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Studies on Costa Rican Odonata.

II and III.—The Habits, Structure and Transformation of the Plant-dwelling Larva of Mecistogaster modestus.

BY

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Studies on Costa Rican Odonata.

II.—The Habits of the Plant-dwelling Larva of Mecistogaster modestus.*

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Announcement has already been made in the News (Calvert 1910 *a* and *b*) and elsewhere (Ibid., 1909 *c*, 1911) of the discovery, in Mexico by Mr. F. Knab and in Costa Rica by the writer,

Two epiphytic Bromeliads on a branch of *Erythrina*, Cartago, Costa Rica, July 4, 1909. Photograph by Amelia S. Calvert.

of Odonate larvae living in the water which collects between the bases of the leaves of Bromeliads growing upon trees, and of the rearing of the imagos of *Mecistogaster modestus* Selys from these larvae.

*Number I, on The Larva of Cora, was published in Entomological News XXII, pp. 49-64, plates II and III, February, 1911.

The pineapple is the most familiar example of this family of plants, although, of course, it is not an epiphyte. The epiphytic bromeliads of Costa Rica, in addition to the Tillandsiae, pertain to the genera *Androlepis, Aechmea, Billbergia* and *Pitcairnia*, according to Wercklé (1909). Their range is from sea-level to the craters of such volcanos as Irazu (11,000 feet, 3300 metres), but they are most abundant in the moister parts of the country. To the naturalist traveling along the usual route from Limón to San José, the most striking difference between the almost constantly moist Atlantic slope and the Pacific side, with its definite dry season, is the much greater number of bromeliad and other epiphytes on the former.

On the pruned trees of the poró (*Erythrina*) and other species which form the *cercas* or hedges, surrounding the fields and pastures near Cartago (Atlantic slope), bromeliads with leaves five to ten inches (12.5-25 cm.) in length are extremely abundant. They frequently but not invariably contain water and usually harbor some insects, especially Blattidæ, but they never furnished any Odonate larvæ, nor were imagos of *Mecistogaster* ever met at this altitude (4750 feet, 1450 metres), in our experience.

Epiphytic bromeliads of greater size (*i. e.*, with leaves two to three feet, 60-90 cm., long) occur in forests both below and above this elevation, but our collections of Odonate larvæ from them, as well as our observations of *Mecistogaster* adults, were made at altitudes lower than 3300 feet (1000 metres). The leaves of these plants spring from such a very short stock that their bases are close together and the blades of the leaves in contact with each other for several inches. As a general rule a number of stocks grow side by side on the same host tree, whose trunk or branch they may completely encircle, and as the stocks may be attached to each other it is not easy to separate one individual plant from its fellows. The leaves, with the length mentioned, taper from base to apex, diverge from their fellows and either stretch up stiffly for their entire length or droop over gracefully near their tips; owing to their stiffness and their serrated spiny edges, they must be handled carefully to avoid scratched and bleeding hands. The stocks are attached to the host trees at very varying distances from the ground—from less than a foot to more than fifty feet (15 metres).

On account of the size and formidable defenses of these plants, it was our usual practice to select those whose attachment was not more than fifteen feet above the ground, throw a long rope over one or more stocks, pull on both ends of the rope so that it would slide between the tree trunk and the bromeliad and break the roots which fastened the latter to its host. Some water and some of the most active insect inhabitants of the epiphyte would be lost in this operation. As soon as the bromeliad reached the ground, it was placed with its crown of leaves directed upward and the upper parts of the leaves cut off with a knife to get rid of the inconvenience of the spines. Beginning with the outermost leaf of the whorl, the leaves were removed one by one, carefully stripping each to its attachment to the stock and taking out the animals lying between the leaf bases with a forceps and placing them in bottles.

The first time that I found bromeliadicolous Odonate larvæ was October 3, 1909, at Juan Viñas, Costa Rica. Three distinct clumps of epiphytic bromeliads had been examined without success that day, at different points along the road and trail which leads from the railroad station down to the iron bridge over the Rio Reventazon. To quote from our diary: "The fourth and last bromeliad was in the forest about 200 feet above the river and 10-12 feet above ground on a tree trunk. * * * After half an hour's tugging and pulling, the mass, consisting of three plants and weighing surely not less than fifty pounds, fell to the ground. I cut off the leaves as before and very soon found a dragonfly larva between the bases of two leaves not many leaves in from the circumference. In the hour I remained after the plants fell, no other larvæ were found and there was much still to be examined, so I left the plants where they had fallen. At 9 A. M. [Oct. 4] I resumed

cutting off leaves as before, and when I had removed all the larger ones I carried the three stocks, still so firmly united that I was unable to separate them with my little knife, and weighing fifteen pounds or more, to a spring farther down the canyon side so that I might wash out the mud when necessary to make more careful search. In all the bromeliads examined these two days there was much mud between the leaves, chiefly the outer ones, as well as dead leaves of trees which have fallen from the above or, perhaps at times, have been carried in by wind. At noon—after three hours' constant work—I finished the examination and had found two more dragonfly larvæ."

This clump of bromeliads was tenanted, in addition to the Odonate larvæ, by a young scorpion (*Centrurus margaritatus* Gerv.) two inches long, which had just moulted, the exuvia also found; two species of Phalangids (*Metergimus signatus* Bks., *Cynorta* sp.), a Pseudoscorpion (*Chelanops* sp.), and Coleoptera, both adults (*Metamasius dimidiatipennis* Jekel; *Alegoria dilatata* Castelnau; *Cryptobium* sp., or genus allied thereto; an Endomychid genus, new, near *Trochoideus; Cercyon* or *Phaenonotum* sp.; and *Phaenonotum tarsale* Sharp) and larvæ (Elaterids, probably of the genus *Semiotus* and others allied to what is considered the larva of *Dolopius;* a Lampyrid of an unknown genus, but apparently related to *Photuris;* a Sphæridid, possibly *Phaenonotum tarsale*) a Dipterous larva (Stratiomyid) with a circle of setæ at its hind end; two Heteroptera, the subglobular shiny *Chlaenocoris dissimilis* Dist. and a flat nymph of (probably) *Belminus rugulosus* Stal; a Hepialid caterpillar; a small earwig ("too immature to be determinable; probably it is a *Labia*, possibly *L. annulata* Fabr."); ants of an undescribed species of *Apterostigma*. The weevil, *Metamasius dimidiatipennis*, bore many Acari (a species of *Uropoda*) on its legs, and another larger Acarine (*Celanopsis* sp.) was present between the leaves; finally in the mud between some of the leaves was a fair-sized earthworm (an immature *Andiodrilus biolleyi* Cog. di Mar.) quick in its move-

ments and with a peculiar smooth proboscis which was frequently thrust out and looked like a spine.*

Of all these inhabitants of the bromeliad, the Pseudoscorpion, the flat Reduviid *Belminus* and the Elaterid larvæ referred to *Semiotus* (?) appear to possess the most adaptive body form, *i. e.* flattened to correspond to the crevices between the broad leaf bases. This is best marked in the *Semiotus* (?) larvae which measured 1—1½ in. (25-40 mm.) long, one-quarter inch or more (5+ mm.) wide and less than one-eighth inch (< 3 mm.) in thickness.

The list here given of the cotenants with the Odonate larvæ does not include by any means all the *bromeliadicoli* which we met in Costa Rica, but is interesting as giving a glimpse of the organic environment of the special subject of this paper.

Again at Juan Viñas, on December 17, 1909, we pulled down a large epiphytic bromeliad from about 12 feet above ground, "although it took all our combined weight and strength to do it and were rewarded by finding seven or eight good specimens of Odonate larvæ of different sizes. This bromeliad had, among other animals, a few of the large black ants, *Odon-*

*Specimens of the bromeliadicoli were submitted to specialists and I acknowledge with thanks the identifications of the earthworm by Dr. J. Percy Moore, of the ants by Prof. W. M. Wheeler, of the earwig by Dr. Malcolm Burr (through Mr. J. A. G. Rehn), of the Arachnida by Mr. Nathan Banks, of the Coleoptera by Mr. E. A. Schwarz, of the Heteroptera by Mr. O. Heidemann and of the Lepidopterous larva by Dr. H. G. Dyar. The identification of the last four named groups was arranged by Mr. Frederick Knab, who himself determined the Stratiomyid larva.

Of the ant *Apterostigma* sp., Prof. Wheeler, after examining these specimens and also others from Costa Rica *not* collected in bromeliads, wrote: "It is a fungus growing ant of the most primitive and, at the present time, most interesting genus of Attii. No species of this genus has ever been taken in Bromeliads. All of the known species have been described from cavities in rotten wood where they build a peculiar fungus garden using caterpillar excrement as a substratum, and enveloping the whole garden in a mycelial web which is not known to exist in any of the other genera of Attiine ants." Since, as stated above, a caterpillar also lived in this same clump of bromeliads, doubtless the usual living conditions of *Apterostigma* were satisfied here.

tomachus hastatus Fabr., with enormously developed jaws, bent near the tip, which are carried wide open and measure one-quarter inch from tip to tip; occasionally they would be snapped shut with a very audible click."* We were by no means always successful, however, either in finding Odonate larvæ in bromeliads or in pulling down the plants from the trees, as records in our diary for La Emilia in November, 1909, and at Juan Viñas in February and March, 1910, show. Our last collection from them was on April 26, 1910, when we examined clumps of bromeliads on trees near the edge of a clearing about 100 feet below the railroad tracks west of Juan Viñas station, altitude about 3200 feet. Here we "found a few larvæ of *Mecistogaster* with the accompaniment of spiders, cockroaches, mosquitoes, slugs, planarians, earthworms and big-jawed ants." Among the *Mecistogaster* larvæ was one smaller than any we had previously found and I carelessly did not immediately separate it from its larger brethren; when I turned to do so it had disappeared, and we had no doubt that it had suffered from the cannibalistic habits of all its tribe.

The fate of our bromeliadicolous Odonate larvæ was as follows. The three of October 3-4, 1909, reached our headquarters at Cartago alive and were placed in separate glass tumblers, each containing a little water and a miniature bromeliad from the neighboring *cercas*. They were fed with, and were seen to eat, smaller dragonfly larvæ. The larva of Oct. 3 (No. 49) died in the act of moulting, Oct. 8, being unable to cast the skin from its head and especially the mask. One of those of Oct. 4 died from some unknown cause and its hinder parts were eaten by its companion before separation; the other (No. 48) moulted between Oct. 15 and 24, while we were absent, and again on Dec. 25, but died Dec. 30-31.

The larvæ obtained Dec. 17, 1909, were similarly arranged at

*Commenting on specimens of this species, Prof. Wheeler wrote: "I find in my collection a series of specimens taken in bromeliads at Alto de Serra in the Province of São Paulo, Brazil, by von Ihering. Apparently it has a habit of nesting in such places." We found it in a number of bromeliads in Costa Rica.

Cartago, but were supplied more often with Chironomid larvæ; they did not seem as voracious as most Odonate larvæ are. They were numbered 54 to 61. No. 54 died Jan. 3, 1910. No. 55, without further moulting, transformed April 6 as *Mecistogaster modestus* ♂. No. 56 died in attempted transformation April 11. No. 57 probably moulted Jan. 19-29 during our absence and transformed April 18 as *Mecistogaster modestus* ♀. No. 58 moulted and died Jan. 19-29. No. 59 moulted Dec. 25 and transformed April 4 as *Mecistogaster modestus* ♀. No. 60 probably moulted Feb. 15-18 during our absence, as fragments of an exuvia were found Feb. 19; moulted March 29-30 and was found dead April 3. No. 61 moulted Jan. 7-16 and again March 13-16 and was lost probably in the earthquake of May 4, as we have no record for it later than March 16.

The larvæ of April 26, 1910, (Nos. 1-3) were at once preserved in alcohol, as were the pre-metamorphic exuviae and the dead larvæ resulting from our collections of Oct. 3-4 and Dec. 17, but not all the exuviæ have been available for the present study.

Our diary for April 28, 1910, at Juan Viñas, records: "We went down the road to the river [Reventazon] * * * At the bromeliad cluster* from which we obtained the larvæ on December 17 last, from which *Mecistogaster modestus* transformed in our room at Cartago this present month of April, a single male of this species was sitting on the tip of a leaf and was easily caught with the net. Before reaching this tree we passed another also with bromeliads of an apparently different species. Around these bromeliads two females of *M. modestus* were fluttering and alighting and altho' we did not see them making any motions of oviposition, one of them disappeared into the leaf bases as if she might be on such an errand. On the outside of one of the yard-long leaves, about six inches from the apex, was an exuvia of *modestus* which we were able to get." The diary for May 1, 1910, reads: "Went down to the Revent-

*In December we had pulled down some, but not all, of the stocks forming this cluster, leaving the others as a control.

azon. As I passed the cluster of bromeliads around which two females of *Mecistogaster modestus* were seen flying by us on Thursday, a female of this species was transforming on the outside of a leaf. I was able to secure both her and her exuvia [8.30-9 A. M.]." "All these observations show that in spite of their unnatural surroundings and perhaps lower temperature, our larvæ at Cartago were not retarded in their development as compared with their free relations in their native forest."

The origin of the bromeliadicolous habit of the larvæ of *Mecistogaster modestus* may possibly be accounted for in the following manner. The majority of the species of *Mecistogaster* are South American and some of them occur along the Amazon, where also are the headquarters of the Bromeliaceæ (Wittmack 1888, p. 39). As is well known, "thousands of miles of forest" along this river are inundated in each wet season, so that a person "will travel through this forest for days, scraping against tree-trunks and stooping to pass beneath the leaves of prickly palms, now level with the water, though raised on stems forty feet high." (Spruce, 1908, vol. I, p. 229; Wallace, 1853 etc., chap. vii). At such periods of high-water, epiphytes, whether of the Bromeliaceæ or of other families, would often be just at the water's surface, or only slightly submerged, and would offer to Zygopterous Odonata quite ordinary and usual places for oviposition. An association with certain plants might thus be formed by *Mecistogaster* or its ancestors, which would persist even when the water-surface was much below the level of the epiphytes. Only such plants as could retain water for long periods of time (weeks and months) would permit the development of essentially aquatic larvæ and the water must be renewed from time to time. This last condition would prevent the survival of *Mecistogaster* wherever the rainfall was too intermittent. Once the association of this insect with bromeliads,† or any other suitable plant, were formed it might persist with the spread of the insect away from the regions of deep yearly inundation (the Amazon or elsewhere), where we conceive its

† It is suggestive that the legion Pseudostigma Selys, to which *Mecistogaster* belongs, and the Bromeliaceae are confined to tropical America.

possible origin to have occurred, to the forest at Juan Viñas where the trees which harbored our larvæ were far, far above the highest flood marks of the Rio Reventazon. *M. modestus*, *M. ornatus* and *Megaloprepus coerulatus*, as we saw them in Costa Rica, usually fly above the underbrush and when disturbed, rise to a height of many feet above the ground.

The excessively long abdomen of the adults of *Mecistogaster* and its allies (*Megaloprepus, Microstigma, Pseudostigma, Anomisma*) may be a special adaptation to the life of their offspring in water-containing plants, since the abdomen of the larva of *M. modestus* is no longer, proportionally, than in other Agrioninæ. The space between the leaf of a bromeliad and the leaf next without decreases downward, and if *Mecistogaster's* eggs are deposited in the plant tissue in or near the contained water, in accordance with the general habit of the Zygoptera, it would often be necessary for the female to reach far down into crevices possibly too narrow to admit of the entrance of her thorax and wings. The long abdomen with the ovipositor near its hind end would therefore be of distinct advantage, and it will be a matter of great interest to ascertain, by future observations, if the lengths of abdomens seen in various members of the legion Pseudostigma of de Selys are correlated with peculiarities in length in the plants or other objects in which they oviposit.

(The larva and transformation of *M. modestus* will be described and figured in Number III of these Studies.)

Supplementary Note on Plant-dwelling Odonate Larvae.—In addition to the records of plant-dwelling Odonate larvae already mentioned in the NEWS (Calvert, 1910 *b*), Mr. Frederick Knab has called my attention to a paper by G. F. Leicester (1903), containing the following statements: "One of the most important breeding places [for mosquitoes] in the jungle is the water which collects in the bamboo, either in the stumps of old bamboo or in the cavities of fallen bamboos which in some cases have cracked in drying and allowed water to accumulate in them, or even in standing living bamboos in which some insect has bored a hole in the stem and allowed water to enter (p. 291). * * * Other natural enemies [of mosquito larvae living in the same places, in addition to the carnivorous mosquito larvae *Megarhinus*] are the larvae of certain species of Agrionidae, Libellulidae and Chironomidae." (p. 292).

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IBID.—1910 *c*. Zoological Researches in Costa Rica. Old Penn Weekly Review of the University of Pennsylvania, IX, pp. 165-170. Nov. 12. With figure (p. 167) of the fully-expanded *Mecistogaster modestus* and its exuvia. The remarks on *Mecistogaster*, but not the figure, were reprinted in Entom. Mo. Mag. (2) XXII, pp. 17-18, Jan., 1911, under the title "Dragonflies breeding in rain-water collected at the leaf-bases of Bromeliads," with comments by G. C. Champion.

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A BROMELIADICOLOUS CADDIS-WORM.—*Apropos* of the article on bromeliadicolous dragon-fly larvae in this number of the NEWS, the following item from a letter from Mr. K. J. Morton, of Edinburgh, Scotland, is of interest: "Longer ago than I care to think, Fritz Müller, amongst other curious habitations of Trichopterous larvae, sent me some caddis cases taken from the water present between the sheaths of Bromeliads found on trees in the primeval forest growth of Southern Brazil."

Studies on Costa Rican Odonata.

III. Structure and Transformation of the Larva of Mecistogaster modestus.

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(Plates XVII-XIX)

The early stages of this long-bodied dragon fly whose discovery and habits have been described in the NEWS for November, pages 402-410, furnish the following

DESCRIPTION OF THE LARVA OF M. MODESTUS.

Material Studied:

(*a*) From Juan Viñas, Costa Rica.

No.			Total length including caudal gills.	Body length excluding caudal gills.
48	♀	larva	(gills lacking)	11 mm.
49	♀	"	15 mm.	11.5 "
54	♀	"	10.5 "	7 "
55	♂	exuvia	(gills lacking)	21.5 "
56	♂	partly transformed		
57	♀	exuvia	25 mm.	19.5 "
58	♀	larva	23 "	19 "
58	♀	exuvia	(gills lacking)	
59	♀	exuvia	" "	19.5 "
61	♂	exuvia of March 13-16	" "	(in fragments)
1	♂	larva	25.5 "	21 mm.
2	♀	"	24 "	20 "
3	♀	"	17.5 "	14 "
	♀	exuvia of April 28	(gills imperfect)	(distorted)
	♀	" " May 1	23.5 mm.	19.5 mm.
	♂	" " Dec. 17	(gills lacking)	(distorted)
101	?	larva recovered from crop of No. 1		(in fragments)

(*b*) From Orosi, Costa Rica, March, 1911, collected by Sr. C. Picado T., and forwarded by Prof. J. F. Tristan.

♀ exuvia dimensions as above, 20.5 and 18 mm.

♂ exuvia dimensions as above, 23 and 19.5 mm.

(*c*) From Cordoba, Mexico, April, 1908, bred by Mr. F. Knab. (See Calvert, 1910.)

♀ exuvia (distorted).

Mature larva.

Description based on larvæ Nos. 1, 2 and 58, and exuviæ of 55, 57, 59, April 28, May 1, Orosi (2) and Cordoba.

Color, pale yellowish- to reddish-brown, according to the length of time which has elapsed since moulting; posterior ends of abdominal segments darker.

Head concave in the middle posteriorly for the reception of the prothorax, angles of the hind margin rounded off and clothed with short hairs and short spines. Compound eyes distinct. Ocelli indicated by three pale yellow spots.

Antennæ 7-jointed, ratios of the lengths of the joints in an antenna detached from larva No. 1 and in alcohol under a cover-glass: 18, 20, 33, 26, 19, 12, 7; joints 1 to 7 successively decreasing in thickness (Pl. XVII, Fig. 3), the distal ends of joints 3-6 a little thicker than the proximal ends; naked, except for a whorl of long and very delicate hairs on the middle of the 2nd and 7th joints and near the distal ends of the 4th, 5th, 6th, and, in some, also the 3rd, joint; in dry exuviæ, *e. g.* after metamorphosis, these hairs are often matted down on the antennæ and not visible except under a compound microscope.

Ventral surface of each gena with a row of about twenty short spines parallel to the posterior margin of the compound eye, the spines directed forward.

Mandibles one-branched, apex of left mandible with five teeth, first (counting from the dorsal margin) and third shorter than the other three, ventralmost longest; apex of right mandible with four teeth more nearly equal in size, ventralmost longest.

Maxillæ very similar to those of the larva of *Cora* described and figured* in the first study of this series, except that the attenuate tip of the inner lobe bears *two*, instead of three teeth.

Labium, when at rest, reaching almost or entirely to the hind edge of the prothorax; mentum about twice as wide at the level of the articulations of the lateral lobes as at its proximal end (Pl. XVII, Fig. 6), strongly produced distad to form the median labial lobe which lacks the slightest trace of a median cleft, but bears 32-41 crenulations on each side of the median line (Pl. XVII, Fig. 2), usually a short blunt spine in the excision between each crenulation and the next; three or four pairs of setæ near the middle and other shorter setæ situated more proximad and more laterad, and a number of very short pointed spines near the crenulated distal margin, on the dorsal mental surface; each lateral mental margin in the distal half with 14-21 short conical articulated spines, which series is continued mesad by about 4 similar spines on a thickening near the articulation of mentum and lateral labial lobe; on the ventral mental surface are two pairs of moderately long setæ, one pair proximal to, the other pair distal to, the level of articulation of the lateral labial lobes, and many small

*Ent. News, XXII, p. 53, pl. III, Figs. 29, 31.

setæ. Lateral labial lobes (Pl. XVII, Fig. 5) with a long tapering terminal articulated spine and two tapering distal teeth, the inner (mesial or ventral) of which is the longer, 6-7 setæ between the terminal spine and the base, and a group of 4-6 (8-9 Cordoba) short conical spines on the lateral margin opposite the most proximal seta.

Thorax without well-developed tubercles or other peculiar structures. Mesostigmata latero-dorsal, between prothorax and mesothorax, elongated transversely. Metastigmata smaller, lateral, close to the anterior margin of the somite. In the alcoholic larvæ, the front wing-pads reach to slightly posterior to the middle of abdominal segment 4 (Nos. 1 and 2), or to the anterior edge of 5 (No. 58), the hind wing-pads to the hind end of segment 4 (Nos. 1 and 2) or to the middle of 5 (No. 58). In the (metamorphic) exuviæ, the point reached by the front wing-pads varies from the anterior edge of 4 to one-fourth the length of 4, and that reached by the hind wing-pads from one-third to one-half the length of 4. These differences between the larvæ and the exuviæ are probably due to the distortion produced by the process of exuviation.

Legs slender, with very short hairs on the longitudinal carinæ, tarsi three-jointed with two untoothed claws which are curved and very sharp at the apex (Pl. XVII, Fig. 1), no empodium; on the distal part of the tibiæ and on each lateral margin of the plantar surface of the tarsal joints are one or more rows of strong, trifid (or less frequently quadrifid or pinnate) spines (Pl. XVII, Fig. 4), whose length ranges from .07 mm. to .15 mm.

Abdomen subcylindrical, of ten complete segments, decreasing gradually in width and in height from 1 to 10, without dorsal or lateral hooks, covered with minute hairs .1 mm. long. Viewed ventrally, the lateral margins of each of segments 1-7 widen caudad from the anterior end to two-thirds or three-fourths of the segment's length and thence narrow to the posterior end. Hind dorsal margin of 10 in the middle shallowly concave and produced upward (dorsad).

Rudiments of accessory male genitalia visible under the chitin on the ventral side of abdominal segment 2. Male gonapophyses represented by two strong sharply-pointed spines on the ventral side of 9, situated at three-fourths of the segments' length, about half as long as 9 and projecting ventrad and caudad to the level of the middle of 10.

Female gonapophyses: ovipositor, in the alcoholic larvæ, reaching to the middle (No. 2), or to seven-eighths (No. 58) of abdominal segment 10, in the exuviæ to seven-eighths of 10, or to beyond this segment for a distance equal to about one-eighth of the length of 10; the sharply-pointed genital valves reach to the middle of 10 (No. 2), or to barely beyond 10 (No. 58), or in the exuviæ to beyond 10 for as much as one-third of the length of 10.

Rudiments of the superior appendages or 'cercoids' of the imago viewed dorsally half as long, or less than half as long, as 10, digitate, bent more or less ventrad near the middle of their length in the male, nearly straight in the female, pale brownish-yellow. (Pl. XVII, Fig. 8, *sa*).

The three caudal gills much darker in color than the abdomen, lozenge-shaped or diamond-shaped in transverse section of the anterior portion or stalk (which comprises one-half to three-fifths of the total length of the gill), the vertical diameter greater than the horizontal, the four angles distinctly keeled or carinate, the carinæ minutely serrate (less marked on the lateral carinæ of the median gill and on the mesial carina of each lateral gill), each serration bearing a short hair; on the two lateral gills the dorsal serrations are larger and fewer than the ventral serrations, while on the median gill the dorsal serrations are smaller and more numerous than the serrations of the ventral edge. The height of each gill (*i. e.*, its vertical diameter) increases gradually from the base caudad to one-half or three-fifths of the total length and then expands more abruptly into the thinner, foliaceous, terminal portion (Pl. XVII Figs. 12, 13, Pl. XVIII, Fig. 10), which may taper rather rapidly to an acute apex or may end as a fully rounded convexity. The lateral carinæ of the anterior stalk of the gill are not continued on to the terminal foliaceous portion, but the dorsal and ventral carinæ are continuous with the non-serrated but sparsely hairy dorsal and ventral edges of the foliaceous part. The maximum height of the foliaceous part is about twice the maximum height of the stalk. The caudal gills are held in life so that the foliaceous part is vertical (Pl. XVIII, Fig. 11).

The following viscera are described from larva No. 1, the only one which has been dissected as yet.

The fore-gut reaches to the middle of the third abdominal segment, the mid-gut to the anterior end of the seventh abdominal segment (Pl. XVII, Fig. 8). The distinct gizzard is armed with eight larger and eight smaller longitudinal chitinous folds, all bearing teeth (Pl. XVII, Fig. 9), whose formula may be written $8\left(F\frac{5''\pm}{6'\text{-}10'}, f\frac{2''\text{-}3''}{2'}\right)$

(cf. Higgins, 1901, pages 132, 133, 136.)

The rectum opened longitudinally and spread flat has three wider cellular (glandular?) longitudinal areas, one of which is mid-dorsal, the other two right-ventral and left-ventral respectively, separated by narrower, non-cellular, longitudinal bands (Pl. XVII, Fig. 10). The nuclei of the cellular areas can be seen in the unstained rectum, but become much more distinct after staining (alum carmine was employed). Each of these three cellular areas is supplied with a branching trachea which for the ventral areas is a derivative, direct or indirect, of the lateral trachea of the same side of the body (Pl. XVII, Fig. 7); the origin of the mid-dorsal rectal trachea was not determined. The three non-cellular longitudinal bands of the rectum had, when the viscus was first opened, the shiny, silvery appearance which suggests enclosed air, but no tracheæ could be followed into these bands. The chitinous lining of these bands was much wrinkled into short folds.

The crop of this larva (No. 1) contained fragments of a smaller larva of the same species which belong undoubtedly to the small larva referred to on page 407 as having been collected at the same time; these fragments were identifiable as follows: A large part of the head, most of the mentum with left labial lobe and much of the right labial lobe still attached, groups of two or more abdominal segments, and two of the caudal gills. The crop also contained a mosquito larva 4.2 mm. long, comprising head, thorax and abdomen all in one piece; and most of the body of a copepod measuring .3 mm. long. The size of these fragments is such as to excite wonder that they were not more minutely subdivided by the mouth-parts, unless indeed their size is due to unusual 'bolting' by the larva under the stimulation of capture. Behind the gizzard the contents of the alimentary canal were much smaller particles and if the food fragments in the crop were not abnormally large, there is here more evidence of a subdividing function in the gizzard than I was able to adduce on another occasion (Calvert, 1899, p. 416).

The arrangement of the principal tracheæ is indicated in Pl. XVII. Figs. 7, 8. It does not differ in any important features from that shown in a large-scale (unpublished) drawing which I made many years ago from a living larva, 2 mm. long, of the European *Agrion puella*. The chief tracheæ of two caudal gills have also been figured (Pl. XVII, Figs. 12, 13) from the preserved material. Unfortunately, no study of the finer tracheoles was made from life, when alone they can be distinctly traced.

The ventral nerve cord consists of suboesophageal, pro-, meso-, and metathoracic pairs of ganglia (these last three in their respective somites and very distinct from each other), and seven pairs of abdominal ganglia as follows: the first in the middle of segment 1, the second near the hind end of 2, the third at the articulation of 3 and 4, the fourth to the seventh in the extreme anterior ends of 5, 6, 7 and 8 respectively.

Developmental Changes in the Larva.

Comparison of larvae Nos. 48, 49, 54, 3 and that (No. 101) recovered from the crop of No. 1 and the exuviae of 58 and 61 listed on page 449, have furnished only the following differences from the above description of the mature larva:

	Larva No. 101	Larva No. 54	Larva No. 48	Larva No. 49	Larva No. 3	Exuvia of No. 61	Exuvia of No. 58	Larva No. 58 (for comparison)
Total length in mm. incl. caudal gills	?	10.5	?	15	17.5	?	?	23
Body length in mm. excl. caudal gills	?	7	11	11.5	14	?	?	19
Width of labium in mm. at level of articulation of lateral lobes	1.3	1.8	2.15	*	2.09	3	3.15	3.67
Number of crenulations on one-half of distal margin of mentum	21	26, 27	29,31	28 ? 28	31.28	34	36, 40	37, 41
Number of lateral spines on distal half of mentum	....	10	11,13	*	*	15, 16	15	16
Mesostigmata	....	not visible	visible, but slightly dev'd	not visible	present	present	present	present
Metastigmata	....	{ Future site marked by a darker point }			present	present	present	present
Front wing-pads reach to	....	two-thirds of metathorax	two-thirds of abd. seg. 1	hind edge of abd. seg. 1	ant. margin of abd. seg. 1	*	ant. margin of 2	ant. margin of 5
Hind wing-pads reach to	....	hind edge of abd. seg. 1	one-half of abd. seg. 2	two thirds of abd. seg. 2	ant. edge of abd. seg. 2	*	middle of 2	middle of 5
Points reached by ♀ gonapophyses, viz.: Ovipositor { fore pair	....	one-eighth of 9	two-fifths of 9	hind edge of 9	three-fifths of 9	(♂)	one-fourth of 9	seven-eighths of 10
Ovipositor { median pair	....	three-fourths of 9	hind edge of 9	hind edge of 9	hind end of 9	(♂)	one-fourth of 9	seven-eighths of 10
genital valves (hind pair)	....	one-third of 10	one-half of 10	middle of 10	slightly beyond hind end of 9	(♂)	middle of 9	barely beyond 10
Cercoids	....	....	....	one-fifth as long as 10	....	....	one-fourth as long as 10	one half as long as 10
Caudal gills	foliaceous terminal part narrower (pl. xvii, f. 11)	foliaceous terminal part wider	foliaceous terminal part wider (pl. xvii, f. 12)				lost	

* Not determined.

In this table the forms compared have been arranged in order according to size from the smallest to the largest. The increase in total length and in body length is accompanied with increases in the number of crenulations and of spines of the mentum and in the lengths of wing-pads and of female gonapophyses except in larva No. 3. Miss Butler (1904) has found an increase in the number of distal mental crenulations to take place with increasing age in the larva of *Lestes uncatus*, while a lack of constant correlation between increased size and increased length of wing-pads has been noted by Balfour-Browne (1909, p. 278) and Backhoff (1910, p. 654) for larvae of several species of European Agrionines.

A comparison of the last two columns of the table is interesting as showing the amount of change which can take place within ten days after a moult.

General Features of the Larva.

In spite of their unusual habitat, the larvae of *M. modestus* show very few differences from the general Agrionine type of larva, the stalked caudal gills of the later stages being one of these. As in most, perhaps all, Zygopterous larvae, the caudal gills may be lost without interfering with growth, development and transformation (Pl. XVIII figs. 1-7, Pl. XIX fig. 8). Only two features of the larvae seem to be distinct adaptations to their environment, viz., the divided spines of the tarsi and distal ends of the tibiae, and the strongly-curved, sharply-pointed tarsal claws, both classes of structures being apparently of assistance in moving up and down the steeply-inclined or vertical surfaces of the bromeliad leaves. So little has been done, however, in comparing the minuter details of Odonate larvae that it is not certain that these features are peculiar to *Mecistogaster*. It is also important to note that the larva shows nothing of the hypertrophy of the abdomen which is so striking a characteristic of the imago. This great increase in abdominal length is accomplished only at metamorphosis and is clearly brought out by the figures on Plates XVIII and XIX.

Transformation.

As related on page 407 the larvae collected at Juan Viñas were brought to Cartago and placed in glass tumblers, The opening of each tumbler was covered with a piece of netting. In the early days of April, 1910, we noted that some of these larvae showed signs of approaching metamorphosis, so we took care that some leaves of the small bromeliad in each glass touched the netting and thus afforded a means whereby the larva could reach the latter and there attach itself for transformation.

On April 4 larva No. 59 had so attached itself and at 8.15 A. M. the splitting of the cuticle on the thorax began. By 8.30 A. M. the thorax, head, legs, wings and first four abdominal segments were disengaged and hanging from the exuvia which was attached to the under side of the netting, the body of the imago being sustained entirely by the hind end of the abdomen which was still within the exuvia; the wings were about 10 mm. long. At 8.40 A. M. the imago was completely free from the exuvia and clinging to the netting by its legs. In the meantime we had set up our camera in a convenient position in our room; then pinned the netting cover with the exuvia and expanding imago on it to the door of the wardrobe and obtained the photographs which are reproduced as figure 8, Plate XVIII, and figures 1-8, Plate XIX. The imago made its first flight at 1.53 P. M. It lived in captivity until April 11.

Larva No. 55 transformed April 6 and, with the experience obtained from No. 59, we were able to secure photographs of earlier stages in metamorphosis (Pl. XVIII, figs. 3-7). The whole series of figures on these Plates, together with their explanation, may dispense with further description here. As will be seen from an examination of them, the great length of abdomen of the imago is a relatively sudden acquisition and is not foreshadowed by the size of the larva. This may be still more appreciated by comparing our figures with those of the transformations of other Odonata as given, for example, by Latter (1904) and Ward (1910). The decrease in thickness of the abdomen between the stages represented in Pl. XIX, figs. 6 and 7 is also noteworthy.

On page 410 a hypothesis as to the usefulness of this long imaginal abdomen has been suggested.

Efforts to secure a pairing between ♂ 55 and ♀ 59 were unsuccessful.

The Specific Identity of this Mecistogaster.

In the *Biologia Centrali-Americana* (Calvert 1907, p. 354) I was doubtful as to whether Costa Rican examples of *M. modestus* should be referred to the race *iphigenia* Selys or not. In describing *iphigenia* (from Bogota and Panama) de Selys wrote (1886, p. 22): "La seule différence à noter en comparant ces exemplaires au type [de *modestus*] du Mexique, c'est que *dans les deux sexes*, la raie humérale interne est reduite á une virgule basale trés courte," and on the following page he states, "♀ Le bout des quatre ailes blanc laiteux."

The material now before me is more extensive, so far as Costa Rica is concerned, than that available when the *Biologia* was written and consists of the following imagos:

Costa Rica, Juan Viñas (2 ♂ No. 55 and April 28, 1910, and 3 ♀ ♀ Nos. 57, 59, and May 1; also the ♀ by Bruner quoted in Biol Cent. Amer.), Orosi (1 ♀ by Sr. Picado) and Tuis (1 pair in coitu and 1 ♀ June, 1907, by Mr. C. H. Lankester, forwarded by the late Prof. Biolley and now in the Acad. Nat. Sci., Phila.)

Guatemala, Purula (3 ♂ 3 ♀) and Cubilquitz (1 ♀) cited in Biol. Cent. Amer.

Mexico, Presidio in Vera Cruz (2 ♂ 2 ♀) and Atoyac (1 ♀) cited in B. C. A., Cordoba (fragments of two individuals reared by Mr. F. Knab).

The pair from Tuis and the Juan Viñas male of April 28 have fully colored thoraces and on comparing them with the equally well colored examples from Presidio and Atoyac, the internal humeral ray is no shorter in the former than in the latter. The Juan Viñas female by Bruner has this ray of the same length as the other Costa Rican specimens.

As stated in the *Biologia* volume, page 57, one female from Presidio has the tips of the wings milky, as described by de Selys for *iphigenia;* this female has the pterostigma creamy-

white. The other Presidio female and the Atoyac female have the pterostigma reddish and brownish respectively, but the tips of the wings are not milky. All the Costa Rican females now before me have the veins at the apices of the wings white but in none of them is the membrane of the wing as milky as in the first mentioned Presidio female which has the veins at the apex brownish or blackish. My belief, as expressed in the *Biologia*, p. 57, is that reddish and brownish pterostigmata in this species indicate greater age than a white stigma. None of the Costa Rican females before me have red or brown pterostigmata, although two of the males have them dark brown.

Judged by the length of the internal humeral ray there seems to be no reason for separating the Costa Rican specimens from the Mexican, and as milkiness at the apex of the wings of the females is evidently not a geographical character, whatever else its significance may be, I refer all the Costa Rican specimens to *modestus*.

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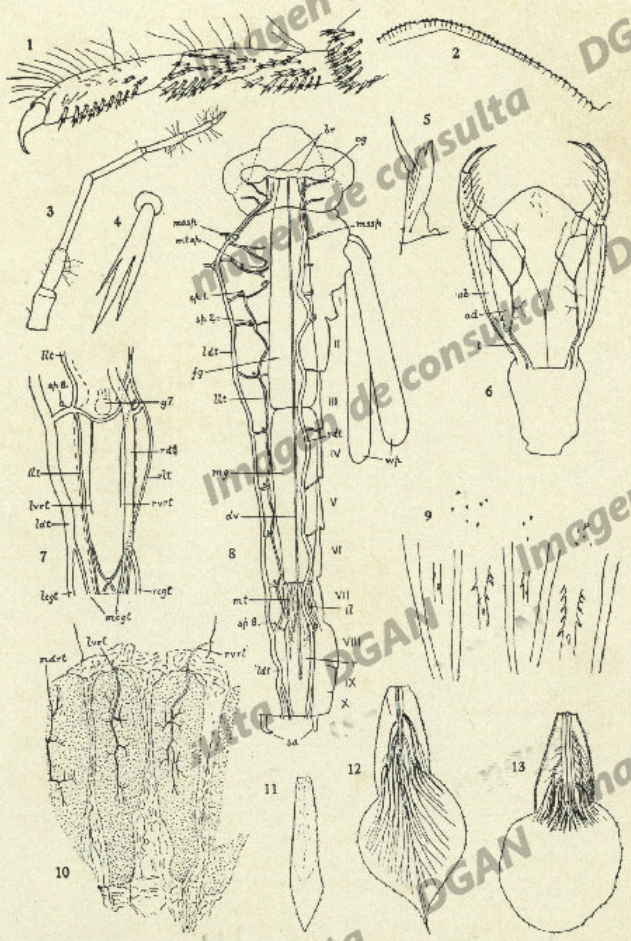


MECISTOGASTER MODESTUS CALVERT.

EXPLANATION OF PLATES XVII-XIX.

(All three Plates refer to *Mecistogaster modestus Selys*).

PLATE XVII.

Fig. 1. Tarsus and distal end of tibia, larva No. 2. x 33.

Fig. 2. A little more than the right half of distal margin of mentum, dorsal surface, larva No. 1. x 28.

Fig. 3. Right antenna, larva No. 1. x 18.

Fig. 4. A single trifid spine from the proximal tarsal joint of fig. 1, length .07 mm. x 370.

Fig. 5. Lateral labial lobe from exuvia of larva No. 49. x 14.

Fig. 6. Labium, larva No. 1. x 8.

Fig. 7. Principal tracheae supplying the rectum, larva No. 1. The outlines of the ileum and rectum are shown by broken lines. The left dorsal trachea (*ldt*) has been turned to the left out of its normal position. x 9.

Fig. 8. Some of the principal viscera of larva No. 1. The outline of thorax and first seven abdominal segments has been shown on the right side only, the dorsal body-wall being supposed to have been entirely removed from these segments, but its right half retained and spread out to the right in segments 8-10. The dorsal trachea is in normal position on the right (*rdt*), but turned over out of position (*ldt*), and the lateral trachea (*llt*) also exposed, on the left. The dotted lines on the head show the outlines of the compound eyes. x 4½.

Fig. 9. One-fourth of the gizzard armature as seen when the viscus is cut lengthwise and spread out flat, larva No. 1. x 45.

Fig. 10. Inner surface of the rectum, larva No. 1, cut lengthwise to the right of the mid-dorsal line and spread out flat. x 16.

Fig. 11. A caudal gill of larva No. 101. x 9.

Fig. 12, 13. Caudal gills from larvae Nos. 48 or 49 and 1, respectively. x 9.

All these figures drawn by camera lucida and compound microscope.

Abbreviations:

ab, abductor muscle.
ad, adductor muscle.
br, brain (cerebral ganglia).
dv, dorsal vessel.
fg, fore gut.
g7, seventh abd. ganglia
il, ileum.
lcgt, trachea to left caudal gill.
ldt, left dorsal trachea.
llt, left lateral trachea.
lvrt, left ventral rectal trachea.
mcgt, trachea to median caudal gill.
mdrt, mid-dorsal rectal trachea.
mg, mid-gut.
mssp, mesostigma.
mt, Malpighian tubules.
mtsp, metastigma.
og, optic ganglion.
r, rectum.
rcgt, trachea to right caudal gill.
rdt, right dorsal trachea.

rlt, right lateral trachea.
rvrt, right ventral rectal trachea.
sa, superior appendages (cercoids) of imago.
sp. 1, *sp*. 2, *sp*. 8, spiracles of 1st, 2nd and 8th abd. segs., respectively.
t, trachea.
wp, wing pads.
I-X, abdominal segments 1 to 10.

PLATE XVIII.

Figs. 1, 2. Larva No. 55, placed on the netting out of water for comparison.

Figs. 3-7. Larva No. 55, transforming April 6, 1910. Figs 3-5 show the tracheal linings being pulled out of the right thoracic spiracles as white lines.

Fig. 8. Larva No. 59, transforming April 4, 1910, 9.05 A. M. (For continuation of this series see Plate XIX).

Fig. 9. Ventral surface of metamorphic exuvia No. 55.

Fig. 10. Dorsal surface of metamorphic exuvia No. 57. After transformation the exuvial coverings of the gills as they dry become shriveled. In this case special care was taken to spread them out on a piece of paper that they might dry in approximately natural shape attached to the paper.

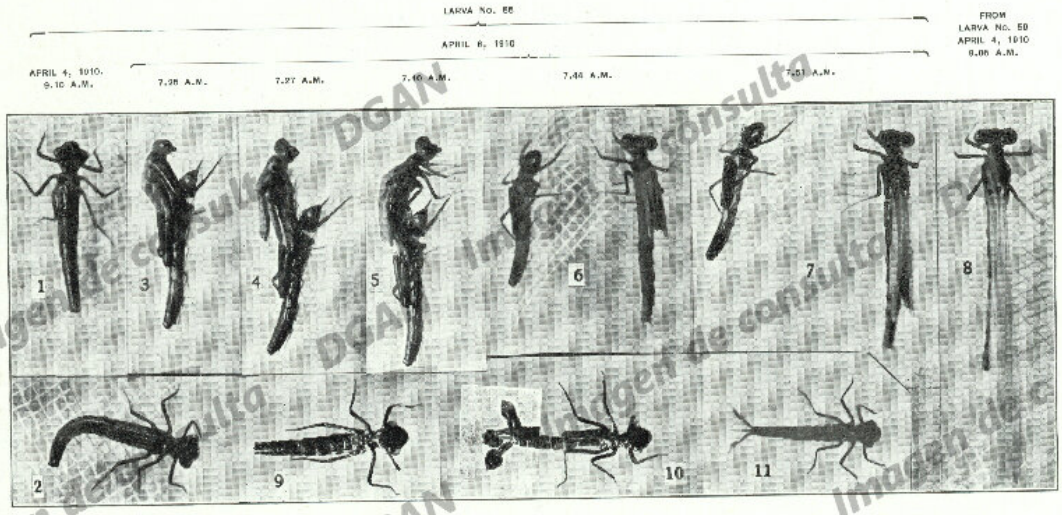
Fig. 11. Larva No. 57 photographed alive in water, March 2, 1910.

PLATE XIX.

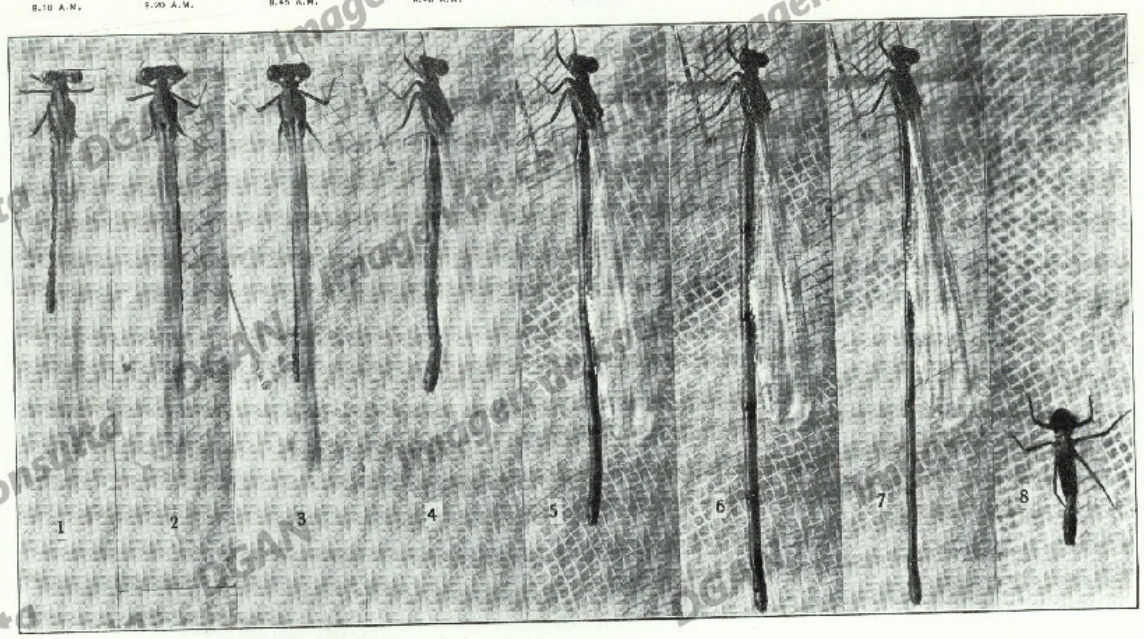
Figs. 1-7. Larva No. 59, transforming April 4, 1910. Between the taking of photographs 3 and 4 the netting was shifted to bring the imago into side-view.

Fig. 8. Metamorphic exuvia of No. 59 after transformation, April 4, 1910, at 10.46 A. M.; 20 mm. long.

All figures on Plates XVIII and XIX from photographs by Amelia S. Calvert.



MECISTOGASTER MODESTUS—CALVERT.



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