THE HABITS AND EARLY STAGES OF THE DRAGONFLY, *GOMPHAESCHNA FURCILLATA* (SAY)

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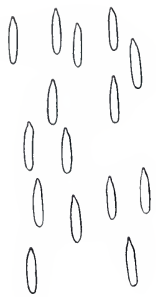
In the year 1917, while at Cornell University, the writer made a few observations on the habits and first three instars of the dragonfly, *Gomphaeschna furcillata* (Say). With the rearing of the third instar, study was interrupted, and no further opportunity has occurred for its continuation. This species appears to be limited to sphagnum bogs and is recorded from Maine south to Georgia and west to Ohio. A second species, *G. antilope* Hagen, the habits of which are unknown, is recorded from New Jersey, Maryland, Pennsylvania, and Virginia. The two species have venational characters which suggest relationship to the related family Gomphidae; hence the question has been raised as to whether the nymph might show gomphine characters. We present the following notes because of this possible relationship and also the fact that Gomphaeschna, considered one of the primitive genera in this family, is almost the last genus of large dragonflies north of Mexico whose nymphal stages are undescribed.

Gomphaeschna was discovered about the small sphagnum bog at Ringwood, on the highland, seven miles east of Ithaca, New York. One specimen was taken one mile and a half farther east on Bear Creek. In the latter part of May or early June, 1917 (exact records lost), fifteen to twenty individuals were captured while they were flying up and down the road that passes the Ringwood bog. Fully as many others escaped. Those taken were mostly males which, though not teneral, were not fully mature. Though at that time the neighboring ponds and streams were closely inspected for emerging individuals, the bog was unsuspected.

On June 27, 1917, after observing a half dozen or so individuals, a female Gomphaeschna was followed from the road into the sphagnum bog to the east. She settled and oviposited in the soft, rotten part of the root of a small tree in the middle of the sphagnum area. As the part chosen was six inches above the shallow water, she was easily observed. Over an area three inches long and two inches wide she tried various spots with the tip of her abdomen and eventually inserted her ovipositor more than thirty times. Except that the tips of the eggs were visible and all had their sharp points up, they showed no particular arrangement. (See Figures 1 and 2.) Thus her actions in oviposition were those of Aeschnid females in general. After oviposition, the female was captured and taken to the laboratory.

On July 7, when the third trip was made to Ringwood, only three males were seen. None were found during a fourth trip made on July 14. From these data it appears that the height of abundance on the wing was past on June 27. This relatively early flight season for dragonflies on the highlands east of Ithaca suggests primitiveness (Kennedy, 1928).

At the laboratory, the wood containing the clutch of eggs was partially submerged in a shallow dish of water. The first nymph was found July 23, 1917, twenty-seven days after oviposition. By July 30 practically all the eggs appeared to have hatched; my records, however, state that one more hatched between August 4 and August 6.



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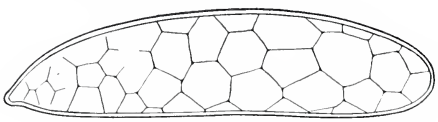

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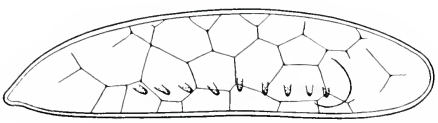

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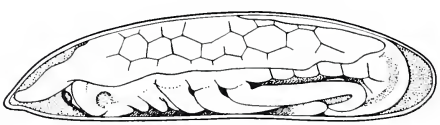

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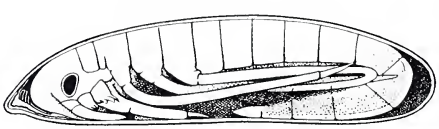

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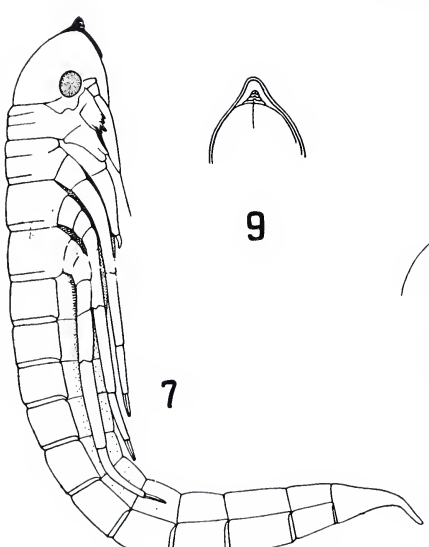

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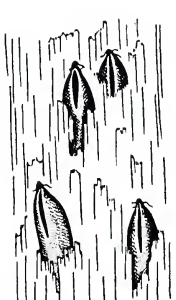

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FIG. 1. Arrangement of eggs in surface of rotten tree root. The pointed end is the anterior end. FIG. 2. Egg-shells after the emergence of the pronymphs. FIG. 3. Egg seven days after oviposition showing the reticulation of the surface (?) of the contents. FIG. 4. Egg twelve days after oviposition showing nine pairs of appendages and reticulation clearing up at poles of egg. FIG. 5. Egg nineteen days after oviposition. Appendages well developed; reticulation reduced to dorsal area. FIG. 6. Egg twenty-six days after oviposition. Pronymph developed except for some joints in the appendages. FIG. 7. Pronymph free from the egg-shell. FIGS. 8-10. Views of the egg-burster.

The Speed of Development. By the scattering of the hatching dates, the speed of development was not the same in all the eggs of this (probably) single clutch. (There is a possibility, of course, that other females had oviposited previously in the same wood.) This difference in developmental speed was shown also in the development of the young nymphs. Sixteen nymphs (Nos. 401-416) were segregated into as many vials. The remainder were continued in a porcelain dish. All were fed Paramecia. On August 20, when all the material still living was preserved, less than half of those in the porcelain dish were in the second instar. The records for the sixteen nymphs segregated July 25 and reared individually follow: on the first careful examination, August 2, one had died in Instar I; six had passed into Instar II. On the second examination, August 13, seven more had passed into Instar II. By August 16, the two remaining had reached Instar II. These records indicate that the length of Instar I was from 10 to 19 days.

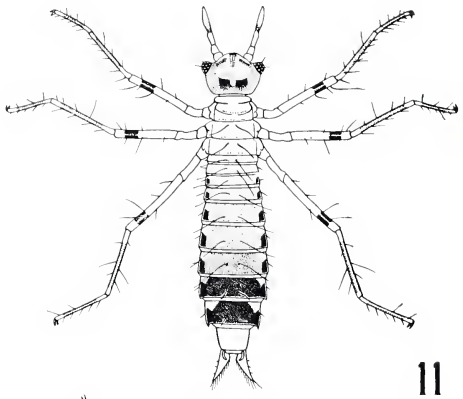
Only one nymph (No. 403) passed into Instar III. This was segregated July 25, passed into Instar II, August 2, and into Instar III, August 12-13. It died in Instar III, August 19-20. With this nymph the length of Instar II was 10-11 days. An examination of its labium showed that at death it was not yet in the preliminary stages of moult. (Figure 28 shows this preliminary stage in another nymph.)

Embryological Notes. Camera lucida drawings from live material of four stages in the development of the embryo are shown in Figures 3-6. On July 3, seven days after oviposition (Fig. 3), the only feature visible was the reticulation of some subchorion membrane. The reticulations appeared to be "cellular" areas. On July 8, twelve days after oviposition (Fig. 4), nine appendages were visible on the ventral surface. This stage appeared to follow the revolution of the embryo, because the four oblique appendages, which were probably antennae and mouthparts, were at the anterior pole of the egg. The general reticulation was breaking up at the poles of the egg. On July 15, nineteen days after oviposition (Fig. 5), the head, body and appendages were taking on pronymphal form, except for the dorsal region where there was yet a remnant of the reticulated area. (Notice the partially developed egg-burster which appears in this stage as a growth on the *inner* surface of the pronymphal envelope.) On July 22, twenty-six days after oviposition (Fig. 6), the pronymph was fully formed, except that not all the segments of the appendages were yet distinct.

Figure 2 shows some of the empty, ragged-tipped eggshells, which are brown after the emergence of the nymph. The raggedness was not noticed in the freshly laid eggs.

The Egg-burster and Hatching. Hatching takes place through a slit in the chorion (Fig. 2), probably produced by movements of the pronymph, and aided by the sharp, sclerotized egg-burster. The use made of the egg-burster is indicated by the forward-bending motions of the head which are continued for some moments after release from the egg-shell (Fig. 10).

The pronymph is the last embryonic and the first free stage. In Gomphaeschna, it wriggles free from the egg-shell and struggles to the



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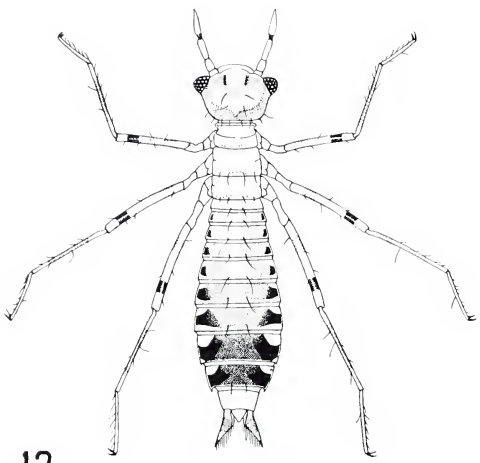

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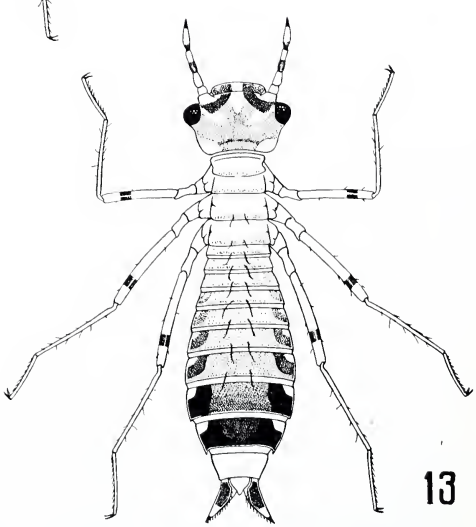

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FIGS. 11-13. Instars I, II, and III, respectively.

substratum by flopping movements of the abdomen and remains bent in an L-shape. The legs and other appendages remain rigid. In a very few minutes, or sometimes almost as soon as freedom from the egg is accomplished, the pronymphal skin rips along the mid-dorsal line, and the first instar nymph pulls itself out, extends its legs, and assumes a very cocky pose. (In Anax, another Aeschnid, the pronymphal skin remains in the egg-shell, the first instar nymph being the first free stage.)

Pronymph. (Figures 7-10.) Because few pronymphs have been described and group characters are unknown, we shall not attempt a detailed technical description. In Gomphaeschna it is 3.75 mm. long, which is 1.75 mm. longer than the egg, and nearly 2 mm. longer (frons to tip of candal appendages) than Instar I. Except for the dark eyes and the sclerotized tips of the mouth-parts it is without color.

Balfour-Brown (1909) figures the pronymph of *Ischnura elegans* Lind., which is Zygopterous. In Gomphaeschna the conical terminal segment is twice the length of abdominal segment 10; in Ischnura it is four and one-half times as long as segment 10. In Gomphaeschna the eye is twice the width of antennal segment 1; in Ischnura it equals that segment. In Gomphaeschna, the egg-burster is well developed. In Ischnura, little or no egg-burster occurs, while the nymph ruptures the chorion through a swelling of its head which appears to drive some fluid ahead of it into the anterior end of the egg-shell. From the preceding there appear to be some subordinal differences between the pronymph of Ischnura (Zygopterous) and that of Gomphaeschna (Anisopterous).

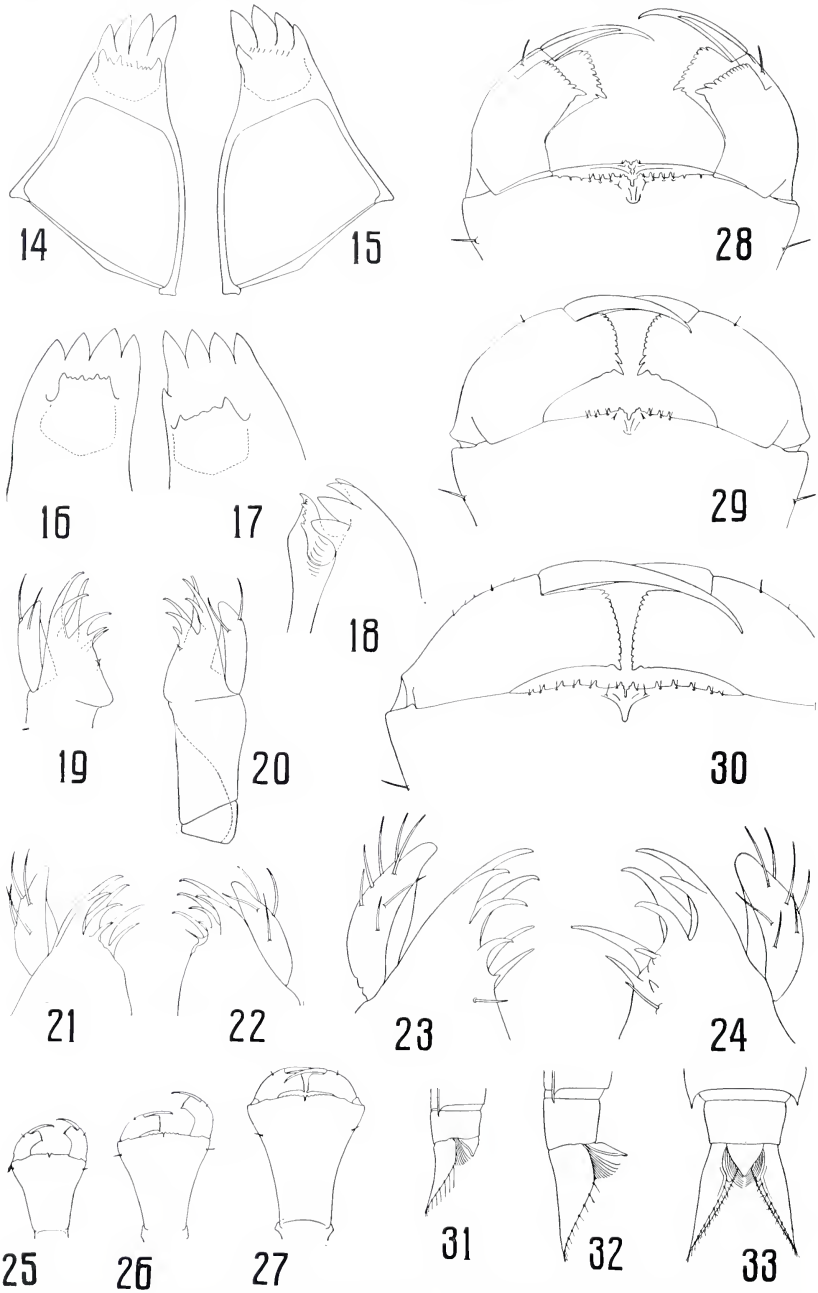
In Gomphaeschna, legs 2 and 3 (Fig. 7) show what appear to be subcoxal segments. This puzzled me when the figure was drawn in 1917 as I had not heard of subcoxal segments. To determine whether they are true segments or not will require further study.

Balfour-Brown's Figure 4 is wrong in that the right fore leg is shown extending to the apex of abdominal segment 6, while its mate extends to segment 8, where its tip turns forward. In this illustration, the distal part of the left fore leg is probably leg 3 improperly drawn on the base of the former. Such a mistake could have happened very easily under a high magnification of a whole mount.

Instar I. (Figures 11, 14, 15, 19, 20, 25, 28 and 31.) Length 1.75-2.00 mm., when fully extended a half-hour after ecdysis of the pronymphal skin. Aeschnid in general form characterized by long hairs (Fig. 11). Color pattern distinguished by pairs of spots on abdominal segments 3 to 9, with segments 8 and 9 very dark. Legs with conspicuous subapical ring. No wing pads. Tarsi one-segmented.

Head with frons arched forward more than in later instars, from eye to eye 120° of a circle. Compound eyes with two bristles each and tending to a conical shape. "Posterior angles" of head rounded; occiput square across. Antennae three-segmented; segments 1 and 2 subequal in length, segment 3 almost three times the combined length of 1 and 2, constricted at midlength.

Mandibles (Fig. 14, left and 15, right) with four long incisor teeth each. The left with a poorly developed row of minute teeth on the inner base of incisor row. (This inner row in later instars develops into the



FIGS. 14 and 15. Inner views of left (14) and right (15) mandibles of Instar I. FIGS. 16 and 17. Inner views of left (16) and right (17) mandibles of Instar III. FIG. 18. Ventral view of apex of left mandible of Instar III, showing molar teeth and fossa. FIGS. 19 and 20. Ventral views of right (19) and left (20) maxillae of Instar I. FIGS. 21 and 22. Ventral views of right (21) and left (22) maxillae of Instar II. FIGS. 23 and 24. Ventral views of right (23) and left (24) maxillae of Instar III. FIGS. 25-27. Views of dorsal or inner surfaces of the labia of Instars I (25), II (26), and III (27). FIGS. 28-30. Views of dorsal or inner surfaces of labia of Instars I (28), II (29), and III (30). Figure 28 is of a larva in the initial stages of ecdysis from Instar I into Instar II. The labial teeth of both instars are visible. FIG. 31. Lateral view of abdominal segment 10 and appendages of Instar I showing the epiproct, the left paraproct, and hairs of the respiratory valve. FIG. 32. Lateral view of abdominal segment 10 and its appendages in Instar III. FIG. 33. Dorsal view of same parts of Instar III as shown in figure 32.

molar prominence and in the exuvium is usually split from the incisor row as its base is on a membraneous area.) Right mandible (Fig. 15) with no molar row of teeth but with a short incisor tooth at base of the lowest or ventral incisor.

Maxillae (Fig. 19, right, 20, left) with an inner and an outer row of three teeth each. Two hairs on the palp.

Labium Aeschnid; when folded extending to between middle coxae (Fig. 28). Each lateral lobe with eight terminal teeth plus the larger single tooth at its inner angle. Anterior edge of mentum with two teeth at its middle between which a minute notch.

Abdomen 3¼ times as long as wide; widest at segments 7 and 8. Posterior "angles" of segment 8 angular but without hooks, of segment 9 with hooks as long as the intersegmental membrane. Segment 10 one-half as wide as segment 8.

Anal appendages three, a short, triangular epiproct (*appendix dorsalis*) one-half to three-fifths as long as segment 10, and two three-cornered, acutely pointed paraprocts twice as long as segment 10. No cerci.

In the use of terms for the abdominal appendages Snodgrass, (1935) has been followed. The epiproct is called the *appendix dorsalis* by Tillyard (1917). The paired appendages which we have termed paraprocts, following Snodgrass, are called *cerci* by Lucas (1930) and by Calvert (1934) who follow Heymons (1904). The upper pair of caudal appendages, which in Gomphaeschna have not appeared yet in Instars I-III, are termed *cercoids* by Heymons and *cerci* by Snodgrass. We have not been able to distinguish the sexes in Instars I and II by any difference in the epiproct as is shown in later instars.

Instar II. (Figures 12, 21, 22, 26 and 29.) Length 2.5 mm. General form as in Instar I but with head more angular. No wing-pads or cerci. Tarsi one-segmented. Differing from Instar I in having antennae four-segmented, the constriction in the terminal segment of Instar I having been completed. Color pattern (from preserved material) similar to that of Instar I, except for changes in head color and a faint band about each paraproct. Hairs not proportionally as long, hence less conspicuous than in Instar I.

Left mandible as in Instar I. Right mandible with its first well-developed molar teeth, at the outer end of which row, the odd or fifth incisor tooth.

Maxillae (Figs. 21 and 22) as in Instar I, except for four hairs on the palp. Labium (Figs. 26 and 29) as in Instar I, but with 10-11 terminal teeth on lateral lobe and three extra teeth on each side of original middle pair on anterior edge of mentum. Each of the eight mental teeth with a minute bristle at its outer side. Abdominal structures as in Instar I.

Instar III. (Figures 13, 16-18, 23, 24, 27, 30, 32 and 33.) The single individual, No. 403, reaching this stage, 3 mm. long. Except for greater size, general form similar to that of Instars I and II. Antennae four-segmented, tarsi one-segmented, no wing pads or cerci. Color in general as in earlier stages, except antennae with tips black, a band on base of

apical and subapical segments. Two distinct spots developed between the eyes on dorsal surface of head. Bands on middle of paraprocts distinct. (Color sketched from live nymph in 1917.)

Mandibles, as in previous instars, but molar row of teeth better developed and more remote from incisor row; that on the right mandible being twice as far below incisors as that on the left. Each molar row with a fossa (Fig. 18) developed between it and the incisors. (Figure 18 is a fore-shortened end-view of the fossa.)

Maxillae (Figs. 23 and 24) with four teeth in each row and at least seven hairs on the palp. (Figure 24 shows one tooth in the outer row damaged and replaced by a peg.)

Labium (Figs. 27 and 30) differing from that in previous instars in having on each lateral lobe 12 apical teeth plus the large tooth on the inner angle; anterior edge of mentum with five teeth on each (?) side of middle pair of teeth. (In this individual five on left and four on right side.) Caudal appendages (Figs. 32 and 33) as in Instars I and II.

General Considerations. From the characters of the first three instars the nymph is wholly Aeschnid in the strict sense. It has no Gomphid characters in antennae or in labium. We can only speculate on the generic characters of a fully grown nymph. The present data suggest that the occipital "angles" of the head may be rounded and that segment 9 has spines while segment 8 is without. Probably cerci and a spine on the epiproct develop in later stages. The color pattern suggests the spotted pattern of the nymph of *Nasiaeschna pentacantha* (Rambur) which rates as a primitive Aeschnid.

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