A NEW PRIMITIVE *HELICOPSYCHE* FROM MADAGASCAR (TRICHOPTERA: HELICOPSYCHIDAE), WITH PHYLOGENETIC ANALYSIS OF AFROTROPICAL SPECIES

Johanson, K. A., 2002. A new primitive *Helicopsyche* from Madagascar (Trichoptera: Helicopsychidae), with phylogenetic analysis of Afrotropical species. – Tijdschrift voor Entomologie 145: 9-17, fig. 1-11, tables 1-3. [ISSN 0040-7496]. Published 1 June 2002.

A new species of the subgenus *Petrotrichia* Ulmer, 1910 within the genus *Helicopsyche* von Siebold, 1856 (Trichoptera), *Helicopsyche anomana* sp.n. is described. A cladistic analysis was executed to establish its phylogenetical relationship to other *Petrotrichia* species. The results of the analysis shows that the species is the sister species to *Helicopsyche giboni* Johanson, 1997, and together they form a basal clade within the Afrotropical *Helicopsyche* and also within the Helicopsychidae.

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Key words. – *Helicopsyche anomana* sp. n.; Helicopsychidae; Trichoptera; phylogeny; Madagascar.

With the description of *Helicopsyche palpalis* (Ulmer, 1910) from Mahé, Seychelles, Ulmer described the first *Helicopsyche* von Siebold, 1856 from the Afrotropical region. It was originally described within a new hydroptilid genus *Petrotrichia* Ulmer, 1910, but was synonymized with *Helicopsyche* by Marlier & Malicky (1979). The taxon name *Petrotrichia* Ulmer, 1910 was maintained by Johanson (1998) as a valid monophyletic subgenus taxon for all Afrotropical *Helicopsyche* by Johanson (1998). The phylogenetic relationship of the ten East African *Petrotrichia* was outlined by Johanson & Willassen (1997) without including the two Madagascan species and the Seychellean *H. kantilali* Marlier & Malicky, 1979. They concluded that the East African species are monophyletic. In a cladistic analysis, Johanson (1998) argued that the *Petrotrichia* forms a basal clade within the genus *Helicopsyche*. With *H. anomana* sp. n. described herein, the subgenus *Petrotrichia* now comprises 14 species, of which *anomana* and *giboni* Johanson, 1997 are known from Madagascar; *H. palpalis* (Ulmer, 1910) and *H. kantilali* from the Seychelles; and all the remaining ten species (*H. barbata* Johanson, 1993, *H. pedunculata* Johanson, 1993, *H. ulugurensis* Johanson, 1993, *H. usambarensis* Johanson, 1993, *H. annae* Johanson, 1993, *H. tanzanica* Johanson, 1993, *H. stolizei* Johanson, 1993, *H. jacque-*

mart Johanson, 1993, *H. bifida* Johanson, 1993, and *H. marlieri* Jaquemart, 1957) are all restricted to Tanzania and eastern Zaire.

The Madagascan *Helicopsyche* fauna was recently unknown until Johanson (1997) described *H. giboni*. A second species was kindly sent by Dr. F. M. Gibon and is herein described.

The present understanding of the Madagascan *Helicopsyche* fauna is that it is poor in species compared to the East African mountains of the Eastern Arc. But both the low number of species and sites where specimens are collected indicates that the island is also poorly known, and that extensive collecting activity will probably lead to the discovery of more species.

METHODS

The morphological terminology follows Johanson (1998). The holotype is deposited at the Swedish Museum of Natural History, Stockholm, Sweden.

Helicopsyche (Petrotrichia) anomana sp.n.

Type material. – Holotype ♀: Madagascar: Rianila Basin, Sahatandra River, at Ambodirina, 48°20'28"E, 19°01'32"S (LRSAE coll.) [no date given].

Figs. 1-3. *Helicopsyche anomana* sp.n., male holotype. – 1, Right wings; 2, hindwing hamuli, highly magnified; 3, VIth sternite, lateral view.

Figs. 4-8. *Helicopsyche anomana* sp.n., male holotype. – 4, Genitalia, lateral view; 5, genitalia, dorsal view; 6, genitalia, ventral view; 7, phallus, lateral view; 8, phallus and phallic processes, dorsal view.

Diagnostic characters

The male is characterized by having rounded fore wing apex; no abdominal reticulation; anteriorly pointing dorsal part of segment IX; distally hook-shaped tergum X; superior appendages which originate dorsally; slender and distally dorsally bent, simple, gonocoxites; and very long dorsal processes on phallus. *H. anomana* can be separated from its sister species, *H. giboni*, by having forewing with R_5 originating proximally to crossvein R_3-R_4 ; in *H. giboni* R_5 originates on line with this crossvein; *anomana* has shorter hamuli row; and *anomana* has two phallic processes present, while *giboni* has four phallic processes. *H. anomana* is slightly larger than *giboni*.

Etymology

The name *anomana* is a paraphrase of the Latin *abnormis*, abnormal, and referring to the odd genitalic morphology.

Description

Male (holotype). – Head: maxillary palp with 2 equally long joints; cephalic warts rounded, slightly elevated; postantennal warts rounded, flat; eyes with interommatidial setae; vertex dorsally and anteriorly rounded. Thorax: pronotum and mesoscutum each with one pair setal warts; spurs 2, 2, 4; fore leg posterior spur shorter than anterior spur. Wings (figs. 1, 2): Fore wing 4.1 mm; Dc long, about $\frac{1}{3}$ x wing length; forks 1 and 2 present; fork 1 originates from distal $\frac{1}{4}$

Fig. 9.
Distribution of *Helicopsyche giboni* Johanson, 1997 and *Helicopsyche anomana* sp.n. on Madagascar.

of Dc, about as long as fork 2 and cell between the two forks; M and Cu, apparently fused along their length, except the distal part; the fused veins bear long longitudinal sensilla; slender, plate-like setae scattered in proximal R and M sectors; proximal Cu₂ runs parallel with wing margin; A-veins apparently absent. Hind wing 3.4 mm; with eight hamuli restricted to short median row; no forks present; A₁ and A₂ present. Nygma absent in both wings. Abdomen: sternites without reticulation; sternite VI with large process and runs posteroventrally (fig. 3). Genitalia (figs. 4-8): Segment IX, lateral view, short, dorsally extended into anterior triangular (fig. 4), with anterior margin strengthened (fig. 4); in dorsal and ventral view broadly cleaved. Tergite X, lateral view (fig. 4), large, continuous with segment IX; basally broad and tapers strongly towards median part; distal part hooked upwardly; two lateral setae pairs present on median part (figs. 4 and 5). Superior appendages (fig. 5), tuboid, originate between the Xth tergal branches and run posteriorly, each with two apical setae. Gonocoxite simple, without secondary branch; in lateral view (fig. 4), proximally sub-

straight; apex slightly angled dorsally and supports four setae; the basomedian process conspicuous, oriented posteroventrally, and with two apical setae. In ventral view (fig. 6), smoothly curved medially; basomedian processes oriented posteromedially. Basal plate indistinct, but with two anterolateral processes (fig. 6). Phallus (fig. 7): short, strongly curved ventrally, with long processes originating dorsally on basal part (fig. 8) having two apical setae (fig. 8).

Distribution

The species, represented by a single male, is only recorded from its type locality, at the Sahatandra River in the Rianila Basin, located in the middle part of the eastern coast of Madagascar (Fig. 9). The locality is close to the type locality of the other species, *H. giboni*.

PHYLOGENETIC RELATIONSHIP

Methods

A phylogenetic analysis including all Madagascan, Seychellean and eight out of ten East African *Heli-*

Figs. 10-11. Results of the cladistic analyses. – 10, Strict consensus tree before successive reweighting. Based on 9 shortest trees. The subgenus *Petrotrichia* is shaded; 11, Strict consensus tree after successive reweighting. Based on 3 shortest trees. The subgenus *Petrotrichia* is shaded. Node numbers refer to synapomorphy list in Tab. 3 and the text.

copsyche is executed. The following two East African species, *H. marlieri* and *H. stoltzei*, were excluded from the analysis in order to reduce the amount of uncertainties in the data matrix due to lack of other characters but genital ones. The outgroup was selected to include basal representatives of related species groups within *Helicopsyche*, and also the genus *Rakiura* (Helicopsychidae), as well as representatives of related families by the genera *Sericostoma* (Sericostomatidae), *Hydrosalpinx* (Hydrosalpingidae), *Petrothrincus* (Petrothrincidae), *Alloecella* (Calocidae), *Ernodes* (Beraeidae) and *Antipodoecia* (Antipodoeciidae). The characters used and data matrix are presented in tables 1 and 2, respectively. The data matrix comprises 96 characters of which 18 are multistate characters (3, 18, 21, 29, 30, 32, 45, 46, 56, 60, 61, 67, 70, 71, 77, 80, 83 and 92). All multistate characters, except characters 61, 67 and 92, were treated as linearly ordered. Initially, all characters were equally weighted. PAUP* (Swofford 1998) was used to find most parsimonious trees. Totally 1000 replicate searches were performed with different starting points, and all minimal length trees were retained in each replicate.

To reduce the effects of homoplasious characters in

the analysis, a successive reweighting approach (Farris 1969) was performed. A base weight of 1.00 was given non-homoplasious characters, and a similar analysis to the initial one was performed.

Results

The initial analysis resulted in nine shortest trees within a single island. The strict consensus tree is given in fig. 10 and shows that the subgenus *Petrotrichia* is monophyletic, as is indicated on grey background. In *Petrotrichia*, the basal clades were not fully resolved in that the Madagascan, Seychellean and mainland groups formed three distinct monophyletic clades within a trichotomy. This due to two alternative configurations: one which groups the Madagascan species into a basal *Petrotrichia* clade, or alternatively as a sister group to the Seychellean species clade. After reweighting, three shortest trees were obtained, all identical to a subset of the shortest trees found in the initial analysis. The strict consensus tree based on reweighted characters is given in fig. 11. In this tree, the Madagascan species (node 3 in fig. 11) constitutes a monophyletic group and comes out as the sister group to the Seychellean species (node 4 in fig. 11).

The result corresponds with that in Johanson (1998), i.e. the species-relationship in the clade comprising the Afrotropical species. This tree is preferred over competing trees as it is based on analysis that downweighted homoplasious characters. The character state transformations for nodes 1-5 in fig. 11 are listed in table 3.

The unambiguous characters supporting the monophyly of the Madagascan species are: presence of a long trichoid setae along forewing Cu_1+M ; the forewing M and Cu_1 are almost fused; the segment IX, best seen in lateral view, has its dorsal part anteriorly extended; the genitalia has a basal plate divided into dorsal branches; the gonocoxite is slender and distally angled dorsally; the tergum X is divided into two widely separated branches and has its distal part dorsally hooked. In addition, several ambiguous characters support the monophyly (see table 3).

The monophyly of the two Seychellean species (node 4 in fig. 11) is supported by the presence of one unambiguous character: the secondary branch of gonocoxite has a strong, apical seta. In addition, the clade is supported by the absence of a fore leg posterior spur (also absent in *H. lata* and *vazquezae*); the reduction of the Cu_2 (also reduced in *Alloecella*); the short, wart-like superior appendage (also in *H. vazquezae*); and the secondary reduction of sclerous processes on the phallus (also in *H. pedunculata*).

The clade comprising both the Madagascan and Seychellean species (node 2 in fig. 11) forms a sister group to the mainland species (node 5 in fig. 11). The group of Madagascan and Seychellean species is supported by the presence of a rounded forewing apex, which is the only character that unambiguously supports the monophyly of that clade. Other, ambiguous characters are: the presence of eye ommatrichia (also in *Sericostoma*); the hindwing breadth over hindwing length ratio is less than 0.22 (secondary modified in *anomana*); and the absence of abdominal reticulation (also in non-helicopsychids).

CONCLUSION

Classifying *H. anomana* together with the other primitive *H. giboni* is supported by several synapomorphies. It is also clear that the Madagascan species

form a clade that is the sistergroup to the Seychellean species, which in turn forms a sistergroup to the East African mainland species. Johanson (1998) concluded that the subgenus *Petrotrichia* is one of the oldest groups within Helicopsychidae. It was probably present in Africa at the time when Africa and South America broke off about 100 MYA. However, ancestral species probably dispersed to the Seychelles and Madagascar from East Africa more recently, probably later than 55 MYA (Johanson 1998: 124). *H. anomana* can thus be considered as one of the most primitive species within the family Helicopsychidae.

The Helicopsychidae fauna of Madagascar is probably richer than presently observed. And presence of primitive Helicopsychidae clades in this region should entail a stronger focus on that part of the distribution range of the family. Detection of more species would likely add valuable information to a better understanding of Helicopsychidae phylogeny and biogeographical pattern.

REFERENCES

- Farris, J. S., 1969. A successive approximations approach to character weighting. – *Systematic Biology* 18: 374-385.
- Johanson, K. A., 1997. Description of *Helicopsyche giboni* sp.n. from Madagascar (Trichoptera: Helicopsychidae). – *Braueria* 24: 5-6.
- Johanson, K. A., 1998. Phylogenetic and biogeographic analysis of the family Helicopsychidae (Insecta: Trichoptera). – *Entomologica Scandinavica Supplement* 53. 172 pp.
- Johanson, K. A. & E. Willassen, 1997. Are the African species of *Helicopsyche* von Siebold, 1856 (Insecta: Trichoptera: Helicopsychidae) monophyletic? – *Tropical Zoology* 10: 117-128.
- Marlier, G. & H. Malicky, 1979. A new *Helicopsyche* from the Seychelles (Trichoptera, Helicopsychidae). – *Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen* 30: 110-112.
- Swofford, D. L., 1998. PAUP*. Phylogenetic Analysis Using Parsimony (*and other methods). version 4. – Sinauer, Sunderland, Massachusetts.
- Ulmer, G., 1910. Trichoptera. – In: Percy Sladen Trust. Expedition, Indian Ocean in 1905. – *Transactions of the Linnean Society of London* 3: 41-54.

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Table 1. List of characters used in the cladistic analysis. The character alternatives are scored in the matrix in table 2. “#” refers to character numbers.

Character state description

- 1 Maxillary palp proximal joint with medial stout setae absent (0), present (1).
- 2 Maxillary palp distal joint as long or longer than proximal joint (0), shorter (1).
- 3 Maxillary palp 5-jointed (0), 3-jointed (1), 2-jointed (2).
- 4 Frontal tentorial opening with black line absent (0), present (1).
- 5 Postantennal warts absent (0), present, flat (1), present, tuboid (2), present, tuboid and bifurcated (3), present, associated with cephalic warts (4).
- 6 Eye ommatrichia absent (0), present (1).
- 7 Tentorial arm lateral process present (0), absent (1).
- 8 Tentorial bridge process present (0), absent (1).
- 9 Fore leg posterior spur as long as anterior spur (0), shorter than anterior spur (1).
- 10 Fore leg posterior spur present (0), absent (1).
- 11 Cervical sclerite uniformly pale (0), with strongly pigmented margin (1).
- 12 Pronotum with setal warts in two pairs (0), one pair (1).
- 13 Mesonotum postnotal line present (0), absent (1).
- 14 Mesonotal warts present 0, absent (1).
- 15 Forewing length over Dc length more than 4.5x (0), less than 4.5x (1).
- 16 Forewing apex slightly pointed (0), rounded (1).
- 17 Forewing distance between broadest part to apex over length of broadest part less than 1.2x (0), more than 1.2x (1) (see fig. 16 in Johanson 1998)
- 18 Forewing fork 1 originates proximally or medially on discoidal cell (0), on distal half (1), close to or on distal corner (2).
- 19 Forewing basal R_5 originates proximally to R_3 - R_4 (0), on line or distally (1).
- 20 Forewing fork 3 present (0), absent (1).
- 21 Forewing crossvein R-M ends well into M_{1+2} (0), R-M ends on point of bifurcation of M to M_{1+2} and M_{3+4} (1), R-M meets M before bifurcation of M (2), R_5 tangent to M (3).
- 22 Forewing Cu_{1b} present (0), absent (1).
- 23 Forewing Cu_2 present (0), absent (1).
- 24 Forewing A_{1+2} meets wing margin at some distance from fork 5 (0), very close to fork 5 (1).
- 25 Forewing nygma in fork 2 present (0), absent (1).
- 26 Forewing nygma in thyridium cell present (0), absent (1).
- 27 Forewing long trichoid setae along Cu_1 absent (0), present (1).
- 28 Forewing M_4 sensilla basiconica on M_4 in number of two (rarely one) (0), absent (1).
- 29 Hindwing hamuli absent (0), straight, and exceeding 0.37-0.54 wing length (1), curved, and exceeding 0.37-0.54 wing length (2), curved, exceeding 0.58-0.63 wing length (3).
- 30 Hindwing breadth over length less than 0.22 (0), 0.24-0.38 (1), more than 0.41 (2).
- 31 Hindwing anterior margin substraight (0), sigmoid (1).
- 32 Hindwing fork 1 shorter than its stalk, and with proximally oriented R_2 (0), shorter than its stalk, and with distally oriented R_2 (1), longer than its stalk, and with distally oriented R_2 (2).
- 33 Hindwing fork 1 present (0), absent (1).
- 34 Hindwing Dc present (0), absent (1).
- 35 Hindwing fork 3 present (0), absent (1).
- 36 Hindwing M includes more than one vein (0), includes only one vein (1).
- 37 Hindwing crossvein M-Cu present (0), absent (1).
- 38 Hindwing Cu_1 divides into Cu_{1a} and Cu_{1b} (0), simple (1).
- 39 Hindwing Cu_2 is separate from Cu_1 (0), basally fused with Cu_1 (1).
- 40 Hindwing Cu_3 present (0), absent (1).
- 41 Hindwing nygma in fork 2 present (0), absent (1).
- 42 Forewing M and Cu_1 well separated (0), almost fused and with long setae (1).
- 43 Tergite I dorsal setose structure absent (0), present (1).
- 44 Tergites I-VIII anterior margins straight or convex (0), concave (1).
- 45 Abdomen with sternal reticulation absent (0), present on sternum III only (1), present on sternites II-V (2).
- 46 Abdominal sternum VI without process (0), with stump process (1), with pointed process (2), with truncated process (3), with tongue shaped process (4).
- 47 Abdominal sternites without transverse apodeme (0), transverse apodeme present (1).
- 48 Sternite IX membranous areas absent (0), membranous areas present (1).
- 49 Sternite IX not extended or divided (0), extended posteriorly and divided (1).
- 50 Segment IX with pleural apodeme to k-axis bent downward running anteriorly (0), in right angle to k-axis (1), bent upward running anteriorly (2). (see fig. 26 in Johanson 1998)
- 51 IXth pleural apodeme present (0), absent (1).
- 52 Tergum IX dorsally oriented, rounded process absent (0), present (1).
- 53 Segment IX, lateral view, with dorsal part anteriorly rounded (0), dorsal part anteriorly pointed (1).
- 54 Superior appendage long and slender (0), short and wart-like (1).
- 55 Superior appendage base completely sclerotized (0), with membranous area (1).
- 56 Superior appendage located laterally (0), dorsolaterally (1), dorsally (2).
- 57 Superior appendage with small, basal process absent (0), present (1).
- 58 Basal plate undivided (0), divided into dorsal branches (1).
- 59 Gonocoxite primary branch anterior margin concave (0), straight or convex (1).
- 60 Gonocoxite simple, with only primary branch present (0), with very short secondary branch (1), with secondary branch about half as long as the primary branch (2), with secondary branch as long as primary branch (3).
- 61 Gonocoxite primary branch distally gradually broader and with apex rounded (0), uniformly broad and apex pointed ventrally (1), slender and tapering (2), slender and needle shaped (3), proximal part angled posteriorly and distally parallel with secondary branch (4), short, and directed dorsally (5), uniformly broad, not with pointed apex (6), slender, and angled dorsally (7).
- 62 Gonocoxal secondary branch median setae present (0), absent (1).
- 63 Gonocoxal secondary branch apical seta absent (0), a

- single, long seta present (1).
- 64 Gonocoxal basomedian process absent (0), present (1).
- 65 Gonocoxal basomedian branch megasetae absent (0), dorsoapical megasetae present on posterior oriented consoloid process (1), apical megasetae on tube-shaped posteriorly oriented process (2).
- 66 Gonocoxite secondary branch basomedially not produced (0), produced medially (1).
- 67 Gonocoxite basomedian branch absent (0), present on basal plate, and short (1), present basally on primary branch, and long (2).
- 68 Gonocoxite primary branch volsella absent (0), present (1).
- 69 Phallus slightly curved (0), strongly curved ventrally (1).
- 70 Phallic sclerous process, if present, without microtrichia (0), scattered with microtrichia (1), with microtrichia in crown (2).
- 71 Phallic sclerous processes absent (0), one pair present (1), two pairs present (2).
- 72 Tergum X laterally slender (0), laterally broad (1).
- 73 Tergum X with anterodorsal margin straight or convex (0), hooked dorsally (1).
- 74 Tergum X ventroapically not enlarged (0), enlarged (1).
- 75 Tergum X widely divided apically (0), narrowly divided apically (1).
- 76 Tergum X with apical division shorter than 1.2 x its segment breadth (0), longer than 1.2x its segment breadth (1).
- 77 Tergum X with dorsal setae in number of 2-4, mainly 3 (0), 5-9 (1), more than 9 (2).
- 78 Tergum X, dorsal view, proximally fused (0), proximally separated (1).
- 79 Female with process on sternite VI absent (0), present (1), secondarily reduced (2).
- 80 Female ductus bursa more than 2x longer than spermathecal sclerite (0), between 1-2x length of spermathecal sclerite (1), less than 0.5x length of spermathecal sclerite (2).
- 81 Female with base of spermathecal gland present medially on sperm duct (0), distally on sperm duct (1).
- 82 Female segment IX dorsal part uniformly sclerotized (0), with membranous area (1).
- 83 Female pleurite IX comb area formed by microtrichia absent (0), present and without cells (1), present and with cells (2).
- 84 Female segment IX parameres present laterally (0), absent (1).
- 85 Female segment IX with setae in group (0), no setae in group (1).
- 86 Female tergum IX rounded dorsally (0), tapering dorsally (1).
- 87 Female segment X with dorsal branch oriented posteriorly (0), curved ventrally (1).
- 88 Larval case enclosure perforated (0), with split (1).
- 89 Larval case uncoiled (0), dextrally coiled (1).
- 90 Larval antennae originate close to anterior margin of head capsule (0), midway between eye and anterior margin of head capsule (1).
- 91 Larval head carina absent (0), slightly developed (1), well developed (2).
- 92 Larvae with pronotal megasetae on anterior margin absent (0), with few lateral megasetae (1), with lateral and median megasetae (2), with median megasetae (3).

- 93 Larval pronotum postmedian dark spots absent (0), present (1).
- 94 Larval fore leg femur with two dorsal setae (0), with many setae (1).
- 95 Larval fore leg femur 1.2-2.0 x longer than its trochanter (0), less than or equally long to its trochanter (1).
- 96 Larval abdominal gills present (0), absent (1).

Table 3. List of character transformations supporting the monophyly of the clades shown by node number 1-5 in fig. 11. Character numbers in bold indicate characters with unambiguous character transformations; "Node #" refers to the node numbers in fig. 11; "Character #" refers to the character numbers listed in table 1; "ci" refers to the consistency indices for the characters supporting the clades 1-5 in fig. 11; and "State change" refers to the character state change for each character supporting clades 1-5 in fig. 11.

Node#	Character#	ci	State change
1	15	0.200	1 → 0
	22	0.333	0 → 1
	32	0.400	1 → 2
	37	0.500	0 → 1
	38	0.333	0 → 1
	51	0.333	0 → 1
	56	0.500	0 → 1
	62	0.500	0 → 1
	71	0.286	0 → 1
	76	0.333	0 → 1
	79	1.000	0 → 1
	80	1.000	1 → 2
	85	0.200	1 → 0
	95	0.500	1 → 0
2	6	0.500	0 → 1
	16	1.000	0 → 1
	30	0.667	1 → 0
	45	0.667	1 → 0
	60	0.176	3 → 1
3	14	0.200	1 → 0
	15	0.200	0 → 1
	17	0.500	0 → 1
	27	1.000	0 → 1
	28	0.333	0 → 1
	33	0.333	0 → 1
	42	1.000	0 → 1
	53	1.000	0 → 1
	56	0.500	1 → 2
	58	1.000	0 → 1
4	60	0.176	1 → 0
	61	1.000	0 → 7
	62	0.500	1 → 0
	73	1.000	0 → 1
	77	0.400	1 → 0
	78	1.000	0 → 1
	85	0.200	0 → 1
	10	0.500	0 → 1
	40	0.500	0 → 1
	54	0.500	0 → 1
5	63	1.000	0 → 1
	71	0.286	1 → 0
	24	0.500	0 → 1
	71	0.286	1 → 2
	92	1.000	0 → 3

Table 2. Character matrix derived from the character list in table 1.

	0000000001	1111111112	2222222223	3333333334	4444444445	5555555556	6666666667	7777777778	8888888889	9999999
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	123456
<i>Anipodocia</i>	0-10?01100	0110-01--0	0001000011	0201111000	0000001000	0000000010	0-0-0--000-	01000000??	??????????	??????
<i>Ernodes</i>	0010000110	01?1-00--0	0000000011	0101101100	0000000000	00000000??	1000000000-	00000000??	??????????	??????
<i>Alloecella</i>	0-00000000	0111-00?-0	2010000011	02000010?1	0000000000	0000010010	2-0-0--001-	00000100??	?????????01	??????
<i>Petrothrincus</i>	000000?00	0011000100	0100000?11	0200111100	00?000?010	00000100?3	1000000000-	000000?0??	?????????01	??????
<i>Hydrosalpinx</i>	0000001110	0111000110	0100000111	0201111100	0000000000-	1000010002	3000000000-	000000?0??	?????????00	??????
<i>Sericostoma</i>	0-10110000	0110000010	0000000101	0101100000	0000000000	0000100002	0000000001-	0000001000	1000000100	001100
<i>anomana</i> sp. n.	1020111110	0100111101	0100111121	1-11101100	110002100-	1010020100	7000000010	10100101??	???????????	??????
<i>giboni</i>	1020111110	0100111111	?100111120	1-11101100	110002100-	1010020100	7-0-0--0001	2010010112	1001100???	??????
<i>barbata</i>	1020001110	0101000201	1101110021	1201101100	100012110-	1000000003	0100010110	200001101?	?001000011	130001
<i>pedunculata</i>	1020001110	0101000201	1101110021	1201101100	100012110-	1000000003	0100010110	00000110??	???????????	??????
<i>annae</i>	1020101110	0101000111	0101110021	1201101100	101012100-	1100110003	0100000002	20010110??	???????????	??????
<i>Jacquemarti</i>	1020101110	0101000111	0101110021	1201101100	101012100-	1000111003	0100000001	20010110??	???????????	??????
<i>usambarensis</i>	1020101110	0101000111	0101110021	1201101100	101012100-	1000110003	0100000001	20010110??	???????????	??????
<i>uluquirensis</i>	1020101110	0101000111	0101110021	1201101100	101012100-	1000110003	0100000002	20000110??	???????????	??????
<i>bifida</i>	1020101110	0101000111	0101110021	1201101100	101012100-	1000111003	0100000001	20010110??	?101011???	??????
<i>tanzanica</i>	1020101110	0101000111	0101110021	1201101100	101012100-	1100110003	0100000002	10010110??	?101111011	130001
<i>palpalis</i>	10201111?1	0101010101	?100110020	1201101101	10?002100-	100?0?0003	0110000000-	00000110??	???????????	??????
<i>kantilali</i>	10200111?1	0111010111	?10011002?1	1201101101	10000?100-	1001010001	0110000000-	00000110??	?001000011	100001
sp. E	0121001110	1000000110	0000110021	1001000000	1000241002	0000000000	6--10-000-	01001120??	???????????	??????
<i>lata</i>	0?100011?1	0?00100100	0010110?2?1	1-11100000	1000221000	0000000000	0-0-0--?00-	00000000??	???????????	??????
<i>comosa</i>	0021001110	1000100110	0000110021	1001100010	1001241001	0000000010	6--11-000-	01000020??	???????????	??????
<i>fistulata</i>	0021001110	1000100110	0000110021	1001100010	1001241001	0000000000	6--11-000-	01000020?1	0021000???	??????
<i>beacota</i>	0120101110	?000100000	0000110021	1101100000	1000231000	0000000003	5000001?0-	00000020?1	0021000???	??????
<i>poutini</i>	0120101110	0000100100	0100110021	1101000000	10002?1001	0000000003	400000100-	0001002001	0001100???	??????
<i>vazquezae</i>	002?0001?1	1101000100	0010110021	1001100000	1000221000	0001000000	0-0-0--000-	00000010?1	0001100011	120111
<i>Raktiura vernde</i>	1020100100	0011100-01	?000110022	0-10000000	1001010010	0000000003	?00000200-	00000020?0	?000100111	111011