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The Odonata of Sulawesi and adjacent islands. Part 4. A new genus and species of Chlorocyphidae from South-East Sulawesi

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Key words.— Chlorocyphidae; new genus; new species; Sulawesi; phylogeny.
A new genus and species of Chlorocyphidae (Insecta: Odonata: Zygoptera), *Watuwila vervoorti*, from SE Sulawesi (Indonesia) is described. A preliminary phylogenetic analysis of the genera of the family indicates that the genus represents a relatively old lineage.

Introduction

Recent studies of the Odonata of the Indonesian island of Sulawesi (formerly Celebes) have already revealed several interesting novelties (e.g. van Tol, 1994). Some parts of the islands have been investigated rather thoroughly as early as the 19th century, but also these areas may still yield undescribed species, particularly representatives of elusive Platystictidae and Megapodagrionidae. On more remote places of the island, we may still hope for more conspicuous, yet unknown species. All these findings may significantly add to our understanding of the biogeography of Wallacea.

In the 1980's and early 1990's I have been able to investigate several places of which no or hardly any Odonata were previously known. In 1989, the '1989 RMNH Expedition to Sulawesi' was organized by the National Museum of Natural History at Leiden, in close co-operation with LIPI Jakarta, the Zoological Museum at Bogor, the Sam Ratulangi University at Manado (Sulawesi Utara), and the Haluoleo University at Kendari (Sulawesi Tenggara). During this expedition, members of the expedition climbed Gunung Watuwila, one of the mountains in the southern part of Pengunungan Mengkoka. The Mengkoka mountains were hardly studied faunistically since Heinrich was searching for the rail *Aramidopsis plateni* (Blasius) in this area in 1931-1932. Heinrich's localities were in the central part of this mountain (see Heinrich, 1932: 8), where he unfortunately made only limited collections of insects. The top of Gunung Watuwila is possibly located at c. 2500 m, but the highest camp we made for collecting Odonata was at c. 1050 m along a stream. This place yielded a most interesting fauna, of which a remarkable species of Chlorocyphidae, to be attributed to a new genus, is described in this paper.

The present discovery of a new species, to be assigned to new genus in the Chlorocyphidae, confirms the special position of the island of Sulawesi for this group of dragonflies. Two other endemic genera of Chlorocyphidae are known from Sulawesi, the highly aberrant *Disparocypha* Ris (see Ris, 1916), with one described species (*D. biedermanni* Ris, 1916), and the *Sclerocypha* Fraser, also with only one

species included (*S. bisignata* (McLachlan, 1870)) (see Fraser, 1949).

It is a pleasure and honour for me to dedicate the present paper to the former director of the National Museum of Natural History at Leiden, Professor Dr Willem Vervoort, on the occasion of his 80th birthday.

Abbreviations used: RMNH = National Museum of Natural History Naturalis, Leiden; MBBJ = Museum Zoologicum Bogoriense, Cibinong, Indonesia.

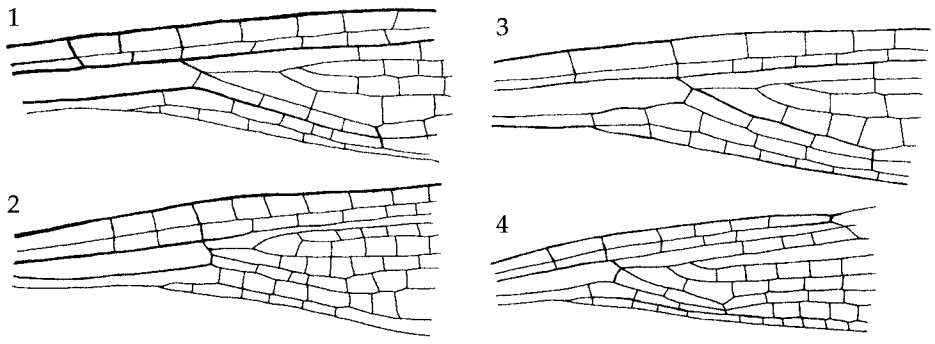
Systematic part

Watuwila gen. nov.

Diagnosis.— A predominantly red-coloured member of the Chlorocyphidae. Habitus very similar to red-coloured *Libellago*-species, including the regional species of the *Libellago rufescens*-group of species of Sulawesi (Van Tol, in prep.), by the general colouration and the presence of dark tips in the forewing only. It also shares the following generic characters with *Libellago* (figs 1-4) (naming of veins according to the modified Tillyard-Fraser system): the R2 vein is straight in line with the superior sector of the Arculus, and the sectors of the Arculus are arising from the same point. It differs, however, from *Libellago* by the presence of a pterostigma in the male forewing (typically absent in *Libellago*, but present in *L. stictica* and *L. stigmatizans*), the presence of a secondary antenodal crossvein between the primaries, and the presence of numerous antenodal crossveins (six or less in *Libellago*). The last three characters are shared with the genus *Rhinocypha*, where species like *R. pagenstecheri* are also remarkably similar in general appearance. Another closely related Sulawesi genus is *Sclerocypha* Fraser, which differs from *Libellago* by the presence of 8-9 antenodal crossveins, and (usually) a secondary crossvein between the primaries, but especially a notable thickening of the Costa in the male forewing. *Sclerocypha bisignata* does not have a pterostigma in the forewing of the male. An analysis of the relationships of these genera is presented in the last paragraph of this paper. The genus is thus characterized by unique combination of wing venational characters, as mentioned above and not realised in any of the other genera in the family.

Type species.— *Watuwila vervoorti* spec. nov.

Etymology.— After name of the mountain Gunung Watuwila. Feminine.



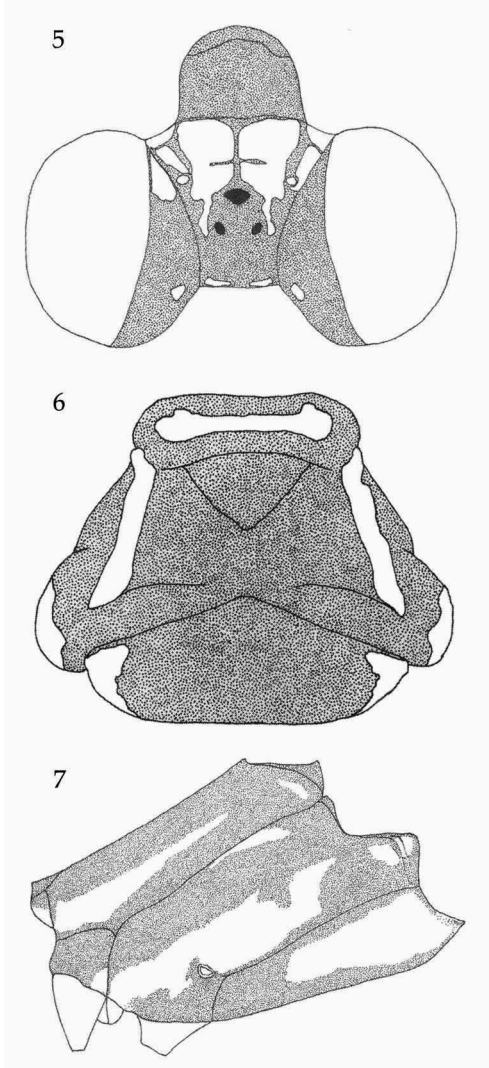
Figs 1-4. Base of wing of 1, *Watuwila vervoorti* spec. nov.; 2, *Rhinocypha sumbana* Förster; 3, *Sclerocypha bisignata* (McLachlan); 4, *Libellago semiopaca* (Selys).

Watuwila vervoorti spec. nov.
(figs 1, 5-7)

Material.— Holotype male: 'Indonesia, Sulawesi Tenggara: south of Sanggona: Gunung Watuwila. Sungai Lalonduwasi near Centipede camp. Small, shaded stream in very steep valley. Clear running water over boulders. Small pools. c. 3°49'S 121°40'E. c. 1050 m asl. Sample 89JvT035. 2-4.xi.1989. Leg. J. van Tol' (in RMNH) [JvT 16315]. – Paratypes: Same data, 2 males (one in RMNH, one in MBBJ) [JvT 16316, 16317].

Diagnosis.— Colouration strikingly similar to species in the *Libellago rufescens*-group of Sulawesi. Colouration and general appearance also very similar to *Sclerocypha bisignata* (McLachlan, 1870) as defined by Fraser (1949), but Costa not thickened and male with pterostigma in forewing. Specimens of *Sclerocypha bisignata* show variation in the presence of an additional antenodal crossvein between the primaries. Differing from typical *Libellago* species by the presence of a pterostigma in fore and hindwing of the male (females always with pterostigma in all wings), a higher number of antenodal crossveins (forewing with 11 Ax, hindwing with 9 Ax), and an additional antenodal crossvein between the primaries. See further under generic diagnosis. Inferior appendages very short. Conspicuous markings include the extensive pale marking of the head in frontal view, pale innerside of femur and tibia of fore leg and the blood-red abdomen with the posterior one-fifth of each segment black.

Description of male holotype (JvT no. 16315).— Labium with submentum and basal part of prementum and labial palps yellowish white; remaining parts shiny brownish black. Maxillae, underside of mandibles and labrum shiny black. Head (fig. 5) in frontal view creamish white, except for the clypeus. Mandibles creamish white as the genae and the frons, but genae with a U-shaped dark marking under the antennae. Clypeus far protruded as in other members of the family. Middle of frons with a narrow black stripe, the pale markings extending posteriorly along the



Figs 5-7. *Watuwila vervoorti* spec. nov. 5, Head in dorsal view; 6, Prothorax in dorsal view; 7, Synthorax, in left lateral view.

ocelli. Remaining part of head dull black with small postocular spots and a paired small spot on hind margin of occiput. Antennae brownish black, flagellum of both antennae absent in holotype.

Thorax. Prothorax (fig. 6) dull black; anterior lobe with rather narrow yellowish transversal stripe, somewhat wider at the tips, not connected with a relatively wide yellowish longitudinal marking along the margin of the middle lobe; side lobe with extensive yellow marking round, somewhat extruded on dorsal side; lateral corners of hind lobe with triangular pale marking. Synthorax (fig. 7) with antehumeral stripe anterior one-third wide, the posterior two-thirds narrow, a small spot near ante-alar triangle. A short pale stripe over posterior side of humeral suture. Extensive pale markings over metepisternum leaving the area anterior to the stigma free; also a large triangular black indentation on ventro-posterior side. Metepimeron with large pale triangular marking. Legs brownish black, but inner side of femur and tibia of foreleg, and basal parts of inner side of middle and hind legs creamish white. Right hind leg missing. Wings with pterostigma in both fore and hindwings; tip of forewing with dark spot. Forewing formula for ante- and postnodal crossveins 18.11 | 11.19, hindwing formula 16.8 | 9.19, with a secondary cross-vein between all primaries. Abdomen blood-red, but first segment black with a large yellow spot on lateral side of segment 1, anterior one-sixth of segment 2 black and two black spots on posterior margin; intersegmental annuli black, and posterior one-fifth or one-sixth of segment 3-9 black, ventrally black markings usually somewhat more extensive, especially on segment 9; segment 10 blood-red dorsally, black on ventral side. Sternites black, but with a paired triangular blood-red spot on segment 9.

Measurements.— Hindwing 29 mm, abdomen including appendages c. 24 mm (abdomen not straightened).

Paratypes.— no. 16316 [photographed specimen] wing formula forewing 18.11 | 10.17 and hindwing 18.8 | 7.17; hindwing length 29 mm, abdomen 23 mm; no. 16317 wing formula forewing 21.9 | 9.18 and hindwing 16.9 | 8.18; hindwing length 29 mm, abdomen 23 mm.

Etymology.— Named after the former director of the National Museum of Natural History (Leiden), Professor Dr Willem Vervoort.

Ecological notes.— Around 1000 m above sea level, the Lalonduwasi river is only a few meters wide, with large boulders and heavy shade (fig. 8). Near the camp a fallen tree had just made an opening in the canopy, providing an opportu-

Fig. 8. The Lalonduwasi stream on Gunung Watuwila. Type locality of *Watuwila vervoorti* spec. nov.

nity for sun-loving insects to come to the stream. The species occurred only in low numbers at the stream, mostly in the forested part (specimens of *Libellago rufescens* are restricted to open stretches of rivers). As usual in Chlorocyphidae, the specimens frequented the spots where the sun reached the water. On the same spot, I collected specimens of *Macromia irina* Lieftinck (see van Tol 1994: 90).

Distribution.— Only known from the type locality, SE Sulawesi.

Phylogenetic relationships

So far, phylogenetic relationships of the genera and species of Chlorocyphidae are poorly understood. Fraser (1949) provided a revision of the family, discussing many characters used for distinguishing genera. He did not, however, propose a phylogeny for the whole family. Laidlaw (1950) again studied the taxonomy of the family, but he also included a reconstruction of the history of the family. This reconstruction was based on subjective reasoning rather than on interpretation of the available evidence ... "The family took shape in Tertiary times in the great plateau of S.E. Asia, the Sunda Shelf, now represented by the lands of Malaysia and Wallacea". He proposed an ancestor of the group "probably not very unlike the existing *Libellago*". He also supposed that the genus *Chlorocypha* "must have reached Africa at some time later than the Miocene period". The diagnoses of all genera with enumeration of the diagnostic characters have been used for table 1 of the present publication.

Although I am confident that several characters of body colouration will ultimately be shown to be useful for the recognition of the relationships between species, the use of such characters for distinguishing genera seems rather limited. On the other hand, characters of wing venation may also be of limited use when reduction has played a major role, and other structural characters, such as the secondary genitalia of the male, are so uniform that they do hardly provide useful characters for phylogenetic analysis at the species-level (see Cowley, 1937). According to Cowley, all species of *Libellago*, including *Sclerocypha bisignata*, have a similar penis structure (his group 2), which is also shared with several species now included in *Rhinocypha*, e.g. *R. pagenstecheri* Förster, 1897. Within the framework of the present study I have not been able to study this character in all taxa.

I have prepared a data matrix (table 1) of the characters used to characterize the SE Asian genera of Chlorocyphidae, plus *Chlorocypha*, a genus confined to Africa. This matrix is predominantly based on characters of the wing venation, and may serve as a start for further analysis of the phylogenetic relationships of the presently recognized genera of the family. In total 11 characters were used for 14 taxa. The data matrix was analysed with Paup 3.1.1, and resulted in one tree of length 19, CI 0.737, RI 0.792. With *Chlorocypha* as designated outgroup, the only tree is shown in fig. 8. Two groups of genera are central in the results. One group including *Disparocypha, Cyrano, Sundacypha* and *Calocypha*, is characterized by an Arculus situated distal to Ax2. The second group, including *Libellago, Pachycypha, Melanocypha, Sclerocypha* and *Watuwila*, is characterized by the sectors of the Arculus arising from one point, and the origin of R2, which is straight. Unfortunately, the relationships of both groups to the genus *Rhinocypha* is not resolved by the present analysis. A further analysis, based on characters of species rather than genera, is necessary to reveal the relationships of

Table 1. Characters of genera of Chlorocyphidae.

	1	2	3	4	5	6	7	8	9	10	11
Chlorocypha	0	0	0	0	0	0	0	0	0	0	0
Disparocypha	0	0	0	0	0	3	1	0	0	1	1
Libellago	1	1	1	0	1	0	0	1	0	0	0
Pachycypha	0	1	1	0	1	0	0	1	0	0	0
Rhinocypha	0	0	0	0	0	1	0	0	0	0	0
Sclerocypha	1	0	1	1	0	1	0	1	0	0	0
Sundacypha	0	0	0	0	0	2	1	0	0	0	0
Watuwila	0	0	1	0	0	1	0	1	0	0	0
Rhinoneura	0	0	0	0	0	1	0	0	0	0	0
Calocypha	0	0	0	0	0	2	1	0	0	0	0
Paracypha	0	0	0	0	0	1	0	0	1	0	0
Indocypha	0	0	0	0	0	0	0	0	0	0	1
Melanocypha	1	1	1	0	0	1	1	1	1	0	0
Cyrano	0	0	0	0	0	1	1	0	0	1	1

Characters used: 1, Pterostigma in male forewing (0) present, (1) absent. - 2, Secondary antenodal crossveins (0) present, (1) absent. - 3, Sectors of Arculus (0) separate, (1) originating from one point. - 4, Costa of male (0) normal, (1) thickened. - 5, number of antenodal crossveins (0) eight or more, (1) six or less. - 6, Origin of the anal vein (0) at Ax1 or proximal to it, (1) between Ax1 and Ax2, (2) at Ax2 or distal to Ax2, (3) absent. - 7, Position of Arculus (0) at Ax2 (in some specimens just a fraction distal to Ax2, maximal as in fig. 4), (1) distinctly distal to Ax2. - 8, Origin of R2 (0) arched, (1) straight. - 9, Cells Anal vein-hindwing (0) one row, (1) two rows. - 10, CuP ends (0) distal to nodus, (1) proximal to nodus, (2) at nodus. - 11, Intercalated vein MA-CuP (0) absent, (1) present.

the SE Asian Chlorocyphidae in more detail. One of the expected results is a paraphyletic nature of the genus *Rhinocypha* in the present sense. An interesting additional outcome of the present study is the position of the genus *Sclerocypha*. In recent catalogues it is usually included in *Libellago*, but that opinion can only be defended if also the species now included in *Pachycypha* and *Melanocypha* would be assigned to the genus *Libellago*.

Biogeographical notes

Sulawesi is well-known among biogeographers for its abundance of island endemics, including mammals such as the anoa *Anoa depressicornis* (H. Smith, 1827) and the babirusa *Babyrousa babyrussa* (Linnaeus, 1758). Investigations during the last twenty years have resulted in a further understanding of species diversity and distribution within the island. For instance, there is a general pattern of groups of closely related taxa with parapatric distribution. This has been demonstrated for cicadas (Duffels, 1990) and aquatic and semi-aquatic bugs (e.g. Polhemus & Polhemus, 1988, 1990; Nieser & Chen, 1993; Nieser, Zettel & Chen, 1997), and also for some groups of Odonata (van Tol, 1987 and in prep.). On the other hand, also absence of groups that are speciose in Borneo is a common phenomenon. Various examples in plants and vertebrates are summarized in Whitmore (1981); to which the Odonata families Platycnemididae and Euphaeidae can be added.

The Chlorocyphidae provide illustrations of various of these trends. The following conclusions, drawn from the phylogenetic tree in fig. 9, are to be considered preliminary since they are based on a limited number of characters, and a relatively poor understanding of the outgroups. The first example is *Disparocypha biedermanni*, with many autapomorphies, for which is sometimes even assigned to a separate subfamily. The genus *Watuwila*, although an island endemic as well, is of a different nature. Both genera clearly belong to two different clades, indicating that their common ancestor must have lived relatively long ago. *Disparocypha* seems to be an example of a highly aberrant taxon of relatively recent origin. The position of the genus *Watuwila* suggests a relict nature of *W. vervoorti*, where the younger genus *Libellago* has spread over most parts of Southeast Asia.

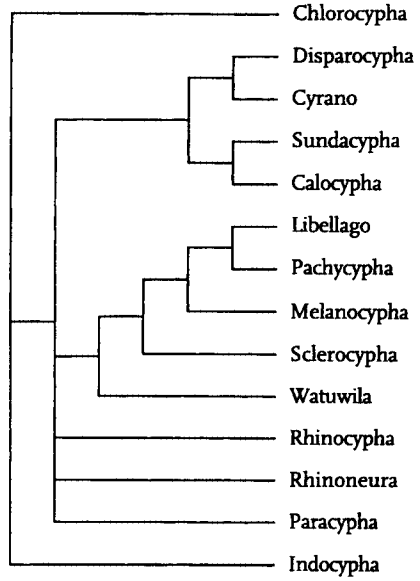


Fig. 9. Phylogenetic tree of 14 genera of Chlorocyphidae. See text and table 1.

Another trend is illustrated by a species of *Libellago* in Sulawesi. The taxon now known as *L. rufescens*, has developed geographically defined recognizable populations, which I hope to treat in another paper soon.

Recently published reconstructions of the geological history of Indonesia (Hall, 1996; 1997, see also the biogeographically most relevant discussion by de Boer, 1995) suggest a long history of isolation of Sulawesi, while various parts remained submerged until 5 to 15 million years ago. This long isolation may explain why so many groups of the Bornean fauna do not occur on Sulawesi. The complex geological history during the last 10 million years, reflected today in the complicated structures of the mountains in Central Sulawesi, must have had significant impact on speciation processes through isolation of populations of genetically plastic species. Differences in altitude over short distances, in combination with an overall short distance to the sea, will also have caused a high diversity in climatological conditions, like temperature and annual rainfall during periods of cool or dry climate. This fact might have improved the likelihood of survival of such unique forms as *Watuwila* and *Disparocypha* on Sulawesi.

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