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THE ODONATA OF SULAWESI (CELEBES), INDONESIA AN INTRODUCTION [1]

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During Project Wallace, an entomological expedition to the Dumoga-Bone National Park in northern Sulawesi, special attention was paid to the Odonata. Although the dragonfly fauna of Sulawesi is still imperfectly known, at least 143 species have been recorded up to now. The absence of Platycnemididae and Euphaeidae is notable ; Protoneuridae are rare contrary to islands West as well as East of Sulawesi. The fauna of the Dumoga-Bone National Park includes approx. half of the species recorded from Sulawesi. – Some notes on the ecology of the species are given. It appears that all species confined to primary forest are endemic to Sulawesi, while nearly all species of secondary biotopes are widely distributed in Southeast-Asia. The fauna of the larger rivers takes an intermediate position for this aspect.

INTRODUCTION

The dragonfly fauna of the Indo-Australian archipelago is relatively well understood, which is particularly the result of more than 50 years of study by Dr M. A. LIEFTINCK (cf. GEIJSKES, 1984 ; GEIJSKES & KIAUTA, 1984). The Odonata of Malaysia (i.e. the Malay peninsula, Sumatra, Java, Borneo and the adjacent small islands), Buru, New Guinea and of the island groups around New Guinea have all been thoroughly investigated by him. Revisions of several other island faunas of the Indonesian archipelago, however, are still lacking. One of the most important of these is Sulawesi (Celebes). This is perhaps due to the fact that LIEFTINCK collected on Sulawesi only in 1982, but he already had important collections under his care. These were mainly

[1] Results of Project Wallace No. 3.

made in the 1930's and 1940's. Some new taxa have already been described from this material (e.g. LIEFTINCK, 1936 ; 1948), but most have remained unpublished so far.

In 1985 I had the opportunity to join the Wallace expedition to northern Sulawesi. This "largest entomological expedition ever held" was organized by the Royal Entomological Society of London ; more than a hundred scientists studied the fauna and flora of the Dumoga-Bone National Park, situated between the Gorontalo and the Minahassa districts in the northern branch of Sulawesi. As a preparation for my work in that area I had, partly in cooperation with Dr. LIEFTINCK, already prepared a checklist of the Odonata of the whole island and a complete revision including keys and new descriptions may be expected during the next few years.

In this paper I would like to present a concise introduction to the composition of this fauna, a comparison of it with the Odonata of other islands in Indonesia, and finally give an account of the Dumoga-Bone National Park and its dragonfly fauna. Firstly, however, I will summarize the present knowledge of plate tectonics in this area, since this will give an impression of the peculiar geological history of Sulawesi, which certainly has had a great influence on the fauna of this island.

TOPOGRAPHY AND GEOLOGICAL HISTORY

Sulawesi is the central island of Wallacea, the contact zone of the Laurasian and Australian continents. Its surface amounts to 18.900 km^2.

The geological history (AUDLEY-CHARLES, 1981 ; AUDLEY-CHARLES *et al.*, 1981) is very complicated and indeed quite remarkable, since Sulawesi was formed only 15 million years ago by a collision of two islands, one belonging to Laurasia and the other to the Australian continent. The history starts approximately 140 million years ago, when Gondwanaland started splitting. Australia/ New Guinea/ Antarctica, and initially also India/ Madagascar moved eastwards from its previous position, the east coast of Africa. Soon thereafter Madagascar/ India again split off and India moved to the Asiatic coast during the following 85 million years. Subsequently it was pushed again further northward, partly covering a former landmass south of Tibet, and partly folding this and so causing the Himalaya. The plate with Antarctica/ Australia/ New Guinea moved more slowly eastward. After the splitting of Antarctica and Australia/ New Guinea some 53 million years ago, this plate collided with the Laurasian plate only 10-15 million years ago. In fact geologists believe that this process is still continuing, since the ridge

between Antarctica and Australia is still spreading. The result of this is, however, hard to detect, since the present-day geological situation is very complicated with sinuous contact and deformation zones between these continents.

There is also discussion among geologists on the way the two parts of Sulawesi have collided. Some of them believe that in the beginning of this process this island combination was pushed against the east coast of Borneo, and only thereafter has moved to its present position (HAMILTON, 1979). Another option for a connection between SE Borneo and SW Sulawesi was proposed by AUDLEY-CHARLES (1981). Since vast areas of the Makassar Strait are shallower than 180 m, at least during the late Pleistocene glaciations the sea level on earth was sufficiently low to expose this landmass.

This sort summary means for the biogeography that, next to newly arrived ready flyers among the Odonata, we may expect to find species of Oriental as well as Australian (Papuan) origin. Besides, one has to bear in mind that the tumultuous history of the island may have caused an impoverishment of the fauna of certain habitats, particularly of the "Australian" part.

ODONATA OF SULAWESI

Important collections of dragonflies were made during the 19th century. Quite a lot of the endemic species were already described by DE SÉLYS-LONGCHAMPS, mainly from material collected by e.g. VON ROSENBERG and FRUHSTORFER. Thereafter in the 20th century only during the 1930's and 1940's were dragonflies collected, e.g. by L. COOMANS DE RUITER, F. C. DRESCHER, L. L. A. MAURENBRECHER, J. J. VAN DER STARRE and L. J. TOXOPEUS. Most of these collections were presented to LIEFTINCK, who described several new species from this material. These collections are now in the Rijksmuseum van Natuurlijke Historie (Leiden) ; duplicates are in several other museums in Europe and in the Museum Zoologicum Bogoriense. Apparently no collections have been made between the early 1950's and the early 1980's. In 1982 Dr LIEFTINCK, assisted by Mr S. S. PARIWONO, collected in South and Central Sulawesi ; Mr PARIWONO has collected there again in 1983. Now I have collected some hundreds of specimens, predominantly in the Dumoga-Bone National Park ; during the same expedition several other entomologists also made smaller or larger collections in this area.

The checklist now includes 143 species, viz. 50 Zygoptera and 93 Anisoptera. This number is relatively low as compared with e.g. Borneo (259

species) or Sumatra (222 species) (Table I). It is, however, rather close to Java (156 species), which island is smaller as well as much better investigated.

A further comparison of the Odonata families of Sulawesi with those of Borneo (Table II) reveals that there are some remarkable deficiencies in the Sulawesian fauna. These include e.g. the absence of the Platycnemididae and Euphaeidae and the very low number of Protoneuridae.

Table I

Surface, number of species in Zygoptera and number of species in Anisoptera of four islands in the Indonesian archipelago (data from Borneo, Sumatra and Java from LIEFTINCK (1954), not updated).

	Surface (1000 km²)	Number Zygoptera	Number Anisoptera
Borneo	540	128	131
Sumatera	474	87	135
Sulawesi	189	50	93
Jawa	132	57	99

Table II

Number of species per family of Odonata on Sulawesi and Borneo. Data from Borneo as given by LIEFTINCK (1954), data from Sulawesi original.

	Sul	Bor		Sul	Bor
ZYGOPTERA			ANISOPTERA		
Amphipterygidae	0	1	Aeshnidae	15	26
Calopterygidae	2	4	Gomphidae	2	20
Chlorocyphidae	8	19	Cordulegastridae	0	2
Euophaeidae	0	8	Corduliidae	7	13
Lestidae	3	5	Libellulidae	69	70
Megapodagrionidae	2	8			
Coenagrionidae	23	37			
Platycnemididae	0	15			
Platystictidae	11	13			
Protoneuridae	1	18			
Total	50	128	Total	93	131

The Protoneuridae are certainly of Gondwanaland origin ; one subfamily (Protoneurinae) is confined to (South) America, one (Caconeurinae) occurs in India and adjacent areas, while the third one (Disparoneurinae) can be found in Africa, Asia and Australia. A closer look at the last subfamily shows that most genera are lacking or have only a very limited number of species in the contact zone of Laurasia and Australia s.l. Examples are given for the

Afrotropical-Oriental genus *Prodasineura* (Fig. 1) which is absent from Sulawesi although it shows a considerable radiation in Borneo ; this genus is thus a perfect illustration of a Wallace line distribution. On the other hand, one has the genus *Nososticta* (Fig. 2), which has radiated in New Guinea into nearly 30 taxa, whereas on the western edge of its range only a very limited number of species are found. One (endemic) species is widespread on Sulawesi, another one is distributed over Java and Sumatra, but this genus is otherwise confined to the Australian region.

According to WATSON (1981, 1982) the Australian species of *Nososticta* belong to a group of stream dwellers with northern affinities (together with e.g. the libellulids *Tetrathemis* and *Nannophlebia*). They all have a northern and northwestern distribution in Australia, and do not follow the cooler south- and central eastern seaboards as is usually the case with taxa with presumed Gondwanaland affinities. The question whether the genus *Nososticta* has an old (Tertiary) northern or southern origin remains in my opinion open to discussion as long as the phylogenetic relationships of this group are uncertain. In fact the same may be true for *Nannophlebia*. Papuan distribution patterns may certainly have arisen from stocks of Asian as well as of Australian origin.

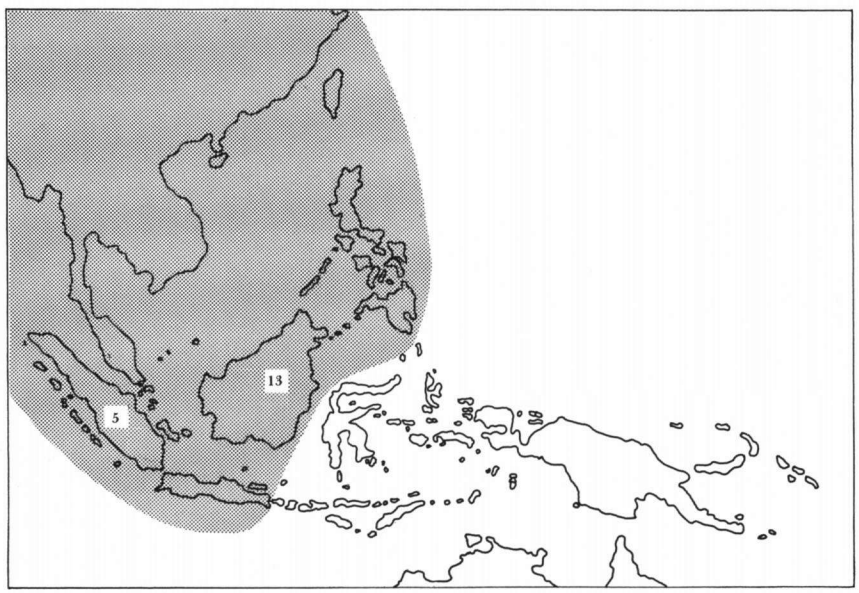

Fig. 1. Distribution of the genus *Prodasineura* Cowley, 1934 (Protoneuridae) in the Oriental region. Map mainly based on data in DAVIES & TOBIN (1984).

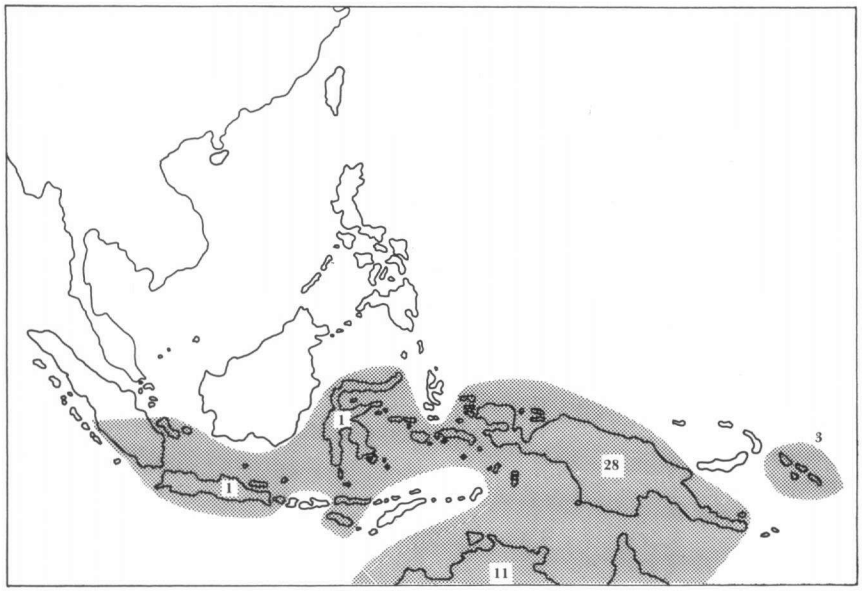

Fig. 2. Distribution of the genus *Nososcticta* Selys, 1890 (Protoneuridae) in the Oriental region. Map mainly based on data in DAVIES & TOBIN (1984).

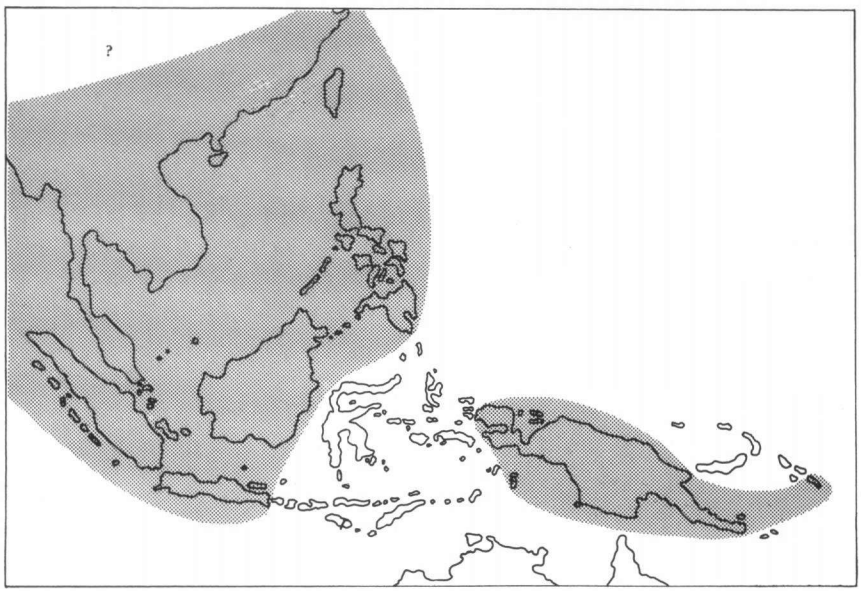

Fig. 3. Distribution of the subfamily Calicnemidinae (Platycnemididae) in the Oriental region. Map mainly based on data in DAVIES & TOBIN (1984).

My final example is the subfamily Calicnemidinae of the Platycnemididae. The subfamily is widespread in the Oriental region (Fig. 3) and several genera (e.g. *Coeliccia* and *Risiocnemis*) include many species. Calicnemidinae also occur in the Papuan subregion (genus *Idiocnemis*), but again also this group needs further taxonomic study before we can decide on the origin of this distribution.

The Oriental genus *Protosticta* (Platystictidae), however, has reached Sulawesi, and has developed here about fiveteen closely related taxa, nearly all with apparently small ranges. Only three species have been described up to now, but seven new ones have to be described from material now available.

THE DUMOGA-BONE NATIONAL PARK

The Dumoga-Bone National Park is a mountainous area in the centre of the north branch of Sulawesi, between the Gorontalo and the Minahassa. Its surface area is approx. 3.000 km^2, being nearly the whole catchment area of the rivers Dumoga and Bone, as well as of several other, smaller rivers. The establishment of this national park was strongly stimulated by the World Bank, since the adjoining valleys were made suitable for agriculture during a development project. These valleys are now irrigated by water of the rivers running from the primary forest, and it was understood that the preservation of the forest was needed to safeguard the hydrology of the valleys.

Vast areas of the Dumoga-Bone National Park are still undisturbed primary forest and, consequently, very hard to explore. There is only one road running along the north coast, and in fact quite a distance from the actual virgin forest. Most of the area can be explored only on foot, but also trails and tracks are very scarce. In the first few months of 1985 servicemen and scientists worked hard to make a few paths through the forest, mainly over the ridges to reach the hill and mountain tops (up to 1817 m, Gunung Poniki).

Rivers and other running waters are not very abundant in the (eastern) part of the park. Two larger streams are very close to the base camp, viz. the Toraut and Tumpah. Further one larger, permanent tributary of the Tumpah ("Waterfall Creek") and a few smaller, and at least partly temporary, brooks and spring areas could be studied. In the close vicinity of the base camp a few tanks (ponds) and ditches in cultivated areas are inhabited by aquatic invertebrates.

The Odonata collected in the running waters in the forest are summarized in Table III. Nearly all species here appeare to be endemic to Sulawesi,

whereas the secondary habitats are nearly exclusively inhabited by eurytopic, widely distributed species. We also established a quite obvious seasonality in the occurrence of the species. Several that were abundant as larvae in the waters, were not or hardly represented as adults during our stay. Seasonality is perhaps much stronger than one would expect in this environment without significant climatological seasonality (temperature as well as precipitation).

Table III

Dragonfly species recorded as adult insects along the running waters in the Dumoga-Bone National Park. *Paragomphus capitatus* only found as larva
(e = species endemic to Sulawesi ; R = rivers ; C = creeks ; B = brooklets).

			R	C	B
Calopterygidae	*Neurobasis kaupi* Brauer, 1867	e	●	●	
Chlorocyphidae	*Libellago rufescens* (Selys, 1873)	e	●	●	
Chlorocyphidae	*Libellago xanthocyanea* (Selys, 1869)	e	●		
Chlorocyphidae	*Rhinocypha frontalis* Selys, 1873	e	●	●	●
Megapodagrionidae	*Celebargiolestes cinctus* (Selys, 1886)	e			●
Coenagrionidae	*Pseudagrion ustum* Selys, 1876		●	●	
Platystictidae	*Drepanosticta ephippiata* Lieftinck, 1937	e			●
Platystictidae	*Protosticta simplicinervis* Selys, 1885	e	●	●	●
Protoneuridae	*Nososticta flavipennis* (Selys, 1886)	e		●	●
Gomphidae	cf. *Paragomphus capitatus* (Martin, 1909)	e	●	●	●
Libellulidae	*Nannophlebia aglaia* Lieftinck, 1948	e			●
Libellulidae	*Diplacina militaris* Ris, 1909	e	●	●	
Libellulidae	*Diplacina* nov. spec.	e			●
Libellulidae	*Orthetrum pruinosum* (Burmeister, 1839)		●		
Libellulidae	*Diplacodes trivialis* (Rambur, 1842)		●		
Libellulidae	*Celebothemis delecollei* Ris, 1912	e	●	●	

Summarizing, we may conclude that species richness on Sulawesi seems to be somewhat lower than expected, that most of the endemic species seem to be of Oriental rather than Australian origin, while the others seem to have Papuan affinities, and finally that the Odonata of primary forest streams are nearly all endemic to Sulawesi. The fauna of the secondary habitats are all widely distributed species.

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