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A REVIEW OF THE GENUS *RHAGADOTARSUS*, WITH DESCRIPTIONS OF THREE NEW SPECIES (HETROPTERA: GERRIDAE)

J. T. Polhemus and **P. B. Karunaratne**

ABSTRACT.- *Rhagadotarsus* (*Rhagadotarsus*) *kraepelini* Breddin and *Rhagadotarsus* (*Caprivia*) *hutchinsoni* China are redescribed. Three new species are described and placed in the subgenus *Rhagadotarsus*; *R. anomalus* (Australia, Papua New Guinea), *R. borneensis* (Indonesia; Irian Jaya, East Kalimantan) and *R. taprobanicus* (Sri Lanka).

INTRODUCTION

The genus *Rhagadotarsus* has two subgenera; the subgenus *Caprivia* China contains only *R.* (*C.*) *hutchinsoni* which is widespread in Africa, and the nominate subgenus *Rhagadotarsus* which until now contained a single described species, *Rhagadotarsus kraepelini* Breddin, widespread in the Australasian region. This paper is focused primarily on the nominate subgenus *Rhagadotarsus*, however a redescription and distributional records are given for *R.* (*C.*) *hutchinsoni*.

Over a number of years the authors have collected and studied specimens of *Rhagadotarsus* from numerous localities. Most of these belong to the widespread species *R. kraepelini*, however we have separated several new species which are described below. The genus *Rhagadotarsus* exhibits much less morphological diversity than the New World sister genus *Rheumatobates*, and the characters separating the species are rather subtle which may explain why previous workers have overlooked the undescribed species.

Most of the material reported herein was collected during several expeditions by the senior author during the last decade, sponsored in part by the National Geographic Society, and by the second author during his lengthy investigations of the aquatic Heteroptera fauna of Sri Lanka. Institutional abbreviations are given in the acknowledgments section. The CL numbers following locality data refer to a coding system used to reference ecological data. All measurements are given in millimetres.

J. T. Polhemus - University of Colorado Museum, 3115 S. York, Englewood, CO 80110, United States of America. **P. B. Karunaratne** - 116 Sunethra Devi Road, Nugegoda, Sri Lanka.

BIOLOGY

The life history and behavior have been reported by Hoffmann (1936) for *R. kraepelini* and Wilcox (1972) for *R. anomalus* (reported as *R. kraepelini*; Wilcox, 1979). At Canton, China, where Hoffmann made his observations, these insects breed over most of the year and overwinter as adults, producing 5 or 6 generations per year; Wilcox reported year-round mating near Cairns, Queensland, Australia. Mating was observed by Hoffmann, but it remained for Wilcox (1972; Fig. 2C) to illustrate the positioning of the male and female during copulation with the male astride the female. The sulcus of the male venter of all species and the associated hair tufts of *R. anomalus* and individual long setae in *R. kraepelini* (Figs. 1-4) suggest to us that the long slender female genital segments fit closely with the male venter during mating, and that the hairs are sensory in nature and may assist in positioning for copulation. Oviposition was observed by Wilcox only in floating objects that had been just been used by males for signalling, however it is assumed that other sites may be used also. The insertion of eggs into soft objects by means of the well developed ovipositor had been predicted, but Wilcox was apparently the first to observe it.

The sexual behavior of *R. hutchinsoni* in Uganda was described in some detail by Nummelin (1988), and his findings generally agree with those given above for other species. The males establish territories with good oviposition sites, then possession is advertised by ripple signals.

Hoffmann (1930, 1936) described for *R. kraepelini* the peculiar habit of pushing small bits of floating material with the front legs, usually a short twig. Wilcox (1972) investigated this behavior in detail and showed that in addition to grasping floating objects, males produce signals of patterned sequence surface waves that are of several kinds, some for calling and courtship, intended for females, others aggressive, intended for competing males (Fig. 5). D. A. and J. T. Polhemus later noticed the same behavior in *R. anomalus* in Queensland, Australia, and in *R. kraepelini* at Lake Sebu on Mindanao in the Philippines (J. Polhemus, 1990). Murphy (1990; for *R. kraepelini* in Singapore), and Nummelin (1988; for *R. hutchinsoni* in Uganda) reported similar observations, thus it seems likely that all species of the genus will be found to exhibit this behavior.

The food habits of *Rhagadotarsus* are the same as most gerrids, almost any insects trapped in the surface film. These bugs are rather feeble swimmers, thus require a water surface free from scum or otherwise they become entangled and drown.

DISTRIBUTION

The distribution given by previous authors for African and Australasian *Rhagadotarsus* assumed only one widespread species in each of the two subgenera. With the recognition of four species instead of one in the nominate subgenus *Rhagadotarsus*, some clarification is required. Calabrese (1980) gave the distribution of both subgenera together in a rather diagrammatic way that implied a continuous distribution of the genus across most of the tropical Old World, when in fact the distribution is discontinuous from Sudan and Somalia to India. To our knowledge, the genus has not been recorded from the Arabian Peninsula, Iran, Pakistan or western India. The distribution of the subgenera *Caprivia* (African) and *Rhagadotarsus* (Australasian) was more correctly depicted by Andersen (1982). The known distribution of each species is given below, and for the nominate subgenus *Rhagadotarsus* distribution maps are given for the four species recognized in this work (Figs. 6-9).

TAXONOMY

Rhagadotarsus Breddin

Rhagadotarsus Breddin, 1905: 136. Type-species, *Rhagadotarsus kraepelini* Breddin, 1905, by monotypy.
Nacebus Distant, 1910: 152. Type-species, *Nacebus dux* Distant, 1910, by monotypy. Synonymized by Bergroth 1918: 122-123.
Caprivia China, 1931: 408. Subgenus, type-species, *Rhagadotarsus* (*Caprivia*) *hutchinsoni* China, 1931, by original designation and monotypy.

Key to the subgenera of *Rhagadotarsus* Breddin

1. Length of pronotum medially about 1/2 the length of head. Mesonotum not clearly sutured off from pleura. Abdominal tergites 2-6 subequal in length. Length greater than 5 mm. ..... *Caprivia* China

   Length of pronotum medially about 1/4 to 1/3 the length of head. Mesonotum clearly sutured off from pleura. Abdominal tergites 2-6 not subequal in length, some clearly longer than others. Length less than 5 mm. ..... *Rhagadotarsus* Breddin

Rhagadotarsus (*Caprivia*) *hutchinsoni* China

Rhagadotarsus (*Caprivia*) *hutchinsoni* China, 1931: 408. Type, male, Caprivi Strip, Namibia (as South Africa), (BMNH).

Material examined.- (All JTPC, all apterous unless noted). GHANA: 7 males, 5 females, Tafo, coll. J. A. & S. Slater, R. T. Schuh, 4.x.1967; ZAIRE: (as Belgian Congo), 1 male, 2 females, 39 mi. E. of Masi Manimba, coll.E. S. Ross & R. E. Leech, 5.viii.1957. KENYA: 3 males, 10 females, 1 macropterous female, Stony Athi River, near Nairobi, CL 1651, coll. J. T. Polhemus, 29.i.1980.

Localities from the literature.- NAMIBIA: Caprivi Strip, between Botswana and Angola and Zambia (China, 1931). KENYA: Kikoko R., 2° 12' S, 37° 43' E (Hynes, 1955). BELGIAN CONGO, FRENCH CONGO, SOUTH AFRICA (actually Namibia; see discussion below), SUDAN (Matsuda,1960). GUINEA, IVORY COAST (Poisson,1965). SUDAN, CONGO, DAHOMEY (Linnavuori,1971). SOMALIA: Ola Uager, 1° 11' S, 43° 14' E (Sallier Dupin, 1973). UGANDA (Nummelin,1988).

Distribution.- Subsaharan Africa.

Diagnosis.- *R.* (*C.*) *hutchinsoni*, the only species in the subgenus, may be separated from all members of the nominate subgenus *Rhagadotarsus* by the characters given in the subgeneric key, by the different leg proportions, and by the more elongate body shape. Excellent figures of the male were provided by China (1931) and the female by Matsuda (1960). A habitus figure was provided by Hungerford & Matsuda (1960). The female of this species is similar in form to the male, and the shape of the genital segments is similar to other members of the genus.

The type-locality of this species is commonly referred to as South Africa, but actually it is the Caprivi Strip in Namibia, on the northern border of Botswana. Current knowledge sug-

gests this is the southern limit of distribution.

Description.- Length, apterous male, 5.26 mm; apterous female, 5.99 mm. Ground color grey black, heavily marked with pruinose silvery gray; prosternum anteriorly, longitudinal stripe along inner eye margin, broad median area on pronotum, orange brown. Antennae black. Coxae, trochanters of all legs, all femora basally, mesosternum basally anterad of coxae, yellowish brown to leucine.

Structural characteristics: Antennal formula I-IV: 0.78; 0.17; 0.34; 0.45 in both male and female. Antennae clothed with very short recumbent setae; segment IV slightly curved.

Head long (0.56), interocular space broad (0.45), eye width 0.22; posterolateral angles raised, hind margin depressed. Entire body including head clothed with very short dense appressed pubescence. Pronotum length 0.28, width 0.73, posterior margin concave, medially almost straight. Mesonotum long (1.12), wide (0.78); anterior and posterior margins convex; lateral margins slightly convex, not sutured off from pleura as in *Rhagadotarsus* s.s., but lateral margins faintly indicated. Metanotum and abdominal tergite 1 fused, division indicated laterally by deep depressions, combined length 0.34, posterior margin sinuate. Abdominal tergites slightly narrowing posteriorly, tergites 2-6 subequal (0.25), 7 longer (0.39), 8 longest (male 0.90, female 1.23), 9 short (0.28). Male abdominal sternite 7 depressed, broadly shallowly excavate, forming a weak sulcus extending anteriorly onto sternite 5, becoming shallower anterad and forming only a very slight median depression on sternites 2-4; lateral margins of depression without medially directed setae or tufts. Male genital segments long, somewhat modified; sternite 8 broadly, deeply excavate over basal 2/3, depression narrowing caudally and terminating well before apex. Connexiva broad, somewhat raised. Fore femur regularly set with two parallel rows of ventrally directed setae, plus a number of shorter setae. Middle and hind femora each set with a ventral row of medium length setae, less numerous distally. Claws long, slender, similar. Measurements of legs as follows: Femur, tibia, tarsal-1, tarsal-2 of male fore-leg, 1.40, 0.50, 0.06, 0.22; middle-leg, 3.25, 2.58, 0.90, 0.62; hind-leg, 2.97, 1.23, 0.17, 0.39: female fore-leg, 1.46, 0.62, 0.06, 0.28; middle-leg, 3.58, 2.80, 0.95, 0.67; hind-leg, 3.08, 1.23, 0.22, 0.28.

Habitat.- Specimens of this insect were collected from ponds and the slower reaches of moderate sized rivers throughout its range.

KEY TO *RHAGADOTARSUS (RHAGADOTARSUS)* BREDDIN

1. Length of hind femur clearly less than length of metanotum and abdomen combined. Females with long setae scattered on distal half of third, all of fourth antennal segments. 2

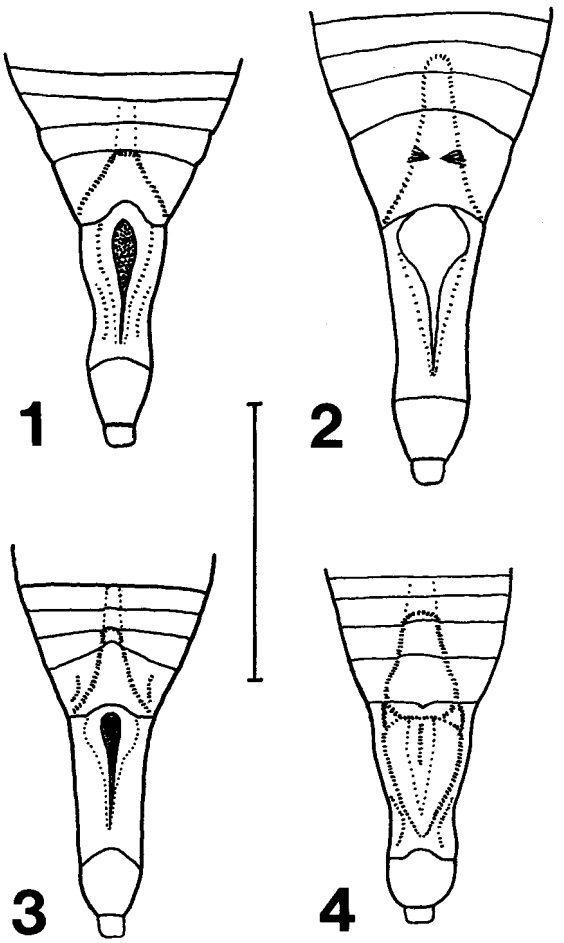
   Length of hind femur clearly greater than length of metanotum and abdomen combined. Females without long setae on distal antennal segments. 3

2. Fore femur dorsally leucine over basal 1/2 in males, basal 2/3 in females. Male fore femur stout, fusiform, bent at basal third; depression on sternite 8 broad, not narrowed into a line caudally; abdominal segments deeply broadly excavate on sternite 7, prominent sulcus extending anteriorly onto caudal part of sternite 5 (Fig. 4). .... *R. taprobanicus*, new species

Fore femur dorsally leucine over basal 2/3 in males, basal 4/5 in females. Male fore femur slender, not fusiform, slightly curved on basal third; depression on sternite 8 broad basally, narrowed into a line caudally; abdominal segments deeply broadly excavate on sternite 7, prominent sulcus extending anteriorly onto anterior part of sternite 6 (Fig. 3). .....*R. borneensis,* new species

3. Median pruinose mark on base of head, when present, medially prolonged anteriorly, never divided. Length of antennal segment I about 2.25 X eye width. Male with abdominal segments deeply broadly excavate on sternite 7, without prominent sulcus extending anteriorly onto other sternites; depression without medially directed tufts of golden setae on middle of sternite 7 (Fig. 1). .....*R. kraepelini* Breddin

Median pruinose mark on base of head, when present, lyre or chevron shaped, sometimes divided. Length of antennal segment I about 3.0 X eye width. Male with abdominal segments deeply narrowly excavate on sternite 7, sulcus widening anteriorly, extending anteriorly onto sternites 5 and 6; margins of sulcus set with 2 (1+1) medially directed tufts of golden setae on middle of sternite 7 (Fig. 2). ..... *R. anomalus,* new species



Figs. 1-4. *Rhagadotarsus* spp., male abdominal terminalia, ventral view. 1, *R. kraepelini* Breddin; 2, *R. anomalus* new species; 3, *R. borneensis* new species; 4, *R. taprobanicus* new species Scale bar = 1 mm.

***Rhagadotarsus kraepelini* Breddin**

(Figs. 1, 5-9)

Rhagadotarsus kraepelini Breddin 1905: 137. Types, males and females, Tjibodas, Java, in Deutsches Entomologisches Institut, Berlin?

Nacebus dux Distant, 1910: 153. Types, sex unknown, Calcutta, India, BMNH? Synonymized by Bergroth 1918: 122-123.

Material examined.- (all in JTPC; many males & females at each locality, all collected by J. T. & D. A. Polhemus unless otherwise noted): INDONESIA: Irian Jaya Prov.: Biak Is., Wafor R., N of Biak, 30m, water temp. 25° C, CL 2643, 16.x.1991; Vogelkop, artificial pond 3 km E of Klagalo R. at old Klagagi oil field, S of Soring, 80m, water temp. 28.5° C, CL 2625, 1.x.1991. Jawa Barat Prov.: 1 male, 1 female, Java, iii.1939, n. c. Kalimantan Timur Prov.: waterfall and stream, 11 km N of Samarinda, CL 2091, 27.viii.1985. Nusa Tenggara Barat Prov.: Sumbawa, Bela R., 28 km SW of Bima, CL 2172, 19.x.1985. Nusa Tenggara Timur Prov.: Sumba, Mataiyang Spring at Lewa Paku, 62 km SW Waingapu, El. 550m,

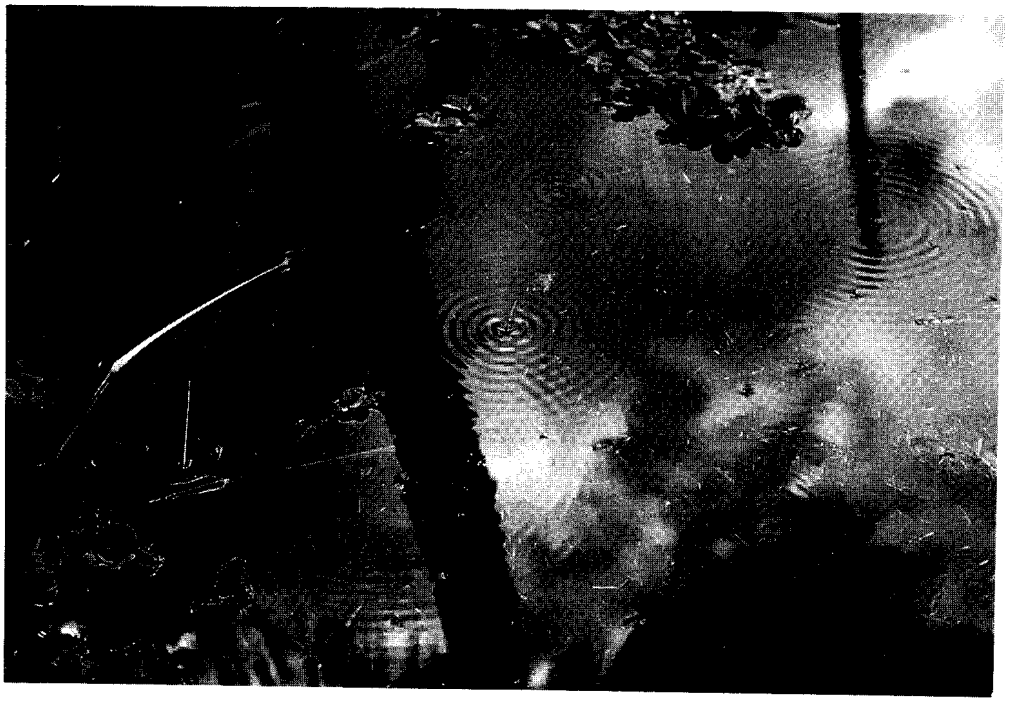


Fig. 5. Males of *Rhagadotarsus kraepelini* communicating by means of ripple signals. (Lake Sebu, Mindanao, Philippines.)

water temp. 25° C, CL 2598, 14.ix.1991; Sumba, Patawang R. at Patawang, 55 km E of Waingapu, El. 10m, water temp. 30° C, CL 2603, 15.ix.1991. Sulawesi Tengah Prov.: pond 1 km SE of Kamarora, Lore Lindu Nat. Pk., El. 660m, CL 2158, 8.x.1985. Sulawesi Utara Prov.: Lake Mala (Moat), E of Kotamobagu, 0° 44' N, 124° 27' E, El. 1000m, CL 2113, 10.ix.1985; ponds at Project Wallace base camp, Toraut, CL 2119, 12.ix.1985. Sumatra, Bengkulu Prov.: Sungai Bantiring, 7 km E of Bengkulu, El. 50m, water temp. 32° C, CL 2580, 6.ix.1991; Sungai Air Gedang, 23 km E of Bengkulu on Curup Rd., El. 100m, water temp. 31.5° C, CL 2581, 6.ix.1991. EAST MALAYSIA: Sarawak, lake at Bau, CL 2054, 10.viii.1985. WEST MALAYSIA: Pahang: pond SW of Kuantan, CL 2085, 22.viii.1985; river 65 km NE of Segamat, CL 2086, 22.viii.1985. Selangor: pond in Templar Park, N of Kuala Lumpur, CL 2069, 17.viii.1985; pond along old Gombak rd., 23 km E of Kuala Lumpur, CL 2071, 16.viii.1985. PAPUA NEW GUINEA: West New Britain: 2 males, 2 females, Dami Cr., saline freshwater, 8.i.1989, I. Lansbury. PHILIPPINES: Leyte, Leyte Prov.: Allovera R., S of Ormoc, CL 1986, 17.vii.1985. Luzon: 1 macropterous male, 2 females, Laguna, Magcarlan, coll. V. Gapud, 16.xii.1977; Lubang Islands, rice paddy, coll. W. K. Reisen, 14.i.1971. Mindanao: South Catabato Prov.: Lake Sebu, El. 400m, CL 1991, 19.vii.1985. Negros Oriental: 2 females, San Jose, lake, Balinsasavao, El. 133m, coll. C. S. Sanchez, 2.iv.1981. Palawan; Langoban R., Langoban, 84 km NW of Puert Princesa, CL 2015, 28.vii.1985. SINGAPORE: 7 males, 7 females, all macropterous, mangrove stream, Mandai, coll. L. Cheng, 5.viii.1976. SRI LANKA: many specimens from most provinces, P. B. Karunaratne (USNM), K. L. A. Perera (JTPC). THAILAND: Chiang Mai Prov.; trib. to Nam Chai R., above Fang Hort. Sta., El. 500m, CL 2202, 15.ix.1985. VIET NAM: 1 mi. N of Quang Tri, coll. A. R. Gillogly, 15.vi.1970.

Localities from the literature.- CHINA: Canton (Hoffmann, 1941). MYANMAR (BURMA): lower, Mudon, Amherst Distr. (Distant, 1910); upper, Inle Lake (Paiva, 1918). TAIWAN: northern, Taihoku; central, Jitsugetsutan Lake (Esaki, 1925). INDIA: Kerala (Andersen, in litt.); Andhra Pradesh, Guntur (Rupavathi, 1985); West Bengal, Calcutta (Distant, 1910). INDONESIA: Jawa Barat Prov., nr. Buitenzorg (Bogor) (Lundblad, 1933); Sumatra, east coast, Lake Perlanaan (Hungerford, 1933). PALAU: Babelthaob (Esaki, 1937).

Only selected localities within the range of this common and widespread species have been given, with emphasis on new records and those delimiting the known distribution.

Distribution.- Southern and Southeast Asia, Malay Archipelago, Micronesia.

Diagnosis.- See notes under *R. anomalus*, new species.

Description.- Length, apterous male, 3.47 mm; apterous female, 4.31 mm. Ground color black, heavily marked with pruinose silvery gray; prosternum except medially, short longitudinal stripe along inner eye margin joined with occiput, broad median area on pronotum, orange brown. Antennae black, segments brownish distally. Coxae, trochanters of all legs, all femora basally, mesosternum basally anterad of coxae, yellowish brown to leucine.

Structural characteristics: Antennal formula I-IV, male: 0.42; 0.28; 0.39; 0.39, female: 0.45; 0.28; 0.39; 0.39. Antennae clothed with very short recumbent setae; segment IV slightly curved, convex side set with a brush of short semi-erect setae plus a few slightly longer setae.

Head long (0.45), interocular space broad (0.50), eye width 0.22. Entire body including head clothed with very short dense appressed pubescence. Pronotum length 0.17, width 0.73, posterior margin concave, medially almost straight. Mesonotum long (0.90), wide (0.78); ante-

rior and posterior margins convex; lateral margins slightly convex, sutured off from pleura. Metanotum and abdominal tergite 1 fused, division indicated laterally by deep depressions, combined length 0.22, posterior margin sinuate. Abdominal tergites narrowing posteriorly, tergites 3-5 subequal (0.14), 2 and 6 longer (0.17), 7 long (0.22), 8 longest (male 0.45, female 0.78), 9 short (0.22). Male abdominal sternite 7 depressed, broadly excavate, forming a sulcus extending anteriorly onto posterior half of sternite 6, becoming shallower anterad and forming only a very slight median depression on sternites 5 and anterior part of 6, continuing on 2-4 as a dark median stripe free of pruinosity; lateral margins of depression on sternite 7 set with a few scattered medially directed stiff setae, not forming tufts. Male genital segments long, somewhat modified; sternite 8 broadly, deeply excavate basally, depression deeper and hair-free medially forming a sulcus narrowing caudally and terminating before apex. Connexiva broad, somewhat raised. Fore femur regularly set with two parallel rows of ventrally directed setae, each row with 8 or 9 long erect setae, plus a number of shorter setae. Middle and hind femora each set with scattered long ventrally directed setae, plus a ventral row of medium length setae, less numerous distally. Claws long, slender, similar. Measurements of legs as follows: Femur, tibia, tarsal-1, tarsal-2 of male fore-leg, 1.23, 0.45, 0.06, 0.22; middle-leg, 3.47, 2.63, 1.06, 0.50; hind-leg, 2.63, 1.29, 0.28, 0.22: female fore-leg, 1.29, 0.45, 0.06, 0.22; middle-leg, 3.81, 3.02, 1.29, 0.67; hind-leg, 2.97, 1.40, 0.28, 0.28.

Habitat.- Specimens of this insect were collected from ponds and the slower reaches of moderate sized rivers throughout its range. Specimens from Singapore were collected on a tidal mangrove stream (Cheng), and those from New Britain on "saline freshwater" (Lansbury). It thus appears that this species has a tolerance for brackish water.

Esaki (1930) remarked on the rarity of macropterous specimens, yet Fernando (1964) found that the species is a frequent colonizer of isolated and ephemeral pools in Malaysia.

Remarks.- According to Horn and Kahle (1935-37) Kraepelin's collections from Java are in the Hamburg Museum, however one of us (JTP) studied this collection in 1984 and did not see any type material of *kraepelini*. In the same work (loc. cit.) Breddin's collection is said to be in the Deutsches Entomologisches Institut, Berlin, a collection which we have not studied. Lundblad (1933) studied the type, but did not say where it is located. There does not seem to be any doubt about the identity of this species, and we have specimens from Java that match the original description.

Excellent habitus figures of this species have been provided by Esaki (1925), Hungerford and Matsuda (1960) and Andersen (1982). Structural details have been illustrated and discussed by Lundblad (1933), Matsuda (1960) and Andersen (1982). The macropterous form was illustrated by Esaki (1930). Hoffmann (1936) published the life history, and in his catalog (Hoffmann, 1941) summarized the literature and distribution. Surface wave communication has been reported for *R. kraepelini* (J. Polhemus, 1990; Murphy, 1990); see Biology section.

Rhagadotarsus anomalus, new species
(Figs. 2, 8)

Material examined.- Holotype - apterous male, AUSTRALIA, Queensland, Jourama Falls National Park, CL 1716, coll. J. T. & D. A. Polhemus (ANIC), 13-viii-1983.

Allotype - apterous female, AUSTRALIA, Queensland, Jourama Falls National Park, CL 1716, coll. J. T. & D. A. Polhemus (ANIC), 13-viii-1983.

Paratypes.- (All collected by J. T. & D. A. Polhemus unless otherwise noted; all apterous unless noted). AUSTRALIA: Queensland: 7 males, 17 females, same data as holotype; 9 males, 3 females, Mulgrave River, 10 km W. of Gordonvale, CL 1725, 15.viii.1983; 8 males, 3 females, Upper Mulgrave River at Goldsborough Rd. bridge, CL 1726, 15.viii.1983; 3 males, 3 females, Annan River estuary, 10 km W. of Cooktown, CL 1737, 19.viii.1983; 5 females, Isabella Creek, 20 km W. of Cooktown, CL 1740, 20.viii.1983; 3 males, 3 females, Hann River at Peninsula Development Rd., CL 1745, 21.viii.1983; 3 males, 3 females, 5 nymphs, Claudie River, Iron Range, CL 1752, 24.viii.1983; 4 males, 5 females, 7 nymphs, Gordon Cr., Iron Range, CL 1755, 24.viii.1983; 3 males, 2 females, 1 nymph, Jardine River at Peninsula Development Rd., CL 1761, 27.viii.1983; 1 female, lake nr. Somerset, Cape York, CL 1764, 28.viii.1983 (JTPC). Northern Territory: 2 males, 1 macropterous male, 1 female, 1 macropterous female, 1 n, stream, Robin Falls, CL 910, coll. J. T. Polhemus, 12.xii.1977; 2 males, stream, Nr. Darwin, Coomalie Creek, CL 913, coll. J. T. Polhemus, 11.xii.1977; 1 macropterous male, 3 macropterous females, Daly River, CL 906, coll. , J. T. Polhemus, 11.xii.1977; 1 male, 2 females, stream nr. Daly River, CL 907, coll. J. T. Polhemus (JTPC), 11.xii.1977; 4 males, 2 females, Berry Springs, 50 km. SE kof Darwin, coll. J. L. & M. Gressitt (BPBM), 12.iii.1961. PAPUA NEW GUINEA: Western Province: 1 male, 2 females, Nr. Balimo, Aramia River, CL 1773, 2.ix.1983; 12 males, 20 females, Bossett's Lagoon, coll. K. G. Hortle (JTPC), 27.vi.1985.

Distribution.- Australia (Northern Territory, Queensland), Papua New Guinea.

Diagnosis.- *Rhagadotarsus anomalus* new species most closely resembles *Rhagadotarsus kraepelini* Breddin. The males may be easily separated by the differences in the male abdominal venter. The females are very similar in most characters but those of *anomalus* are characterized by the longer first antennal segment and differently shaped pruinose markings on the base of the head.

Description.- Length, apterous male, 3.92 mm; apterous female, 4.93 mm. Ground color black, heavily marked with pruinose silvery gray; ventrolateral part of head, most of anterior acetabulae, short longitudinal stripe along inner eye margin, occiput, median spot on pronotum, orange brown. Antennae black, segments brownish distally. Coxae, trochanters of all legs, mesosternum basally anterad of coxae, yellowish brown to leucine.

Structural characteristics: Antennal formula I-IV: 0.68; 0.28; 0.34; 0.39 in both male and female. Antennae clothed with very short recumbent setae; segment IV slightly curved, convex side set with a brush of short semi-erect setae plus a few slightly longer setae.

Head long (0.45), interocular space broad (0.50), eye width 0.22. Entire body including head clothed with very short dense appressed pubescence. Pronotum length 0.17, width 0.78, posterior margin concave. Mesonotum long (0.95), wide (0.84); anterior and posterior margins convex; lateral margins straight, sutured off from pleura. Metanotum and abdominal tergite 1 fused, division indicated laterally by deep depressions, combined length 0.28, posterior mar-

gin sinuate. Abdominal tergites narrowing posteriorly, tergites 3-5 subequal (0.11), 2 and 6 longer (0.14), 7 long (0.34), 8 longest (male 0.67, female 1.26), 9 short (0.17). Male abdominal sternite 7 depressed, excavate, forming a sulcus extending anteriorly onto sternite 6, becoming shallower anterad and forming only a slight median depression on sternites 4 and 5; each margin of sulcus at basal 1/3 of sternite 7 set with a sharp tuft of stiff medially directed light colored setae. Male genital segments long, somewhat modified; sternite 8 broadly, deeply excavate basally, depression narrowing caudally forming a sulcus terminating before apex. Connexiva broad, somewhat raised. Fore femur regularly set with two parallel rows of ventrally directed setae, each row with 8 or 9 long erect setae, plus a number of shorter setae. Middle and hind femora each set with a ventral row of medium length setae, less numerous distally. Claws long, slender, similar. Measurements of legs as follows: Femur, tibia, tarsal-1, tarsal-2 of male fore-leg, 1.23, 0.50, 0.06, 0.28; middle-leg, 3.53, 2.69, 1.46, 0.56; hind-leg, 2.91, 1.34, 0.28, 0.28: female fore-leg, 1.34, 0.62, 0.06, 0.28; middle-leg, 4.09, 3.14, 1.74, 0.62; hind-leg, 2.86, 1.46, 0.34, 0.28.

Etymology.- The name *anomalus* derives from *anomalos* (Gr.), different, referring to the nature of the male abdominal venter.

Habitat.- Specimens of this insect were collected from ponds and the slower reaches of moderate sized rivers throughout its range.

Remarks.- This species was extensively studied by Wilcox (1972) in Australia where he observed individuals communicating by surface waves; later Wilcox (1979) identified it in error as *R. kraepelini*. Calabrese (1980) reported the genus *Rhagadotarsus* from Irian Jaya (New Guinea) and northwestern Australia; each record may refer to any of three species, *R. anomalus*, *R. borneensis* or *R. kraepelini*.

Rhagadotarsus taprobanicus, new species
(Figs. 4, 9)

Material examined.- Holotype - apterous male, SRI LANKA, North Central Prov., Polonnaruwa District, Hingurakgoda, coll. K. L. A. Perera (USNM), 10.ii.1964.

Allotype - apterous female, SRI LANKA, North Central Prov., Polonnaruwa District, Hingurakgoda, coll. K. L. A. Perera (USNM), 10.ii.1964.

Paratypes (All apterous unless noted).- SRI LANKA: North Central Prov.: 1 male, 3 females, same data as holotype (JTPC); 1male, 1female, Kalawewa, coll. G. M. Henry (USNM), 23.i.1937; Northern Prov.: 1 macropterous female, Kokmotte Bungalow, 0.5 mi. NE Wilpattu N. P., coll. K. V. Krombein, P. B. Karunaratne, S. Karunaratne, D. W. Balasuriya (USNM), coll. K. L. A. Perera (USNM), 10.ii.1964; 6 males, 6 females, 1 nymph, between Kumbulamunai and Tahannimuruppu, P. B. Karunaratne (USNM, JTPC), 14.iv.1966; 3 males, 2 females, 1 macropterous female, Mulative, 28th mile Puliankulam - Nedunkerni Rd., from slow flowing stream, P. B. Karunaratne (USNM, JTPC), 12.v.1965; 1 male, Vauniya, coll. K. L. A. Perera (JTPC), 10.iv.1964.

Distribution.- Sri Lanka; see map, Fig. 9.

Diagnosis.- *Rhagadotarsus taprobanicus* new species most closely resembles *Rhagadotarsus borneensis* n. sp., but differs as shown in the key. The males may be easily separated by the differences in the male abdominal venter, and males of *taprobanicus* lack the long setae beneath the fore femur. The females are very similar in most characters but those of *taprobanicus* are characterized by the smaller size and proportionately smaller eyes.

Description.- Length, apterous male, 2.97 mm; apterous female, 3.25 mm. Ground color black, heavily marked with pruinose silvery gray; large wedge-shaped spot along inner eye margin, occiput, entire median part of pronotum, orange brown. Antennae blackish brown, segment I lighter basally, distal two segments brownish. Coxae, trochanters of all legs, basal 1/2 (male) to 2/3 (female) of fore femur, mid and hind femora basally, broad areas on acetabulae, most of prosternum, yellowish brown to leucine.

Structural characteristics.- Antennal formula I-IV: 0.34; 0.22; 0.28; 0.34 in both male and female. Antennae clothed with very short recumbent setae; segment III set with several moderate length setae on basal half, plus two long setae distally; segment IV slightly curved, convex side set with a brush of short semi-erect setae plus 5-6 longer setae.

Head long (0.34), interocular space broad (0.39), eye width 0.20. Entire body including head clothed with very short dense appressed pubescence. Pronotum length 0.11, width 0.67, posterior margin concave. Mesonotum long (0.78), wide (0.62); anterior and posterior margins convex, the latter less so; lateral margins slightly convex, sutured off from pleura. Metanotum and abdominal tergite 1 fused, division indicated laterally by deep depressions, combined length 0.28, posterior margin sinuate. Abdominal tergites slightly narrowing posteriorly, tergites 3-4 subequal (0.08), 2, 5 and 6 longer (0.11), 7 long (0.17), 8 longest (male 0.42, female 0.73), 9 short (0.17). Male abdominal sternite 7 depressed, excavate, forming a sulcus extending anteriorly onto middle of sternite 5, becoming shallower anterad and forming only a median depression on sternite 5. Male genital segments long, somewhat modified; sternite 8 broadly, deeply excavate basally, depression shallower and narrower caudally but not forming a sulcus. Connexiva broad, slightly raised. Fore femur of male set with short stiff setae beneath plus a few longer ventrally directed setae; fore femur of female regularly set with two parallel rows of ventrally directed setae, each row with 5 or 6 long erect setae, plus a number of shorter setae. Middle femora each set with a ventral row of short setae, less numerous distally. Claws long, slender, similar. Measurements of legs as follows: Femur, tibia, tarsal-1, tarsal-2 of male fore-leg, 0.90, 0.45, 0.06, 0.17; middle-leg, 2.07, 1.79, 0.67, 0.34; hind-leg, 1.57, 0.90, 0.22, 0.17: female fore-leg, 0.84, 0.42, 0.06, 0.17; middle-leg, 2.13, 1.96, 0.70, 0.39; hind-leg, 1.57, 1.01, 0.22, 0.17.

Etymology.- The name *taprobanicus* refers to the country of origin, and is derived from Taprobane, the old Latin name for Sri Lanka.

Habitat.- Specimens of this insect were collected from the slower reaches of moderate sized rivers and irrigation channels in the North and North Central Provinces in the low country dry zone. In rivers where it occurs with *R. kraepelini*, the latter is found along the margins whereas *R. taprobanicus* is found in midstream, often in association with *Ventidius* and *Naboandelus* species.

Rhagadotarsus borneensis, new species
(Figs. 3, 7, 8)

Material examined.- Holotype - apterous male, INDONESIA; Kalimantan Timur Prov., waterfall and stream, 11 km NE of Samarinda, CL 2091, coll. J. T. & D. A. Polhemus (USNM), 27.viii.1985.

Allotype - apterous female, INDONESIA; Kalimantan Timur Prov., waterfall and stream, 11 km NE of Samarinda, CL 2091, coll. J. T. & D. A. Polhemus (USNM), 27.viii.1985.

Paratypes.- (All collected by J. T. & D. A. Polhemus; all apterous unless noted): INDONESIA; Kalimantan Timur Prov.: 7 males, 2 females, same data as holotype (JTPC). Irian Jaya Prov.: 12 males, 6 females, swamp forest pond, S of Walio oil field, nr. Kasim, El. 10 m, water temp. 30° C, CL 2620, 29.ix.1991; 2 males, 2 females, 7 nymphs, Salawati Island, Wagom Mountains, Wajar River, W of Sorong, El. 0-30 m, water temp. 28° C, CL 2623, 30.ix.1991; 2 males, Klagalo River at old Klagagi oil field, SE of Sorong, El. 50 m, CL 2627, 1.x.1991; 11 males, 7 females, 3 nymphs, Airtiba River, 3 km NW of Krooy, nr Kaimana, El. 17 m, CL 2640, 13.x.1991; 1 female, Nabire River, 5 km E of Nabire, El. 65 m, water temp. 27° C, CL 2642, 14.x.1991 (JTPC).

Other material.- 1 macropterous female, INDONESIA; Sumatera Utara Prov.: temporary roadside pool, 14 km. NE of Prapat, El. 1000m, CL 2196, coll. J. T. & D. A. Polhemus (JTPC), 12.ix.1985 (provisionally placed here, but not placed on map; see discussion).

Distribution.- Indonesia: Irian Jaya, Kalimantan Timur.

Diagnosis.- *Rhagadotarsus borneensis* new species most closely resembles *Rhagadotarsus taprobanicus* n. sp., but differs as shown in the key; see also diagnosis under the latter.

Description.- Length, apterous male, 3.25 mm; apterous female, 4.31 mm. Ground color black, heavily marked with pruinose silvery gray; large wedge-shaped spot along inner eye margin continuing onto occiput, entire median part of pronotum, yellow brown to orange brown. Antennae blackish brown, distal two segments brownish. Coxae, trochanters of all legs, basal 2/3 (male) to 4/5 (female) of fore femur, mid and hind femora basally, most of anterior acetabulae, broad area ventrally on middle acetabulae, yellowish brown to leucine.

Structural characteristics: Antennal formula I-IV: 0.39; 0.17; 0.34; 0.39 in both male and female. Antennae clothed with very short recumbent setae; segment III set with several moderate length setae on basal half, plus two long setae distally; segment IV slightly curved, convex side set with a brush of short semi-erect setae plus 3-4 longer setae.

Head long (0.42), interocular space broad (0.39), eye width 0.22. Entire body including head clothed with very short dense appressed pubescence. Pronotum length 0.11, width 0.67, posterior margin concave. Mesonotum long (0.90), wide (0.73); anterior and posterior margins slightly convex; lateral margins slightly convex, tapering somewhat posteriorly, sutured off from pleura. Metanotum and abdominal tergite 1 fused, division indicated laterally by deep depressions, combined length 0.28, posterior margin sinuate. Abdominal tergites slightly narrowing posteriorly, tergites 3-5 subequal (0.09), 2 and 6 longer (0.11), 7 long (0.17), 8 longest (male 0.45, female 0.84), 9 short in male (0.22), longer in female (0.34). Male abdominal sternite 7 depressed, excavate, forming a sulcus extending anteriorly onto middle of sternite 5, becoming shallower anterad and forming only a median depression on sternite 5. Male genital seg-

ments long, somewhat modified; sternite 8 broadly, deeply excavate basally, depression abruptly narrowing caudally, forming a sulcus on caudal 2/3 of segment terminating before apex, median part of basal depression and caudal sulcus hair free, black. Connexiva broad, slightly raised. Fore femur of male and female regularly set with two parallel rows of ventrally directed setae, each row with 5 or 6 long erect setae, plus a number of shorter setae. Middle femora each set with a ventral row of short setae, less numerous distally. Claws long, slender, similar. Measurements of legs as follows: Femur, tibia, tarsal-1, tarsal-2 of male fore-leg, 1.01, 0.45, 0.06, 0.17; middle-leg, 2.46, 2.35, 0.78, 0.34; hind-leg, 2.13, 1.26, 0.17, 0.17: female fore-leg, 1.06, 0.50, 0.06, 0.17; middle-leg, 2.63, 2.52, 0.84, 0.39; hind-leg, 2.24, 1.20, 0.22, 0.22.

Etymology.- The name *borneensis* refers to the origin of the type-series.

Habitat:- In Kalimantan specimens of this insect were collected, along with *R. kraepelini*, from a large pool below a waterfall in hilly country. In Irian Jaya this species was collected from the slow or still parts of streams, whereas in the same area *R. kraepelini* was found only on a pond near the Klagalo River.

Remarks.- The macropterous female from Sumatra keys to *R. borneensis* but has only the base of the fore femur light, thus may represent yet another undescribed species. If additional material shows this to be *R. borneensis*, the fore femur coloration will prove to be unreliable as a key character.

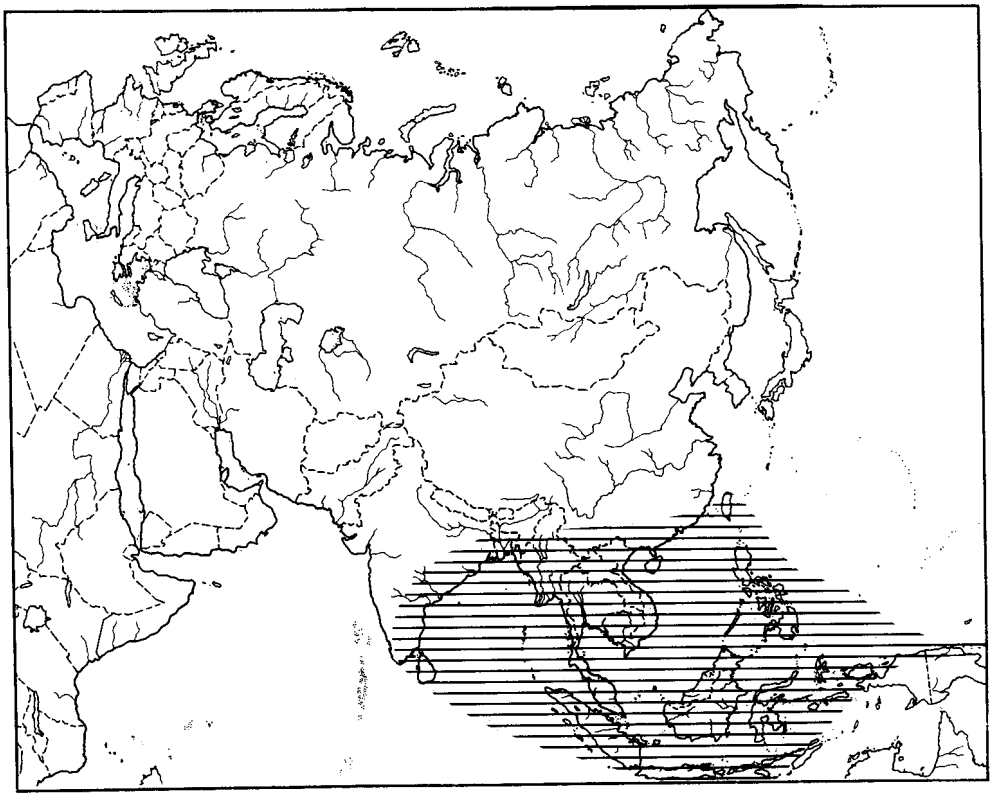


Fig. 6. Distribution of *Rhagadotarsus kraepelini* (in part).

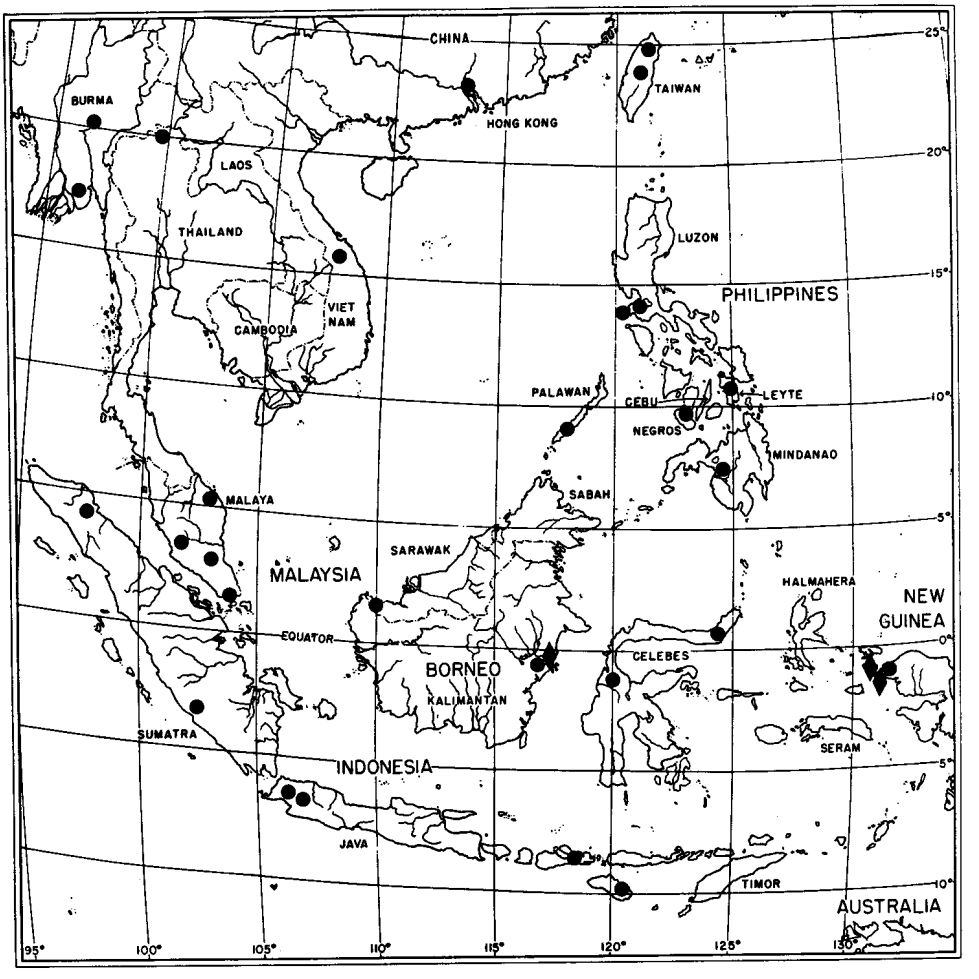


Fig. 7. Distribution of *Rhagadotarsus* spp. *R. borneensis* (in part) (diamonds); *R. kraepelini* (in part) (circles).

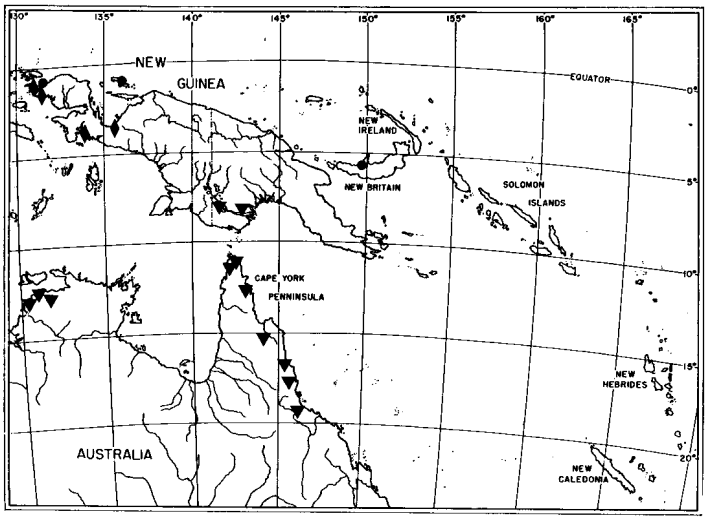


Fig. 8. Distribution of *Rhagadotarsus* spp. *R. anomalus* (triangles); *R. borneensis* (in part) (diamonds); *R. kraepelini* (in part) (circles).

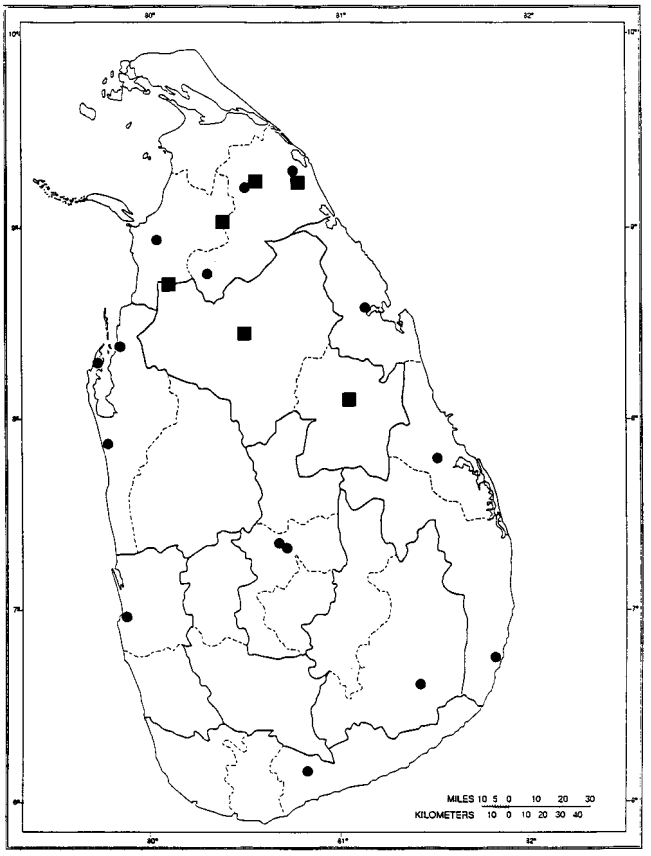


Fig. 9. Distribution of *Rhagadotarsus* spp. on Sri Lanka. *R. kraepelini* (in part) (circles); *R. taprobanicus* (squares).

CLADISTIC ANALYSIS

The subgenus *Rhagadotarsus* was analyzed, with the subgenus *Caprivia* as the outgroup. A set of 8 characters was used in the analysis, as follows, with the plesiomorphic character state given first. Character states were assigned with reference to the gerrid groundplan given by Andersen (1982), although the interpretation given here differs in some regards.

1. Pronotum length: long; short.
2. Abdominal tergites, length: subequal; different lengths.
3. Male abdominal segment 8, length: short, broad; long slender.
4. Male abdominal segment 7, modified with setae tufts: no; yes.
5. Male fore femur bent: no; yes.
6. Male fore femur with long ventral setae: no; yes.
7. Hind femur, length: short; long.
8. Male ventrite 8 with distinct sulcus: no; yes.

The resulting cladogram is shown in Fig. 10. *Rhagadotarsus* (*R.*) *taprobanicus* is the only species for which a unique apomorphy is established by the character set used here. The cladogram suggests that the closest relationship exists between the taxa presently closest geographically.

Character analysis.- The characters states have generally been assigned on the basis of the rules given by Polhemus (1985: 92-93). Elaboration of structure is considered to be the derived state, establishing the state of characters 4, 5, 6 and 8. Other character states were decided as follows:

Character 1. The plesiomorphic pronotum of an apterous gerromorphan is considered to have three equal length segments, thus an extremely short pronotum is considered apomorphic.

Character 2. The plesiomorphic abdomen of a gerromorphan is considered to have equal length tergites, thus an abdomen with variable length tergites is considered apomorphic.

Character 3. The long slender tergite 8 is considered to be apomorphic, as the state in the outgroup *Caprivia* and in gerrids in general is short.

Character 7. The relatively long hind femur is considered apomorphic because of the shorter hind femur in the outgroup, and in gerrids generally.

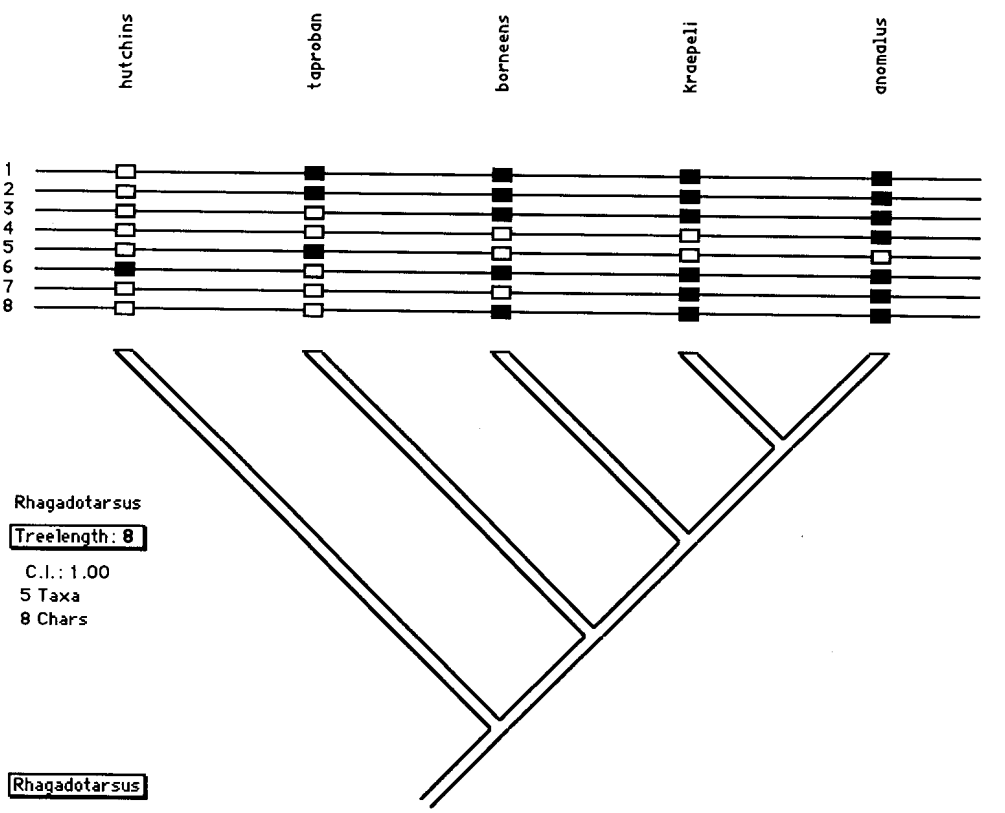


Fig. 10. Cladogram of *Rhagadotarsus* spp. Character and state names: 1-Pronotum length: long; short. 2-Abdominal tergites, length: subequal; different lengths. 3-Male abdominal segment 8, length: short, broad; long, slender. 4-Male ventrite 7 modified, with tufts of setae: no; yes. 5-Male fore femur bent: no; yes. 6-Male fore femur with long ventral setae: no; yes. 7-Hind femur, length: short; long. 8-Male ventrite 8 with distinct sulcus: no; yes. Data: *hutchinsoni* 00000100; *taprobanicus* 11001000; *borneensis* 11100101; *kraepelini* 11100111; *anomalus* 11110111.

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