

A NEW SUBSPECIES OF *GOMPHUS (GOMPHURUS) SEPTIMA* FROM THE DELAWARE RIVER OF NEW JERSEY, NEW YORK, AND PENNSYLVANIA (ODONATA, GOMPHIDAE)

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Abstract

Gomphus (Gomphurus) septima delawarensis is described from the Delaware River, NJ, PA, and NY (Type locality: Flatbrookville, NJ). The new subspecies differs from nominate *G. septima septima* Westfall (new status) mainly by differences in the male cerci and epiproct, and in the female vulvar lamina and lateral occipital horns. The larvae of the two subspecies are similar and differ widely from other *Gomphurus* by the rounded dorsal tubercles on abdominal segments 6-8, and by the highly shortened row of teeth on the lateral palp of the labium. *Gomphus septima* is most closely related to the *vastus* group of *Gomphurus*.

Introduction

The discovery of this new subspecies of gomphid dragonfly from the Delaware River is remarkable. In the eastern heartland of American natural history studies (Boston to Philadelphia) virtually no Odonata taxa have been described from newly collected material in the past seventy years. In 1985 to 1989 FLC found numerous unidentified larval exuviae (one with associated wings) along the banks of the Delaware River, mainly near Flatbrookville, on the Warren-Sussex County line, New Jersey (Stutz 1992). These were recognized as belonging to a dragonfly of the subgenus *Gomphurus*, but further identification could not be made. In 1993 Ken Soltesz, studying the Odonata of the upper Delaware River for the New York Natural Heritage program and for the National Park Service, found exuviae of the same taxon at three widely separated localities: Port Jervis, Orange County, and Cochecton and Callicoon, Sullivan County, New York. Soltesz also collected an adult male of this taxon (Soltesz 1993) on a rock in the middle of a swift part of the river at Minisink Ford, Sullivan County. It was found to be very close to the species *Gomphus (Gomphurus) septima*, originally described from Alabama but known today only from North Carolina. Unknown to us, the larva of *septima* had been discovered but not yet described, thus preventing an association with the Delaware River exuviae. The new subspecies is highly disjunct

(more than 600 km) from known populations of *septima septima* in central North Carolina. The apparent requirement of this species for clean, rocky rivers with muddy and silty reaches suggests that extant populations in the intervening rivers between the Delaware River and North Carolina might not be found. Differences between the subspecies are considerable, and they could be justified as separate species rather than subspecies. However, they are clearly very closely related, and we have chosen to describe them as subspecies, especially as no material from the intervening part of the Eastern United States has been found.

The interest caused by this discovery inspired several odonatists to visit the Delaware River, and during a twenty-day period in 1994 at least 42 males and seven females were taken. In 1995 additional specimens were taken, and the range was extended upstream to Downsview, Delaware Co., NY, immediately below the Pepacton Dam on the East Branch of the river. Soltesz had taken a dead larva partially emerged, and F.L.C. took a live larva at Narrowsburg, Sullivan Co., NY, thus establishing the connection between the exuviae and the imagoes. The distribution of the insect covers 360 km along the Delaware River from Mercer Co., NJ, to Delaware Co., NY. Most of the specimens were collected from a 50 km reach between Barryville and Callicoon, Sullivan Co., NY.

***Gomphus septima delawarensis* n. ssp.**

The species description is composite, based on the holotype and allotype, but with minor variations (almost entirely dimensional or venational) being noted where appropriate. The species shows remarkably little variation within the type series.

Description

Male

A moderately large, club-tailed gomphid dragonfly with pale colors greenish yellow and dark colors dark brown-black grading to dark reddish brown posteriorly.

Head. Labium, maxillae, and mandibles yellowish basally, labium gray distally; second palpal segment, apex of maxillae and mandibles brown; labrum and genae yellowish white, base of labrum with narrow black line; anteclypeus pale yellow green, apex with narrow black line; postclypeus and antefrons greenish yellow with frontoclypeal suture narrowly darkened; basal 1/5 of dorsal antefrontal surface brown, brown area expanded anteriorly over medial third and near antennal bases; antennae and postfrons "vertex" black with lateral edge of postocellar ridge greenish brown; postocellar ridge depressed medially, extended to compound eyes laterally; compound eyes in life bluish gray dorsally, gray ventrally; occiput greenish yellow swollen anteriorly, occipital crest with slight medial indentation and with fringe of long black hair-like setae; posterior surface of head black dorsally, yellowish white ventrally.

Thorax. Prothorax dark brown, anterodorsally with large medial yellow spot, dorsomedial lobe with paired medial and lateral greenish yellow areas, posterodorsal

flange greenish yellow. Pterothorax mostly pea green to grayish green with broad bands of base color along sulci; dorsal mesanepisternal green stripes broadly confluent with green collar stripe below and extended posterolaterally above to form typical inverted "7" stripes of *Gomphurus*, mid-dorsal brown band slightly widened anteroventrally, dorsally narrower and ventrally wider than mesanepisternal green stripes at mid length, mid-dorsal carinae greenish yellow below peak, lateral mesanepisternal pale stripes narrow and slightly curved, extended from base of mesanepisterna to 2/3 height, separated from mesanepimeral green areas by brown bands along mesopleural sulci, these bands about 3 times the width of lateral mesanepisternal green stripes; katepisterna brown dorsally, light green over ventral half; thoracic sternum light green; mesanepimeral green stripes broadly confluent with metanepisternal green stripes above metathoracic spiracle, brown band along intersegmental interface limited to narrow brown area below spiracle and short dash above, metanepisternal and metanepimeral green areas separated by brown band along metapleural sulci which may be diffuse ventrally; dorsolateral carinae and antearals brown.

Legs. Coxae and metatrochanters pale green, pro- and mesotrochanters brown; femora black, often with external pale stripe on metafemora, interior surface of pro- and mesofemora pale greenish yellow; tibiae and tarsi black, leg spines black; prothoracic tibial laminae pale, about 1/5 length of tibiae.

Wings. Venation dark brown, costa yellowish green with black spines; pterostigmata dark brown; membrane hyaline; basal subcostal crossvein absent; antenodal crossveins 12-16 (fore wing), 8-10 (hind wing); postnodal crossveins 10-14 (f.w.), 10-13 (h.w.); bridge crossveins 4-8 (f.w.), 4-6 (h.w.); crossveins under pterostigmata 3-4 (f.w.), 2-5 (h.w.); triangles, subtriangles, and supradiangles without crossveins, except triangles occasionally 2-celled; costal side of fore wing triangle averaging 0.94 length of proximal side (range 0.84-1.08), costal side of hind wing triangle averaging 1.43 length of proximal side (range 1.18-1.65); gaff 1/2-3/5 length of inner side of triangle; anal loop 1-celled; anal triangle 3-celled.

Abdomen. Black marked with greenish yellow and yellow; terga 1 and 2 greenish yellow, with dark sublateral band above auricles, band extended ventrally below midline posterior to auricle; auricles greenish yellow with 50-60 black denticles restricted to posterior edge; tergum 3 greenish yellow with sublateral black band, this band expanded posteriorly to antecostal suture, beyond antecostal suture dorsal pale spot elongate ovate with slight subapical constriction; terga 4-6 black with full length lanceolate mid-dorsal stripes constricted at antecostal suture, laterally with pale green stripe along ventral border strongly constricted posterior to antecostal suture and again near apex; tergum 7 black, yellow anterolaterally, laterally with yellow constricted slightly at antecostal suture, mid-dorsal lanceolate greenish yellow spot extended 8/10 length of segment and slightly constricted at antecostal suture; tergum 8 black, with laterobasal yellow spot extended just beyond midlength laterally; expanded lateral rim of tergum 8 dark brown, dorsum with small midbasal yellow triangular spot, tergum 9 dark brown with large lateral semicircular yellow spot, with posterolateral corner brown and with yellow rim lightly shaded with brown; tergum 10 dark brown, lighter ventrally; sternum brown; intersegmental membrane 2-6 brown, 7-9 yellowish white.

Terminalia. Cerci gray brown, apically evenly tapered in dorsal view (Fig. 1) to a narrow tip, with sharp lateral projection at 60% of length; in lateral view (Fig. 3) strongly uparched with an inferior keel on apical 1/3, tapering in lateral view to fine apical point, this keel with a thickened ventral rim; epiproct in lateral view about 25% shorter than cerci, shining black, bent abruptly dorsally at tip; in dorsal view forked with divergent rami tightly curved nearly 90 degrees at apex, with slightly expanded tip in anterodorsal view (Fig. 11).

Secondary Genitalia. Anterior hamules dark, erect, of “thumb and knuckles” type, terminally expanded into near-cylindrical subquadrangular lobe (“thumb”), with four to five internal teeth (“knuckles”) as seen apically, sinus approximately of equal width throughout. Posterior hamule (Fig. 5) dark, with terminal hook, flattened, semi-recumbent, expanded at about 60% of the length to prominent anterior triangular point and shoulder with 5-7 denticles, deflected apically and tapering to a point which is bent first laterally and then ventrally, forming an apical compound bend. Penis red brown, hood black externally, filament and membranes pale, translucent, segment 1 about 2.1 mm long with penile hood erect, in lateral view with basal width approximately equal to length; apex level, with narrow rim, vesicle cup-like with lateral rims thickened proximally; segment 2 “J” shaped, length about 1.3 mm, distal portion globose without retractor spine; segment 3 about 1.3 mm long excluding prepuce and strongly constricted basally, prepuce elongate with distal projection longer than high in lateral view; segment 4 about 0.5 mm long, with apex strongly upturned; flagella short, about 0.16 mm long, each slightly outcurved and separated by wide “U”-shaped notch; inner edge with lateral pale, translucent expansions, basally tubular with small basal fringe.

Female

Color and color pattern as in male.

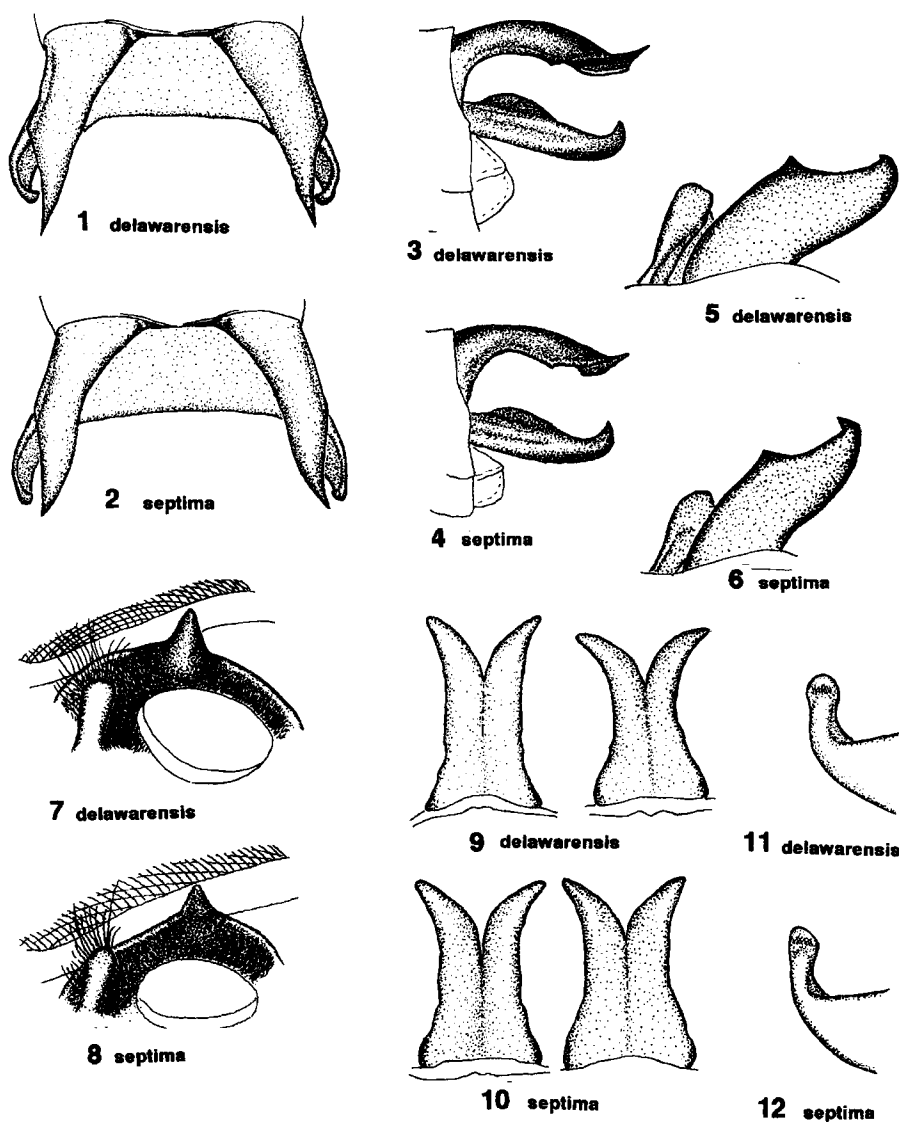
Head. Prominent black, shining, lateral horns rising from base of circum-ocellar ridge (Fig. 7), between lateral ocellus and eye, dorsolaterally directed, about 0.22 mm high, with straight taper and clearly separated from eye; occiput with rounded V-shaped medial depression in anterior view and also in dorsal view on posterior side.

Thorax. As in male.

Legs. As in male, but with more extensive pale color on hind femur.

Wings. Triangle of fore wing with costal side averaging 0.97 of proximal side (range 0.90-1.12); triangle of hind wing with costal side averaging 1.57 of proximal side (range 1.42-1.84);

Abdomen. As in male but with lateral stripes nearly complete on 4-7, interrupted only at transverse carina. Vulvar lamina (Fig. 9) half the length of 9th sternum, flattened, contracted in middle, and variably flared apically into two laterally curved, tapered rami; ratio of length to narrowest width: average 2.55 (range 2.39-2.67); ratio of basal width to narrowest width, average 1.60 (range 1.35-1.81). Flare of apices of the vulvar laminae developmentally variable.



Figures 1, 3, 5, 7, 9, 11. *Gomphus septima delawarensis*. Figs 2, 4, 6, 8, 10, 12: *G. s. septima*. 1, 2: male cerci, dorsal view. 3, 4: male terminalia, lateral view. 5, 6: male posterior hamules, lateral view, inverted. 7, 8: female ocellar rim with horns, mediiodorsal view. 9, 10: female vulvar laminae (two specimens each), ventral view. 11, 12: tip of male epiproct, anterodorsal view, showing rounded tip.

Larva

Known through the recovery of numerous exuviae on the river bank as well as one live larva; one exuvia contains partially emerged adult the head structures of which match the adult male of *delawarensis*.

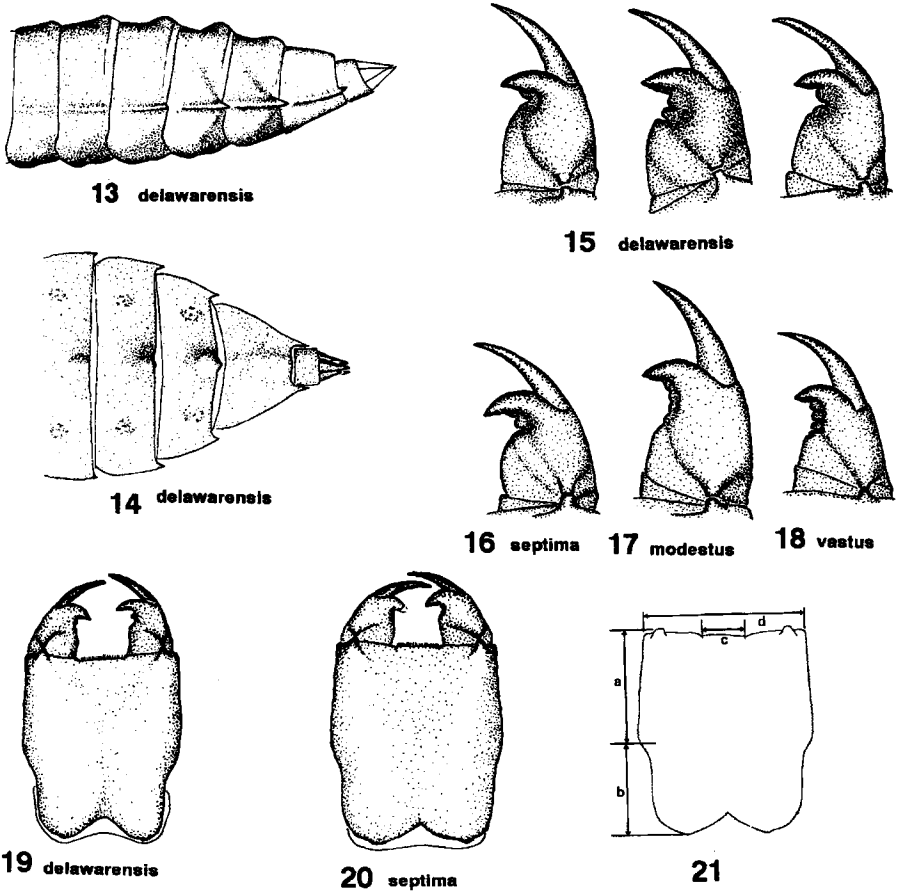
Head. Antennal segment 3 elongate-depressed, slightly widened distally, about 0.3 as wide as long, upcurved in the apical half, and slightly incurved; laterally and medially fringed with long, hair-like setae, dorsal papilliform setae apparently absent. Antennal segment 4 about 2/3 as wide as base of segment 3, and strongly upturned. Prementum (Fig. 19) gradually narrowed in basal 1/2 to about 7/8 apical width, basal width about 2.41 mm, apical 1/2 slightly convergent anteriorly, apical width about 0.95 maximum width; ligula even, 0.25 ± 0.01 apical width of prementum (c/d of Fig. 21) with fringe of moderately long setae (about 1/5 as long as ligula) and lacking medial tooth-like denticle; labial palps ending in sharply pointed incurved hook-like spine with 1-2 large quadrate teeth between base and apical spine; teeth of mesal margin set in concavity along 1/3 length of labial palp immediately proximal to apical hook; palp dentition variable, 75 percent of palps with single prominent tooth, 25 percent with two prominent teeth; in about 25%, single tooth located on inner side of apical hook, in remainder located in center of sub-terminal concavity; several palps also with one or two additional indistinct crenulations; dorsal surface of head with fine granulations, cuticular granules not deeply pigmented.

Thorax. Pro- and mesotibiae with strong burrowing hooks, much smaller on hind tibia; wing cases parallel.

Abdomen. Acuminate-ovoid in shape (Fig. 14), widest at segment 6, ventral width 40% length; lateral taper gradually increasing on segments 7 and 8, decreasing on 9; segment 9 twice as long at mid line as basal width, 9 with lateral length 1.75 times width of 10; abdomen dorsally covered with minute granules which become darkly pigmented medially, and almost devoid of setae; dorsomedian tubercles (Fig. 13) depressed and vestigial on segment 4, well developed on 5-8, and rounded-ridge-like on 9, extended beyond posterior cuticular margin of segments 5 or 6-9, those of segments 5-7 gradually increasing in height, largest on 7 and 8 with strong, blunt, apically directed triangular projections, that of segment 8 slightly more appressed, and that of 9 appearing level or with only slight apical elevation in lateral view; segments 6-9 with lateral spines directed posteriorly, relative lengths 0.2-0.3:0.6-0.7:0.8-0.9:1.0, respectively, lateral spines of segment 9 about 0.8 times length of mid-dorsal length of segment 10; lateral spines on 6-9 with ratios of length to mid-dorsal length of segment 9 as follows: 6: 0-6%; 7: 11-17%; 8: 19-22%; 9: 26-27%; lateral margins of segments 7-9 granulate, without stout spine-like setae; cerci about 1.4 times mid-dorsal length of segment 10 and about 3/4 length of epiproct in male, 8/10 in female, apex of male epiproctal tubercles at about 2/3 length of epiproct, paraprocts and epiproct subequal in length.

Dimensions

Adult male: total length 55.5-57 mm; abdomen including appendages: 40.0-43.5 mm; hind wing 30.5-32.5 mm; hind femora 9.3-9.6 mm; pterostigmata 3.2-3.5 (fore wing) and 3.7-4.0 (hind wing). Adult female: total length 55.0-57.0 mm; abdomen including appendages 38.5-42.0 mm; hind wing 32.0-34.5 mm; hind femora 9.5-10.0 mm; pterostigmata 3.4-3.8 (fore wing), 4.2-4.8 (hind wing). Exuvia: total length 32.0-34.5 mm, abdomen 20.0-21.5 mm, hind femora 5.0-5.5 mm, prementum (excluding palpi) 3.5-3.8 mm.



Figures 13, 14, 15, 19. *Gomphus septima delawarensis*. Figures 16, 20: *G. s. septima*. Figure 17, *G. modestus*; Figure 18, *G. vastus*; Fig. 21 schematic view of prementum of labium, showing dimensions referred to in text. 13 and 14; lateral and dorsal views of terminal segments of larval abdomen; 15, 16, 17, 18: larval labial palps; multiple specimens for *G. s. delawarensis*, showing variation; 19, 20: prementum of labium, ventral view.

Material studied (all Delaware River)

Abbreviations

FLC, Frank Carle; FLCII, Frank Carle II; KS, Ken Soltesz; TWD, T. Donnelly; OSF, Oliver S. Flint Jr., NMNH; AB (Allen Barlow). Exuviae (not paratypes) included and put in parentheses.

Holotype male: New York: Sullivan Co., Skinners Falls, 11 June 1994 (OSF); **allotype female,** same data as holotype (OSF); **paratypes:** New Jersey: Sussex-Warren Co., line; 0.7 km south of Flatbrookville; 4 June 1994, 4 males, 2 females, (also 8 exuviae); same locality, 13 males, 2 females, 23 June 1994 (FLC); (same locality, 20 exuviae, 27 May-18 June 1985 (FLC, FLCII)); New Jersey: (Mercer Co., Delaware R. at Scudders Falls, 1 exuvia, 4 June 1989 (FLC)); (New Jersey: Warren Co., Delaware R. 3.2 km S of Delaware Water Gap, 2 exuviae, 3 June 1988 (FLC)); (New Jersey: Warren Co., Delaware R. 0.2 km S. of Pequest R., 1 exuvia with wings, 4 June 1989 (FLC)); Pennsylvania; Pike Co., Lackawaxen, 1 male, 10 June 1994 (KS); (same locality, 2 exuviae, 12 June 1994, 9 July 1995 (FLC, TWD)); (Pennsylvania; Wayne Co., Delaware R. at Narrowsburg, 9 exuviae, 9 June 1994 (FLC)); same locality, 1 female larva and reared adult, 27 May 1995 (FLC); (Pennsylvania: Delaware R. at Damascus, 1 exuvia, 9 June 1994 (FLC)); (New York; Orange Co., Port Jervis, 1 exuvia, 1993 (KS)); New York: Sullivan Co., end of Grassy Swamp Road (1.7 km N of Westcolang PA), 10 males, (also 3 exuviae), 11 June 1994 (FLC); (New York; Sullivan Co., Delaware R. at Barryville, 7 exuviae, 12 June 1994 (FLC)); New York: Sullivan Co., end of Tusten Rd. (1.5 km S. of Tusten), 1 male, (also 9 exuviae), 12 June 1994 (FLC); New York, Sullivan Co., Tusten Station, 12 males, (also 1 exuvia), 13 June 1994 (FLC & FLCII); same locality, 4 males, 23 June 1994 (FLC & FLCII); New York: Sullivan Co., Minisink Ford, 1 male, 13 June 1993 (KS); New York: Sullivan Co., Skinners Falls, 2 males, 4 June 1994 (KS); same locality, 7 males, 1 female, 7 June 1994 (KS); same locality, 2 males, 10 June 1994 (TWD); same locality, 1 male, 1 female, 11 June 1994 (OSF); same locality, 5 males, 6 June 1995 (TWD); same locality, 3 males, 13 June 1995 (TWD); same locality, 4 males, 18 June 1995 (TWD); same locality, 1 male, 21 June 1995 (TWD); (same locality, 1 exuvia with partially emerged adult, 1994 (KS)); New York: (Sullivan Co., Delaware R. at Callicoon, 6 exuviae, 1993-1994 (KS)); New York; Delaware Co., Downsville, 1 male 1 female, 10 June 1995 (AB).

The holotype and allotype are deposited in the National Museum of Natural History, Washington, D.C.

The subspecies is named for its occurrence in the Delaware River.

This species is very similar to *Gomphus septima septima* Westfall, from which it may be distinguished by the following characters:

Male ventroapical cercal keel: in lateral view of *delawarensis* (Fig. 3) with even, thickened ventral margin; in *septima* (Fig. 4) the keel is smaller, with a more tapered, unthickened margin.

Male, inner margin of cerci: in dorsal view of *delawarensis* (Fig. 1) straight; in *septima* (Fig. 2) curved mesally in apical half.

Male epiproct tip: in anterodorsal view of *delawarensis* (Fig. 11) with thickened tip (width 0.16 mm) whose dorsal rim is evenly curved; in *septima* (Fig. 12) the tip is narrower (width 0.13 mm) and more pointed.

Male, posterior hamule: in lateral view of *delawarensis* (Fig. 5) with tip barely visible; in *septima* (Fig. 6) the tip is bent more ventrally.

Male, anterior hamules; apical sinus in apical view: parallel-sided in *delawarensis*; tapered in *septima*.

Male, anterior hamules; rim of apical lobe: straight in *delawarensis*; rounded in *septima*.

Male, middle segment of penis: ventral view of ventro-apical internal plates, darker flange of anterior border: scarcely protrudes from adjoining, inflated, pale, poorly sclerotized tissue in *delawarensis*; protruding noticeably from adjoining tissue in *septima*.

Female, lateral postfrontal horns: in *delawarensis* (Fig. 7) black, shining, erect, conical, arising from swollen base within lateral occipital rim, 0.22 mm high, in *septima* (Fig. 8) pale red brown, conical, smaller, 0.16 mm high, arising from lateral occipital rim, and lacking swollen base.

Larval ligular width (ratio c/d of Fig. 21): 0.251 (± 0.008 , $n = 9$) in *delawarensis*; 0.205 in sole specimen of *septima*.

Larva, ratio of length of prementum (a + b, Fig. 21) to hind femur, viewed laterally: 0.662 (± 0.011 , $n = 9$) in *delawarensis*; 0.726 in sole specimen of *septima*.

Larva, inner margin of labial palp: basally straight and apically curved in *delawarensis* (Fig. 15); curved throughout inner margin in sole specimen of *septima* (Fig. 16).

Less diagnostic differences are as follows:

Adults, dark ground color: dark brown in *delawarensis*; red brown in *septima* (this character in the closely related species *G. vastus* varies geographically and is probably of no diagnostic significance).

Female, vulvar lamina, ratio of maximum basal width to longitudinal distance from base to beginning of apical division: averages 0.95 in 6 specimens of *delawarensis*, two specimens of *septima* have this ratio 1.08 and 1.21; however, two specimens of *delawarensis* are 1.09 and 1.11.

Larva, longitudinal position of mid point of sharp taper in prementum (ratio $b / (a + b)$ of Fig. 21): 0.395 (± 0.03 , $n = 9$) in *delawarensis*; 0.389 in sole specimen of *septima*. Variable, 5 of 9 specimens have ratio 0.402-0.444; 4 of 9, 0.380- 0.395.

Gomphurus septima delawarensis and *G. s. septima* comprise a closely related allopatric subspecies pair. The adult males may be separated most quickly and reliably by the lateral views of the cerci, and the adult females by the lateral ocellar horns. The larva of *s. septima* is known only from a single exuvia collected by Ken Tennesen on the Rocky River, North Carolina; differences in the prementum have been found between this exuvia and those of *delawarensis*; however, they may, with the recovery of additional material, be shown to have less diagnostic value.

The tip of the epiproct of the male and the lateral ocellar horns of the female are correlated characters that may help to associate the males and females of the same species. The epiproct tips probably engage the stout female ocellar horns during pairing as a tactile recognition signal. The lateral spread of the epiproct rami of *delawarensis* (27 males, 2.22-2.62, av. 2.47 mm) is slightly less than the spread of the horn tips (8 females, 2.51-2.66, av. 2.59 mm) and the longitudinal extent of the epiproct is just sufficient to clear the occiput and engage the horns (including their swollen bases) when the epiproct is placed on the female face during pairing (as a tactile recognition signal). In *delawarensis* the epiproct tips are broader and the female ocellar horns stouter;

in *septima* the male epiproct tips are narrower and the female occipital horns smaller. For a smaller series of *septima* these dimensions are very similar (7 males, av. 2.55 mm; 4 females av. 2.54 mm).

Discussion

The adult characters of *Gomphurus*, as given by Carle (1982), are: head width about 3/4 length of hind femora, fore wing triangles with costal side shorter than proximal side, and lateral rims of abdominal tergum 8 black along apical half. Further adult characteristics, although not unique to *Gomphurus*, also characterize *delawarensis*, including expanded abdominal segments 7-9, veins A1 and A2 linked basally with a single-celled anal loop; anterior hamule of "thumb and knuckles" type (Needham 1948), posterior hamule inclined and massive with a distinct shoulder and end hook, paired penile flagella, and penile segment 1 hood-like with dish-like penile receiver (Needham 1901; Needham and Westfall 1955; Walker 1957, 1958; Carle 1982). *Gomphus septima delawarensis* and *s. septima* are unique among *Gomphurus* in several respects, including: male cerci with large keel-like ventrosupical lobe, male anterior hamuli with well developed thumb and weakly developed knuckle spines, female occiput deeply cleft, larval labial palps strongly hooked with spine-like apices and 1-2 large quadrate inner teeth, larval abdomen with well developed mid-dorsal abdominal tubercles, larval lateral spines of segment 9 about 0.8 mid-dorsal length of segment 10, and larval abdomen without lateral spine-like setae. *G. septima* is most closely related to the *dilatatus-modestus* species pair, all three sharing the short apical penile segment and well developed male lateral cercal spine. These three species in turn form a subset of the *vastus* species group, characterized by the hook-like labial palps of their larvae.

Larvae of *delawarensis* and *septima* can be readily separated from other *Gomphurus* by the rounded central dorsal tubercles of the abdominal segments 6 through 9 (which are unique within North American *Gomphus*, s. lat.), and by the sharp-margined dentate portion of the labial palp, which is highly shortened compared with other *Gomphurus* (Figs 15-18) and is occupied by only one or two well formed teeth. The larvae of *delawarensis* and *septima* (a single exuvia of the latter) are best separated from each other by the size of the prementum and the relative width of the ligula (summarized above). Additionally, the ligular setal brush also is slightly shorter in *G. septima*, and the incurved end hook of the labial palp seems slightly larger. The lateral abdominal spines are less developed in *G. s. septima*. The thinned tooth-bearing inner rim on the labial palps of both *delawarensis* and *septima* are notably shorter than in larvae of the *vastus* group, which are themselves shorter than remaining species of *Gomphurus* (*fraternus* et al.).

Biology

Most captures of adults (subsequent to the lone 1993 specimen) were along cleared areas away from the water (such as the course of the railroad paralleling the river). However, at the Flatbrookville locality, several adults were collected over water during a very brief period shortly after 19:00 h (EDT). At this time males perched on rocks along a 5-m section of a pool area of the river, and one male was observed to seize a female just as she flew down to the water surface. The tandem position was achieved within a meter of the water surface, and the pair flew directly to the tree tops.

Feeding behavior was observed near the Tusten Road site. Males were observed along the rock outcrops above the river perching on large rocks and logs from 14:15 to 19:15 h (EDT). At the Skinners Falls locality, adults were observed landing in clear areas adjacent to the railroad tracks, mainly after 15:00 h (EDT).

Oviposition was observed on 23 June 1994 at 19:52 h (EDT). A female landed on a large rock about 10 m from the shore. She then oriented herself towards the water while vibrating her wings in the warm-up mode. While holding the tip of her abdomen slightly upturned she extruded a small cluster of eggs. She flew then to a second rock and then over the water in wide loops, tapping the water three times at about 4-m intervals. She then flew directly to the tree tops.

The conservation status of the insect is not clear. Large rivers in the eastern United States may be especially vulnerable to a variety of forms of degradation (Carle 1979, 1982, 1989). Although much of the Delaware river, including the sections with the largest number of occurrences of *delawarensis*, is protected by the National Park Service through the Wild and Scenic Rivers designation, a larger difficulty for the insect might be the prevention of silt accumulation during the summer months when the larvae are very small. The impoundment at the headwaters of the Delaware (Cannonsville Reservoir in 1963 and Pepacton Reservoir in 1955; also the smaller tributary Neversink Reservoir in 1954) has almost certainly modified the river by removing the finer sediment in the upstream portion of the river (Donnelly 1993). The upper Delaware has a noticeably reduced variety and abundance of those Odonata whose larvae burrow in the benthos (gomphids, *Cordulegaster*, *Macromia* and *Didymops*, as well as unionoid bivalves) as compared with the unimpounded tributary Beaverkill (Carle unpub.) and nearby Susquehanna (Donnelly unpub.). Sedimentological studies of the Delaware River were not made prior to impoundment in the 1950s; thus there is no documented evidence for habitat change. However, unpublished studies of bottom depth show that erosion and armoring of the bottom has occurred subsequent to impoundment. Ken Soltesz (pers. comm.) has obtained anecdotal evidence of change from residents of the river at Port Jervis who remember more extensive occurrence of silt prior to impoundment.

A live larva of *delawarensis* was found in a quiet part of the Delaware River in a mixed silty, gravel, and rock bottom at a depth of more than a meter. Most larvae of the subgenus *Gomphurus* burrow in fine sand or silt in slower parts of rivers, but such substrate is scarce, especially on the upper Delaware River. The armoring of the bottom of the Delaware (Donnelly 1993) suggests that *delawarensis* may be very local in the upper part of the river. If the larval habitat of *delawarensis* requires fine sediment,

then further impoundment would be most unwise. Forty years have now passed since the first major impoundment of the Delaware, and the probability of further change from this effect is likely to be small. However, physical modifications to the river might have already imperiled this most interesting dragonfly. We note that several favorable locations for finding exuviae are at or immediately downstream of tributary streams or small rivers and speculate that these streams furnish fine-grained sediment during the critical summer months when the larvae are very small.

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