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MAY-FLIES OF FALL CREEK.

BY ANNA H. MORGAN.

Limnological Department, Cornell University.

The following paper is a preliminary study of the ecology of the May-flies in the streams about Ithaca, N. Y., more especially in Fall Creek. In these, as in most fresh water streams, the nymphs of this order are abundant. In Fall Creek they are the dominant insects of the stream during the months of April, May and June, and by their fine adaptations to diverse environments they offer a satisfying field of study to any brook traveler. The nymphs may be easily secured, but only imagoes exist in most collections, and these usually as dried distorted specimens whose life-histories are little known. The winged or aerial life lasts but a few days at most; the nymphal or aquatic life may extend over two or three years. The imago exhibits great specialization of parts concerned with reproduction and more striking atrophy of other parts than may be seen any where else among insects. Imagoes of all the groups are remarkably alike in superficial appearance. The nymphs, on the other hand, display a series of adaptations as diverse as their environments. Only by rearing specimens from nymphal to adult life may these two stages be linked together. Many of the life-histories of those species found in Eastern North America have been made known. It has been with the hope of adding to the number of these life-histories, as well as with the purpose of gaining more knowledge of the habits of those already known, that this study has been begun. The earlier American workers, Say, Hagen and Walsh* scarcely took up

* Walsh, B. D. On the pupa of the Ephemerinoid genus *Baetisca* Walsh. *Proceed. of the Ent. Soc. of Philadelphia.* 1864. pp. 200-206.

* Walsh, D. B. List of the Pseudoneuroptera of Illinois. *Proceedings of the Natural Sciences of Philadelphia.* 1862.

the rearing of nymphs but by their descriptive work they laid the foundation for the life-history studies which have followed. Berry† '03 reared and described the nymphs of *Habrophlebia americana* Banks, (which nymph is not a *Habrophlebia* but a typical *Leptophlebia*), *Blasturus cupidus* Say, and *Callibaetis ferruginea* Walsh. A note on the nymphs of the genus *Tricorythus* was published by Cockerell and Gill '06‡. The largest number of life-histories of Eastern North American forms has been written by Professor James G. Needham in *Bulletins* 47, 68, and 86 of the New York State Museum, and includes the following species:

Bull. 47.

Heptagenia pulchella Walsh.
Baetis pygmaea Hagen.
Siphylurus alternatus Say.
Caenis diminuta Walker.
Hexagenia variabilis Eaton.
Ephemera varia Eaton.
 Bull. 124.
Ephemerella dorothea Needham.
Potamanthus diaphanus Needham.

Bull. 86.

Chironetes albomanicatus Needham.
Ameletus ludens Needham.
Choroerpes basalis Banks.
Baetis pygmaea Hagen.
Callibaetis skokiana Needham.
Ephemerella bispina Needham.
Caenis allecta Needham.
Leptophlebia praepedita Eaton.
Heptagenia interpunctata Say.
Ecdyurus maculipennis Walsh.
 By Mr. W. E. Howard.
Polymitaerays albus Say.

With the exception of *Callibaetis skokiana*, *Ephemerella bispina*, *Ephemerella dorothea*, and *Potamanthus diaphanus*, all of these species have been taken in or near Fall Creek. For some of these further biological data have been secured. In addition to them eight species have been bred which it is believed have not been before recorded. These are all from Fall Creek with the exception of one, *Ephemerella cornuta*, reared for me by Miss Lucy W. Smith at Salisbury, Connecticut, and here included in the *Ephemerella* group. The life-histories which are given are those of *Iron fragilis*, sp. nov., *Epeorus humeralis*, sp. nov., *Ephemerella rotunda*, sp. nov., *E. tuberculata*, sp. nov., *E. cornuta*, sp. nov., *E. deficiens*, sp. nov., *E. plumosa*, sp. nov., and *E. spinosa*, sp. nov. The description of the female imago has been added to Prof. Needham's life-history of *Ameletus ludens*, and the *Caenis allecta* which he placed provisionally in that genus has on rearing been established in *Tricorythus*.

† Berry, Edward. New or Hitherto Unknown Ephemerid Nymphs of the Eastern U. S. *Am. Natural.* Vol. XXXVII, pp. 25-31. 1903.

‡ Cockerell, T. D. A., and Marie Gill. *Tricorythus*, a Genus of May-flies. *Univ. of Colo. Studies*, Vol. III. No. 3, 1906.

PHYSICAL FEATURES OF FALL CREEK.

The vicinity of Ithaca consists of two highlands between which lies the basin of Cayuga Lake. The west highland known locally as West Hill is a long regular slope, while East Hill upon a terrace of which Cornell University stands, is furrowed with gorges made by streams flowing downward to the lake. On the gradual incline of the Eastern highland these streams flow along as quiet meadow brooks, or broadening out over stony beds are caught in a maze of ripply shallows, but on reaching the steep terraces of the highland they plunge downward through the narrow gorges by a succession of cascades till they come to the plain below. These streams coming far from their source and fed by many tributary waters are flooded and turbulent in the spring, but gradually dwindle to mere brooklets with trickling falls during the mid and late summer, when the tributaries fail of their supply. Few of the main streams become wholly dry. In March and April rich flora and fauna spring from their banks and waters, while through the dry season they supply enough water for the maintenance of life and the reproduction of another generation. Fall Creek, which bounds the Cornell Campus on the north, is a type of these streams.

About one mile east of the campus Fall Creek flows over a broad nearly level bed thickly strewn with flat stones and rocks which project from the water except at periods when the stream is swollen. On one side the creek is bordered by a soft sandy shore, on the other by a shelving ledge. Beyond this point, where the ledge gives place to soft drift, there is a series of permanent pools which mark the entrance of a small tributary spring. A cross section of this upper portion of the stream represents a variety of situations great enough to shelter widely different types of May-fly nymphs. Clinging to the surfaces of the stones in the mid current are the flat nymphs of *Epeorus*, *Iron*, *Ecdyurus* and *Heptagenia*; clambering in the trash which has collected between the stones are the nymphs of *Ephemerella*; on the sheltered surfaces or in the quiet border waters are *Heptagenias* about to transform in company with *Leptophlebia*, *Siphurus*, and *Ameletus*; hidden in the sandy sweeps are *Caenis* and *Tricorythus* and burrowing in the soft muck banks are *Hexagenia* and *Ephemera*. Changing from this gradual descent

Fall Creek cuts downward through a narrow gorge, widens into the artificial pond known as Beebe Lake, hurries through a deep gorge and over a series of falls, cascades and riffles to the marsh below. This lower creek is inhabited by those true dwellers of the rapids, *Chironetes albomanicatus* and *Baetis pygmaea*.

To the north of the lower portion of Fall Creek a small streamlet known as Pleasant Brook follows a parallel course to the lowlands. Its pools and cascades shelter a fauna similar to that of Fall Creek if somewhat less rich. This brook possesses the advantage of small size which makes its study easy. Devoid of tributaries to flood it in time of rain, and shut in by shrubbery, this stream furnished a safe place for the rearing cages of nymphs which were captured in Fall Creek.

METHODS OF REARING AND COLLECTING.

Rearing and collecting were begun on April 1, and continued to August, 1, after which only irregular collecting trips were made to the Creek. The only satisfactory method of rearing May-flies is one which keeps them in their own environment or in conditions closely imitating it. For this purpose Prof. Needham used a cylindrical cage made of wire cloth with a cheese-cloth cover. Such cages are the most convenient for carrying in a knapsack and many May-flies have been successfully reared in them. The space within them, however, is small and all surfaces are perpendicular to the water. If the imago becomes entangled, or if it is not strong enough to keep its footing on the upright surface it falls back into the water and drowns, or at least will never be able to transform. When two or three insects are in the same cage, particularly if the cage is in a strong light, there is danger of one or all falling into the water. For these reasons I have designed another cage, which though less conveniently carried about, has the merit of being more roomy and of supplying one slanting surface. This cage may be made of fine copper or galvanized wire cloth. A stiff cloth which will not bend easily will make the best cage. The cages which I used in Fall Creek were about five inches square on the bottom and five inches in height. Such a cage is easily cut and folded from a single piece of wire cloth. In the diagram shown in Fig. 2, the continuous heavy lines represent the cut edges, the lighter lines the folded edges of the laps, and the

dotted lines the angles of the bottom, back, sides, front and cover. The laps on the sides should be folded over the cut edges of the bottom and the front and then securely fastened with solder. The cover may then be pushed down and secured by a wire catch or by a rubber band placed about the cage. When in use a stone should be placed in the bottom of the cage. This will serve the double purpose of keeping the cage upright and of providing a foot hold for the nymphs enclosed within it. In Fig. 1 the completed cage is shown inserted in the water. A represents the stone placed in the cage.

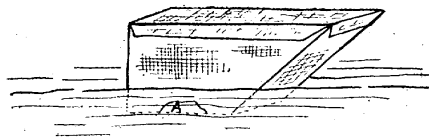


Fig. 1.

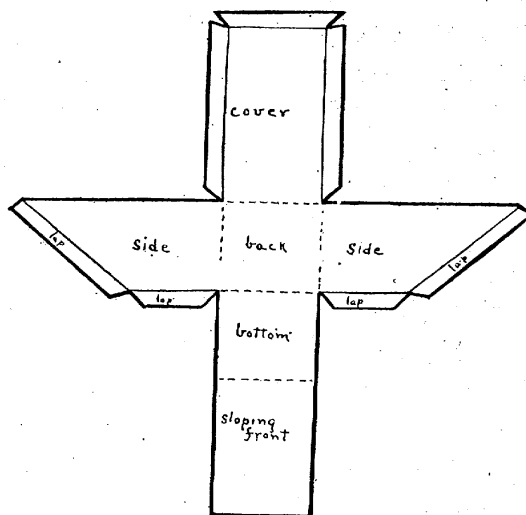


Fig. 2.

Fig. 1. Cage for rearing May flies, showing position in the water.

Fig. 2. Diagram to show construction of cage.

It is best not to insert the cage much more than two inches in the water except where a lowering in the stream is expected. Nymphs confined in this cage will naturally crawl up the sloping side for emergence and the sub-imagoes will find an easy grade on which to walk up to the light. The sub-imagoes will sit on the under side of the cover, but if it be lifted with some care the insects may be safely transferred from the cage to the collecting box.

Many times nymphs are collected for rearing in places not often visited. Such nymphs may be transported alive in jars of their native water with plants or stones to furnish forage and foot-hold. Fragile forms like *Epeorus* and *Heptagenia* may be better carried in a can of cotton or sphagnum thoroughly saturated with water. The nymphs should be carefully placed on the surface with a thin, very wet layer above them. If carried in this way they will arrive at their destination in much more perfect condition than if jostled about in a can of water. If a running water aquarium, or better, a convenient small stream is not available, the nymphs brought home for rearing may be placed in flower-pot saucers in which rapid evaporation will keep the water sweet. Small stones projecting from the water should be provided for emerging places. A cylinder of wire cloth with cheese-cloth top may be slipped over the dish so that the sub-imago may be easily caught.

In large aquaria where several kinds of insects are kept, care should be taken to exclude carnivorous beetles, and dragon-fly and damsel-fly nymphs for which May-flies are choice food. May-fly nymphs are mostly herbivorous and need only a supply of diatom-covered stones for forage and some aquatic plants like *Chara* or *Nitella* upon which they may depend for foot-hold and hiding. Needless to say the temperature of such an aquarium should be kept as nearly as possible to that of the streams. Of the nymphs which I have endeavored to keep in the aquarium of Cornell University, *Blasturus cupidus*, *Callibaetis fluctuans*, and *Siphylurus alternatus* proved most hardy. These lived from one to four weeks in rather adverse conditions, the water in the aquarium having been treated with aluminum sulphate for drinking purposes.

ECOLOGY AND DESCRIPTIONS.

The May-flies found during the past summer in or very near the Creek will be grouped under the three family heads given by Prof. Needham in Bull. 86. Notes and description of new species are given under their respective headings.

EPHEMERINAE.

***Polymitarcys albus* Say.**

Two sub-imagoes were captured near night-fall on June 20.

Potamanthus sp.

Only two partly grown nymphs of this form were found. Both were taken on June 29 in sandy mud washed by a gentle current.

Hexagenia variabilis Eaton.

Full grown nymphs of *Hexagenia variabilis* Eaton the largest of our burrowing May-flies, were found abundantly on the sunny afternoon of May 16 in company with *Ephemera* and the large dragon-fly *Cordulegaster*. At the place where they were Fall Creek is a leisurely brook meandering through sparse woodland and open meadow, and hemmed in by soft muck banks. In one such area the sloping banks were mined by *Hexagenia* nymphs, the open burrows showing only two or three inches apart. Most of the burrows were apparent by their round openings, but from some hairy caudal setae protruded at full length. When a nymph was pulled out it speedily began to burrow again, placing the forelegs together with the blade-like tarsi held vertically. It next pressed them forward and outward at the same time wedging the head between them in the cavity thus made. This movement was followed by a sudden lurch of the body forward accompanied by wriggling of the abdomen. During these motions the second pair of legs was folded close up to the body, while the third pair was held outstretched ready to brace against the mud. These motions rapidly repeated enabled the nymph to bury itself in a surprisingly short time. Some of the soft ooze taken from where the burrows were most numerous was later examined in the laboratory and found to be packed with diatoms. Stomachs of two of the nymphs were found full of silt and diatoms showing that the nymphs had found plentiful forage as they burrowed. Between two and five o'clock of this afternoon about twenty-five sub-imagoes emerged within a few yards distance. They flew up slowly and usually settled on low shrubs. Many were captured on near-by alders two to five feet from the ground where the yellow markings on their bodies and wings made them conspicuous.

***Ephemera simulans* Walker.**

No representatives of this genus were collected previous to June 14 when a female specimen was captured at large near upper Fall Creek. From June 23 to 30 full grown nymphs were found about two inches below the surface in a muddy basin connected with the main stream. Near this place a swarm of *Ephemera* consisting of three to four hundred individuals was dancing about fourteen feet in air at half past seven o'clock in the evening of June 29th. Their steady rising and falling continued over the same area as long as the light kept them visible. One female captured from the swarm was placed on the surface of water in the laboratory. She was unable to fly and lay prone upon the surface. Immediately the last four segments of the abdomen began to move spasmodically and eggs poured forth from the oviducts. At the end of one minute the abdomen was empty, and the glass spread with a single layer of white, firmly adherent eggs, easily distinguished with the naked eye.

No *Ephemera* nymphs were found in the lower Creek up to this time, that cleaner portion being nearly devoid of mud. On the first of July, however, the water in Beebe Lake was allowed to run off, bringing into the Lower Creek large quantities of mud. Three days later the shores below the dam were again examined. Tracks similar to those made by earth-worms covered the bottom near the shore-line. Nymphs were crawling over the surface and setae could be seen projecting from many burrows. From an area of about ten square feet thirty nymphs were removed.

HEPTAGENINAE.

Represented entirely by dwellers in rapid water, this family is the dominant one in number, and the most homogeneous in nymphal form. It is represented here by four of its six North American genera *Heptagenia*, *Epeorus*, *Ecdyurus*, and *Iron*, given in order of their relative abundance. As a family the Heptageninae has taken possession of the rapid, thoroughly oxygenated water and the alga-covered stones of the middle stream, apparently coming into the calmer waters only at transformation time. In order to secure and keep this position against the mechanical force of the water acting upon them

all alike, they have been forced into a series of similar adaptations. The principle feature of these adaptations are: a generally depressed body; dorsally placed eyes and flaring margins to the head; spreading legs with flattened femora and lateral pectinations on the claws; a series of over-lapping gill lamellae, and flat widely diverging caudal setae.

Heptagenia interpunctata Say.

Five species of the genus *Heptagenia* were collected and reared during the summer, but only the very common *H. interpunctata* will be listed until further work can be done upon them. *H. interpunctata* was common from April 30, when I found nearly grown nymphs beneath the flat stones in a tributary of the creek up to August 1, after which little collecting was done. During this time many emergings were observed, the greater number occurring between two and five o'clock in the afternoon.

Ecdyurus maculipennis Walsh.

Associated with *Heptagenia* and *Epeorus*, but with a preference for more gently flowing water, *Ecdyurus maculipennis* is a frequent dweller in the quieter border water of swift currents. My first collections are dated June 3. From this date till July 25 it was a common associate of *Heptagenia* and *Epeorus*, slightly smaller and a swifter runner than either of them. It also bears transportation and change of water with greater hardiness.

Iron fragilis.

The nymph of this species was described by Prof. Needham in 1905. In addition to this description there have been but two records of this genus in North America, *Iron nitidus*,* Oreg. Cal. and *I. longimanus*,† Colorado. The first nymphs of this species collected during the summer were found on May 9, in Coy Glen, the stream from which Prof. Needham's specimens were taken. Here thick growths of *Cladophora* and diatoms support an abundant May-fly population. The nymphs live in the swiftest water, on the under side of the stones, in the falls, or on the smooth rock floor. A census of the inhab-

* *Iron nitidus* Eaton. Rev. Monog. 246, 1885. Oreg. Cal. Banks, Cat. Neur. Insects. Am. Ent. Soc. '07.

† *I. longimanus*, Eaton, Ent. Mo. Mag. XVIII, 26, 1881. Rev. Monog. 245, 1885.

itants of twenty stones measuring about seven by eleven inches revealed the following inhabitants listed in the order of abundance, Simulium, Blepharocera, May-flies (*Epeorus*, *Iron*, *Baetis*), Stone-flies and Parnidae. In competition with such structures as the sucking disks of *Blepharocera* and the limpet like form of the water-penny (*Parnidae*), *Iron* has developed a successful hold fast of its own. The first pair of gill lamellae are very large and scoop shaped with their hinder edges overlapping the succeeding lamellae, and their front edges meeting beneath the posterior portion of the thorax. The lamellae diminish in width posteriorly and the last pair are incurved beneath the abdomen. The edges of the lamellae have a thickened border and when closely pressed to the supporting surface a successful holdfast is formed. This is one of three closely allied genera, *Epeorus*, *Iron*, and *Rhithrogena*, which represent remarkable modifications for life in rushing water. All three possess closely overlapping gill lamellae and but two caudal setae. The main differences are in the shape of the ventral abdominal disk which in *Epeorus* is incomplete, the first and last pairs of lamellae being distant; in *Iron* nearly complete, the first and last pairs of lamellae nearly meeting; in *Rhithrogena* the disk is completed by the perfect apposition of these lamellae.

The mouth-parts (Pl. X, fig. 1) are completely hidden from above by the flaring margin of the head with its bordering fringe of soft hairs. Viewed from beneath the small labrum (Pl. X, fig. 1r) may be seen curving downward and backward over the tips of the mandibles and maxillae (md. a. and mx. a) to meet the median flaps of the broad labium (l. l. e.) The labium is flat and its outer surface (l) fits close down to the surface upon which the insect is foraging. Along the anterior margin of the outer surface of the labial palp is a series of incurving hairs (l. l. a.), behind these a set of overlapping plates, and still farther backward a single strongly chitinized scraper, (l. c.) On the inner surface of the palp is a semi-circular patch of inwardly directed hairs (l. b.) Closely apposed to the inner surface of the labium is the outer surface of the hypopharynx (fig. 1 hy), made up of two lateral, and one median portion, distinct, except at their bases. The separation of the two lateral portions from the median portion leaves a gutter-like trough between them on the inner side. The labial palpi are freely movable horizontally. They are moved outward, then

pressed slightly downward and inward when feeding. Sometimes the labial palp is slipped between the median (fig. 1, l. e.) and the lateral flaps (fig. 1, l. d.), sometimes over the inner sides of both. In the first case the plates on the outer sides of the palp are brushed by the hairs on the inner side of the median flap while the semi-circular patch of hairs (l. b.) on the inner side of the palp is brushed by those on the outer side of the lateral flap. In the second and more frequent case the outer side of the palp is brushed by both flaps and the semi-circular patch of hairs fits into the chitinized gutter on the adjacent surface of the hypopharynx (hy. a.) Directly above the median portion of the hypopharynx are the grinding surfaces of the maxillae (mx. b.) with those of the mandibles (md. b.) directly above them. Food scraped inward by the labial palps is evidently deposited beneath the hypopharynx. From here it is probably sucked up into the mouth cavity through the slits between the median and lateral folds. The maxillary palps act in a manner similar to those of the labium, but because of their position above the hypopharynx, they must be able to place the food directly in the mouth cavity. The inwardly curving hairs on the lateral borders of the labrum help to keep the food in the mouth while it is being chewed up.

The foregoing observations were made by placing a nymph in a shallow dish of water, throwing a strong light upon it and studying it with a binocular microscope. The nymph was uneasy in this unnatural position and kept its mouth parts continually moving. Nymphs may be studied under more natural conditions if they are placed in a glass-bottomed box with a small amount of forage. The box may be placed upon some support which will elevate it above the table. The bottom may then be tilted at any easy angle and the nymphs studied with a hand lens from beneath.

Occurrence, habitat. The dates on which nymphs or imagoes were collected range from May 1 to June 15. These nymphs were all taken in cool, shaded waters and were most abundant during the early part of the season. The data for those reared in cages is as follows:

- 1 male emerged May 11, a. m., transformed May 13, a. m. Coy Glen.
- 1 male emerged May 12, a. m., transformed May 14, a. m., Pleasant Brook.
- 3 females emerged May 30, p. m., transformed June 1, p. m. Pleasant Brook.
- 1 female, 1 male emerged June 10, a. m., transformed June 12, M. Fall Creek.

Between the hours of two and four of June 15 about twenty emergings were witnessed from one view-point in a narrow swift portion of Coy Glen Brook. The nymphs popped from the surface of the water and flew unsteadily upward in the sunlight for about 20 or 30 feet when they veered into the tree tops or settled on the side of the gorge.

Iron fragilis sp. nov.

Measurements.

| | Length of body | Length of setae | Length of Wing |
|-----------------|----------------|-----------------|----------------|
| Male imago | 7 m. m. | 21 m. m. | 7 m. m. |
| Male subimago | 6.5 m. m. | 14 m. m. | |
| Female imago | 7 m. m. | 15 m. m. | |
| Female subimago | 6.05 m. m. | 14 m. m. | |

Male imago. (Plate X, figs. 2, 3 and 4). (In alcohol). Body extremely delicate and fragile. General hue dull yellowish white, appearing hyaline in segments 2-7 of the abdomen. Eyes, conspicuous, grayish. Head, parchment color with the eyes gray, darker below; antennae, light brown except for white basal segment; ocelli, ringed with conspicuous, broad band of dark brown. Thorax, yellowish shading brownish above, pale below. Pronotum deeply notched behind. The lateral lobes of the pronotum and the median portion of the mesothorax shaded brown. A sub-triangular area of brown on either side of the median posterior elevations of mesothorax and metathorax. Legs, dull yellowish, the femora with a conspicuous dark brown spot at the middle. Tarsi with joinings and claws brown. Forelegs (Pl. X, fig. 3) longer than the body, its tarsal claws identical with those of the other two. Wings, (Pl. X, fig. 2) hyaline, sub-hyaline near the tip in costal and sub-costal regions. Abdomen. Tergites 1-9 with their posterior borders delicately shaded by transverse bands of brown growing more distinct posteriorly. Sternites, pale. Forceps pale, broad at the base and conspicuous (Pl. X, fig. 4). Setae 2, pale slightly brownish at the base.

Male sub-imago. The sub-imago differs most markedly from the imago in the following respects. The forelegs and setae are shorter, the forceps less conspicuous, and the wings are of the usual grayish sub-hyaline appearance. Head with occiput brownish. Bands of ocelli less prominent than in the imago. Thorax, brown, prominent ridges of mesothorax and metathorax shaded with brown, but without definite sub-triangular markings. Pleurae and sternum with ridges shaded brown. Coxae suffused with brown. Abdomen with tergites 1-10 suffused with brown, the transverse band of brown more distinct than in the imago. An irregularly shaped patch of white in the center of each segment near the pleura. The posterior lateral angles of the tergites whitish.

Female imago. Body heavier than that of the male, all over dull yellowish color; legs of nearly equal length; setae 2. Head with eyes

distant and dark grayish, a whitish area of the head showing between them. Thorax, with the pronotum distinctly lined with brown. Sub-triangular areas on mesothorax and metathorax present but less distinct than in the male. Abdomen with tergites shaded with brownish, a distinct transverse band of brown near the posterior border. Sternite 7 produced backward in a rounded lobe whose posterior edge touches that of sternite 8. Sternite 9 produced backward in a lobe with a shallow median indentation on its posterior margin.

Female sub-imago. General color much darker than the male imago. Thorax shaded all over with brown. Sternite 7 produced backward only half the length of sternite 8. The prolongation of sternite 9 much less pronounced and its posterior margin barely indented.

Epeorus humeralis.

(Pl. IX, fig. 1, 2, 7.) The genus *Epeorus* is represented in Fall Creek by this single species. It is closely allied to *Iron* but differs from it in the greater distance between the lamellae of the first and last pairs of gills. These nymphs are much larger than those of *Iron fragilis*, but are harder to transport because of the extreme brittleness of the bases of the lamellae.

Occurrence, habitat. Full grown nymphs and imagoes were taken at various dates from May 25 to July 15. This species is very common in the swift waters associated with *Heptagenia* and *Baetis*.

Epeorus humeralis sp. nov.

Measurements.

| | Length of body | Length of setae | Antennae |
|-----------------|----------------|-----------------|-----------|
| Male imago | 10 m. m. | 20.5 m. m. | |
| Male subimago | 9 " | 12.5 " | |
| Female imago | 9.5 " | 13 " | |
| Female subimago | 10 " | 11.5 " | |
| Nymph | 11 " | 11 " | 2.5 m. m. |

Male imago. (Pl. IX, fig. 2, 7). (Live specimen). General color dull yellowish, becoming sub-hyaline on segments 2-5 of the abdomen. Conspicuous dark brown spots at middle of femora in all winged stages, larger than those in *Iron fragilis*; the body less fragile than that of the preceding species; the humeral cross vein blackish; the foreleg about three quarters the length of the body. Head, yellowish white; eyes conspicuous olive green, intersected in the lower portion by a brown band, ventral edge margined by a narrow black band border behind, this in turn by a white band of the same proportions; antennae brown, a brown ridge extending from their basal segments to the inner margins of the eyes; carina on middle of front brown; ocelli ringed with olive. Thorax, above yellowish white, translucent; pronotum partially hidden by the eyes, its lateral lobes shaded with dark brown; mesonotum buffy with edges brown and elevations lighter; scutellum fuscous.

Below, pale whitish yellow, mesonotum margined at the apex with a transverse band of brown. Pleurae and coxal areas pale with irregular shadings of dark brown. Legs whitish; coxae with dark brown spot; femora with conspicuous brown spot and a brownish band just before the apex; more distinct on the anterior legs; tarsi with flap and claw similar to that of *Iron fragilis* (Pl. X, fig. 3) and identical in all three legs. Wings hyaline with the humeral cross vein blackish brown (in all adult stages). Abdomen, pale whitish, translucent on segments 2-5. Tergites with distinct transverse brown pencilings on their posterior borders and a median broken line of brown more distinct on the posterior portions of the tergites. Sternites pale without markings. Forceps pale, (Pl. IX, fig. 2). Setae whitish.

Female sub-imago. General color of the body slightly darker than that of the imago. Abdomen darker, less translucent. Wings grayish, sub-hyaline. Thorax with markings less sharply defined and general color darker than that of the imago. Abdomen with the tergites suffused with brownish.

Female imago. (Live specimen). Forelegs shorter than those of the male. In specimens containing eggs the abdomen is a bright salmon pink, which does not fade readily in alcohol. Head, with eyes similar to those of the male, but smaller and distant being separated by a broad unmarked portion of the occiput. The dark bands of the ocelli are incomplete and a trifle narrower than those of the male. Thorax, with the pronotum exposed showing the prominent median indentation of its posterior margin; an area on either side the median line with a longitudinal blotch of brown. Abdomen with the tergites slightly darker brown than in the male. Sternite 7 prolonged two thirds the length of sternite 8. Sternite 9 slightly shorter and but shallowly notched on its posterior border.

Nymph. (Pl. IX, fig. 1). Body depressed, widest across the mesothorax gradually tapering to the last abdominal segment. Nymph larger and broader than *Iron fragilis* with its lamellae flaring; the lamellae of the first and last pairs of gills distant from one another and the tracheation of the lamellae conspicuous. Posterior lateral angles of the abdominal segments produced into backwardly directed spines which guard the bases of the lamellae (Pl. IX, fig. 1). Color, olive-greenish blotched and shaded with brown, pale below. Head with eyes and ocelli prominent, the latter with dark lunate bands on their inner margins. Antennae slender and bare. Lateral margins of the prothorax rounded anteriorly, and flaring. Legs flattened with a row of rather long soft hairs on the posterior margins of the femora and tibiae. General shape conical, rounded above, slightly flattened below. Gill lamellae obliquely reclinate with fasciculate filaments on the dorsal side of their bases. Setae 2, about as long as the body.

BAETINAE.

This heterogenous group was represented in the summer's collecting by *Blasturus cupidus*, *Leptophlebia praepedita*, *Leptophlebia mollis*, *Choroterpes basilis*, *Callibaetis fluctuans*,

Ephemerella excrucians, *Caenis hilaris*, *Siphylurus alternatus*, *Chironetes albomanicatus*, *Ameletus ludens*, *Tricorythus allectus*, *Ephemerella rotunda*, sp. nov., *E. tuberculata*, sp. nov., *E. cornuta*, sp. nov., *E. deficiens*, sp. nov., *E. plumosa*, sp. nov., and *E. spinosa*, sp. nov. All of these were taken in Fall Creek except the before mentioned *E. cornuta*. The descriptions of these species of *Ephemerella* is here given together with that of the female imago which has been added to Prof. Needham's life-history of *Ameletus ludens*. *Tricorythus allectus*, which was placed in that genus by Prof. Cockerell has been established there by several rearings.

***Blasturus cupidus* Say.**

From April 20 to May 1 this species was the dominant May-fly of the quiet pools. On April 30 observations were made in a sheltered pool, tributary to Fall Creek. This pool was about fourteen feet long by five feet wide, carpeted with decaying leaves, and bordered on one side by a thick mat of *spirogyra*. Between 11:30 and 12:30 o'clock in the bright sunlight, about forty nymphs emerged and the sub-imagoes were captured. A few records of individual emergings were taken of which the following is typical. A nymph appeared from beneath some leaves, came close to the surface of the water and swam about there till a stick was found which projected out of it. It immediately clambered up the stick, thrust its head out into the air and rested there with its gills motionless, but apparently swallowed large gulps of air. Very soon a median split appeared in the mesothorax, widened toward the prothorax and then to the metathorax. The head and eyes of the sub-imago appeared, the mesothorax, then the metathorax, and finally by a sustained pull, terminating in a jerk, the wings were extricated from the wing pads and erected. Apparently exhausted by this effort the insect then paused with the posterior portion of the abdomen and the setae still lying loosely in the cast skin. By another jerk the body was wholly freed from the skin. The insect rested an instant upon the water's surface with its setae held widely divergent and upward, in their natural alert position. Immediately after this it fluttered upward and settled on a low shrub. The entire time from the appearance of the nymph to the completion of its emerging was ten minutes. Of this period, one minute was occupied in swimming, one in taking in air, and three minutes occurred between the appearance of

the median slit in the nymphal skin and the complete freeing of the sub-imago. After its first short flight the insect remained on the shrub for about five minutes before disappearing higher up in the air. This custom of resting upon near-by objects is a habit varying with the species and apparently also with weather conditions. For example, sub-imagos of *Chirotonetes albo-manicatus* which usually fly upward immediately on emerging in clear weather walk about for a while on the shore, or take very short first flights on dark days. The period of greatest effort during emergence is that which precedes the splitting of the nymphal skin. The splitting is doubtless urged on by the distention of the alimentary canal which is caused by the air or water which has been swallowed.

Mating flights of *Blasturus cupidus* were observed over Fall Creek in the late afternoon of April 31, the height of their transformation season. About thirty individuals flying in close ranks rose and fell at varying altitudes of ten to thirty feet. When at their greatest height they were scarcely distinguishable against the sky, but when they were lowest the forelegs and the setae might be discerned. The forelegs were held stiffly, straight forward from the head, and the setae, projected at a wide angle behind, appearing to vibrate as the insects swung downward. After a few moments of ecstatic rising and falling, one of the individuals flying high in the swarm descended to one of the lowest, coupled with it and veered obliquely downward and across the stream. When about to alight on the opposite shore the two separated, one disappeared and the other turned back and flew close to the surface of the stream frequently brushing the water with the abdomen. Such matings were three times observed. Attempts to capture a fertilized female failed. The eggs brushed from the abdomen into the rapidly running water were, of course, impossible to find.

Leptophlebia.

Occurrence, habitat. Nymphs of this genus were found in a greater variety of situations than any other group. While it is for the most part a genus which belongs to the small rills it also takes advantage of the secluded places in the larger streams. Two species were common in this locality. These were *Leptophlebia mollis*, common after May 20, and *L. prae-pedita*, collected frequently after May 29.

Leptophlebia praepedita Etn.

This species has already been noted by Prof. Needham (Bull. 86, N. Y., State Mus.) This species is diurnal. Companies of them were seen dancing in bright sunlight on the afternoon of May 29, June 3, 20 and 21. A mating flight on May 29 occurred about five o'clock just above a dashing water-fall of Fall Creek. As the swarm rose and fell at alternate heights of ten to fifteen feet their silvery wings and bodies shone in the sunshine like falling snow-flakes. After half an hour of continuous flying and soaring the swarm gradually disappeared. Of the specimens captured all were males. Earlier in the afternoon a similar but smaller swarm was seen flying above a small tributary rill. This swarm did not at any time fly higher than six feet above the water. Practically the whole swarm was captured at one sweep of a large net. Of the captured insects forty were males and one was a female.

Choroterpes basalis Banks.

This species is plentifully represented in the Creek. The nymph is described in Bull. 86 of the N. Y. State Museum. Little attention was given to this species beyond the collection of nymphs which were constantly associated with *Heptagenia*.

Ephemerella.

This genus is nearly as diversified in habit as *Leptophlebia*. The nymphs have been found in pipe drains, in the gravel and trash of still pools, beneath leaves in springs, in the border waters of the creek and in its swiftest ripples. Like *Leptophlebia* they have been found in rather small numbers and widely scattered. My dates for rearings and captures range from the second week in May to the last of July. Better results would have been obtained if attention had been paid to this group earlier in the season for some species were very rarely found by May 10th.

Ephemerella serrata sp. nov.

Occurrence, habitat. The small nymph of this species was found occasionally in restricted areas of the upper Creek where it crawled about on stones, or in the trash, which was washed by running water. It was found in similar situations at Sheffield, Mass. My reared specimens of this species are dated

June 3rd. Collections of the nymphs were made June 12, 14, and July 1. By July the nymphs were becoming scarce. several cast skins were found on the dry stones of the shore, after the last date, but no nymphs were seen.

Measurements.

| | Length of body | Length of setae |
|--------------|----------------|-----------------|
| Male | 5 m. m. | 6 m. m. |
| Female imago | 4.5 m. m. | |
| Nymph | 5 m. m. | 1.2 m. m. |

Male imago. General color brown, paler on the legs and below. Head, above, eyes very prominent, upper division reddish brown, lower one darker. Front of head light, antennae light brownish; ocelli white, the lateral ones with an inner lunate band of brown, the median one with a complete ring of brown. Thorax, above yellowish shaded with brown; mesonotum with its posterior margin edged with brown. Ridges of the pleurae shaded with brown. Sternae pale with sub-quadrangular areas of brown before the middle legs and a median shield of brown behind them. Legs pale with a transverse band of brown at the distal end of the femora; first tarsus of the foreleg but slightly longer than the second; the third twice as long as the fourth. Wings hyaline, brownish at the base. Abdomen, brownish above, pale below. Setae 3, pale, the joinings of the basal segments ringed with brown.

Female imago. Eyes small and distant showing the light colored occiput between. Body more robust and abdomen slightly darker than that of the male. Foreleg twice as long as that of the male.

Nymph. Small with head and thorax rounded and the setae curving forward over the abdomen. General color a muddy yellow with darker markings on the dorsal side, pale below. This species is easily distinguished from *Ephemerella deficiens* by its double median row of spines on tergites 4-7 and by its generally lighter color. Head smooth, (Pl. VI, fig. 5); antennae light brownish, first and second basal segments edged with brown. Thorax, prothorax with a tubercle like elevation on either side the median line. Legs (Pl. VII, fig. 2) with the femora rather stout and their hinder margins bordered with a row of stout hairs sparsely distributed. Claws serrate (Pl. VII, fig. 2) with a chitinous ridged plate on the underside of the tarsus (Pl. VII, fig. 2). Abdomen, above, segments 5-6 pale marked with brown pencilings, other segments brown with darker edges. A double row of irregularly triply dentate spines extending over segments 4, 5, 6 and 7. The lateral margins of segments 4-9 spinose with their posterior lateral angles becoming more acuminate posteriorly. Gills present on segments 3-7; Elytroid lamella absent; the superior lamella simple; the inferior fimbriate lamelliform. Abdomen, beneath, pale with a median row of distinct linear brown spots on sternites 1-9. Setae, 3, sparsely beset with coarse hairs; color, pale with a transverse band of brown across the center.

Ephemerella deficiens, sp. nov.

Occurrence, habitat. Of similar habitat and closely associated with *Ephemerella serrata* in rapid waters, this species is the more common of the two and was collected frequently during the first half of May. It closely resembles *E. serrata* in shape and size, but the whole body is blackish while the gill lamellae, the legs, and the setae are nearly white.

Measurements.

| | Length of body | Length of setae |
|------------|----------------|-----------------|
| Male imago | 5 m. m. | Setae lost |
| Nymph | 5.2 m. m. | 2.5 m. m. |

Male imago. General color blackish, thorax blackish brown. Head, eyes prominent, upper division reddish brown, lower division blackish brown (living specimen); ocelli white; antennae, carina and rings of ocelli brown. Thorax, above, pronotum brown; the mesothorax and metathorax blackish brown with blackish edges; pleurae brown with edges blackish; sternum brown with a broad transverse band of yellow behind the first pair of legs. Legs nearly white; coxae and an indefinite band at distal end of the femur brown. Wings hyaline shaded with brown at the base. Abdominal segments shaded with brown giving the effect of annular bands dark on the dorsum, paler beneath. Setae 3, pale at the base. (Only the bases of the setae remained when the specimen was taken from the cage). Forceps and penes are figured in Pl. IV, fig. 4.

Nymph (Pl. VI, fig. 4, Pl. VII, fig. 4, Pl. VIII, fig. 4). Color blackish brown, femora brown, gills, tibiae and tarsi whitish. Body broadest at the metathorax, the thorax arched, the abdomen slightly depressed and curving upward at the posterior end. Setae held upright or curved over the abdomen. Head, bluntly wedged shaped; ocelli inconspicuous whitish; antennae pale with a band of brown just above the basal segment. The maxillae with their palpi totally absent (Pl. VIII, fig. 4). Thorax, above blackish brown, the prothorax bordered laterally by a pale longitudinal band with a brown spot at its center; the prothorax and mesothorax with a longitudinal stripe of pale yellowish on either side the median line. Legs (Pl. VII, fig. 4) with the coxae and femora brown, the under side of the latter with a distinct hook shaped area of whitish. Tibia and tarsi pale whitish, the first two pairs of tibiae with a broad middle and a narrow proximal band of brown; the tarsi of all the legs with a middle band of brown and with the claws similar (Pl. VII, fig. 4). Abdomen above dark blackish brown. The posterior lateral angles of segments 9-10 pale whitish; the lateral margins of segments 1-9 spinose serrate with their posterior lateral angles produced into flat spines which become more acuminate posteriorly; segment 10 without spines and with its posterior margin truncated. Gills present on segments 3-7; Elytroid cover absent; gill lamellae whitish shaded with brown at the base, superior lamina entire, the inferior one bifid.

Abdomen, beneath, brown without markings. Setae 3, with a circlet of spines at their joinings. A broad band of brown across the two outer ones.

***Ephemerella lata*, sp. nov.**

Occurrence, habitat. This species was first taken in Sandy River, Me., a stream similar to Fall Creek, where it was very common. Attempts to rear these nymphs were unsuccessful in both Sandy River and Fall Creek therefore a description of the nymph only can be here included. It occurs in the most rapid water of the stream crawling on the stones much like *Heptagenia*. My dates for its capture in Fall Creek are June 20 and 24. It is apparently a rare species in the stream.

Measurement.—Nymph. Length of body 7.2 m. m. Length of setae 3.5 m. m.

Nymph (Pl. VI, fig. 6; Pl. VII, fig. 1). General color brown with the prothorax and the eighth tergite conspicuously white. The fore femora very stout (Pl. VI, fig. 6) and edged with stout spines. Body arched above. The ventral side of the body and the legs flattened and modified for clinging to smooth surfaces. Head, sub-quadrangular with the broad truncate ledge projecting forward above the rounded heavily fringed frontal border (Pl. VI, fig. 6). Antennae with a conspicuous triangular ledge projecting above their bases. (Mouth-parts are figured on Pl. VIII, fig. 1). Thorax, prothorax two-thirds as long as the thorax, conspicuously whitish but with the posterior portion shaded brownish, the degree varying in different ages and individuals; mesothorax without markings; metathorax concealed from above. Sternum flattened, brown with pale suture lines. Legs (Pl. VII, fig. 1) with the femora pale marked by a pale transverse band; tibiae brown with two pale transverse bands. Abdomen, rounded above, flattened below. Gills on segments 3-8. Elytroid cover absent. Segments 4-9 with their posterior lateral angles produced backward into flat spines; segments 5-8 with their lateral margins spinose serrate; segments 4-7 with a double median row of small tubercles which arise near the posterior border. Sternite 9 produced backward into a median rounded lobe and two lateral flat spines. Setae 3, light brownish ringed at their basal joinings with darker brown.

***Ephemerella tuberculata*, sp. nov.**

Occurrence, habitat. But a single specimen of this species has been taken. This was a nymph captured on June 22 in the gently flowing border water of the upper Creek.

Nymph, measurements. Length of body, 10.5 m. m.; length of setae, 4.5 m. m.

Body stout arched above, flattened below. Color above dark, below pale, with a median double row of distinct brown spots. Fore-femora very wide (Pl. VII, fig. 5). The head (Pl. VI, fig. 2) with two

large erect tubercles on the occiput. Head, sub-quadrangular slightly flattened with the head projecting forward; a triangular ridge with the median ocellus at its apex projecting above the slightly indented fringed frontal margin. (Pl. VI, fig. 2). Left maxilla figured on Pl. VIII, fig. 3. Thorax, more than half the length of the trunk; color dark above, all except the prothorax pale below; prothorax, above slightly arched and flaring at its postero-lateral angles, a tubercle at the middle of the lateral margin and a smaller one on either side the middle of the posterior margin; mesothorax with one median tubercle. Legs, with femora unevenly brown above, pale below; tibiae brown with a pale transverse band through the middle; tarsi brown with a pale transverse band at the proximal end. Fore-femur (Pl. VII, fig. 5) shorter and thicker than the others and with its anterior margin unevenly toothed. Anterior edges of the other femora entire. Upper surfaces of all the femora with wart-like elevations; posterior edge of the first femur and anterior and posterior edge of the other femora with a row of sparse hairs. Abdomen with gills present on segments 3-8, without Elytroid cover, superior lamina entire; inferior lamina bifid fimbriate. Segments 2-7 with a median double row of spines; posterior margins of segments 1-7 and 9-10 edged with short hairs; posterior margin of segment 8 with numerous longer hairs. The posterior lateral angles of segments 3-10 produced backward into flat-pointed spines. Setae 3, with numerous hairs on their outer and inner margins.

***Ephemerella rotunda*, sp. nov.**

(Pl. VI, fig. 1; Pl. VII, fig. 3; Pl. VIII, fig. 5; Pl. IX, fig. 6.)

Occurrence, habitat. This species was taken in portion of Pleasant Brook, where there was little water and that strongly tainted by pipe drains. But four nymphs were captured. The two which were successfully reared proved to be females. The dates for their rearing were June 8 and 10.

Measurements

| | Length of body | Length of setae |
|-----------------|----------------|-----------------|
| Female imago | 10.5 m. m. | 14 m. m. |
| Female subimago | 10 m. m. | 10 m. m. |
| Nymph | 10.2 m. m. | 6 m. m. |

Female imago. Thorax luteus; legs luteus or whitish; abdomen brown; setae luteus with very distinct brown joinings. Head parchment color. Thorax, above, luteus slightly darker on the mesothorax; pleurae luteus to whitish with brown edges. Axillary cords (Snodgrass, '09, *The Thorax of Insects and the Articulations of the Wings*, p. 553) of the fore-wing prolonged into slender acute spines which project backward on either side of the hinder lobe of the mesothorax. Axillary cords of the hind wings prolonged in similar but less prominent spines. Wings hyaline, costal region sub-hyaline (Pl. IV, fig. 6); abdomen brown, pale at joinings and beneath. Color evidently mostly due to contained ova. Sternite one longer than those following; ster-

nite 7 with its posterior portion overlapping sternite 8 and with its posterior margin bilobed. Setae 3, nearly equal length, pilose; color pale luteus with distinct brown rings at the joinings.

Female subimago. Wings sub-hyaline and veins brown. Segment 7 not bilobed as in the imago.

Nymph (Pl. VI, fig. 1; Pl. VII, fig. 3; Pl. VIII, fig. 5). Head and body rounded and smooth, and without tubercles. Legs small in comparison with the size of the body. Head, rounded and without elevations (Pl. VI, fig. 1). The left maxilla is shown on Pl. III, fig. 5. Thorax, above smooth. Color, mottled brownish without definite markings. Prothorax wider than the head its lateral margins slightly flaring, and its width equal to that of the mesothorax; metathorax concealed from above. Legs weak, the femora poorly developed and with a row of hairs on its posterior margin (Pl. VII, fig. 3). Abdomen, above rounded, gills present on segments 3-7, the posterior margins of segments 4-9 with a double median row of small spinose elevations; segments 3-9 with their posterior lateral angles produced into flat spines whose margins are spinose serrate. Setae brownish indefinitely banded with whitish; basal joinings with circlets of hairs.

***Ephemerella cornuta*, sp. nov.**

Occurrence, habitat. This, before mentioned species, was reared at Salisbury, Connecticut. The dates given by Miss Smith for its capture and rearing are July 20, 21. But two stages, those of the male sub-imago and the nymph are represented.

Measurements.

| | Length of body | Length of setae. |
|---------------|----------------|------------------|
| Male subimágo | 10.5 m. n. | |
| Nymph | 10 m. m. | 6. m. m. |

Male subimago, general color pale luteus with annular bands of brown on the abdomen. Eyes prominent. Head with ocelli white, encircled with broad bands of blackish brown; carina, frons and occiput pale; antennae light brown. Thorax, above pale luteus; the prothorax irregularly streaked with brown. Axillary cords of the fore-wing produced into a slender point extending backward on either side the median lobe of the metathorax, such prolongations not evident in the hinder wing. Legs, pale, the fore femora lightly shaded with brown. Wings, sub-hyaline, brownish at the base (Pl. IX, fig. 5). Abdomen pale whitish, with annular bands of brown shading. Setae 3, whitish.

Nymph. Body slender, and tapering from the mesothorax. Fore femora shorter and wider than the others and with its anterior margin unevenly toothed (Pl. VII, fig. 6). Head, with prominent incurving horns just below the antennae; general shape sub-quadrangular with the posterior angles rounded, and the frontal margin fringed with hairs and projected forward; origin of the antennae partly hidden by the curving ledges at the bases of the horns (Pl. VI, fig. 3). (Left maxilla

shown on Pl. VIII, fig. 6.) Thorax, mottled brownish; prothorax quadrangular, its angles closely fitting to the mesothorax. Legs with the margins of the second and third femora entire; the first femur figured on Pl. VII, fig. 6. Abdomen, rounded above, flattened below; without dorsal spines or tubercles. Gills on segments 3-7; posterolateral angles of segments 3-9 produced into flattened spines becoming more acuminate posteriorly; posterior margins of segments 2-10 sparsely edged with hairs; lateral margins of segments 3-9 spinose serrate. Setae, pale, except for a single brown ring at the base of each.

Tricorythus allectus Needham.

This species was described by Prof. Needham in Bull. 86, N. Y. State Mus. as *Caenis allecta*, but afterward referred by him to the genus *Tricorythus*, in Bull. 124 N. Y. State Mus.

Occurrence, habitat. These nymphs are closely associated with *Caenis*, though they have not thus far been often found in the ill smelling mud generally preferred by that nymph. They clamber about in fine silt and sand, and the particles which adhere to their hairy bodies make them practically invisible. A handful of mud which appears to contain no sign of life, will after a few minutes draining, reveal slowly moving bits of mud which may prove to be either *Caenis* or *Tricorythus* according to the quality of the mud. *Tricorythus allectus* is one of the commonest species in Fall Creek. During June and July, the imagoes may be found strewn upon the surface of little protected inlets along its shores, or caught in the meshes of the spiderwebs on walls and bridges near it.

Measurement. Length of body 6.5 m. m. Length of setae 4 m. m. Mouth—parts and gill lamella (Pl. XI.) The nymphs of *Tricorythus* may be at once distinguished from those of *Caenis* by the shape of the elyroid gill cover, rounded at the end in *Caenis*, distinctly triangular in *Tricorythus* (Pl. XI, fig. 1). Color yellowish, pale below; abdomen marked with transverse bands of brown broken by a median longitudinal pale stripe. Elyroid lamella prominent, purplish brown at the base. Body all over sparsely beset with hairs. Antennae pale with basal segments brown. Legs pale with a blackish spot at the proximal joint of each tibia. Gills not wholly hidden by elyroid lamellae. Lateral spines on segments 2-9. Setae 3.

Caenis.

This genus is plentifully represented by *Caenis hilaris*, Say, and by nymphs of some other species not yet reared here.

Chironetes albomanicatus Needham.

Occurrence, habitat. Nymphs of this abundant species were found full grown in the dashing waters of the falls and riffles from the latter part of May to August 12th. In May they were seen to emerge in greatest numbers during the late afternoon and twilight. They crawled up on the shore leaving their cast skins clinging to the stones or less often they flew up directly from the mid current. The dark wings and body and the white forelegs of the sub-imago made it very conspicuous as it rested upon the gray stones or flew upward. Robins made a regular custom of coming to the shores and collecting the insects as they emerged. From four to six nymphs might be often seen projecting from their beaks.

Siphylurus alternatus Say.

This elegant species has been found to be very desirable for the indoor aquarium. It lives in still pools and demands only a minimum supply of fresh water and plenty of plant food. It was common all through April, May, and a portion of June. Nymphs kept in the laboratory aquarium nearly all lived to emerge and doubtless could have been kept there several months had they been taken early enough.

Baetis pygmea Hagen.

This species has been found chiefly interesting for its habits of egg-laying. From early June to late August the stones in the waters of the creek were covered with small elongate egg-patches rounded at one end, narrower and sharply squared off at the other. Plate XII, fig. 1 shows a stone about seven by ten inches in size on which the egg masses were scattered with average abundance. The surface upon which the eggs rested was the down-stream side of the stone and that portion where they were thickest was nearest to the surface of the water. On the same plate (fig. 2) is shown a photograph in which the patches are enlarged sufficiently to show the individual eggs. The laying of the eggs may be seen if one closely watches some stone which is marked as a favorite site by the presence of many masses. The following observation was made through an ordinary reading glass, but the processes may be easily seen with the naked eye.

Flying close to the surface of the water, the insect alighted on a stone projecting slightly from the water and well protected from the force of the current on its downstream side. She

immediately walked to the protected side and downward to the water. First, wrapping her wings about the abdomen, she made several attempts to immerse her head and thorax. This appears to be the critical stage of the performance, for many females are washed from the stone while attempting it. Once beneath the surface she started on a tour of inspection for the proper surface. This tour lasted for several minutes during which time she continually walked to and fro, pausing, feeling with the abdomen, and passing on unsatisfied. When a suitable place was finally found she braced her legs firmly, bent the abdomen downward, curved the setae upward and pressed the openings of the oviducts closely to the surface. The whole abdomen was then swung from side to side with a slow pendulum-like motion, each stroke leaving an irregular row of minute white eggs adhering to the surface. The strokes were at first somewhat circular and longer than those which followed. As the egg mass grew in length the insect moved forward a little to allow the eggs to lie in succeeding rows. When the egg supply was exhausted she stopped with a jerk of the abdomen and proceeded to clamber out of the water. When examined in the laboratory the abdomen of this female was found to contain only a few undeveloped eggs in the ovaries and none in the oviducts.

***Ameletus ludens* Needham.**

Occurrence, habitat. In Pleasant Brook on April 25 nymphs of *Ameletus ludens*, were found in great abundance resting upon the bottom or darting about much like the nymphs of *Callibaetis*. They were the dominant insect of the stream at this time. One soft bottomed pool about four feet long, and two wide yielded about 300 nymphs in half an hour's collecting, and many more remained. Full grown nymphs were placed in cages for purposes of rearing. The female subimago was found to correspond with Prof. Needham's description given in Bull. 86 of the N. Y. State Mus. Attempts were then made to secure a male to add to the life-history since Prof. Needham was unable to procure one. The results of the rearing were as follows:

| | | | |
|-----------|------------------------------|-----------|----------|
| April 29, | 1 nymph emerged, transformed | April 30. | Female. |
| April 30, | 1 nymph | " | May 1. |
| May 7, | 1 nymph | " | May 8. |
| May 8, | 3 emerged nymphs, | " | April 9. |

Repeated rearings failed to secure a male specimen. An enclosure was then made in a neighboring rill by means of boards

and fine meshed wire-cloth. Over this, a cheese-cloth tent was erected, and in it a large number of nymphs were placed. The records of the results obtained are as follows:

| | | | | |
|--|---|---|---------------|------------------------|
| May 8, 12 nymphs emerged before 12 M., transformed before May 9, 12 M. All Females. | | | | |
| May 10, 40 All Females. | “ | “ | before 12 M., | “ before 12 M., May 9. |
| May 12, 25 All Females. | “ | “ | before 12 M., | “ May 13, before 12 M. |

That these nymphs emerged so regularly before noon was doubtless due to the fact that the sunshine reached the tent only at this time and in the late afternoon. Rearings were made as long as the season lasted but neither among the reared specimens nor among the nymphs collected could a male be found. A few specimens of the same species were also collected in two other streams near Ithaca, but no males were found. The fact that no male specimens have been taken neither in collecting, or rearing, indicates a case of parthenogenesis in this species.

Female imago. Measurements. Length of body 10 m. m. Length of setae 10 m. m. Color bright reddish brown with whitish areas on the thoracic pleurae. Abdomen reddish brown slightly paler beneath with the ventral ganglia marked by darker areas. Antennae brown, paler at the base, the second segment very long. Thorax brown; legs brown, the third pair slightly paler than the others; wings hyaline with their bases shaded with brown and the veins very distinct. Setae brown with their joinings distinctly lined with brown.

SUMMARY.

1. The physical features of Fall Creek make possible the greatest variety of aquatic conditions. A study of the abundant May-fly fauna which lives under these conditions has revealed a series of striking adaptations to environment.

2. One may best observe the nymphs and secure adults of uncommon species by rearing the insects in their own surroundings. For this purpose a new type of breeding cage has been described and figured.

3. Observations upon representatives of 17 different genera have shown some interesting points in structure and ecology. Among these have been described the structural adaptations of various nymphs, the striking peculiarities of *Ephemerella* nymphs, the emerging of *Blasturus cupidus*, the swarming of *Ephemera* and *Leptophlebia*, and the egg-laying of *Baetis*.

4. No male specimen of *Ameletus* was secured either by collection or among 83 reared specimens. I have, therefore, suggested that this species may present a case of parthenogenesis.

EXPLANATION OF PLATES. (All figures much enlarged.)

PLATE VI.

Heads of *Ephemerella* nymphs.

| | | | |
|---------|--------------------|--------------------|----------|
| Fig. 1. | <i>Ephemerella</i> | <i>rotunda</i> | sp. nov. |
| " 2. | " | <i>tuberculata</i> | " |
| " 3. | " | <i>cornuta</i> | " |
| " 4. | " | <i>deficiens</i> | " |
| " 5. | " | <i>serrata</i> | " |
| " 6. | " | <i>lata</i> | " |

PLATE VII.

Legs of *Ephemerella* Nymphs.

| | | | | | |
|---------|------------|---------|--------------------|-------------|----------------------|
| Fig. 1. | Right legs | of | <i>Ephemerella</i> | <i>lata</i> | sp. nov. |
| " 2. | " | foreleg | " | " | <i>serrata</i> " |
| " 3. | " | " | " | " | <i>rotunda</i> " |
| " 4. | " | " | " | " | <i>deficiens</i> " |
| " 5. | " | " | " | " | <i>tuberculata</i> " |
| " 6. | " | " | " | " | <i>cornuta</i> " |

These drawings are all made from the upper or dorsal aspect. The enlarged sketches of the claw and tarsus of each show the ventral aspect of the tarsus with its chitinous comb which is used in clinging to the rocks.

PLATE VIII.

Mouth-parts of *Ephemerella* nymphs.

Fig. 1. Mouth-parts of *Ephemerella lata*. sp. nov.; r. md., right mandible; l. md., left mandible; lr., labrum; l., labium; mx., left maxilla; hy., hypopharynx, viewed from above.

| | | | | | |
|---------|--------------|----|--------------------|--------------------|----------|
| Fig. 2. | Left maxilla | of | <i>Ephemerella</i> | <i>serrata</i> | sp. nov. |
| " 3. | " | " | " | <i>tuberculata</i> | " |
| " 4. | " | " | " | <i>deficiens</i> | " |
| " 5. | " | " | " | <i>rotunda</i> | " |
| " 6. | " | " | " | <i>cornuta</i> | " |

PLATE IX.

Epeorus and *Ephemerella*.

Fig. 1. *Epeorus humeralis* sp. nov. Portions of the 3rd and 4th abdominal segments of the nymph with gills removed, to show lateral spines.

| | | | | |
|---------|-------------------|----|-------------------------------------|-----------------------|
| Fig. 2. | Forceps and penes | of | <i>Epeorus humeralis</i> , sp. nov. | (From below.) |
| " 3. | " | " | <i>Ephemerella serrata</i> | sp. nov. (From below) |
| " 4. | " | " | <i>deficiens</i> | " (From below). |
| " 5. | Wings of | " | <i>cornuta</i> | " |
| " 6. | " | " | <i>rotunda</i> | " |
| " 7. | " | " | <i>Epeorus humeralis</i> | " |

PLATE X.

Iron fragilis sp. nov.

Fig. 1. Mouth-parts of the nymph; l, outer aspect of the labium; ll., inner aspect of the labium; r. md., right mandible; l. md., left mandible; hy., hypopharynx.

Fig. 2. Wings.

Fig. 3. Foreleg of the male imago.

Fig. 4. Forceps and penes from below; dotted lines represent the portion of the penes hidden by the last sternite.

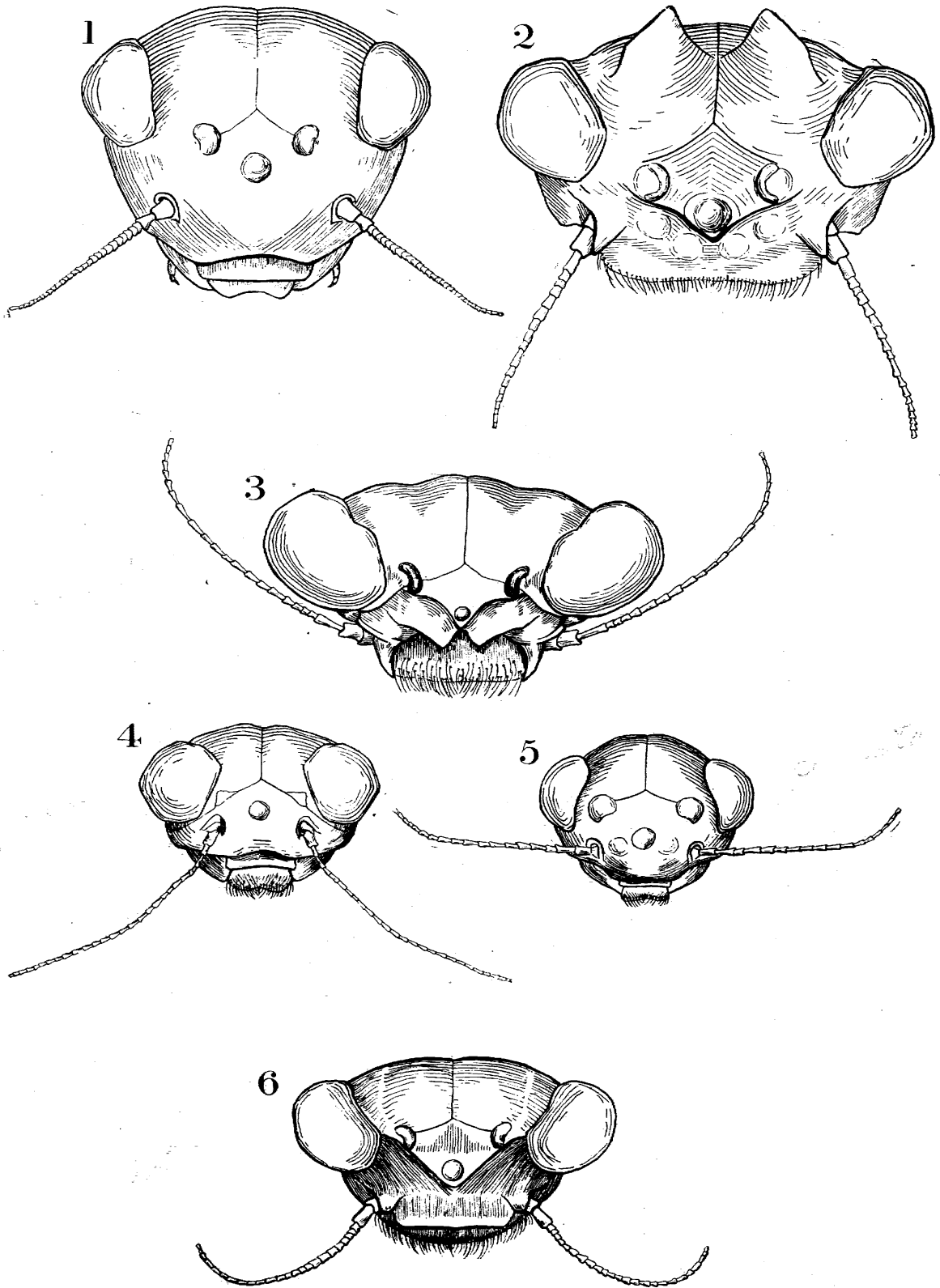
PLATE XI.

Tricorythus allectus Needham.

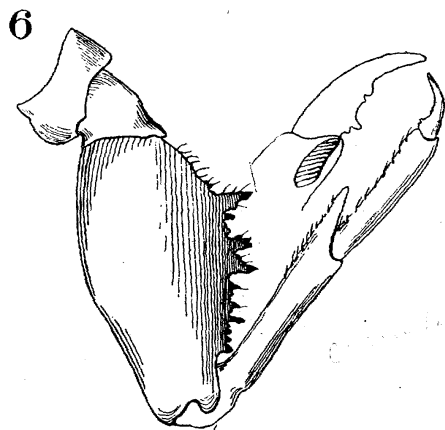
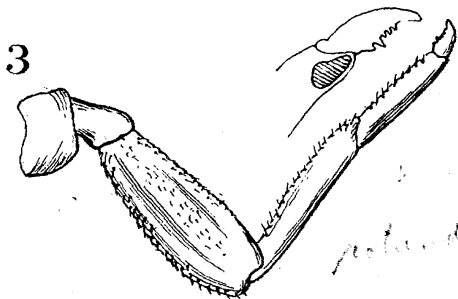
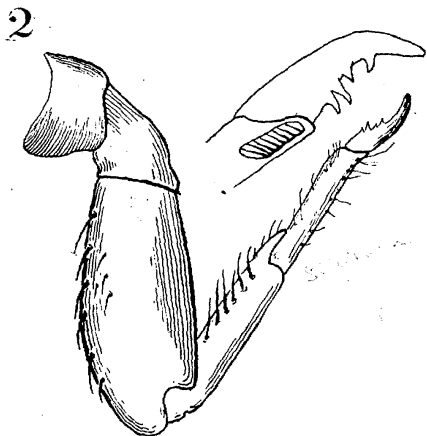
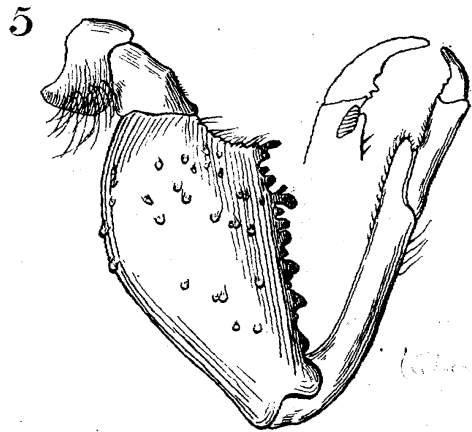
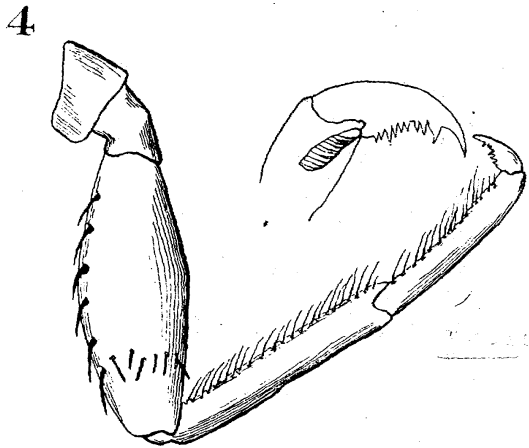
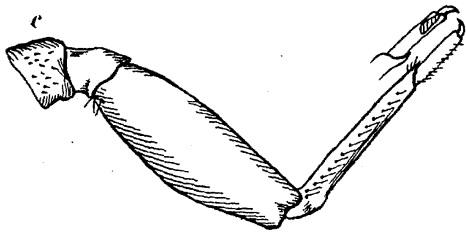
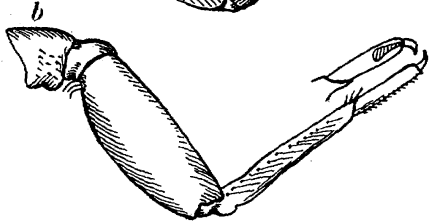
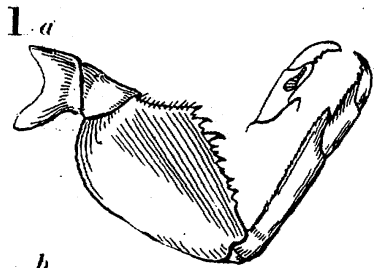
| | |
|----------|--|
| Fig. 1a. | Elytroid lamella; hy., hypopharynx; |
| " 1r. | labrum; r. md., right mandible; l. md., left mandible. |
| " mx. | left maxilla; l., labium. |

PLATE XII.

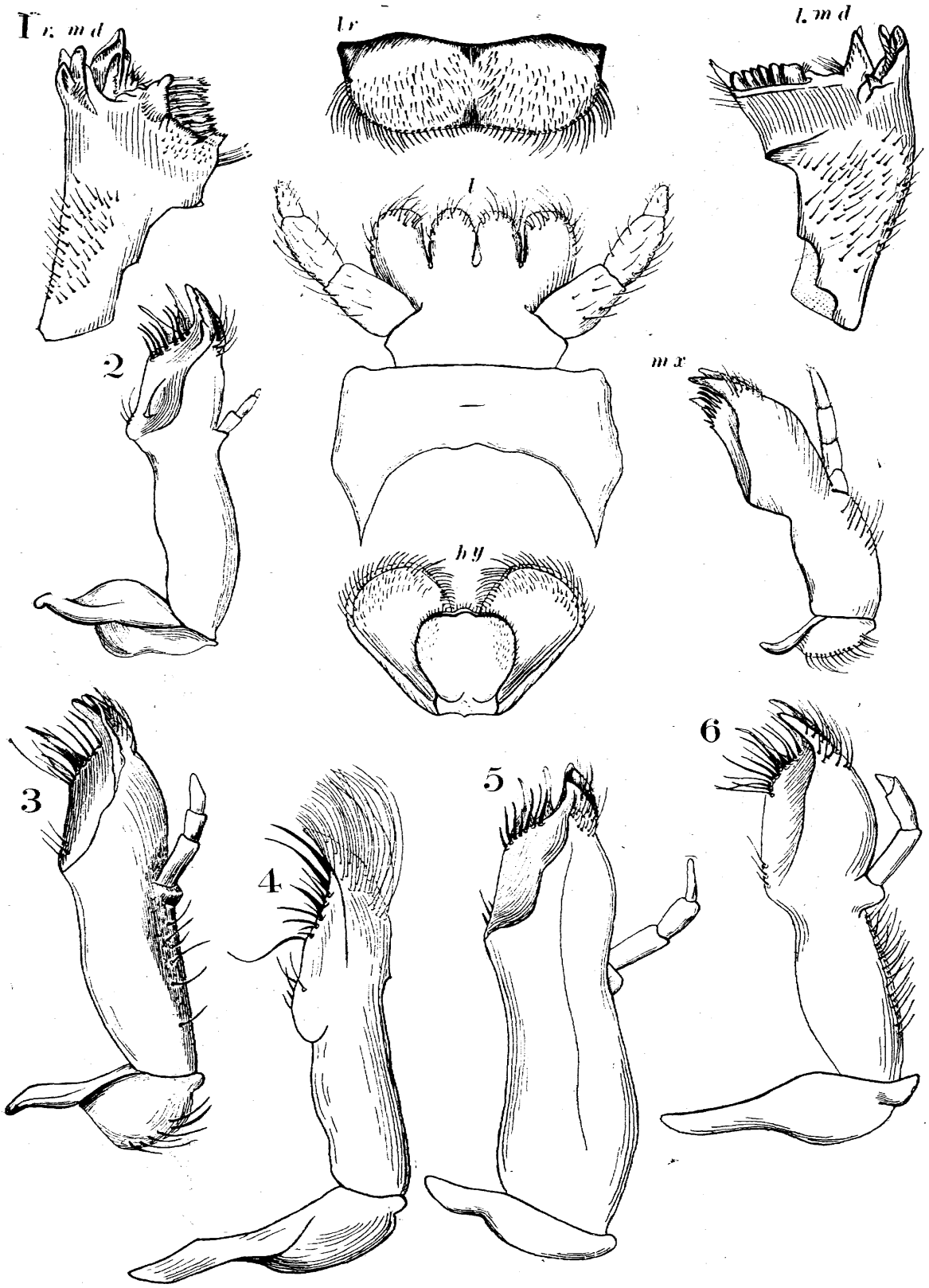
| | |
|---------|---|
| Fig. 1. | Surface of stone covered with masses of <i>Baetis</i> eggs. |
| " 2. | A few of the masses enlarged. |



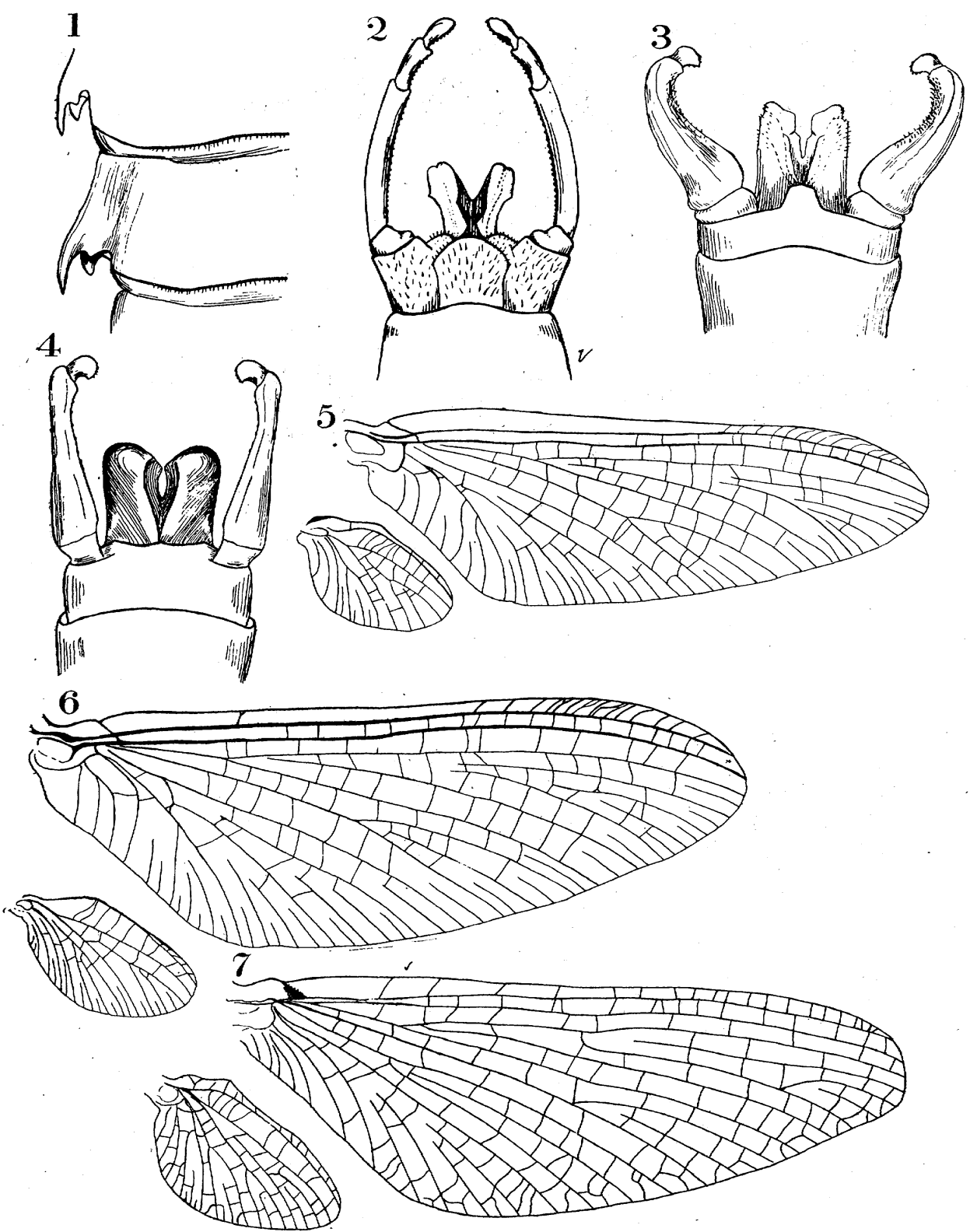
A. H. Morgan



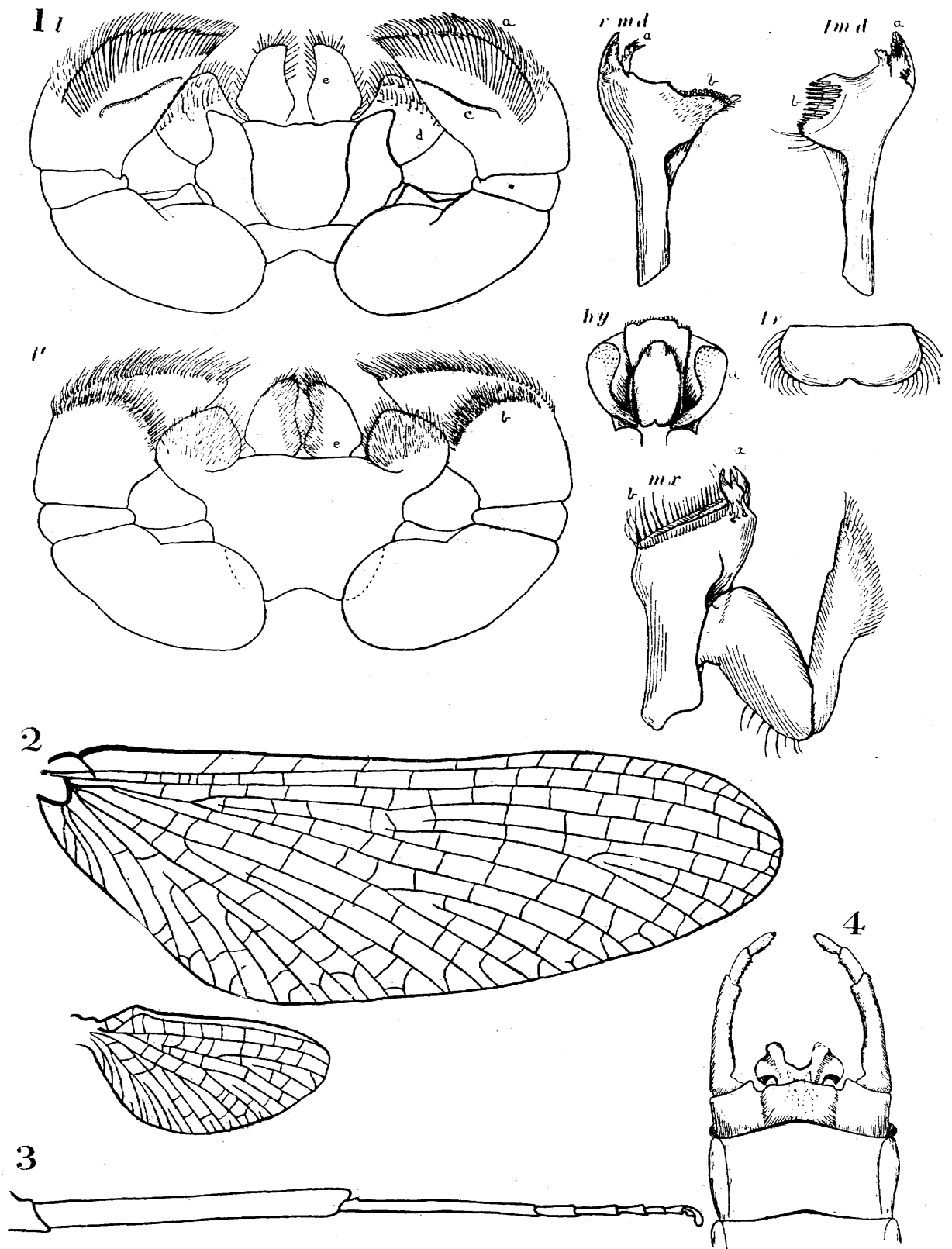
A. H. Morgan.



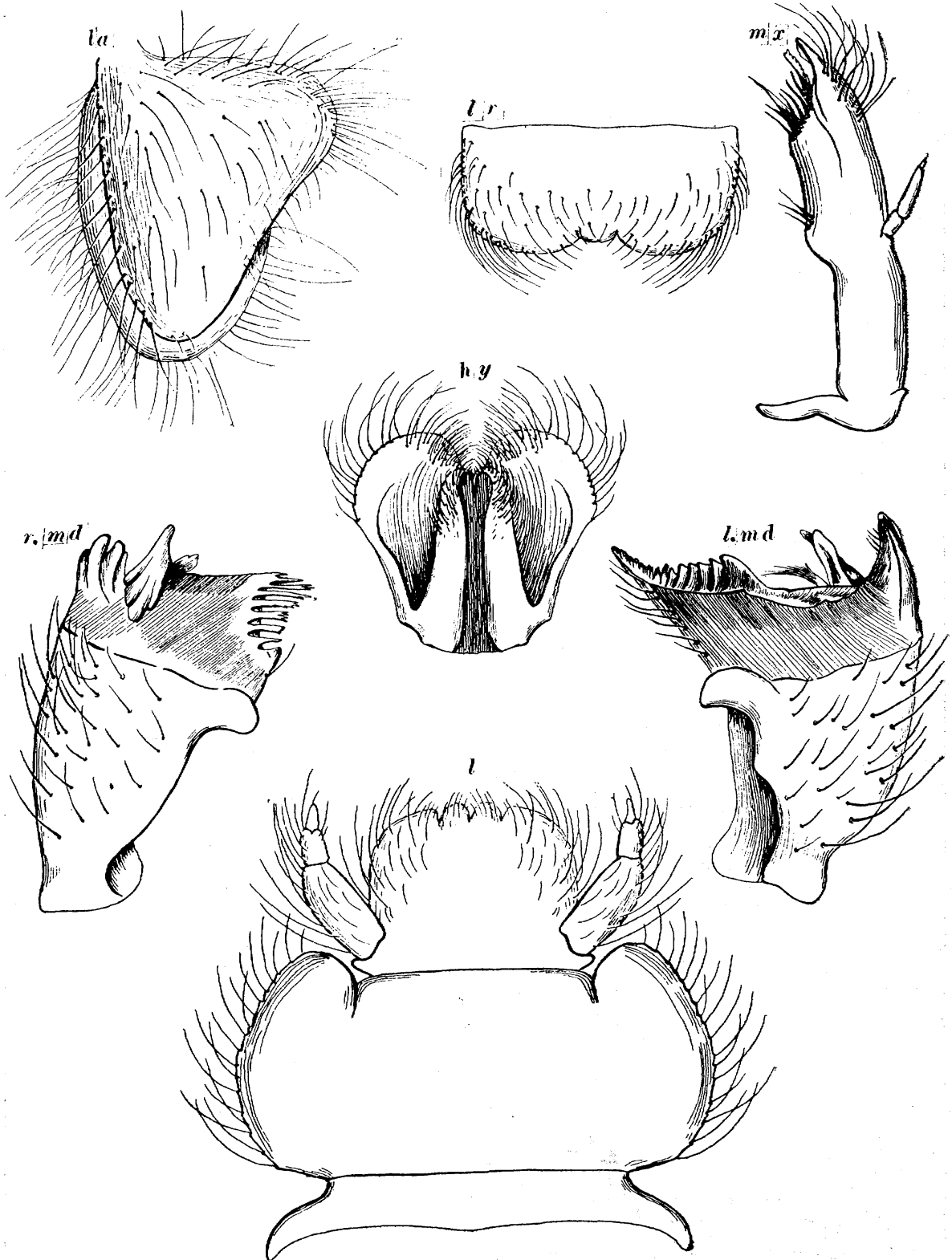
A. H. Morgan



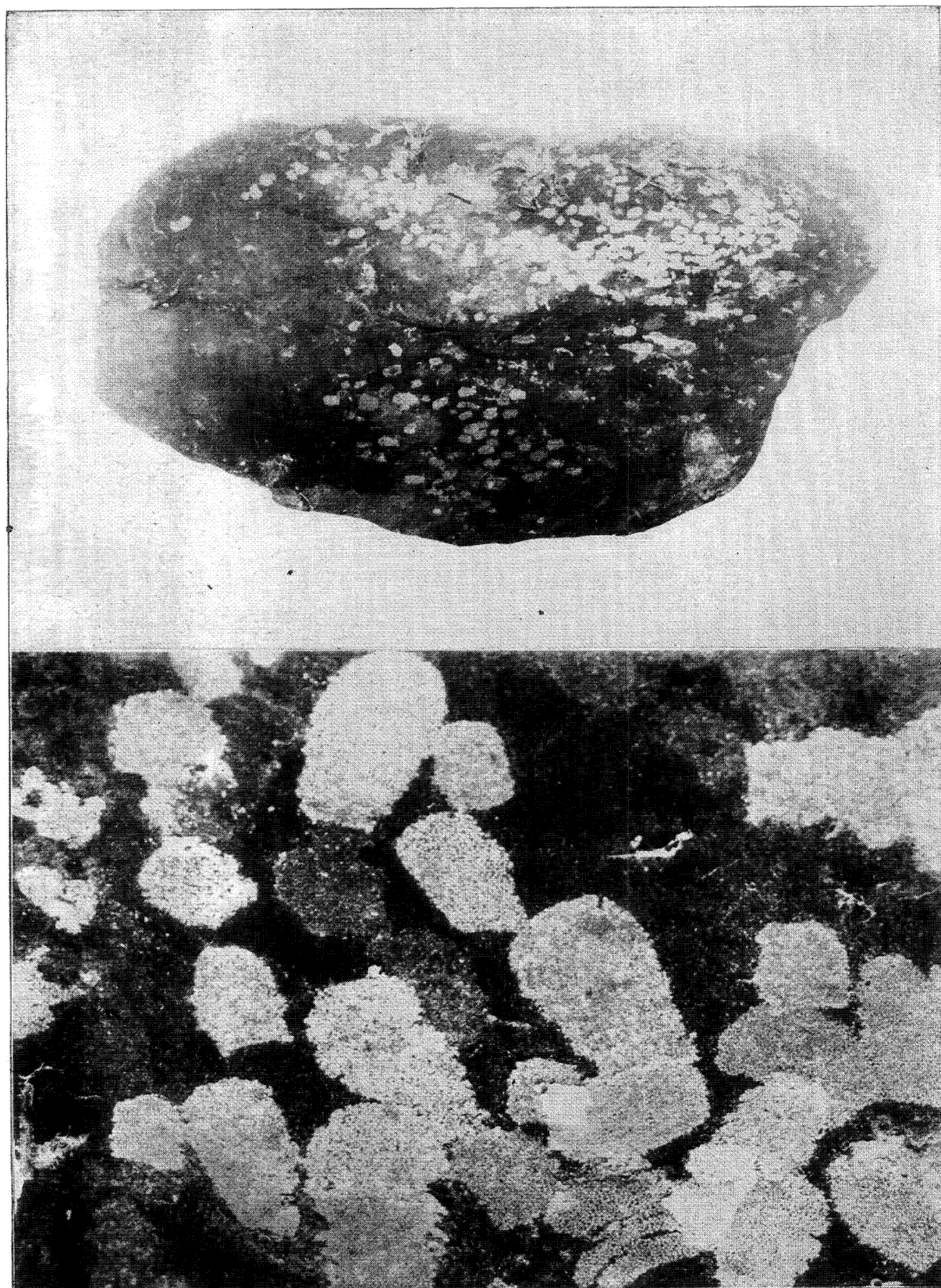
A. H. Morgan



G. H. Morgan.



A. H. Morgan.



A. H. Morgan.