FURTHER STUDIES ON SOUTHEAST ASIATIC SPECIES OF *MACROMIA* RAMBUR,

with notes on their ecology, habits and life history, and with descriptions of larvae and two new species (*Odon., Epophthalmiinae*)

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CONTENTS

I. Introduction

Although about fifteen years have elapsed since the writer commenced a critical study of the adults and larvae of the Asiatic species of *Macromia*, the results obtained so far are still insufficient and unfortunately do not in any way pretend to completeness. The slow progress that has been made has chiefly been due, apart from the intervening war years, to the difficulties experienced in discovering and rearing the nymphs and to the time and leisure required for obtaining a proper field of knowledge of the various species. It would therefore have been better, perhaps, to have delayed the publication of these notes for some years until more material had been collected. However, as most of the habitations where observations were made in the past are still inaccessible, I have been obliged to discontinue for an indefinite time the work necessary for

that purpose. This being the case, it was decided to place on record all the information so far obtained on the ecology and morphology of the larvae, and to issue analytical keys to the adults and immature stages of the Malaysian species at present known, including new records of localities and the descriptions of two new species. I hope to deal with the perfect insects and nymphs of other species (chiefly from China and the Papuan Region) on another occasion.

Although most of the material has been collected by the writer, the source of information is also to be found in the collections made by Messrs M. W. F. TWEEDIE in Malaya many years ago, and by Mr W. C. VERBOOM in Sumatra. To these gentlemen I wish to express my sincere thanks for their kind interest and help.

II. The Odonate fauna of a lowland stream in West Java

Before entering into a discussion of the life-histories and taxonomy of some Malaysian species of *Macromia* and of the various types of larvae, it seems worth while to describe briefly the topography and climate of the principal station in Java where life-history studies were made, and for a better understanding of these facts it appears useful also to give a general picture of its dragonfly fauna along with some ecological notes.

TOPOGRAPHY AND HABITAT

The following notes are mainly the result of four years collecting, at irregular intervals, chiefly at a small forest stream known as the Tjibarangbang, which crosses the inland road from Bogor to Banten about seven kilometres west of the village of Djasinga, between Ngasuh and Tjigelung. This little stream forms part of the drainage system of the Tjidurian which takes up many tributary rivers of fairly great length, nearly all of them flowing through cultivated country. One of these, the Tjibeureum, is only a foot-hill stream originating from a wooded hill-complex of perhaps 300 m above sea-level and south-eastwards about 5 kilometres distant from the point where the Tjibarangbang makes its appearance. The hilly topography of this area causes the Tjibarangbang to be one of a multitude of strongly meandering brooks which on the most detailed maps are indicated only by dotted lines. In reality, however, it is perhaps over twenty-five kilometres in length. Prior to the Japanese invasion (1942) and the subsequent reckless deforestation all over the island, it was the only stream within easy reach flowing through country where patches of secondary — or even virgin — forest had been left more or less untouched.

From its origin to the point where it flows into the Tjitundun (110 m alt.), this little stream makes only a descent of less than 25 metres within a distance of 10-15 km in a straight line. The smaller part of the area is

undulating and rises gently towards the low watersheds, whose spurs in places reach the bank of the stream. Up-stream it was explored for about one kilometre and down-stream a little less that distance. Its various tributaries are small rivulets across which one may easily step or jump, but the average width of the main stream is about six to eight metres.

At the point where it comes out of the forest is a rocky declivity over which the stream debouches through a narrow passage, terminating in a small fall, over which a stone bridge has been built. For half a mile or so above this bridge it flows through dense woods, but it is wide enough to admit the sunlight to a greater or less extent. Several smaller cascades and gentle rapids occur in the forest up-stream and here it is narrower with a sandier or stonier bottom; for the greater part of the explored stretch, however, it is just a shady brook with clear water, shallow ripples and sand bars, with intermittent pools or stretches of quiet and deeper water. Apart from the stony flats and gentle rapids, which are often covered with a slithery growth of bright green algae, there are but few rocky exposures along the course of the stream and there is little or no aquatic vegetation, except at the more open places in small bays and quiet bends where the current is much reduced and where lenitic conditions prevail. As to the velocity of the current in the stream, no attempt has been made to state the rate of flow as it is very variable during a short space of time and also in adjacent places.

At various places where there is a general decrease in the tractive power of the stream an increasing amount of finer deposit is seen which may form banks of gravel and coarse sand. Fine sand and silt occurs in strips of sediment along the banks and at many localities as shoals or as sand-spits in mid-stream.

From the above notes it will be clear that the Tjibarangbang presents a wide range of micro-topographic and biotic conditions and a great diversity of aquatic habitats.

CLIMATIC FACTORS

There are no data about the climate of the locality itself, but there has been for many years a meteorological station at Djasinga Estate (90 m alt.), 6 kilometres in a direct line NE from the Tjibarangbang bridge, and there are also data for Tjigelung (175 m alt.), which is almost 2 kilometres distant in a WSW direction. The climates of these two stations are practically alike, but owing to slight differences in elevation some of the climatic factors, in particular the rainfall, differ a little in the two places, especially the average maxima of daily rainfall. I have calculated the mean results of the figures available [1]) for both stations and these will give a sufficiently good general picture of the rainfall of our area.

[1]) Rainfall figures are taken from observations made during the period 1879-1922 by the Royal Magnetical and Meteorological Observatory at Batavia (Djakarta). See: *Verh. Kon. Magn. & Meteorol. Obs.* Batavia, 14, 1925, and *ibid.*, 23, 1931.

There are no definite wet and dry seasons, but the rainfall is higher during the west monsoon (November to March) than during the east monsoon (May to September). The mean annual rainfall is about 3570 mm. The wettest month (February) has a mean rainfall of 365 mm, the driest (July) of 205 mm. The number of days in each month with a measurable amount of rain varies from 20.4 during the wettest month (January for 1907-22) to 9.5 during the driest (July) and amounts to 192 per annum. The mean maximum daily rainfall is about 76 mm during the wettest month and 50 mm during the driest (116 mm annually), the recorded absolute maximum being 160 mm. The fact that there are averagely almost 44 rainy days during the four consecutive driest months of the year, proves that there is never a shortage of water.

Long periods of rain lasting a fortnight or longer are only frequent during the wet season months December to February, but weeks of continuous rain may occur in other months of the year (e.g. April 1936 and March 1937). For the rest of the year the mornings are nearly always bright, but heavy showers starting about midday or shortly afterwards and soon followed by a sudden rise of the water are common in all seasons of the year. In such cases the rain — often accompanied by squalls of wind — nearly always falls vertically and with great violence.

The range of mean temperatures for the different months of the year are very small, much smaller than the range between day and night, though even that is always less than 7°C.

COMPOSITION AND ECOLOGY OF THE ODONATE FAUNA

The most striking part of the fauna is — or was — the insect life, especially Odonata and Ephemeroptera, which here were found in an abundance and variation wholly unknown in ordinary lowland areas of West Java, where every stream flows through open cultivated country and which, as a result of the changed physical character of both the stream itself and its environment, have lost practically all autochthonous faunal elements.

It would have been convenient to examine the relations between the various animals and their environments in order to obtain an adequate idea of the economy of this stream. In a future more comprehensive paper I hope to discuss its faunistic ecology as a whole. Owing to the difficulty of identifying most immature organisms, and a great number of adults as well, I had for the present to be satisfied with the determination of the Odonata. These have been studied more or less carefully, and as may be seen from Table I, our list of the Tjibarangbang dragonflies comprises 32 lotic species. We know the habitat of the nymphs of most of these pretty definitely, but of a few (*Onychothemis culminicola* and *Macromia septima*) nothing is yet known, in spite of a careful search.

TABLE I. HABITAT PREFERENCE OF DRAGONFLY NYMPHS IN FOREST STREAM TJIBARANGBANG, WEST JAVA

Species (32) (Nymphs of 28 species identified.)	Rheobionts						Rheophiles		
	Clinging to rocks & hiding under stones	Clinging to aerial roots & hiding among root mats	Among débris assembling between stones in rapids & cascades.	Burrowing in fine gravel & sand	In clean sand of shoals & bars underlying moving water	Among leafy trash & débris in shallow water	Among algal growths on flats & stones	Among semiaquatic vegetation	In rock pools & almost stagnant water (benthic)
Euphaea variegata (RAMB.)	+								
Dysphaea dimidiata SELYS	+								
Drepanosticta gazella LIEFT. [1]	+								
Vestalis luctuosa (BURM.) [1]		+							
Rhinocypha f. fenestrata (BURM.)		+	+						
Libellago l. lineata (BURM.)		+							
Libellago sumatrana (SELYS)		+							
Prodasineura autumnalis (FRAS.)		+							
Prodasineura delicatula (LIEFT.)		+							
Notoneura insignis (SELYS)		+							
Neurobasis chinensis florida HAG.		+					+	+	
Macromia cydippe LAIDL.		+	+						
Idionyx montana KRÜG.			+				+		
Trithemis festiva (RAMB.)			+			+	+		+
Copera marginipes (RAMB.)		+	+			+	+	+	
Pseudagrion p. pruinosum (BURM.)		+				+	+	+	
Paragomphus r. reinwardti (SELYS)				+					
Megalogomphus icterops (MARTIN)				+					
Burmagomphus javicus SCHMIDT				+					
Macrogomphus p. parallelogramma (BURM.)				+					
Gomphidia javanica FÖRST.			+			+			
Macromia erato LIEFT.					+				
Macromia gerstaeckeri KRÜG.					+				
Macromia septima MARTIN					?				
Leptogomphus l. lansbergei SELYS						+			
Microgomphus chelifer thelyphonus LIEFT.						+			
Tetracanthagyna degorsi MARTIN						+			
Onychothemis culminicola FÖRST.						?	?		?
Ictinogomphus d. decoratus (SELYS)						+	+	+	
Orthetrum chrysis SELYS						+	+		+
Trithemis aurora (BURM.)							+	+	+
Pseudagrion r. rubriceps SELYS							+	+	

1) Species restricted to the upper reaches of main stream and smaller tributaries.

This list needs some explanation. It shows not only that there is a variety of habitat groups within the order, but on examining the columns from left to right one may also notice that these communities vary from the more typical truly lotic conditions to those of lenitic environments. [1])

Accordingly, the classification of these nymphs is based solely upon their habitat preference regardless of their taxonomy. Therefore we see that the true rheobionts appear in the first six columns while the rheophiles find their proper place in the last three columns.

About a dozen species of Odonata which normally develop in stagnant water but which have only incidentally been found at the stream, either in the adult or nymphal stage, have been left out of consideration because casual visitors will not concern us here.

SEASONAL INFLUENCE AND PERIODICITY

It is evident that the climate of the Tjibarangbang area has no sufficiently well-marked periodicity in its rainfall for some seasonal periodicity to be expected in the Odonate fauna, and one would not expect such climatic factors as atmospheric humidity and temperature to vary much over the area at any one time. Therefore these factors would not have great importance in the regional distribution of these insects.

Rainfall on the spot does not necessarily affect the organisms of the bottom fauna since all dragonfly nymphs remain adhered to stones below the surface or keep shelter between root mats, while others are capable of burrowing into sand and mud or hiding among leafy trash. It has repeatedly been noticed that a short periodic rise of the water mark followed by bright weather and a subsequent drop of the level has no influence whatever on adults and nymphs.

Periodic changes in the constitution of the fauna are chiefly brought about by prolonged periods of heavy rainfall, and as soon as flood conditions produce a rise in the river such as will sweep away logs and root up whole trees, then the effect is very considerable, causing great changes in the conformation of the stream bed. Owing to the sudden and often great increase in the volume of water in the stream, the current becomes very swift and considerable amounts of mud and sand are washed away.

The numbers of adults remain very low as long as the flood conditions last. It is unfortunate that only few visits were paid to the spot during periods of high water and dull weather; but as the stream then

1) Biotic conditions prevailing in the stream-bed surveyed are intermediate between the two environments, resembling the one or the other depending upon the rate of flow of the water. There is a definite succession of communities as one proceeds from the wider and sunnier stretches of the stream-bed below the stone bridge to the narrower and more densely shaded portion in its upper reaches above the bridge. These successions alternate and one may find a certain species flocked together in scattered localities over a fairly great distance. Where the stream crosses a small clearing the demarcation of any one region or community is difficult since they merge into each other. However, all species enumerated are obligatory.

is unfordable, the collecting of larvae is impossible and no adults are on the wing.

About the middle of December, 1936, the stream was in spate for at least 10 days and towards the end of that month dragonfly life had greatly diminished. On November 13, 1938, a flood resulting in a rise of almost two metres in the stream caused a marked decrease in the numbers of imagoes and the insects appeared to be unable to recover in the short dry and bright period that followed. This flood produced also a sudden drop in the number of nymphs. Normally, there is a constant succession of generations through the year, leaving no period of absence of larvae or imagoes. However, the unusual high water stages above alluded to submerge all the resting places for emerging larvae at the time that they are due to transform, resulting in the wholesale destruction of the normal accrue of a given population. It is obvious that from that time on the continuous succession of broods is brought to a standstill and only the remaining populations of imagoes are capable of reproduction.

One is naturally led to enquire how the species come safely through the adverse period and are able to make a reappearance when the conditions are again favourable. This we do not yet know. As many parts of the stream-bed are in a state of motion every time a spate arises, we may safely assume that a considerable number of larvae are carried away by the current. This applies particularly to nymphs living among débris such as dead leaves, twigs and similar forest materials stuck between large stones and logs, or to those hiding among trash at the edge of the water; probably also to the sand-dwelling nymphs of *Macromia gerstaeckeri* and allies (*vide postea*). In a previous paper [1]) I have referred to the fact that the younger nymphal stages of *Megalogomphus icterops* live in depressions under small stones of gravel bars at the edge of the stream, hence in the same places where the females oviposit, i.e. over the ripples in shallow water. The more matured larvae, however, whose burrowing capacities are notorious, prefer deeper water and bury themselves in sand and mud. Most likely the last mentioned group is also the most capable of resistance; but one may well ask if there exist definite correlations between any one nymphal stage and its abode in connection with the possibilities of surviving a torrent or flood.

One other point may be taken into consideration in this respect. As is well known, not all dragonflies will necessarily breed near their place of emergence. Adults emerged from larvae dragged away down the river may well find the way back to their favourite haunts instinctively. The results of four years collecting at the Tjibarangbang indicate that nearly all species inhabiting this stream have their own particular spots selected

1) Studies on Oriental Gomphidae, with descriptions of new or interesting larvae. *Treubia*, 18, 1941: 233-253, 7 pls. (p. 237).

by the females as suitable places for oviposition and it has repeatedly been noticed throughout the year that sooner or later the females will come (or return) to these spots when the water has subsided. Shifting of populations may therefore constantly be kept in check by the "homing instinct" of the females, and in that way the equilibrium may ultimately be restored again.

In conclusion we may say that it is merely after prolonged and heavy flood periods that the climate becomes a limiting factor for the occurrence of these riverine Odonata.

PHENOLOGY

For the sake of completeness and in order to gain an idea of the composition and periodicity of the dragonfly fauna of the Tjibarangbang, I have in Table II enumerated the dates of all visits paid to that section of the stream where collections and observations could be made, viz, from April 1935 until January 1939. It must be borne in mind that most visits to this locality were made on Sundays and on various other holiday trips. Other duties prevented me from making regular excursions to the stream and wide gaps exist between them, including one lasting more than a whole year (Oct. 1937 to Nov. 1938) due to the writer's absence on leave in Europe, and again during most of the year 1940. The data accumulated in this Table deal only with those species to which particular attention has been paid, most of the commoner species being left unnoticed. The Table is intended also as a reference list to other species and will be used on future occasions.

TABLE II. CHRONOLOGICAL SUMMARY OF VISITS PAID TO TJIBARANGBANG RIVER (DJASINGA, W. JAVA) SHOWING RECORDED OCCURRENCE OF ADULTS AND LARVAE OF 17 RESIDENT SPECIES OF ODONATA DURING 1935 - 1941.

Legenda:
| Adults on the wing
— Nymphs collected
\+ Adults and nymphs collected
○ Females ovipositing
⊕ Oviposition observed and nymphs collected.

Date of visits	*N. ch. florida*	*D. dimidiata*	*L. sumatrana*	*N. delicatula*	*O. culminicola*	*Macromia*				*G. javanica*	*M. icterops*	*B. javicus*	*P. reinwardti*	*M. parallogramma*	*L. lansbergei*	*M. ch. thelyphonus*	*T. degorsi*
						septima	*gerstaeckeri*	*erato*	*cydippe*								
1935 Apr. 28	|	|	|	|	○						|	|			—			
30	|	|	○		|					|	|		○	|		
May 12	|	—	|							|				○			
26	|								|								—

Date of visits	*N. ch. floridu*	*D. dimidiata*	*L. sumatrana*	*N. delicatula*	*O. culminicola*	*Macromia septima*	*Macromia gerstaeckeri*	*Macromia erato*	*Macromia cydippe*	*G. javanica*	*M. icterops*	*B. javicus*	*P. reinwardti*	*M. parallogramma*	*L. lansbergei*	*M. ch. thelyphonus*	*T. degorsi*
June 6 [1]																		
14																		
23																		
July 27 [1]																		
Aug. 2 [1]																		
4 [1]																		
18																		
Oct. 16																		
Nov. 24																		
Dec. 1																		
6																		
8																		
29																		
1936 Apr. 10																		
30																		
May 3																		
17																		
30 [1]																		
31 [2]																		
June 1 [2]																		
Sep. 20																		
Nov. 1																		
15																		
Dec. 29																		
1937 Feb. 7																		
Mar. 23																		
Apr. 30																		
May 6																		
June 6																		
July 10 [2]																		
18 [2]																		
Aug. 31																		
Oct. 11																		
1938 Nov. 13																		
15																		
Dec. 4																		
1939 Jan. 15																		
Apr. 30 [2]																		
May 14 [2]																		
Nov. 26																		
1940 Oct. 27																		
Dec. 8																		
1941 Jan. 1																		
9																		

[1] Locality visited only after 5 *p.m.*
[2] Locality visited also at dusk.

III. Ecological notes and observations on some *Macromia* larvae

We may now turn our attention to the biology of some species of *Macromia,* since they are the most important from the present point of view. The account which follows concerns not only the four species occurring at the Tjibarangbang, but also two others found at localities in Sumatra and Java which are ecologically different from the one described in the previous pages. The first mentioned species are *M. cydippe, erato, gerstaeckeri* and *septima* (see Table I), while the others are *moorei fumata* and *westwoodii.*

In a previous paper [1]) I have drawn attention to the fact that the larvae of oriental species of *Macromia* can be divided into several groups according to their mode of life. Since that was written the author has obtained further evidence in support of the view that there exist definite correlations between the habitat of the various larvae and their bodily structure.

It should be clearly understood that no species of *Macromia* have so far been found in swift or torrential streams where the bottom is practically free from plant débris or from sand. Accordingly, they have not undergone considerable morphological changes or developed strong adhesive structures by means of which they can withstand very swift currents [2]). In spite of that the adaptive peculiarities of structure and habit developed by *Macromia* nymphs seem to be worthy of consideration as an ecological factor in determining the distribution of the species.

HABITAT PREFERENCE

Although preference of *Macromia* nymphs for stream life is characteristic of the genus as a whole, the majority of the species inhabiting the temperate regions of the world are found in sluggish streams with a silty bottom, while certain ones are found in both streams and lakes. As to the tropical Asiatic species, it is only natural to expect that the essential conditions which would enable them to live also in the hot plains, should be shady forest-streams with an abundant supply of oxygen and maintaining a low temperature [3]). These conditions also exist to a certain extent in the almost stagnant pools of streams at higher altitudes above the sea, and although in both habitats we find the more advanced

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[1]) On some Odonata collected in Ceylon, with descriptions of new species and larvae. *Ceylon J. Sci.* (B), 22, 1940: 93-96, fig. 3 (larval structures), pl. 1, fig. 1 (exuvia of *M. zeylanica* FRAS.).

[2]) For interesting ecological studies on stream-dwelling insects in temperate regions, the reader is referred to the articles of G.S. DODDS & F.D. HISAW, entitled "Adaptations of Mayfly nymphs to swift streams", and "Adaptations of Caddisfly larvae to swift streams", *Ecology,* 5, 1924: 137-148, 2 pls, and *ibid.,* 6, 1925: 123-137, figs. See also E. PERCIVAL & H. WHITEHEAD, "A quantitative study of the fauna of some stream-bed", *Journal of Ecology,* 17, 1929: 282-314.

[3]) *M. cincta* RAMB. probably breeds in stagnant water; its larva is still unknown.

nymphal forms of *Macromia*, it is in the smaller streams with a moderate current that we find the most specialized types of larvae, which are adapted to a life in running water. Assuming that quiet waters were the first to be peopled by the ancestral members of the subfamily, it is likely that the swifter waters were invaded gradually by more highly specialized forms.

The accompanying sketches of cross-sections through a stream-bed (p. 668) may give an impression of the habitat preference of some species of *Macromia* larvae. It must be emphasized, however, that not all of these types do occur together in the same portion of stream. The so-called submontane species, known to occur preferably in mountainous regions where the water maintains a low temperature, are exemplified by the habitation *a*; here the nymphs either live among decaying plant material on the bottom of cold deep pools, or lie buried in surface sand in places where the strength of the current at all events is diminished. On the other hand, the habitations *b*, *c* and *d* indicate the abode of species frequenting the lower reaches of the stream, which flow through hilly or almost flat country, but which have a swifter current.

[I have followed THIENEMANN [1]) in distinguishing between a lotic and lenitic shore zone in the bed of a strongly meandering stream. In a sluggish forest-brook with a feeble descent sharp lines can not always be drawn between these habitats: notwithstanding the presence of surface eddies and water of considerable depth, even the lotic bank at the convex bends of the stream may be characterized by a retarded current resulting in a shore vegetation and aquatic fauna which more or less resemble those characteristic of lenitic environments.]

ADAPTIVE MODIFICATIONS OF FORM AND STRUCTURE IN RELATION TO HABITS AND ENVIRONMENT

The adaptive modifications of Malaysian *Macromia* nymphs to their environment may be divided into two main groups, comprising (1) species that withstand the current by hiding among vegetable obstructions and root mats, and (2) species showing adaptations which enable them to avoid the current by living buried in the substratum. No sharp lines can of course be drawn between current-resisting and current-evading insects and, as we will see, the ability to withstand the current is by no means lacking in the flat sand-dwellers of the *gerstaeckeri* group, which therefore could as well be classified as current-resisting species. Both groups solve the problem of retention in the stream in a different way and they have their own problems of locomotion in search of food and in flight from enemies.

1) A. THIENEMANN, Das Leben der Binnengewässer, Stuttgart, 1927.

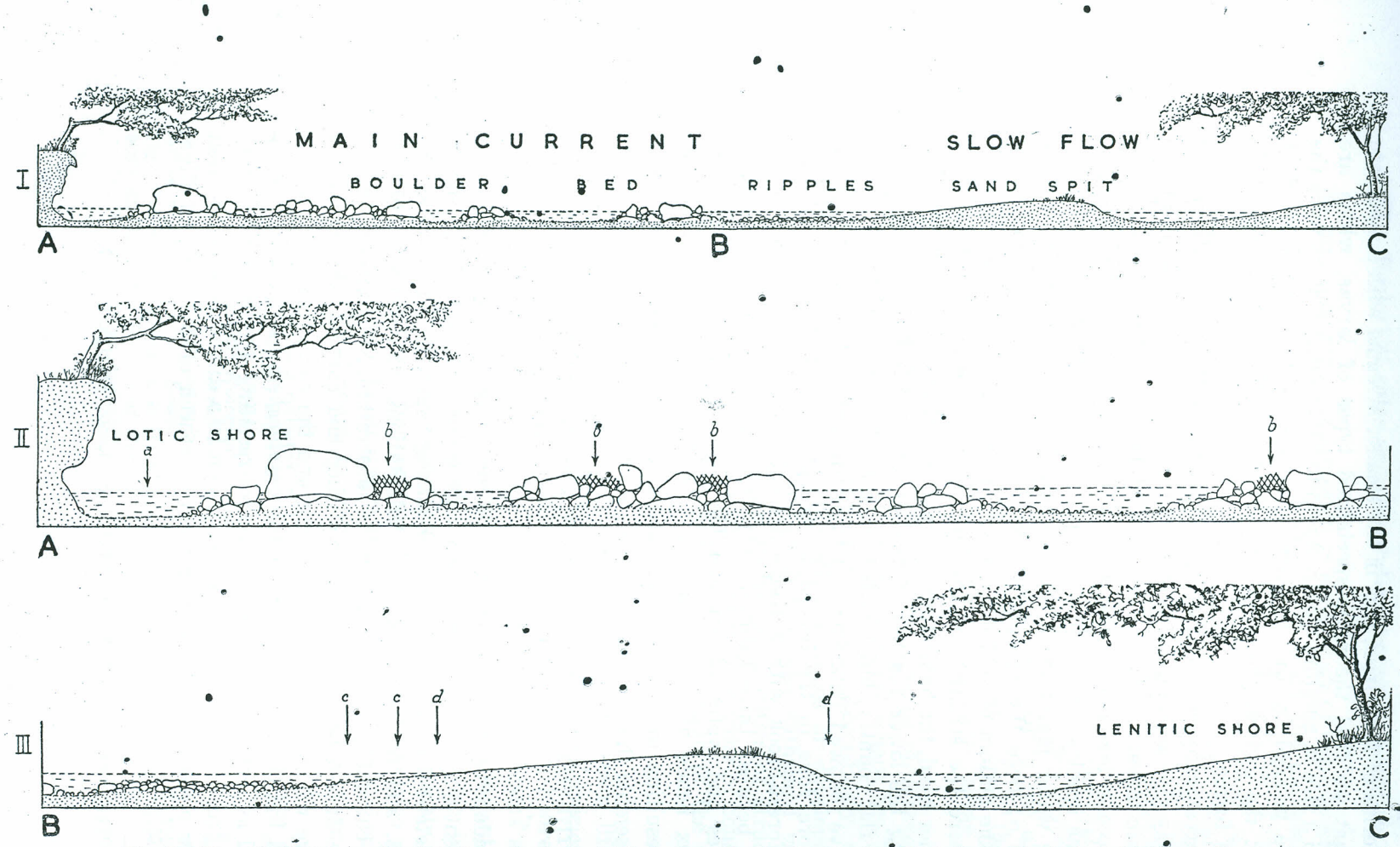

Fig. I. Hypothetical cross-section through the bed of shady upland stream in West Java. Typical habitat of *Macromia*. — Fig. II and III. The same through portions A — B (main current) and B — C (slower current) of same stream, showing habitat preference of the larvae of four species of *Macromia*, viz *a* — *M. moorei fumata* (clear cold pools at the foot of cascades, etc.); *b* — *M. cydippe* (among leafy trash assembled between boulders &c in swifter current); *c* — *M. gerstaeckeri* (coarse and fine sand at edge of main stream); *d* — *M. erato* (deposits of fine sand underlying slower current). Nymphs of *b*, *c* and *d* may occur together simultaneously in same section of stream whereas *a* develops in colder parts of its course at higher elevations, but not necessarily in running water.

1. Species that withstand the current by hiding among vegetable obstructions and root mats.

M. cydippe LAIDLAW (fig. 52-53).

As to the nymph of *cydippe* we are sufficiently well informed to establish the fact that it differs widely from the other species in the place of abode it occupies in the stream. At the same time it shows peculiarities of structure and habit not shared by members of the *gerstaeckeri* group.

M. cydippe has none of the striking modifications of the flat-bodied nymphs discussed below, but it is interesting to see that it lives in swifter water than the sand-dwelling and more specialized types. The most noteworthy character of this nymph is seen in a cross-section of the body, which presents an almost perfect equilateral triangle; the back is carinate, sloping away on either side, making a high roof-shaped body. The points of attachment of the slender legs are much closer to either side of the body than in the sprawling species, the legs themselves being considerably shorter in proportion to the body than in the sand-dwelling larvae; they are not noticeably flattened and the tarsal claws are only small and strongly curved (see table of measurements). The requirements of offering least resistance to the current and of exposing the minimum surface of the legs have been met by folding them upwards and by pressing them against the sloping sides of the body.

The nymphs of *cydippe* do not live upon the exposed surfaces of logs and stones, where they receive the full force of the current, but hide themselves among vegetable matter that clogs the passage between large stones and boulders, usually in mid-stream (see sketch of cross-section through river-bed on p. 668). They afford an example of a species only capable of withstanding the current of small cascades and rapids by seeking protection among the choking material accumulated at such places. The ability of the nymph to press itself closely to a leaf is much increased by the perfectly flat and smooth ventral surface of the abdomen which effectively prevents the animal also from being lifted from the substratum by water running under it. A nymph found resting on a dead leaf that is taken out of the water by its pedicel, may remain attached to the wet surface of the leaf, aided by the adhesive power of its abdomen; during the attachment the insect can slide itself along over the surface. It spends most, if not all, of the time among the leafy débris and moves very slowly from place to place, always with the head up stream and blocking the openings through which the water flows. It may thus lie in ambush, waiting for prey. This nymph is apparently unable to swim against the current and is carried away when its hold is broken. It is, for practical purposes, no swimmer, but on being disturbed, clambers through the débris in the sieve basket and tries to escape. As far as

my own experience goes, *M. cydippe* was the only species of its genus to be found also in root mats and, even more frequently, among masses of aerial roots of lianas swaying in the current.

I have not seen any specimen during transformation nor have I found the exuviae of *cydippe*. The nymphs probably climb up the clay banks, crawling away from the water's edge to ascend some tree before transforming and hence may easily escape observation. They were especially abundant on Dec. 1, 1935, Febr. 7 and Aug. 31, 1937, Oct. 27, 1940, and Jan. 1, 1941, but may have been found equally numerous on other days when no particular attention was paid to them.

The full-grown larvae are much sought after by native fisherwomen who collect them eagerly along with small fish, shrimps and mollusks (*Melania*), the ingredients being roasted and consumed indiscriminately as food. On December 1, 1935, I picked 22 full-grown nymphs out of a native woman's basket, the result of a few hours' collecting at the stream. By its dark brown, chestnut and purplish colours this nymph is wonderfully adapted to its environment of similarly coloured rotten leaves, but unlike the Epigomphine larvae and the nymph of *Gomphidia* — which seek shelter among trashy material in quiet edges of the stream — the peculiar habit of "death-feigning" has not been observed in the nymph of *cydippe*.

Although the nymphal gut contents have not yet been carefully examined, it is believed that the larvae will consume any suitable material which is present. Tipulid larvae, snails and shrimps were common in the leafy trash between rocks. Many adults were bred from larvae kept in petri-dishes placed in ordinary breeding cages at Bogor. They were fed with snails and earthworms, which were readily taken.

M. westwoodii SELYS (fig. 55).

As a matter of fact, the nymph of this species should be placed more properly into the next category, or in a group of its own, for although *westwoodii* no doubt is closely allied with *cydippe*, its nymph differs in several respects from that species. In outward appearance and body-structure it has retained the more "primitive" nymphal characters of the genus and may be considered a derivative of lenitic forms that has undergone the minimum structural change for a life in standing or slowly running water at some altitude above the sea. The body is neither so strongly flattened as in the larva of *moorei fumata* and those of the *gerstaeckeri* group (including also such species as *zeylanica* FRASER), nor yet so strongly arched and crested as in *cydippe*. It is easily distinguished from other *Macromia* larvae by its huge labial mask, but approaches *cydippe* by the absence of a frontal tubercle and in having short tarsal claws which, however, are less strongly curved (fig. B). Two nymphs were dredged up from "near a waterfall" at 750 metres

above sea-level, and once a larva was found "in a rice-field" by one of Mr DRESCHER's collectors. Mr DRESCHER found *westwoodii* not uncommonly in the narrow ravines on the southern slope of Mt Slamat (Central Java), but assumes that the nymph may be found among débris at the bottom of pools with almost stagnant water.

2. Species which avoid the current by living buried in the substratum.

The forms united in this group are rather similar in outward appearance, comprising flattened species with sprawling legs, which have excellent powers of swimming. They are represented in the Malaysian fauna by two types of larvae which are entirely dependent of the substratum, but whereas

(a) is a bottom-dweller of deep pools in the bed of mountain streams, showing adaptive specializations for withstanding periodical violent stirring of the water when the river is in spate;

(b) includes true rheobionts that live buried in sand underlying the current of small streams in low country.

The following notes may illustrate the structural features and the habits of these nymphs.

(a) **M. moorei fumata** KRÜGER (fig. 36, 54).

Superficially, there is great similarity in appearance and shape between the nymph of *m. fumata* and those of the *gerstaeckeri* group. There are, however, the following important differences: — the whole insect is more solidly built, the thorax being considerably more robust and also higher, while at the same time the abdomen is very flat and more abruptly depressed beyond the wing cases, tapered to a point posteriorly. The nymph is perfectly clean (from its habit of living) and the chitinous parts are much more heavily pigmented than in the pale sand-dwelling species. The antennae are relatively longer and the facetted portion of the eyes larger and less projecting. The sprawling legs are also much stronger while the femora are distinctly flattened. Lastly, the tarsal hooks are not nearly as long and slender as in *erato* and *gerstaeckeri*, resembling closely those of *westwoodii*. This is significant when we seek to correlate the shape and size of the tarsal claws with the nature of the substratum as we have found that groups (a) and (b) differ markedly in regard to habitat (see under these species and cf. figures A-D).

The nymph of this species is typically an inhabitant of cold deep pools in the bed of rocky forest-streams in mountainous districts. At Luwung Njawa examples of it were dredged up with the débris and coarse sand on the bottom of a series of pools where there was a great

reduction of current, e.g. at the foot of cascades or beneath some tilted boulder which had its downstream end raised. Although in such situations the current may strike the upstream end of a boulder at great velocity, the speed beneath may be practically nil. Here they live, either on the sandy bottom, lying hidden in a sheltered corner or half buried in the muddy trash of the pool. When disturbed, the nymphs swim rapidly and wildly to another place where they suddenly come to rest on the bottom, much in the way of *eratc* and allies. Possibly this larva is adapted to life in deep water, utilising the weight acting on the peculiarly flattened body to press it to the bottom. When carried along by a rush of water this insect, like the sand-dwellers of shallow streams, bends its spidery legs back over the body till the knees of the posterior two pairs nearly meet in the median line, and describes arcs until it comes to rest.

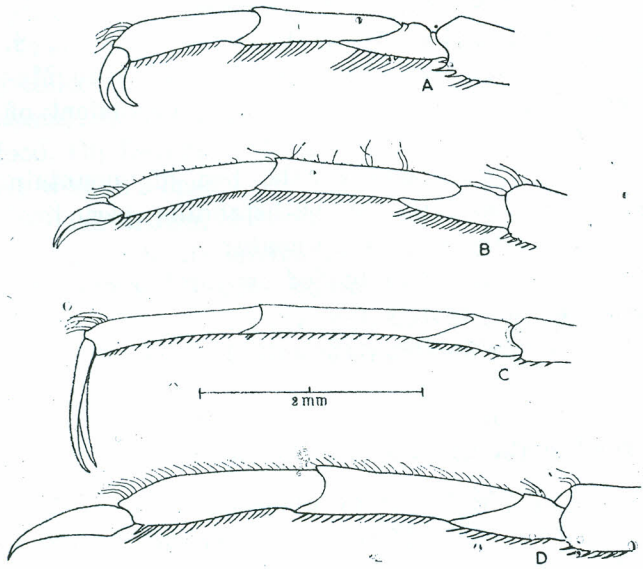

Fig. A-D. Posterior tarsus of full-grown larva of *M. cydippe* (A), *westwoodii* (B), *gerstaeckeri* (C), and *moorei fumata* (D), showing different shape of claws.

The colour-pattern varies a great deal in individual specimens, both in intensity and detail, according to the locality. It may rely for capturing its prey on its protective colouration which sometimes suits its habitat remarkably well, the darkest nymphs being those which occur among rotten leaves (fig. 54).

I am much indebted to Mr VERBOOM who on several occasions supplied me with live specimens collected by him on the slopes of Mt Dempo in South Sumatra, at altitudes from 1200-1500 metres. They were associated with the nymphs of *Chlorogomphus* and of an unknown Gomphid, both species unfortunately remaining unidentified.

Immediately after their capture the nymphs were put into empty cigarette tins containing wet moss and sent to Java by air mail. Many larvae died in transit within three days, or soon afterwards, but several others yielded imagoes at the estate Tjisarua, a locality near Bogor, situated approximately at the same altitude as their natural habitat. In breeding this species in captivity I used large petri-dishes, about 22 cm diam. and 6 cm high. After trying various methods, it was found

that the best plan was to provide the dishes with a thick layer of coarse river sand and to fill them with rain water. To prevent the buried nymphs from being disturbed, it was best to leave the water stagnant and not to change it, only supplying sufficiently to make up for loss by evaporation. These containers were left uncovered in an open verandah until some days before emergence, when the nymphs had ceased feeding. Then smaller dishes were required for isolated specimens which were placed in our breeding cages before transformation.

In captivity the nymphs showed very little activity. In most instances it took many hours or even days before they got accustomed to their new environment. Occasionally they took shelter under rotten leaves, but eventually all nymphs were attracted to sand for concealment. They threw up the sand all over them with their fore legs, writhing with their body and sweeping slowly and deliberately with their legs, scooping out in the process a depression into which they settled until almost completely buried, the abdomen slightly curled up and leaving only the head and the tip of the abdomen visible.

No observations on the feeding habits of this species could de carried out on the spot, and since all available nymphs were reared with a view to obtaining the perfect insects, the gut contents were not examined. As the nymphs when finally buried but rarely moved their position, they had to be fed regularly and separately. In the course of our experiments they were supplied with mosquito larvae whenever available; these were devoured eagerly and in great quantities. Small tadpoles, earthworms and snails also formed part of their diet and were accepted with equal ardour.

(b) **M. gerstaeckeri** KRÜG. and **erato** LIEFT. (fig. 38-39).[1])

The two species under discussion are sand-dwellers *par excellence.* The full grown nymph is a pale sandy yellow creature, showing a delicate and finely mottled pattern of light brown that harmonizes well with the environment. It has a broad and very flattened body and exceptionally long and spidery legs. Though only little expanded, the legs are thin, depressed and radiately arranged, and are held perfectly in a horizontal plane so as to lie nearly parallel with the current. The tarsal claws are remarkably long and slender, almost straight and tapering to a fine point; they will no doubt give a much more stable anchorage in the loose sand than the short hook-like claws of *cydippe* (fig. C). The body is highest at the point of attachment of the wing-buds, which are usually just exposed to the current, becoming flatter posteriorly where the current flows off, thus employing the stream-line principle in reducing resistance in a modified way, very different from the method followed by the limpet-like forms like *cydippe.* The head is also flattened

1) For the nymph of *M. septima* see under that species.

but the facetted portion of the eyes is knob-like and projects strongly upward and forward. When completely submerged, only the eyes and part of the median ridge of the thorax emerge above the sand. It is interesting to recall NEEDHAM's sprightly description [2]) of the habits of nearctic Cordulegasterid nymphs, which, with slight alterations would apply equally well to our present nymphs.

"The nymphs live on the bottom in shallow water, buried in clean sand or in vegetable silt. Though buried they do not burrow, but descend by raking the sand beneath them by sweeping, laterial movements of the legs. When deep enough, they kick the sand up over the back till only the elevated tips of the eyes and the respiratory aperture at the tip of the abdomen are exposed. By placing a live nymph in a dish of sand and water and watching, its method may be observed in a very few minutes. The whole comical performance reminds one strongly of the descent of an old hen in a dust-bath. Once adjusted in the sand, a nymph (unless food tempts) remains motionless a very long time. In a dish of sand on my table, I have had a nymph remain without change of position for weeks, no food being offered it. Let any insect walk or swim near the nymph's head, and a hidden labium springs from the sand with a mighty sweep and clutches it."

In captivity our larvae behaved much in the same way as described, except that the swaying and squirming movements were executed first by the abdomen and later, when buried half way in the sand, also by the fore legs, which sweep the sand on upon the head and body.

Oviposition takes place over the ripples usually at the edge of the stream in very shallow water. There is reason to regard the miniature sandy depressions and hollows between gravel and loose stones as a nursery for a considerable portion of the *Macromia* fauna since only the youngest stages were found there. These little creatures are very flat, coloured pale yellowish speckled with brown, and have enormous sprawling legs. Owing to their minute size and sandy colour they are extremely difficult to detect. The environment probably affords enough shelter to retain a hold and may serve as a centre from which the nymphs migrate when they are about half grown. The later instars gradually seem to change environment as many were raked up and sifted out with sieve baskets from the sandy shore deposits or from the more or less permanent sand banks on the lenitic side of the stream. The current here is only slow, especially during periods of prolonged drought. We have observed that the greatest number of larvae are found in sand which carries a shallow layer of water, *M. erato* especially being the species that lies buried under a thin cover of sand at the very edge between the water-mark and the exposed bars (see sketch on p. 668).

2) J. G. NEEDHAM & C. BETTEN, Aquatic Insects in the Adirondacks. *New York State Mus. Bull.* 47, 1901: 473-474.

This peculiar habitat preference can perhaps be associated with the nature of the food as the full-grown larvae derive their nutriment chiefly from small shrimps, which abound in the shore zone.

Most of the collected nymphs were sifted from the margin of flat shoals left behind by the receding water and from sandy stretches along the banks. They did not appear less abundant in this environment soon after a freshet had caused a marked shifting of the sandy deposits than after a long dry spell when the water was low. This suggests that during a time of flooding the larvae are washed away downstream with the deposits that carried them b e f o r e the rise of the water, and that they do not require a stable substratum for proper development.

The matured nymphs are excellent swimmers, propulsion being performed in the usual anisopterid way, by ejections of water from the respiratory chamber. As a result of its low specific gravity and its flatness, the nymph when trying to escape makes away with astonishing speed, the long legs diverted straight backwards after every ejection. In the stream they orient themselves always with head against the current, waiting for prey in an attitude of alertness. The nymphs are probably able to swim against a moderate current in such places as carry a sandy bottom, and it is possible that they visit the upper surface of the substratum in search of food when the water is low. I have rarely observed this, however, even when kept in petri-dishes in the laboratory, as the nymphs stick rigidly to their environment, covering themselves with sand as soon as the opportunity is given.

At the Tjibarangbang the adults of these two species flew in company of each other, together with *septima* and *cydippe*. They were very scarce and difficult to catch and occurred in about equal numbers, except *septima*, which at times was less rarely met with, and *cydippe*, which far outnumbered all the others. The adult of *erato* is entirely similar in general appearance and habits of flight to *gerstaeckeri* and *septima* and could only be distinguished therefrom by the characters employed in the key.

As to the larvae of *erato* and *gerstaeckeri*, I am unable to find any differences in facies between them in the immature stages. Our figures 38 and 39 are seemingly not alike, but it should be borne in mind that fig. 38 of *erato* represents a living example while fig. 39 of *gerstaeckeri* was made after a fresh individual preserved in spirit (see also pp. 701-702). The description on page 696 will therefore stand for both.

Because of their rarity, the nymphs were collected indiscriminately at all suitable localities in the stream. On examining a sand bar it was noticeable that seldom more than a single or a couple of specimens were found together. All larvae in the penultimate and ultimate instars were carried home alive and raised in order to establish their identity, which

remained unknown until after emergence of the perfect insect in the laboratory at Bogor.

In spite of this, some observations carried out here and at some other breeding places nearby, suggest that the nymph of *erato* more frequently occurs in sand bars at the lenitic side of the stream than does *gerstaeckeri*. Nymphs of *erato* sifted from fine sand at the edge of a brook near Tjipeundeuj, bear witness of this species living also in shallow water with a slow current, provided that the water is clear and the brook is shady. On the other hand, all reared nymphs collected at the river Wai Tebu in South Sumatra, were sieved from sand deposits underlying a swifter current, and yielded only *gerstaeckeri* (see p. 700).

The nymphs could easily be kept together in close quarters without doing harm to each other, but they had to be fed separately with pieces of earthworm or raw meat. Food was accepted only when brought above the head, which suggests that the prey under natural circumstances is captured while passing over with the current.

In our breeding cages transformation took place early in the morning.

DURATION OF LARVAL LIFE

As far as I know, the number of larval instars and the duration of the life cycle is not known for any of the Old World species of *Macromia*, but the larva of most regional species may reach maturity within one year of hatching.

It took me 99 days to rear one nymph of *gerstaeckeri* taken in the ante-penultimate instar, the penultimate and ultimate instars lasting 44 and 55 days, respectively. The ultimate instar of a second nymph lasted 52 days.

IV. Geographical distribution of *Macromia* in Malaysia

Species	Malay Peninsula	Sumatra	Java	Borneo	Bangka	Billiton	Further range
callisto	+						
cincta	?	+	+	+	+	+	Palawan
corycia				+			
cydippe	+	+	+	+	+	+	
erato			+				
euterpe				+			
gerstaeckeri	+	+	+				Philippines ?
mnemosyne				+			
moorei fumata	+	+					Celebes
polyhymnia		+					
septima			+				Tonkin
westwoodii	+	+	+	+			
Total	5	6	7	6	2	2	

Owing to their scarcity, inconspicuous coloration, and retiring habits, the range of most species of *Macromia* is still very imperfectly known. Most, if not all, species have a wide distribution, and we may safely assume that at least some of them will turn up sooner or later in other islands of the Malaysian Subregion. No species has as yet been reported from the island of Bali or from other islands of the Lesser Sunda chain. [The only species definitely known from the Philippine Islands, is *nigrito* NDH. & GYGER, whilst two species are now known to occur in Celebes, viz *irina* n. sp. and *moorei fumata* KRÜG.]

V. Taxonomy of adults and larvae

KEY TO THE KNOWN MALAYSIAN SPECIES OF *Macromia* [1])

1. Anal angle of posterior wing of male well-pronounced but rounded; anal margin between membranula and the angle itself straight to deeply concave . . . . . 2.

1'. Anal angle of posterior wing of male sharply acute; anal margin between membranula and the angle itself concave. Small portion of ventral margin of 2nd abd.-segment of male close to the anterior end of segment, thickened and beset with a bunch of very stiff short bristles. Dorsum of synthorax without distinct antehumeral bands. Dorsum of 10th abd.-segment with acutely pointed triangular process. Sup. anal apps of male pointed and recurved apically and with well-developed extero-lateral tooth on each at about the middle; inf. app. usually a little longer than superior pair. Front of head very dark brown, pyramidal processes black, slightly or not metallic. Segments 2-6 of abdomen black or brownish-black without metallic lustre; 2-4 at least with yellow markings on the dorsum. Posterior wing with more than one cross-vein in the supratriangle. At most two basal cross-nerves in the discoidal field of male posterior wing running directly from M_4 to Cu_1. At least the anal area of posterior wing partly yellow and the extreme base of both pairs with a rusty dark brown mark (male) or with these marks considerably enlarged and quite conspicuous (female). Tips of anterior wings of female nearly always brownish-yellow. Membranula greyish-white. Keel on flexor side of anterior tibia about half as long as or slightly shorter than tibia. Valvula vulvae well-developed, entirely divided into two leaf-like lobes, each of which is somewhat pointed apicad. Genital lobe small, its ventral margin almost straight in lateral view and beset with dense brush-like stiff bristles. Posterior hamuli broad at base, their ventral margin undulated in profile view, then slender, boldly recurved apically so as to be hook-like. Size rather large: ♂ abd. + app. 47-49.5, hw. 43-47.5, pt. 3-3.2 mm; ♀ 50-52, 48-50, 3.0-3.6 mm. Larva unknown. Hab.: Malaya?; Sumatra; Bangka; Billiton; Java; Borneo; Palawan . . . . . **cincta** (RAMB.)

[1]) Including *M. negrito* NEEDHAM & GYGER, from the Philippine Islands.

2. A small anterior portion of the ventral margin of 2nd abd.-segment of male beset with a row of inwardly directed, very stiff, short black bristles. Excavation of frons very broad; upper part divided into two more or less triangular, conspicuously flattened parts, brilliant metallic-green in colour, the lateral border of each of these parts markedly ridged. Front of head dark reddish-brown without yellow markings. Thorax dark golden brown with slight metallic-green lustre at the sides, this metallic colour more conspicuous on dorsal third of mesepisternum. No traces of antehumeral yellow spots or bands. Keel on flexor side of anterior tibia distinctly less than half as long as the tibia. Rarely more than one cross-vein in the supratriangle of posterior wing and usually with at least two basal cross-veins in the discoidal field of posterior wing running directly from M_4 to Cu_1. Triangle of same normal in shape and size, and the veins M_3, M_4, Cu_1 and Cu_2 of same not noticeably strongly curved towards the anal wing border. Wings without basal spots; membranula grey. Abdomen black, segments 2-6 slightly shiny but without metallic-green lustre; 2-5 and 7 with orange-yellow markings. Segm. 10 obtuse-angulate in profile view, with a pair of blunt baso-dorsal tubercles and a prominent mid-dorsal keel. Genital lobe broadly triangular, its ventral margin with a dense brush-like bunch of forwardly directed stiff black hairs. Posterior hamuli long and slender, hook-like, their distal two-thirds gradually curved. Sup. anal apps of male tapering and recurved apically, abruptly and acutely pointed at extreme tips, each with well developed extero-lateral tooth at about the middle; inf. app. equal in length to superior pair. Female resembling the male in most respects, except in venational details. A small basal yellow spot in *c-sc* up to Ax_1 in both pairs of wings. Valvula vulvae very short, deeply divided into two triangular blades, the excavation widely V-shaped. Size rather large: ♂ abd. + app. 48-49, hw. 45-46, pt. 2.3-2.6; ♀ 45-49.5, 45-49.5, 2.7 mm. Larva with a distinct frontal horn (fig. 54). Hab.: Malaya; Sumatra; Java; Celebes . . . **moorei fumata** KRÜGER.

2'. Ventral margin of 2nd abd.-segment of male without a row of inwardly directed short black bristles near its base. Excavation of frons very broad, shaped similarly to *m. fumata* but the upper parts not divided into two conspicuously flattened or framed parts, brilliant metallic-green in colour . . . . . 3.

3. Triangle of posterior wing in both sexes noticeably smaller than that of anterior wing and with the costal and distal sides only little longer than the proximal one (especially in the ♀). Apical portions of the veins M_3 and M_4 in all wings abruptly curved towards the margin of the wing, and veins Cu_1 and Cu_2 in posterior wing also strongly arched, entering the wing-margin approximately under a right angle. Front of head reddish- to dark brown with no yellow markings. Segments 2-6 of abdomen unicolorous dark brown with shining metallic-green lustre, especially brilliant on proximal segments, but entirely without yellow markings in adults.

Segm. 10 with a more or less pointed triangular boss on dorsum near base of segment and with a prominent mid-dorsal keel. Sup. anal apps of male of delicate build, with the apices recurved, gradually tapering to a fine point, and carrying a more or less distinct extero-lateral tooth at about the middle of their length . . . . . 4.

3′. Triangle of posterior wing in both sexes approximately equal in size to that of anterior wing and with the costal and distal sides distinctly longer than the proximal one. Apical portions of the veins M_3 and M_4 in all wings evenly curved, entering the wing-margin at their proximal side under an acute angle; Cu_1 and Cu_2 not so strongly arched and entering the wing-margin under an acute angle. Antehumeral yellow stripes on dorsum of synthorax invariably present, though often narrow and incomplete above. Segments 2-6 of abdomen very dark brown or black, with or without metallic-green lustre, but at least segm. 2 with well-defined clear yellow or orangish spots or bands . . . . . 6.

4. Mesepisterna of thorax brown, upper third with metallic-green reflections, but with no trace of yellow antehumeral stripes. Posterior hamuli not as described below, their apices not tapering to a point. Sup. anal apps of male shorter than the inferior. Ends of veins M_3 and M_4 and of Cu_1 and Cu_2 in posterior wing strongly curved, but less markedly so than in *westwoodii*. Segments 2-5 or 2-6 of abdomen with rich metallic-green lustre . . . . . 5.

4′. Mesepisterna of thorax with a pair of rather well-defined antehumeral yellow bands, broad at base, rather blurred and tapering upwards, extending about three-fourths up the dorsum (effaced in Bornean examples). Posterior hamuli comparatively short and slender, evenly and but slightly curved in side-view, the apices a little outbent. Genital lobe more or less pointed triangular, carrying a dense brush-like bunch of forwardly directed brown hairs, most distinct at apex. Sup. anal apps of male with the apices recurved, gradually tapering to a fine point and carrying a more or less distinct but always small extero-lateral tooth at about the middle of their length. Inf. app. equal in length to superior pair. Veins Cu_1 and Cu_2 in posterior wing very strongly arched and entering the margin under a right angle; ends of veins M_3 and M_4 distinctly *recurved* and entering the wing-margin at their distal side under a slightly acute angle. Two (rarely more) cross-veins in the supratriangle of posterior wing and no basal cross-vein in the discoidal field of same running directly from M_4 to Cu_1 (usually one curved basal cross-vein connecting distal side of t with Cu_1). Wings uncoloured at base; membranula grey. Surface of frontal tubercles strongly transversely wrinkled. Keel on flexor side of anterior tibia one-half as long as tibia. Segments 2-6 of abdomen with rich metallic-green lustre. Female resembling the male in most respects except in venational details. Wings uncoloured or with a pale yellow tinge as far as Ax_1 at extreme base of all four. Valvula vulvae short, deeply and

narrowly divided into two tiny triangular blades, which are hollowed out ventrally and curved a little ventrad. Size rather large: ♂ abd. + app. 48, hw. 45-46, pt. 2.6-2.7 mm; ♀ 48-49, 48-49, 2.3-2.6 mm. Larva without frontal horn (fig. 55). Hab.: Malaya; Sumatra; Java; Borneo . . **westwoodii** SELYS.

5. Posterior hamuli of male short and stout with the basal one-third broad and triangular in lateral view, thence abruptly and strongly curved, with the tips a little broadened, truncated and outcurved. Genital lobe small and rounded, its ventral margin carrying a row of short and dense brush-like hairs which are directed forward. Sup. anal apps with the extero-lateral tooth at about the middle of each extremely small or obsolete. Inferior appendage only little longer than the superiors. Anal angle of posterior wing of male, though well-rounded, more projecting than in the next species and margin of the wing between the membranula and the angle deeply concave. Keel on flexor side of anterior tibia about one-half as long as tibia. Genital structures of female unknown. Size moderate: ♂ abd. + app. 43-45, hw. 42-43, pt. 1.75-2.0 mm, ♀ 44,46, — mm. Larva unknown. Hab.: Borneo . . . . . **euterpe** LAIDL.

5′. Posterior hamuli almost straight in lateral view, the distal two-thirds slender and tapering, the tips carrying a distinct hammer-like process, the point of which is directed obliquely dorsad and cephalad. Genital lobe somewhat longer than in *euterpe*, its ventral margin carrying a limited number of strong erect black marginal bristles. Sup. anal apps with very distinct, acute, extero-lateral tooth at about the middle and with the distal half of each distinctly outcurved. Inferior appendage markedly longer than the superiors. Anal angle of posterior wing more broadly rounded and less protuberant and margin of the wing between the membranula and the angle only slightly concave. Keel on flexor side of anterior tibia less than one-half as long as tibia. Female very similar to the male; valvula vulvae completely divided into two small equilateral, triangular, rounded lobes about one-sixth as long as the 8th tergite, the distance separating them V-shaped and only little wider than the lamellae at base. Size moderate: ♂ abd. + app. 44-46, hw. 39-42, pt. 2.5-2.7 mm; ♀ 43-45, 43.5-45.5, 2.7-2.9 mm. Larva without frontal horn (fig. 52-53). Hab.: Malaya; Sumatra; Bangka; Billiton; Java; Borneo . . **cydippe** LAIDL.

6. Sup. anal apps of male with stout extero-lateral tooth on each at about its middle. Yellow spots on dorsum and sides of abdominal segments 2, on sides of 3 about the transverse carina, on dorsum of 7 at its base, and on sides of 8 (*negrito* also 9) about the middle. Segm. 10 without mid-basal dorsal spine or protuberance, but with tiny longitudinal ridge . . 7.

6′. Sup. anal apps of male with an extero-lateral tooth near the apex of each, or with no sub-apical projection at all. Genitalia not as described in paragraph 7 . . . . . 8.

7. "Sup. anal apps stout and slightly convergent beyond level of exterior tooth, with blunt tips; form of tips obscured by a terminal cluster

of unusually short stout bristles or fine spines; under the more convex portion of their slightly upcurved tips a row of minute denticles". Genitalia not described. "Head black with a yellow band across the rear of the postclypeus ..... Labrum black. Anteclypeus brown. Frons shining metallic-greenish blue". Antehumeral pale stripe "short, running upwards from the middle of the mesinfraepisternum halfway to the crest". Abdomen black, apparently with no metallic lustre. Female with antehumeral yellow stripe a little longer and abdominal markings a little more extensive than in male; valvula vulvae not developed (subgenital plate of allotype figured in original description). "Length, 55 mm; abdomen, 41; hind wing, 38". Larva unknown. Hab.: Luzon . . . . . **negrito** NDH. & GYGER.

7'. Sup. anal apps of male more slender and straight in distal half, directed a little inwards and each tapering to a very fine point, apical portion sparsely fringed with long hairs. Genitalia prominent; hamuli large and very broad basally, plate-shaped, laterally compressed, their distal one-fourth abruptly narrowed and in the form of slender hooks whose pointed tips are slightly thickened and outcurved. Genital lobe broad in distal half, thence narrowed and triangularly pointed. Front of head dark brown, postclypeus with two pale brownish pits. Frons entirely metallic blue, pyramidal processes widely distant, pointed, furrow deep, inner surfaces not flattened nor framed. Antehumeral yellow stripe very narrow, pointed upward, not reaching half-way up the dorsum. Wing-bases with vestigial ferruginous spots in *c, sc* and *cu*. Anal area very broad. Membranula pure white on basal one-fourth, remainder grey. Anal margin between membranula and angle slightly concave. Abdomen black, segm. 3-6 with metallic green lustre. Female unknown. Larva unknown. Size moderate: ♂ abd. + app. 45-46, hw. 36, pt. 2 mm. Hab.: Borneo . . **mnemosyne** LIEFT.

8. Genital hamule more or less constricted approximately half-way its length, the distal one-third (or less) abruptly narrowed, slender, hook-like or sickle-shaped . . . . . 9.

8'. Genital hamule not constricted half-way its length, long and very slender, the distal two-thirds at least more or less vermiform in profile view . . . . . 12.

9. Sup. anal apps of male with distinct, though often small, exterolateral tooth near apex. Posterior hamule usually noticeably constricted about half-way its length. The constriction followed by a posterior convexity after which the hamule is suddenly narrowed, hook-like or sickle-shaped. Margin between membranula and the anal angle markedly concave. Cross-vein in anal triangle of male posterior wing almost straight . 10.

9'. Sup. anal apps of male sub-parallel, with no trace of an exterolateral tooth near apex, each nearly straight and tapering gradually from base to apex, which is slightly recurved; tips interiorly fringed with long black hairs. Inf. app. a little longer than superior pair. Posterior hamule not noticeably constricted half-way its length and with no distinct sub-

apical posterior convexity before the end-hook, distal one-fourth tapering to a point. Face and frons dark reddish-brown with no yellow band on postclypeus; upper part of frons and vertex metallic-green. Synthorax with sharply defined yellow antehumeral band extending rather more than half-way up the dorsum. Keel on flexor side of anterior tibia less than one-half as long as tibia. Margin between membranula and the anal angle slightly concave. Cross-vein in anal triangle of male posterior wing markedly convex anteriorly. Neuration open. Segments 2-6 of abdomen

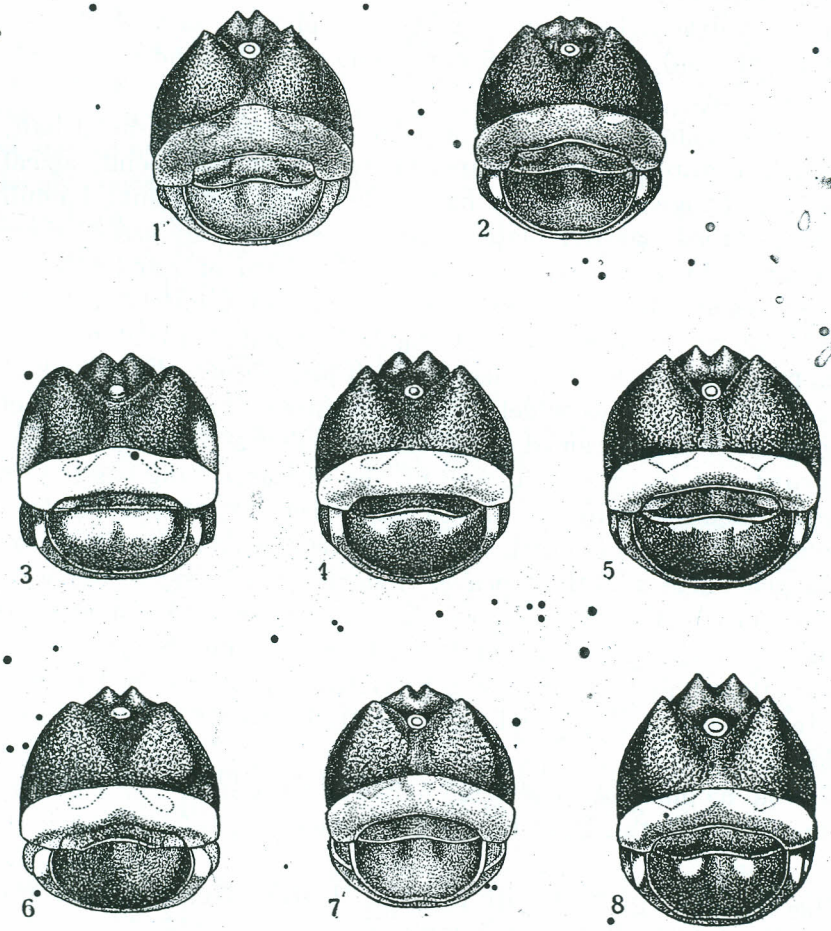

Fig. 1-8. Frontal view of head of *M. septima*, ♂ Djasinga, W. Java (1); *corycia*, ♂ Sarawak, N. W. Borneo (2); *spec. indet.*, ♀ Pengalengan, W. Java (3); *erato*, ♂ Djasinga, W. Java (4); *erato*, ♀ Djasinga, W. Java (5); *gerstaeckeri*, ♂ Pengalengan (type), W. Java (6); *gerstaeckeri*, ♀ Jor Camp, Malaya (7); and *urania*, ♂ Than Moi, Tonkin (8).

black with slight metallic-green lustre; 4-6 with no yellow markings; 2 with large oblique yellow lateral spot running down from the auricle towards antero-ventral border of segment, and with a pair of small mid-dorsal transverse spots; 3 with very small baso-lateral transverse streak and a pair of minute mid-dorsal spots. Basal mark on 7 restricted to dor-

sum, slightly produced posteriorly, and occupying little more than one-fifth of the segment's length; 8 with elongate orange mark extending half-way back. Segm. 10 with no dorsal process but with blunt longitudinal carina. Size small: ♂ abd. + app. 42, hw. 35, pt. 1.75-1.8 mm. Female unknown. Larva unknown. Hab.: Sumatra . . . . . **polyhymnia** LIEFT.

10. Front of head reddish- to dark brown including postclypeus: no bright yellow transverse stripe or band on the latter. Keel on flexor side of anterior tibia less than one-half as long as tibia . . . . . 11.

10'. Front of head reddish- to dark brown, strongly contrasting with a transverse yellow band on postclypeus. Mandible-bases with a yellow spot. Labrum blackish-brown, anteclypeus somewhat lighter; postclypeus bright yellow, a diffuse brownish line or stripe along anterior border. Frons and vertex metallic blue-black (fig. 6). Thorax metallic blue-black, yellow marks sharply delimited; antehumeral yellow bands extending about half-way up the dorsum. Keel on flexor side of anterior tibia about one-third as long as tibia. Neuration open. Only 6 cells in anal loop of posterior wing. Segments 2-6 of abdomen black with dark metallic-green lustre; 4-6 unmarked. Segm. 2 with large, rather oblique and very irregular, yellow lateral spot running down from the auricle towards antero-ventral border

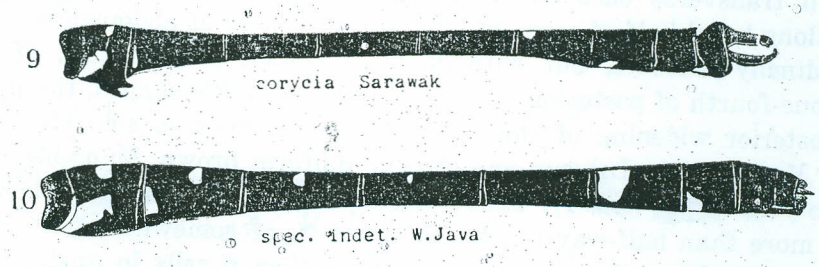

Fig. 9-10. Abdomen of *M. corycia*, ♂ Sarawak, N. W. Borneo (9) and of *spec. indet.*, ♀ Pengalengan, W. Java (10).

of segment; with a pair of small mid-dorsal transverse dots, isolated and more or less pointed laterad (type and lectotypes) or communicating with the lateral spot by a fine anastomosis; and with small crescentic lateral spot along posterior margin. Segm. 3 only with small baso-lateral transverse streak. Basal mark on dorsum of 7 short and annular, not or only very little produced posteriorly and occupying about one-fifth of the segment's length; 8 with small oblique latero-ventral mark extending back about one-third of segment's length; 9 either with minute latero-ventral basal spot (including type) or entirely black (fig. 11). Basal two-thirds of segm. 10 hollowed out above and finely longitudinally carinate, thereafter raised so as to form a small and very blunt mid-dorsal prominency (fig. 28). Posterior hamule with the rounded sub-median posterior convexity obtuse-angulate in side-view. Genital lobe very broad basally, tips abruptly tapering to a blunt point (fig. 25). Sup. anal apps slightly convergent and curved towards each other as far as level of lateral tooth, then more

abruptly bent inwards, the blunt tips not projecting beyond the extero-lateral tooth when viewed from aside. Apex of inf. app. strongly upcurved (fig. 28). Female almost similarly coloured to male, segm. 2 of abdomen in addition with basal crescent-shaped mid-dorsal yellow streak, and 8-9 unmarked (fig. 12-13). Neuration open. Only 6-8 (rarely up to 10) cells in anal loop of posterior wing. Valvula vulvae not developed, free margin of 8th sternite very little produced and slightly swollen on each side of the middle (upper division invisible). Size small and variable (*vide postea*!): ♂ abd. + app. 34-39, hw. 29-32.5, pt. 2.0 mm; ♀ 32-37, 31.5-36, 2.0 mm. Larva with frontal horn. Hab.: Malaya; Sumatra; Java; ? Philippines . . . . . **gerstaeckeri** KRÜGER.

11. Sup. anal apps of male a little convergent, each almost perfectly straight from base to apex and provided with a stout extero-lateral tooth situated well before the apex; tip from lateral tooth to apex plainly visible in profile view (fig. 26-27). Segments 3-5 of abdomen black, with paired yellow spots on mid-dorsum, 2-6 slightly shiny but with no metallic-green lustre. Yellow transverse band roundabout segm. 2 not interrupted by black laterally. Basal orange spot on segm. 7 conspicuous, broadly overlapping sides and slightly produced posteriorly at the median carina; 8 with a pair of small transverse baso-dorsal spots and a conspicuous latero-ventral mark along basal half of segment (fig. 16). Segm. 10 of abdomen strongly longitudinally carinate, but without blunt dorsal process (fig. 26-27). Distal one-fourth of posterior hamule slender and sickle-shaped, the preceding posterior widening of the hamule evenly convex in side view (fig. 20-21). Vertex high. Labrum and clypeus uniform brown. Mandible-bases with no yellow spot (fig. 1). Yellow antehumeral bands usually extending rather more than half-way up the dorsum (♂), of somewhat shorter and narrower (♀). Neuration open. Rarely more than 6 cells in anal loop of posterior wing. Female almost similarly coloured to male, but all yellow spots on abdomen enlarged; segm. 3 in addition with small transverse baso-lateral streak and 6 nearly always also with a pair of transverse streaks on mid-dorsum; basal spot on 8 often confined to ventral surface of tergite (fig. 17). Anal area of posterior wing broader and more densely reticulated; anal loop made up of 9-14 cells. Valvula vulvae small, free margin of 8th sternite slightly produced and divided into two swollen ridges, each bearing a short leaf-like tubercle the tip of which is outbent and pointed, pressed closely against te body-wall. Size moderate: ♂ abd. + app. 42-44, hw. 34-37, pt. 2.1-2.6 mm; ♀ 40-43.5, 36-39, 2.4-2.6 mm. Larva unknown. Hab.: Tonkin; Java . . . . . **septima** MARTIN.

11′. Sup. anal apps. of male almost parallel, each straight from base to near apex, which is rather abruptly inflected and provided with a small extero-lateral tooth situated at the bend of the appendage; distance from lateral tooth to apex very short, the tips barely visible in profile view (fig. 29). Segments 3-5 of abdomen black with low metallic-green lustre,

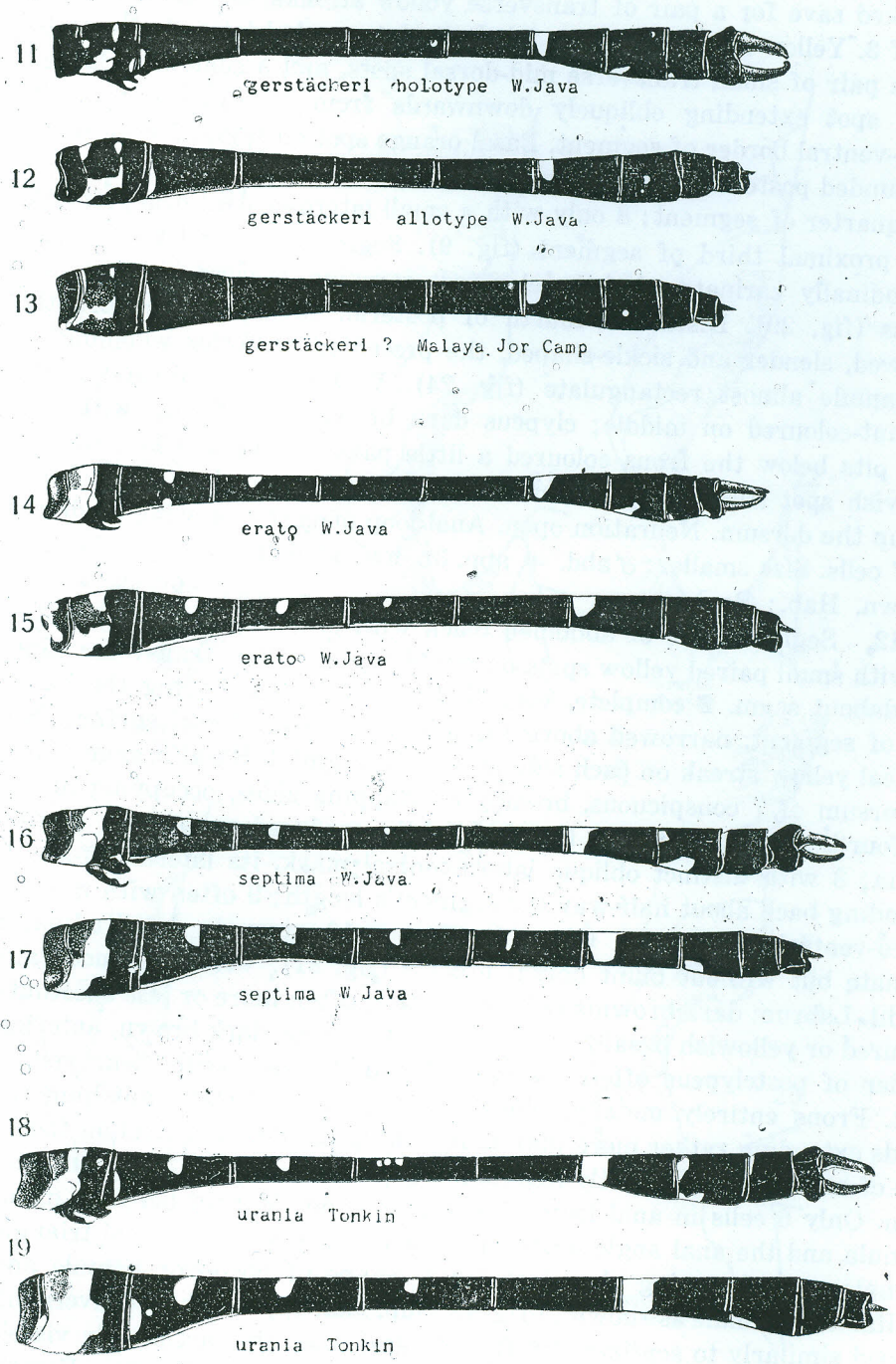

Fig. 11-19. Abdomen of *M. gerstaeckeri*, ♂ Pengalengan (type), W. Java (11); *gerstaeckeri*, ♀ Pengalengan (allotype), W. Java (12); *gerstaeckeri?*, ♀ Jor Camp, Malaya (13); *erato*, ♂ Djasinga, W. Java (14); *erato*, ♀ Djasinga, W. Java (15); *septima*, ♂ Djasinga, W. Java (16); *septima*, ♀ Djasinga, W. Java (17); *urania*, ♂ Than Moi, Tonkin (18); and *urania*, ♀ Than Moi, Tonkin (19).

unmarked save for a pair of transverse yellow streaks, one each side, at base of 3. Yellow marks on segm. 2 broadly interrupted laterally, so as to form a pair of small transverse mid-dorsal spots, and a somewhat larger lateral spot extending obliquely downwards from the auricle towards antero-ventral border of segment. Basal orange spot on segm. 7 very small and rounded posteriorly, restricted to the dorsum, occupying less than the basal quarter of segment; 8 only with a small latero-ventral orange mark along proximal third of segment (fig. 9). Segm. 10 of abdomen finely longitudinally carinate, slightly elevated, carrying a very blunt dorsal process (fig. 29). Distal one-fourth of posterior hamule more abruptly narrowed, slender and sickle-shaped, the preceding posterior widening of the hamule almost rectangulate (fig. 24). Vertex low. Labrum black, chestnut-coloured on middle; clypeus dark brown, postclypeus with the small pits below the frons coloured a little paler. Mandible-bases with a yellowish spot (fig. 2). Yellow antehumeral bands extending about half-way up the dorsum. Neuration open. Anal loop of posterior wing made up of 6-7 cells. Size smaller: ♂ abd. + app. 38, hw. 33.5-34, pt. 2 mm. Female unkown. Hab.: Borneo . . . . . **corycia** LAIDL.

12. Segments 3-6 of abdomen black with low metallic-green lustre, 3-5 with small paired yellow spots on mid-dorsum. Yellow transverse band roundabout segm. 2 complete, very broad laterally, occupying the basal half of segment, narrowed above the auricles and on dorsal surface. No vertical yellow streak on each side at base of segm. 3. Basal orange mark on dorsum of 7 conspicuous, broadly overlapping sides, occupying about one-fourth of the segment's length, slightly produced posteriorly at the carina; 8 with distinct oblique latero-ventral mark, its lateral off-shoot extending back about half-way the segment's length; 9 often with minute latero-ventral basal spot (fig. 14). Segm. 10 strongly longitudinally carinate but without blunt dorsal process (fig. 31). Vertex of moderate height. Labrum dark brownish-black or black, often more or less chestnut-coloured or yellowish basally on middle. Anteclypeus dark brown, anterior border of postclypeus often obscured. Mandible-bases with clear yellow spot. Frons entirely metallic blue-black (fig. 4-5). Yellow antehumeral bands extending rather more than half-way up the dorsum. Keel on flexor side of anterior tibia slightly less than one-half as long as tibia. Neuration open. Only 6 cells in anal loop of posterior wing. Margin between membranula and the anal angle markedly concave. Cross-vein in anal triangle of male posterior wing almost straight. Shape of posterior hamule and genital lobe of male as shown in fig. 23. Sup. anal apps slightly convergent, shaped similarly to *septima;* tip from lateral tooth to apex plainly visible in profile view, and usually abruptly and finely pointed (fig. 31). Female almost similarly coloured to male, except that the transverse yellow band of abd.-segm. 2 is nearly always interrupted mid-laterally, the dorsal spots on 3-5 being somewhat enlarged. Baso-dorsal orange spot of segm. 7

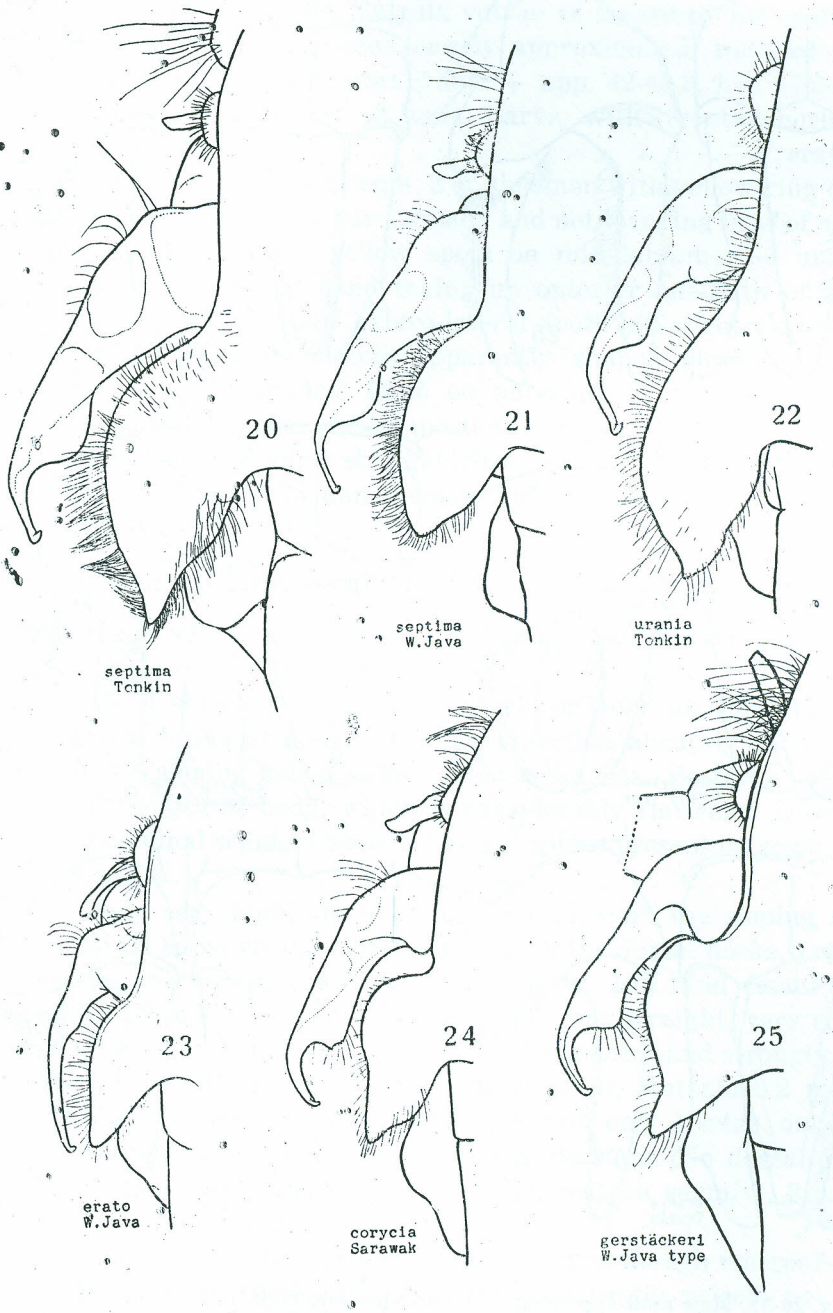

Fig. 20-25. Male genitalia of 2nd abd.-segment of *M. septima*, Hoa Binh, Tonkin (20); *septima*, Djasinga, W. Java (21); *urania*, Than Moi, Tonkin (22); *erato*, Djasinga, W. Java (23); *corycia*, Sarawak, N. W. Borneo (24); and *gerstaeckeri*, Pengalengan (type), W. Java (25).

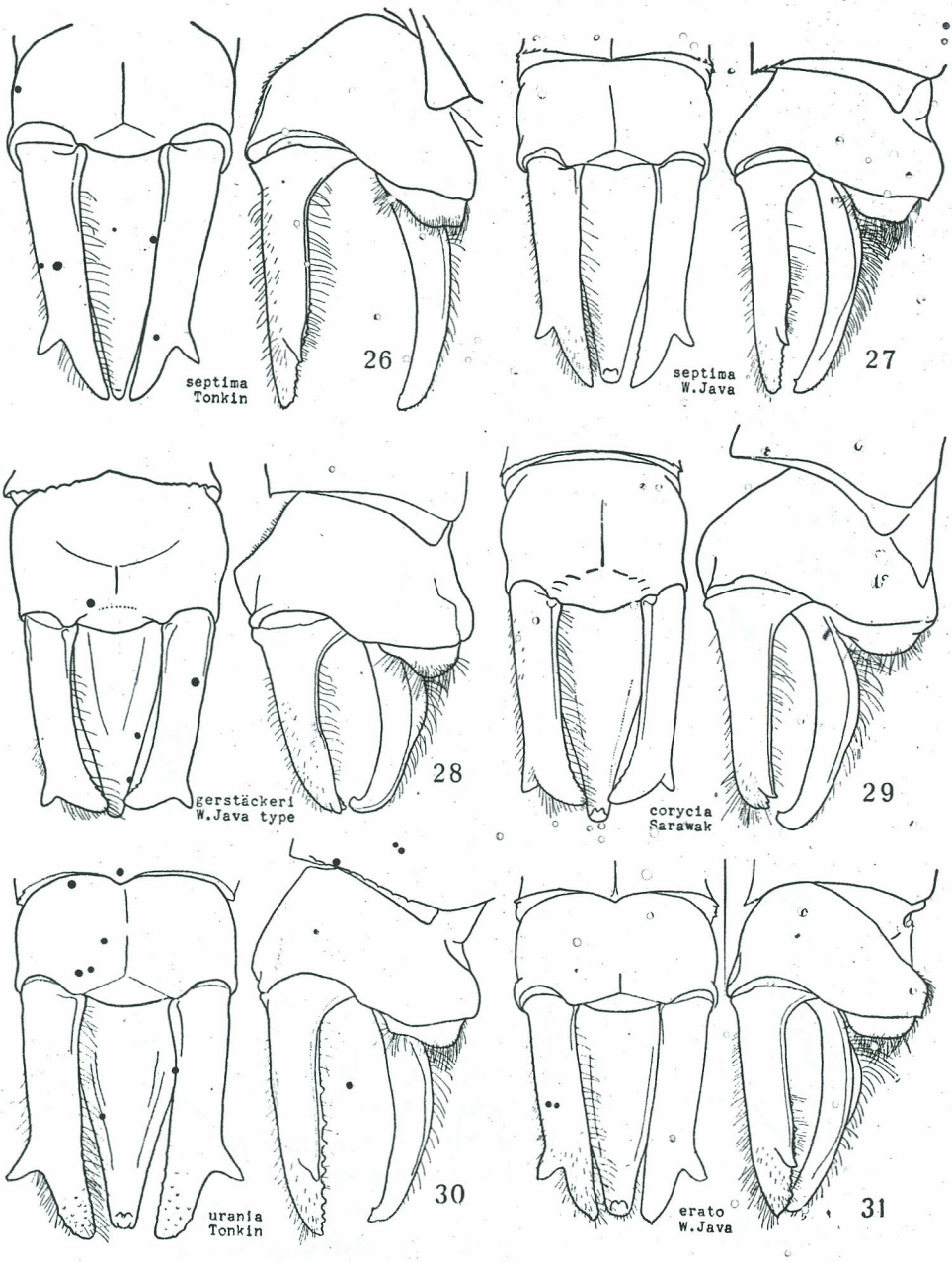

Fig. 26-31. Male anal appendages, dorsal view and right lateral side, of *M. septima*, Hoa Binh, Tonkin (26); *septima*, Mt. Tjimerang, W. Java (27); *gerstaeckeri*, Pengalengan (type), W. Java (28); *corycia*, Sarawak, N. W. Borneo (29); *urania*, Than Moi, Tonkin (30); and *erato*, Djasinga, W. Java (31).

semicircular, rounded posteriorly; basal spots on 8 reduced and usually confined to ventral surface of tergite (fig. 15). Anal loop of posterior wing made up of 7-14 cells. Valvula vulvae as described for *septima*, but the lobes of the upper division closely approximated, rounded and not outbent apically. Size moderate: ♂ abd. + app. 42-43.8, hw. 35.2-37.3, pt. 2 mm; ♀ 39-40.4, 37.4-38.4, 2 mm. Larva with frontal horn. Hab.: Java . . . . . **erato** sp. n.

12′. Teneral holotype: Segm. 2 of abdomen with yellow ring covering its anterior half, though narrow dorsally and not touching base of segment; 3 with a pair of minute yellow spots on mid-dorsum; 4-6 unmarked; 7 with transverse dorsal band taking up anterior one-fifth of segment. Sup. anal apps with small extero-lateral tooth at about two-thirds of their length. Posterior hamule apparently shaped similarly to *erato*. Neuration open. Antenodals 14.15 on anterior, 11 on posterior wings; postnodals 5 on anterior, 7.8 on posterior wings. Anal margin between membranula and anal angle straight. Size smaller: ♂ abd. + app. 35 + 3 (circa), hw. 31.5, pt. 1.75 mm. Female unknown. Larva unknown. Hab.: Kelantan (Malay States) . . . . . **callisto** LAIDL.

KEY TO THE KNOWN LARVAE OF MALAYSIAN *Macromia*

1. Head with frontal border almost straight, evenly convex or slightly concave . . . . . 2.

1′. Head with distinct blunt tubercle or horn on forward edge of frons. Dorsal hooks of abdomen in cross-section abruptly raised, not in line with the sloping sides of the abdominal terga. Posterior leg longer than whole length of body, which is considerably flattened. Dorsal hook on 10th abdominal segment absent. Lateral spines present on segm. 8 and 9 of abdomen . . . . . 3.

2. Body very high, strongly roof-shaped, with the sloping sides of the abdominal terga straight and in line with the dorsal hooks. Legs short and slender, posterior pair shorter than body, and hind femur shorter than width of abdomen. Anterior border of frons straight, very shallowly notched on middle. Tarsal claws of posterior leg short and strongly curved, only about half as long as third tarsal segment. Antennae 2 mm long. Labial mask of moderate size; lateral lobe with only 4 setae, only 3 wide and deep indentations, and 4 very large projections. No dorsal spine on 10th abdominal segment. Lateral spines present on segm. 7, 8 and 9 of abdomen. Body-length not exceeding 23 mm. . . . . **cydippe**

2′. Body not so high, rather strongly arched though not roof-shaped, and with the dorsal hooks in cross-section abruptly raised, not in line with the sloping sides of abdominal terga. Legs very long and spidery, posterior pair longer than body, and hind femur longer than width of abdomen. Anterior border of frons convexly rounded. Tarsal claws of posterior leg short and gently curved, less than half as long as third

tarsal segment. Antennae long, 3.5 mm. Labial mask of huge size; lateral lobes with 5 setae, 6 narrow indentations, and 7-8 projections. Dorsal ridge of 10th abdominal segment with short but distinct apical projection. Lateral spines present only on segm. 8 and 9 of abdomen. Body-length 23-24 mm. . . . . **westwoodii**

3. Body not exceeding 20 mm in length. Antennae shorter than 2 mm. Tarsal claws of posterior leg very long and slender, nearly as long as third tarsal segment. Distal margin of lateral lobe of labium with at least 5 indentations and 6 projections . . . . . 4.

3′. Body-length 24 mm or more. Antennae at least 3 mm long. Tarsal claws of posterior leg comparatively short, about three-fifth as long as third tarsal segment. Distal margin of lateral lobe of labium with 6-7 indentations and 7-8 projections . . . . . **m. fumata**

4. Distal margin of lateral lobe of labium usually with only 4-5 indentations and 5-6 projections. Body-length 18 mm or more . . **erato**

4′. Distal margin of lateral lobe of labium usually with 5-6 indentations and 6-7 projections. Body-length 18 mm or less . . **gerstaeckeri**

UNIDENTIFIED LARVAE

Only those larvae which could definitely be associated with the adults were studied and described in detail. A few unidentified *Macromia* nymphs from various sources (all belonging to the *gerstaeckeri* group) are merely recorded here, only one of these being figured (fig. 37).

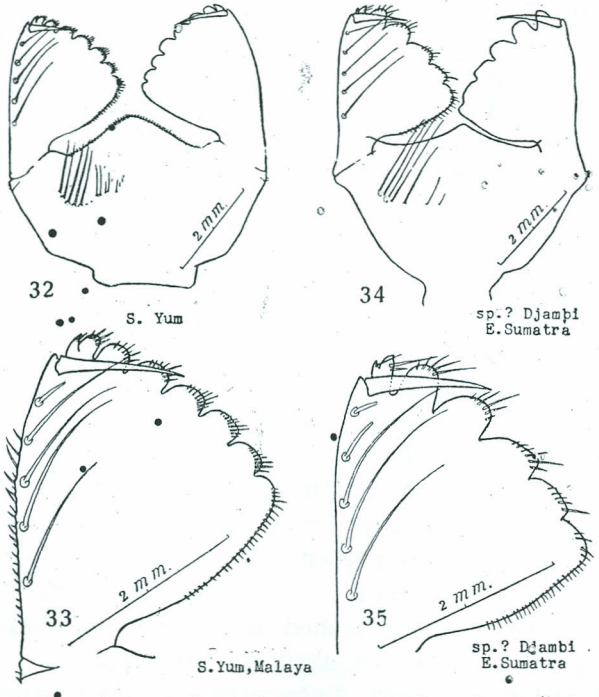

Fig. 32-35. Larval structures. Interior view of labium of *M. moorei fumata*, penultimate instar, from River Yam (Perak) Malaya, (32-33); the same of unidentified larva from Bangko (Djambi), E. Sumatra (34-35).

Malaya Peninsula. — 1 ult (small specimen), Perak, Stream Lasah, 1. iii. 1933, M. W. F. TWEEDIE. Possibly the larva of *callisto* (in bad condition).

Sumatra. — 1 ult, W. Sumatra, Djambi Expedition, near Bangko, 10.vii.1925, O. POSTHUMUS, "roadside in open rubber plantation." — 2 ult, S. Sumatra, Benkulen, 300 m, Air Musi, x.1941, Dungus Linggih, W. C. VERBOOM. — 1 exuvia,

id., Benkulen, Lake Ranau, 500 m, 20. vii. 1937, L. COOMANS DE RUITER. — 1 penult, Lampongs, Wai Lima, 300 m, xi. 1921, H. H. KARNY.

Djambi, Bangko, 10. vii. 1925 (fig. 34, 35, 37) : — Size larger than *gerstaeckeri*. Total length 19.0 mm. Median lobe of labium with 5 long and 2 smaller setae on either side. Lateral lobes each with 5 setae; 5 marginal indentations and 6 projections, the first projection divided. Dorsal hooks on segm. 4-7 of abdomen more strongly developed than in *gerstaeckeri*.

DESCRIPTIONS AND RECORDS OF ADULTS AND LARVAE

Macromia septima MARTIN (fig. 1, 16, 17, 20, 21, 26, 27).

1904. MARTIN, Mission Pavie, Zool. 3 : 211 (pars!). — ♀ Java only.
1929. LIEFTINCK, Tijdschr. Ent. 72 : 67 (key), 100-103, fig. 19-20 (♂ genit., apps). — ♂ (allotype), ♀ W. Java.
1934. LIEFTINCK, Treubia, 14 : 434, notes. — Java.
1935. LIEFTINCK, loc. cit. 15 : 193, bionomics. — Java.

Material studied. — T o n k i n (1 ♂ ad.) ; Tonkin, Hoa Binh, A. DE COOMAN, in coll. F. C. FRASER. — W. J a v a (10 ♂, 12 ♀) : Res. Bogor, Djamparang Tengah, 4-600 m, Mt Tjimerang and Mt Malang, 500-700 m, x-xi. 1934, iii and ix. 1935, ix. 1936, iv. 1937 and i. 1940, native collectors (5 ♂, 2 ♀ ad.) ; Tjibeber, Mt Bèsèr, ca 800 m, iv. 1936, native coll. (1 ♂) ; 3 ♂, 10 ♀ (ad.), Res. Bantam (Banten), Djasinga, Tjibarangbang River, 150 m, 1,6, 8 and 29. xii. 1935, M. A. LIEFTINCK; 1 ♂ (ad.), same district, Tjibeureum River, 150 m, 16.x.1935, M. A. LIEFTINCK. Two adult ♀ from Djasinga, 1. xii. 1935, have been compared with the adult gynetype in the Paris Museum, 14.vi.1938, labelled: "Java, Fr. (UHSTORFER)", (yellow label in SELYS's hand), "*M. septima* ex coll. Selys" (MARTIN).

TABLE OF MEASUREMENTS OF SOME JAVAN *Macromia* LARVAE

	cydippe	*westwoodii*	*m.fumata*	*erato*
Body-length	22.0-22.7	23.5-24.0	24.3	18.0
Body-height [1]	6.0-6.4	5.4	6.0	3.6
Length head	4.4	5.0	5.0	3.0
Width head	5.8	6.8-7.0	6.3	4.9
Length labium	7.8	9.0-9.7	7.7	7.0
Length antenna	2.0	3.5	3.5	1.7
Posterior leg	18.8	26.0-26.5	27.5	22.0
Posterior tarsus	3.5	3.7	5.0	5.5
Posterior tarsal claw	0.6-0.7	0.6-0.7	1.3	1.3
Length abdomen	15.0	14.3-14.5	15.2	10.7
Width abdomen	9.4-9.6	9.0-9.3	9.8	7.2

[1] The abdomen in all species is considerably lower than the measured highest point of the body, which is situated more anterad.

This species apparently has a wide distribution and will doubtlessly be found also in Sumatra and other islands of the Malaysian subregion. The only authentic specimen reported from outside Java is a male from Tonkin, which DR FRASER kindly sent me for inspection and comparison with other examples (fig. 20). Except for its superior size, it does not differ in any way from Javan specimens.

I have not been able to include in this paper a description of the larva of *septima*, as I have neither reared it nor seen nymphs which I could safely assign to this species. A prolonged search at all suitable streams in low country yielded only the larvae of *erato* and *gerstaeckeri*. As *septima* was the only species of the group regularly brought home by native collectors from the hill-country of the Djampangs (West-Java), at altitudes varying from 400 to 800 metres above sea-level, its frequent occurrence at higher elevations suggests that the principal breeding places of this species are streams with a swifter current. It is therefore likely that at the Tjibarangbang *septima*, though occurring somewhat less sparingly here than the allied species of the group, is not associated with these in the nymphal stage and develops in other, ecologically different, portions of the stream.

I have still kept an old cast skin of presumably this species found in the bed of a rocky forest-stream near Bantarpeundeuj (15 km N. of Pameungpeuk, S. W. Java, 400 m alt.). As it lacks the whole mentum the identity of this exuvia must remain doubtful.

Macromia corycia LAIDLAW (fig. 2, 9, 24, 29).

?1909. MARTIN, Cat. Coll. Selys, 17, Cordul: 70 (descr., partim?). — Borneo (*Gerstaeckeri*).

1922. LAIDLAW, J. Str. Br. Roy. As. Soc. 85 : 220 (key), 225, fig. 5 (♂ genit.). — ♂ Sarawak.

1929. LIEFTINCK, Tijdschr. Ent. 72 : 66 (key), 99 (not seen).

1936. KIMMINS, J. Fed. Mal. States Mus. 18 : 67. — ♂ add. descr., Sarawak.

Material studied. — N. W. Borneo: 1 ♂ ad., Sarawak, Mt. Dulit, R. Koyan, 2500 ft, primary forest, 18.xi.1932, Oxford Univ. Expedit., B. M. HOBBY & A. W. MOORE, B. M. 1933-254, ex Brit. Museum 1937.

The present example is one of a series of four males, all from the same locality, which have been commented upon by KIMMINS (*loc. cit.*). All specimens agree in having a narrow vertical yellow spot on either side at the base of segment 3 of the abdomen whilst segm. 8 is marked laterally with an oblique yellow spot towards its base (fig. 9).

LAIDLAW compared *corycia* with *urania* and *callisto* instead of *gerstaeckeri*, which was unknown to him at the time of describing *corycia*. These last two species are in fact very closely related.

The larva is unknown.

Macromia callisto LAIDLAW.

1902. LAIDLAW, Proc. Zool. Soc. Londen: 76-77. — ♂ and (?) ♀ Kelantan (*gerstaeckeri*).
1922. LAIDLAW, J. Str. Br. Roy. As. Soc. 85 : 221 (key), 225 - 226, fig. 6 (♂ genit.). — Same specimens.
1929. LIEFTINCK, Tijdschr. Ent. 72 : 67 (key), 104 (not seen).

Unfortunately this interesting little species has been described from a single very teneral ♂ with badly shrivelled head. Of this part of the body no good description could be given, and according to the first published notes on this example only the yellow colour of the "nasus" is obvious.

M a l e. — The absence of a prominence on the dorsum of the 10th segment has explicitly been mentioned by LAIDLAW, and this character separates it from *gerstaeckeri* from which it seems to differ also in the anal margin of the posterior wing, between the grey membranula and the anal angle, which in the ♂ of *callisto* is straight, whereas in *gerstaeckeri* it is distinctly incurved (concave). The best character, however, that should be used as a means of distinction between *gerstaeckeri* and *callisto,* is found in the shape of the genital hamule, which in *callisto* is long and slender, evenly narrowed towards the apex and almost straight (very similar to that of *erato*), whereas in *gerstaeckeri* the distal third of the hamule is abruptly narrowed and hook-shaped.

F e m a l e. — From the description of the allotype of *callisto* it is impossible to separate it from the ♀ of *gerstaeckeri*. There is no proof that LAIDLAW's pair from Kelantan belong to the same species. The two females from the Malay Peninsula examined by me (one from Camp Jor, the other from Kuala Kangsar, in Perak) fit LAIDLAW's description closely, but at the same time are absolutely indistinguishable from genuine specimens of *gerstaeckeri* from Sumatra and Java, and for that reason are identified with *gerstaeckeri* (fig. 7, 40).

More material of *M. callisto* is urgently needed to enable its description to be completed and to settle its status generally. The holotype is in the Mus. Comp. Anat., Cambridge.

Macromia erato, sp. n. (fig. 4, 5, 14, 15, 23, 31, 38, 45-47).

Material studied. — W. J a v a (4 ♂, 7 ♀) : 1 ♂ (juv., ex larva), 7 ♀ (ad.), Res. Bantam (Banten), Djasinga, Tjibarangbang River, 150 m, 18.vii.1937 (♂ larva ult, transformed 29.vii.1937), 1 and 6.xii.1935 (4 ♀), 10.iv. and 1.xi.1936 (2 ♀), 10 & 18.vii. 1937 (3 larvae), and 4.xii.1938 (1 ♂), M. A. LIEFTINCK; 1 ♂ (ad.), Res. Bogor, Djampang Wetan, Tjiajunan, 6-700 m, iv.1940, native collector; 2 ♂ (ad.), Bogor, Botanic Garden, 250 m, 12 and 17.ii.1945, native collector. H o l o t y p e ♂: Bogor, Botanic Garden, 250 m, 17.ii.1945; allotype ♀: Djasinga, Tjibarangbang River, 4.xii.1938.

Probably nearest to *callisto* LAIDLAW.

M a l e (ad., holotype). — Labium brown, the median lobe lemon-yellow with a diffuse brownish median spot along its border. Mandibles

chestnut coloured, bases conspicuously lemon-yellow. Labrum dark brown with a very diffuse, transverse, yellowish mark at its base. Anteclypeus blackish-brown, the postclypeus bright greenish-yellow, only the anterior margin finely bordered with brown. Frons entirely metallic blue-black; pyramidal processes rugosely punctate, transversely wrinkled anteriorly, their inner surfaces not flattened nor framed. Vertex purplish-black. Occiput and rear of the head shining black (fig. 4).

Synthorax brilliant metallic-green, with a pair of sharply defined, straight and rather broad yellow antehumeral bands; these are abruptly rounded off above, extending slightly more than half-way up the dorsum, and continued downwards on the mesinfraepisternum almost as far as the ventral border of the latter. Ante-alar triangles bright chrome-yellow. Thoracic sides with a sharply defined broad yellow band across the spiracle; this band only slightly narrowed upwards, widest (1.2 mm) at level of the spiracle. Venter, including the under surfaces of the posterior pair of coxae, pale creamy-yellow, as is also a narrow stripe bordering the latero-ventral margin of the metepimeron; this marginal stripe encroaches on upon the underside and meets the cream-coloured Y-shaped band separating the metepimera from the poststernum, so as to leave a pair of sharply delimited, narrowly ovate, purple-black metepimeral spots, pointed to the rear, and a slightly larger triangular spot on the poststernum.

Legs long and slender, black; coxae dark reddish-brown exteriorly, cream-coloured underneath; anterior pair of trochanters yellow on the inside. Posterior femur 8.0 mm long. Tibial keels whitish, occupying distal four-ninth of anterior pair, absent on intermediate pair, and full length of posterior pair but not extending quite to base of tibia.

Wings colourless, anal area faintly suffused with pale yellow. Costa with a fine interior yellow line extending from base almost up to nodus. Pterostigma small, about four times as long as it is deep, dark reddish-brown in colour. Membranula unicolorous dark grey, not extending as far as the end of the anal triangle. Distal side of anal triangle (A_3) very feebly curved from base as far as the anal angle, which is rounded; margin of posterior wing between membranula and the angle concave, about equal in length to the distal (smallest) cell of the anal triangle. Nodal index $\frac{6.14.14.\ 7}{9.\ 9.\ 9.11}$; *ht* $\frac{3.4}{2.2}$; *Cux* $\frac{6.5}{4.3}$. Only one large basal cell between anal triangle and anal loop. Anal loop made up of 6 cells without central cell.

Abdomen slender; segm. 2 (and base of 3) and 8-9 considerably inflated in dorso-ventral, less so in lateral dimension, apical segments widest at base of segment 10. Colour dull black, segm. 3-4 with very slight metallic-green lustre. Segments 2-6 and 7-9 marked with yellow as shown in fig. 14 (paratype) and as follows (type) : 2 with complete, broad, slightly oblique basal yellow ring, occupying the entire basal half of the sides (including the auricles), but slightly irregular and narrowed above that level, so

as to cover the middle one-third of the dorsum, and slightly indented by black anteriorly on middle. Segm. 3-6 each with small, rounded mid-dorsal orange-yellow spots placed just in front of the transverse carina, progressively smaller from before backwards, deeply indented by black anteriorly in the median line on 3 and 4, completely divided into two on 5 and 6, those on 6 extremely small. Segm. 7 with a transverse dorso-lateral basal mark of orange-yellow, rounded off on both ends laterally and not extending down as far as the latero-ventral margin, ceasing posteriorly at the transverse carina and hence occupying a little less than one-third of the segment. There are, in addition, two small longitudinal basal yellow streaks, one on each side, placed on the ventral portion of the seventh tergite. Segm. 8 with a pair of irregular, more or less oblique, orangish side-spots, placed before the middle of the segment along margin and encroaching on upon the antero-ventral portions of the tergite. Remaining segments, genitalia and anal appendages black. No dorsal tubercle or boss on segm. 10, but instead of this a sharp mid-dorsal longitudinal ridge along full length of segment.

Genitalia and appendages shaped as shown in fig. 23 and 31.

Paratypes. — In one adult ♂ (Tjiajunan) the yellow band on postclypeus is narrower, its lower one-third being obscured. The lateral thoracic yellow stripe is 1.0 mm broad and of even width throughout. The transverse yellow band on abd.-segm. 2 is constricted somewhat above the auricles, and the orange spots on the dorsum of 6 are wanting. In a second paratype (Bogor) the yellow twin-spots on the dorsum of segm. 3 and 4 are still more reduced (absent on 5 and 6), whilst in the teneral male from Djasinga, these dorsal spots are rather intermediate in size, though absent only on segm. 6.

Nodal indices: $\frac{7.15.16.5}{11.10.11.8}$; $\frac{7.15.14.6}{9.10.\ 9.9}$; $\frac{5.16.14.5}{8.11.10.8}$ *ht* $\frac{3.4}{2.2}$; $\frac{3.3}{2.2}$; $\frac{3.3}{2.2}$; *Cux* $\frac{5.6}{4.4}$; $\frac{4.4}{3.3}$; $\frac{6.4}{4.4}$. Anal loop invariably made up of 6 cells.

F e m a l e. — Resembles the male very closely in almost every respect except for the wing-venation and sexual characters. The differences in the colour-design are slight and may be given as follows. The postclypeus is invariably yellow save in one example, in which there are traces of a diffuse narrow brownish stripe along anterior border. Labrum always with ill-defined orangish mid-basal spot (fig. 5).

Wing-membrane more or less deeply suffused with brownish-yellow, rather cloudy in aged individuals. All wings with very minute dark brown or ferruginous marks at extreme base in the spaces *c*, *sc* and *cu*; these spots not nearly extending half-way out between base and Ax_1 and very diffuse; apex of anterior wing with a slight yellow tinge about the pterostigmal region. Nodal indices variable, $\frac{6.14.15.5}{8.11.10.8}$, in the allotype; *ht* usually $\frac{3}{2}$, more rarely $\frac{4}{2}$ and occasionally $\frac{4}{3}$; *Cux* $\frac{4—6}{4—5}$. Anal loop more elongate

than in the male and usually consisting of 11-13 cells including one or two central cells; in three females the loop is made up of 8-10 cells, and in two extremes with a nodal index of $\frac{6.12.11.9}{9.15.15.6}$ and $\frac{6.16.16.7}{10.11.11.9}$, the loops of both wings contain 7 (no centrals) and 14 (three centrals) cells, respectively.

Abdomen with the basal segments moderately inflated in lateral, more distinctly so in dorso-ventral dimension; third segment evenly narrowed towards apex, hence abdomen not constricted at that point but slightly spindle-shaped, with the apical segments also somewhat expanded (widest at base of 8). Yellow marks sharply defined, as shown in fig. 15; the band roundabout segm. 2 narrower above than in the male and broken up into three pieces by a broad posterior intrusion of the coppery-brown ground-colour, the transverse yellow mid-dorsal mark thus pinched off not indented by black, but widest on middle. In all specimens segments 3, 4 and 5 carry a pair of small, subtriangular or crescent-shaped orange-yellow spots, just anterior to the transverse carinae; these spots are restricted to the dorsum, growing smaller backwards and of minute size on 5, whilst segm. 6 is unmarked. A fine yellow stripe, widest on 3, borders the ventral margin of tergites 2-6 or 2-7, and in two females there is a tiny transverse yellow streak on either side along the basal margin of 3. Baso-dorsal mark on segm. 7 similar to the male though a little smaller, straight cut off or very slightly projecting posteriorly, with rounded side-edges; ventral mark of 7 as in male. The eighth segment lacks the ventro-lateral yellow marks found in the male.

Genital structure scalariform, not surpassing end of segm. 8; margin of eighth sternite a little swollen, its middle portion finely carinate and slightly excised, abruptly changing into a pair of closely approximated, subquadrangular, shining black lamellae; these lobes are concave ventrally and directed upwards so as to press tightly against the body-wall.

Anal appendages black, equal in length to segm. 10, cylindrical, the tips slightly outbent and acutely pointed.

Measurements. — ♂ abd. + app. 42.0, hw. 36.0, pt. fw. 2.0 mm (holotype); 42.2-43.8, 35.2-37.3, 2.0 mm (paratypes); 39.5, 35.0, 2.0 mm (bred from larva); ♀ 40.4, 38.0, 2.0 mm (allotype); 39.0-40.0, 37.4-38.4, 2.0 mm (parallotypes).

As far as at present known, this rare species is confined to a few scattered localities in West Java. The two males from the Botanic Garden at Bogor were collected at random, possibly at the small tributary of the Tjiliwung, which is a shady brook with few suitable breeding places. I have never noticed the species here nor did I find the nymphs, but the insect is very easily overlooked.

Description of full grown larva.

Surface smooth, apex of frontal horn, postorbital and occipital lobes laterally, the occipital border as well as various parts of the dorsal

surface of the body, finely and closely granulate on account of numerous microscopical warts, distributed in patches and spots, forming a very distinct pattern. Pro-, meso- and metapleurae and all of the coxae fringed with long soft hair tufts; legs (especially the femora) and abdominal segments laterally, with short and more scanty pubescence.

Head of moderate size, almost twice broader than long, length and breadth ratio about 6 : 10, height and breadth ratio 3.6 : 5.0; greatest diameter of head almost at the posterior two-thirds of its length, sides strongly bulging behind the eyes, thence convergent, the lateral occipital angles again somewhat protuberant, rounded, and carrying a small nipple-shaped tubercle on either side; occipital border gently concave when viewed from above. Dorsal surface of head in side view flat behind the eyes, sloping down anterad at level of posterior border of eyes. Diameter of the facetted portion of eyes markedly shorter than the lanceolate interior prolongations, very prominent, knob-like, projecting considerably beyond the contour of epicranium in profile view and directed obliquely forward and upward. Vertex small and flat; ocelli indicated. Frons more or less pentagonal, only little broader than long, its surface strongly concave; anterior border produced triangularly forward, forming a distinct knob-like tubercle whose apex is gently upturned and rounded. Antennae in length equal to their distance apart;

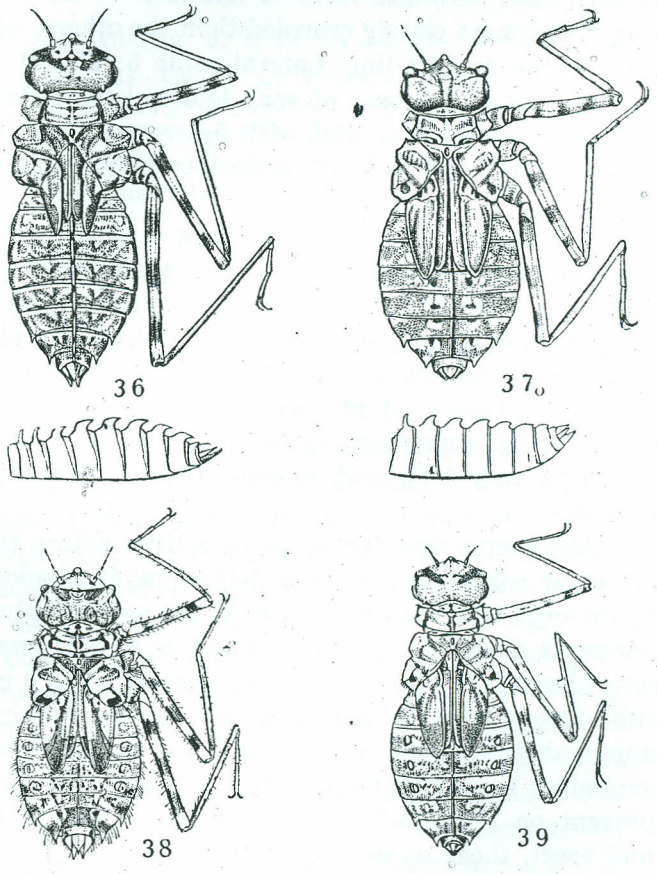

Fig. 36. Larva of *M. moorei fumata* (penult), River Yum (Perak), Malaya, and left side view of abdomen of same showing dorsal hooks. Fig. 37. Full-grown larva of *M. spec. indet.*, Bangko (Djambi), E. Sumatra, and left side view of abdomen of same showing dorsal hooks. Fig. 38. The same of *M. erato* (alive), Djasinga, W. Java. Fig. 39. The same of *M. gerstaeckeri*, Stream Lasah (Perak), Malaya.

first two segments thickened, the remainder slender, 1 almost twice as long and thick as 2, the slender distalia approximately equal in length to 2 (4 distinctly shorter than the rest).

Labium of great size, projecting a little beyond anterior border of head; submentum extending back to level of anterior border of metacoxae. Median lobe very short with distal margins rather concave and meeting under an obtuse angle, apex a little protuberant, short setae along free margin more closely set, shorter and more numerous laterally than towards the middle, as shown in fig. 41, 43 and 46. Mental setae 7-10 on each side, arranged more or less in a V, the 5 outermost considerably longer and more closely crowded than the others, which decrease in length towards the median line. Lateral setae 5; almost invariably 1 additional shorter seta at the base of each lateral lobe. Lateral lobes with 4-5 deep V-shaped indentations and with 5-6 rounded projections; in addition to these the first and last projection, or only the last on left or right side, divided.

Lateral propleural process very strongly protuberant, in the form of a narrowly triangular tubercle, rounded above and at the apex, which is directed cephalad and furnished with a tuft of long pencil-hairs; mesopleurae also a little produced antero-laterally, forming a bluntly rounded angulation and provided with a similar tuft of marginal hairs. Thorax depressed, of moderate size. Wing-cases reaching as far as the middle of 6th abdominal segment.

Legs very long and spidery, femora laterally compressed but very slender.

Abdomen ovate, widest at or a little before the middle of its length, posterior segments approximately equal in shape to *m. fumata*, but the apical ones and the anal pyramid not so strongly pointed; very flat, all segments almost as much depressed as in *m. fumata*, height and breadth ratio about 1 : 2.6. Lateral spines on segm. 8 and 9 relatively small, pointed, sub-equal in length, directed caudad and very slightly laterad, the extreme apices distinctly curved upwards and very little inwards; spine on 9 extending back slightly beyond the middle of segm. 10. [1]) Dorsal hooks present on segm. 3-9, the anterior ones distinctly laterally compressed and erect, those on succeeding segments very short, progressively lower and longer with dorsal margin rounded. Tenth segment and appendix dorsalis feebly carinated, or with no indication of a dorsal keel; anal pyramid about 1½ times as long as segm. 10, the appendages approximately equal in length to one another.

Colour-pattern. — Sandy-yellow variegated with yellowish- to dark brown, as shown in fig. 38 (living specimen). A pair of squarish blackish-

[1]) Living nymphs (fig. 38) nearly always have the abdominal segments less extended than alcoholic specimens, and in them the lateral spines of segm. 9 may reach even a little beyond the apical margin of the tenth segment.

brown patches at the root of the posterior wings stand out clearly from the rest of the body. Interior ocular prolongations, pro- and mesonotal ridges, rings of femora and apical portions of wing-buds, conspicuously brown, as also a double row of dark specks on abdominal segments 6-9 on each side of the dorsal spines (better shown on fig. 37 of a related but unidentified species). Lateral oval or slightly reniform (8-shaped) twin-spots on segm. 4-8 always distinct. Intersegmental membrane between segm. 4-10 with twice interrupted brownish streaks. Ridges and apices of dorsal and lateral hooks obscured.

Macromia gerstaeckeri KRÜGER (fig. 6, 7, 11-13, 25, 28, 39-44).

1899. KRÜGER, Stett. Ent. Zeitg. 60: 335 - 338. — ♂♀ W. Java.
1907. MARTIN, Cat. Coll. Selys, 17, Cordul.: 70 (partim).
1929. LIEFTINCK, Tijdschr. Ent. 72: 68 (♂♀ key), 106 - 107. — ♀ S. Java.
?1937. NEEDHAM & GYGER, Philipp. J. Sci. 63: 53, pl. 3 fig. 56 (♀ wings). — ♀ Philippines, notes (identity very doubtful).

Material studied. — Malay Peninsula: 1 ♀ (ad.), Pahang-Perak frontier, Jor Camp, 2000 ft, 1901, ALBERT GRUBAUER (ex FÖRSTER collection). — S. Sumatra (2 ♂, 6 ♀): 2 ♂ (juv., ex larva), 6 ♀ (4 ad., 2 juv., ex larva), Res. Lampong, foot of Mt Tanggamus, Wai Tebu, 300 m, 28.xii.1939 (♂ and ♀ larva, transformed at Bogor, medio ii.1940); 19-31.iii.1940 (♂ and ♀ larva, transformed at Bogor, iv.1940); and several larvae in alcohol, 19-31.iii.1940, all M. A. LIEFTINCK. — W. Java (6 ♂, 8 ♀): 5 ♂ (juv., ex larva), 1 ♀ (ad.), 6 ♀ (juv., ex larva), Res. Bantam (Banten), Djasinga, Tjibarangbang River, 150 m, 6.xii.1935 (♀ ad., compared with allotype Mus. Stettin); 18.vii.1937 (♂ larva penult, transformed at Bogor, 24-25.x.1937); 31.viii.1937 (1 ♂ 2 ♀ larvae ult, transformed at Bogor, 8-9.ix.1937, 9-10.ix.1937, and 15-16.ix.1937); 31.viii.1937 (1 ♀ larva penult, transformed at Bogor, 25-26.x.1937); 4.xii.1938 (♂ larva ult, transformed at Bogor, 13.i.1939); 15.i.1939 (2 ♂ 1 ♀ larva ult, transformed at Bogor, 12-13.iii.1939, 16-17.iii.1939, and 9-10.iv.1939); 26.xi.1939) (♀ larva ult, transformed at Bogor, 25-31.xii. 1939); all M. A. LIEFTINCK. 1 ♂, 1 ♀ (ad.), labelled: "Java occident. Pengalengan, 4000', 1893, H. FRUHSTORFER", and "*Macromia gerstaeckeri* KRÜG. L. KRÜGER 1927 determ."; both in the Stettin Museum.

The correct spelling of the name of this species is *gerstaeckeri*. KRÜGER's type is the only fully matured male which has come under my notice so far. This male was in good condition when it was returned to the Stettin Museum. To KRÜGER's excellent description only the following additional noted are required:

Anal loop of hind wing made up of 6 cells. Mandible-bases with a yellow spot. Anteclypeus brown; postclypeus yellow. Abd. + app. 39.5, hw. 34.5 mm.

The allotype female is doubtless conspecific. Anal loop made up of 6 or 8 cells.

KRÜGER's "zweite Weibchen" is different from all other species known from Java and is possibly new. This species is briefly discussed under the next, spec. indet.

I have been unable to find any differences in the wing venation by which *gerstaeckeri* could be held apart from *erato* and it exhibits the same variation as that species as to the nodal index and the anal loop.

No individual variation is exhibited in the colour-pattern of the thorax and abdomen between specimens of both sexes from Sumatra and Java. In aged individuals of both male and female the yellow band on the postclypeus averages narrower than in *erato* and in most specimens has acquired a darker yellow tint than in the last mentioned species. In one adult female from Sumatra the postclypeal band is ill-limited and faded to a dark yellowish-brown. In the matured female from Jor Camp (Malay States) referred here with slight doubt, the postclypeal band is somewhat obscured, and this may be correlated with the absence of a clear yellow spot on the mandibles in this specimen.

Measurements. — Malaya: ♀ abd. + app. 36.5, hw. 35.0, pt. fw. 2.0 mm. Sumatra: ♀ 35.5-37.0, 34.0-36.0, 2.0 mm. Java: ♀ 37.0, 35.0, 2.0 mm. — Individuals reared from larvae in the ultimate instar are often markedly smaller than adult ones. Java: ♂ abd. + app. 37.0-38.0, hw. 30.5-32.5 mm (living examples); 34.0-37.5, 29.0-32.5 mm (dried examples); ♀ 32.0-36.5, 31.5-35.5 mm (dried). Sumatra: ♂ 37.5-39.0, 33.0-33.5 mm (dried); ♀ 35.5-36.0, 34.0-35.0 mm (idem).

This species is a very close relative of *M. corycia*, from Borneo. Also nearly allied with *erato*, but the average size of *gerstaeckeri* is smaller and the yellow facial, thoracic and abdominal marks besides being more reduced, differ in shape. It is also similar to *septima*, and at localities where the three were associated, they occurred in about equal numbers.

In the Lampong district this little species occurred sparingly in the rocky bed of the Wai Tebu, a fairly fast-flowing stream about three times as wide as the Tjibarangbang (discussed earlier in this paper) and flowing through dense virgin jungle. Other noteworthy Anisoptera frequenting this stream were species of *Zygonyx*, *Acrogomphus*, *Onychogomphus*, *Sieboldius*, and *Chlorogomphus*. The nymphs of these were all found in places with a swifter current, whereas the females of *M. gerstaeckeri* were captured whilst ovipositing in shady places under the lenitic bank on the opposite side of the stream, where the water was shallow and flowed over a pebbly bottom. The larvae, sifted from sand bars close to the water's edge, were kept alive and brought to the rest-house where they were released in bowls with sand and water. After

two days the nymphs were taken out of the water and put in small containers with wet moss. After a five hours' drive by motor-car they were liberated in the washing tubs of the cabin on board steamer, in which they remained about 12 hours. The next morning they were again transferred to moss-filled receptacles, and although especially those which were approaching metamorphosis did not survive the long imprisonment and the continuous change of milieu, several nymphs remained in good condition during the next three hours' drive back to Bogor. Here they were placed in our rearing jars, supplied with food

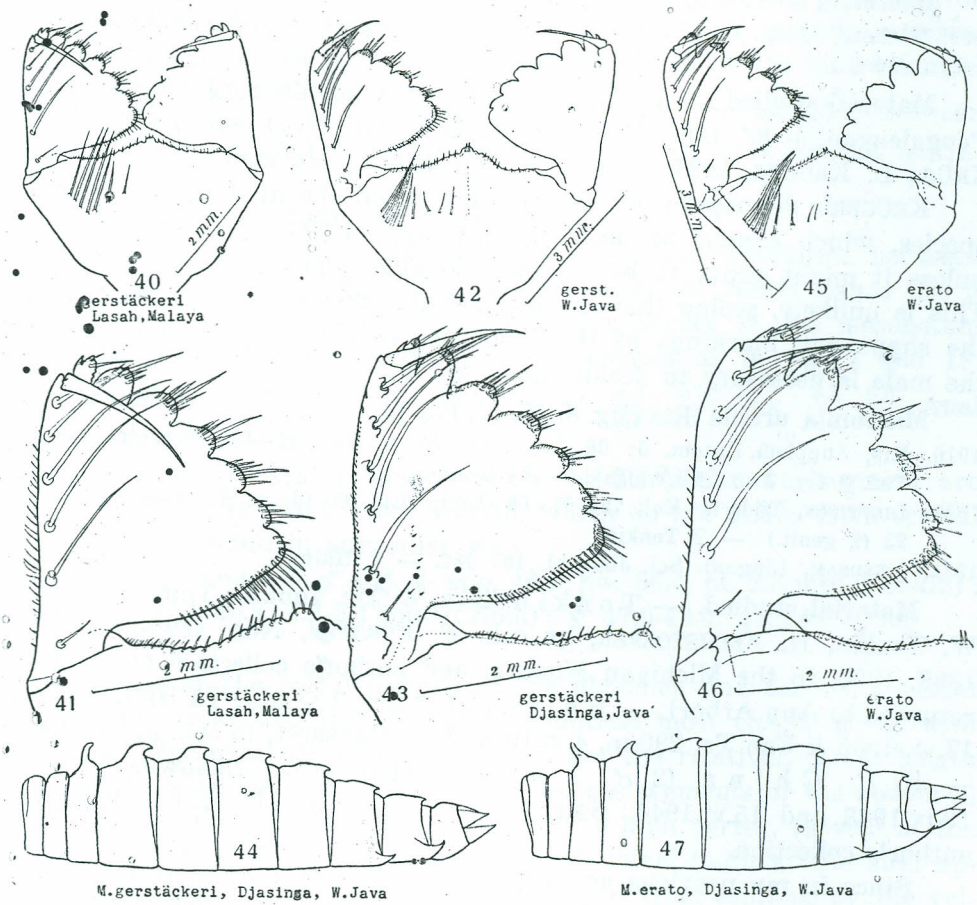

Fig. 40-44. Larval structures of *M. gerstaeckeri*, from Stream Lasah, Perak (40-41), the same from Djasinga, W. Java (42-43 ultimate ♂ larval instar, 44 exuvia ♀). Fig. 45-47. The same of *M. erato*, Djasinga, W. Java (45-47, ultimate ♂ larval instar).

and allowed to transform in the course of the next months. In order to enable the emerging insect to crawl up the sides of the breeding cage, it was essential that some sort of connection be established between a rough stone projecting from the water in the petri-dish and the wall of the cage.

The full-grown larva of *gerstaeckeri* is practically indistinguishable from that of *erato*. The dorsal margins of the hooks on the middle abdominal segments are perhaps a trifle more prominently convex than in *erato*, but apparently the length of the hooks on segments 7, 8 and 9 is subject to individual variation in both species. Besides being a little smaller in size, the nymph of *gerstaeckeri* differs from that of *erato* in that the lateral lobes of the labium bear 5 to 6 marginal indentations instead of only 4 to 5, the latter being the deepest in *erato* (cf. fig. 40-47).

Macromia spec. indet. (fig. 3, 10).

1899. KRÜGER, Stett. Ent. Zeitg. 60: 336, 337 - 338 (♀ pars). — ♀ W. Java (*Gerstaeckeri*).

Material studied. — W. Java: 1 ♀ (ad.), labelled: "Java occident. Pengalengan, 4000', 1893, H. FRUHSTORFER", and "*Macromia gerstaeckeri* KRÜG., L. KRÜGER, 1927 determ.", in the Stettin Museum.

KRÜGER's description leaves no doubt about the distinctness of this species, which cannot be matched with any of the described species, unless it might prove to be an exceptionally large specimen of *erato*. This is unlikely, seeing that the abdominal yellow spots are larger and the shape and markings of the frons are different. The discovery of the male is necessary to decide upon its status.

Macromia urania RIS (fig. 8, 18, 19, 22, 30).

1916. RIS, Supplem. Entom. 5: 66 (key), 68 - 70, textfig. 42 - 43 (♂ genit., apps), Taf. 3 fig. 2 - 3 (♂♀ wings). — ♂♀ Tonkin.

1929. LIEFTINCK, Tijdschr. Ent. 72: 67 - 68 (key), 104 - 106 (descr. ♀, synonymy), fig. 22 (♀ genit.). — ♀ Tonkin.

1931. NEEDHAM, Lingnan Sci. Journal, 10: 232. — ♀ Hainan.

Material studied. — Tonkin (2 ♂, 4 ♀): Tonkin, Than Moi, and W. Tonkin, H. FRUHSTORFER, ex coll. F. FÖRSTER, Nos 1894-96, 1887, 1898, 1900, in the Michigan Museum and author's collection (1 ♂, 4 ♀ returned to Ann Arbor). — Hainan (1 ♂ juv., 1 ♀ ad.), Ta Hian, 600 m, 17.vi. 1935 & Fan Ta, 290 m, 4.vi.1935, J. L. GRESSITT, in coll. J. COWLEY. — S. E. China (2 ♂, 1 juv.): Fukien prov., Shaowu, 500 m, 19.ix.1943 and 15.vi.1944, HSIU FU CHAO leg., in coll. H. F. CHAO and author's collection.

Since in my previous account I had not been able to examine and comment upon the males of this northern species I have thought it advisable to offer some sketches and notes on specimens now available from Tonkin and East China. As *urania* clearly belongs to the *gerstaeckeri* group, its inclusion here would seem to be justified.

It does not occur in the Malaysian subregion and for that reason has been excluded from our key to the regional species (see, however, LIEFTINCK 1929).

Male (Than Moi). — Differs from the original description only in the following points.

In one ♂ the labrum is blackish-brown with two minute yellow spots on middle at base. The yellow band on the postclypeus almost interrupted on middle by a tiny triangular off-shoot of the brownish-black stripe bordering the anterior margin. In the second example the head is coloured as shown in fig. 8. Length of posterior femur 9.0 mm. Tibial keels occupying exactly the distal one-half of anterior pair and full length of posterior pair but not extending quite to base or apex of tibia.

Distal side of anal triangle (A_3) evenly and but slightly curved from base as far as the anal angle, which is rounded; margin of posterior wing between membranula and the angle only very slightly concave, about equal in length to the second (smallest) cell of the anal triangle. Nodal index $\frac{6.15.16.\ 8}{8.11.11.10}$; *ht* $\frac{4.3}{2.2}$; *Cux* $\frac{5.4}{4.4}$. Only one large basal cell between anal triangle and anal loop. Anal loop made up of 6 cells without central cell.

Abdominal markings as in fig. 18.

Male (Shaowu). — Identical with the Tonkinese specimens discussed above, but both differing in that the antehumeral yellow bands are a little longer, their distance from the upper border of the mesonotum being 1.7-2.0 mm. Head-markings and abdomen as in fig. 8 and 18. Nodal indices $\frac{7.15.17.7}{10.11.11.9}$ and $\frac{6.16.16.\ 7}{10.10.11.10}$; *ht* $\frac{4.4}{2.3}$, $\frac{4.4}{3.2}$; *Cux* $\frac{5.5}{4.4}$, $\frac{6.5}{4.4}$. Anal loop with 6-8 cells.

The latero-ventral yellow spots on the 8th abdominal segment are entirely absent in two ♀ from Tonkin, which do not differ from typical examples of *urania* in any other way.

Measurements. — ♂ abd. + app. 46.5, hw. 36.4, pt. 2.3 mm (Tonkin); 49.5-51.5, 39.0-40.8, 2.2-2.4 mm (China); ♀ 47.0-48.0, 40.0-42.0 mm.

As far as the colour-pattern of the abdomen and the male sexual organs are concerned this species is doubtless most closely allied with *septima*. Characteristic features of both are the relatively great length and the very slender form of the intermediate segments of the abdomen, the acutely pointed frontal tubercles and the high vertex, as well as the relatively robust and laterally directed sub-apical tooth at the anal appendages of the male. It can be distinguished from *septima* by the yellow postclypeus, the slightly different anal appendages, and by details of coloration. *M. urania* is also nearly related with *erato* and *gerstaeckeri*, especially with the former.

Note. — From the same locality in Fukien (S.E. China) I have examined one male in Mr HSIU FU CHAO's collection, which is almost a replica of *urania* but differs from that species in the colour of the head and in details of the genital organs. This species will be described elsewhere. There is no doubt that a considerable number of species on the Asiatic mainland still await careful study and description, and se-

veral larvae in our collection from China and neighbouring countries cannot yet be identified specifically.

Macromia cydippe LAIDLAW (fig. 48-53).

1929. LIEFTINCK, Tijdschr. Ent. 72: 62 - 63 (♂ key), 73 - 76 (descr., full references), fig. 4 - 6 (♂ apps & genit.). — ♂ Bangka; ♂ Borneo.
1935. LIEFTINCK, Treubia, 15: 192 - 193 (add. descr.). — ♂ W. Java.
1935. LIEFTINCK, Misc. Zool. Sumatrana, 92 - 93: 18. — Sumatra (doubtful).

Material studied. — Malay Peninsula: 1 larva (ult), 1 larva (penult), 1 larva (3-ult), 3 larvae (5-ult), Perak, Lasah, stream near Sungai Plus, 1.iii.1933, M.W.F. TWEEDIE, ex Raffles Museum. — S. Sumatra: 1 larva (ult), 1 larva (penult), Res. Benkulen, Air Musi, Dungus Bindjei, 100 m, x.1941, W. C. VERBOOM; 1 larva (penult), 2 larvae (juv.), Res. Palembang, Lahat, forest-brook, 17.iv.1948, W. C. VERBOOM. — Billiton I.: 1 ♂ (ad.), C. Billiton, waterfall near Gunung Tadjem, 27.x.1936, F. J. KUIPER; 1 ♀ (ad.), C. Billiton, Begantung, 50 m, 17.ix.1936, F. J. KUIPER. — Bangka I.: 1 ♂ (ad.), Lubuk Besar, 20 m, 15-30.ix.1949, A. J. KOSTERMANS. — Borneo: 1 ♂ (ad.), E. Borneo, Kutai, Sangkulirang, Kariorang, v.1937, M. E. WALSH. — W. Java (many specimens, both sexes, and numerous larvae, in spirit or transformed at Bogor): Res. Bantam (Banten), Djasinga, Tjibarangbang River, 150 m, 26.v.1935 till 1.i.1941 (all seasons), M. A. LIEFTINCK.

Allotype ♀: W. Java, Djasinga, Tjibarangbang River, 150 m, 1.xii. 1935, M. A. LIEFTINCK.

As the female of this rare species had not yet been made known, it may now be described as follows:

Female (ad., Djasinga). — Labium pinkish-buff. Labrum and mandibles clay-colour or cinnamon, the tips of the former reddish-brown. Clypeus tawny-olive, as is also the frons anteriorly. Frons short, its anterior surface distinctly flattened, forming two more or less triangular, coarsely and rugosely striate areas, which are separated by a deep sulcus and well marked off from the rest of the frons; colour ochraceous-tawny with very slight metallic-blue lustre on top only. Vertex trapezoidal, its two dorsal projections very blunt, blackish-brown with dark blue reflections. Occipital triangle and rear of the head glossy brownish-black, with a small yellow lateral spot along the eye-margin, followed by a light brown ventral area. Legs black, the coxae and bases of anterior femora brown.

Wings clear, except the bases which are slightly and diffusely tinged with pale yellow; costal half of the apices of anterior wing between nodus and apex often also palely saffronated. Neuration as in the male. Antenodals 16-17 in fore, 10-12 in hinder wing; postnodals 6-7 in fore, 8-10 in hinder wing. *Cux* $\frac{4\text{-}6}{4}$; *ht* $\frac{3\text{-}4}{1\text{-}2}$. Anal loop made up of 11-14 cells. Membranula dark grey, lighter towards base.

Thorax with the mesepisterna tawny on russet in colour, the dorsal one-third to one-fifth (or even less) acquiring a brilliant metallic-green lustre. Ante-alar triangles bright yellow. Sides also brilliant metallic-green, except the yellow stripe crossing the spiracle and a similar stripe along posterior border of metepimeron confluent with the pinkish-buff underparts; poststernum somewhat darker with slight metallic reflections.

Abdomen with the basal segments moderately, the terminal segments only slightly expanded laterally; terminal segments rather high and compressed with strongly developed acute mid-dorsal carinae, rather similar in shape to *westwoodii*. Colour of basal segments dark reddish-brown; 1 without metallic shine, 2-6 with brilliant metallic-green lustre, the ground-colour on 2 and basal part of 3 shining through, these segments with traces of tiny reddish transverse streaks just in front of the transverse carinae; otherwise unmarked, except a fine yellow line bordering the tergites ventrally. Segm. 7-10 and appendages black; 7 with well-defined, light orange-yellow, dorso-lateral mark occupying about the basal one-third of segment, but produced on mid-dorsum so as to form a triangular or sagittate apical protuberance often extending half-way the segment's length.

Valvula vulvae short, divided into two nearly equilateral triangular blades which are bluntly pointed; the area separating them approximately equal to or a little larger in size than each of the lobes.

Measurements: abd. + app. 43.5-45.5, hw. 43-46, pt. 2.8-3.0 mm.

A single slightly immature male was captured for the first time in Java on May 26, 1935 at the Tjibarangbang (*loc. cit.*, 1935). In spite of apparently favourable conditions during four subsequent visits it was not noticed until November 24th and afterwards, when I came across it again at the same locality. The males were scarce, at most two or three being observed at any one time. Although fairly easily recognised from the three other species of *Macromia* by their larger size, they were very inconspicuous owing to their dark colours and slender forms, patrolling shady and deep-lying stretches of the stream. They frequently covered beats of at least fifty metres, skimming very swiftly over the water's surface, flying from shade into sunlight and back into shade again. The males were only noticed from about 8 *a.m.* till shortly after noon. On no occasion did I observe this species in the copulatory act, but ovipositing females were frequently seen over the ripples, mostly under the wooded banks in shady places and sometimes as late as 3 *p.m.*

As appears from our records (p. 664-665), the species was observed or captured during all seasons of the year, from May 1935 till January 1941. It was only noticed 19 times out of a total of 42 daytime visits paid to this stream, the total catch numbering only 12 males and 4

females. One male and one female, which I mistook for an other species as they flew at an altitude far out of reach of the net, were brought down with dust-shot from a .410 Gecado rifle.

Description of full grown larva.

Surface smooth, basal segment of antenna, postorbital lobes, prothorax laterally, and coxae, shortly pubescent. Exterior surface of all femora, and the abdominal segments 7-10 (incl. anal apps) laterally with a row of short spinulose setae. Dorsal surface of head posterior to the eyes, pronotum and meso-metanota, granulate on account of fine wartlike tubercles distributed in patches or stripes forming a definite colour-pattern.

Head comparatively small, less than twice as broad as long, length and breadth ratio about 7 : 12, height and breadth ratio 5 : 6; greatest diameter of head distinctly posterior to the middle, the postorbital lobes more protuberant and the side-margins both before and after the eyes more strongly convergent than in *westwoodii;* occipital lobes rounded; carrying on either side just above the side-edges a low blunt conical tubercle of small size; posterior border long, slightly sinuous when viewed dorsally. Head, including the eyes, otherwise shaped similarly to *westwoodii.* Frons almost rectangular, about twice wider than long, its surface a little convex and covered with microscopical warts on middle; anterior border almost straight, very shallowly notched as seen from above, rectangulate and bluntly rounded in profile view, without scale-like setae along margin. Antennae short, only little longer than their distance apart; first two segments thick and cylindrical, the first twice as thick as the second, the remaining segments slender; 1 only little longer than 2, 3 equal in length to 2 or 5, 4 a little shorter than these, and 6 and 7 slightly longer again than 5.

Labium considerably smaller than in *westwoodii,* a little projecting beyond anterior border of head but the lateral lobes not visible in dorsal view. Submentum extending back as far as the middle of abd.-segm. 1. Median lobe very short and little projecting on middle, distal margin straight, free margin with few widely spaced strong setae, 3-4 of these close together at apex. Mental setae closely crowded, 5 on each side, and usually 2 much shorter ones on either side situated more anterad and mesiad. Lateral setae 4; usually 1-2 (occasionally more) additional short setae at the base of each lateral lobe. Lateral lobes with only 3 exceptionally deep indentations, and with 4 blunt projections. In addition to these, the first projection (on one or both sides) is nearly always shallowly excavated, whilst the last (apical) projection is deeply notched so as to form an additional, more or less finger-shaped process just before the movable hook (curled upwards in fig. 50).

Lateral propleural process as described for *westwoodii,* its anterior border swollen, covered with numerous warts and with a tuft of soft

hairs along margin. Thorax less robust than in *westwoodii*. Wing-cases reaching back to slightly beyond posterior border of 5th abdominal segment.

Legs short and slender; femora not dilated but somewhat compressed laterally.

Abdomen rather large, intermediate segments almost parallel-sided, greatest width very slightly behind the middle; last three segments rather abruptly decreasing in width; very high and triquetral in cross-section (height and breadth ratio about 1 : 1.6), the dorsal hooks almost in line

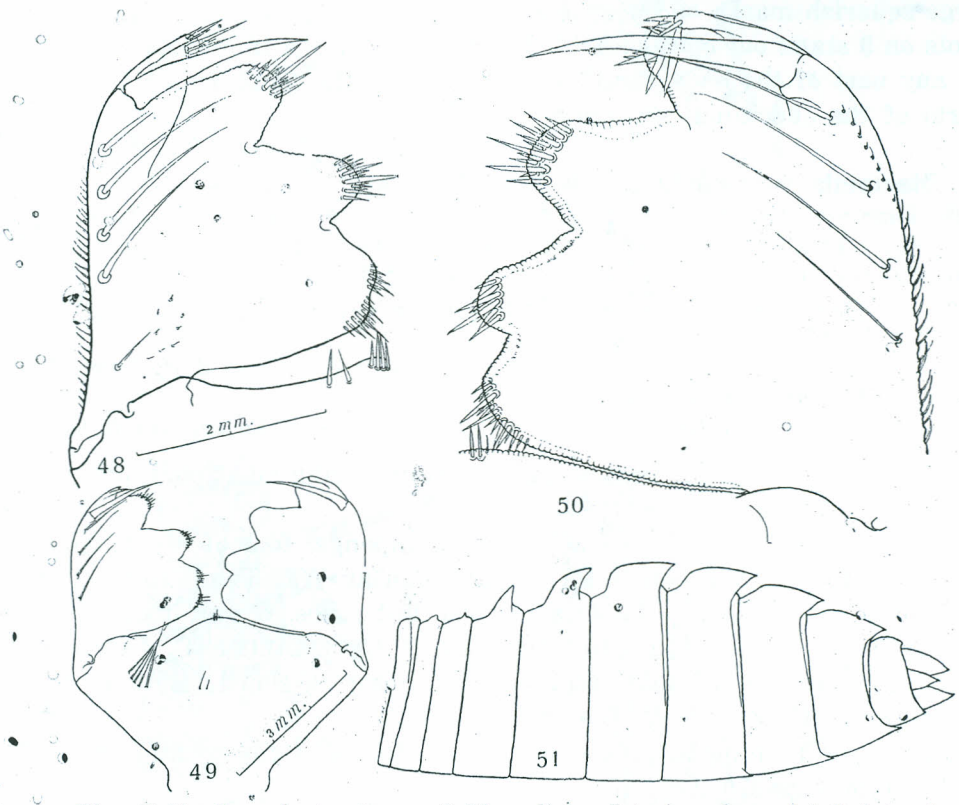

Fig. 48-51. Larval structures of *M. cydippe*. Interior view of left lateral lobe of labium, Stream Lasah, Perak (48); labium (49), right lateral lobe of same (50), and left side view of abdomen (51), of ♀ Djasinga, W. Java (49-51).

with the sloping tergites. Lateral spines on segm. 7-9 short but acutely pointed, subequal in size and length, that on 7 a little more projecting laterad than the others, that on 9 extending about half-way the length of segm. 10. Dorsal hooks present on segm. 2-9, those on 2 to 4 erect, 2 and 3 variable in shape and length (often very small, fig. 51), those on succeeding segments progressively less sharply bent backward, with the dorsal margins longer and straighter, the distal hooks declivous and closely approximated. Mid-dorsal keel on segm. 10 and on appendix

dorsalis distinct; anal pyramid less than 1½ times as long as segm. 10, appendix dorsalis equal in length to the cerci, the cercoids a little shorter.

Colour-pattern. — Ground-colour in life a delicate vinaceous-tawny, mottled with mikado-brown; some parts of the head, apices of all femora, tibiae entirely, and the last five or six segments of abdomen, much darker than the rest of the body, walnut- or Vandyke brown. These colours very striking in live examples (fig. 53), but much faded in alcoholic larvae (fig. 52). Light pattern consisting of paler areas on the frons, on meso-metapleurae, base of hinder wings, and abdominal segments; a pair of large squarish marks on dorsum of segm. 6 and a pair of smaller twin-spots on 9 stand out more clearly than the rest. No definite smooth areas on any part of the body except on the sides of the frontal plate and on parts of the abdominal segments.

Macromia westwoodii SELYS (fig. 55, 59-61):

1929. LIEFTINCK, Tijdschr. Ent. 72 : 62 (♂♀ key), 69-72 (descr., full references), fig. 1 (♂ apps), 2 (♂ genit.), 3 (♀ genit.). — ♂♀ C. & W. Java (*westwoodi*).
1931. LAIDLAW, J. Fed. Mal. States Mus. 16: 218 — ♂ Perak (*westwoodi*).
1934. LIEFTINCK, Treubia, 14: 434-435 (notes, bionomics). — ♂♀ W., C. & E. Java (*westwoodi*).
1935. LIEFTINCK, loc. cit. 15: 191-192 (add. descr. & notes). — ♀ S.W. Sumatra, ♂♀ W. Borneo (*westwoodi*).
1942. FRASER, Proc. R. Ent. Soc. Lond. (B) 11: 102. — ♂ Penang (*westwoodi*).

Since last reporting on this species, the following additional material has come to hand:

S. W. Sumatra: 1 ♂ (ad.), Res. Lampongs, foot of Mt Tanggamus, Giesting, 450 m, small forest stream near Wai Tebu, 19.iii.1940, M. A. LIEFTINCK. — W. Java: 2 larvae (ult), Res. Bogor, foot of Mt Salak, 750 m, waterfall Andong, 5.v.1940, F. GROENEVELDT. C. Java: 1 larva (ult), Res. Banjumas, foot of Mt Slamat (S-slope), Baturraden, ca 800 m, 8.vii.1929, F. C. DRESCHER.

Little or nothing is yet known of the habits of the nymph of this species (see page 670).

Description of full grown larva.

Surface smooth, basal antennal joints, prothorax laterally, and coxae, finely pubescent; body otherwise granulate on account of fine, somewhat darker warts, which are distributed in patches or stripes forming a definite colour-pattern.

Head very large, less than twice as broad as long, length and breadth ratio about 8 : 13, height and breadth ratio 5.5 : 7; greatest diameter of head distinctly posterior to the middle, sides roughly convex, but the occipital lobes convergent, broadly rounded, without nipple-shaped or conical tubercle, occipital border very slightly concave when viewed dorsally. Dorsal surface of head in side view evenly convex behind the eyes,

slightly sloping down anterad at level of posterior border of eyes. Eyes large; diameter of facetted portion only slightly shorter than the triangular interior prolongations, raised, globular, not very protuberant, lying well within the outline of epicranium and vertex in profile view. Vertex small, slightly raised; ocelli indicated. Frons trapezoidal, only slightly

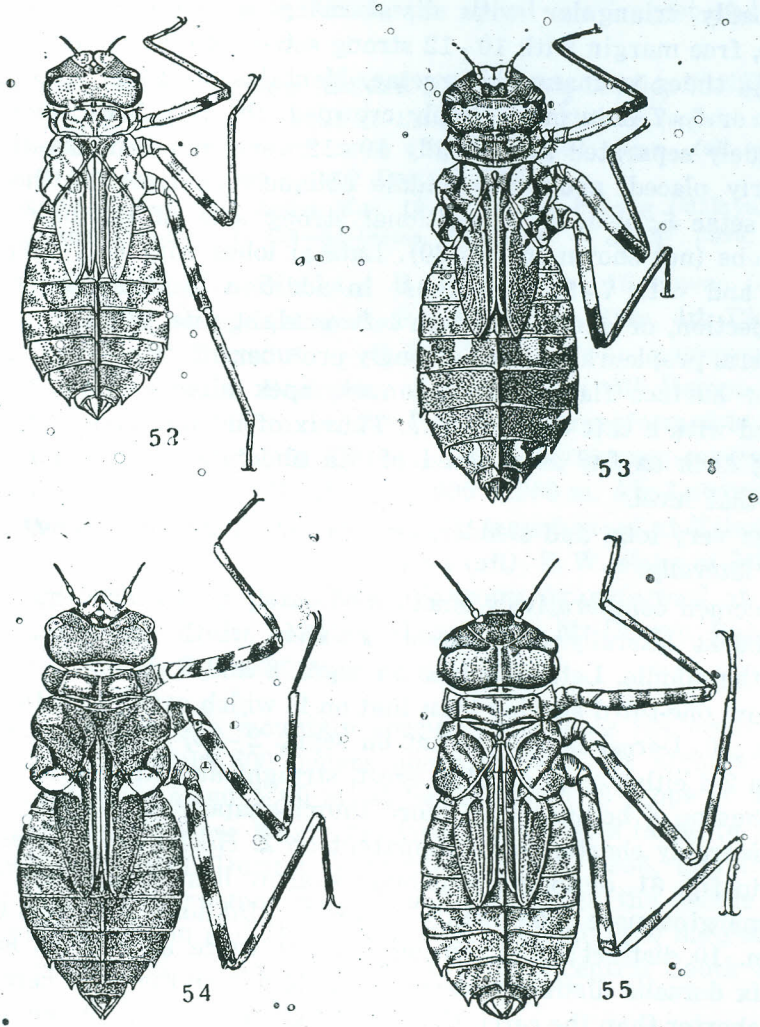

Fig. 52. Full-grown larva of *M. cydippe*, Stream Lasah (Perak), Malaya (spirit specimen). Fig. 53. The same from Djasinga, W. Java (alive). Fig. 54. The same of *M. moorei fumata*, Air Selangis (Benkulen), Sumatra (alive). Fig. 55. The same of *M. westwoodii*, Mt Slamat, C. Java (spirit specimen).

wider than long, its surface a little convex; anterior border distinctly convex in dorsal view, forming a projecting and acute-angulate, almost sharp ridge furnished with a dense row of short scale-like spines. Antennae in length nearly two times their distance apart; first two segments thickened, the first twice as thick as the second, the remaining

segments slender and tapering; 1 + 2 subequal in length to 3 + 4, 3 distinctly longer than 2 or 4; 5, 6 and 7 subequal in length to 4.

Labium of huge size, a little projecting beyond anterior border of head and anterior edges of lateral lobes just visible in dorsal view. Submentum extending back to anterior border of metacoxae. Median lobe broadly triangular with distal margins straight, apex obtuse-angulate, free margin with 10 - 12 strong setae between which are placed about 1½ times as many short setae. Mental setae 9 - 11 on each side, the 5 - 6 or 5 - 7 outermost closely crowded, the remainder shorter and more widely separated and usually 10 - 12 very minute spike-like setae, irregularly placed, about the middle obliquely in front of the others. Lateral setae 5; usually 1 additional strong seta at the base of each lateral lobe (not shown in fig. 60). Lateral lobes with 6 - 7 deep indentations, and with 7 - 8 projections; in addition to these the first and last projection, or one of these on left or right side, divided.

Lateral propleural process strongly protuberant, triangular in outline, its upper surface flat, beneath convex, apex directed cephalad, blunt, furnished with a tuft of soft hairs. Thorax of moderate size. Wing-cases reaching back as far as the end of 6th abdominal segment or a little beyond that level.

Legs very long and slender, femora not dilated but somewhat compressed laterally.

Abdomen comparatively small, moderately roof-shaped but with the dorsal hooks laterally compressed; greatest width at or very slightly behind the middle. Lateral spines on segm. 8 and 9 strong, pointed, that on 8 about one-third shorter than that on 9, which extends as far as apex of segm. 10. Dorsal hooks present on segm. 2 - 10, laterally compressed, those on 2-4 either very slender, erect, straight and finger-like in profile view (that on 4 being rather more thumb-shaped and slightly curved), or considerably shorter and unapparent on 2. Hooks on 5 - 10 shaped as shown in fig. 61, or longer and more sharply bent backwards, with the dorsal margins more prominently convex. [1]) Mid-dorsal keel and end-hook of segm. 10 distinct; anal pyramid almost twice as long as segm. 10, appendix dorsalis distinctly keeled, a trifle longer than the cercoids and a little shorter than the cerci. (Mid-dorsal keels on segm. 10 and app. dors. insufficiently shown in fig. 55.)

Colour-pattern. — Mottled with light and darker brown caused by microscopical scales on a yellowish-brown background, more conspicuously in fresh examples than in the alcoholic larva of fig. 55. Wart-like tubercles on dorsal surface of head behind the eyes arranged in longitudinal

[1]) Our examples from Mt Salak differ from the one of Mt Slamat (fig. 61), in that all dorsal hooks are better developed and longer, those on 2-4 being very slender as described above, whilst those on the succeeding segments are also more conspicuous owing to the abdomen being less distended.

rows surrounding two more or less reniform smooth areas on either side of the median line (not shown in fig. 55). Segm. 4 - 10 each with a pair of smooth areas on outer half of the distance from middle line to lateral margin, the outermost row reniform and both rows surrounding patches of brown, stripy warts which are better defined than in the figure. Femora with three brown transverse bands, the apical one longest and darkest.

Macromia moorei fumata KRÜGER (fig. 32, 33, 36, 54, 56-58).

1928. LAIDLAW, Proc. Zool. Soc. London: 133-134. — ♂ Pahang (*moorei malayana*).
1929. LIEFTINCK, Tijdschr. Ent. 72: 63-64 (♂♀ key), 80-84 (descr., full references), fig. 10 (♂ apps & genit.). — ♂♀ Java; ♂ Celebes.
1931. LAIDLAW, J. Fed. Mal. States Mus. 16: 218. — ♂ Pahang (Malaya).
1934. LIEFTINCK, Treubia, 14: 433-434 (notes, bionomics) — ♂♀ W. Java.

Material studied. — Malay Peninsula: 16 larvae (4 penult, 4 3-ult, remainder younger stages), Perak, Sungai Yum, 4th Plus River, 15.iii.1933, M.W.F. TWEEDIE. — S. W. Sumatra: numerous larvae (different stages), Res. Benkulen, S. E. slope of Mt Dempo, Gunung Agung Estate, 1200 - 1300 m, ix.1941 (1 ♀ larva, transformed at Tjisarua Est., W. Java, 1000 m alt., 21.xii.1941), W. C. VERBOOM; several larvae, same region, S. E. slope of Mt Dempo, 1000 - 1200 m, Air Luwung Njawa, ix.1941, W. C. VERBOOM (1 ♂ larva penult, transformed at Tjisarua Est., W. Java, 1000 m alt., 7.i.1942). 1 ♂ larva (ult), S. W. slope of Mt Dempo, Air Selangis, 1300 m, ix.1940, W. C. VERBOOM (transformed at Tjisarua Est., W. Java, 1000 m alt., i.1941); 1 larva (ult), Mt Dempo, Pagar Alam, 1500 m, x.1941, W. C. VERBOOM.

This is decidedly a mountain species which does not occur below a level of approximately 600 metres above the sea. Its highest recorded altitude in Java is about 1500 m, at Selabintanah (S. slope of Mt Pangrango, W. Java), whence I have received a few males taken in June and July, 1935 and 1936. During September-October, 1936, and in March, 1937, it was not uncommon near Situ Lembang, in the saddle between Mt Tangkuban Prahu and Mt Burangrang, at about 1100 metres alt.

Our reared individuals from Mt Dempo, in central South Sumatra, differ in no way from Javan examples.

Description of full grown larva.

Surface smooth, basal antennal joints, the frontal horn, postorbital and occipital lobes laterally, the coxae posteriorly, and the lateral margins of all abdominal segments, with short scale-like hairs; body otherwise finely and closely granulate on account of numerous microscopical warts, distributed in patches or stripes forming an indistinct colour-pattern.

Head of moderate size, less than twice as broad as long, length and breadth ratio about 8.5 : 13, height and breadth ratio 5.2 : 6.4; greatest diameter of head immediately behind the eyes; postorbital and occipital

lobes strongly convex, sides less convergent posteriorly, lacking any tubercles; occipital border long, evenly and slightly concave when viewed dorsally. Dorsal surface of head in side view evenly convex behind the eyes, sloping down anteriorly at level of posterior border of eyes. Eyes

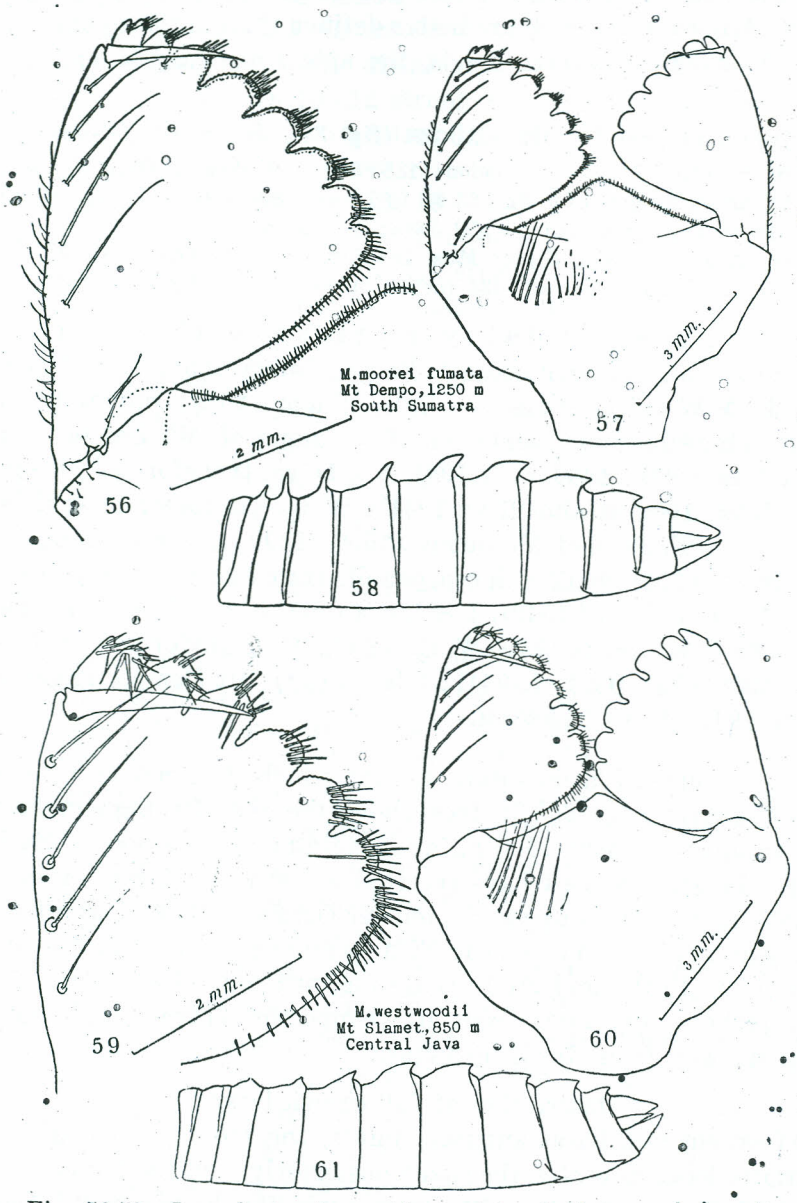

Fig. 56-58. Larval structures (♂ exuvia) of *M. moorei fumata*, Air Selangis (Benkulen), Sumatra. Interior view of left lateral lobe of labium (56), of labium (57), and left side-view of abdomen (58).
Fig. 59-61. The same of larva of *M. westwoodii*, Mt Slamat, C. Java.

large; diameter of facetted portion distinctly shorter than the triangular interior prolongations, raised, globular, more protuberant than in *west-*

woodii or *cydippe*, projecting a little beyond the outline of epicranium in profile view. Vertex small, with slightly convex upper border; ocelli indicated. Frons hexagonal, about one-third wider than long, its surface strongly concave, produced anteriorly in a slightly upcurved blunt and rounded horn-like process, furnished with short scale-like spines. Antennae about one-third longer than their distance apart; first two segments thickened, subequal in length, the first about 1½ times as thick as the second, the remaining segments slender and tapering; 3 less than twice as long as 2, 4 about as long as 2 and very little longer than 5, 6 and 7, which are about equal in length to each other.

Labium of moderate size, projecting a little beyond anterior border of head; submentum extending back to level of posterior border of mesocoxae. Median lobe broadly triangular with distal margins very slightly concave, apex blunt, free margin fringed with numerous short setae as shown in fig. 56. Mental setae 9-10 on each side, the 5-6 outermost more closely crowded than the remainder which decrease in length towards the middle; usually 6-12 minute spike-like setae, irregularly arranged, about the middle obliquely in front of the others. Lateral setae 5; usually 1 (rarely 2) additional strong setae at the base of each lateral lobe. Lateral lobes with 6-7 deep indentations and with 7-8 projections; in addition to these the first and last projection, or one of these on left of right side, divided.

Lateral propleural process protuberant, rectangulate, its upper surface concave, beneath convex, apex furnished with a tuft of soft hairs; pronotum with the side-margins swollen and carrying a distinct blunt tubercle directed upward. Thorax of great size. Wing-cases reaching back as far as the end of 6th abdominal segment.

Legs exceptionally long and spidery, femora more distinctly compressed laterally than in *cydippe*.

Abdomen ovate, greatest width across segm. 6, apical half noticeably more drawn out than in either *westwoodii* or *cydippe*, apex definitely pointed; very flat, segments more depressed than in *westwoodii* and almost half as high across segm. 6 than in *cydippe* (height and breadth ratio about 1 : 2.7). Lateral spines on segm. 8 and 9 relatively small, pointed, that on 8 about one-third shorter than that on 9 which extends almost half-way the length of segm. 10. Dorsal hooks present on segm. 2-10, strongly laterally compressed, those on 2-4 erect, more or less finger-like in profile view, those on succeeding segments progressively longer and less sharply bent backward with the dorsal margins longer and straighter, that on 10 blunt and reduced to a small roundish tubercle unapparent in profile view. Appendix dorsalis with no distinct keel; anal pyramid about twice as long as segm. 10, appendix dorsalis subequal in length to the cerci, the cercoids a little shorter.

Colour-pattern. — Ground-colour in life very dark greyish-brown to brownish-black. Legs light brown; all femora with three, the tibiae with two, sharply defined blackish-brown rings; tarsi obscured. Body without clearly defined pattern but with a conspicuous light grey or yellowish patch on the metapleurae above, some pale colouring in front of the vertex, and two more or less distinct pale spots on the pronotum (fig. 54). No definite smooth areas on any part of the body except two narrow areas on the frons, two pairs of somewhat reniform bare patches placed in the main axis of the head on the epicranium, and on the lateral parts of the abdominal segments.

DESCRIPTION OF A NEW SPECIES OF *Macromia* FROM CELEBES.

Macromia irina, sp.n.

Material studied. — Celebes: 1 ♂ (semiad.), S. Celebes, foot of Mt Lompobatang, Borong Rapao, 800 m, viii.1949, A. DIAKONOFF.

Male (holotype). — Head shaped similarly to *moorei fumata* KRÜG., but dorsal surface of frons not divided into flattened and framed parts; pyramidal processes elevated, rounded above, their anterior surface somewhat flattened and finely transversely wrinkled. Vertex small, evenly rounded above, its lateral angles produced laterally into small projecting cones, at the apex of which the lateral ocelli are situated. Head unicolonous cinnamon-rufous, including the frons, which is slightly shiny but devoid of steely reflections. Tips of mandibles chestnut-coloured. Pile short, black. Occiput glossy black. Rear of the head brown; a pair of yellowish-brown spots on either side behind the eyes. Antennae brown.

Pro- and synthorax uniform Mikado-brown; dorsal surface and anterior half of mesepimera with metallic-green lustre most distinct on upper part of mesepisterna, the brown ground-colour shining through about the humeral suture; sides almost lustreless. Dorsum of thorax with dark grey hairs, pubescence on the sides silvery-grey. Ante-alar triangles dirty yellowish.

Legs very slender but decidedly shorter than in *m. fumata*, hind femur 9.0 mm long, reaching back as far as base of posterior hamuli; colour uniform orange-cinnamon, including tarsi and spines. Keel on flexor side of anterior tibia light brown, barely one-fourth as long as tibia and not reaching its apex; keel absent on middle tibia and extending along distal four-fifths of posterior tibia, tnough its projecting point does not reach just as far as the apex of the former.

Wings broader and apices decidedly more rounded than in *m. fumata*. Membrane hyaline, but all wings at extreme base with minute rusty-brown spot in *c-sc*. One short pentagonal undivided basal cell between anal triangle and loop, the succeeding pair of cells about equal in size to the first. Arculus situated between Ax_2 and Ax_3 in all wings. Nodal in-

$\frac{10.17.17.\ 9}{12.11.12.11}$; $ht\ \frac{4.3}{2.2}$; $Cux\ \frac{6.6}{5.5}$. Triangle of anterior and posterior wing nearly equal in size; proximal side in hind wing very little shorter than costal and distal sides. Discoidal field of anterior wing commencing with two rows up to about three cells basal to node. Three basal cross-veins in discoidal field of posterior wing running directly from M_4 to Cu_1. Veins M_3 and M_4 less strongly waved, and Cu_1 and Cu_2 more gradually curved towards the anal border, than in *m. fumata*.

Anal angle of hind wing distinctly projecting, but not acute; anal margin between membranula and the angle itself markedly concave. Cross-vein in anal triangle straight. Membranula relatively short and narrow, not extending beyond the cross-vein in anal triangle, greyish-white in colour. (In *m. fumata* and several other species the membranula extends halfway between the cross-vein and the apex of the triangle.) Anal loop normal, made up of 8 cells without central cell. Pterostigma small, cinnamon-coloured.

Abdomen short but of the usual shape, brownish-black in colour marked rather diffusely with rich orange-cinnamon, as follows: 1-2 dark brown on dorsum and upper half of sides, the remaining parts Mikado-brown; dorsum of 2 with two pairs of transverse yellowish streaks at the transverse carina and shortly before posterior margin; 3 Mikado-brown as far as the transverse carina, thereafter black with diffuse light brown ante-terminal ring; 4-5 similar to preceding segment but the basal half rather obscured dorsally; 6 black except diffuse light brown basal and apical rings, the latter interrupted by black at the dorsal crest; 7-10 orange-cinnamon, the middle three-fifths of 7 velvet-black, and the sides of 8 a little obscured; dorsal carinae of 8-10 blackish. Dorsal surface of 10 rather pinched, longitudinally carinate and carrying a distinct, triangular boss just before posterior border of segment.

Anal appendages cinnamon-buff. Shape of superior pair in dorsal view similar in principle to those of *westwoodii* and *m. fumata* but without any indication of an extero-lateral tooth; in profile view they appear much broader, the basal half of each being in fact twice as broad as the apical half which diminishes rapidly in width just after the end of the ventro-lateral ridge, the tips being slender, a little outcurved and pointed; marginal hairs along inner border of distal half long, black in colour. Inferior appendage similar in shape to *westwoodii*, equal in length to superior pair.

Genitalia of second segment resembling most closely those of *westwoodii*. The basal one-fourth of the tergite is provided along its ventral margin with a row of few short forwardly directed black bristles, followed by a dense tuft of much longer, soft pale brown hairs, beyond which the ventral margin is almost hairless. Genital lobe elongate-oval, densely covered on the inside and at the apex with strong forwardly directed black

bristles. Posterior hamuli pale brown in colour, suggestive of those of *westwoodii* but, when viewed laterally, the outer border is straighter and rather undulated half-way its length instead of distinctly convex, the end-hooks being abruptly bent upwards under a right angle; in ventral view the hamuli appear strongly convergent with closely approximated tips.

Abd. + app. 44.0, hw. 41.5 + 13.5, pt. 2.0 mm.

Female unknown.

This interesting new species no doubt finds its proper place near *moorei* SELYS, which ranges from India (*m. moorei* SELYS) through Malaysia to Celebes (*m. fumata* KRÜGER). It also recalls the Malaysian *westwoodii* SELYS and allies in certain respects. In 1929 (*loc. cit.*) I have placed these species in two different sections of the genus; and although it is not to be implied from this that I regard *irina* as a transition form, the groups defined earlier are admittedly artificial. *M. irina* should be easily recognized by the uniformly rufous colour of the head, thorax and legs, the complete absence of a yellow lateral thoracic stripe crossing the spiracle being a unique negative feature of this species. It is easily distinguished from *m. fumata*, which occurs also in South Celebes, by the rounded frons and vertex, the more rounded wings and details of venation, the different shape of the posterior hamule, and the absence of an extero-lateral tooth at the superior anal appendages. The very short keel on the anterior tibia would likewise seem to be a specific character.