ON MNEMONICA AURICYANEA WALSINGHAM.[1]

(With Plates IX–XVI)

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Micropteryx auricyanea Walsingham, Trans. Am. Ent. Soc. Phila., p. 204, 1882.
Eriocrania auricyanea Walsingham, Entom. Record, London, x, p. 162, 1898.
Eriocephala auricyanea Dyar, List N. A. Lep. no. 6018, 1903.
Mnemonica auricyanea Meyrick, Genera Insectorum fasc. 132, p. 5, 1912.

The only published note on the biology of any American species of the superfamily Micropterygidoidea is by Wm. D. Kearfott (Entom. News, p. 129, 1902). He discovered the mine and the larva of what was presumably this species in the leaves of chestnut, and obtained pupæ, but did not succeed in rearing the imago.

One of the authors (Busck) for several years has collected and studied these larvæ and succeeded last spring in the rearing of a large number of the exquisite moths. As the American literature on this group is so scant, it is deemed worth while to give the following notes on the life-history, and on the remarkable structure of this American species, although most of the facts have long been known from closely allied European species.

Mnemonica auricyanea is a small (12–14 mm. alar expanse) strongly iridescent, golden bronze moth, sprinkled with scintillating, bright metallic purple scales. The entire life of this little insect above ground, covers but a few weeks. All the rest of its life, more than eleven months, is passed under ground confined within its cocoon.

The imago issues in April and lays its eggs singly on the opening leaves of the Cupuliferæ, (chestnut, oak and chinquapin). In May the larva makes a large, bulgy blotch mine in the leaf. It feeds up rapidly, within a week or ten days, falls to the ground and burrows down into the soil to a remarkable depth in proportion to the size of the insect, sometimes as deep as a foot. It spins a small, very tough, oval cocoon of silk, within which it remains curled up as a larva during the summer and fall. During the winter the larva transforms into a most remarkable pupa, which possesses long, arm-like, toothed, movable mandibles, with which it cuts the tough cocoon in early spring and with which it digs its way like a mole up to the surface of the ground, where the imago issues.

The egg is rather large, oblong, 0.5 mm. by 0.2 mm., soft, white, finely sculptured with minute dots. The female has a short, horny ovipositor and inserts the eggs singly into the young leaf near the edge, generally on the outer half. Dissection of the

[1] Presented at meeting of April 2, 1914.

female abdomen shows that the number of eggs laid by a single female is about forty.

The mine, (figs. 38–39), begins as a narrow line which runs out towards the edge of the leaf. This early part of the mine is normally obliterated and makes a fissure in the leaf as this grows. This fissure is a very characteristic feature of infested leaves. After this short linear part the mine broadens out into a large bulgy blotch, which always runs out to the edge of the leaf, and normally involves the tip or one or more of the lobes. The mine is suggestive of a beetle or a sawfly mine. The entire parenchyma of the leaf is eaten out and the mine is equally visible from both sides of the leaf. It is semi-transparent, so as to show plainly the larva and the black frass, which is voided in long, irregularly curled threads, lying loosely within the mine.

The full grown larva (fig. 1), is 9–10 mm. long, apodal, whitish in color, somewhat flattened. Head small, flat, horizontal, light yellow with dark brown trophi. Thoracic segments large and bulging, first segment with lightly chitinized but rather strongly pigmented, dark brown thoracic shield and sternal plate. Abdominal segments evenly tapering to the last joint. The skin is shagreened, due to numerous minute, closely set, spine-like projections (fig. 3), all directed backward and probably used in the locomotion. One pair of thoracic and eight pairs of abdominal spiracles.

In the head (figs. 6–7), the two halves of the epicranium are dorsally strongly prolonged backwards, separated by the very deep upper portion of the occipital foramen; ventrally also they are prolonged backwards, but only half as far as on the upper side. Ventrally on the inner margin of each side of the epicranium is a large triangular piece, the hypostoma,[1] which supports the transverse bridge-shaped part of the tentorium.

On the upper side of the epicranium is found one long anterior seta, three minute setæ and several sensorial punctures, somewhat asymmetrically arranged. On the under side are found one large and five small setæ. No true ocelli, but only a large, strongly pigmented, ventral eyespot on each side near the antennal base.

The front[2] is nearly triangular, but the converging edges do not quite meet posteriorly at the occipital foramen. These edges are strongly chitinized and interiorly developed into the endoskeletal frontal ridges. The front contains two pairs of sensorial punctures but bears no setæ.

[1] This is probably the post-gena of Kellogg, Kansas Univ. Quarterly, vol. II, p. 53, 1894.

[2] We employ this term which was first used by Lyonet, (*Traité anatomique de la chenille qui ronge le bois de saule*, p. 34, 1762), and which has been adopted by Wm. T. T. Forbes, (A Structural Study of Some Caterpillars, Ann. Ent. Soc. America, vol. III, p. 96, 1910).

From the posterior end of the front runs on each side a curved translucent line to the outside of the antennal base, limiting a large, triangular area which may be homologous to the so-called adfront of Forbes; each of these areas contains two small setæ posteriorly.

The epistoma[1] is well developed and bears two pairs of minute setæ.

The epistoma is connected with the labrum by a large soft-skinned part, the post-labrum of Lyonet, (the "clypeus" or "anteclypeus" of Packard, Sharp and others).[2]

The labrum (fig. 4) is large and well chitinized, bilobed, the anterior edge rounded and slightly emarginate; on the upper side it bears one central pair of strong setæ and along the edge five pairs of smaller setæ. On the under side of labrum and slightly projecting in front of it, is the fleshy epipharynx (fig. 5) armed along the anterior margin with a series of spines and bearing on each side a large tuft of long hairs. It also has a pair of sensory pits, and two pairs of small, symmetrically arranged, elongate, elliptical, chitinous plates,[3] the proximal ones with a little tooth. The margin of the epipharynx is strengthened by lateral rod-shaped sclerites.

The antennæ (fig. 11), are short, three-jointed;[4] the basal joint is large, membranous, without spines. The second joint is well developed and well chitinized. It bears two large spines and two sensory processes. The third joint is much smaller and bears one seta and two sensory processes, the larger one of which is slightly chitinized around its base.

The mandibles (fig. 10), are strong and placed horizontally. They have three, large, pointed teeth, and a fourth, small rudimentary tooth, indicated only on the ventral side. The large, bluntly terminating cutting edge is separated from the teeth by a small incision. The outer edge bears two strong setæ, the apical one of which is on the base of the fourth rudimentary tooth. At the base of the cutting edge is a bunch of long branched hairs.

[1] Epistoma is the chitinized marginal area between the two processes on which the fossæ of the mandibles articulate. This part Forbes calls "clypeus," (l.c. p. 96, footnote), on the supposition "that this name agrees better with its homology in other orders."

[2] Forbes does not give it any name at all, and applies, as mentioned, the term "clypeus" to the epistoma.

[3] Compare the similar structure in Coleopterous larvæ mentioned by Geo. H. Carpenter and Mabel C. MacDowell in, "The Mouthparts of Some Beetle Larvæ, With Especial Reference to The Maxillulæ and Hypopharynx," The Quarterly Journal of Microscopical Science, vol. 57, 1912, pp. 373–393, figs. 10, 191, 24, and 25.

[4] We accept with reservations, Trægaardh's interpretations, (in his valuable paper, Arkiv. for zoologi, vol. 8, 1913. Stockholm). Possibly his first joint is but a basal membrane and the terminal sensory process a true joint.

The maxillæ, labium, mentum and submentum[1] are inserted in the deeply curved hypostoma.

The maxillæ (figs. 8–9), are large. The cardo is separated from the lower part of the stipes by a transverse separating line which can be seen by a careful examination. The cardo is without any setæ but terminates basally in a more strongly chitinized part. The stipes is large and bears one strong and one small seta. The palpiger is free and bears a long seta. It is fused with the subgalea and the maxillary lobes: the flat lacinia and the more joint-like galea.[2] The lacinia on the dorsal side is furnished with long stiff spines and soft hairs. The maxillary palpus is two-jointed, the basal joint having a fine transverse line and four strong spines on the dorsal side, and the terminal joint several small sensory processes.

Along the margin towards the labium the palpiger has a rod-like chitinization, which at the base is connected with a similar structure along the margin of the hypopharynx. From the connecting point starts first a staff-like thickening along the stipes, second, a similar thickening around the lateral border of the epipharynx and third, a free, rod-like prolongation to the carinated frontal suture.

The labium is somewhat broader than long with two pairs of sensory punctures; the labial stipites form an incomplete chitinous basal ring. The labial palpi have a broad short basal joint, an elongated, narrow second joint with a single seta and a minute apical joint also bearing a seta. The spinneret (the fused labial lobes) protrudes beyond the palpi and is placed ventrally, well within the anterior margin of the labium. The mentum (fig. 9), is large and unchitinized, at the base separated from a short submentum by a bow-shaped transverse line. It has a single pair of sensory punctures. The submentum is also unchitinized. On the dorsal side of the labium towards the mouth cavity, the hypopharynx is provided with a series of long branched hairs. Further down is found a chitinized plate with the rudimentary third pair of maxillæ, the socalled maxillulæ (fig. 8). They are provided with short spines and correspond exactly to homologous elements described in the beetle larvæ by Carpenter and Mabel MacDowell, (l. c. p. 375).

The body tubercles (figs. 2–3) are only discernible by their setæ, which are themselves rather small. The arrangement

[1] Forbes, (l.c. p. 96), states, "The lower lip in caterpillars is formed of the maxillæ as well as the labium," but this is a confusion of terms, as the term labium and lower lip hitherto have been regarded as synonyms.

[2] This may be more correctly interpreted as the digitus laciniæ figured by Comstock in a Coleopterous maxilla, fig. 605, in his Manual, 1895. If so, the galea is absent.

is primitive. Utilizing Dyar's numbers, these setæ may be interpreted as follows: I, II, IV, V, and VII, nearly in a line on the posterior annulet of the segment; VI small and a little in front of this line; III obliquely above and behind the spiracle, with a minute IIIA obliquely before the spiracle. Besides these, there are two minute spines (x) on the dorsal half of each joint. Thoracic legs and abdominal prolegs are wanting.

The larva is full grown about ten days after the hatching of the egg. It then cuts a small semi-circular slit in the upper epidermis of the leaf, and leaves the mine, dropping to the ground, where it at once digs down until it finds a suitable place in which to make its cocoon. Normally this is attained within a few inches or even less from the surface of the ground, often next to a stone, but in the breeding jars[1] some went down six to eight inches and there are records of even greater depths, depending presumably upon the nature and humidity of the soil. There the larva bends itself into a circle and pushes the soil aside to make a small firm cell in which it then spins its oval cocoon.

The cocoon is so tight fitting around the larva and is made of so closely woven tough silk that it is difficult to cut it open with dissecting needles without injuring the larva within. The cocoon is about 2 mm. by 4 mm., of whitish silk and with small grains of earth and sand firmly incorporated in its surface. The larva remains within this cocoon apparently unchanged during summer and fall, and not before sometime during the winter does it transform into a pupa, which also very nearly fills out the cocoon.

The pupa (figs. 19–20–21) is most extraordinary, unlike any other Lepidopterous pupa, and reminding one much more of those of Trichoptera. It has all appendages free and unfused and all the body segments movable. The head especially can be moved up and down and sideways. There is, of course, no room within the narrow confines of the cocoon for these movements, but if a pupa is taken out and lightly touched with a brush, it responds with the most grotesque nodding of its head and with the swinging out of the enormous mandibles in a deliberate manner. While all of the other appendages are loose, not glued together as is normal in a Lepidopterous pupa, it is mainly the head and the mandibles and abdominal segments, which are movable and which

[1] Common large flower pots were used. These were filled with clean sand and sifted soil, liberally mixed with small pieces of rock, and the mined leaves were laid on top thereof. As soon as the larvæ had left the leaves, these were taken away, The pots were then buried flush with the ground, inside an unheated breeding house, where they were sheltered from sun and rain, but still exposed to nearly outdoor temperature during the winter. The pots were watered half a dozen times from May to the following January, and were then placed within breeding cases for the emergence of the moths.

are utilized in locomotion, when the pupa digs up through the earth. The legs are rather feeble and immovable and are not used for this purpose as has been asserted.[1]

The pupal skin is very thin and transparent, so that the imaginal hairs and scales, as well as the eyes and ocelli can be plainly seen through it. The only part of the pupa which is strongly chitinized, besides the large mandibles, is the supporting mouth-frame (figs. 14–18) formed by epistoma, pleurostoma and hypostoma.

From the front projects downwardly a large, peculiar, beak-like, soft process, reaching above and beyond the base of the labrum. On the upper part of the front are two pairs of long, curved, stiff hairs, the same which persist on the head of most Lepidopterous pupæ (fig. 16).

The eyes are large. The antennæ are free throughout their entire length and run in a broad curve over the base of the wings and rest on the costal edge of the wings, reaching nearly to their tips. The first joint is large and elongate, four times as long as the succeeding joints. The tufts of hairs on the imaginal joints are plainly visible through the pupal sheath.

The labrum is large, subquadrate, with incurved front margin. It is rather firm and bears six pairs of long stiff bristles.

The most conspicuous of the mouth parts are the very long, stout, curved, armlike mandibles (fig. 15). These are strongly chitinized and dark brown in color. Their fossa and condylus are strongly developed and firmly jointed to the mouth frame. Their inner edge is sharply serrated nearly to the end and the apex is broadened out into a formidable club, which is abruptly cut off with a flattened, somewhat hollow end, the edges of which are armed with several strong teeth. They are capable of a strong outward swinging movement, which is used to tear the tough cocoon and afterwards to dig up through the soil.

The mandibles are moved by strong muscles (fig. 18), identical with the abductor and adductor mandibulæ found in insects with biting mouthparts, and the minute imaginal mandibles can be found within their base by dissection (fig. 14). In this connection we refer to Chapman's peculiar statement in his otherwise very lucid account of an "*Eriocranid*" pupa.[2]

[1] Sharp, in his textbook, p. 327, 1909.

[2] "That a Lepidopterous pupa should have jaws is remarkable enough; that they should be of such immense size proportionately to the insect and should be functionally active seems at first sight incredible; but the still more remarkable fact remains, that active and powerful as they are, there are no visible means of working them, as they are pupal structures, used only immediately before the emergence of the imago and have no corresponding imaginal parts attached to them.

"The whole question, how these jaws are worked, will form an interesting

The maxillary palpi (fig. 17), are bent upon themselves in five sharp curves, with the last joint pointed downwards and forwards.

The two halves of the proboscis are widely separated and outwardly curved, with their tips nearly meeting in the middle line forming a heart-shaped figure.

The labium and its three-jointed palpi are pointed downwards in two straight, divergent staffs, reaching beyond the curved proboscis.

The strongly angulated patagia,[1] (fig. 19), overlap the base of the wings behind.

The legs are folded loosely along the body, the posterior tarsi reaching beyond, and curved around the tip of the abdomen.

On the back of the pupa is a peculiar structure, the morphology and function of which is not clear to us. It consists of an unpaired, thin-walled, strap-like, longitudinal band (fig. 21, *x*), made up of three separate appendages in prolongation of each other and attached to the middle line of respectively the second and third thoracic and the first abdominal segments.

Each abdominal segment bears two lateral pairs of strong stiff spines. The spiracles are small and circular.

In early spring when the pupa is mature and ready for the emergence of the adult, the cocoon is split open by an outward movement of the mandibles which tears through the tough silk. The pupa then wriggles out of the cocoon and laboriously digs upward through the earth by the help of the mandibles, swung from the exceedingly movable head and pushed on by the movements of the abdomen. When it finally has made its way to the surface, it lies immovable for some time, during which the last acts of the transformation to adult take place. The mandibles become immovable through the withdrawal of the imaginal skin and mandibles, together with the strong muscles which remain in the imaginal head. The pupal skin now splits open on the median line of the first and second thoracic segments. The long-haired head and thorax of the imago appear in the slit and the fully developed moth issues. It at once seeks some support from which to hang with backwardly extended wing, as is usual with freshly emerged moths, but it is very quickly in condition for active flight. It is interesting to note that if the cocoon is taken out of the sand and placed on the surface for observation, as was done

research for some microanatomist. I fear my own training leaves me unequal to carry the matter much further. I am however, thoroughly satisfied on two points: first, that there are no muscles attached to these jaws, second, that there are no imaginal jaws within them, whose movements compel those of the pupal ones." Chapman, Trans. Ent. Soc. Lond. 1893, pp. 255–263.

[1] The patagina of Busck, by mistake.

with several, the pupa has a period of rest after emergence from the cocoon, during which the mandibles and the head work furiously at the least irritation with a hair-pencil, or even without such. This period evidently corresponds to the time it normally takes the pupa to work its way through the soil to the surface. Later on comes the period of immovability of the mandibles, which fail to respond even if sharply irritated. This corresponds to the resting period when the pupa under normal conditions has reached the surface.

The imago has the head (fig. 22) and face strongly tufted with long gray, brown and white hairs, which obscure the eyes and mouthparts. The antennæ are simple, dark brown, with two longitudinal light yellow lines throughout their length. Thorax strongly haired, the long brown and gray hairs arranged in three large whorled tufts, two over the patagia and one posteriorly. Forewings elongate elliptical, thickly covered with large golden scales, evenly interspersed with numerous single purplish blue metallic scales; cilia light golden brown Hindwing dark golden brown, with a purple sheen, semitransparent at base; cilia gray. Abdomen brownish gray, in the female terminating in a short, stout, brown, horny ovipositor. Legs dark gray sprinkled with purple scales; posterior tibiæ with long, sparse thin hairs on the upper side and with two pairs of well developed spurs. Alar expanse 10–13 mm. The venation is given in figures 12–13.

From the several clearly primitive characters which they possess in common, more especially in the neuration and the mode of keeping the wings together by the so-called jugum (the clavus of Spuler), there can be no doubt that the Eriocranidæ and the Micropterygidæ represent the most ancestral group of Lepidoptera. This has been generally recognized by all modern Lepidopterists, but there has been considerable difference of opinion as to the relative systematic value of these groups. Some authors have considered the active biting mouth parts of the adult Micropterygidæ of sufficient systematic value to separate this group as a distinct superfamily or even subclass. On the other hand, Meyrick regards the passage to sucking mouth parts in the Eriocranidæ as a purely biological change of structure of much less systematic significance, and he treats the two groups as closely allied subfamilies.

The actual presence of rudimentary but unmistakable mandibles also in the Eriocranidæ tends to support Meyrick's opinion of close correlation, but his description (Genera Insectorum), contains some misstatements and omissions in the anatomy of the head structures in the two groups. We consider that the differences both in the mouth parts and in the venation, as well as of the larvæ, justify separate family rank for the Eriocranidæ and the Micropterygidæ of which the latter are by far the more ancestral, as shown in the following comparison of their head structure.

The adult Micropterygid (*Micropteryx ammanella* Hübner, is used in this comparison), has true, well developed, strongly chitinized, functional mandibles (fig. 35). These are in a general way similar to those just described in the Eriocranid pupa, but are much contracted. They have well developed fossa and condylus, jointed on the mouth-frame and are moved by strong abductor and adductor muscles. Their outer end is sharply cut off and palmate as in the Eriocranid pupa and toothed on the edges. The upper one of the outer teeth is more pointed and larger than the rest.

In the adult Eriocranid (*Mnemonica auricyanea* Walsingham) are found by dissection similar but rudimentary and unchitinized mandibles (figs. 27, 31, 33). These have not the palmate apex, and the fossa and condylus are hardly discernible, while the ligament connecting them to the mouth frame is large and cushion-like. In the pupa these mandibles are plainly visible within the base of the pupal mandibles (fig. 14), and they possess strongly developed abductor and adductor muscles (fig. 31), identical with those in the pupa. These muscles and the development within the corresponding pupal structure definitely prove the mandibular nature of these organs.[1] The presence of true biting mandibles in the Micropterygidæ is therefore not of such fundamental importance as Sharp, Tutt, and others have assigned to it, the less so as rudimentary mandibles may be distinguished in certain much higher Lepidoptera.[2] But the further presence of all the

[1] Compare Chapman's statement, above quoted, in footnote, page 156–7, which has been accepted by subsequent writers, as Sharp and Meyrick. The former states, page 308 in his textbook, (The Cambridge Natural History, vol. VI, Insects, part II, 1899), "The opinion entertained by Walter that Micropteryx proper, (his 'höhere Micropteryginen,' Meyrick's 'Eriocranianæ') also possesses rudimentary mandibles is considered by Chapman, no doubt with reason, to be erroneous." Further in the same manual, p. 437; "All the information we possess points to profound distinctions between *Micropteryx*, (our 'Eriocranidæ'), and *Eriocephala*, (our 'Micropterygidæ,' Walter's 'niedere Micropteryginen') for whereas, in the former the mandibles drop off from the pupa, so that the imago has no mandibles, in the latter, the mandibles exist." Meyrick, in his monograph of the Micropterygidæ (*Genera Insectorum*, 912, p. 3), simply states in the diagnosis of his subfamily *Eriocraninæ*, "No mandibles." On the other hand, it should be noted that Alfred Walter in his excellent work on the morphology of the Lepidoptera, (Jenaische Zeitschrift für Naturwissens., Bd. 18, 1884, neue Folge Bd. II, p. 751–807, 2 plates), has correctly interpreted these structures in what he calls the "höhere Micropterygidæ."

[2] The weak and functionless mandibles have been recognized later by Kellogg, (The Mouthparts of the Lepidoptera, Am. Nat. vol. 29, p. 546, 1895), by Packard, (On a new Classification of the Lepidoptera, Am. Natur.

other trophi also identical with those found in insects with biting mouth parts, and even maxillulæ lobes on hypopharynx (fig. 37), proves the Micropterygidæ a much more ancient group than the Eriocranidæ, which possess none of these characteristics but has a true sucking mouth.

In the Micropterygidæ the maxillæ consist of a well developed cardo and stipes (figs. 36–37), a palpiger which carries the six-jointed palpus, and a subgalea which carries a distinct, well chitinized lacinia with a few setæ, and a two-jointed galea, the basal joint of which is short and well chitinized, while the terminal joint is soft and leaf-shaped, with a longitudinal series of setæ.

The Eriocranidæ (figs. 29–30), also possess distinct cardo and stipes, as well as a six-jointed palpus, and the galea is also two-jointed, but they lack altogether the lacinia, and the terminal joint of the galea is developed into one of the hollow sheaths of a true proboscis, is curved, has the typical serrations (figs. 25–26), which serve to connect it with the other half of the proboscis, and has the usual parallel ring structure and surface cilia placed in transverse lines.

Both the Micropterygidæ and the Eriocranidæ possess a labium with a well developed, three-jointed palpus, the apical joint with the usual sensitive groove,[1] represented merely by a depression containing the rows of sensitive cones. But in the Micropterygidæ is found a setæ-bearing lobe, corresponding to the galea of the maxillæ, issuing from the so-called basal joint of the palpus, which should rather be interpreted as stipes labii. Of this setæ-bearing lobe there is no vestige in the Eriocranidæ. Finally, only the Micropterygidæ, as already mentioned possess the two maxillulæ lobes, lateral to the hypopharynx.[2]

The authors are under great obligations to their friend Rev. J. DeGryse, for the several excellent figures (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 19, and 21), of the larval and pupal structures, which he has studied most diligently and carefully, thus contributing very considerably to the value of this paper.

The other figures, except the venation, were drawn by Adam Böving.

vol. 29, p. 636, 1895) and by Francis X. Williams, (A New Eriocrania from the Pacific Coast, Ent. News, p. 14, 1908).

[1] Pointed out by O. Von Rath: Zool. Anzeiger 1887, p. 627; Zeitschrift f. Wissench. Zoölogie, Bd. 46, 1888.

[2] These investigations of the maxillary, labial, and maxillulary structures fully substantiate the writings of Dr. Walter, who has already pointed out most of the above mentioned characters in his excellent paper. In the middle of the hypopharynx is plainly seen in our slides, both of the Micropterygidæ and the Eriocranidæ, the opening of the salivary glands, which Walter was not able to discern on account of the condition of his material.

EXPLANATION OF PLATES.

PLATE IX. *Mnemonica auricyanea* Walsingham, larva.

Fig. 1, lateral view of full grown larva.

Fig. 2, lateral view of flattened larval skin; SP, thoracic spiracle; *sp*, abdominal spiracles.

Fig. 3, details of the sixth abdominal segment, lateral view; *x*, small unnumbered setæ.

PLATE X. *Mnemonica auricyanea* Walsingham, larva.

Fig. 4, dorsal view of epipharynx, labrum and post-labrum; *ex*, epipharynx; *lr*, labrum; *pl*, post-labrum; *mb*, median bristles.

Fig. 5, ventral view of epipharynx; *eh*, hairtuft; *ep ext*, exterior epipharyngeal plate; *ep int*, interior epipharyngeal plate; *er*, rod along the margin; *es*, sensory puncture; *ex*, epipharynx.

Fig. 6, dorsal view of head, *a*, (on detail A), dorsal mandibular articulation; *af*, adfront; *afl*, adfrontal line; *an*, annulus around the antennal base; *c*, (on detail A), carinated lateral margin of front; *c*, (on detail A), epistoma; *epc*, epicranium; *f*, front; *of*, occipital foramen; *pl*, post-labrum.

Fig. 7, ventral view of head; *epc*, epicranium; *h*, hypostoma with *i*, impression where tentorium is attached; *m*, mentum; *ocl*, eyespot.

PLATE XI. *Mnemonica auricyanea* Walsingham, larva and wing venation of the imago.

Fig. 8, maxillæ, hypopharynx and maxillulæ; *bb*, branched bristles; *ds*, duct of salivary glands; *epc*, margin of epicranium; *g*, galea or digitus lacinia; *hr*, chitinous rod of hypopharynx; *hx*, hypopharynx; *l*, lacinia; *mp*, basal joint of maxillary palpus; *mxl*, maxillulæ; *spr*, spinneret.

Fig. 9, ventral view of maxillæ and labium; *cr*, cardo; *crr*, chitinization along inner edge of cardo; *lp*, basal joint of labial palpus; *lst*, labial stipes; *m*, mentum; *mpI*, basal joint of maxillary palpus; *mpII*, terminal joint; *plg*, palpiger; *sm*, submentum; *r*, chitinous rod along the inner margin of lacinia; *st*, maxillary stipes; *str*, chitinous rod along the margin of maxillary stipes.

Fig. 10, left mandible, ventral view.

Fig. 11, dorsal view of right antenna; *an*, annulus around antennal base; *at*, large papilla or terminal joint.

Fig. 12, venation of forewing.

Fig. 13, venation of hindwing.

PLATE XII. *Mnemonica auricyanea* Walsingham, pupa.

Fig. 14, labrum and mandibles of the imago within the labrum and mandibles of the pupa; labrum and mandibles of the pupa indicated with dotted lines; *mf*, mouthframe.

Fig. 15, ventral view of left mandible.

Fig. 16, dorsal view of head; *ant*, antenna; *fs*, frontal setæ; *lp*, labial palpus; *lr*, labrum; *md*, mandible; *mf*, mouth frame; *mp*, maxillary palpus; *bk*, beaklike prolongation of front; *pr*, proboscis.

Fig. 17, ventral view of head; *epc*, epicranium; *h*, hypostoma; *lp*, labial palpus; *m*, mentum; *md*, mandible; *mp*, maxillary palpus; *ofI*, anterior part of occipital foramen; *ofII*, posterior part of occipital foramen; *oc*, compound eye; *pr*, half part of proboscis; *sm*, submentum; *tb*, bridge of tentorium; *st*, stipes.

Fig. 18, mouth frame and mandible with musculature, dorsal view; *ab*, abductor muscle of mandible; *ad*, adductor muscle of mandible; *d*, dorsal process of mouth frame on which fossa of the mandible articulates; *mf*, mouth frame; *t*, tendon; *v*, ventral socket of mouth frame on which condylus of mandible articulates.

PLATE XIII. *Mnemonica auricyanea* Walsingham, pupa.

Fig. 19, lateral view; *pt*, patagium.

Fig. 20, ventral view.

Fig. 21, dorsal view; *x*, thin-walled dorsal appendices.

PLATE XIV. *Mnemonica auricyanea* Walsingham, imago.

Fig. 22, lateral view of head; *ant*, antenna; *e*, epistoma; *epc*, epicranium; *f*, front; *lp*, labial palpus; *l*, labrum; *md*, mandible; *mf*, mouth frame; *mp*, maxillary palpus; *ocl*, ocellus; *pl*, post-labrum; *pr*, proboscis.

Fig. 23, epipharynx and hypopharynx; *mm*, membrane of mouth; *ex*, epipharynx; *hx*, hypopharynx; *pap*, sensory papilla; *ph*, pharynx; *sc*, scales; *w*, sensory wart.

Fig. 24, dorsal view of head; *an*, antennal ring; *epc*, epicranium; *f*, front; *oc*, compound eye; *ocl*, simple eye; *ha*, hair-bearing area.

Fig. 25, apex of right half of proboscis from inner side.

Fig. 26, base of right half of proboscis from inner side; *ci*, cilia belonging to the external parallel series; *fri*, stiff connecting fringes of ventral margin; *th*, transverse ring-structure.

Fig. 27, ventral view of head; *ex*, epipharynx; *h*, hypostoma; *hx*, hypopharynx; *m*, attachment of mentum; *md*, mandible; *mx*, attachment of maxilla; *ofI*, anterior portion of occipital foramen; *ofII*, posterior portion of occipital foramen; *tb*, bridge of tentorium; *v*, ventral mandibular articulation.

Fig. 28, ventral side of labium; *lp*, labial palpus; *m*, mentum; *VR*, organ discovered by Von Rath.

Fig. 29, buccal surface of left maxilla; *c*, cardo; *gI*, basal joint of galea; *gII*, terminal joint of galea developed as left half of proboscis; *h*, hypostoma; *mp*, maxillary palpus; *plg*, palpiger; *sgl*, subgalea.

Fig. 30, ventral side of right maxilla; *c*, cardo; *gI*, basal joint of galea; *gII*, terminal joint of galea; *mp*, maxillary palpus; *plg*, palpiger; *sg*, subgalea; *st*, stipes.

PLATE XV. *Mnemonica auricyanea* Walsingham, imago, figs. 31–33.

Fig. 31, ventral view of right mandible; *ab*, abductor muscle; *ad*, adductor muscle; *t*, tendon.

Fig. 32, frontal view of head; *ant*, antenna; *epc*, epicranium; *e*, epistoma; *f*, front; *lr*, labrum; *lp*, labial palpus; *m*, mentum; *md*, mandible; *mp*, maxillary palpus; *pl*, post-labrum; *plg*, palpiger; *pr*, proboscis (= terminal joint of galea); *sm*, submentum.

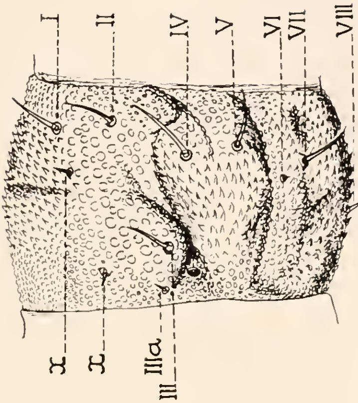


Fig 3

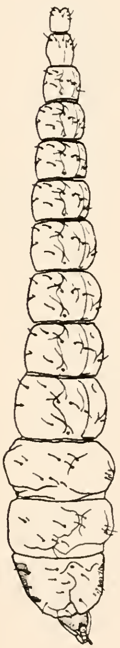


Fig 1

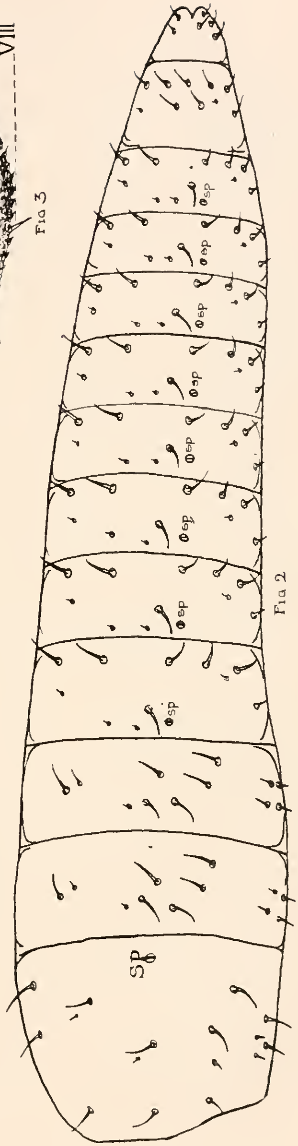


Fig 2

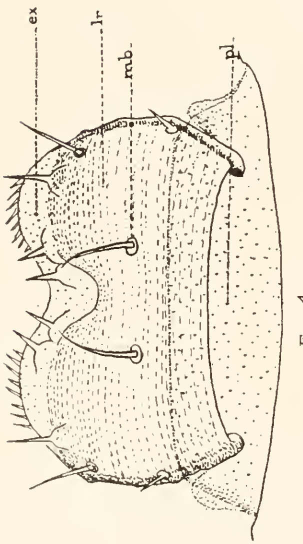


FIG. 4

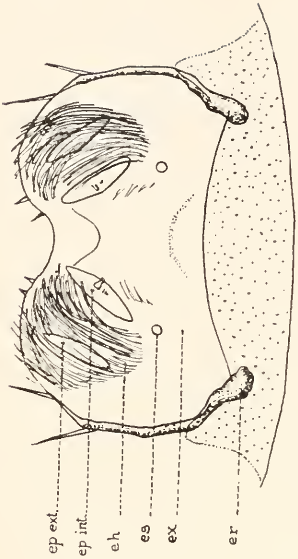


FIG. 5

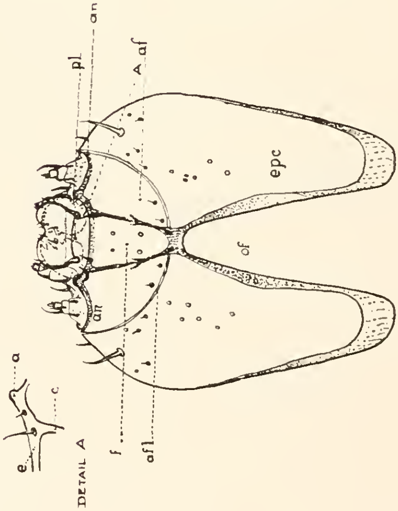


FIG. 6

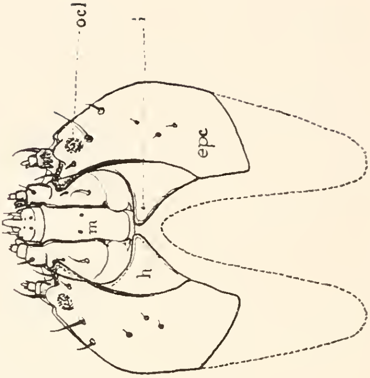


FIG. 7

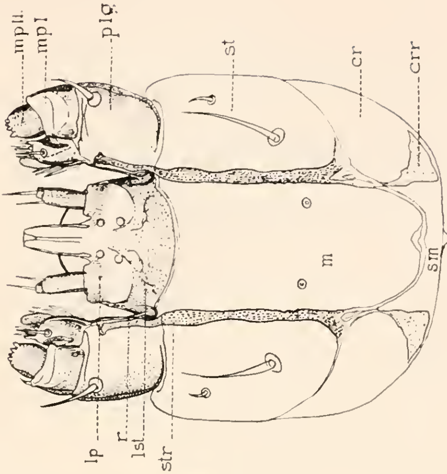


FIG. 9

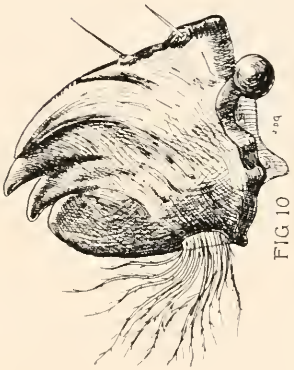


FIG 10

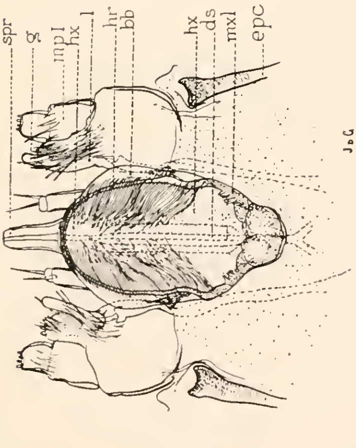


FIG. 8

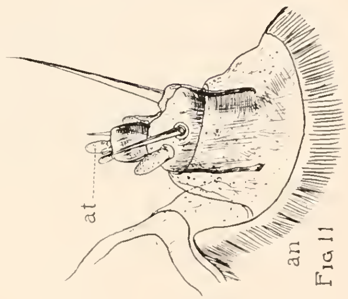


FIG 11


FIG. 12


FIG 13

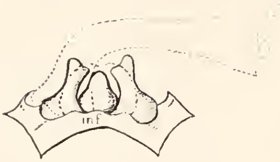


Fig. 14

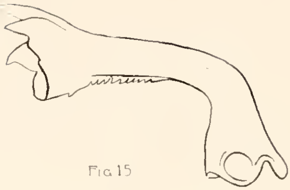


Fig. 15

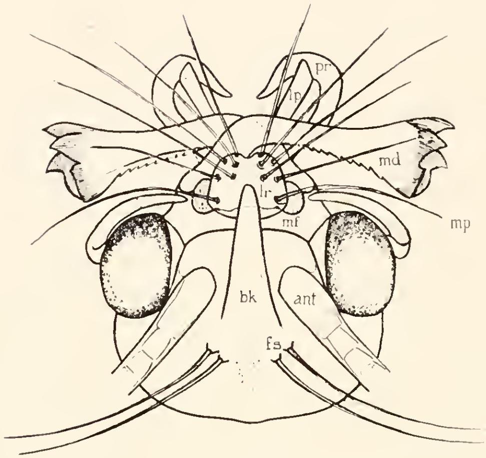


Fig. 16

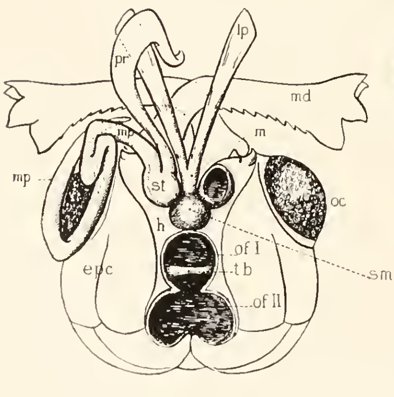


Fig. 17

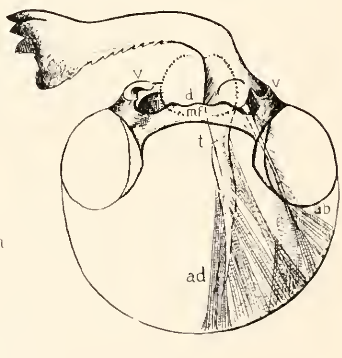


Fig. 18

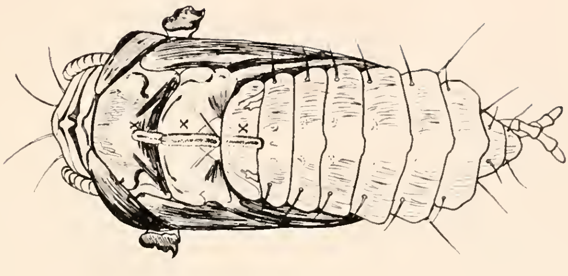


FIG. 21

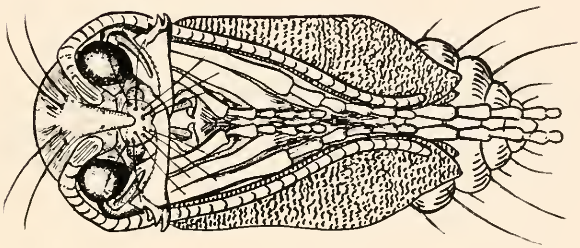


FIG. 20

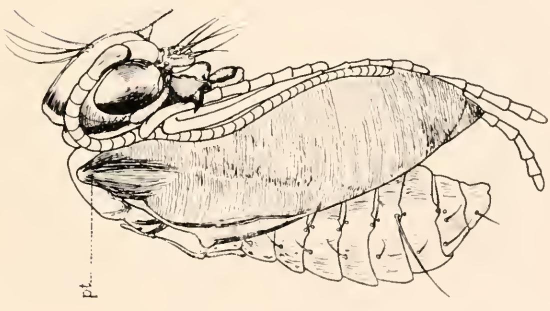


FIG 19

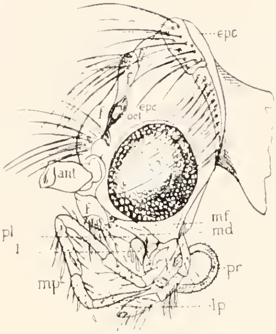


Fig 22

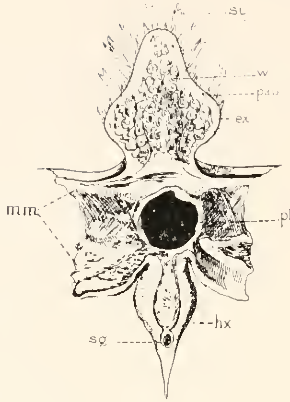


Fig 23

Fig 25

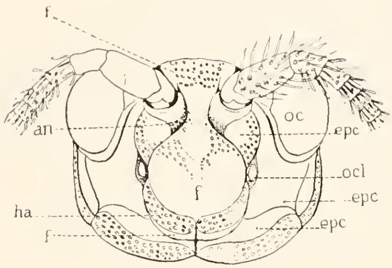


Fig 24

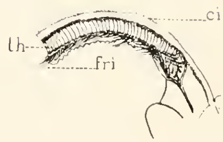


Fig 26

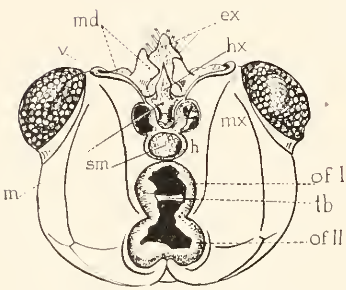


Fig 27

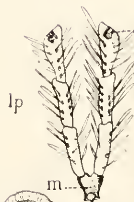
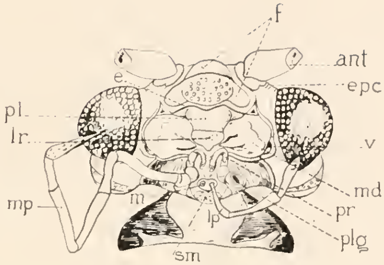


Fig 28

Fig 29

Fig 30

Fig. 31



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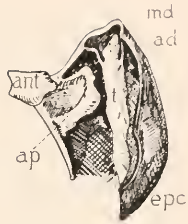

Fig. 33

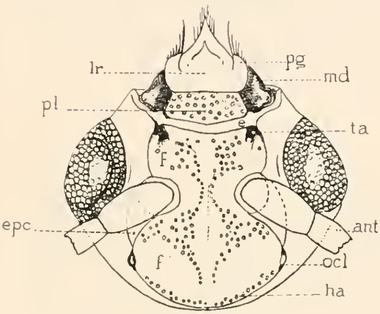

Fig. 34

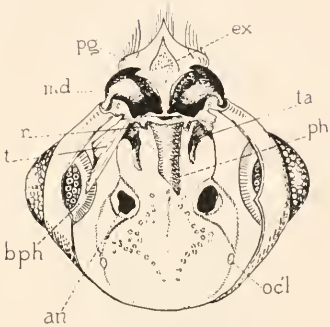

Fig. 35

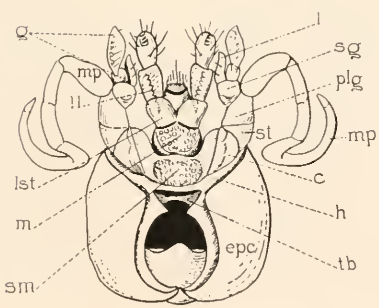

Fig. 36

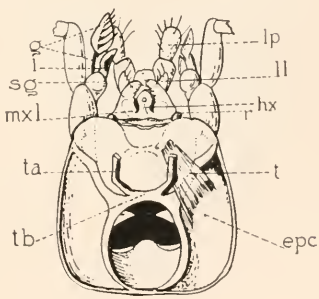

Fig. 37

Fig 38.

Fig. 39.

Fig. 33, interior view of a piece of the head of a dry specimen; *ad*, adductor mandibuli; *epc*, epicranium; *md*, mandible; *t*, tendon; *ap*, process to which antennæ muscles are attached.

Micropteryx ammanella Hüber, imago, figs. 34–37.

Fig. 34, dorsal view of head; *ant*, antenna; *epc*, epicranium; *ha*, hair-bearing area; *lr*, labrum, *md*, mandible; *oel*, ocellus; *pg*, pilifer; *pl*, post-labrum; *ta*, spot indicating the interior attachment of tentorial arm.

Fig. 35, upper portion of head from inner side; *an*, antennal ring; *ex*, epipharynx; *md*, mandible; *ocl*, ocellus; *pg*, pilifer; *ph*, pharynx; *r*, endoskeletal rod; *t*, tendon of mandible; *ta*, tentorial arm.

Fig. 36, ventral view of head; *c*, cardo; *epc*, epicranium; *g*, galea; *h*, hypostoma; *l*, lacinia; *ll*, labial lobe; *lst*, labial stipes; *m*, mentum; *mp*, maxillary palpus; *plg*, palpiger; *sg*, subgalea; *sm*, submentum; *st*, stipes; *tb*, tentorial bridge.

Fig. 37, lower portion of head from inner side; *epc*, epicranium; *g*, galea; *hx*, hypopharynx; *l*, lacinia; *ll*, labial lobe; *mxl*, maxillula; *lp*, labial palpus; *r*, endoskeletal rod; *sg*, subgalea; *t*, tendon of mandible; *ta*, tentorial arm; *tb*, tentorial bridge.

Plate XVI. *Mnemonica auricyanea* Walsingham.

Fig. 38, young mine and egg puncture in chestnut leaf.

Fig. 39, old mines.

AQUATIC BEETLES, ESPECIALLY HYDROSCAPHA, IN HOT SPRINGS, IN ARIZONA.[1]

By E. A. Schwarz, *Bureau of Entomology.*

In 1891 on the occasion of the meeting of the A. A. A. S. at Washington, D. C., I prepared for publication a letter just received from our lamented friend and former president of this Society, Mr. H. G. Hubbard, relating to insect life in the hot springs of the Yellowstone National Park. This letter has been published in the Canad. Ent., vol. 23, pp. 226–230. At the same time I made myself a little acquainted with the literature on insect life in hot water and found that in America there is only one paper referring to this subject, namely by Dr. A. S. Packard, published in the American Naturalist on a Stratiomyid (Diptera) larva found in Wyoming. (This same paper is mentioned by Dr. Sharp in the Cambridge Nat. History.) In this instance the Dipterous larva was found in hot water *estimated* only 20 or 30° below the boiling point. In the case of Mr. Hubbard's observations in the Yellowstone Park he expresses his regrets at not

[1] Presented at meeting of April 2, 1914.