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A study of certain Massachusetts Trichoptera with special reference to the genus Frenesia (Limnephilidae).

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A STUDY OF CERTAIN MASSACHUSETTS TRICHOPTERA WITH SPECIAL REFERENCE TO THE GENUS *FRENESIA* (LIMNEPHILIDAE)

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A Study of Certain Massachusetts Trichoptera with Special Reference to the Genus Frenesia (Limnephilidae).

Oliver S. Flint, Jr.

Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science.
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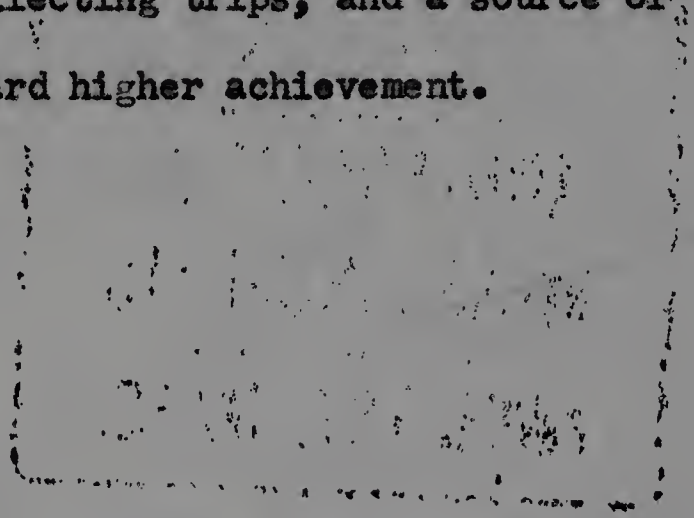
DEDICATION

To my wife, Ruth, who has been a constant companion on collecting trips, and a source of inspiration toward higher achievement.



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INTRODUCTION

The Trichoptera, or caddis flies, are unusual in that they pass their larval and pupal stages in water. About 800 species have been described from the Nearctic region, but the immature stages of only a small fraction of this number are known. The larval stages of 73 species are listed by Denning (1937) as having been described up to that date, but many of the species are not recognizable from the available descriptions. The most valuable single addition to our knowledge of immature stages is a paper by Ross (1944), who prepared keys to many genera and species; however, since he was limited almost exclusively to Illinois material for their preparation, even these keys are often incomplete or incorrect.

The present study was undertaken in the hope of broadening our understanding of the biology of this order. The field area selected was the State Fish Hatchery in Sunderland, Massachusetts, which provided a varied trichopterous fauna and was easily accessible throughout the year. Before the specific problem on the biology of Frenesia was undertaken, a year was spent in general collecting and becoming familiar with Trichoptera as a whole.

PROCEDURE

Adult caddis flies were collected once a week from the beginning of emergence in May to the last of the flight season in the fall. Immature stages were collected throughout the year.

Collection of the adults involved mainly sweeping the vegetation along the watercourses with an insect net. A favorite resting place was found to be the underside of a cement bridge (station 5), where certain species could be taken during most of the season. Late in the fall certain genera, especially Neophylax, were collected by beating evergreen boughs which overhung the streams.

Adults were killed in the field with a cyanide or ethyl acetate "killing bottle." On return to the laboratory the insects were transferred to 70% alcohol, in which they were permanently preserved.

The larvae were collected by dragging a Ward's scraper net across the bottoms of the brooks and pools, although sometimes the bottom material was turned over by hand and the caddis cases picked out. In the larger pools it was possible to locate the cases by sight on the bottom and on trailing vegetation.

The larvae have a high mortality rate when out of their

environment if transported in water only; they were, therefore, collected in jars filled with moist leaves and moss, to which was added no more than a quarter inch of water. In the laboratory some of each type were boiled in water and then preserved in 70% alcohol. The remaining larvae were put into an aquarium to be reared.

A large wooden aquarium divided into 13 sections, eight of which are 30" x 11" and five of which are 18" x 12", was used for rearing the insects in the laboratory. Water from the town water supply enters one end of the aquarium and a drain is provided at the other. The water flows through at least six inches of a charcoal and sand filter before entering the pools. Openings which may be opened or closed as desired, control the water level. An individual section could be shut off to provide lentic conditions. Water flow was set at about 1.5 gallons per minute, and at this flow the temperature averaged 16° C. The aquarium was never entirely satisfactory for many species, possibly because of chlorine content of the water; late in the season, therefore, pillow cages were used. These cages, containing larvae and pupae, were set in the streams at the fish hatchery. A number of specimens of Frenesia were reared satis-

factorily by this method.

Correlation of larvae and adults of many species by rearing proved rather difficult. A more satisfactory way in which several stages were correlated was by use of a metamorphotype as outlined by Milne (1938). A metamorphotype is a mature pupa within the pupal case; the adult's genitalia are fully developed under the pupal skin, permitting positive identification by the genital structure of most species. The associated larval sclerites are generally found in a mass at the rear of the pupal case. Thus in a single caddis fly case, there may be present the larval sclerites, the pupa, and the adult genitalia.

Drawings of the genitalia were made from specimens cleared in warm KOH and then placed in glycerine. The larvae and pupae were drawn from specimens in alcohol. All drawings were made using an ocular micrometer and graph paper.

Collecting in the area was started in the fall of 1953 and continued until late May of 1955. This allowed two seasons' observations on Frenesia, and a full summer's collecting the other species.

AREA

Only the northeastern section of the Sunderland fish hatchery was studied intensively, because this was the area where the caddis flies were concentrated.

The fish hatchery itself is situated at the foot of a large gravel delta, deposited shortly after the Pleistocene glaciation. The stream which flows out onto the delta sinks into the gravel about a mile east of the hatchery, where the water reappears as many springs along the eastern margin.

The water that flows from these springs is very pure and of uniform flow throughout the year. Mr. John Norell, superintendent of the hatchery, stated that the temperature of the water where it rises from the ground is 46-47°F. all year. The water as it leaves the hatchery area during the summer is 50-53°F.

The streams, with the exception of the one flowing under the cement bridge which arises further up the slope, all arise from springs within the hatchery area. The brooks as they leave the area average a foot in width and 2-3 inches in depth. They are fast flowing, and have a bottom of sand, or of silt and roots; only the brook flowing under the cement bridge has a rocky bottom.

Most of the ground, except around the pools, is swampy and covered to a large extent with a low growth of Symplocarpus foetidus (L.)Nutt.(skunk cabbage), and densely forested with Acer rubrum L.(red maple), Betula lutea Michx. f.(yellow birch), and Tsuga canadensis (L.)Carr.(hemlock). Certain aspects of the flora suggest a northern affinity: Habenaria dilatata (Pursh)Gray, Clintonia borealis (Ait.) Raf., Trillium undulatum Willd.(painted trillium), and Taxus canadensis Marsh.(ground yew). Since the ground is saturated continuously with water at a low temperature these conditions are not too surprising.

SECTION I. Systematic Studies on the Genus Frenesia

THE GENUS FRENESIA BETTEN AND MOSELY

References

Frenesia Betten and Mosely

1940. Betten & Mosely, Francis Walker Types of Trich.:165.
1944. Ross, Ill. Nat. Hist. Surv. Bull. 23(1):199.
1952. Schmid, Arch.f. Hydrobiol. 47:78-81.

Genotype by original designation: Limnephilus difficilis Walker.

Review of Literature

The genus Frenesia was established in 1940 by Betten and Mosely for the species difficilis Walker, missa Milne, and praeteritum Walker. Ross in 1944 established a new genus, Grensia, for praeteritum, leaving difficilis and missa in Frenesia.

The species difficilis, when described by Walker (1852), was placed in the genus Limnephilus, as the generic concept of that day was nearer our present subfamily or genus group concept. Later Hagen (1861, 1864) and McLachlan (1863) placed the species in the genus Enoicyla because of identical spur counts. In 1878 this species was first placed in the genus Chilostigma by Hagen in Lintner, but Provancher (1887, 1888) and Banks (1892) trans-

ferred it to the genus Cryptothrix. The basis for this latter change is not clear. Ulmer (1907) returned the species to Chilostigma, characterized by a distinct stigma and the apical curving of veins Sc, R_1, and R_2, where it remained until the genus Frenesia was established for it.

Milne (1935) originally placed missa in the genus Chilostigma, where it remained until Betten and Mosely (1940) moved the species to the genus Frenesia.

Descriptions

The genus has been adequately characterized for the adult stage by Betten and Mosely (1940), but for completeness of this study a redescription of the adult is included. The larval and pupal stages have not been described previously at the generic level.

Adult. Antennae $1\frac{1}{4}$ times length of body; basal segment $\frac{1}{2}$ as long as head. Maxillary palpi of male 3-segmented, first segment short, second and third subequal, twice length of first; in female 5-segmented, second, third, and fifth subequal, first and fourth about 3/4 length of others. Labial palpi 3-segmented; segments broad, subequal in length; apical segment oval, twice as long as broad. Legs with spur count 1,2,2; spur of fore leg bent

apically, set on a prominence; numerous black spines present on tibia and tarsi, except last tarsal segment, of all legs; fore legs of male with comb of short dark setae on inner surface of tibia, femur with shallow groove set with many very short pale setae. Fore wings with sharply defined stigma; veins and membrane with many erect hairs; wing broadened apically, width at widest about 1/3 of length; costal margin distinctly bowed; apex rounded. Veins Sc, R_1, and R_2 distinctly curved at stigma; cord aligned with base of stigma; discal cell twice as long as its petiole. Hind wing hyaline; stigmal area present; short hairs present along anterior portion.

The genus clearly belongs in the Chilostigma complex of genera, based on the characteristics of the distinct stigma and the curving Sc, R_1, and R_2. The genus has been adequately separated from other Nearctic genera by Ross (1944).

A seeming difference in the wing length of the two species was noted in the field. In order to determine if a valid difference existed a series of specimens of both sexes of both species was measured to the nearest half millimeter and the results tabulated as shown in Table 1.

Table 1.

Group	Number Measured	Range in Size	Mean
difficilis male	26	11-15 mm.	13.19 mm.
difficilis female	24	11-15 mm.	12.65 mm.
difficilis male and female	50	11-15 mm.	12.93 mm.
missa male	30	9.5-13 mm.	11.45 mm.
missa female	34	9-11.5 mm.	10.62 mm.
missa male and female	64	9-13 mm.	10.99 mm.

The results indicated an average difference between species of 2 mm., although there was an overlap in size.

These measurements and results were then treated statistically by the method outlined by Brown (1951), yielding the results shown in Tables 2 and 3.

Table 2.

Group	Mean	Probable Error of Mean	Standard Deviation	99% Limits	% Within Limits
difficilis					
male	13.19 mm.	0.14 mm.	1.06 mm.	10.46-15.92 mm.	100%
female	12.65	0.13	0.92	10.28-15.02	100
male and female	12.93	0.16	1.09	10.12-15.74	100
missa					
male	11.45	0.11	0.88	9.18-13.72	100
female	10.62	0.13	0.78	8.61-12.63	100
male and female	10.99	0.12	0.93	8.54-13.39	100

The heading titled "99% Limits" indicates that 99% of the specimens in a population should fall within these limits. That the series were fairly homogeneous is shown by the fact that all specimens measured actually did fall within these limits.

Table 3.

Groups Compared	Difference Between Means	Probable Error of Difference	"t" Score of Difference
difficilis male female	0.54 mm.	0.19 mm.	3-
missa male and female	0.83	0.17	5-
difficilis male *missa* male	1.74	0.18	9+
difficilis male *missa* female	2.57	0.19	14-
difficilis female *missa* male	1.20	0.17	7+
difficilis female *missa* female	2.03	0.18	11+
difficilis mean *missa* mean	1.94	0.17	11

Probably the most significant figures in Table 3 are the "t" score figures. This number is related to the probability of drawing the two samples from the same general population. A score of 3 will occur in about 1 in 12 samples drawn from the same popu-

lation, and therefore is of little significance. However, a score of 7 (which will occur in about 1 in 500,000 samples from the same population) or above is very significant, as the probability of the sample coming from the same population is remote. On the basis of 7 as being significant, it is evident that the difference in size between the sexes of the same species is not valid, yet the difference of size between species, anyway they are compared, is valid.

Larva. Head broadly ovoid in frontal aspect; antennae situated midway between eye and anterior margin of head. Labrum strongly rounded; anterior margin emarginate medially; six pairs of major setae situated on upper surface; a brush of hairs laterally. Mandibles with two setae on outer surface; small brush of hairs on inner surface of left mandible. Maxillary palpi 4-segmented; labial palpi 2-segmented. Prothorax with numerous blade-like setae, shorter than any other setae, most abundant along anterior margin. Prosternal spine short, not extending beyond apices of front coxae. Femora of front legs shortened and broadened. Abdomen with spacing humps much flattened. Fringe line present from segments three to eight. Gilla arising in groups of one to three, present from segments two to seven.

The larvae of the family Limnephilidae are for the most part quite homogeneous structurally. A possible relationship with Glyphopsyche missouri Ross, the only other described species in the Chilostigma complex, is suggested by the common character of short blade-like setae on the prothorax. The character of the setae on the ventral portion of the anal proleg, used by Ross (1944) for separation of the genus Frenesia, is a specific character of missa only. Ross' key may be corrected by deleting couplets 5 and 6, and substituting the following for them.

5. Pronotum with numerous short blade-like setae along anterior margin 6

   Pronotum lacking the blade-like setae 7

6. Legs banded with red and black ..... Glyphopsyche

   Legs a uniform light brown ..... Frenesia

Pupa. Labrum semicircular; distal bristle group composed of 5 long hooked setae; proximal group of 3 slender setae. Mandibles inflated at base, slender, blade-like apically; two bristles on outer surface. Front and vertex with 4 pairs of long black setae. Antennae extending caudally to about seventh abdominal segment. Gills arising in groups of 2-3, about as long as the segment bearing them. Lateral fringe strongly developed,

present from posterior half of segment 5 to segment 8, curving ventrad and ending on the caudal margin of the segment. Dorsal anterior hook plates from segment 3-7, each bearing from 2-5 hooks; dorsal posterior hook plate on segment 5, with 8-11 hooks. Ninth segment with 3 long hairs ventrally; dorsal scabrous patch near base of anal projections. Anal projections rod-like, slightly curved and with scabrous patch apically.

Although many pupae have been described from this family, most descriptions are not sufficient to allow a separation of the genera. At present it is not possible to separate pupae of the genera Limnephilus, Glyphopsyche, and Frenesia.

Distribution

The genus is confined to the eastern margin of the Nearctic Region. Representatives of the species have been recorded from Nova Scotia to Virginia and from the Atlantic seaboard to Minnesota.

Keys to the Species

Adults

1. Size larger (11-15 mm., averaging 13 mm.); male claspers attenuate, ventral arms of 10th tergite brown, sinuous, not angled sharply dorsad; females with 9th sternite

bilobed apically ..... difficilis

Size smaller (9-13 mm., averaging 11 mm.); male claspers truncated apically, ventral arms of 10th tergite black, angled sharply dorsad near base; female with 9th segment forming a collar around the dark scoop-shaped 10th segment ..... missa

Larvae

1. Ventral membranous portion of anal prolegs with 10-12 setae ..... missa

Setae on ventral membranous portion of anal prolegs lacking ..... difficilis

Pupae

1. Apex of anal process with 2 long setae .. difficilis

Apex of anal process with 1 long seta ..... missa

THE SPECIES FRENESIA DIFFICILIS (WALKER)

References and Synonymy

1835.	Phryganea	coagulata	Harris, in Hitchcock, Report on the geology, minerology, botany, and zoology of Massachusetts:62.
1852.	Limnephilus	difficilis,	Walker, Cat.Neur.Brit.Musl:34.
1861.	Enoicyla	"	Hagen, Smiths. Misc.Coll.:768.
1863.	"	"	McLachlan, Ent. Ann.:158,162.
1864.	"	"	Hagen, Verh.Zool-Bot.Ges.Wien.4:812.
1873.	Platyphylax	coagulata	Hagen, Proc.Bos.Soc.Nat.Hist.15:296.
1877.	Cryptothrix	coagulatus	Provancher, LeNat.Can9:260.
1878.	Chilostigma	difficile	Lintner,10th Rept.N.Y.Comm.Fish:22.
1878.	Cryptothrix	coagulatus	Provancher, Pet.Faun.Ent.Can.:136.
1892.	"	difficilis	Banks, Trans.Ent.Soc.Amer.19:364.
1899.	Chilostigma	pallida	Banks, Trans.Ent.Soc.Amer.25:209.
1907.	"	difficile	Ulmer, Gen.Insect.Fasc.60:70.
1907.	"	difficilis	Banks, Amer.Ent.Soc.:40.
1915.	"	difficile	Lloyd, Jour.N.Y.Ent.Soc.23:208.
1920.	"	difficilis	Britton, Conn.Geol.Nat.Hist.Surv. Bull.31:31.
1926.	"	difficile	Leonard, Corn.U.Mem.101:530.
1926.	"	"	Sibley, Bull.Lloyd Lib.27:108.
1934.	"	"	Betten, N.Y.Sta.Mus.Bull.292:367.
1935.	"	"	Milne, St.N.Amer.Trich.2:35,50.
1940.	Frenesia	difficilis	Betten & Mosely, Francis Walk. Types of Trich.:165-168.
1941.	"	"	Ross, Trans.Amer.Ent.Soc.67:105.
1944.	"	"	Ross, Ill.Nat.Hist.Surv.Bull.23(1):199, 299.
1946.	"	"	Procter, Biol.Surv.Mt.Desert Reg.:212.
1952.	"	"	Schmid, Arch.f.Hydrobiol.47:83-86.
1953.	"	"	Morse & Blickle, Ent.News 64:99.

Immature stages

1915.	Chilostigma	difficilis	Lloyd, Jour.N.Y.Ent.Soc.23:208.
1921.	"	"	Lloyd, Bull.Lloyd Lib.21:7-72.
1926.	"	difficile	Sibley, Bull.Lloyd Lib.27:202.

Review of Literature

Limnephilus difficilis was described by Francis Walker (1852) from a specimen taken in Nova Scotia by Lt. Redman. The description, typical of that era, was short and inconclusive, and would apply equally well to many other Trichoptera. Hagen studied Walker's types and in 1863 McLachlan published some of Hagen's notes supplemented by his own. Hagen's notes as published stated, "... app. inf. long acute, straight, inflated at base." This characteristic of the claspers separates difficilis immediately from related species. Betten and Mosely (1940), in their study of Walker's types, redescribed the type and illustrated genitalia and wings, leaving no doubt as to identity of the species. The type of the species is a male which is presumably still in the collection of the British Museum (Natural History) in London.

Harris (1835) had previously listed the species as Phryganea coagulata without authority, stating that all species so listed were as yet undescribed. Hagen (1873) stated that at that time there were fragments of three specimens in Harris's collection bearing the label Platyphylax coagulata Say in Say's handwriting, yet neither Say nor Hagen published a description of the species, which left the name a nomen nudum. The three

specimens are in the Harris collection at the M.C.Z. in Cambridge, Massachusetts, one specimen bearing the label "Holotype, Platyphylax coagulata Hag. nec Say"; the other two are labelled "paratype." The holotype is also labelled "C. difficilis Wlk., Det. 1936 L. J. Milne." Since the lengths of the fore wings of this specimen and the other two are all 13 mm., greater than the lengths generally found in missa, there seems little reason to believe that these specimens are not difficilis. The first description of coagulata is by Provancher (1877), who cites Say as authority, and lists difficilis as a synonym. The length, 0.60 pce. (16 mm.), and wing expanse, 1.15 pce. (31 mm.), given in the description match exactly the measurements of difficilis, leaving no doubt as to the identity of the specimen.

In 1899 Banks described a single female specimen from Ithaca, New York as Chilostigma pallida, differentiating it from difficilis by its pale yellow color. This color may well have been due to fading in the specimen, or possibly the western population may be lighter in color. Milne (1935), and Ross (1944), considered it to be a synonym of difficilis, a finding with which the present author is in agreement.

Further descriptions have been given by Lintner (1878), Lloyd (1915), Ulmer (1907), Sibley (1926), Betten (1934), Milne (1935), and Schmid (1952). Additional distributional data have been supplied by Banks (1892, 1907), Britton (1920), Hagen (1861), Leonard (1926), Morse and Blickle (1953), Procter (1946), and Ross (1939, 1944).

Descriptions

The adult of difficilis has been adequately described by Betten and Mosely (1940) and Schmid (1952); it is redescribed here for the sake of completeness. Lloyd (1915, 1921) gave an inadquate description of the larva and pupa, both of these stages are more completely described here.

Adult. Length from 11-15 mm., averaging 13 mm. in male, 12.5 mm. in female. Coloration in general golden brown; quite hairy in appearance.

Head brown, grading to fuscous on dorsum. Setae pale, those posterior to eye darker. Antennae brownish; about 1¼ times the length of body; basal segment about ½ the length of head. Setae on basal segment pale, those on succeeding segments dark, most numerous near center of segments giving them

the appearance of having alternating light and dark bands. Head with 3 pairs of raised setaceous warts on epicranial area; the 2 anterior pairs small, situated between lateral and median ocelli, each bearing 3-4 setae; posterior pair large, ovoid, with many pale setae.

Thorax and legs brown, grading into fuscous in several places on pleura. Pronotal setaceous warts large, covering most of dorsum; setae pale except for a few dark lateral ones. Pleura covered with pale setae. Mesoscutal warts small, elongated in axis of body; each with 6-7 pale setae. Mesoscutellar warts represented by irregular row of 3-6 setate spots. Tegulae fuscous; covered with both pale and dark setae. Postnotum and metanotum glabrous. Mesepimeron with row of pale setae along caudal margin; metepisternum with setaceous wart on antero-dorsal angle; meso- and metaepisternum with row of setae along ventral margin.

Coxae of fore legs with 2 rows of setae, one on outer surface, the other on inner; coxae of mid and hind legs with row of setate spots along outer surface. Tibia and tarsus of all legs with many black spines, lacking on last tarsal segment. Spur formula 1,2,2; spur of fore leg bent apically.

Fore wing light brown, irregularly speckled and spotted with white; cell 3A all pale colored. Both veins and membrane with numerous dark macrochaetae; costa with many shorter macrochaetae. Fore wings broadened in stigmal area; width about 1/3 of the length. Venation as in Fig. 3. The longer-winged specimens are lengthened disproportionately in the area beyond cord. Hind wings hyaline; stigmal area fairly well developed; many small macrochaetae anteriorly.

Abdomen dark brown to fuscous, with scattered hairs along margins of sclerites.

Male genitalia (Fig. 1A-D). Scabrous patches posterior to eighth tergite separated by area almost lacking setae. Ninth segment forming fused ring around abdomen. Tenth tergite divided into two pairs of short dorsal arms, apressed to membrane, each with distal group of setae, and pair of appressed elongate, slightly sinuous, ventral arms extending caudad. Cerci much elongated, lying laterad and slightly ventrad to ventral arm of tenth tergite; with group of pale setae apically. Upper penis sheath extending out over base of aedeagus like a shelf; ventral surface with many short setae. Claspers fused at their bases to ninth segment; apex

drawn out into a rod-like projection, curving slightly toward the center line, inflated at the base, this portion bearing many dark setae. Aedeagus scoop-shaped at apex; from dorsal aspect rather strongly constricted near middle; dorsal arms blunt with small apical denticulations.

Female genitalia (Fig. 1E-G). Lateral processes of subgenital plate obtusely angulate at posterio-medial angles. Lobes between eighth and ninth sternites without group of setae. Ninth segment with row of short setae extending around segment near the middle. Two large setaceous patches on posterior half of ninth tergum, which seem to be separated from the rest of segment by indistinct sutures and may represent claspers which have fused to ninth segment. Ninth segment ventrally with bilobed projection extending beyond dorsum; many short setae near base of this projection.

Larva. Length of mature larva 14 mm., width 2.5 mm; general shape eruciform; abdomen widest at the first segment, tapering slightly caudad; head and thoracic sclerites deep brown, legs pale brown, abdomen nearly white.

Head broadly oval in frontal aspect; front rugose; with many very short, downward pointing, flattened setae;

long dark setae arranged as in Fig. 4D. Many inconspicuous pale muscle insertion marks on posterior half; a circular group of 6-8 marks at apex of fronto-clypeus.

Labrum light brown, very strongly rounded laterally; anterior margin with median emargination. Six pairs of setae on dorsum: 3 on antero-lateral margin, inner pair very short and broad; 2 in transverse row across center of labrum; one midway between marginal and center rows. Three pale spots or pits on dorsum: one median just anterior to transverse row of bristles; one caudad to each seta of the pair midway between the marginal and transverse rows. A brush of hairs on the margin mostly between the two posterior marginal setae.

Mandibles heavy, dark brown, slightly asymetrical. Two hairs near base of outer surface; brush of hairs on inner surface of each mandible.

Maxillae and labium with sclerotized parts light brown. Maxillary palpi 4-segmented (not 3 as shown in Lloyd (1921) fig. 109). Patch of fine hairs at base of maxillary lobe; its tip with numerous peg-like projections. Labial palpi 2-segmented.

Prothorax with anterior margin shallowly emarginate;

groove arising at the point of articulation with leg and extending weakly over dorsum along posterior margin. Numerous short blade-like setae on notum, clustered principally along anterior margin; a few longer setae scattered among these. Prosternal spine short, not extending beyond apices of front coxae.

Mesothorax rectangular; low ridge extending around posterior margin and forward halfway on lateral margin; linear dark spot on postero-lateral angle. A few pale muscle-attachment scars obliquely across middle. Setae clustered near middle of anterior half, and along lateral and posterior portion.

Metathorax with three pairs of small sclerites on dorsum: small ovate pair in antero-medial section, with 7-9 setae; larger roughly triangular pair posterior and laterad to the first, with 8-9 setae; third pair on lateral margin, elongate, widened posteriorly, anteriorly with numerous setae.

Legs paler than thorax; fuscous at articulations of femur and tibia, and of coxa and trochanter. Fore legs shortest, femur considerably broadened, with 2 clear blade-like

setae on posterior margin, 2 more similar setae on trochanter. Middle legs longest; 2 long dark setae on posterior margin of femur. Hind legs slightly shorter than middle pair; one long dark seta on posterior margin of femur. All legs with brush of fine hairs on posterior apical portion of trochanter, row of very short flattened setae along posterior margin of femur, and numerous long black setae on the coxae and femora.

Abdomen almost pure white; fringe line present from third to eighth segments. Spacing humps of first abdominal segments small and flattened. A group of 9-10 setae on each side of dorsal hump; another group of 5 on upper surface of lateral hump; about 25 setae scattered over sternum. Mature larva with oval sclerotized rings on abdominal sternites 3-7. Posterior margin of eighth tergite with about 20 hairs. Ninth segment with 2-3 hairs laterad of dorsal chitin plate. No hairs on membranous ventral portion of anal prolegs.

Case. Length 14-18 mm., width 3-4 mm. Cylindrical, sometimes slightly curved. Constructed mainly of flattened sand grains - especially quartz and mica; generally some plant material incorporated, and if used in any quantity, the case becomes quite

irregular.

Pupa. (Fig. 5A). Length 13-15 mm. Color creamy white, turning golden brown near time of ecdysis. Labrum (Fig. 5D) semicircular. Each distal bristle group consisting of 5 long, stout, hooked setae; each proximal bristle group consisting of 3 slender setae. A very short seta on each side of labrum anterior to distal group of bristles. Three pale spots, one posterior to each short seta, the third median.

Mandible (Fig. 5C) inflated at the base; apex thin, blade-like, with numerous serrations on the inner margin. A pair of black setae on outer surface near base.

Front and vertex with four pairs of long black setae: first pair posterior to proximal bristle group of labrum; second pair antero-laterad to these; third pair between bases of antennae; last pair on vertex. Another pair on epicranium near eyes; these may be accompanied by one or two shorter setae at times. Antennae extending posteriorly to caudal margin of seventh abdominal segment; second antennal segment with tuft of 8-10 setae, longest seta about as long as the segment.

Pronotum with widely separated pair of setae. Mesonotum with a seta on each side near anterior margin; two setae on each

side about halfway to posterior margin. Metanotum with three pairs of setae arranged as on mesonotum.

Coxae of fore legs with a group of 2-6 setae on inner surface; coxae of middle legs with 2 setae on ventral surface, one proximal, the other distal. A fringe of hairs on each side of tarsi of middle and hind legs.

Wing pads extending caudally to anterior margin of the fourth abdominal segment.

Each abdominal tergite with pair of widely separated setae on the posterior margin. Segments 2-8 with two pairs of sclerotized rods: one pair dorsal, running from anterior to posterior margin (each rod overlies lateral margin of tergite of adult); second pair ventral, in a similar position. Strong lateral fringe beginning in posterior half of fifth segment, extending posteriorly to caudal margin of eighth segment, curving ventrally there and ending near mid-ventral line. Gills present from posterior margin of second segment to anterior margin of seventh segment; arising in tufts of 2-3, in general as long as the segment which bears them. Anterior dorsal hook plates present from segments 3 to 7, number of hooks varying from 2 to 5, but usually 3 or 4; posterior hook

plate on segment 5 with 8-11 hooks. Eighth tergite with about 30 setae in irregular row along caudal margin. Ninth segment with transverse row of 9-10 setae dorsally about midway of segment. Dorsal scabrous patch with interspersed short hairs on ninth segment near base of anal process. Ninth segment ventrally with 3 large, often flattened and twisted hairs near caudal margin. Anal processes (Fig. 5B) slender, rod-like, curved apically; almost 1½ times the length of ninth segment, cluster of short scabrous setae and two large hairs at apex; third hair near the middle; and fourth in the basal 1/3.

Distribution

Adults of this species have been recorded from the following states or provinces: Nova Scotia, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, Pennsylvania, District of Columbia, and Virginia.

From a study of these records it would be expected that this species can be taken from the Gulf of Saint Lawrence on the north to Virginia on the south, and from the Atlantic westward to the Appalachian Mountains.

THE SPECIES FRENESIA MISSA (MILNE)

References and synonymy

1878.	Chilostigma	coagulata	Lintner, 10th Ann.Rept.N.Y. Comm.Fish:22.
1934.	"	coagulatum	Betten, N.Y.Sta.Mus.Bull.292: 367.
1935.	"	missum	Milne, St.N.Amer.Trich.2:35,50.
1940.	Frenesia	"	Betten & Mosely,Francis Walk. Types Trich:165.
1944.	"	missa	Ross,Ill.Nat.Hist.Surv.Bull. 23(1):199-200,299.
1946.	"	"	Procter,Biol.Surv.Mt.Desert Reg.12.
1952.	"	"	Schmid, Arch.f.Hydrobiol.47: 81-83.
1953.	"	"	Morse & Blickle, Ent.News 64:99.

Immature stages

1944.	Frenesia	missa	Ross, Ill.Nat.Hist.Surv.Bull. 23(1):199-200.

Review of Literature

Chilostigma missum was described by Milne (1935). He differentiated it from difficilis on the basis of the shape of the genital parts in both male and female. The type of missa was retained in the Milne collection, and is now presumably in the collection of the Illinois Natural History Survey.

Descriptions and figures of both male and female have been given by Ross (1944) and Schmid (1952). Ross also included a brief description of the larva and a few ecological

notes. The species was transferred to the genus Frenesia by Betten and Mosely (1940). Additional distributional data have been supplied by Morse and Blickle (1952) and Procter (1946).

The species was undoubtedly recognized some years before its description, however. Hagen in Lintner (1878) stated that, "This species (i.e. difficilis), is much like the first (i.e. coagulata=missa?), but a little larger, and the male and female have different genital parts." Although five years earlier Hagen had stated that the names might be synonymous, he evidently recognized in 1878 that two species were involved, and started calling Walker's species difficilis and the other smaller one coagulatum. Betten (1934), following the statment of Hagen (1878), figured the male of what is now called missa but labelled it coagulata. This name, however, had been published with a description for difficilis by Provancher (1877) and so it was unavailable for this species.

Descriptions

Ross (1944) described the genitalia and Schmid (1952) the whole adult very adequately, but, for comparison of the two species, missa is being redescribed. The larva, which was

incompletely described by Ross (1944), and the pupa are being compared with the corresponding stages of difficilis.

Adult. Similar to difficilis, differing in the following respects:

Length shorter, from 9-11 mm., averaging 13 mm.

Front of head with many dark setae; some dark setae often mixed in with pale setae on posterior warts; one large black seta in male, 2 in female posterior to lateral ocelli. Anterior warts smaller than in difficilis, with only 1-2 setae.

Pronotal warts with numerous dark setae interspersed among pale ones.

Venation similar, though in several individuals M_1 and M_2 had fused for nearly $\frac{1}{4}$ of their length beyond r-m, producing a condition very similar to the one shown by Betten (1934) pl. 54, fig. 2.

Male genitalia (Figs. 2A-D). Scabrous patches posterior to eighth tergite more diffuse, tending to run together on dorsum. Medial dorsal arms of tenth tergite in caudal aspect angulate near apex of inner side; outer arm longer, approaching length of inner arm; ventral processes of tenth tergite black, angled sharply dorsad near base. Cerci short

and pad-like. Claspers fused to ninth segment, truncate, with numerous setae. Dorsal penis sheath not shelf-like, instead a narrow strip across membrane. Aedeagus from dorsal aspect only slightly sinuate near middle; dorsal arms darkened, apex acute.

Female genitalia (Fig. 2E-G). Lateral processes of subgenital plate acutely angulate at postero-medial angle. Lobe between eighth and ninth sternites bearing a brush of hairs. Ninth segment forming a tubular collar around the apparent tenth segment. Claspers indistinct, fused to intersegmental membrane, bearing many dark setae. What may be tenth segment dark scoop-shaped, unlike anything in the female of difficilis.

Larva. The larva of missa (Fig. 6A) is very similar to that of difficilis, differing in the following ways:

Length of mature larva 11-12 mm., as opposed to 14-15 mm.

Head (Fig. 4D) and mouthparts (Fig. 4C) morphologically identical, differing only in being smaller.

All thoracic sclerites (Fig. 4A) in general more hairy. At least three major setae laterad of anterior sclerites of metathorax. The long blade-like setae on posterior margin

of femora clear yellowish on all legs (Fig. 4E-G).

First abdominal segment (Fig. 4A) more hairy; about 15 setae on each side of dorsal hump; venter with approximately 50 setae. An irregular row of 8-10 setae laterad of chitinous plate on dorsum of ninth segment. Each anal proleg with 10-12 setae on membranous ventral portion (Fig. 4B).

Case. Similar to difficilis, but shorter (12-14 mm.) and generally composed of equidimensional sand grains, rarely with plant material.

Pupa. Same as difficilis in structure, but shorter (12-13 mm.) and with shorter anal processes.

Anal processes (Fig. 6B) are only about as long as ninth segment. One long black seta at apex of each process. The two setae along the side of each process exhibiting considerable variation in placement, often one or the other lacking.

Distribution

Records for this species are available from Maine, Vermont, New Hampshire, Massachusetts, New York, Pennsylvania,

Maryland, District of Columbia, Virginia, Illinois, Michigan, and Minnesota.

It would seem that probably the north-south distribution is the same as for difficilis; however, it extends westwardly into the north central states.

Section II. Biological Studies on the Genus Frenesia

THE ADULT STAGE

Flight Period

The time of emergence for adults of the two species of this genus is very unusual, as no other caddis fly in the east flies so late in the year. In Sunderland the earliest date for missa was October 24, difficilis not being found until November 1. Morse in personal correspondence records the earliest date for difficilis: October 3, at Lee, New Hampshire. One of the paratype series at the MCZ in Harvard bears the earliest recorded date for missa: October 17, Ithaca, New York, at electric light. Locally they become numerous in early November, declining in abundance in late November. During most of December they are hard to find although on very warm days they may appear in numbers again. The latest record for difficilis is December 27, for missa January 8, both of these occurring in Sunderland. It would seem that in this locality at least missa has a longer flight period by several weeks.

There are three known records of difficilis appearing

in the spring: Morse & Blickle (1954), VI-24-46, Durham, N.H.; a specimen at the MCZ, VI-21. Glen Carlyn, Va.; and a specimen in the Univ. of Mass. collection, VI-22-35, Amherst, Mass. These may represent individuals that developed slowly and then were prevented from emerging in the fall by cold weather, or they may represent a small brood of this species that normally emerges in the spring and may overwinter in the larval or pupal stage rather than the egg stage.

These insects fly mainly during the daytime, but Morse & Blickle (1954) record taking several specimens of difficilis in a light trap. When not flying, they are found on grasses and herbs, which, being dead and brown in the fall of the year, render the protectively colored caddis flies very inconspicuous. When disturbed, the insects fall from their resting places and feign death, but if annoyed further they right themselves and attempt to escape by running or flying.

Temperature Relations

Flight starts when the temperature rises to 45-55° F. Only the males were taken at these temperatures, the females preferring temperatures about 10° higher.

The ability to withstand low temperatures is remarkable. Some individuals were left outdoors overnight when the temperature dropped to about 20° F. In the morning they could hardly move, yet when taken indoors and warmed up they were soon moving around normally. They may even be found outdoors after freezing weather has set in, and in one instance an adult difficilis was seen walking over frozen ground.

Length of Life

A series of experiments was performed in the laboratory to determine the length of life of adults at room temperature (about 73° F.). Since no reared specimens of a known age were available, adults collected in the field were used. They were placed in Stender dishes with dried grass and a one-inch square of blotter moistened with water. Under these conditions 27 adults of difficilis lived an average of 7.5 days, one surviving for 10 days. Seven adults of missa similarly confined lived an average of 6.1 days, one surviving 9 days. At low outdoor temperatures with lowered metabolic rates one would expect them to live another week or so.

Feeding

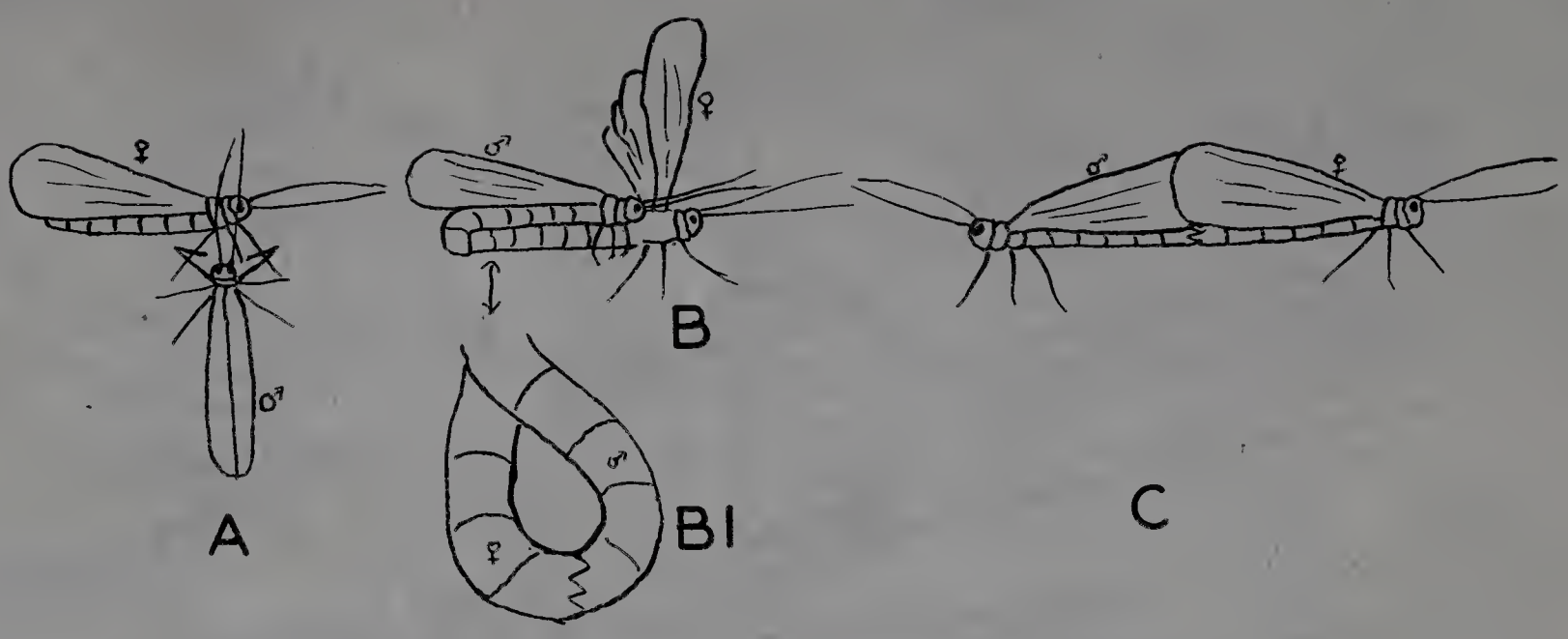
The specimens confined in the Stender dishes were often seen to go through feeding motions on pieces of grass. Individuals move slowly along the grass, lapping or cleaning it with the haustellum in a manner similar to that of a fly. What they were obtaining from the surface is not known.

In order to ascertain if supplementary nutrients would prolong their life, another series of experiments was performed using a sugar solution (33% sugar by volume) instead of water to moisten the blotter. With the sugar solution available 16 difficilis adults lived an average of 11.6 days, one surviving for 14 days. Five missa adults averaged 8.6 days, two surviving for 10 days. These results indicate an average increase of survival time of 4 days in difficilis and 2.5 days in missa, showing that they are able to utilize such nutrients.

Mating

Many times specimens were observed mating in a pint-sized jar, in which they were placed for transport to the laboratory. The process was never observed in nature but is doubtless the same as described here.

The male, when in proximity to the female, becomes very excited, running rapidly over the grass and bottle. Upon meeting the female he tries to grasp her with his front legs. If successful, he holds her at the bases of her front and hind legs, usually from the right side, between the femora and tibiae of his own front legs. The body of the male is thus at about right angles to the body of the female (Fig. A). The male possesses a row of spines on the inner surfaces of the femora and tibiae of the front legs. Apparently the spines allow him to grasp the female securely. The head of the male is very close to the legs of the female, and sometimes he seems to be stroking the bases of her legs with his mouthparts. Next the female raises her wings and the male crawls onto the dorsum of her abdomen, facing the same direction as she. At this point copulation takes place (Fig. B), the male's right side being attached to the female's left (Fig. B1). The pair stays in this position for about one minute, whereupon the male crawls off on the same side he mounted. They now assume the normal position, attached by their genitalia and facing opposite directions (Fig. C).



Often the male does not grasp the legs of the female as he should, and she continues to move while he tries to correct his hold. Sometimes the male succeeds, but often he does not and is dragged around for some time before being brushed off. On some occasions the female fails to raise her wings and the male is shaken off despite all efforts.

It was noted several times that a male of one species would try to mate with a female of the other. In no instance were they able to copulate. Either the female would not raise her wings, or if she did and he attempted to mate, they were unable to do so and soon separated. In one instance a male of missa was observed on the back of a male difficilis trying to mate.

In the laboratory, duration of copulation may vary considerably, the pair generally remaining in copula from one to one and a half days. A single case of extreme length of time in copulation was noted. A pair of missa mated on November 6th and remained in copula until November 23rd, when the female was found dead and slightly mouldy, still being dragged around by the male. In this case the pair must have been unable to separate, as it required considerable force to separate them.

One pair of difficilis was observed to mate twice. A mating pair was put into a container; a day later they separated. Four days afterward they were found in copula again and continued so for about 30 hours. No eggs were laid after either mating.

THE EGG STAGE

Oviposition

Oviposition was never observed, either in the field or in the laboratory. Only once was an egg mass laid in any culture. In this case a dozen adults of difficilis were confined in a screen cage 8-inches in diameter by 12-inches in

height. A large clump of grass was placed on the bottom of the cage, and the whole cage was placed in an aquarium with one inch of ater on the bottom. On the fifth day an egg mass was found on one side of the sod.

Appearance

The eggs are deposited in masses of 100-200, embedded in a gelatinous matrix. The masses when laid are about 2 mm. in diameter, spherical, yellow in color, with the eggs almost contiguous. As the gelatin absorbs water, the mass swells until it is about 20 mm. in diameter, remaining roughly sperical in shape, and varying in color from colorless to light yellow. The eggs are now separated by the gelatin by distances 2-3 times their diameters.

Habitat

The egg masses are deposited out of water, on soil or vegetation, as is typical for the family. A representative site was on grass roots and moss that overhung boards which formed the sides of a pool (station 3). The eggs were three feet above water, often occurring in groups of 4-6 masses in a small pocket, possibly where a pebble had fallen out. In other

instances they were found partially covered by vegetation on dead grass and leaves an inch above water level. Large clumps of Juncus effusus L. growing in some of the pools were commonly used as sites for oviposition. The masses were placed on leaves about an inch above water level. The eggs were moist in all of these situations, being either in seepage areas or on moist substrata.

Duration

Oviposition occurs during late November and early December, but hatching is delayed until the following spring. The egg masses are often frozen solid during the winter, sometimes even having an ice cap. The exact time of hatching varies depending on the season. It occurred in mid-March in 1954, but not until a moth later in 1955. In 1955 the spice bush (Lindera Benzoin (L.) Blume) was coming into full bloom at the time of hatching.

In order to determine how long the egg stage lasts under different conditions, egg masses were put into Stender dishes with a little water added to prevent dessication. The dishes were then covered and kept at different temperatures.

One series was kept at 23°C., a second at 16.5°C., and a third at 5°C.; these required 13, 22, and 35 days respectively to hatch. These results indicate that at normal freezing temperatures outdoors in the winter very little development occurs.

The eggs do not undergo a true diapause during the winter. This fact was proven when a female difficilis laid an egg mass in the laboratory; this egg mass, which was never subjected to freezing temperatures, hatched in 22 days. It is thus cold and not a diapause which retards development and prevents hatching in the fall.

Hatching

The egg masses remain in a semi-solid state even if submerged in water or alcohol for several months. They liquify only when the emerging larvae start crawling through the mass. The eggs cease development and die if the mass is submerged for over a day, and after a week the eggs are commonly surrounded by a halo of mold. Several masses that were hatching were placed in water. The larvae already hatched and the eggs containing larvae ready to hatch lived, but the

rest of the eggs ceased development and soon died.

The larvae stay in or on the mass for a day or so after hatching. In no case were they observed to start building a case while in the jelly. The young larvae may be washed into the water by heavy dews or rains, as recorded by Wesenberg-Lund (1908) for the genus Glyphotaelius. However, some were seen crawling around in a dry Petri dish several days after hatching. This observation suggests that the larvae may leave the egg mass and start searching for water.

THE LARVAL STAGE

Case-making

The first case made by the larva of difficilis consists of fine organic debris. The larva starts by scraping up a mass of debris with its legs. The mass is then cemented by the larva rolling it around with its front legs and mouthparts, spinning silk over it. When the condition of the mass is suitable the larva curls into a "C" shape, and by spinning silk over the debris attaches the mass around the middle of its abdomen. The larva is still uncovered at both ends, but more debris is added to the first band, eventually completing

the case. If another larva happens by, the first is not averse to collecting some material from the newcomer's case for its own. The process of case-making is rapid, the first one being completed in about 15 minutes.

Within several days, larger pieces of plant material are added to the case increasing its rigidity. These pieces of plant material are attached at irregular angles, so that a case has a rather ragged appearance. These smallest cases consist completely of organic material: pieces of wood, leaves, seeds, and bark; one larva had even added a beetle elytron to form one side of the case. By the end of the first stadium sand grains are being added, and at maturity the case is in a large part mineral matter, with pieces of plant material added here and there.

The larva of missa constructs its case from sand grains, not plant material, and continues to do so throughout its life. For this reason the young larvae of the two species may be separated easily, difficilis using organic matter in its case, missa using only sand. At maturity the cases look much more alike, because missa occasionally uses organic matter in its case, and difficilis sometimes builds its case only of mineral

matter. However, at this stage they may still be separated with a great deal of certainty, since missa utilizes a preponderance of small, equidimensional sand grains, while difficilis uses larger, often flattened pieces of rock and vegetation in construction of its case.

Habitat

Available records indicate that larvae develop in clean unpolluted water only. Lloyd (1921) reported difficilis in a small stream flowing out of a sphagnum bog. Ross (1944) records missa as occurring in a seepage area as well as in a stream nearby. Both species occur at the fish hatchery in streams and pools that are spring-fed and unpolluted.

The larva of missa seems to prefer the streams and seepage areas. Ross (1944) states that "... the larvae were congregated in a little seepage area near the bank and were thriving in water scarcely deep enough to cover their cases. Many of the individuals were feeding on leaves and twigs so that most of the insect and its case was actually out of water. Later we found that odd specimens would live in the stream itself; and, since the seepage areas frequently dried

up, it is possible that the reservoir in the stream is chiefly responsible for the preservation of the species in this area." At the fish hatchery, larvae of missa were not observed in large enough numbers in the streams to sustain the adult population found in the same area. Even though it is likely that larvae develop in some of the many seepage areas present at the fish hatchery, no specimens were found in such locations by this investigator.

The record for difficilis indicates that larvae always occur under water and not in seepage areas. Lloyd (1921) recorded larvae in certain portions of a small brook only. They are numerous in certain pools and in most of the brooks at the fish hatchery.

Food

The food of the larva seems to be mostly dead organic matter. Ross (1944) records missa as feeding on leaves and twigs. On the basis of stomach examinations Lloyd (1921) stated that difficilis fed on leaves and decaying wood. All observations and dissections of specimens from the fish hatchery by the present author corroborated these statements.

Duration

The larvae are first found in the spring from mid-March through April; the exact date depends on the season. Development proceeds rapidly during the summer, and the larvae mature in September or October. No study was made on the numbered larval instar; however, Siltata (1907) records 5-6 instars for certain other species of caddis flies.

THE PUPAL STAGE

Pupation

When ready for pupation, the larva attaches the anterior end of its case by silken threads to a rock, root, stick, or other vegetation. The ends of the case are then closed with sand grains, and a silken web is woven over the inside. Ten or a dozen small openings are left at each end; these allow water to circulate through the case.

Habitat

The larvae of difficilis which develop in the pool (sta. 1) seem to favor the submerged bases of the clumps of Juncus effusus L. for pupation. Dozens of pupae may be found

attached at all angles to the leaves and roots at the base of such a plant. Often the larvae burrow beneath small stones and the resulting pupae may be found attached under such objects.

The larvae which develop in streams commonly attach to stones; however, one mass of roots, covered by their cases, was discovered in a brook (sta. 2). Lloyd (1921) described a very similar instance.

The pupae of missa were found in conjunction with those of difficilis in the stream. They were also observed attached to corners and crevices in the boards along the sides of some pools, where they might be situated three feet above the water. In some cases water was constantly trickling over them, but in others they were simply on moist substrata.

Duration

Pupation does not occur immediately after attachment of the case by the larvae. A brief prepupal stage of 1-2 weeks interveness; the prepupae may be found in late September or early October.

The pupal stage itself lasts 3-4 weeks; pupae may be found in October and throughout November.

Emergence

The pupa leaves its case by cutting away the anterior end, though at times it may emerge more laterally than anteriorly. A few strands of silk are often left holding the end so that a "door" swings back into place after the pupa has left. It then swims to some emergent object where it crawls out of the water a distance varying from a quarter of an inch to a foot or so. Next, it attaches itself to some irregularity in the substratum by its front tarsal claws. When the time for ecdysis comes, which may be either immediately or 15-20 minutes after leaving the water, pumping motions begin in the abdomen and sweep forward. The whole body moves forward slowly until the front legs hold the body from further forward movement. The pupal integument splits along the mid-dorsal line of the thorax, and the adult emerges rapidly. The front legs are the first to emerge, followed rapidly by the antennae and middle legs; the hind legs, wings, and abdomen are freed last. The wings as they emerge from the pupal skin are fully expanded, although not yet fully colored and hardened. The process of ecdysis takes only 4-5 minutes if nothing unusual happens; however, the pupa may fall

back into the water if it is not attached securely.

When large numbers of individuals are emerging, the cast skins may form a line on an object suitable for emergence. The boards forming the dam of a pool (sta. 1) where difficilis bred had a line of cast skins just above and parallel to, the water's edge, while other skins were scattered intermittently farther up.

Section III. Records and Descriptions of Other Trichoptera

RHYACOPHILIDAE

Rhyacophila torva Hagen

This species is common in eatern United States, being reported from New Hampshire south to the District of Columbia and west to Wisconsin.

One female was taken at the fish hatchery on July 16, 1954, near the cement bridge (station 5). A small rocky-bottomed stream flowing under the bridge forms a typical habitat for a rhyacophilid. Species taken in conjunction with it were *Parapsyche apicalis* (Banks), *Lepidostoma sommermanae* Ross, and *Phylocentropus lucidus* (Hagen).

No immature stages of this species were found. Descriptions of the larvae were given by Vorhies (1909) and Lloyd (1921).

Rhyacophila invaria (Walker)

Since this species was described from specimens collected in Nova Scotia, it undoubtedly occurs throughout eastern North America. However, it has been recorded in the U. S. only from Pennsylvania (Ross, 1941).

One male was taken at the fish hatchery on July 9, another on July 30, and a third on August 6, 1954 from stations 5 and 9. They were associated with Wormaldia moesta (Banks), Phylocentropus lucidus (Hagen), Parapsyche apicalis (Banks), Lepidostoma sommermanae Ross, and L. vernalis (Banks).

A number of pupae and prepupae were collected on August 6, 1954, from the small stony brook (station 9) just upstream from the cement bridge. Three larvae, corresponding in all structural details with the sclerites from pupal cases, were taken on October 20, 1954, in a mass of leaves at station 6.

With the aid of Ross' key (1944) to the species of larvae of Rhyacophila, these specimens as well as the larva of R. torva should be placed in R. vibox Milne. On the basis of existing descriptions, the larvae of invaria cannot be separated from those of torva and vibox. However, since the larvae of invaria has not been described previously, and since it is possible to separate it from other species given by Ross, a description is given below.

Larva

Length 10-12 mm., width 1.5-2 mm. Shape campodeiform; similar to R. fenestra Ross (see Ross, 1944, fig. 133). Color of sclerites straw yellow marked with light brown; membranous areas pale purplish with paler lines. No gills present.

Head capsule (Fig. 7A) longer than broad in the ratio of 3:1; sides nearly parallel. Color straw yellow, narrowly brownish along anterior margin, light brown band across posterior dorsal half; fronto-clypeus pale, light brown along anterior margin, and on posterior fourth; occipital foramen narrowly bordered by black; muscle insertion marks pale.

Fronto-clypeus with 4 laterally situated pairs of setae: 2 pairs in a row on anterior margin; 1 pair at median constriction; last pair just posterior to widest part of posterior half. Four pairs of pale circular marks, almost certainly not setae: one posterior and median to the two antero-lateral setae; second lateral, situated midway on anterior half; third posterior to seta at median constriction; last spot posterior to posterior seta. A single median pale

mark on anterior margin. Each side of head with 9 setae: one curved pale seta on anterior margin; 2 long and 1 short setae anterior to eye; two more just posterior to eye; one posterior to widest part of fronto-clypeus, one small seta posterior to last, and another small seta ventrad.

Labrum strongly rounded; anterior margin not emarginate. Three setae on each side of labrum; many fine setae on lateral margins. A number of internal ridges or rods arising near base of labrum and ending at base of setae or pale marks.

Mandibles dark, asymmetrical. Right mandible more slender with one strong tooth on inner surface; left mandible with several apical teeth, and one on inner surface. No hairs or brushes.

Maxillary palpi (Fig. 7B) 4-segmented: second segment longest; fourth 2/3 length of second, slightly longer than first; third shortest, 1/3 length of second. Maxillary lobe slightly longer than segment 2 of palpi, ending in several setae and a finger-like lobe which is tipped by single seta. Labial palpi 2-segmented; apical segment slightly longer than basal.

Prothorax straw yellow; brownish oval area centered on midline in the posterior half; black band along posterior and lateral margin; pleural sclerites mostly black. Three large setae in emargination at antero-lateral angle; three very short setae on lateral lip of this emargination. One seta on lateral margin 1/3 of way to posterior angle. Six setae in single row over dorsum near middle of segment.

Mesothorax with one pair of short submedial and one pair of long lateral setae near anterior margin; one pair of long sublateral setae near posterior margin. Metathorax lacking submedial setae, otherwise the same as mesothorax.

Legs pale yellow. Fore legs much shortened and broadened. Proepimeral spur 3 times as long as broad, with single large black apical seta.

First abdominal segment with one pair of long lateral setae near middle; one pair of submedial setae on venter. All remaining abdominal segments with similar setae plus one pair of sublateral setae posterior to lateral seta; sublateral seta with one or two short pale setae near its base. Sclerite on dorsum on ninth segment with one pair of submedian

setae, another pair of long setae on postero-lateral angle, and single short seta between them.

Anal claw without an auxiliary spur. Color a translucent yellow.

Pupa

Length 8 mm., width 2 mm. Color of head and appendages yellowish white, abdomen and thorax purplish.

Head (Fig. 7D) bearing on each side 3 setae near posterior margin of epicranium; one near center of epicranium; one medial near base of antennae; two above lateral margin of labrum; one at antero-lateral angle of the face. Basal segment of antennae with two setae.

Labrum semicircular, with 3 setae in each proximal bristle group, 4 in each distal bristle group.

Mandibles (Fig. 7C) yellowish brown, curved apically. Right mandible with three teeth, the two distal teeth and inner margin beyond them serrate. Left mandible with 2 teeth, apical tooth and margin beyond it serrate. Two setae near base of outer surface.

Antennae extending caudad to anterior half of fifth segment.

Pronotum with 3 setae on each side. Mesothorax and metathorax with one pair of setae submedially near anterior margin, another pair sublaterally in posterior half of segment. Tegulae each with 2 dark and one light setae.

Coxae of fore legs with 4 setae on ventral surface; mesothoracic legs with one seta on coxae. Femora of fore legs with one seta apically on ventral surface, two setae apically on dorsal surface; middle legs dorsally with 2 setae at apex. Tarsi of middle legs with a hair fringe on both sides of all segments but last. Tibial spurs of all legs well developed.

Anterior abdominal hook plates (Fig. 7E) present on segments 3 to 7; posterior plates on segments 3 to 5. Hooks on each anterior plate 3-5, plus several small ones, born on raised part of plate; posterior plates with many small hooks on caudal half of each plate.

Each abdominal segment with 8 pairs of setae: 2 submedially on dorsum; 1 sublaterally on dorsum; 2 laterally; 1 sublaterally on venter; 1 equi-distant from midline to side on venter; the last submedially on venter.

Apex of abdomen with lobes containing developing genital parts.

Case

No larval case is constructed, but a case of small pebbles is made by the larva just prior to pupation. This behavior is typical of the genus.

PHILOPOTAMIDAE

Wormaldia moesta (Banks)

This species is widespread throughout eastern and midwestern North America. Ross (1944) recorded it from Georgia, Indiana, New York, North Carolina, Ohio, Ontario, Tennessee, Virginia, West Virginia, and Wisconsin. The season of emergence in Illinois is March 7 to September 19 (Ross, 1944), and in New Hampshire from June 19 to July 6 (Morse & Blickle, 1953).

One female believed to be of this species was taken at station 10 on July 30, 1954, with Rhyacophila invaria (Walker), Phylocentropus lucidus (Hagen), Parapsyche apicalis (Banks), and Lepidostoma sommermanae Ross, and L. vernalis (Banks).

The larva of this species was described by Ross (1944), who separated it from that of W. shawnee Ross. Betten (1934) figured the larval labrum and coxa of the fore legs of W. moesta.

PSYCHOMYIIDAE

Phylocentropus lucidus (Hagen)

This species is widespread in the eastern part of North America. Ross (1944) recorded it from New York, Nova Scotia, Pennsylvania, and Tennessee. Other records are: New Hampshire, May 8 to August 30 (Morse & Blickle, 1953); Maine, July 16-30 (Procter, 1946).

This species is one of the commonest spring and summer forms found at the fish hatchery. It was taken during 1954 from June 1 to August 6 as follows: June 1-4 specimens with Lepidostoma ontario Ross, L. sommermanae Ross, Thelio-psyche parva Banks, and Parapsyche apicalis (Banks); June 2 - 2 specimens with Lepidostoma sommermanae Ross; June 8 - 17 males, 1 female; June 20 - 3 males with Rhyacophila sp.; July 9 - 6 males with Lepidostoma sommermanae Ross; July 10 1 male; July 16 - 1 male, 1 female with Rhyacophila torva Hagen, Parapsyche apicalis (Banks), and Lepidostoma sommermanae

Ross; July 30 - 13 males, 2 females with Rhyacophila invaria (Walker), Wormaldia moesta (Banks), Parapsyche apicalis (Banks), and Lepidostoma sommermanae Ross; L. vernalis (Banks); August 6 - 1 female with Parapsyche apicalis (Banks), Pycnopsyche divergens? (Walker), and Lepidostoma sommermanae Ross.

Specimens were most commonly taken by sweeping the vegetation along the brooks at stations 7 and 10. In all instances the males outnumbered the females 8 to 1; whether this ratio is one of actual sex frequencies or simply a result of the collecting method employed is not known.

The larva of P. lucidus was described by Betten (1901, 1934) and Sibley (1926). Vorhies (1909) described the larva of another species of the genus, P. placidus (Banks) (=maximus Vorhies). The larvae, which live in sandy streams with little or no bottom vegetation, construct a permanent, branched tubular case most of which is embedded in the bottom. At the fish hatchery the cases were embedded in the muck and sand on the bottom (stations 8 and 10).

Polycentropus sp.

One female of this genus was taken on July 30, 1954,

by sweeping the vegetation at station 10.

The genus is a large one; 26 species are listed by Ross (1944), and since 1944 this number has been increased. Since the females of only a few species are known, it was impossible to determine to which species the specimen belonged.

HYDROPSYCHIDAE

Parapsyche apicalis (Banks)

This species is recorded from several northeastern states. Morse and Blickle (1953) reported it in New Hampshire from June 22 to June 30. In Sunderland it was taken from May 11 to October 1, and thus has one of the longest flight seasons of any caddis fly found at the fish hatchery. Adults were most frequently collected as they were resting on the underside of the cement bridge (station 5).

Individual records are as follows: May 11, 1955 - 1 male with Lepidostoma vernalis (Banks); May 20 - 1 male with Lepidostoma vernalis (Banks); June 1 - 1 male with Phylocentropus lucidus (Hagen), Lepidostoma ontario Ross, L. sommermanae Ross, and Theliopsyche parva Banks; July 16 - 1 male, 1 female with Rhyacophila torva Hagen, Phylocentropus lucidus

(Hagen), and Lepidostoma sommermanae Ross; July 30 - 2 females with Rhyacophila invaria (Walker), Wormaldia moesta (Banks), Phylocentropus lucidus (Hagen), and Lepidostoma sommermanae Ross; August 6 - 1 with Phylocentropus lucidus (Hagen), Pycnopsyche divergens? (Walker), and Lepidostoma sommermanae Ross; August 13 - 2 males, 1 female with Rhyacophila invaria (Walker), and Lepidostoma sommermanae Ross; August 23 - 5 males with Lepidostoma sommermanae Ross; September 22 - 1 female with Lepidostoma sommermanae Ross; October 1 - 1 female with Neophylax nacatus Denning, and Lepidostoma sommermanae Ross.

Larvae were found in abundance in most of the streams at the fish hatchery either between leaves on the bottom or under stones and rocks. They constructed a crude shelter of vegetable debris and small stones. The net for catching food was on the whole poorly developed. Pupae were found in firm, very rough shelters of organic debris.

Ross (1944) figured the head, mandibles, and a portion of the abdomen of the larva and the caudal extremities of the pupa of P. cardis Ross. The larva of P. cardis may easily be separated from that of P. apicalis by the presence

of 6-10 scales in the tufts on the dorsum of the abdominal segments of the latter, as compared with 1-2 scales in P. cardis. The pupae are also easily separated because that of P. cardis has a short thumb-like projection on the inner apical angle of the caudal appendages when viewed in caudal aspect, that of P. apicalis lacks this projection. Since the larva of the latter species has not been heretofore described, a description is included below.

Larva. Length of mature larva 18-20 mm.; width 2.5-3 mm. Campodeiform, of rather uniform width throughout, last three abdominal segments tapering abruptly; shape typical for the family (see Ross, 1944, fig. 281). Sclerotized areas brown, legs paler brown; abdomen pale purplish.

Head (Fig. 8A) roughly rectangular; posterior part slightly expanded; anterior margin strongly rounded. Dorsum dark brown; pale around eyes, along posterior margin, and ventrally. Muscle insertion marks pale. Dorsal area with many small flattened setae; laterally with a patch of short pointed setae. Gular sclerite rectangular, completely separating genae.

Labrum narrow, 3.5 times as wide as long. Dorsum

with many fine anteriorly-pointing setae; several long dark setae submedially. A large brush of curved hairs borne on antero-lateral angle.

Mandibles as depicted by Ross (1944) for P. cardis, but the brush of hairs on the inner surface shorter.

Maxillae and labium (Fig. 8B) ventrally with many dark setae borne on the posterior sclerites. Maxillary palpi 4-segmented; second and third segments shortest, about one-half the length of the first and fourth. Maxillary lobes with several apical papillae and setae.

Thoracic tergites pale brown, margined with black as follows: pronotum on posterior half of lateral margin and posterior margin; mesonotum along almost complete margin, interrupted submedially on posterior margin, with a crescentic mark medially; metanotum black except anterior margin pale laterally. All sclerites with numerous short flattened black setae. Pleurites pale brown, marked with black.

Legs light brown, margined with black at base of coxae, and on mid- and hind legs at articulation of femur and tibia.

Mesosternum with one pair of gills; metasternum with two pairs. Two pairs of sublateral gills on first and seventh abdominal sternites, three pairs of gills similarly placed on segments two through six. One small lateral gill on segments three and seven, two on segments four to six. All gills with 1-2 or 6-8 branches borne at apex.

Abdominal segments 1-8 with many flattened scale-like setae scattered over dorsum and sides. Each segment with two pairs (eighth segment with only one) of tufts of these flattened setae posteriorly, each tuft with 6-10 scales in addition to 1-2 normal setae.

Eighth sternum with one pair of submedian angulate sclerites, each bearing 7-9 setae along caudal margin. Ninth segment with one pair of sclerites covering sternum, each with many dark setae caudally; single small sclerite sublaterally on venter, bearing one long dark seta caudally; dorsum with paired sublateral trapezoidal plate each with one large dark seta near middle of caudal margin.

Anal prolegs pale brown. Each with many short pale setae and scattered long dark ones. Anal brush poorly

developed, with 8-10 long hairs.

Pupa. Length 9-10 mm., width 2-3 mm. Color yellowish white, abdomen purplish. Abdominal processes sclerotized, recurved, and excavated apically.

Head with many long dark setae on front and vertex. Basal segment of antenna with 4 setae. Labrum strongly rounded, with lateral basal lobes; with many dark setae.

Mandibles (Fig. 8D) elongate, toothed apically; left mandible with 4 teeth, right one with 5 teeth. Outer surface basally with 15-20 long dark setae.

Pronotum with many short dark setae sublaterally, one pair of long dark setae submedially. Mesonotum with many short dark setae submedially on anterior half; single pair of long dark setae posteriorly. Tegular area with 7-8 long dark setae. Metanotum with setae arranged as on mesonotum.

Coxae of fore legs with 15-20 setae ventrally; middle legs with 8-9 setae. Trochanter of fore and middle legs each with about 15 setae. Femur of fore leg with single seta at apex. Tarsi of middle legs with poorly developed fringe.

Abdominal sternites 2-7 with 2 pairs of gills sublaterally, each with a number of filaments apically. Lateral projections on segments 3-7; single of segments 3-7, double on other segments; tips of projections either singly or doubly bifid. Dorsum with numerous dark setae, longest along posterior margin.

Hook plates (Fig. 8E) present on segments 3-7 on anterior margin, on segments 3 and 5 on posterior margin.

Anal processes (Fig. 8C) recurved and excavated apically. Lateral cluster of long dark setae basally. Numerous short scabrous setae on caudal surface.

Cheumatopsyche sp.

One partially grown larva of this genus was collected on November 9, 1953. No adults were taken at the fish hatchery, and since there are over 20 species within our range, it was impossible to determine to what species this individual belonged.

The larva of C. analis (Banks) was described by Elkins (1936), but Ross (1944) was unable to find structural characters to separate five species reared in Illinois.

PHRYGANEIDAE

Eubasilissa pardalis (Walker)

No adults of this species were taken, but larvae were collected on October 20, 1954, November 2, 1953, and March 21, 1954 in the pools at stations 1 and 4.

One larva, presumably of this species, collected on March 21, 1954, was put into an aquarium containing a 6-inch cube of rotten birch; within a day the larva began to tunnel in, and in five days it excavated a tunnel large enough to get the entire case, 3-4-inches long and as thick as a lead pencil, out of sight. The adult emerged on about the first of June, but unfortunately escaped, and thus its identity was never absolutely established.

The larva was described by Lloyd (1915, 1921).

Ptilostomis sp.

Three larvae belonging to this genus were collected on November 2, 1954, in association with Eubasilissa in a leaf-covered pool (station 4). No adults were taken.

Four species of this genus occur in the eastern part of North America; it was therefore impossible to

determine to what species these larvae belong.

The immature stages of P. postica (Walker) were described by Vorhies (1909), Lloyd (1921), Sibley (1926), and Betten (1934). Evidently Ross has reared all four species as he (1944) made the statement that no characters have been found which separate the larvae into species.

LIMNEPHILIDAE

Platycentropus prob. radiatus Say

Larvae of this genus were first taken in October, when many small cases made of plant matter in the typical cross-stick type of construction appeared. Nearly mature larvae were taken in late March, at which time the case was made of finer plant material cut off so as to form a compact case, often fuzzy in appearance. No adults were taken at the fish hatchery, but records for Amherst indicate a continuous flight period from June 12 to August 3.

The immature stages have been described by Lloyd (1921), Sibley (1926), Betten (1901, 1934), and Ross (1944).

Limnephilus consocius Walker

No adults were found at the fish hatchery, but many larvae were taken that agree well with Lloyd's (1921) description of this species.

The young larva is unusual in that it builds a case out of leaf fragments which is triangular in cross section. By the following spring the case has been changed to a rough cylinder, composed mostly of flattened pieces of rock. The case of a mature larva is similar in appearance to one made by Frenesia difficilis, but it is longer (20 mm., compared to 18 mm.), and wider (5-6 mm., compared to 3-4 mm.). The pupal case is generally closed by one large pebble, rather than by a number of smaller ones as in F. difficilis.

Eggs hatch in the fall, and individuals overwinter in the larval stage. The larvae mature during the following spring and summer. Pupae were found at the fish hatchery only on August 6, and the following week adults had emerged and disappeared. Morse and Blickle (1954) record the flight season in New Hampshire as being from April 24 to August 15.

It is impossible to determine this species as Limnephilus by using Ross's key (1944) because it has only single gill filaments; Ross characterized the genus by the presence of multiple gill filaments. In this key a larva would run to Pycnopsyche, from which it may be separated by lack of a dorsal hump on the first abdominal segment.

Pycnopsyche prob. divergens (Walker)

One female of P. divergens was collected at the fish hatchery (station 6) on August 6, 1954. Three specimens, all females, emerged in the laboratory: one on August 20, two on August 27. Since females only were taken, it is impossible to be certain of this identification.

Larvae, probably of the same species, were fairly common in most of the streams that were full of leaves. The young larvae make a flat, two-sided case of roughly circular leaf fragments, similar to that recorded by Lloyd (1921) for P. scabripennis (Ramb.). Late in the fall or the following spring the case type is changed to a rough,

irregular one made mostly of plant fragments.

The insects pass the winter in the larval stage, young larvae first being found in October. They remain active during the winter. In the laboratory, specimens pupated in early August, emerging late in the month. The few records of adults are scattered throughout the months of August and September.

Immature stages of many species of Pycnopsyche have been described: P. gentilis (McL.) by Sibley (1926); P. guttifer (Wlk.) by Lloyd (1921), Sibley (1926), and Betten (1934); P. luculentus Betten by Betten (1934); P. scabripennis (Ramb.) by Lloyd (1921) and Sibley (1926); P. subfasciata (Say) by Vorhies (1909), Sibley (1926), and Elkins (1936). However, it is impossible to separate these species on any characters so far employed.

Neophylax nacatus Denning

This species was described in 1941 from specimens collected in New Hampshire, Vermont, and Virginia. It is undoubtedly widely distributed throughout eastern U.S., although as yet it has not been reported again.

Three specimens were taken on October 1, 1954, and

one additional male on October 25, by beating evergreen trees at station 6; they were found in conjunction with Lepidostoma sommermanae Ross, and Parapsyche apicalis (Banks).

The larvae are common in many streams possessing a rocky bottom. Their behavior is well known; each larva becomes full grown in early summer, when it seals the case, attaches it to a rock, and passes the summer in aestivation, pupating in the fall without opening the case. One rather flattened rock about 8-inches in diameter had 81 cases attached to it, most of the cases being in one small area about 4-inches long by 2-inches wide. Pupation occurs in the latter part of August or early September.

The larva of N. nacatus has never been described, but N. concinnus McLachlan (=autumnus Vorhies) was described by Vorhies (1909), Lloyd (1921), and Ross (1944), and N. consimilis Betten was partially figured by Betten (1934). It is not known what species Lloyd (1921) figured as N. concinnus, because his determination was evidently wrong.

Pale muscle insertion marks on the posterior part of the fronto-clypeus, and the presence of a prosternal

horn in N. nacatus will separate it from N. concinnus. The species recorded as N. concinnus by Lloyd (1921) is easily separated from N. nacatus by the pale mesonotum and head of Lloyd's species. The figures given by Betten of N. consimilis are not complete enough to separate this species from N. nacatus.

The association of adult and larva is based on a male metamorphotype. Many larvae were collected the sclerites of which were identical to those of the metamorphotype; these larvae were used in part of the description for length and for setation.

Larva. Length of prepupa 5-6 mm., width 1-1.5 mm. Color of sclerites mostly deep brown to pale brown, marked with black or yellowish. Abdomen cream-colored, reddish dorsally. Shape eruciform, almost cylindrical (Fig. 9A).

Color of head deep brown, paling from region of eyes posteriorly. Six to eight pale muscle insertion marks posterior to eye, none on fronto-clypeus.

Head in frontal aspect longer than wide. Low broad ridge on genae paralleling posterior half of fronto-

clypeus. A definite tubercle situated on low projection near middle of fronto-clypeus, in lateral aspect (Fig. 9F) curved dorsad and slightly longer than wide. Fronto-clypeus with three pairs of setae: 2 pairs of long dark setae in transverse row near anterior margin; third pair pale and curved mesad, inserted at antero-lateral angles; many pale spots, evidently not setae. Genal halves each with 7 setae: 1 small seta near apex of fronto-clypeus; 2 long black setae posterior to eyes, another small seta laterad; 1 long stout seta anterior to eye; 1 long seta at antero-lateral angle, another small seta laterad.

Labrum (Fig. 9D) twice as wide as long, rounded laterally. Curving row of six dark setae posterior to anterior margin. Anterior margin very hairy.

Mandibles (Fig. 9E) nearly triangular, black, with single apical ridge-like tooth; no teeth on inner surface. A brush of hairs on inner margin of each mandible. Outer surface with one large and one small seta.

Pronotum (Fig. 9C) rounded anteriorly, projecting out over head. Anterior margin with comb of short pale

setae; black setae scattered over the rest of the dorsum. Color of pronotum light yellowish brown, posterior half irregularly mottled with brown. Black inverted "Y"-shaped mark at postero-lateral angle; black line interrupted near the middle, extending over dorsum near posterior margin. A short membranous prosternal horn present.

Mesonotum (Fig. 9B) rectangular, about twice as wide as long, the anterior margin with rectangular mesal emargination. Color brown, pale near center of sclerite, black "L"-shaped mark on postero-lateral angle.

Metanotum with three small sclerites: anterior pair very small, bearing only one long seta; posterior one larger, about one-third width of segment, bearing one long seta, and two smaller ones; lateral pair long, strap-like, with three long and three short setae on anterior half.

Legs yellowish brown, marked with black at articulations of coxa and trochanter, and of femur and tibia. All legs about the same structurally, fore leg only slightly widened.

First abdominal segment with irregular row of 7-8

setae on each side of dorsal tubercle, 2-3 more setae on dorsal part of lateral hump. Sternum with uneven row of 4-5 setae on each side, and sublateral thumb-like membranous projection; three setae between this projection and lateral hump.

Abdominal segments 2-8 dorsally and ventrally with a pair of submedian hairs; second segment with additional single antero-lateral hair.

Lateral fringe line from anterior margin of segment 3 to posterior margin of segment 7. Gills simple, appearing to be constant in arrangement. Transverse oval sclerotized rings on venter of segments 3, 4, and 5. Chitin plate (Fig. 9G) on ninth tergum with 15 setae. Three long and 2 short black setae borne on sclerite around anal claw. Anal claw with single small sharp dorsal tooth.

Pupa. Length 7 mm., width 1.5 mm. (Fig. 9I). Color creamy, dorsum of abdomen reddish.

Head with 4 pairs of fine hairs on front and vertex; one pair on vertex, second near base of antennae, third submedially near base of labrum; fourth mesad of lower part of eye. Labrum semi-circular: proximal bristle group of three

slender setae; distal group of 5 long hooked setae. Mandibles inflated at base, becoming flattened and blade-like in distal 2/3; two setae near base on outer surface.

Antennae longer than body, curling up and around terminal abdominal segments.

Mesothorax with scattered group of 5-6 short setae on each side of anterior half; 2 pairs of sublateral setae on posterior half. One seta on tegular area. Metanotum with 2 paired setae, one on anterior half, the other on posterior half.

Coxae of front legs with 1 seta near base; of middle legs with one seta near base, another near apex. Trochanter of front and middle legs with 2 setae on outer surface. Hind legs curving dorsad beyond apex of abdomen.

Posterior margin of first abdominal segment with one row of short scabrous setae. Hook plates (Fig. 9J) anterior on segments 3 to 7; posterior plate on segment 5. Anterior plates with 3-5 large hooks and varying numbers of short hooks; posterior plate with 25-30 short hooks. Segments 1-8 each with single pair of submedial setae both dorsally and ventrally. One pair of sublateral sclerotized

rods dorsally and ventrally on segments 1-8. Fringe line well developed, extending from middle of segment 5 to posterior margin of segment 8, where it curves ventrad and ends. About 12 fine setae ringing the posterior margin of segment 9. Tenth segment ventrally with 4 pairs of setae, dorsally scabrous for posterior half. Anal processes (Fig. 9H) very slender, over twice as long as tenth segment.

Neophylax sp.

Throughout the summer many larvae of another species of Neophylax were taken in conjunction with N. nacatus, from which nacatus differed by having dark colors on the head and thorax. The species is the same or closely related to the one described by Lloyd (1921) as N. concinnus. Since no adults of any species of Neophylax except nacatus were taken, it was impossible to determine to what species these larvae belonged.

Limnephilidae sp.

The larvae of an unknown genus and species of this

family were common in the leaf-clogged brooks, especially in the fall. They were taken on October 25, 1954, November 2 and 9, 1953, and March 21, 1954.

In Ross's key (1944) these larvae would be placed in Pycnopsyche. They may represent another species of Pycnopsyche, but they differ from all larvae of this genus examined by the present investigator in that the first abdominal segment is ventrally very hairy, and the case, made completely of sand grains, is taperedand slightly curved. It is likely that the larvae belong to a genus of Limnephilidae whose early stages have not yet been described.

MOLANNIDAE

Molanna sp.

Larvae of this genus were commonly taken during most of the year at station 8 where they lived in water scarcely deep enough to cover their cases. They lived on or in the top quarter inch or so of dark silt and muck so that the pale cases were very conspicuous.

The following species have been described in their immature stages: M. blenda Sibley by Sibley (1926);

M. flavicornis Banks by Neave (1933) and Denning (1937); M. tryphena Betten (as cinerea Betten) by Betten (1901, 1902, 1934); M. uniophila Vorhies by Vorhies (1909) and Ross (1944). Unfortunately it is as yet impossible to separate these immature stages.

LEPIDOSTOMATIDAE

Lepidostoma ontario Ross

This species is northeastern in distribution, having been previously reported form Ontario, New Hampshire, Maine, and Nova Scotia by Denning (1954). A male and female were taken on June 1, 1954 by sweeping vegetation along a stream; with it were Phylocentropus Lucidus (Hagen), Parapsyche apicalis (Banks), Lepidostoma sommermanae Ross, L. ontario Ross, and Theliopsyche parva Banks.

The immature stages have not yet been described. One fully developed male pupa taken on September 22, 1954 is described below.

Pupa. Length 6 mm., width 1 mm. (Fig. 10E).

Head with 4 pairs of setae; 1 pair submedially, and 1 laterally near anterior margin, another pair anterior

to base of antennae; last pair on vertex.

Labrum (Fig. 10A) roughly quadrate, anterior margin slightly curved. Distal and proximal bristle groups each with 2 long black setae twisted at apex; anterior margin with several small setae. Mandibles (Fig. 10B) inflated at base, apically thin and blade-like; two setae on outer face near base.

Antennae extending caudad to anal processes.

Mesonotum with 2 pairs of seta: 1 submedial near anterior margin; second submedial near center of segment. Metanotum with 1 pair of submedian setae near center of segment.

Coxae of fore legs with 4 setae on ventral face; middle legs with 2 setae on latero-ventral surface. Hind legs extending caudad to ninth segment. Wing pads extending to caudal margin of fith abdominal segment.

Single gills present dorsally on posterior margin of abdominal segments 3-7, ventrally on segments 4 and 5 at least. (Gills are difficult to see and some may have been missed.) Fringe line present laterally from middle of segment 3 to 8th segment where it curves ventrad.

Sublateral paired sclerotized rods present ventrally on segments 2-8. Segment 1 dorsally with a roughly trapezoidal plate, much narrowed anteriorly, postero-lateral angles projecting caudad and each bearing a seta. Dorsal anterior hook-bearing plates (Fig. 10D) with 2-4 hooks; posterior hook plate with 7 hooks. Ninth segment dorsally with a row of about 12 setae on caudal margin. A pair of membranous lobes arising laterally on ninth segment, curving mesad and meeting beneath anal processes. Anal processes (Fig. 10C) roughly "U"-shaped; 2 setae laterally in basal half; apex of each arm with 4 long black stout setae, and 2 shorter thinner ones.

Case. The pupal case is typical for the genus; it is square in cross section, formed of rectangular pieces of leaf and bark.

Lepidostoma vernalis (Banks)

The species is listed by Denning (1949) from New York, North Carolina, New Hampshire, and Massachusetts.

Three males were taken at the fish hatchery under the cement bridge (station 5) as follows: May 11, 1955

with Parapsyche apicalis (Banks); May 20, 1955, with Parapsyche apicalis (Banks);July 30, 1954, with Rhyacophila invaria (Walker), Wormaldia moesta (Banks), Phylocentropus lucidus (Hagen), and Parapsyche apicalis (Banks).

The immature stages have not been described.

Lepidostoma sommermanae Ross

This is another species of eastern U.S. distribution, having been reported from New York, New Hampshire, North Carolina, and Massachusetts by Denning (1954). At the fish hatchery it was one of the commonest species and it had the longest flight season.

Following are individual records: June 1, 2 males, 1 female with L. ontario Ross, Theliopsyche parva Banks, Parapsyche apicalis (Banks), Phylocentropus lucidus (Hagen); June 2, 2 males, 4 females with Phylocentropus lucidus (Hagen); July 9, 4 males, 3 females, with Phylocentropus lucidus (Hagen), Rhyacophila invaria (Walker); July 16, 1 female, with Parapsyche apicalis (Banks), Phylocentropus lucidus (Hagen), Rhyacophila torva Hagen;

July 30, 9 males, 5 females, with Rhyacophila invaria (Walker), Wormaldia moesta (Banks), Phylocentropus lucidus (Hagen), Parapsyche apicalis (Banks), Lepidostoma vernalis (Banks); August 6, 6 specimens, with Phylocentropus lucidus (Hagen), Parapsyche apicalis (Banks), Pycnopsyche? (Walker); August 13, 5 males, 2 females, with Rhyacophila invaria (Walker), Parapsyche apicalis (Banks); August 23, 2 males, 6 females, with Parapsyche apicalis (Banks); September 22, 1 female, with Parapsyche apicalis (Banks); October 1, 3 males, 1 female, with Parapsyche apicalis (Banks), Neophylax nacatus Denning; October 15, 1 male, 1 female, floating dead on water.

L. sommermanae was most commonly taken on the underside of the cement bridge (station 5), although adults were also collected by sweeping or beating evergreens.

The immature stages have not been described.

Lepidostoma sp.

Larvae of this genus were taken frequently in both fall and spring of 1954 and 1955. They were found

in the small streams, some of the pools, and the sand spring (station 7).

The larvae make two distinct types of cases, an observation already recorded by Vorhies (1909) for L. bryanti (Banks) (=wisconensis Vorhies) and Ross (1944) for L. liba. The case type common in the fall is cylindrical, slightly tapered, and made of fine sand grains. In the spring, summer, and sometimes in the fall, a case square in cross section and made of plant fragments is common. A transition type, found in March and April, is cylindrical at the posterior end, and square at the anterior.

Larval stages of three species have been described to date: L. bryanti (Banks) (=wisconensis Vorhies) by Vorhies (1909); L. griseum (Banks) by Sibley (1926); and L. liba Ross, by Ross (1944). The larvae of Lepidostoma cannot be identified to species on the basis of present descriptions.

Most of the larvae collected are undoubtedly those of L. sommermanae because it is the commonest species.

Theliopsyche parva Banks

This relatively rare species has been known only from the type series taken at Woodworth's Lake, Culton Co., New York (Ross, 1946). Two females and a male were taken at the fish hatchery on June 1, 1954, by sweeping vegetation. They occurred with Phylocentropus lucidus (Hagen), Parapsyche apicalis (Banks), Lepidostoma sommermanae Ross, and L. ontario Ross.

The immature states are unknown for any members of this genus.

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To all these the author extends grateful appreciation.

Figure 1, Frenesia difficilis (Walk.), adult.

1A. Male terminalia, lateral.

1B. Male terminalia, caudal.

1C. Aedeagus, lateral.

1D. Aedeagus, dorsal.

1E. Female terminalia, lateral.

1F. Female subgenital plate, ventral.

1G. Female ninth segment, ventral

Figure 2, Frenesia missa (Milne), adult.

2A. Male terminalia, lateral.

2B. Male terminalia, caudal.

2C. Aedeagus, lateral.

2D. Aedeagus, dorsal.

2E. Female terminalia, lateral.

2F. Female subgenital plate, ventral.

2G. Female terminalia, caudal.

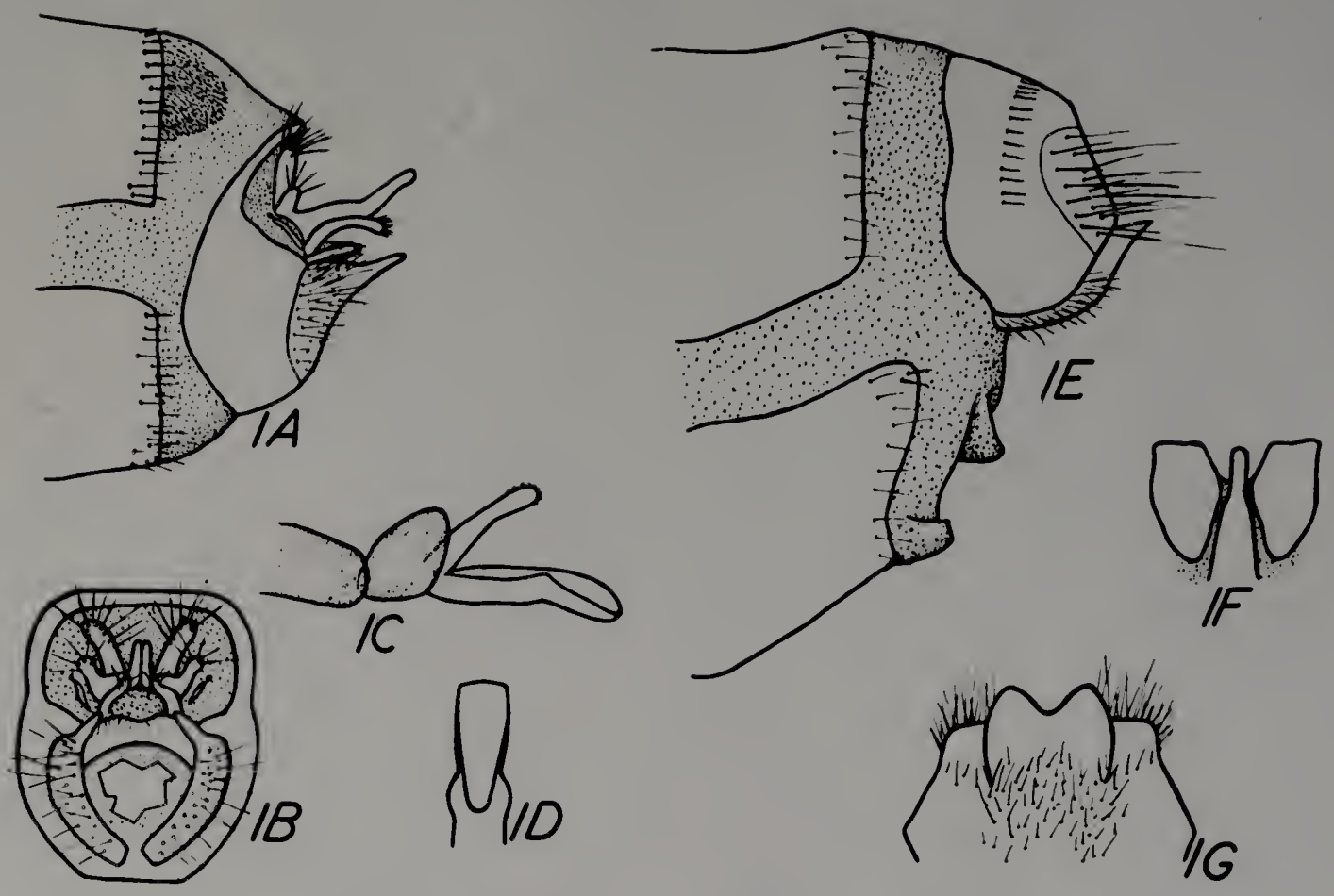


FIG.1 FRENESIA DIFFICILIS (WALK.)

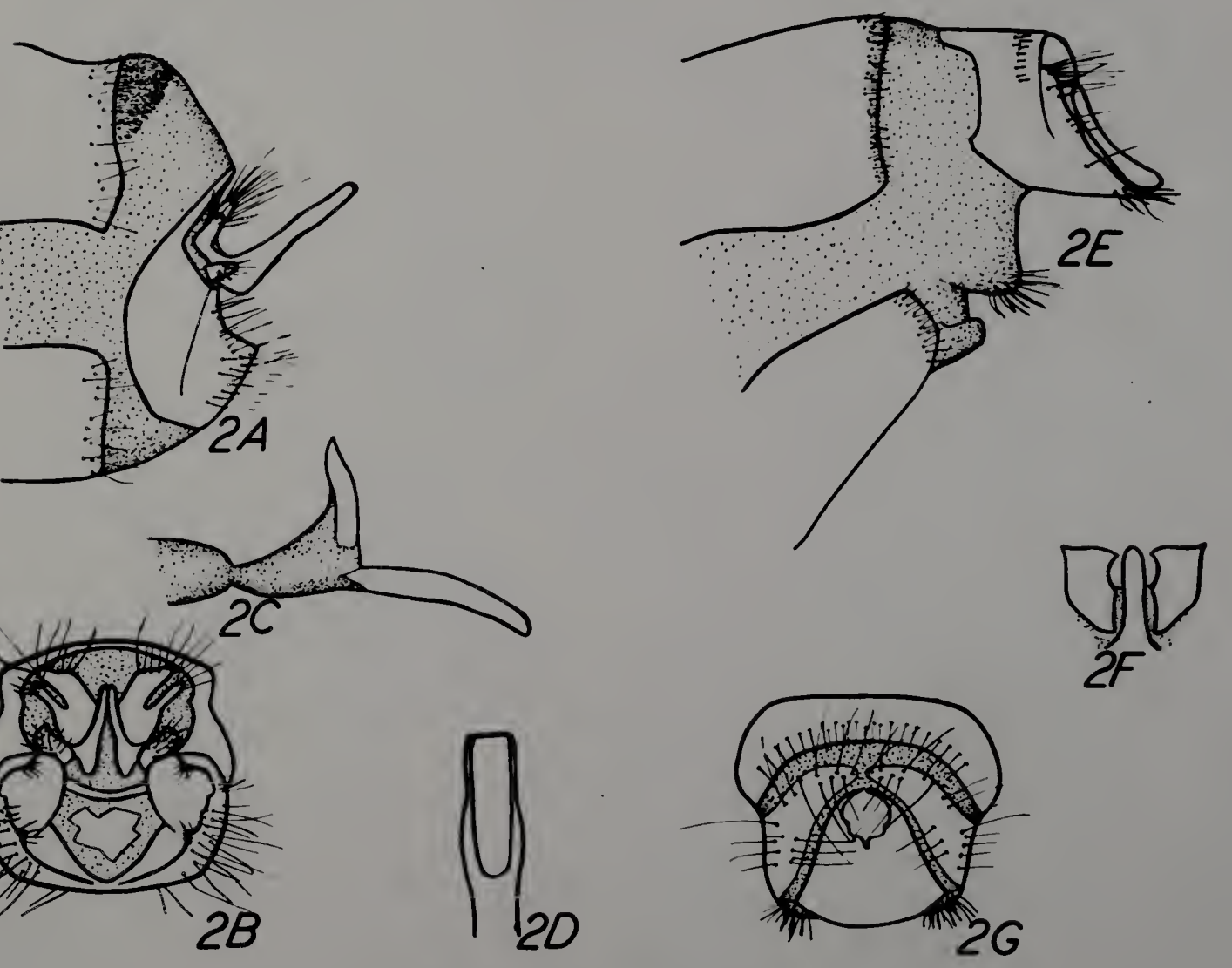


FIG. 2 FRENESIA MISSA (MILNE)

Figure 3, Frenesia difficilis (Walk.), adult

3A. Venation of right wings.

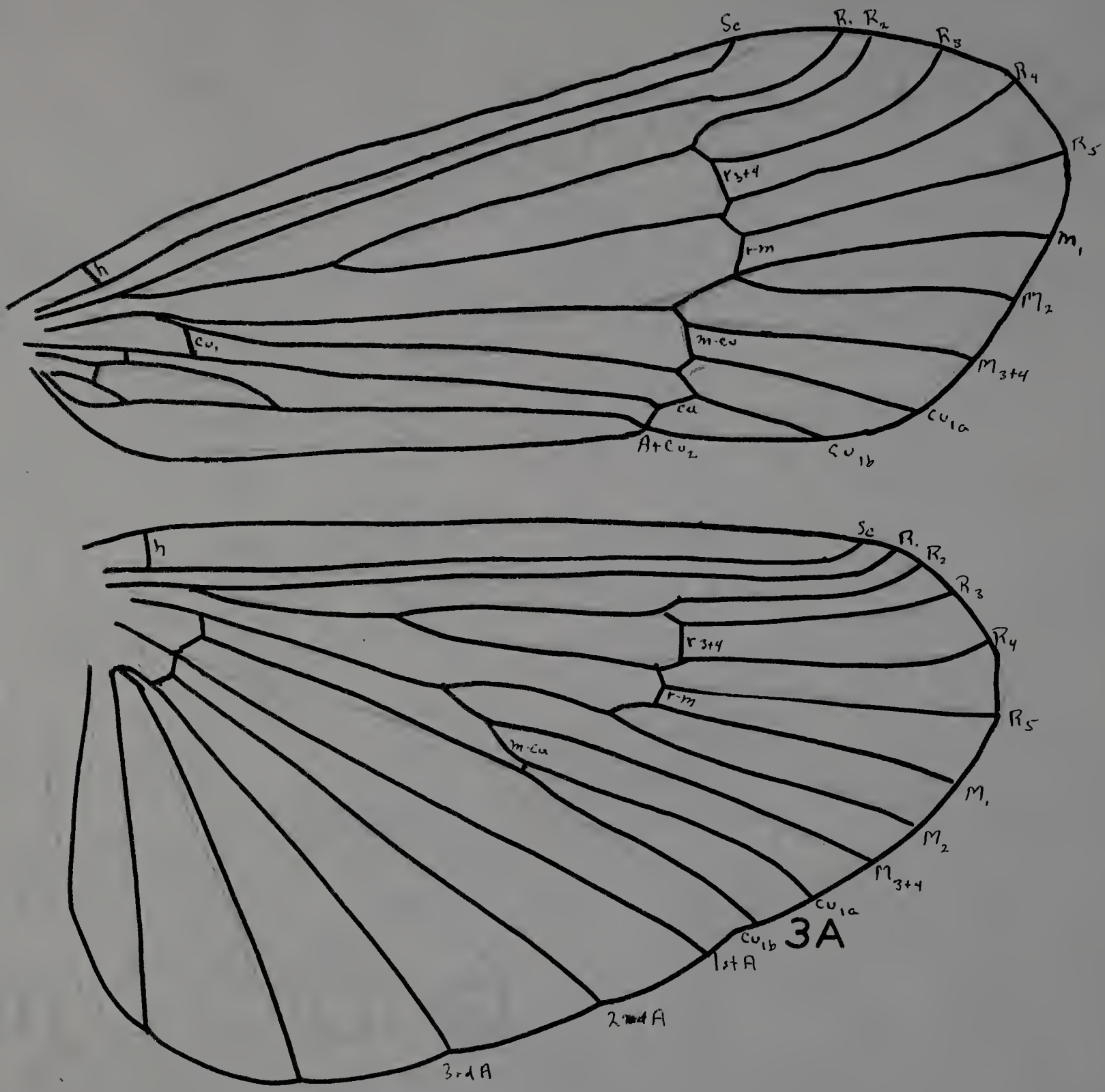


FIG. 3 FRENESIA DIFFICILIS (WALK.)

Figure 4, Frenesia missa (Milne), larva.

4A. Thorax and first abdominal segment, dorsal.

4B. Membranous portion of anal prolegs, ventral.

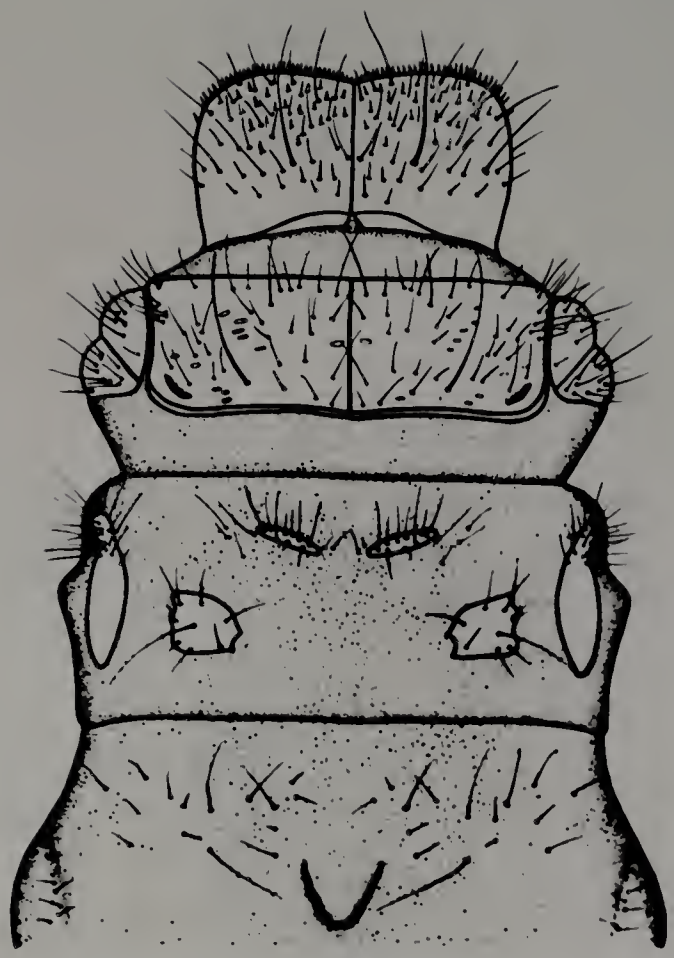
4C. Maxillae and labium, ventral.

4D. Head, anterior.

4E. Fore leg, lateral.

4F. Middle leg, lateral.

4G. Hind leg, lateral.



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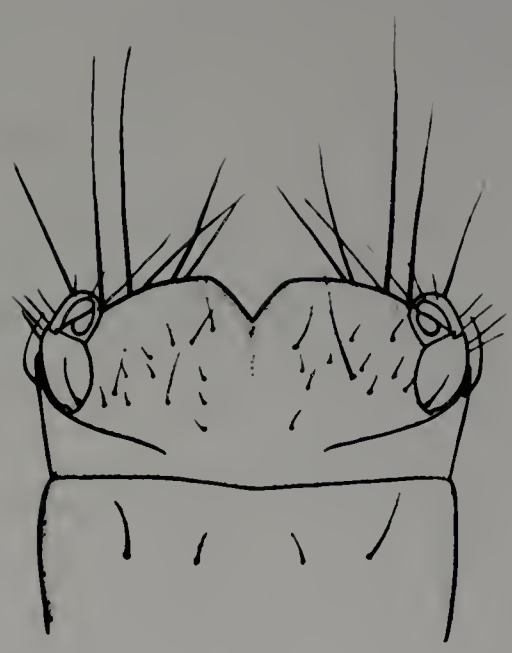

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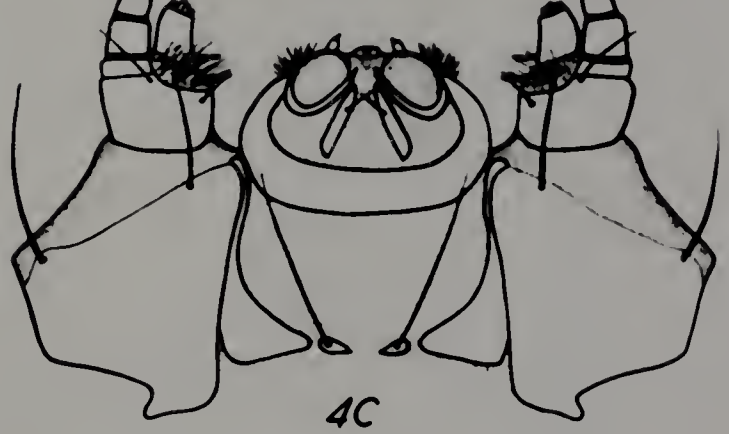

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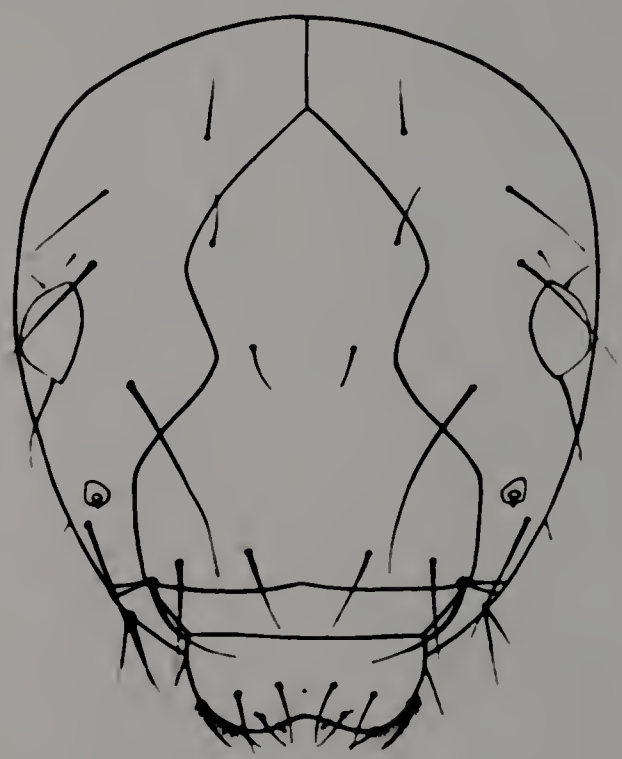
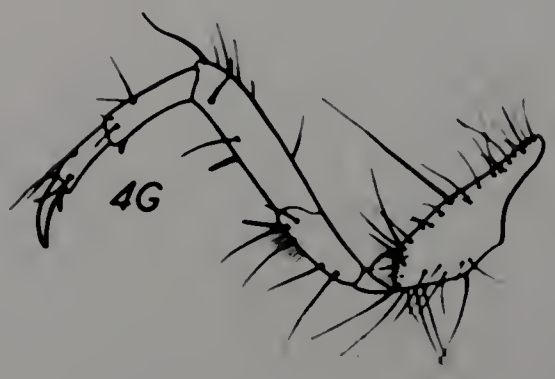


4D

4E

4F



4G

FIG. 4 FRENESIA MISSA (MILNE)

Figure 5, Frenesia difficilis (Walk.), pupa.

5A. Dorsal view.

5B. Anal processes, dorsal.

5C. Mandibles.

5D. Labrum.

Figure 6, Frenesia missa (Milne).

6A. Larva, lateral.

6B. Pupa, anal processes, dorsal.

6C. Pupa, hook plates (a-anterior, p-posterior).

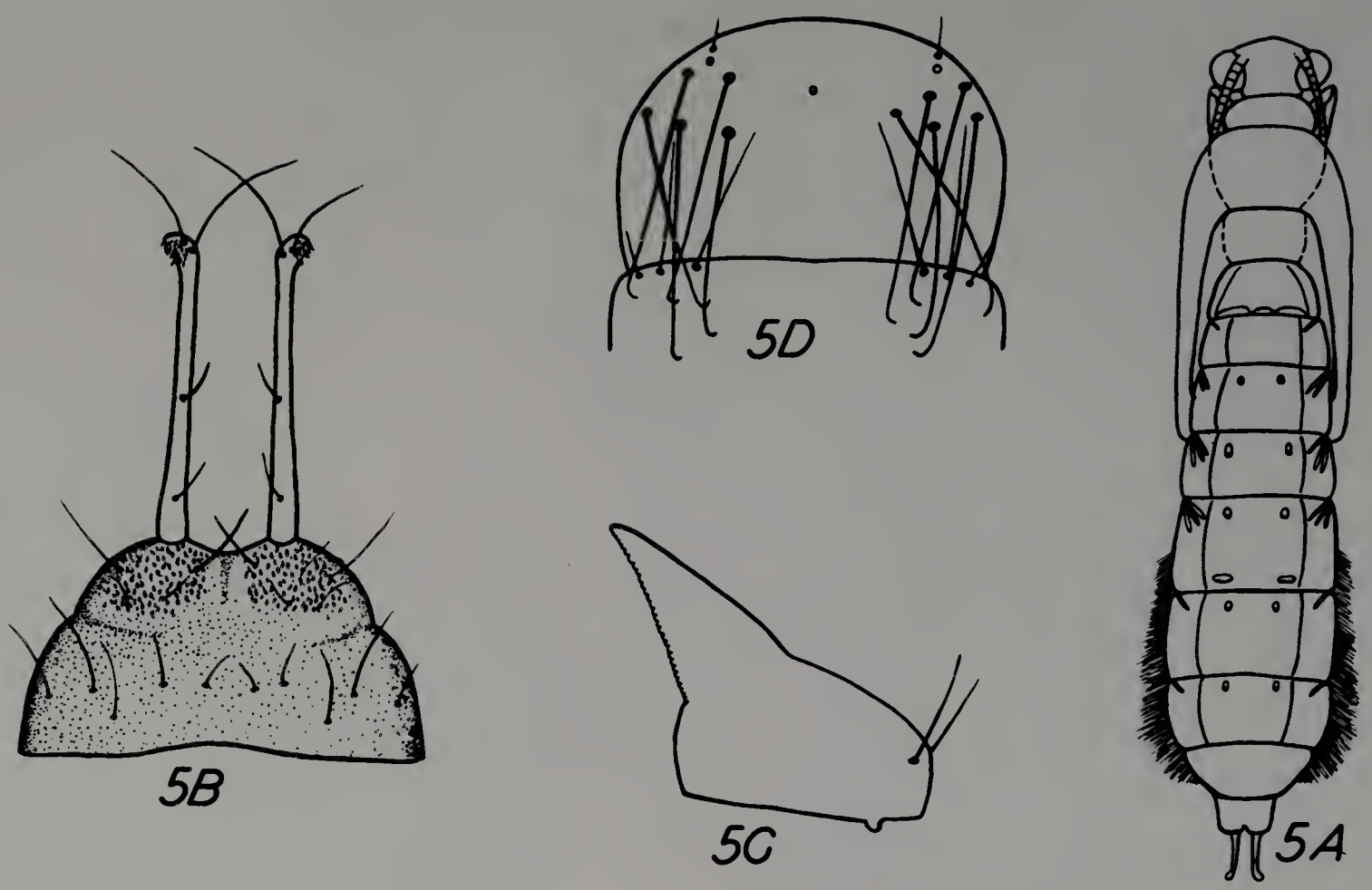


FIG.5 FRENESIA DIFFICILIS (WALK.)

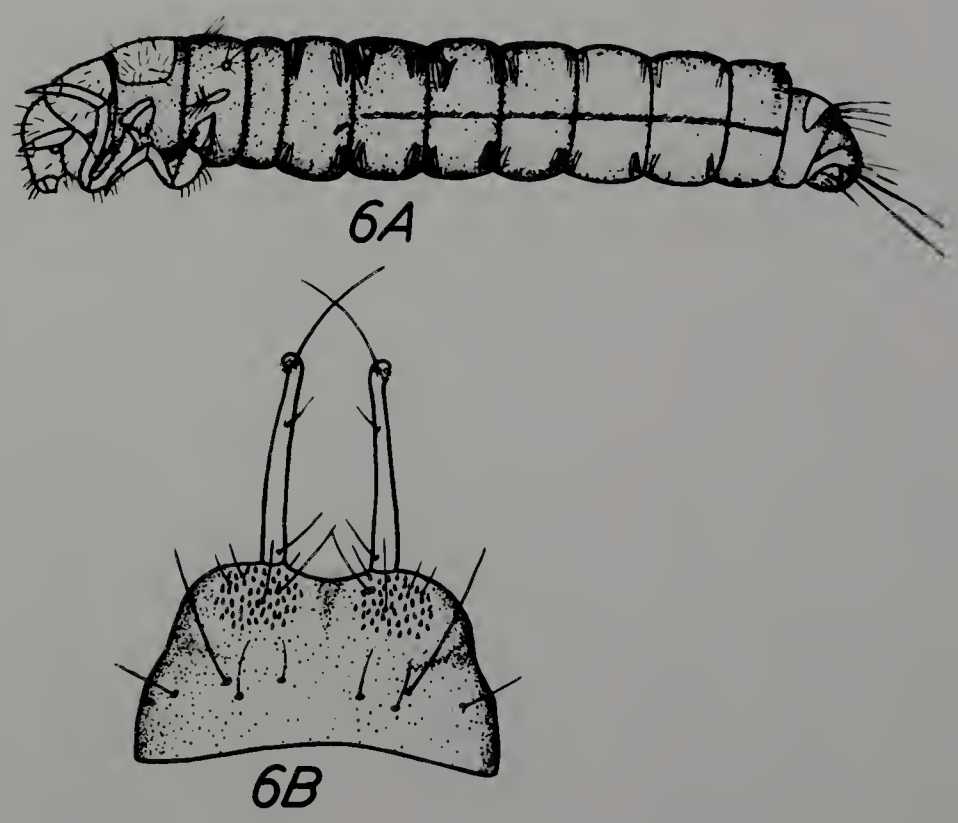


FIG.6 FRENESIA MISSA (MILNE)

Figure 7, Rhyacophila invaria (Walk.).

7A. Larva, head, dorsal.

7B. Larva, maxillae and labium, ventral.

7C. Pupa, mandibles.

7D. Pupa, head, anterior.

7E. Pupa, hook plates (a-anterior, p-posterior).

Figure 8, Parapsyche apicalis (Banks).

8A. Larva, head, dorsal.

8B. Larva, maxillae and labium, ventral.

8C. Pupa, anal processes, caudal.

8D. Pupa, mandibles.

8E. Pupa, hook plates, anterior plates in lateral view.

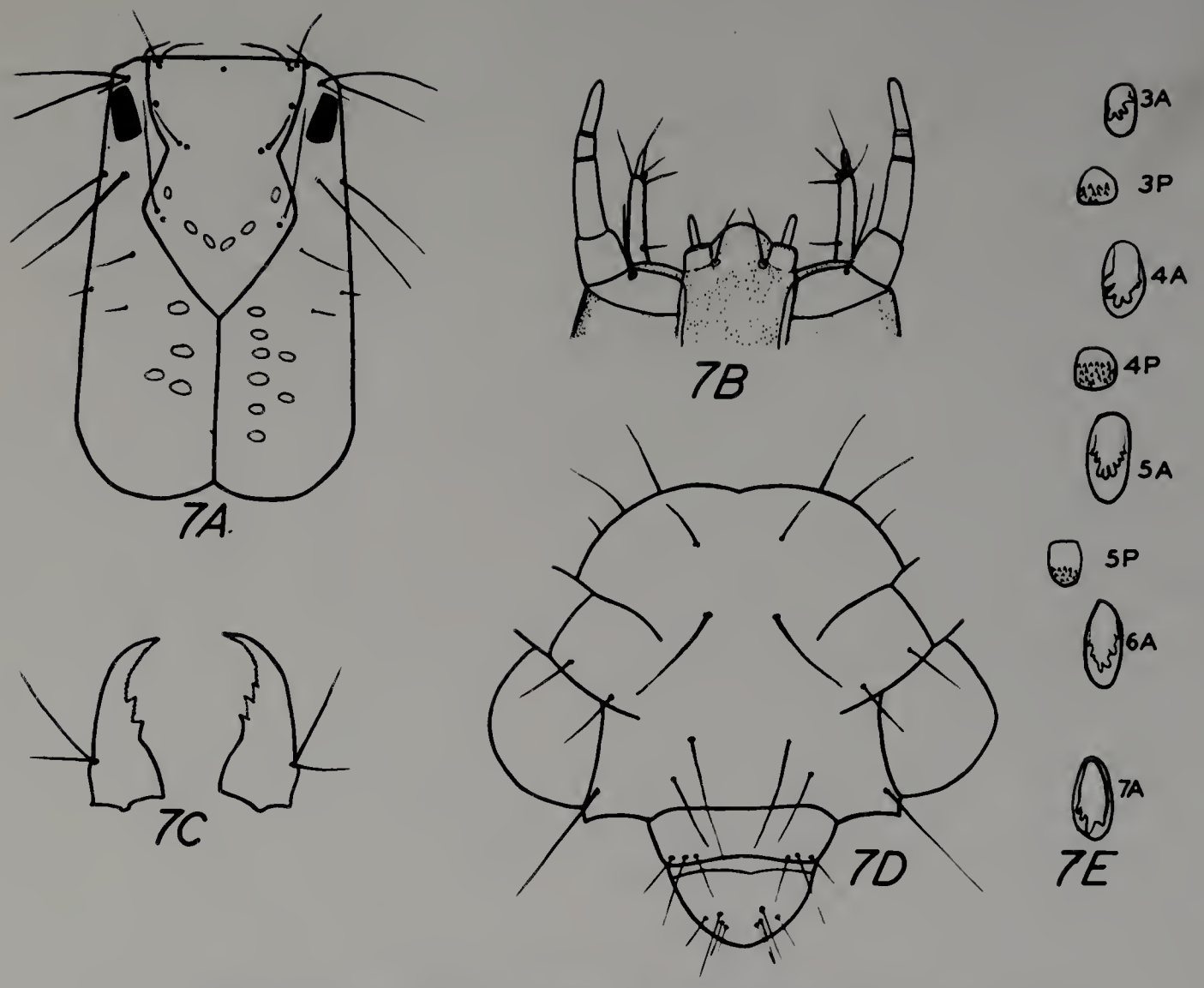


FIG.7 RHYACOPHILA INVARIA (WALK.)

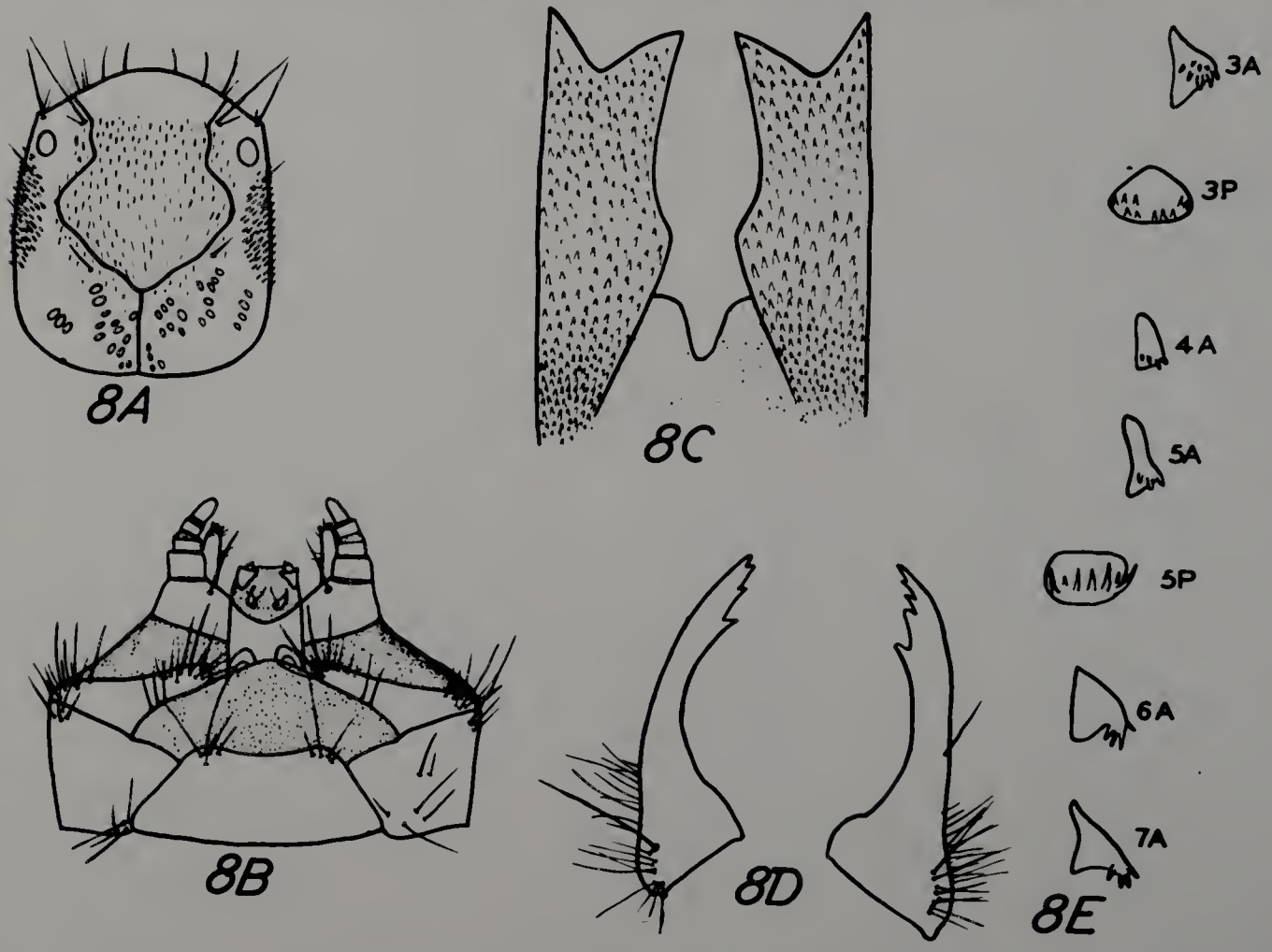


FIG.8 PARAPSYCHE APICALIS (BANKS)

Figure 9, Neophylax nacatus Denning.

9A. Larva, lateral.

9B. Larva, left half of mesothoracic tergite (from metamorphotype).

9C. Larva, right half of prothoracic tergite (from metamorphotype).

9D. Larva, labrum (from metamorphotype).

9E. Larva, mandibles (from metamorphotype).

9F. Larva, frons (from metamorphotype).

F'. Central tubercle, lateral.

9G. Larva, dorsal plate of ninth segment (from metamorphotype).

9H. Pupa, anal processes, dorsal (from metamorphotype).

9I. Pupa, hook plates (a-anterior, p-posterior) (from metamorphotype).

9J. Pupa, dorsal (from metamorphotype).

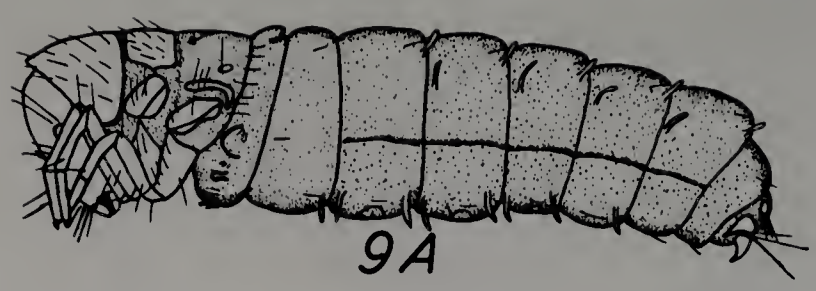
Figure 10, Lepidostoma ontario Ross, Pupa.

10A. Dorsal view.

10B. Labrum.

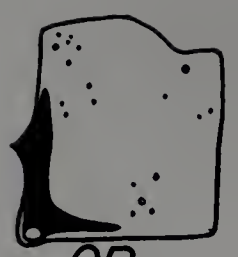
10C. Mandible.

10D. Hook plates.



9A

9C



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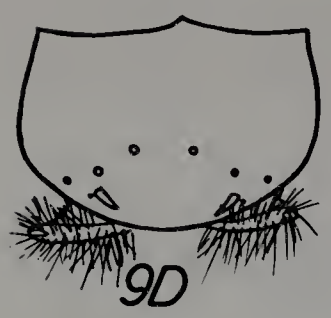

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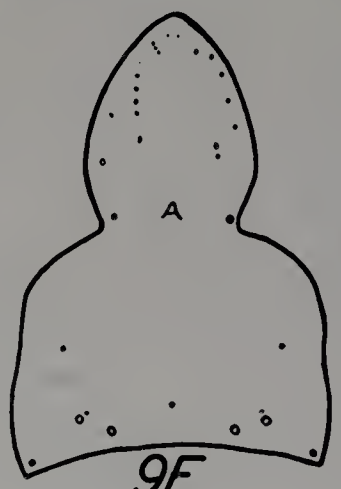

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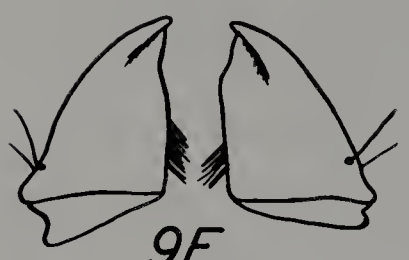
F1



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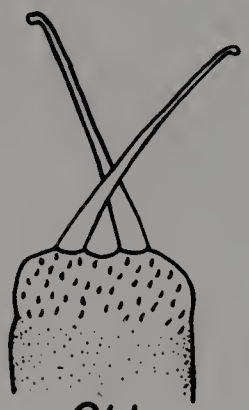

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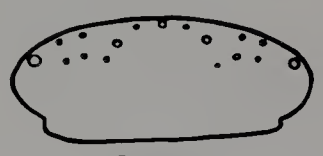

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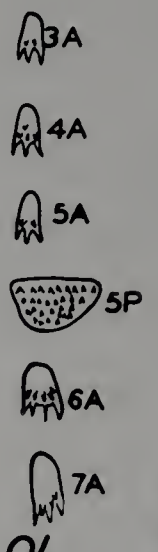

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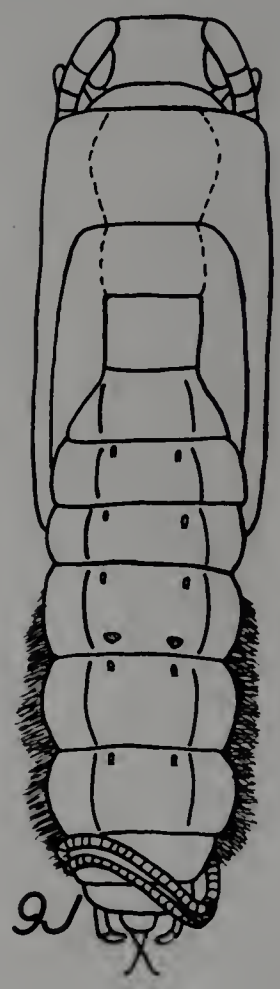

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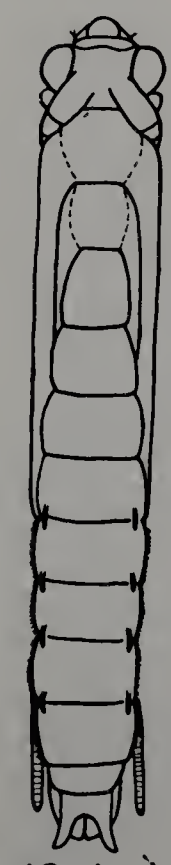
FIG.9 NEOPHYLAX NACATUS DENN.



10A

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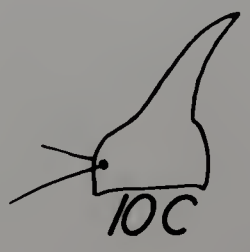

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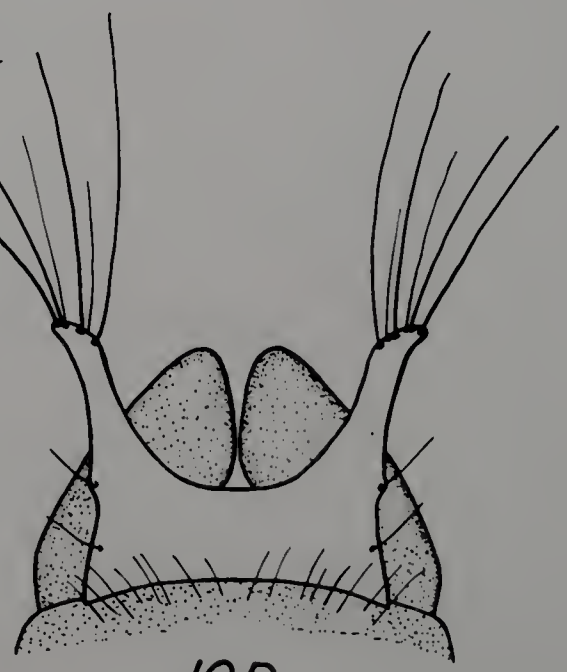

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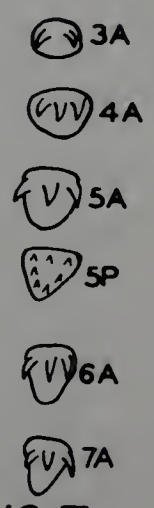

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FIG.10 LEPIDOSTOMA ONTARIO ROSS

Map of the Sunderland State Fish Hatchery

(North-eastern Section).

Station 1. Pool, spring fed, 1-2 feet deep.

2. Stream, gravel bottom, 1 foot wide, 2 inches deep.

3. Grass and moss overhanging rearing pool.

4. Pool, dammed section of stream, 1 foot deep.

5. Cement bridge.

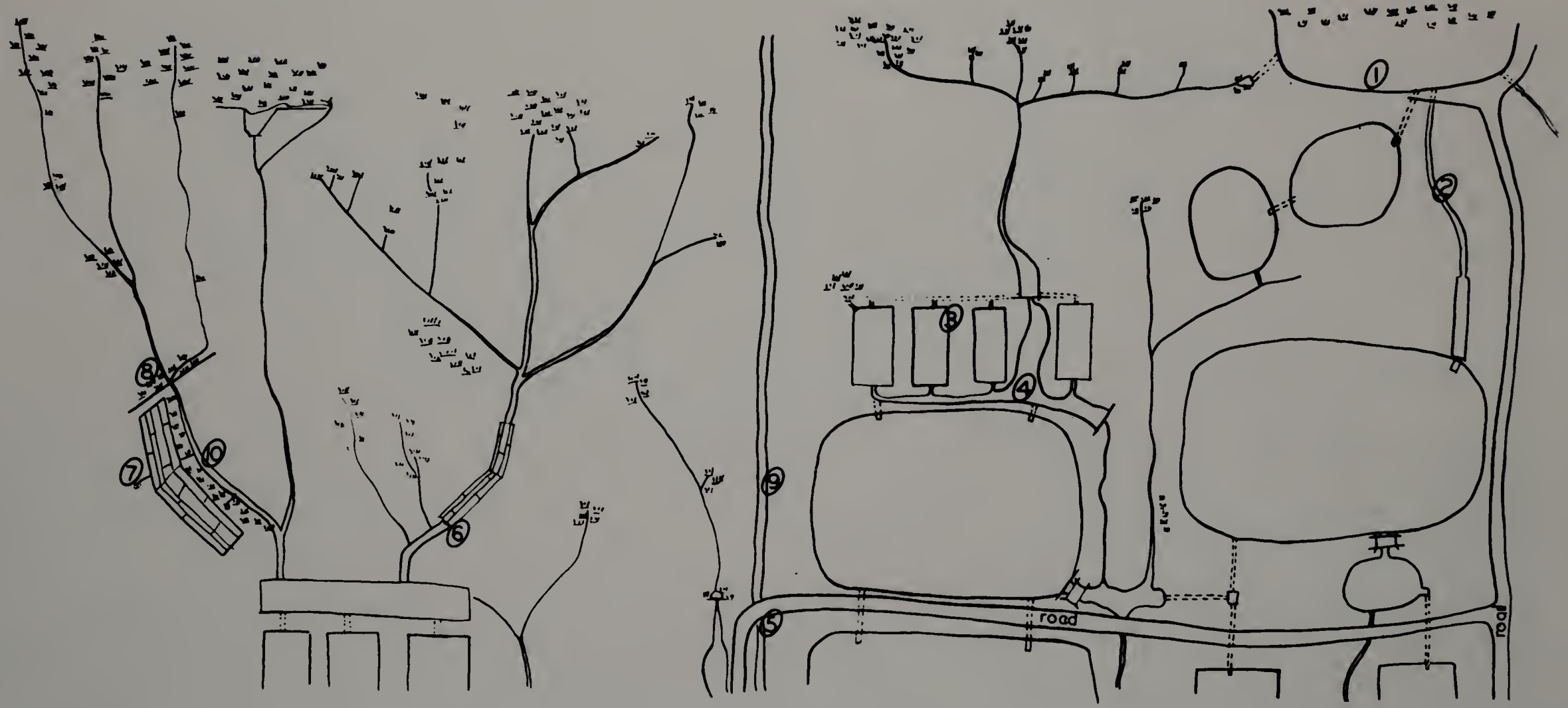
6. Dammed outlet of covered brook and stream beyond, 1 foot wide, 2 inches deep.

7. Spring, sand bottom 10 inches wide, 1 inch deep.

8. Muck above dam, barely under water.

9. Stream, rock bottom, 1 foot wide, 2 inches deep, arising outside of hatchery.

10. Marsh area along brook, sand bottom, barely submerged.



N

MAP OF THE SUNDERLAND STATE FISH HATCHERY
(NORTH-EASTERN SECTION)

20 0 20 Yards

APPROVED:

Marion E. Smith

Norton H. Nicholson

B. M. Honigberg

Charles P. Alexander

DATE: May 20, 1955