BIONOMICAL NOTES ON SOME BORNEAN MANTIDÆ.

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During a five years' residence in Sarawak, Borneo, I have kept in captivity, and under close observation, many species and specimens of *Mantidæ*, and have from time to time jotted down rough notes on their habits, their food, methods of feeding, life-history, &c. The following account is a brief *résumé* of these notes, and, though containing no very important or new facts, may perhaps be of some interest to those readers of 'The Zoologist' who have never had the good fortune to observe these curious insects alive for themselves.

Species of the genus *Hierodula* and *Tenodera superstitiosa* are met with more frequently than any others in Borneo, and, as they are strongly attracted by light and frequently fly into houses at night when the lamps are lit, I have had plenty of opportunities of observing their habits in captivity, and of checking my observations.

A Mantis such as one of these, when first captured, displays considerable ferocity, grasping with its raptorial legs the fingers of its captor with great force, at the same time trying to bite, but after a few days many become comparatively tame, and some of my captives would not only take food from my fingers, but would devour it whilst resting on my hand. It is most interesting to watch a Mantis, e. g. *Hierodula dyaka* (a bright green species), attack a large butterfly, such as an Ornithoptera or Amathusiine when introduced into its cage; the movements of the butterfly are watched closely for some time, the Mantis turning its head from side to side in what appears to be a very intelligent manner; the fore part of the body (the prothorax) is raised, the raptorial front legs are drawn up close against the side of the body, and their yellow inner surfaces turned outwards; the abdomen

is sometimes so strongly dilated as to show the black intersegmental membranes. The butterfly is seized with a sudden snatch, and the Mantis nearly always commences operations by biting through the costal nervures of the fore wings near their origin; if, however, the prey has not been seized in a position favourable for this method of attack, the Mantis bites into the chest so as to sever the wing-muscles. A large Ornithoptera, when first seized, will dash its attacker with great violence against the sides of the cage in its mad struggles for freedom,

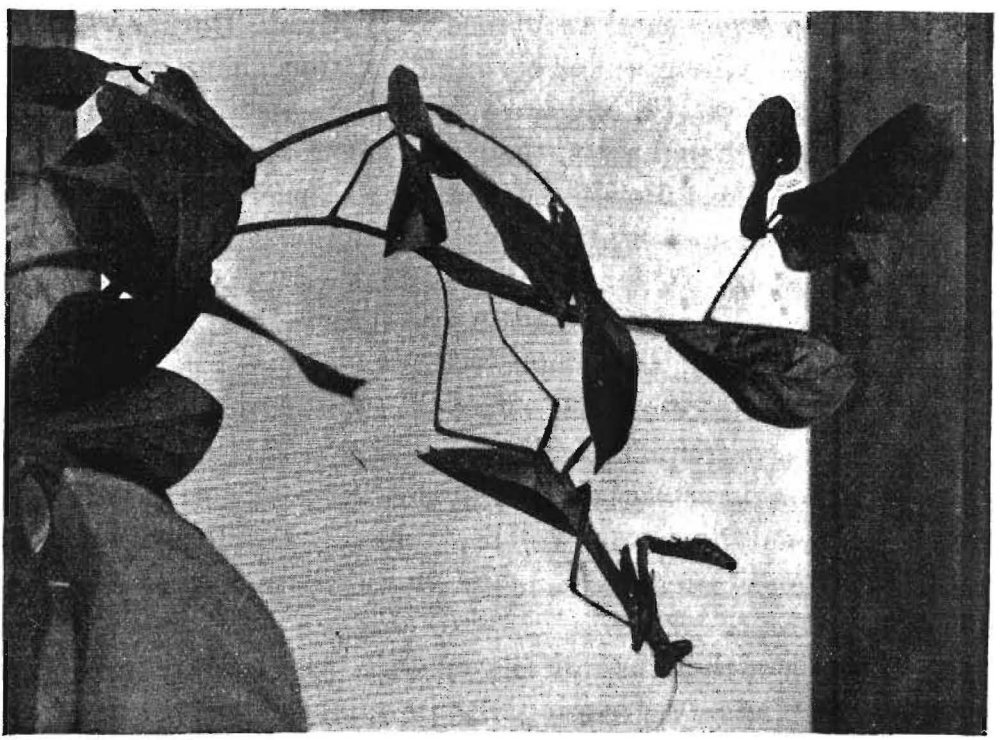

FIG. 1.—*Rhombodera basalis*, De Haan cleaning its left mid-leg after a meal.

but I have never yet seen a Mantis relax its hold; on the contrary, it will with much persistence literally burrow its way into the thorax of the butterfly until the flutterings become weaker and weaker, as one by one the wing-muscles are severed. If the butterfly is one of the weak *Satyrinæ* or a small Nymphaline, the Mantis commences its meal on any part that comes handy—the head, the abdomen, or perhaps the legs; but strong-flying species are always attacked, so far as my observations go, in the way described, and as often as I have witnessed it, I have been irre-

sistibly reminded of a bull-dog trying to pull down a bull. If the Mantis is hungry it will devour the whole butterfly, leaving only the wings, and perhaps the distal part of the legs. After a meal a Mantis will proceed to clean itself; the teeth of the fore femora and tibiæ are picked over by the mandibles, then the fore legs are repeatedly rubbed over the eyes and top of the head, much in the same way as the House-fly, after rubbing its fore tarsi together, passes its legs over its head; finally the tarsi of the middle pair of legs are cleaned in the following way: the prothorax is turned at an angle to the rest of the body, and one of the front legs hooks up one of the middle legs and carries it to the mouth; it is held in position there whilst being cleaned by the mandibles, and then released (Fig. 1). A great many *Mantidæ* have, as is well known, the inner sides of the fore legs coloured in a conspicuous manner, and these conspicuous markings are displayed whenever the insect is meditating an attack on its prey. The green *Hierodulæ*, however, have the inner side of the fore legs merely a pale yellow, which is certainly not very conspicuous; still, as already stated, a Hierodula, when a butterfly is introduced into its cage, always throws itself into an attitude that displays these yellow surfaces to best advantage, not, so far as I can see, to terrorize or fascinate its prey, but merely because a sudden and powerful snatch is more readily made from this position than from any other. I am inclined to believe that in such an unconscious "display"* as this we may see the beginnings of those remarkable attitudes assumed by such floral simulations as the Empusides, which attitudes might well be termed "purposeful displays." † Of course, many species, e. g. *Tenodera superstitiosa*, do not attitudinize in any way whatever when excited, and that I am inclined to regard as the primitive habit; but these species have not got the fore legs coloured on the inside even as conspicuously as the *Hierodulæ*. The dead-leaf-like form (*Deroplatys desiccata*) has the inner side

* By the term "display" I mean the sudden exhibition of brightly coloured or conspicuously marked parts which are concealed during rest.

† I find that I am anticipated in this supposition, for Dr. Sharp, in an interesting paper on *Idolum diabroticum* (Proc. Cambridge Phil. Soc. vol. x. pt. iii.), supposes (p. 180) that "in the past the function of catching in a particular manner has preceded the modifications of structure for doing so."

of the fore femora red-brown, blotched with black and pearly white in a small oval patch on the front border. In another dead-leaf-like species (*D. shelfordi*) the inside of the fore coxa is red throughout its proximal two-thirds, pale bluish in the distal third, the femur has a heavy black blotch about its middle. *D. desiccata*, preparatory to seizing its prey, invariably behaved like the *Hierodula*, i. e. the front of the body was raised, and the fore legs drawn up close against the body, and slightly rotated outwards so as to display their inner surfaces. The black and white blotches show up very conspicuously against the red-brown of the rest of the body. The under sides of the elytra in this species are marked on their outer halves with conspicuous white and madder blotches, but these markings are never displayed. *D. shelfordi* used to adopt a very different attitude when prey approached; the front of the body would be raised and the fore legs stretched out widely at right angles on either side of the body; sometimes the elytra would be raised up, and the wings spread out fan-wise behind them,* the Mantis all the time this attitude was maintained swaying slightly from side to side. The under sides of the elytra in this species are bluish grey, with four large fuscous patches, the wings on the costal border are pale yellowish, but otherwise are coal-black mottled with innumerable fine pinkish-white lines.

A still more remarkable appearance is presented by *Hestiasula sarawaca*. This little Mantis, when at rest, is very cryptically coloured with brown and grey; its fore femora are produced into large flat expansions, which causes them to be disc-like in shape; they are held close together in front of the body, when the insect appears to be of roughly the same diameter throughout, and looks like a piece of wood or excrescence of bark. On the approach of prey, or when irritated, a wonderful transformation takes place; the prothorax is raised, and the fore legs are spread widely out on either side of it; the elytra, wings, and abdomen are also elevated, the wings spread out fan-wise; the front coxæ on their inner aspect are a deep crimson; the plate-like femora are bright yellow, with a black sickle-shaped marking

* A large species of *Gryllacris*, common in Indo-Malaya, when irritated, always raises the elytra and wings fan-wise over the back. The European *Mantis religiosa* "displays" in the same way.

extending along the posterior and proximal borders, and with two small black spots on the anterior border; the under surface of the prothorax is coal-black, and the wings are black, mottled nearly all over with fine chrome-yellow streaks and dashes. During this "display" the antennæ are agitated so rapidly that only an indistinct blur is seen in their place; the fore tibiæ snap down on their femora with a clock-like regularity, a continuous rustling sound maintained by the wings, and the insect sways from side to side, now bolt upright, then right over on one side, then with a swing right over on the other side.

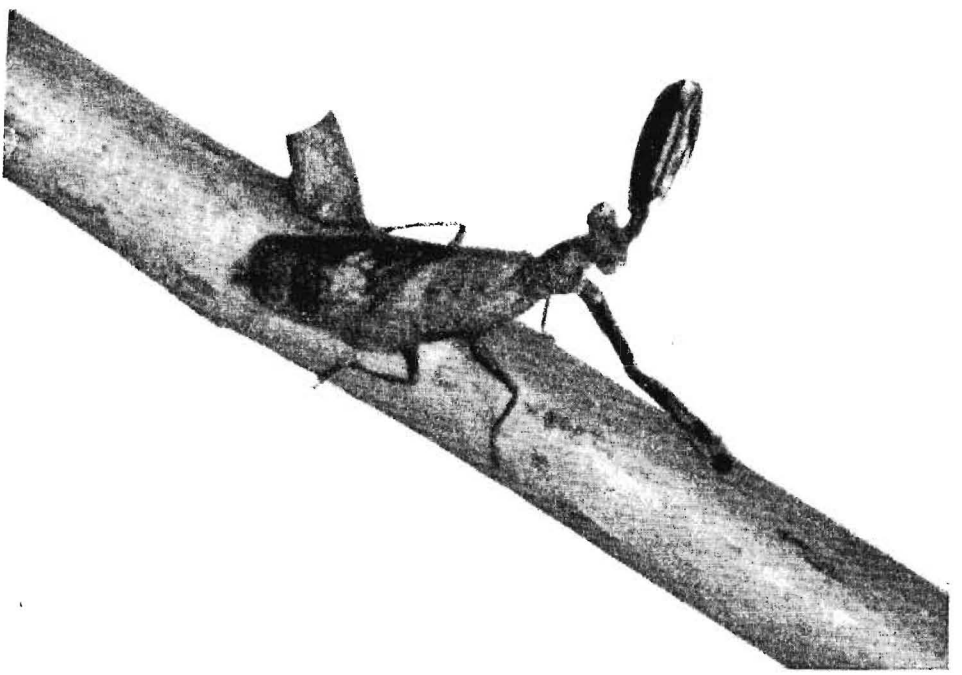

FIG. 2.—*Hestiasula sarawaca*, Westw.; beginning to "display:" front of body raised, fore-legs opening out.

A green and white *Theopropus* (*T. elegans*, Westw.) "displays" in much the same manner as *Deroplatys shelfordi*, but neither the inner side of the fore limbs nor the wings are conspicuously coloured.

What is the meaning of these "displays"? It should in the first place be remembered that they can be induced by irritating the Mantis, as well as by the presence of prey. None of the species described above look in the least degree flower-like when

"displaying," and it is absurd to suppose that butterflies or other insects can be fascinated or attracted by conspicuous markings or weird postures. I can only conclude that these Mantid "displays" are warning attitudes comparable with the warning "displays" of many lepidopterous larvæ (*cf.* the eye-spots of many species of *Chærocampa* amongst the hawk-moths, the black patch in larvæ of *Dasychira* spp. amongst the *Lymantriidæ*, the everted red processes of *Papilio* larvæ, &c.).

Further, I believe that these "displays" have originated from the simple posture of attack or defence into which such a species as *Hierodula dyaka* throws itself when stimulated by the presence of its prey, or by an enemy's attack. As already stated, that posture—in which the fore legs are drawn up close against the sides of the body, and slightly rotated outwards so as to show their yellow inner aspects—is adopted because it is the most convenient for making a sudden snatch at a moving insect, and it has no other purpose. We may imagine that these unconsciously "displayed" parts may become conspicuously marked as in *Deroplatys desiccata*, that still later these parts become more conspicuous, and the attitude better adapted for showing them off, as in *D. shelfordi* and *Hestiasula sarawaca;* finally, that the parts become flower-like, and the "display" a more or less permanent condition in the Mantis's life, as in the Empusides.* In other words, the floral simulation of the Empusides is an outcome of a warning "display," which again originated from a simple posture of defence or attack.† These warning "displays," having then been evolved from a simple posture of attack, it is only natural that they should be made under the stimulus of any excitement, such as the presence of prey or an enemy. A Mantis is naturally a ferocious insect, and its first instinct when stimulated is to seize and destroy the exciting cause; for example, none of the dead-leaf-like species feign death when

* The Empusides are described by many observers as swaying gently when at rest, apparently to imitate the swaying of a flower in a gentle breeze. This swaying movement is, as shown above, characteristic of the warning display of *Hestiasula sarawaca.*

† Dr. Sharp (*l. c.* p. 177) thinks that the position in which the front legs of *Idolum diabolicum* is held is very unusual amongst the *Mantidæ*, but I hope that I have shown that this is not the case.

irritated, as Phasmids and many other cryptically formed insects do, but instantly prepare to attack their assailant.

A very curious and interesting species is *Metallyticus semiæneus;* it is a metallic-green and blue-black, is much flattened dorso-ventrally, and has many other uncommon characteristics; unlike all other *Mantidæ* with which I am acquainted, it runs with great swiftness, and with the gait of a cockroach, *i. e.* literally *ventre à terre*, the body not being raised well off the ground as is the case with its relations. The species is found generally on the bark of trees, but often underneath the bark, and it preys on cockroaches. I endeavoured, with ill-success, to keep specimens of this Mantis in captivity before I discovered that its natural prey was cockroaches; butterflies, flies, termites were never touched, but if a cockroach was introduced into a cage containing this Mantid, it was either pounced on at once or else captured after a long and exciting chase all over the cage.

Theopropus elegans has the curious habit of resting on the femoro-coxal joints of all the legs; it progresses with a curious swaying top-heavy motion, varied with an occasional scrambling leap; the large fore legs of this species appear as if too heavy for it. The hind wings are a beautiful iridescent white, very finely speckled with purple.

Hymenopus bicornis, one of the Harpagides, is a floral simulator throughout the whole of its life-history, with the exception of the first stage. I shall have some remarks to make on the young of this species later on. The adult is a cream-colour, with some brown stains on the elytra; the mid and hind femora are furnished with plate-like expansions, the prothorax is only slightly enlarged, and the fore legs not at all. In the cabinet the insect does not look very flower-like, but when seen hanging perhaps upside down on a bush with the two pairs of ambulatory legs spread wide out, it can readily be mistaken for some curious orchid-like bloom. It makes no "display" on the approach of prey, but quietly waits till that comes within striking distance, an exceptional habit induced doubtless by its floral simulation.

Some *Mantidæ* are much afflicted with a parasitic worm, a long brown thread-like Gordian; the two species that I have found to be most affected are *Hierodula dyaka* and *Rhombodera basalis;* it is, indeed, very seldom that one of the latter is found

without its parasite, which lodges in the fat body above the intestine. Professor Camerano has described this Gordian worm as *Chordodes shipleyi* (Atti della R. Accad. delle Scienze di Torino, vol. xxxiv. p. 3, 1899).

One of my objects in keeping *Mantidæ* alive was to test their likes or dislikes for particular insects, and their appreciation of the warning colours displayed by distasteful insects,* and with this object in view my captives have always been furnished with a most mixed diet. I may say at once that I have found little evidence that *Mantidæ* appreciate warning colours, and still less evidence that they prefer one sort of butterfly to another, or particularly dislike such acknowledged distasteful butterflies as the members of the subfamily *Danainæ*. The black and white day-flying moths of the *Deilemera* (=*Nyctemera*) are, however, invariably refused, and left strictly alone, even when introduced together with cryptical moths and butterflies that are presumably palatable. I have never yet seen a Mantis attack one of these distasteful species, nor have I ever found their half-eaten remains in a Mantis's cage. In this connection it is interesting to note that the large and common Spider (*Nephila maculata*) manifests the same dislike for *Deilemeræ*. I spent several hours one morning introducing insects of the most varied orders into a web of this Spider. All butterflies and many beetles were devoured greedily, but *Deilemera coleta*, and another species of the same genus, the little Bees of the genus *Trigona*, and the Reduviid bug (*Velinus nigrigenu*) were always cut free and flicked out of the web at once. I have several records of *Mantidæ* seizing and partially devouring such *Danainæ* as *Parantica eryx*, *Trepsichrois mulciber*, *Tronga crameri*, and then relinquishing their hold as if their meal was too nauseous to be proceeded with; but these rejected insects have always been dead when relinquished, so that their warning colours were of no value to them in securing them immunity from attack. My records of *Mantidæ* seizing and completely devouring *Danainæ* are, on the other hand, much more numerous, and I have not even had reason to suspect that a prolonged diet of Danaine butterflies

* See Trans. Ent. Soc. London, 1902, pt. iii. p. 297 *et seq.* for a series of experiments on Mantid likes and dislikes, by G. A. K. Marshall ("Bionomics of South African Insects").

has been prejudicial to the health of any Mantis, though Mr. Marshall (*l. c.* p. 309) believes that in some cases a prolonged *Acræa* diet was the cause of the death of some of his captive *Mantidæ*. It is quite possible that the gaudy Acræas are more nauseous than the Oriental Danaines; *Limnas chrysippus* and other species of the same genus are found so rarely in this part of Borneo that I have not been able to experiment with them, which is a matter for some regret, as these are the most gaudy members of the *Danainæ*. I have also tried the experiment of putting several species of butterflies—palatable and distasteful species—into a Mantid's cage all at the same time, and watching to see if any selection was exercised; but, with the aforesaid exception of *Deilemeræ*, the Mantid always appeared perfectly indifferent in its choice, a Danaine being seized as eagerly as any other species if it happened to get within striking distance. A newly captured Mantis will seize and devour any fluttering insect that may be introduced into its cage, purely, I believe, from sheer ferocity, and I think that in all experiments of this nature this fact ought to be taken into account; for example, I have seen a newly-imprisoned Mantis pounce on a male *Trepsichrois mulciber*, and, after nibbling at its head and legs, suddenly nip off the yellow scent-glands which were protruding from the end of the abdomen of the butterfly; the butterfly was then released, recaptured, released again, recaptured again, and finally devoured. Two very strong-smelling Coreid bugs, *Mictis longicornis*, were introduced into a cage containing a species of *Hierodula*, and much to my surprise were completely devoured. It is recorded in Mr. Marshall's paper, that two bugs, *Cyclopelta* sp. and *Physomerus* sp., were never eaten, though often killed, by an Indian Mantis, *Hierodula bipapilla;* on the other hand, that the Coreid *Anoplocnemis curvipes* * was devoured by Baboons.† On the whole,

* The *Coreidæ* are rather a puzzle to supporters of the mimicry theory; they all have a very strong and disagreeable odour, just as the brilliantly coloured *Pentatomidæ* have (cf. *Catacanthus*, *Chrysocoris*, &c.), and yet all are cryptically coloured, and many have the leaf-like expansions on legs and prothorax which we are accustomed to associate with palatable cryptically coloured insects, such as Phasmids and some beetles.

† Another species, *Holopterna alata*, in spite of its offensive smell, is eaten in the Transvaal by a Lizard, Fowls, and Meerkat.—Ed. (*Cf.* 'Zool.,' 1902, p. 393.)

allowing for the assumed greater distastefulness of *Acræinæ*, my results agree well with Mr. Marshall's: we have little or no evidence that *Mantidæ* appreciate warning colours; a distasteful insect when seized is either completely devoured or else half eaten and so killed, and neither here nor in Africa do *Mantidæ* show that aversion to distasteful forms that one might expect, nor do they exercise much, if any, selection in the capture of their prey from amongst a number of butterflies.

I have been able to recognize two types of egg-cases amongst the *Mantidæ* of Borneo: (1) that made by the members of the tribe Mantides; (2) that made by the Harpagides. The former is a large rounded white structure adhering to vertical grass-blades or plant-stems. It consists of two distinct parts—an outer thick covering of spongy texture, being a dried froth, and a dense central mass of eggs disposed symmetrically in closely apposed follicles; the outside is streaked slightly, showing that the outer covering was laid on in successive layers of froth. Such an egg-case is figured in almost every entomological text-book. I believe that the use of the spongy outer covering is to prevent the attacks of parasitic Hymenoptera. An Ichneumon fly would require a very long ovipositor to reach the central mass of eggs; yet such are to be found frequently in Borneo, and on one occasion I disturbed a small Braconid (? *Iphiaulax* sp.) that was resting on a Mantid's egg-case. I reared young Mantid larvæ from these eggs; so either the Braconid had not commenced operations when disturbed, or else had no nefarious designs on the nest at all. Very frequently an egg-case is tenanted by ants, who scoop out much of the outer covering, leaving a mere shell with the central egg-mass attached by a few strands only to the outermost wall; the ants never seem to interfere with the eggs. The Harpagides make a long narrow egg-case, generally cream-coloured, and adhering to more or less horizontal stems and twigs. The eggs are disposed symmetrically along a central axis, and covered with a very thin layer of froth, smooth and shining on the outside. *Theopropus elegans* and *Hymenopus bicornis* are devoted mothers; a captive specimen of the former used always to rest astride her egg-case, and twice I have taken the latter close beside her eggs.

Hestiasula sarawaca makes a nest more or less intermediate

between the Mantid and Harpagid types, *i. e.* it is a long narrow structure adhering to a horizontal twig, but it is covered with an irregularly shaped mass of dried froth, not smooth on the outside, sea-green in colour. The young of Harpagides walk straight out of the ootheca on to the twig to which it adheres; but the young of the Mantides lower themselves from the suspended nest by silken threads to the ground, or to a leaf, and only then begin to rid themselves of the embryonic envelope in which they are encased (see a figure in 'Cambridge Natural History—Insects,' Part I. p. 247).*

The young of *Hierodulæ* are green or yellowish, and quite recognizable as the offspring of their parents. But this is not often the case, *e. g.* the young of *Tenodera superstitiosa*, a brownish-green species, are coal-black, except on the crown of the head, dorsal surfaces of the meso- and metathorax, and the legs, which are salmon-pink; the lateral borders of the prothorax and abdomen are pearly-white; the eyes are pearly-white, with a black streak running down the centre; the four basal joints of the antennæ each bear four long setæ and look feather-like. These little creatures are very active, and look remarkably like ants.

The young of *Metallyticus semiæneus* are chequered on the meso- and meta-notum and on the dorsal surface of the abdomen with white, and the legs are red. Unlike all the other larvæ and pupæ of *Mantidæ* that I am acquainted with, this does not carry the abdomen turned up over the back of the thorax. The newly-hatched young of *Hymenopus bicornis*, when they just emerge from the ootheca, are sealing-wax red, with black head and legs; they then bear a remarkably close resemblance to the young larvæ of a Reduviid Bug, *Eulyes amœna*, even to their method of moving about with abdomen turned up. In this stage the plate-like expansions of the legs are not developed. After the first moult the larvæ become pink or cream-colour, and the femoral expansions make their appearance; from this stage on the insect remains flower-like. The colour of the larva depends a good deal, if not entirely, on the colour of the flowers that it frequents. Recently I had brought to my notice a specimen that

* I have not come across any pre-larval stage such as has been described for the European *Mantis religiosa*.

had been found on a yellow flower with crimson stamens; the larva was yellow, with crimson lines on the abdomen and crimson mid- and hind-axæ. As far as my observations go, this species cannot change its colour in adaptation to its surroundings without moulting. A pink specimen found on a shrub with pink flowers (? *Melastoma* sp.) was kept under a bell-jar standing on a sheet of white paper. After a few days the larva moulted, and was then pure white. A nymph of *Deroplatys desiccata*, on the other hand, that was kept for some days in a box lined with white paper, became noticeably paler in colour.

A full and accurate account of the habits of a pupal *Hymenopus bicornis* may be found in a paper on the Insects of the Skeat Expedition, by Mr. Nelson Annandale (P. Z. S., pt. iv. 1900, pp. 839–848). The same paper contains notes on other Malayan *Mantidæ*.

Description of a New Species of Mantidæ referred to in the above paper by W. F. Kirby, F.L.S., &c.

DEROPLATYS SHELFORDI, sp. n.

Long. corp. 60 millim.; long. pron. 30 millim.; lat. 26 millim.

Female.—Dead-leaf brown; pronotum of a long bell-shape, regularly curved and expanded backwards to its greatest breadth, the hind border curving backwards and inwards to the extremity; lateral borders denticulated on the basal half. Tegmina with no distinct markings except a narrow yellowish discal stripe; wings banded with blackish, and produced into long processes at the extremity, as in *D. truncata*, Guér. Spines of the front femora and tibiæ more or less tipped with black; front femora with a black band towards the extremity on the inner side, intersected by two or three short yellowish stripes; front coxæ with six or eight short straight spines.

Hab. Borneo; Sarawak (Shelford).

Apparently intermediate between *D. truncata*, Guér., and *D. horrifica*, Westw., resembling the former in shape, and the latter in markings.