LIFE STAGES AND BIOLOGY OF *LIMNEPHILUS RHOMBICUS* (TRICHOPTERA: LIMNEPHILIDAE)[1,2]

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ABSTRACT: The life stages, egg, five larval stages, pupa, and adults, of *Limnephilus rhombicus* are described and illustrated. Oviposition occurred from late September until November, with the peak in October. Larval growth was rapid. By the end of November, most larvae were second, third, and fourth instars. Pupae were collected as early as December, but most pupation occurred during late March and early April. Adult emergence began by early May and continued through June.

The Holarctic *Limnephilus rhombicus* (Linnaeus) was originally described as *Phryganea rhombica* (= *L. rhombicus*) by Linnaeus (1758) from specimens collected in Sweden; its type repository is unknown. Betten and Mosely (1940) redescribed *L. rhombicus* based on Walker's specimens (Walker 1852) which include those from St. Martins Falls, Albany River, Hudson Bay, and the type male of *L. combinatus,* its junior synonym, from Newfoundland. The Nearctic distribution of *L. rhombicus* ranges from the Yukon Territory to Colorado, east to Greenland and Illinois, including Minnesota, Wisconsin, Michigan, Saskatchewan, New York, Hudson Bay, Maine, and Nova Scotia (Ross 1944). New records from Watercress Marsh, Ohio (MacLean and MacLean 1984) and from West Virginia (Tarter and Hill 1980) have expanded its distribution and West Virginia records may represent its southern limit. We studied all life stages and biology of *L. rhombicus* from Big Spring Creek, Cumberland County, in south-central Pennsylvania. In this paper we present descriptions of the egg, five larval stages, pupa, and adults of *L. rhombicus* and our observations on its biology. Adult and pupal descriptions are abbreviated since adequate descriptions are provided by Vorhies (1909) and Ross (1944) for adults and Lloyd (1921) for pupa.

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MATERIALS AND METHODS

A population of *L. rhombicus* in Big Spring Creek, West Pennsboro Township, Cumberland County, Pennsylvania, was studied throughout 1975 (Hoopes 1976). Big Spring Creek rises at 165 m elevation as a large spring from a limestone aquifer and flows north 7.6 km to its confluence with Conodoguinet Creek north of the village of Newville.

Larvae of *L. rhombicus* were reared to adults in the laboratory using a modification of Wiggins' (1959) technique. Larvae collected in the field were kept in water filled jars, placed in an ice filled cooler, and transported to the laboratory with an excellent survival rate. Larval transport usually took three hours. In the laboratory each larva was placed in a closed cylindrical nylon screen cage (20 x 4 cm), with fragments of the living plant materials from Big Spring Creek added to each cage. The larvae obtained food and material for case construction from these plant materials. The cages were placed upright in a continuously aerated aquarium with 5-7 cm of the top of the cylinder above water. Water temperature was kept at 20-22°C. Water and plant material were frequently added as needed. Pharate adults (sensu Wiggins, 1977) swam to the surface of the water within the cage and crawled up the inside of the cage where the adult would emerge and rest on the lid. Although oviposition behavior of *L. rhombicus* was not observed, eggs were collected.

Drawings were prepared from specimens preserved in 70-80% ethanol. Measurements were made by an eyepiece micrometer in a stereo binocular microscope calibrated with a stage micrometer. Laval measurements were made on about 30 specimens for each instar except the first-stage larva for which 15 specimens were examined.

The larval gill arrangement was described by the location and number of gills on each abdominal segment: Dorsal - dorsal position, Ventral - ventral position (both closest to the midline); Dorsolateral, ventrolateral - positioned closer to the lateral margin of each segment; thus, "Dorsal: II-1,2" refers to the dorsal position of abdominal segment 2 with one anterior and two posterior gills."

We followed the terminologies of Ross (1944) for wing venation, and of Ross (1956) and Wiggins (1977) for larval chaetotaxy rather than those of Williams and Wiggins (1981) and Denis (1984) because their terminological simplicity was more suitable for this paper. The fine structural detail of larvae as examined by Denis (1984) and the setal nomenclature and homologies as proposed by Williams and Wiggins (1981) were considered beyond the scope of this paper and not followed.

Study specimens are deposited in the collections of the Frost Entomological Museum, The Pennsylvania State University, and the National Museum of Natural History, Washington, DC.

Life Stages of *Limnephilus Rhombicus*

EGGS (Fig. 1): Eggs were yellowish brown and contained a clear, globular, gelatinous matrix at oviposition.

FIRST-STAGE LARVA (Fig. 2): Total length 1.93-2.77 mm. Body with sclerites concolorous brown and membranes whitish. **Head:** Fronto-clypeus indistinct pale area laterally; chaetotaxy in simple arrangement with 4 setae on head posterior to eyes, 2 long setae between eyes and frontal

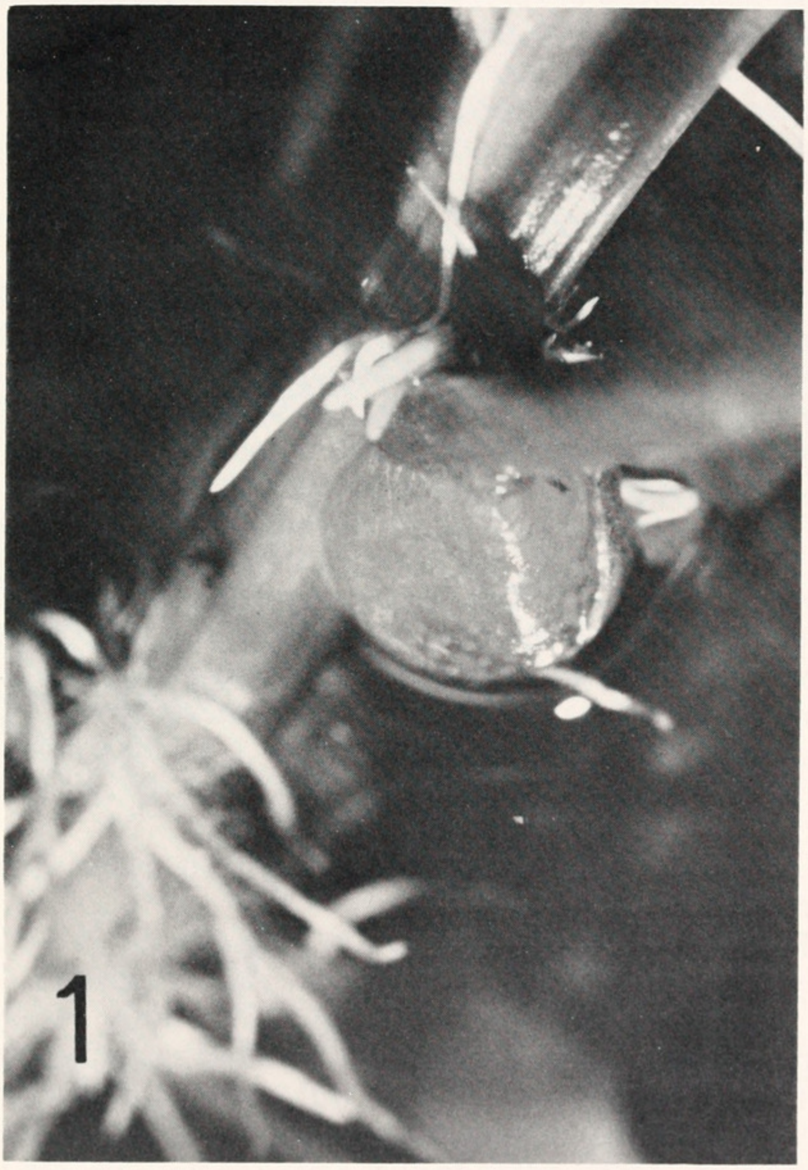


Fig. 1. *Limnephilus rhombicus* egg mass.

suture, longer than head, 2 setae posterior to each eye, 4 setae on anterior margin of fronto-clypeus, 2 lateral setae at constriction of stripe on fronto-clypeus, 4 setae across labrum, and one seta on gena at base of each mandible. **Thorax:** Tergites brown with pronotum and mesonotum posteriorly black; pronotal setal tufts distinct, each with 1-2 setae; mesonotum with distinct setal tufts each with 1 seta; metanotal setal tufts each with 1 seta, each tuft surrounded by a discrete sclerite. **Abdomen:** Pale creamy, segment 1 with 1 seta on each side dorsally and ventrally, 1 seta on dorsal and ventral faces of lateral spacing humps; segment 2 with one seta on each lateral margin; segments 3 to 8 with sparse lateral fringe of filaments; notum of segment 8 with 2 setae; tergite of segment 9+10 with 6 setae, 2 on meson longer than length of segment 8, lateral pairs half that length; lateral sclerites of anal legs each with 4 posterior setae, 1 as long as width of abdomen, others half to one-third that length and 1 lateral seta; no gills present on abdomen.

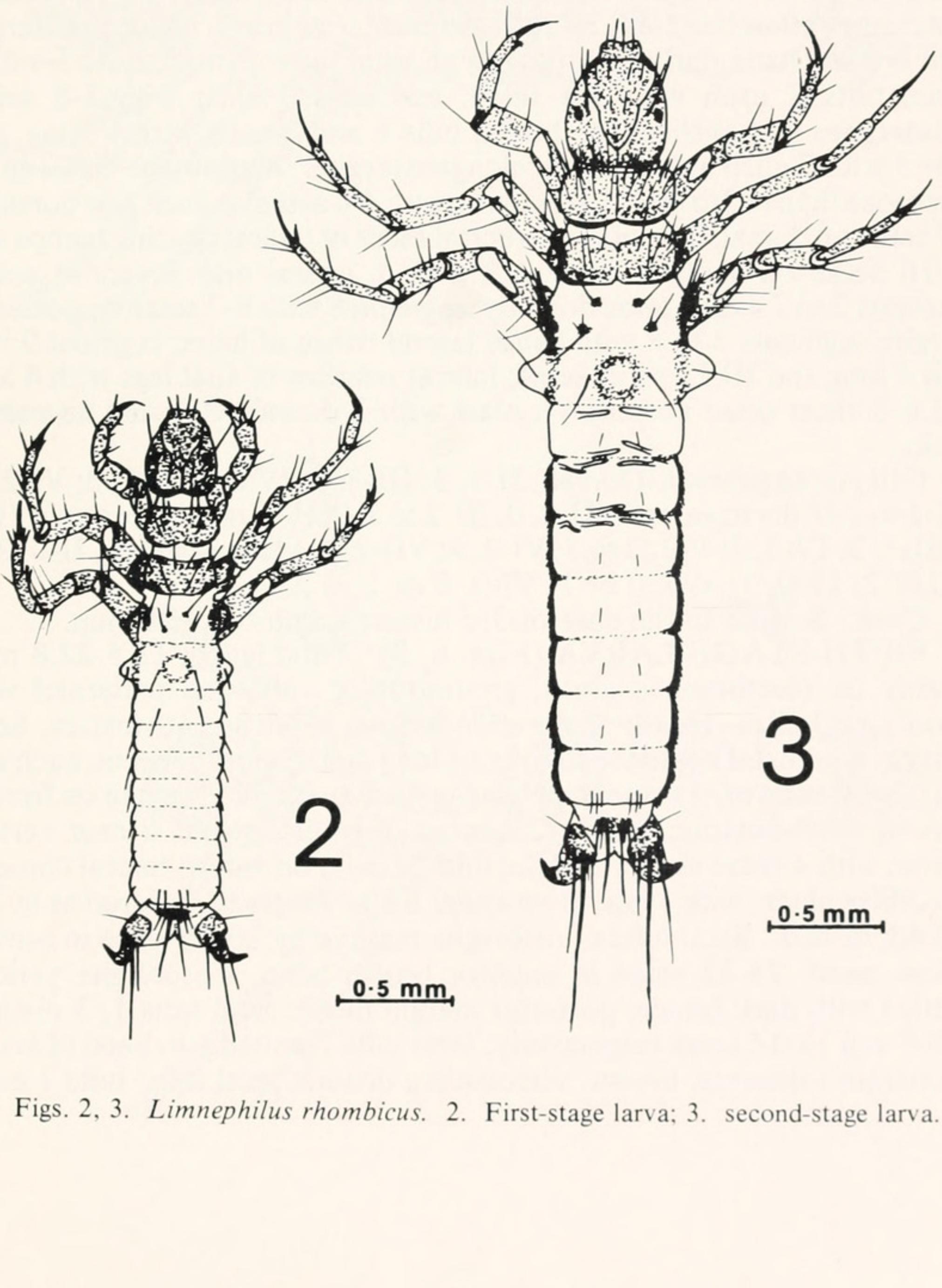
Case.-Constructed of moss stems loosely placed tangential to the cylindrical case; length 2.0-2.67 mm.

SECOND-STAGE LARVA (Fig. 3): Total length 2.75-4.5 mm. Similar to the first instar, unless stated otherwise. Tergites brown with some indistinct pale areas. **Thorax:** Pronotal setal tufts 1, 2, and 3 masked by 14-16 setae on anterior half of tergite. Mesonotal setal tufts 1 and 2, each with 1-2 setae; tufts 3 each with 3 setae. Metanotal setal tufts surrounded by discrete tergites, tufts 1 each with 1 seta, tufts 2 and 3 each with 2-3 setae. **Abdomen:** Creamy; segment 1 with 1 seta on each side dorsally, 2-4 setae ventrally, 1 seta on each dorsal and ventral face of lateral spacing humps; segment 2 with one seta laterally; segments 3 to 7 with 2 setae dorsally; segment 8 with 6 setae; tergite of segment 9+10 with 4 large and 3 short setae; lateral sclerites of anal legs each with 4 large posterior and 1 short lateral setae; anal claw with a single lateral hook.

Gill Arrangement.-Dorsal: II-1, 1; III-1, 1; IV-1, 0; dorso-lateral; II-0,0;III-0 or 1, 1; ventral: II-1, 1;III-1, 1; IV-0 or 1, 0 or 1; ventro-lateral: II-0, 1.

Case.-Similar to that of 1st instar, but plant material more tightly bound; length 1.6-5.0 mm.

THIRD-STAGE LARVA (Fig. 4): Total length 3.4-6.5 mm. Body sclerites yellow with brown pattern. **Head:** Yellow with dark "V"-shaped band on gena contiguous with frontal suture anteriorly but distinct from frontal and epicranial sutures at their junction, fading posteriorly; posterior margin of head brown. Fronto-clypeus with central brown stripe expanded anteriorly; setal pattern complex, with 6 setae arranged transversly on head posterior to eyes, 2 setae between eyes and frontal suture and 1 on gena at base of mandibles; fronto-clypeus with 4 setae on anterior margin, 2 lateral of central stripe, 2 near vertex; labrum with 4 setae across middle, tufts of hairs on antero-lateral corners; mandibles black with 1 lateral seta near base. **Thorax:** Protergite with anterior third dark brown, middle third yellow, posterior third yellow mottled with brown, and its posterior margin black interrupted by pale meson; pronotal setal tufts indistinct with 8 setae in yellow band, 20 setae in anterior brown band; mesotergite light brown with darker mottling; with setal tufts distinct, tufts 1 with 1 seta, tufts 2 each with 3 setae, and tufts 3 each with 5-6 setae; metatergites brown with distinct setal tufts, tufts 1 and 2 each with 4 setae and tufts 3 each with 7 setae anteriorly on an elongate tergite. **Abdomen:** Creamy; segment 1 with 3-4 setae on each side dorsally, lateral spacing humps with 3 setae dorsally and 2 on ventral faces, 6 setae on venter; tergite of segment 9+10



Figs. 2, 3. *Limnephilus rhombicus.* 2. First-stage larva; 3. second-stage larva.

with 4 long and 6 short setae; lateral sclerites of anal legs with 4 long and 2 short posterior setae and 1 lateral seta; claws with 2 hooks and 3 minute dorsal and 2 ventral setae.

Gill Arrangement. Dorsal: II-1 to 2, 2; III-2, 2; IV-2, 1-2; V-1, 1 or 0; VI-1 or 0, 1 or 0; VII-0 or 1, 1; dorso-lateral: II-1; III-2, 0; IV-0-1, 0-1; ventral: II-2, 2; III-2, 2; IV-2, 1; V-1, 1; VI-1, 1; VII-1, 0; ventro-lateral: II-0,2.

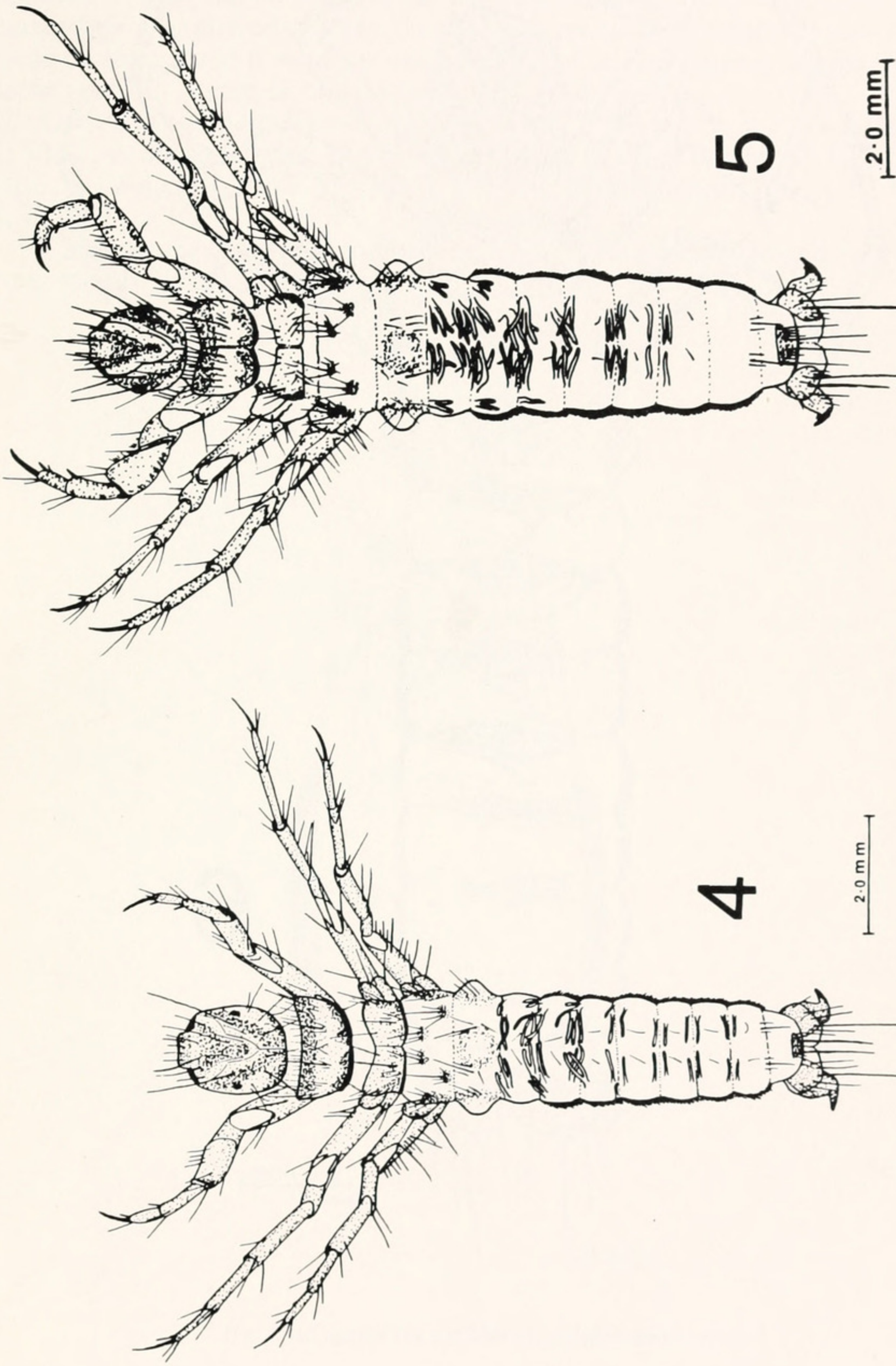
Case. Constructed as in 2nd instar; length 3.0-7.5 mm.

FOURTH-STAGE LARVA (Fig. 5): Total length 7.4-12.5 mm. **Head:** Same as in the third-stage larva but with one more seta between the eye and frontal suture. **Thorax:** Color pattern and chaetotaxy as in 3rd instar, unless stated otherwise; pronotum with more setae, 12-16 setae in transverse yellow band and 24-28 setae in anterior brown band; mesotergite light brown, some darker mottling, with setal tufts distinct, tufts 1 with 2 setae, tufts 2 each with 3-4 setae, and tufts 3 each with 5-6 setae; metatergites with distinct setal tufts, tufts 1 and 2 each with 4 setae, and tufts 3 with 7 each anteriorly on elongate tergite. **Abdomen:** Setae more numerous than in 3rd instar; segment 1 with 4-6 setae on each side dorsally, 7-9 setae on dorsal, 2-3 setae on ventral faces of lateral spacing humps and 14-16 setae on venter; segment 2 with 1 lateral and 2 ventral setae; segments 2 to 7 with 2 setae dorsally; segment 8 with 6-7 setae on posterior margin; segments 3 to 8 with dense lateral fringe of hairs; segment 9+10 with 4 long and 10-12 short setae; lateral sclerites of anal legs with 4 long and 6-8 short setae posteriorly; claw with 3 dorsal setae and accessory hooks.

Gill Arrangement.-Dorsal: II-3, 3; III-3, 3; IV-3, 2; V-2, 2; VI-2, 2; VII-1 to 2, 0; dorso-lateral: II-2, 0; III-2 to 3, 0; IV-0 or 2, 0; ventral: II-3, 3; III-3, 3; IV-3, 3; V-2, 2 to 3; VI-2, 2; VII-2, 1; ventro-lateral: II-0, 2-3; II-0, 1-2; IV-0, 1; V-0, 0 or 1; VI-0, 0 or 1.

Case. Similar to the case of 3rd instar; length 8.1-13.1 mm.

FIFTH-STAGE LARVA (Figs. 6, 8): Total length 11.5-22.8 mm; creamy on membranous areas, ground color yellowish patterned with brown on sclerites. **Head:** Coloration same as in 3rd and 4th instars. Setal pattern: 6 on head posterior to eyes, 2 long and 1 short between each eye and frontal sutures, 1 on gena at base of each mandible, 8 setae on fronto-clypeus; 4 on anterior margin, 2 laterad of central stripe, 2 near vertex; labrum with 4 setae across middle, tufts of hairs on antero-lateral corners; mandibles black, with 1 lateral seta near base. **Thorax:** Colored as in 3rd and 4th instars. Setal tufts of protergite masked by 20-28 setae in central yellow band, 24-32 setae in anterior brown band; mesotergite yellow, mottled with dark brown, posterior margin black; setal tufts 1, 3 distinct with 4 and 10-14 setae respectively; setal tufts 2 united into band of setae; metatergites discrete, brown, surrounding distinct setal tufts; tufts 1 each



Figs. 4, 5. *Limnephilus rhombicus.* 4. Third-stage larva; 5. Fourth-stage larva.

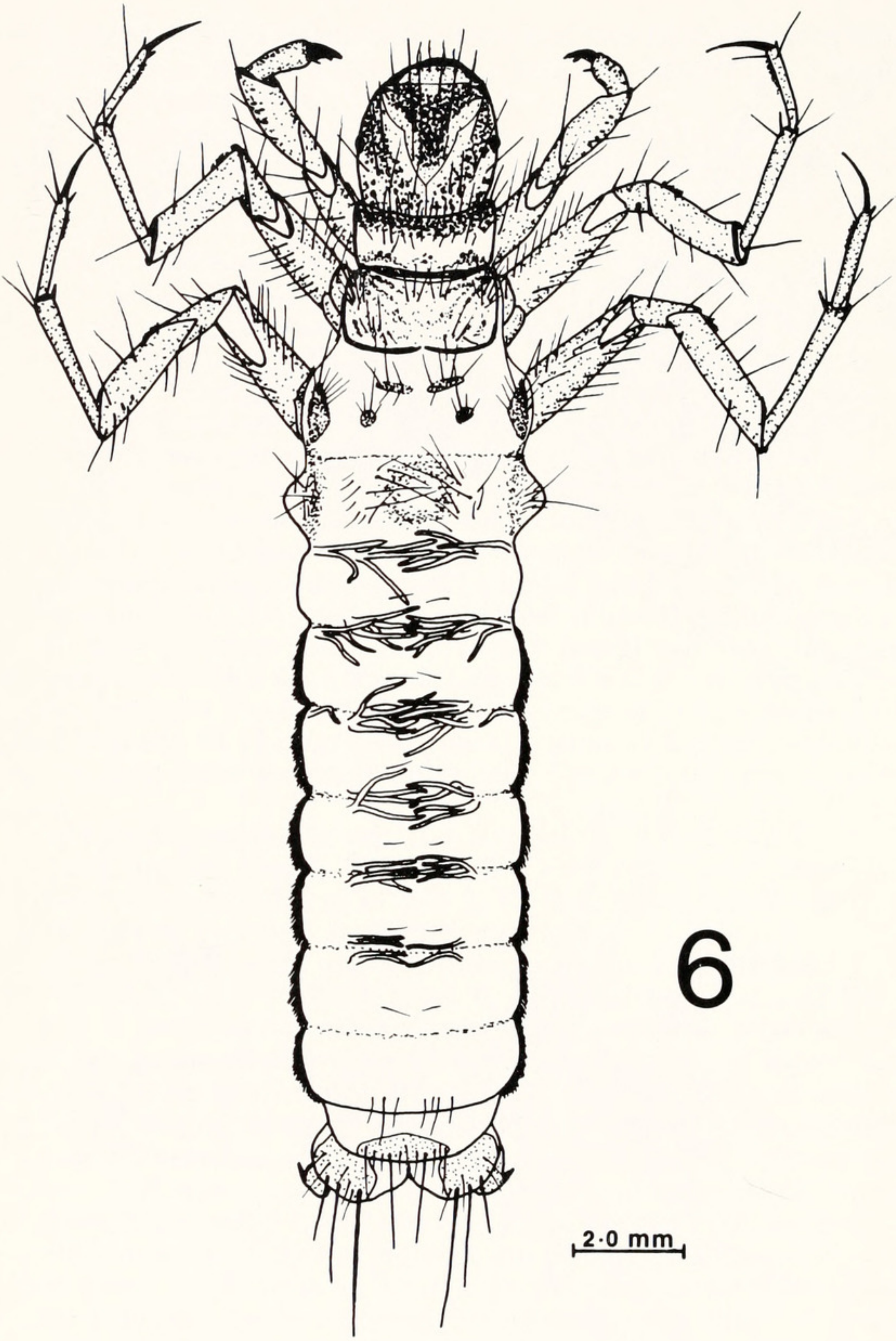


Fig. 6. *Limnephilus rhombicus*, fifth-stage larva.

with 6 setae; tufts 2 each with 4 setae. **Abdomen:** Creamy colored; segment 1 with dorsal and lateral spacing humps. Setal arrangement masked by a profusion of setae; 12-14 setae on each side dorsally, 16-18 setae on dorsal and 6 setae on ventral faces of lateral spacing humps, 50 setae ventrally, setae of other segments as in instar 4.

Gill Arrangement.-Dorsal: II-3, 3; III-3, 3; IV-3, 2; V-3, 2; VI-2, 0 or 1; VII-1, 0; dorso-lateral: II-1-2, 0; III-2 to 3, 0; IV-1, 0; ventral: II-3, 3; III-3, 3; IV-3, 3; V-2 to 3, 2; VI-2, 2; VII-2, 1; ventro-lateral: II-0, 3; III-0, 2; IV-0, 1.

Case. Stems of moss or gravel or both placed tangentially to cylindrical core, length 12.5-22.0 mm.

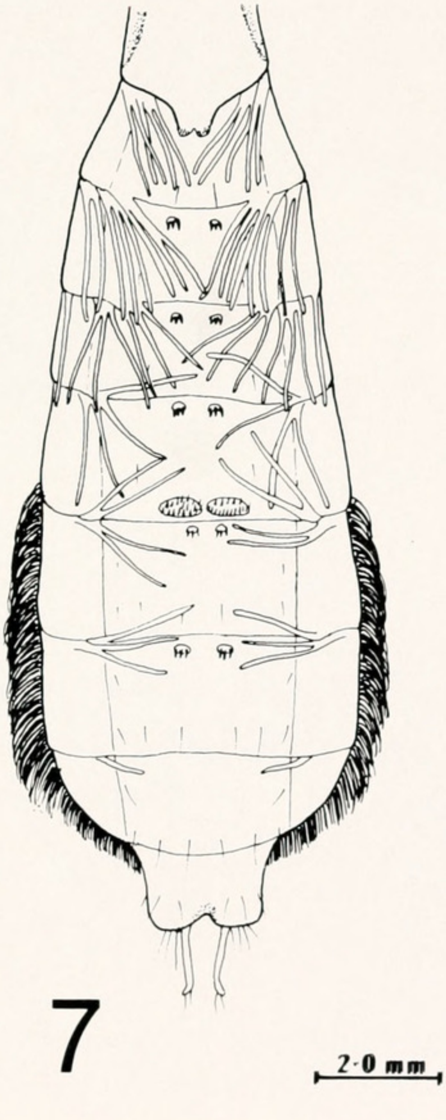


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Fig. 7. *Limnephilus rhombicus,* pupal abdomen.

PUPA: (Figs. 7, 9): Total length 15.5-16.5 mm; body pale yellowish, creamy (Fig. 16). **Head** with 9 pairs of setae; labrum with 5 pair of long hooked setae across middle; mandibles simple, slightly notched on basal mesad margin with 2 setae laterally on base. **Thorax:** Meso- and metalegs modified for swimming with long hairs; pro-, meso-, and metatibia with spur formula 1, 3, 4, respectively, protibial spur short. **Abdomen** (Fig. 7): Gill

Fig. 8. *Limnephilus rhombicus,* fifth-stage larva feeding on aquatic moss.

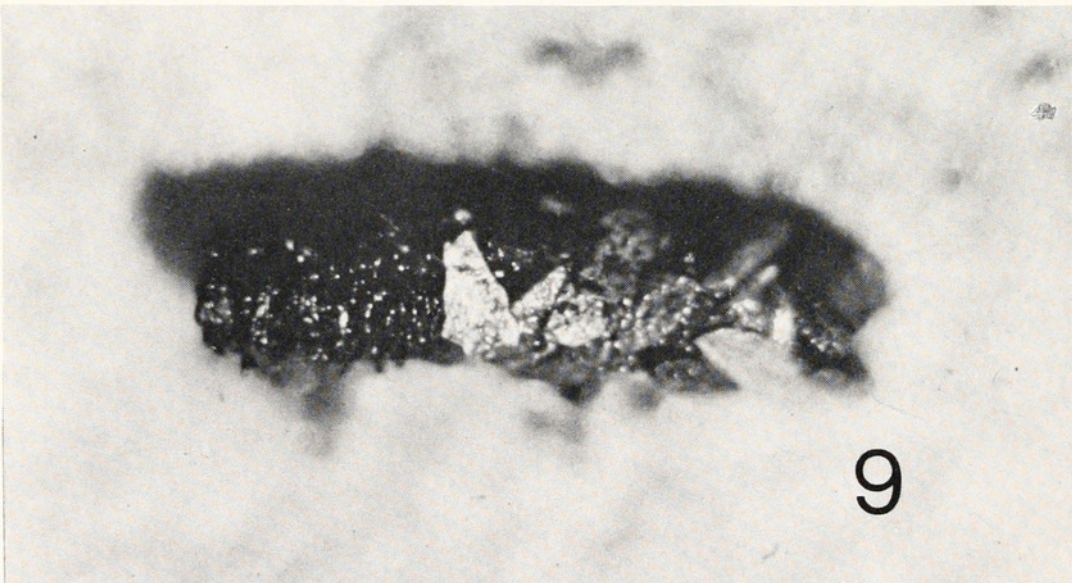

Fig. 9. *Limnephilus rhombicus,* puparium showing extension of anterior end with stones.

filaments 2-3 per cluster, decreasing in length, thickness, and number on posterior segments; paired hook bearing plates on segments 3 to 7; 3 hooks on anterior plates of segments 4-7, 2 hooks on anterior plates of segment 3 and posterior plates of segment 5 each with 16 hooks.

Gill Arrangement.-Dorsal: II-3, 3; III-3, 3; IV-3, 3; V-3, 2; VI-2, 2; VII-2, 0; dorso-lateral: II-3, 0; III-3, 0; IV-1-2, 0; ventral: II-3, 3; III-3, 3; IV-3, 3; V-3, 3; VI-2, 2; VII-2, 2; ventro-lateral: II-0, 3; III-0, 2; IV-0, 1; V-0, 0; VI-0, 0 or 1.

ADULT (Fig. 10): Body brownish yellow to rufous. **Head** with compound eyes black, large, three-fourths length of head, with posterior linear warts bearing brown macrosetae; 3 ocelli present, with 4 warts dorsally, 2 anterior and 2 posterior to lateral ocelli, each bearing several macrosetae. **Thorax** yellow to rufous, massive; prothorax pale dorsally, darker ventrally, with a large wart on each side of pronotum, covering most of dorsum with 7-8 brown macrosetae and numerous small, pale setae. Mesothorax brownish yellow, warts paler, sutures darker; scutum with 8-10 macrosetae on longitudinal yellow warts on each side of meson; scutellum with pale rhomboidal area in apex bearing 8 macrosetae and a few smaller setae. Mesoplurae without setae except on postero-ventral margin; metanotum and basalaries without setae; metaplurae without setae except on postero-ventral margin. **Legs:** Femur, tibia, and tarsi, with

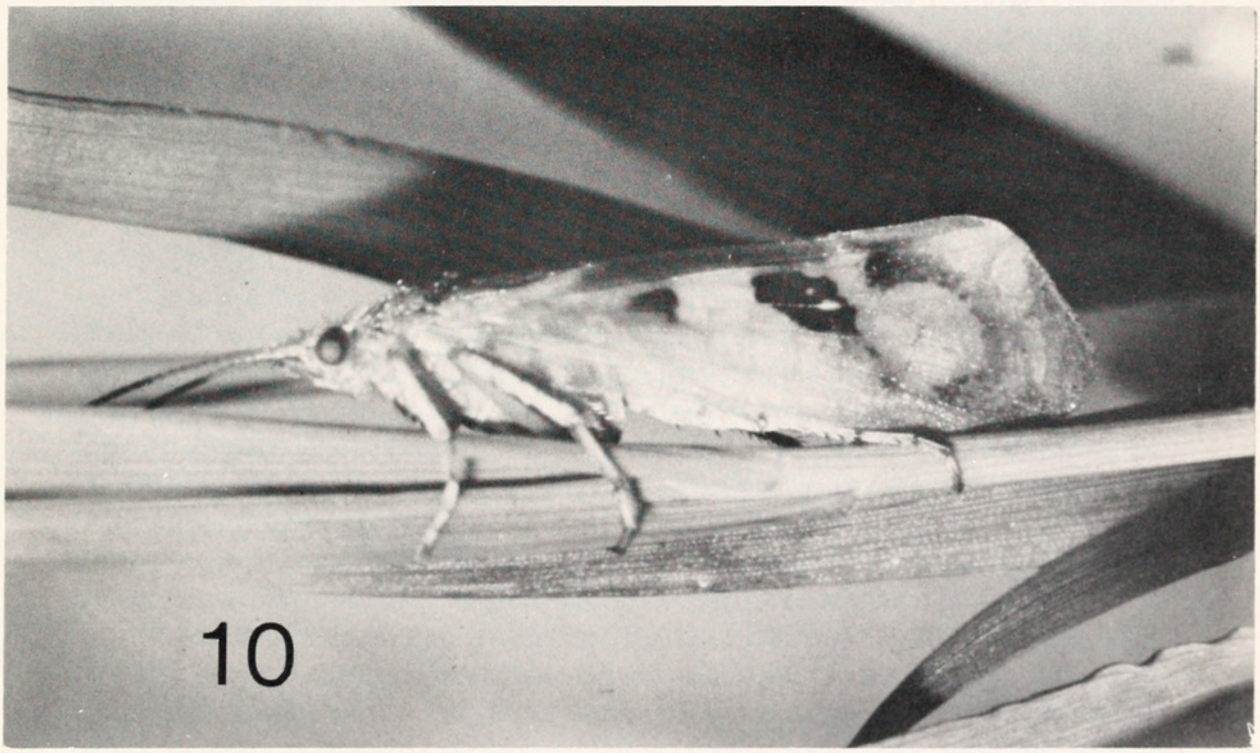

Fig. 10. *Limnephilus rhombicus,* adult.

numerous minute, brown setae; profemur with 2 apical spurs on ventral face; basitarsus longer than second tarsal segment with a yellow apical spur. **Forewings** pale yellow with distinct brown pattern; length 14.8-18.3 mm; costal, subcostal and R_2 cells pale; stigma faintly brown; cells r_3, r_4, r_5, and m_1 with apical two-thirds brown interrupted by pale spots; cells m_2, m_{3+4}, and cu_1 completely brown interrupted by pale areas; cell r_{2+3} faintly brown apically and basally; radial cell posterior to junction of r_{2+3} and r_{4+5} and basally in median cell with large triangular brown area; radial and median cells basally from junction of m_{3+4} with m_{1+2} with a large rhomboidal brown area with brown spot posterior to rhomboidal brown area; cell cu_2 brown apically and anal cell entirely brown; hindwing entirely pale, minute brown hairs sparsely covering wing, hairs longer on margins and apical veins. **Abdomen** brownish yellow, venter with setous posterior margins, especially posterior segments.

FEMALE GENITALIA: Notum of segment 8 setous; median process of ventral genital plate longer than lateral lobes; cerci long, finger-like processes, widely separated at bases by a small lobe. Venter of segment 9 produced posteriorly, conical, bilobed, setous, and widely separated on meson. Segment 10 cylindrical, sclerous, setous posteriorly, cleft nearly to base dorsally, with a shallow emargination ventrally.

MALE GENITALIA: Notum of segment 8 lobed, slightly produced posteriorly, covered with short black pegs; cerci blade-like, rhomboidal, concave mesad, with dorsal margin longer than the ventral; ventral and posterior margin of cerci black toothed. Venter of segment 9 cleft on meson, posterior margin with setae. Clasper produced posteriorly with long black setae. Tergite of segment 10 bilobed, black, blade-like processes. Ventral arms of aedeagus slender basally, broad in middle, tapering apically to fine point bearing several teeth with a cylindrical central process.

Biology

Observations of *L. rhombicus* in Big Spring Creek, Cumberland County, Pennsylvania, provide new details of its biology. Water quality, temperature and discharge of Big Spring Creek did not fluctuate greatly throughout the year: pH 7.5 ($\bar{x}$), range 7.3-7.8; total hardness 168 mg/1 ($\bar{x}$), range 140-190 mg/1; alkalinity 153 mg/1 ($\bar{x}$), range 115-170 mg/1; dissolved oxygen 10.8 mg/1 ($\bar{x}$); range 9.5-11.2 mg/1; and temperature 10.3°C ($\bar{x}$), range 10.0-10.8°C. The stream produces lush growths of autochthonous vegetation, particularly waterweed (*Anacharis canadensis*), curlyleaf pondweed (*Potamogeton crispus*), watercress (*Nasturtium officinale*), speedwell (*Veronica anagallis aguatica*), water starwort (*Callitriche* sp.) and water mosses (*Fontinalis* sp., *Fissidens* sp.). Channels eroded through extensive beds of vegetation and the velocity in these channels was rapid and transported sediments leaving clean gravel bottoms, while the velocity was greatly reduced in weed beds and sediment built up many centimeters deep. Retarded stream flow in the weed beds also led to greater fluctuations in water temperature than in the flowing water in the adjacent channels; during cold weather thin layers of ice sometimes formed over the surface of water and vegetation in these areas of low flow.

Oviposition occurred from late September until November, with the peak in October. On warm, still afternoons in October, adults were seen flying over the surface of the water and weed beds. Clear, gelatinous egg masses bearing 150-300 eggs were found at the water surface on emergent stems of watercress (Fig. 1). Sometime after oviposition the gelatinous egg masses began to liquify and flow down the stems into the water.

Larval growth was very rapid. They fed primarily on watercress and water mosses (Fig. 8) but also consumed dead sculpins (*Cottus cognatus*). By the end of November 1975 no egg masses could be found and most larvae were second, third and fourth instars. Later instars consumed large amounts of vegetation, primarily living water mosses, reducing the once extensive leafy mats to barren areas of stems. Stems were used to construct cases by placing them transversely, tangential to the cylindrical core of silky secretion.

Pupae were collected as early as December, but most pupation occurred during late March and early April. After much growth, fifth instars moved from the extensive beds of vegetation to the gravel bottom channels of more rapidly flowing water. There, fifth instars added gravel to the anterior end of the case. Some larvae added only pieces of gravel on the anterior and posterior end of the cases made from moss stems; others constructed entire cases of gravel and removed posterior portions of moss stems (Fig. 9). Larger gravel, added to the anterior end of the case, oriented the long axis of the case parallel to the flow of the water. Silken meshes were placed over both ends of the case to complete the puparium.

Adult emergence began by early May and continued at least through June. Details of emergence were observed on 8 May 1975. Pupae cut through the end or side of the puparium and swam about vigorously until they encountered an object, frequently mosses, projecting through the surface film. Pupae climbed up on the surface of the moss and remained still for several minutes. Then by swelling the adult thorax, the ecdysial sutures were split. Continued swelling and undulations freed the adult from the pupal exuvium in 30-60 seconds. Adults, without color pattern, remained on the moss until their wings were sufficiently dry to support flight; some were motionless, whereas others walked about. Many toads gathered on the moss beds snapping up pupae and adults as they appeared on the moss surface.

In captivity adults embibed quantities of water and developed distinctive color patterns after several hours (Fig. 10). In Pennsylvania adult flight has been observed from 8 May to 23 December. Seasonal flight activity appeared bimodal, with one mode at emergence and one at oviposition.

DISCUSSION

Wiggins (1977) suggested that *Limnephilus* larvae can be separated into two distinct groups; those with contrasting light and dark color bands on the head and thorax and a second group lacking contrasting color but having prominent spots. While *L. rhombicus* clearly belonged to group 1 on the basis of color pattern in instars III, IV and V, it was not so with first and second instar larvae, which had head and pronotum concolorous brown with indistinct pale areas. The key character used for *Limnephilus* by Wiggins (1977) is on gill number. As Wiggins noted, the increasing number of gills, in both the number per cluster and occurrence on segments, may change at each instar. However, gill number was a good diagnostic character for instars IV and V of *L. rhombicus* from Big Spring Creek.

Instars of *L. rhombicus* can be distinctly separated by color pattern and size of tergites. Novak and Sehnal (1963) showed a similar analysis of head capsules for this species in Europe. A large larva with head capsule width of 1.55 mm was collected in July (Karl and Hilsenhoff 1979). A head capsule of that size would be between those of the fourth and fifth instar using the head width shown by Novak and Sehnal (1963). This suggests that sclerotized structures may be useful to separate instars in a population but not for the species.

The general lotic habitat of *L. rhombicus* may be described from observations at Big Spring Creek and other published accounts. The most obvious common denominator of Big Spring Creek and other reported sites was an abundance of aquatic vegetation or organic detritus (Hickin 1967; Higler 1975; Karl and Hilsenhoff 1979; Lloyd 1915, 1921; Otto 1976; Slack 1936, Vorhies 1909). Hickin's (1967) description of the duration of various life stages in a natural habitat showed temperatures from 10-15°C which suggest minimum temperatures comparable to Big Spring Creek. Such temperature regimes were not universal. Otto (1976) found low survival of larvae in a stream with temperatures of 4.4°C; however, Novak and Seknal (1963) reported temperatures falling to 0°C in *L. rhombicus* habitats. Larvae, being unable to withstand currents stronger than 9 cm/sec (Otto 1976, Higler 1975), tended to remain in and feed on submerged or marginal vegetation where currents were reduced. The increased oxygen consumption of larvae exposed to currents (Roux 1979, Otto 1976) suggests a bioenergetic saving from avoiding currents. Fifth instar larvae at the prepupa stage, however, move into stronger currents with gravel substrates and construct a partial or complete case of gravel (Roux 1979, Cobb et al. 1984). Perhaps the increased weight of the gravel case reduces the energy expended while larvae were active in the stronger current. The larger gravel observed on the anterior end of *L. rhombicus* puparia from Big Spring Creek would further stabilize the case and provide an orientation parallel to the current for efficient water flow through the case.

L. rhombicus must be considered a facultative omnivore. In Big Spring Creek the primary food was aquatic plants, mainly mosses. When deprived of vegetation or when vegetation has been depleted from over grazing, larvae consume a variety of organic matter from dead sculpins to other living trichopterans including their own species.

The adult emergence at Big Spring, lasting from early May through June, was consistent with the flight periods observed in Wisconsin (Longridge and Hilsenhoff 1973), Ohio (MacLean and MacLean 1984), Manitoba (Cobb et al. 1984), West Virginia (Tarter and Hill 1980) New York (Lloyd 1915, 1921), Minnesota (Elkins 1936) and Michigan (Leonard and Leonard 1949). Based on the Rothamsted Insect Survey, Crichton and Fisher (1981) assigned *L. rhombicus* to a group of caddisflies having an extended flight period and normally with a diapause from spring through summer into autumn. This was consistent with the bimodal flight period observed at Big Spring Creek. Denis (1981) suggested that the length of diapause is related to the photoperiod experienced by the females and also the larvae.

The deposition of egg masses above and away from water in Big Spring Creek was similar to that observed by Hickin (1967) and Novak and Sehnal (1963). They also suggested that larvae can hatch and live within the gelatinous egg mass until submerged in water. This was not observed at Big Spring Creek where eggs were most frequently observed on the stems of watercress at the water surface. Vorhies (1909) observation of small larvae (we assume he meant early instars) in July seems suspect.

Biological attributes, such as diapause, oviposition away from water and a gelatinous matrix that protects eggs from desication and freezing, are important adaptations for caddisflies in temporary pools (Wiggins 1973). *L. rhombicus* possesses these attributes, while inhabiting permanent spring-fed streams. *L. rhombicus* shares many characteristics of the limnephiline species, such as *L. individus* (Wiggins et al. 1980), which inhabit temporary pools or transient aquatic habitats. Thus, this species represents the limnephiline with a specialized habitat, perhaps derived from a more generalized Limnephilinae which goes through adult diapause.

L. rhombicus is known in Pennsylvania only from the Cumberland Valley where there are many limestone aquifers. Critical to further understanding of its biology is the clarification of habitat specialization in this species; especially the degree of dependance on spring-fed streams with an abundance of autochthonous aquatic vegetation and relatively stable water temperatures.

Casual collectors who study limnephilid larvae must be cautious because early instars are not always what they appear to be due to changes in coloration, setation, and gill arrangement. Wiggins (1977) noted that his keys were based on descriptions of the final instar and he suggested diagnostic characters may be less effective for earlier instars. The descriptions presented here for the five larval instars of *L. rhombicus* indicate clearly a limit to the utility of Wiggins' (1977) larval keys.

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