrus* was affected by the strong competition of successful and variable *H. longimanus*. Except for its stronghold on Java it has lost its old dominancy on Sumatra and Borneo, where its populations seem to be scattered and small. This can be illustrated with its occurrence on the isolated mountain Kinabalu, a refuge for many more floral and faunal relics on Borneo. This was observed, e.g., in the genus *Ficus*, where Sino-Himalayan and Australian elements have taken refuge to higher altitudes (i.a. Mount Kinabalu) on Borneo, above the common Malaysian flora of the Sunda shelf (Corner, 1964: 38). While *H. longimanus* thus expanded its territory in Indonesia, the species *H. spinifer* and *H. laoticus* established the typically continental populations in the Indochinese region.

The remaining species, *H. liophysa* and its relatives *H. madoerensis* and *H. bengalensis*, have a remarkable distribution area more or less surrounding the large area in which their common relative *H. longimanus* is dominating. This distribution, together with the fact that these three species are the most derived in the whole genus (even more than *H. longimanus*), are convincing indications that they are results of peripheral isolation (Mayr, 1976: 188-210). This complex of four species shows all features of such a mechanism. The strongly variable, successful and widespread parental species *H. longimanus* occupied the islands off Sumatra's south-western coast with a founder population, which possessed a restricted part of the genetic variability of the parental species. In this isolated position, the founder population rapidly evolved into a new type (*H. liophysa*) by development of a high level of genetic variability, when establishing itself in a new ecological niche. A similar example of differentiation by peripheral isolation is shown without doubt by the five subspecies of the wasp *Eumenes flavopictus* found on the same island range (Van der Vecht, 1959: map 7). At the adjacent coast of Sumatra, *H. liophysa* is even sympatric with its ancestral species, probably after successful remigration from the islands to this "mainland". This explanation is supported by the fact that its population on Sumatra shows a higher level of genetic variability than the populations on the islands, enriched as it is by the adaptation to the new, more variable, environment. The same mechanism can be the origin of *H. madoerensis* on Madura, by isolation

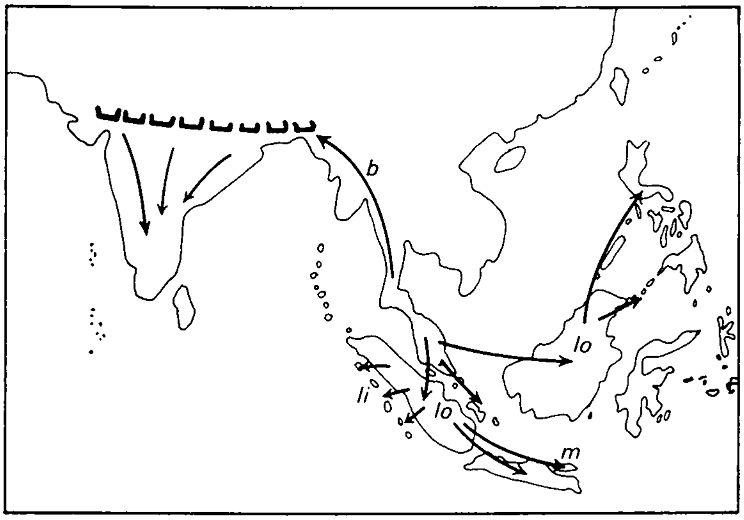

Fig. 71. Dispersal of *Heterometrus* groups during the Pleistocene period; the glaciation of the Himalaya mountain range is indicated, as well as climatically induced migrations in India and dispersal of the species-complex of *Heterometrus longimanus* (*lo*), *H. liophysa* (*li*), *H. madoerensis* (*m*) and *H. bengalensis* (*b*).

from the Javanese form *H. longimanus angustimanus*. It is more difficult to use this explanation also for *H. bengalensis*, since its distribution area does not border directly on that of *H. longimanus*. It is possible, of course, that such was the case in earlier times and *H. spinifer* later wedged in between the two. As a second possibility, *H. bengalensis* may represent an isolated form developed from a far emigrant population of *H. longimanus* or *H. liophysa* via the island bridges of the Andaman Sea, which were continuous during the Pleistocene regressions. Both hypotheses are supported by the occurrence of *H. bengalensis* on the Mergui archipelago off the coast of Tenasserim (Pocock, 1892a: 39), the second hypothesis by the probable occurrence in Port Blair on the Andaman islands (Kopstein, 1921: 129; Meise, 1932: 662; Pocock, 1900b: 98).

During the short Holocene period, the geographic situation was unaltered, the islands stayed isolated and the only changes in the distribution of *Heterometrus* could take place under the influence of increasing human activities. Possible allochthones mentioned above, in this and in other chapters, originate from this period. Still a much more important, even desastrous, biogeographic change was caused by man. In India large-scale deforestations destroyed the vast and ancient natural environment of an immense forest flora and fauna, including *Heterometrus*. This must be the reason why the present distribution of several species in India looks like a muddle (Mani, 1974d: 709, 715, fig. 161; 721-722) and why so many species appear to have accumulated in the southern parts, being confined to the last remains of virgin forest (Mani, 1974b: 637). This irreversible destruction, inevitably resulting in the disappearance of numerous plant and animal species (Mukherjee, 1974: 362, 366-367), has increased hand over hand also in Indochina and Indonesia, thus threatening nature, including the rich *Heterometrus* fauna.

VIII. Systematic list of taxa

The taxon numbers on the left are used in tables; the page numbers on the right refer to descriptions.

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