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The Systematic Status of the Diplopod Genus *Rajasphaera* ATTEMS, 1935

(Sphaerotheriida)

By RICHARD L. HOFFMAN[1])

In connection with a study now being conducted on the giant pill-millipeds referred to the genera *Castanotherium* and *Pulusphaera,* I found it necessary to look into the entire known Borneo fauna of sphaerotheriids, and so became interested in the status of *Rajasphaera montana* ATTEMS. In April of 1975 I had the opportunity to study firsthand the unique type specimen of this remarkable species in the Zoologisches Museum, Hamburg, and now wish to record the substance of my opinion about its position in the classification of the order Sphaerotheriida.[2])

The genera of this order were for many years in a state of taxonomic confusion, and only very recently has a rational classification which reconciles group characters with biogeographic patterns been proposed (JEEKEL, 1974). I believe that the definition of two families Sphaerotheriidae and Sphaeropoeidae on the basis of cyphopod structure, as suggested by Dr. JEEKEL, reflects a fundamental phylogenetic dichotomy, all the more so as the resultant groups are anatomically homogeneous and logically dispersed. It is noteworthy that, contrary to the usual condition in Diplopoda, female characters proved to be more useful in separating families than those of the male. With only a few exceptions the structure of the telopods is generally similar throughout the order. In fact, the basic pattern both within and between the two families is so pervasive that, in my view, any departures from it merit particular consideration.

JEEKEL recognized two subfamilies within the Sphaeropoeidae, one (Sphaeropoeinae) characterized by the presence of two segments distal to the femur of the telopods. This group contained eight nominal generic names, some of them with several established synonyms, largely confined to the mainland of southeast Asia. The second subfamily, Castanotheriinae, embraced six nominal genera in which the two distal segments of the telopod are completely coalesced into a single article. These taxa occur exclusively in the Greater Sunda Islands and the Philippines.[3])

At the time (1935) of describing *Rajasphaera,* ATTEMS did not distinguish subfamilies or tribes within his broad concept of the Sphaero-

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[1]) Address of the author: Prof Dr. RICHARD L. HOFFMAN, Radford College, Radford, Virginia, 24142, USA.

[2]) The cooperation and assistance of Dr. G. RACK in making the specimen available for study are herewith acknowledged with appreciation.

[3]) Actually the known areas for JEEKEL's two subfamilies do not overlap, as the Borneo genus *Bothrobelum,* placed by him in the Sphaeropoeinae, is known only from a female and thus cannot be placed in either subfamily on the basis oft the required male characters. With this exception, all of the Sphaeropoeinae, sensu JEEKEL, occur on the Asiatic mainland and the western Sunda islands.

theriidae, and merely included the new genus, amongst others, in a key for "... indoaustralischen Gattungen mit vielen Sinneskegln auf den Antennen." Here *Rajasphaera* was brought out in the fourth couplet on the basis of details of structure of the telopod syncoxa and the unusual form of tergal pubescence. In a later key to all of the genera of Sphaerotheriidae, ATTEMS (1943) repeated these two distinctions and added another: the form of the basal articles of the telopods. In view of the several major anatomical peculiarities of this genus, it is strange that ATTEMS did not propose some kind of supra-generic taxon for it. K. W. VERHOEFF lost no time in doing so, but his subfamily name Rajasphaerinae was published without diagnosis and is invalidly proposed (VERHOEFF, 1937).

Following some limited experience with species in the genera *Sphaerotherium, Arthrosphaera, Sphaeropoeus,* and *Castanotherium,* I was forcibly struck by the characters of *Rajasphaera montana* upon examining the unique male holotype. Although the cyphopod structure of this species is not known, the mere fact of its occurrence in central Borneo justifies the assumption that it is a sphaeropoeid, and on the basis of the telopod structure JEEKEL referred *Rajasphaera* to the subfamily Castanotheriinae.

Admitting the importance of the main castanotheriine diagnostic character, it nonetheless does not reflect the drastic overall difference in general structure of these appendages that occurs between *Rajasphaera* and all other genera of the Sphaeropoeidae. A comparison of Figures 4 and 6, herein, will bring out the hypertrophy of the prefemur, and diminuation of the tibiotarsus, in *Rajasphaera montana.* Much the same order of difference is evident in the paratelopods also (cf. Figures 5 and 8), those of *Rajasphaera* showing much reduced femoral process and tibiotarsal element.

Finally, and I take this position mainly to put on record another possible way of interpreting the evidence, one might question the practicality of separating subfamilies on the basis of a single character which is perhaps subject to random duplication through independent reductive tendencies, namely the fusion of tibia and tarsus of the telopods into a single segment.

My own preference in character-weighting would result in a system of the sphaeropoeids somewhat different from that advanced by JEEKEL, particularly in assigning much greater importance to the distinctive characters of *Rajasphaera.* Such a classification might be represented in the following way:

Family Sphaeropoeidae BROLEMANN, 1913

Subfamily 1. Sphaeropoeinae BROLEMANN, 1913.

Prefemur of telopods of normal size and shape for the order, femur produced distomedially into an elongate flattened-spatulate process. Syncoxa of telopods with the usual triangular plate. Anterior margin of

terga without dense belt of pubescence, hairs if present sparsely dispersed over tergal surface or confined to a median transverse belt of setae.

Tribe 1. Sphaeropoeini Brolemann, stat. nov. Nomen translatum herein, ex family Sphaeropoeidae Brolemann, 1913. Paratelopod with distinct femoral process; telopod with two segments beyond the femur; coxae of second pair of legs of females separate.

Genus *Sphaeropoeus* Brandt, 1833 (syn. *Lissosphaera* Attems, 1944; *Pantitherium* Attems, 1932). Sumatra, about a dozen species of uncertain taxonomic status, some described under other generic names.

Genus *Leptoprotopus* Silvestri, 1897. Regarded as a synonym of the preceeding genus by Jeekel, but in my view the modified sexual characters of the male of the type species set it off sharply from all other known sphaeropoeids. *L. gladiator* (Pocock) is known only from Sumatra.

Genus *Tonkinobelum* Verhoeff, 1924. Also considered a synonym of *Sphaeropoeus* by Jeekel, but until authentic material of *T. maculatum* can be studied, or the presence of genuine species of *Sphaeropoeus* verified in Indochina, I prefer to keep these two names separate.

Genus *Kophosphaera* Attems, 1936. Four species, eastern Himalayan region (Assam, Nepal, Darjeeling). Very close to the next genus and very possibly a synonym of it.

Genus *Sphaerobelum* Verhoeff, 1924. Four species, Indochina.

Tribe 2. Prionobelini, trib. nov. Paratelopod with femoral process very small, not attaining distal edge of the segment, or represented by a small ridge only; tibia and tarsus of telopod separate; coxae of second pair of legs of female separate.

Genus *Prionobelum* Verhoeff, 1924. Two species, Indochina.

Genus *Chinosphaera* Attems, 1935. One species, southeastern China; one species, Indochina.

Tribe 3. Indosphaerini, trib. nov. Paratelopods and telopods with normal distal processes, tibia and tarsus separate in both; coxae of second pair of legs of females completely coalesced without trace of suture.

Genus *Indosphaera* Attems, 1936. Two species, Assam, Burma.

Tribe 4. Castanotheriini Jeekel, stat. nov. Nomen translatum herein, ex subfamily Castanotheriinae Jeekel, 1974. Paratelopods with one segment beyond the femur, femoral process posterior in position; telopods

with one postfemoral segment, the femoral process large and distally spatulate. Coxae of second pair of legs of females separate (a synopsis of this group is in preparation).

Genus *Castanotherium* Pocock, 1895 (syn. *Borneopoeus* Verhoeff, 1924; *Pulusphaera* Attems, 1935, syn. nov.!). About 20 species, Borneo and the Philippine Islands. The several records for Java and elsewhere (under the name *Pulusphaera*) are doubtless based on mislabeled material. A new genus is to be proposed to accomodate many of the species from Celebes originally described in *Castanotherium*.

Genus *Castanotheroides* Chamberlin, 1920. One species, Palawan Island.

Genus *Luzonosphaera* Wang, 1951. One species, Luzon.

Subfamily 2. Rajasphaerinae, subf. nov.

Prefemur of telopods enormously enlarged, femur relatively much smaller, extending medially behind syncoxal lobes, not projecting distad as elongated spatulate processes; tibiotarsus remarkably small. Femoral process of paratelopods small. Anterior surface of terga with a transverse belt of fine dense short pubescence, projecting caudally in serrated triangular lobes, the terga otherwise smooth and polished.

Genus *Rajasphaera* Attems, 1935. One species, Borneo.

Genera of uncertain taxonomic position or status:

Genus *Bothrobelum* Verhoeff, 1924. This genus remains known only from the female of the type species, and although presumably is referable to the Castanotheriini, it will remain uncertain until topotypic males can be studied.

Genus *Zephronia* Gray, 1832. Based upon a species *ovalis*, possibly the application of the Linnean name *Julus ovalis* to an actual specimen at hand, or, alternatively, the coincidental usage of the same name for a new species. In any case the type specimen of *Zephronia ovalis* Gray cannot at present be found in the British Museum although it was once in the dry collection and presumably had been studied by Pocock. The characters of the paratelopods remain unknown, and so *Zephronia* must be a mystery until some kind of arbitrary action is taken to stabilize the name. Regrettably no precise locality was known for *Z. ovalis*. The status of many Asiatic species now going under the name *Zephronia* must for the present remain uncertain.

This situation is particularly awkward inasmuch as *Zephronia* is the oldest name in the order Sphaerotheriida, and as Jeekel as already noted, it could very easily prove to be a senior synonym of *Sphaeropoeus* or some related younger genus.

The following remarks summarize the extent of our present knowledge of *Rajasphaera montana*. Attems gave a fairly good description and drawings, but overlooked a number of important characters, so that a redescription seems to be in order. Regrettably the telopods and paratelopods are no longer present with the specimen. Presumably they were removed by Attems, as was his custom, and I felt certain they might be discovered in the myriapod collection at the Naturhistorisches Museum in Wien. Through the kind offices of Dr. G. Pretzmann, I was given free access to the alcoholic and preparation material, but extended search proved to be entirely futile. Unless there remains some additional containers in a forgotten depository in the Wiener Museum, I fear that further knowledge of the genitalic structures of this species must await the collection of fresh material in Borneo.

Rajasphaera

Rajasphaera Attems, 1935, Arch. Hydrobiol., Suppl. 14: 126. Monobasic with a new species. Type: *R. montana* Attems, by original designation.

Diagnosis: With the characters of the subfamily as stated above.

Rajasphaera montana Attems (Figures 1—5, 9)

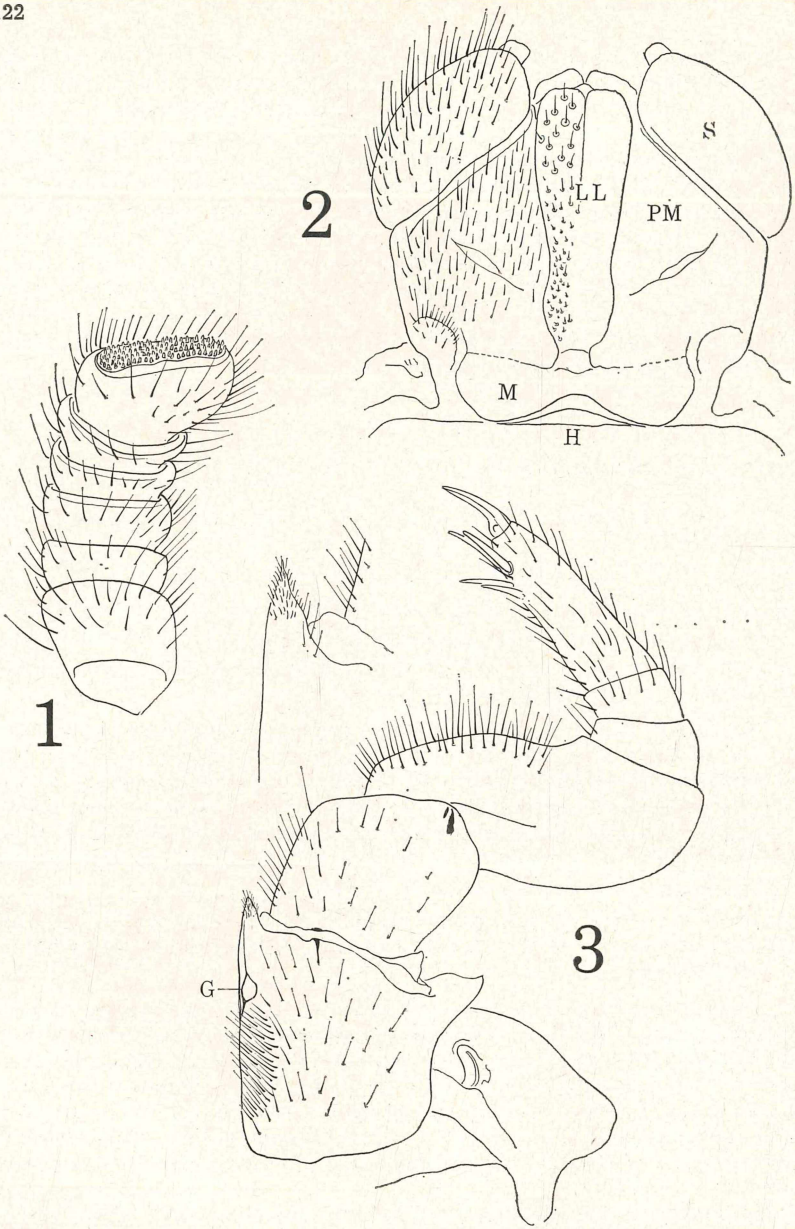
Rajasphaera montana Attems, 1935, Arch. Hydrobiol. Suppl. 14: 132, figs. 18—22.

Type material: Male holotype (Zool. Mus. Hamburg) from Bukit Raja, ca. 1400 m. (0.21 S, 112.41 E), Kalimantan Barat, Borneo; December 1924, Prof. H. Winkler, leg.

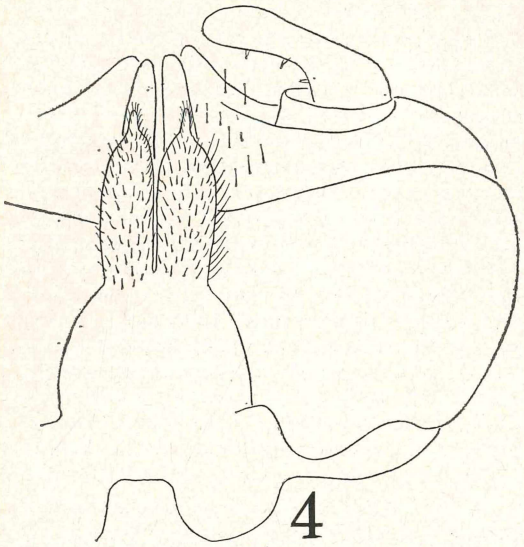
Description: A large smooth polished sphaeropoeid; exposed surfaces of terga and labral margin black, front of head, pleura, and legs light brown; concealed surfaces of terga maroon-red, oblique setose depressions at lateral ends of terga yellow; pygidium deep chestnut brown to the eye, but appearing bright orange with magnification and strong light; antennae greenish-black; distal podomere shading into olive brown.

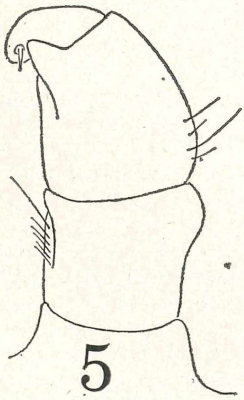
Length of preserved specimen about 50 mm (varies with degree of unrolling); maximum width of 2nd segment, 24.4 mm, of widest midbody segment, 25.3, height of segment at midbody, 16.1 mm; width of pygidium at base, 20.5 mm.

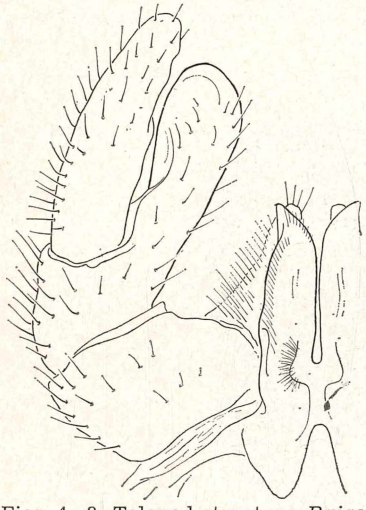
Front surface of head smooth and polished, largely impunctate; clypeus coarsely punctate-rugulose, with sparse yellow setae; a shallow depression each side near antennal socket; labrum narrow, smooth, slightly elevated, with one small median tooth. Ocellaria nearly circular, each with about 80 round ocelli, those adjacent to antennal socket distinctly larger. Antennae (Fig. 1) very short, only the 6th article extending laterad beyond outer edge of ocellaria; articles smooth, impunctate, sparsely set with long setae, dark green except for distal edge which is light green; 6th article expanded to one side but not prominently wider than others, apical sensory field sharply set off from remainder of surface, with about 130 sensory cones placed in an elongated field, narrowed at its midlength; surface of the sensory field reddish, that surrounding it light green. —

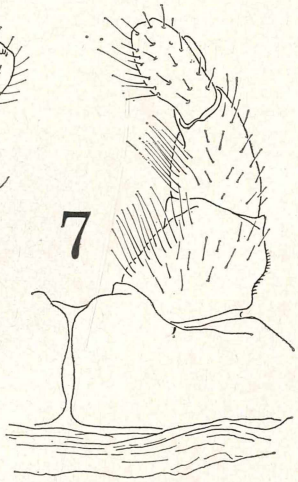


Figs. 1—3: Structural details, *Rajasphaera montana*. — Fig. 1: Antenna. — Fig. 2: Gnathochilarium, setae shown only on left side. Abbreviations: H, hypostoma (gula); LL, lamellae linguales; M, mentum; PM, "paramentum"; S, stipes. — Fig. 3: Second leg, posterior aspect, inset drawing shows apical coxal process enlarged. Abbreviation: G: gonopore.









Figs. 4—8: Telopod structure, *Rajasphaera* and *Castanotherium*. — Fig. 4: Telopods, anterior aspect, of *R. montana*. — Fig. 5: Paratelopod, posterior aspect (Figs. 4 and 5 after Attems, 1935). — Fig. 6: Right telopod, anterior aspect, of *Castanotherium hosei* Pocock, from holotype, to show the normal appearance of this appendage for most sphaeropoeids. — Fig. 7: Left paratelopod, anterior aspect, *C. hosei*, from holotype. — Fig. 8: Left paratelopod, posterior aspect, *C. hosei*, for comparison with Fig. 5.

Gnathochilarium (Fig. 2) with an elongated slender median sclerite, partially divided apically with a median groove and suture, basally subtended by a white median depression; near proximal end this sclerite with numerous tiny round setiferous spots, which become increasingly larger and fewer distally. On each side a large trapezoidal plate with a rounded basal lobe and an oblique depression near the middle; laterally this plate merges into thick connective tissue connecting with base of mandible; distally a broad colorless oblique suture sets off an elongate-oval sclerite set with numerous long setae and a single distal sensory knob. — Collum flat, smooth, and polished, 12.7 mm wide and 3.8 mm long at middle, lateral ends acute and turned forward, anterior edge set off by a fine ridge running parallel to edge, the margin thus formed not notably thicker at midlength. Anterior edge posttended by a single series of minute setiferous punctures; lateral ends with a small field of punctures bearing long slender hairs. — Anterior rim of 2nd segment extremely thin and narrow, continued entirely across dorsum, followed by a shallow transverse groove, set with a few setae behind the ocular region. Anterior margin only very slightly broadened just laterad to ocellaria. Entire surface smooth, polished, and glabrous.

Body terga without special modification, anterior transverse groove small, set off by a minute elevated rim with striated surface, laterally a few microscopic polished granules in a single row. Surface of terga smooth and polished, without trace of punctation. Anterior region of each with a transverse strip of fine, short, dense, fur-like pubescence, extending caudad in a number of subtriangular projections (Fig. 9) about $^1/_4$th

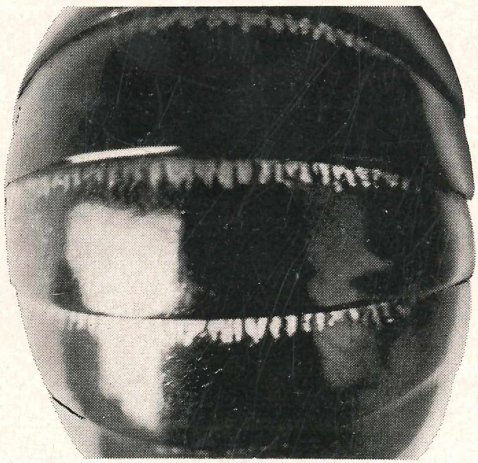


Fig. 9: *Rajasphaera montana,* middorsal aspect of two terga to show form of the transverse pubescent belt on anterior margin, enlarged ca. 5 X.

of the tergal length and contrasting sharply with the smooth and polished surface. — Pygidium densely and finely punctate, the posterior edge not margined or flared, surface with a shallow median depression posteriorly. Black line on inner basal margin long (6.0 mm) and narrow, unbranched. Lower half of inner surface with numerous long silky hairs, upper half with about 6—8 fine transverse striae parallel to lower edge. — 2nd pair of legs (Fig. 3): coxa produced into an apicomedial spine set with about 12 small stout bristles; gonopore small, subcircular, placed almost on the narrow median side of the segment, edged with black pigment; just proximad to gonopore a shallow ovoid depression set with numerous fine short setae; laterally coxa produced into a short acute lobe. Medial ridge on posterior side of femur short, attaining only midlength of segment. Tarsus with two pairs of subapical spurs ventrally, no supraapical spur. — Midbody and posterior legs of normal sphaerotheriid form, the coxae not produced laterad into lobes or spurs, but lateral edge set with one or more rows of acute small tubercules. Ventral tarsal spurs vary from 7 to 10, most usually 8, in a single row near middle of tarsus but becoming paired distally; tarsal claw slender, highly curved, with a small basal ventral denticle, ventral side with a fine median groove. Distal end of tarsus not truncated, supraapical spur placed close to claw. — Telopods missing; ATTEMS' original figures of these appendages are reproduced here as Figs. 4 and 5.

Commentary

Several features in the anatomy of this species require some attention, apart from the singular form of the telopods which has already been noted to the extent possible from ATTEMS' drawings.

In comparison with that observed in *Castanotherium* and *Sphaerotherium,* the gnathochilarium of *Rajasphaera* is remarkable for the prominent definition of a longitudinal median sclerite, more similar to that occurring in the latter genus than in *Castanotherium.* According to ATTEMS' interpretation in 1926, the major sclerite of the gnathochilarium is composed of the fused lingual lamellae and a poorly defined "Zentralkörper". Yet if we recall that in helminthomorph Diplopoda, the lingual lamellae are centrally located, and that each carries a distal palp, it might be reasoned by analogy that the median sclerite in *Rajasphaera* is formed by the partial fusion of the originally separate lamellae. ATTEMS is probably correct in identifying the bilobed transverse basal sclerite as the remnant of the mentum, as there is still a more proximal sclerite subtending it in *Rajasphaera*, which I suppose must be the hypostoma (gula) although this requires verification by muscle studies.

There remains unanswered the question, what is the identity of the large basal lateral sclerite subtending the stipe on each side? It could be assumed either (1) that the original stipe became divided by an oblique suture, or (2) the lingual lamellae, either separate or fused, were prolonged basally to contact the median part of the mentum, thus dividing the

apical part of that element into two lateral parts. This latter view is at this moment plausible to me, and on Figure 2 I indicate the parts in question by the symbol "PM" as abbreviation of the suggested term "paramentum". Naturally this situation must be eventually studied as regards the cranial musculature, assuming that homologies exist with the cranial-gnathochilarial muscles of Helminthomorpha.

In general, the gnathochilarium of *Rajasphaera* is uniformly setose, but the hairs arise mostly from colorless round spots, and those of the distal end of the central sclerite are widely separated. By contrast, in *Castanotherium,* the gnathochilarium is rather densely covered with hairs, and the distal end of the central body most prominently so, being the site of two heavy dense brushes of hairs.

The apical antennal article also differs sharply from that of *Castanotherium* in having the sensory field very sharply set off by an encircling suture, whilst the field itself is prominently reddish in color around the sensory cones with an outer circling band of green. In *Castanotherium* the entire surface of the 6th article is continuous, with the cones appearing to arise from holes. The two genera are clearly not closely related in antennal as well as gnathochilarial characters.

The second legs of the male in *Rajasphaera* are unusual in two respects: one that the coxa is produced into a sharp apicomedian spine, the other that the gonopore is located almost on the medial surface instead of the posterior as is common in the order.

I believe that taking into account the characters of gnathochilarium, antennae, second legs, tergal pubescent belt, telopods, and general facies, *Rajasphaera* is amply entitled to recognition in a separate status of at least subfamily. As it is so generally different from other known Borneo species, I would suspect that more knowledge, especially of the telopod structure and that of the female genitalia, might well justify separate family status.

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