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SOME ACCOUNT
OF THE
'PALAN BYOO' OR 'TEINDOUNG BO'
(*Paraponyx oryzae*),

A LEPIDOPTEROUS INSECT-PEST OF THE RICE-PLANT IN BURMA
WHICH IN THE CATERPILLAR STAGE BREATHES WATER BY MEANS
OF TRACHEAL-GILLS.

BY
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With compliments

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IN January 1882, two specimens (two stages) of a blight which attacks the Rice-plant, the one called in Burmese 'Teindoung Bo,' the other 'Palan Byoo,' were forwarded* for determination to the Indian Museum by the Chief Commissioner of British Burma together with the subjoined translation from the Burmese of a Memorandum† on different kinds of blight by Assistant Settlement Officer MOUNG TOO.

These specimens are in reality three in number—one being a caterpillar and the other two pupæ or chrysalises, and they represent two of the stages in the metamorphosis

* In British Burma Revenue Settlement Department No. 1417, General, January 9th, 1882.

† The different blights to which paddy is liable are said to be four; they are—

(1) Ywetpyatpo;	(3) Satmee;
(2) Pinbo (or Ooshoukpo);	(4) Palanbyoo.

Ywetpyatpo.—When the paddy is about a foot above the ground this blight first appears; it is not of a very serious kind. The paddy does not usually die; it loses its leaves and is weakened. This insect first appears as an egg on the paddy; after three or four days it becomes an insect, enters into the folds of the leaf, nibs it, and lets it fall off. The appearance of this insect is much like a cricket; its colour is green-spotted. When this blight appears it is desirable that there should not be an excess of water in the fields; the

of a small animal belonging to the Heterocerous division of the insectan order Lepidoptera.

They differ, as will be seen, so little from the corresponding stages of an animal whose metamorphoses are completely known even to the minutest detail, that they may, even in the absence of the perfect insect, be accepted with entire confidence as stages of a closely-allied species of moth.

The 'Palan Byoo' is an animal of considerable zoological interest, inasmuch as in its larval stages it is specially modified for a purely aquatic life; having the

water is therefore drawn off, for, should the leaves of the paddy be particularly green and tender, the destruction of the leaves would be excessive. This description of blight is liable to occur from Wagoung (July) till Tawthalinlabyee (September).

Pinbo.—Pinbo, otherwise called Ooshoukpo. This is probably only the above-described insect under a different name; also called Teingdounbo.

For of the insects who nipped the leaves some remain, some are carried off with the leaves, and eventually, wafted by the wind, attach themselves to plants, and crawl up the hollow of the stalk. This blight is liable to occur from Tawthalin (September) to Thadingyoot (October). Should it then appear, the leaves turn white and shortly afterwards some plants die off; the remainder are weakly and do not fruit well.

Satmee.—The above description of blight is frequently also described as 'Satmeelikethee.'

This blight is called after a "sambur's tail." The root of the plant bushes out, and the extremity, instead of sending out fruiting shoots, remains as it is. When this occurs some plants die off outright; some that remain do not increase from the main stem, but branch off the top, and when the time for fruiting comes do not fruit well. This description of blight generally occurs in very good (rich) soil. Should it appear, water should be let into the field, for, should there be a deficiency of water, the paddy is sure to die off. This is also called 'Bouktheik,' and occurs in land flooded by salt-water.

Palanbyoo.—Palanbyoo is another description of blight. It is a flying insect which settles on the paddy. Paddy so attacked discolours. The insect itself is something like the rice-insect. Because paddy so attacked gets white (discolours), this insect is called Palanbyoo. It is not a very destructive kind of blight, and generally occurs from Tawthalin (September) to Thadingyoot (October). When it appears, the water is let out of the fields and consequently the plants dry up, and, when fruiting, do not fruit well. After 10 or 15 days the insect leaves the plants and flies away. By some cultivators said to be the worst kind.

external orifices (stigmata) of its tracheæ in the caterpillar closed and functionally replaced by extensive series of tracheal-gills or organs for extracting oxygen from water, and presenting in the pupa stage a special modification of the cocoon whereby, in a manner at present not very clearly understood, air is extracted from the water, and enters the body by three pairs of the stigmata which at this stage are exceedingly prominent and, moreover, open. Respiration by means of the organs termed tracheal-gills (which are nothing more than fine branches of a closed tracheal system extended into outgrowths of the surface of the body with walls so thin and delicate that exchange of gases can readily take place between the water and the closed system of tubes), though the rule in several groups of insects at one or more stages is yet so exceedingly rare amongst Lepidoptera as to be quite exceptional; only two species of this immense order from all parts of the world having hitherto been shown to possess such organs, namely, the European *Paraponyx stratiotalis*, whose habits, structure, and metamorphoses were admirably described and delineated by the celebrated Swedish naturalist Baron de Geer* about the middle of the past century, and the Brazilian *Cataclysta pyropalis*, which forms the subject of an interesting and well-illustrated essay in last year's volume of Wiegmann's Archiv by one† of the brothers of him whose philosophic researches in biology have made the already famous name of Müller one of the best known to the science of our day. These two forms, with the Palan Byoo, belong to the family

* Mémoires pour servir à l'Hist. des Insectes, 1752, vol. i, pp. 517-541, pl. 37.

† Willh. Müller-Blumenau, Ueber einige in Wasser lebende Schmetterlingsraupen Brasiliens, in Arch. f. Naturgeschichte, 1884, Band i, pp. 194-211, pl. xiv.

Pyralidæ. Other *Pyralidæ* and *Crambidæ*, it is true, have similar aquatic habits, as, for example, those of the genera *Hydrocampa*, *Palustra*, *Philampelus*, *Acentropus*, but in none of them are tracheal-gills present; the explanation of the absence of these structures probably being that the species of the genera mentioned have only comparatively recently passed from an aerial to an aquatic mode of life, and that the action of the new environment upon them has not been sufficiently prolonged to work those adaptive structural changes it has brought about in the European, Brazilian, and Burmese insects.

The caterpillars of the European and Brazilian forms reside, the one beneath a rude shelter formed by itself out of a small piece of the food-plant fastened by silk threads to a leaf, the other beneath a much more complex tent-like silken structure of its own spinning. Both, in correlation with this habit, have the body more or less depressed, with the tracheal-gill tufts more or less lateral and horizontally extended and less numerous; the Brazilian form having the body much the more depressed of the two, and the tracheal-gill tufts much the more lateral and horizontal, much the less numerous, and all reduced to simple unbranched filaments. In the Burmese form, on the contrary, the body of the caterpillar has the typical (subcylindrical) shape of non-aquatic members of the same family, and the innermost series of tufts higher up on the back and more vertical than in the European species, to which in form and structure, as in distributional area, it comes nearest, and from which it differs in matters of detail so trifling as to be at most of specific value; whence it may, with tolerable confidence, be inferred that the Burmese form does not possess the shelter-building instinct (which, by the way, is not yet quite perfectly fixed in the European form), but that it crawls free and uncovered in the midst of the water over the submerged

stems and leaves of its food-plant, and whence also it is a permissible, if not in the present state of our knowledge a probable, suggestion, that the Burmese species is the living representative of the ancestral form common to the three.

PARAPONYX ORYZALIS, n. sp.

The Caterpillar. Fig. 1.

The caterpillar is about 7 millim., or rather more than $\frac{1}{4}$ " long. It was, when received, of a pale whitey-brown colour. It is now red, having been artificially coloured by me in order to render its structure more clearly discernible. When alive it was no doubt protectively coloured to match the plants or other objects amongst which it lived. It is flat ventrally, transversely convex or arched dorsally, rather broader than high, and slightly narrowed at the two ends. The head is not directed horizontally straight forwards, but slopes slightly downwards. It bears a few longish and stiff hairs, and five eyes on each side in a curvilinear series, the concavity of which is directed outwards; the eyes of each side are arranged in two groups, of which one is anterior, and the other posterior; the eyes of the former are close together, three in number, and the two posterior of them are subequal to one another and larger than the anterior; those of the latter are subequal, about equal in size to the front eye of the front group, and separated from one another by an interval about equal to that which separates the anterior of them from the last of the front group; all have a black speck at the outer margin. In addition to the three pairs of thoracic legs, which are sparsely furnished with stiff setæ like those on the head and body, there are present five pairs of short abdominal feet or prolegs on the 6th, 7th, 8th, 9th,

and 12th somites respectively. The stigmata of the 2nd, 3rd, and 4th abdominal somites only are clearly discernible; they are oval, pale brown, imperforate areæ with a raised ring-like rim. A few symmetrically arranged stiff setæ spring from rimmed areæ not unlike the closed stigmata. They differ widely in appearance from the soft and delicate structures now to be described. The whole animal is covered with a perfect forest of soft and delicate white filaments which, owing to the manner in which they have been curled and twisted by the action of the spirit, appear to be in a state of the wildest confusion, but are in reality arranged in a most definite and orderly manner. In the first place, the filaments are arranged in little bundles or tufts; that is to say, two, three, or four of them are united at their bases to form a peduncle or stalk which is continuous with the integument; rarely a tuft is represented by a single filament. The tufts are disposed in four longitudinal rows, extending nearly from one end of the body to the other. Two of these rows are nearer to the middle line of the back, but not to one another, than they are to the other two, which occupy the sides of the body. The former are placed above the longitudinal line in which the stigmata or spiracles lie, and are hence supraspiracular, while the latter lying below this line may be distinguished as the infraspiracular tufts. Moreover, a still closer examination reveals the fact that the infraspiracular tufts are not all inserted on homologous parts, for, while some of them are attached to the outer ends of the terga of the somites to which they belong, others are sternal in position: we may hence subdivide the infraspiracular rows of tufts into a tergal and a sternal series. So that we have two tergal series of tufts, one above and the other below the spiracular line, with one sternal series, on each side of the body. It is difficult, owing to the complex manner

in which they have been curled, twisted, and entangled by the combined action of spirit and of pressure, to determine their precise direction, but, of the two series of tergal tufts, the upper appears to have been directed almost straight upwards, and the lower to have had a slight inclination outwards, whilst the sternal series projected more or less directly downwards, in the living caterpillar. Besides the arrangement in longitudinal rows and series already described, the tufts have a definite arrangement on the several somites of which the insect's body is made up: if we examine an abdominal somite, say the third, carefully, we shall find that there are present two tufts belonging to the supraspiracular series, and two belonging to the lower or infraspiracular series of tergal tufts, and that in each series one of the two tufts lies in front of the other; in other words, that there are an anterior and a posterior supraspiracular, and an anterior and a posterior infraspiracular tuft, and, further, that there are two sternal tufts, one at each end, on each side, or 12 tufts to the somite; consequently, if each of the 12 somites of the body were provided with its full complement of tufts, there would be $12 \times 12 = 144$ tufts in all. But owing to the suppression of some or all of the tufts on certain somites at both ends of the body—for instance, the first somite has no tufts at all, the second and third want the anterior sternal and the anterior tergal of the infraspiracular series, and the last the anterior pleural and all its tergal tufts—the actual number falls much below this.

The following table showing the distribution of the tracheal-gill tufts over one side of the body will, it is hoped, render the foregoing description somewhat more intelligible:—

Tracheal-gill formula of Paraponyx oryzae.

Somites.	STERNAL TUFTS.				TERGAL TUFTS.						TOTAL.			
	Anterior.		Posterior.		INFRASPIRACULAR.		SUPRASPIRACULAR.							
	Anterior.		Posterior.		Anterior.		Posterior.		Anterior.			Posterior.		
I	} Thorax.	0	+	0	0	+	0	0	+	0	0	+	0	0
II		0	+	1	0	+	1	1	+	1	1	+	1	4
III		0	+	1	0	+	1	1	+	1	1	+	1	4
IV	} Abdomen.	0	+	1	1	+	1	1	+	1	1	+	1	5
V		0	+	1	1	+	1	1	+	1	1	+	1	5
VI		1	+	1	1	+	1	1	+	1	1	+	1	6
VII		1	+	1	1	+	1	1	+	1	1	+	1	6
VIII		1	+	1	1	+	1	1	+	1	1	+	1	6
IX		?1	+	1	1	+	1	1	+	1	1	+	1	6
X		?0	+	1	1	+	1	1	+	1	1	+	1	5
XI		?0	+	?1	1	+	1	1	+	1	1	+	1	5
XII		0	+	1	0	+	0	0	+	0	0	+	0	1
		4	+	11	+ 8	+	10	+ 10	+	10	=		53	

which $\times 2$ gives 106, the number of tufts on both sides of the body.

The caterpillar agrees in all essential particulars of structure and habits with that described more than a century and a quarter ago by De Geer, being a thoroughly aquatic pyralid larva which appears to the naked eye to be covered with a shaggy coat of coarse and transparent (in spirit specimens milky-white) hair, and crawls over the submerged leaves of the plant which it infests in the very midst of the water. De Geer's caterpillar has the habit of cutting off an oblong piece from the edge of a leaf which it applies to a hollow of the leaf, fixing it loosely thereto by means of a few threads of silk, so that the cavity enclosed between the two applied surfaces serves to give lodgment to itself. The upper surface of the leaves of the plant upon which this insect lives happens to be concave. The insect, having an instinctive knowledge of this fact, so places

the detached piece upon the leaf that the upper surface of the former comes into apposition with the same surface of the latter, and, by thus turning the two concavities towards one another, gains a more spacious shelter. Secure beneath the bit of green leaf, it devours the leaf, to which the former is so loosely applied as to give the freest possible access on all sides to the currents of aerated water with which it is necessary that its tracheal-gills should be constantly bathed. In correlation with this habit, we find that its body is markedly depressed, and that the tufts of tracheal-gills all occupy the sides of the body, where, owing to the interval which exists between the leaf and its bit, these respiratory organs are completely exposed to the aerating medium without risk of injury from the pressure of the bit. In the Burmese insect, on the contrary, the body is scarcely at all depressed, and the tufts are attached much higher up on the back; from which facts it may with confidence be inferred that the creature constructs no shelter, but crawls about free and uncovered in the midst of the water.

In the Brazilian species (*Cataclysta pyropalis*) lately described by Dr. Wilh. Müller-Blumenau, the body is still more depressed, the tufts are quite lateral in position and reduced to simple and unbranched filaments, and the shelter is a much more complex structure than in the European species.

It is worthy of remark that the aquatic caterpillars which possess no tracheal-gill tufts, and may hence be inferred to have entered so recently on their water life that the changed conditions have not had time to produce the structural rearrangements needed for a truly aquatic life, live in a sort of case from which water is entirely excluded, and are no more aquatic animals in the sense that they are provided with special organs for

extracting oxygen from water than are the men who traverse the sea-bed, their heads encased in divers' helmets: they are simply diving case-bearers.

The caterpillars described by De Geer, by Müller-Blumenau, and by myself, on the contrary, always are, and always require to be, immersed in the water, with which it is of vital importance to them that their bodies should be completely and continuously bathed.

The Pupa. Figs. 2, 2a, 2b.

The pupa is fusiform, being pointed at both ends, obtusely at the anterior and sharply at the posterior end. It is 9.5 millims. long by 2.25 millims. broad in its widest part, its length being to its breadth as four to one, and it is rather broader than high. In colour it is pale brown on the legs, wings, and antennæ, livid brown as to the body and eyes, in spirit specimens. The antennæ, mouth-parts, legs, and wings are symmetrically folded back upon the ventral surface in the usual manner, the posterior legs reaching to a point which lies about midway between the end of the abdomen and the end of the fifth somite of this part in the perfect insect, which, in the specimens before me, is almost ready to emerge, having already separated from the pupa-skin at its posterior end. The pupa is quite smooth and entirely devoid of setæ, except the pair of stout black ones which project forwards and outwards from the truncated front of the head, and are separated from one another by an interval equal to the length of one of them. Not a trace remains of the white branched filaments with which the body of the caterpillar is beset: these were all cast off by the caterpillar at its last moult; but the stigmata of the second, third, and fourth abdominal somites have undergone a considerable development, and at this stage form a series of three tolerably prominent nipple-

shaped projections on each side of the body ; they are certainly open, and, moreover, the prominences on which they are seated have, in growing, broken through the walls of the pupa-skin so as to gain access to the air-chamber of the cocoon ; their orifices are transversely elongated dark-brown slits encircled first by a light-brown and then by a dark-brown ring. The remaining abdominal stigmata are indiscernible without dissection, and they certainly do not pierce the pupa-skin.

The pupa of the Burmesé species agrees in all essential particulars with that of the European form, differing only in its much smaller size, slenderer form, less prominent stigmata (which, moreover, have their mouths directed outwards and upwards, instead of straight outwards), and shorter posterior legs.

The pupa of the Brazilian *Cataglyphis pyropalis* has only the second and third pairs of abdominal stigmata prominent and concerned in pupal respiration, wants the frontal setæ, and differs in other structural details from both the above.

The Cocoon. Figs. 3, 3a, 3b.

The cocoon is spindle-shaped, about 12 millims. long and 2.5 broad in its widest part in front, length to breadth 5:1. It is attached to the middle and sides of a portion of the upper surface of an imperfectly opened leaf-blade, the opposite sides of which are firmly and closely pinched together at either end of it, so that the only one of its sides left exposed to the water is flat and has the outline of an ellipse sharply pointed at both ends, but especially at the aboral end (that towards which the pupa's tail is directed), which is quite acuminate. It is composed of whitish silk, and, though exceedingly tough and close in texture, is yet sufficiently transparent to permit of the general form and characters

of the enclosed pupa being seen through its walls with tolerable facility. There is no interval between the two layers of which it would appear to be composed; these, on the contrary, being so intimately united as barely to be distinguishable from one another. The last cast skin of the caterpillar lies shrivelled up into a pellet in the aboral end of its interior. The pupa does not lie with its ventral surface directly opposite to the exposed face of the cocoon, but slightly turned towards the side which is to its right, and in the closest relation of apposition therewith, thus leaving, on the side of the interior of the cocoon to its left, a cavity into which the three nipple-shaped stigmata of its left side can be seen, through the transparent walls of the cocoon, to project freely. Whether this cavity contains water and the projections on which the stigmata open give lodgment to a respiratory apparatus, analogous to that developed in connection with the rectum in the *Libellulidæ*, for extracting oxygen from water; or whether, as is more probable, it contains air, the openings on the tops of the projections are stigmata leading directly into the tracheal system, and the membranous walls of the cocoon permit of gaseous interchange between the external water and the cavity, my material is neither sufficiently large nor suitable for determining.

EXPLANATION OF THE PLATE.

Fig. 1.—The caterpillar, about four times the natural size.

Figs. 2, 2a, 2b.—The pupa, in three different positions, five times the natural size.

Figs. 3, 3a, 3b.—The cocoon, from in front, from the side, and from behind, respectively, five times the natural size.

2 x 5

2a x 5

2b x 5

1 x 4

3 x 5

3a x 5

3b x 5

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