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MUSEUM OF ZOOLOGY
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A REVIEW OF THE DRAGONFLIES
OF THE GENERA *NEUROCORDU-*
LIA AND *PLATYCORDULIA*

BY

C. FRANCIS BYERS

ANN ARBOR

UNIVERSITY OF MICHIGAN PRESS

JUNE 30, 1937

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FREDERICK M. GAIGE
Director of the Museum of Zoology

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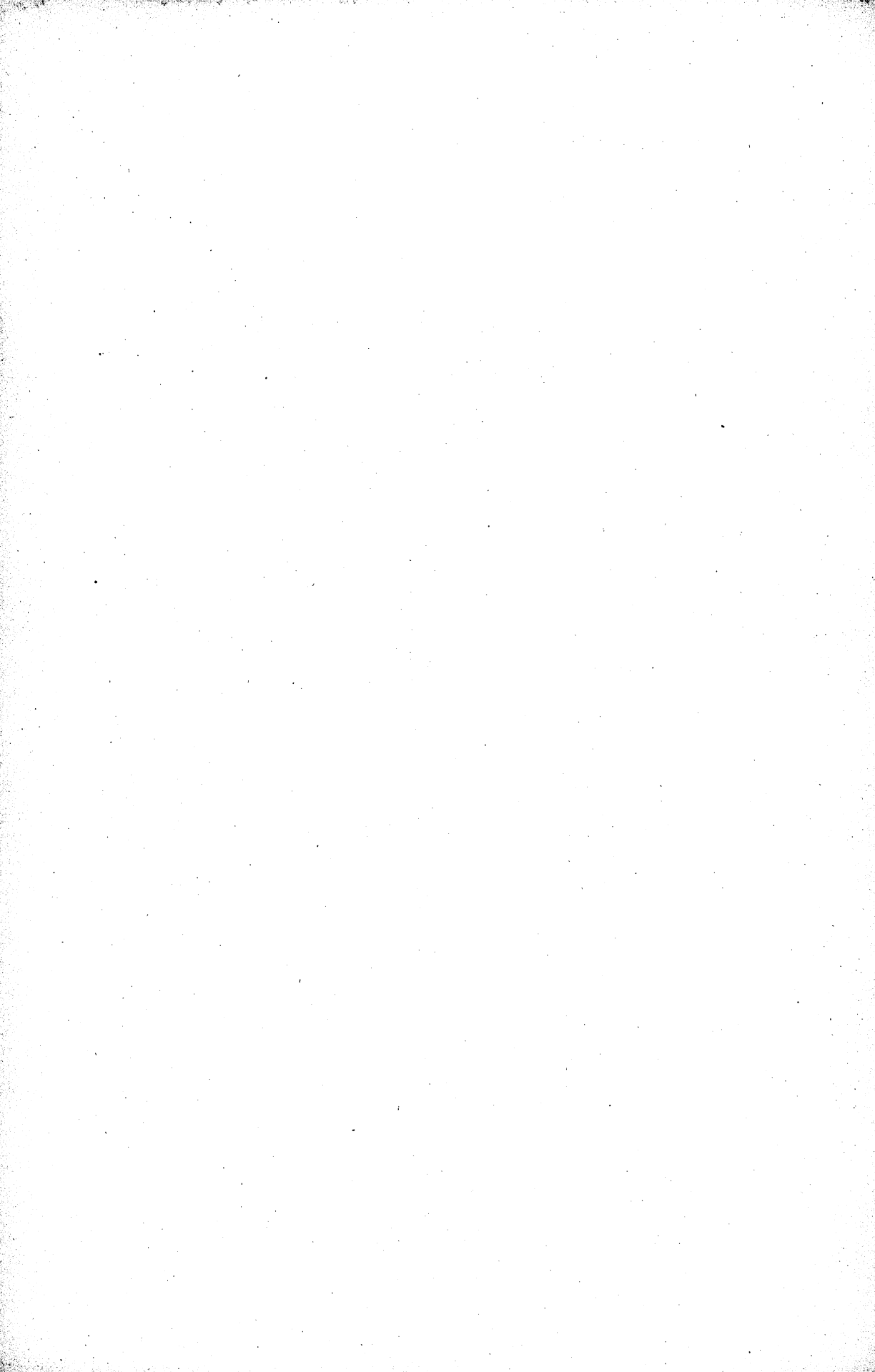
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A REVIEW OF THE DRAGONFLIES OF THE GENERA *NEUROCORDULIA* AND *PLATYCORDULIA**

INTRODUCTION¹

One hundred years have passed since there was read, on July 12, 1836, a paper before the Academy of Natural Sciences of Philadelphia in which Thomas Say described the first species of dragonfly now assigned to the genus *Neurocordulia*. Since then, nearly every American Odonatologist, at least once in his career, has published a paper on this genus. A bibliography of the writings on the genera *Neurocordulia*, established by the Baron de Selys in 1871, and *Platycordulia*, established by E. B. Williamson in 1908, contains the names of the foremost students of dragonflies.

Neurocordulia and *Platycordulia* from North America belong to a group of four genera (Williamson, 1908, Group II), which are primitive members of the Odonate subfamily Corduliinae. The other two members of the group are the genus *Aeschnosoma* from South America and the genus *Libellulosoma* from Madagascar.

The number of species found within each of these genera is small, and specimens are rare. *Platycordulia* and *Libellulosoma* have but a single species each, *Aeschnosoma* is represented by three species, and *Neurocordulia* by four nominal species: *obsoleta*, *yamaskanensis*, *virginiensis*, and *clara*. The latter two are represented in collections by one specimen each (the type female) and the other two by not more than thirty specimens of both sexes (Williamson, 1931).

It is because of the dearth of knowledge concerning these dragonflies, no doubt, that writers feel justified in recording in print every bit of information available about them. Thus, having secured the heretofore unknown male of *N. virginiensis* and having some information about the nymphs of Florida *Neurocordulines* and the nymph of *Platycordulia*, I have succumbed to the urge of writing yet another paper to add to the ever-growing bibliography of *Neurocordulia* and *Platycordulia*.

KEYS

KEY TO THE GENERA OF THE NEUROCORDULINE GROUP

Platycordulia, *Neurocordulia*, *Aeschnosoma*, and *Libellulosoma* constitute the genera of Group II of Williamson (1908). The following characters are used by him to separate this group from the other groups of the the Corduliinae.

* Contribution from the Department of Biology, University of Florida.

¹ The author wishes to express his appreciation to the Museum of Zoology, University of Michigan, for material and aid in the preparation of this paper.

M_4 and Cu_1 of the fore wing slightly divergent. M_3 and M_4 of the fore wing strongly convergent or parallel (not strongly divergent). Proximal angle of subtriangle of fore wing proximal to, on the level of, or only slightly beyond the arculus. Postanal cell of fore wing divided (2-celled). Proximal side of triangle of hind wing on level of, or proximal to, the arculus.

KEY TO ADULTS

- 1—Wing reticulation dense: 3 cubitoanal cross veins; anal triangle of male 3 celled; M_4 and Cu_1 separated by 3 cell rows following the triangle. Toe of anal loop very broad and round, inclosing 9-11 cells; widely separated from hind wing margin by 2 rows of cells. Wings highly colored, antenodal and postnodal cross veins all blotched with brown. Central United States: Oklahoma, Kansas. *Platycordulia*
- Wing reticulation less dense: generally 2 cubitoanal cross veins; anal triangle with 2 cells; M_4 and Cu_1 frequently separated by 2 rows of cells in part of their length following triangle. Toe of anal loop not broad and rounded, frequently pointed, inclosing 3-6 cells; close to margin of wing, separated by a distance of one cell only. Wings clear or moderately colored, at most basal antenodal cross veins blotched with brown. (2)
- 2— M_3 and M_4 of fore wing strongly undulate and converging toward the wing margin. M_1 and M_2 unsymmetrically forked. Toe of anal loop small and blunt inclosing 3-4 cells. Wings uncolored. (3)
- M_3 and M_4 of the fore wing not undulate but running straight and nearly parallel with each other to wing margin. M_1 and M_2 symmetrically forked. Toe of anal loop more or less pointed, inclosing 6-7 cells. Wings variously colored. Eastern North America. *Neurocordulia*
- 3—Fore wing with 10 or more antenodal cross veins. Eyes quite contingent. South America. *Aeschnosoma*
- Fore wing with less than 10 antenodal cross veins. Eyes barely contingent. Madagascar. *Libellulosoma*

KEY TO THE SPECIES OF THE GENUS *NEUROCORDULIA*

- 1—Three rows of cells in part between Cu_2 and hind margin of fore wing. Hind wing 3 rows of cells between A_2 and wing margin. Postnodal cross veins of hind wing numerous, 8-12. Cross vein present (*obsoleta*) or absent in the median space proximal to arculus. Stigma long (3 mm.) followed by 4-5 cross veins. Wing coloration varied (see sections A, B, C, below on wing coloration of the species of *Neurocordulia*). (2)
- Two rows of cells between Cu_2 and hind margin of fore wing. Hind wing 2 rows of cells between A_2 and wing margin. Postnodal cross veins of hind wing 6-7. No cross veins in median space proximal to arculus. Stigma shorter (2.5 mm.) followed by 2-3 cross veins. Superior appendages of male (Pl. IV, Figs. 5, 6) about twice as long as segment 10, pale brown. Female appendages shorter than segments 9+10, about twice as long as segment 10. Vulva entire with broad median notch (Pl. III, Fig. 7). Wing coloration reduced (see section D below). Tarsi fuscous. *virginiensis*
- 2—Wings generally with dark spot on nodus and first 4-6 subcostal cross veins, otherwise colored as indicated in sections A and B below. A cross vein in median space proximal to arculus. Antenodal cross veins of fore wing 7-8. (3)
- Wings with no spot on nodus and only first two subcostal cross veins colored, otherwise

colored as indicated in section C below. No cross vein in median space proximal to arculus. Antenodal cross veins of fore wing 9-11. Superior appendages of male (Pl. IV, Figs. 3, 4) about three times as long as segment 10, black or dark brown. Female appendages shorter than segments 9+10, about twice as long as segment 10. Vulva entire with rectangular median notch (Pl. III, Fig. 6). Tarsi fuscous. *yamaskanensis*

3—Wings with enlarged, dark-colored, anal area, otherwise colored as in section A below. Superior appendages of male (Pl. IV, Figs. 1, 2) about twice as long as segment 10, pale brown. Female appendages short, not as long as segments 9+10, about twice as long as segment 10. Vulva bilobed with deep curved median notch (Pl. III, Fig. 5). Tarsi fuscous. *obsoleta*

Wings with anal areas clear, otherwise colored as in section B below. (Male unknown.) Female appendages long; as long as, or nearly as long as segments 9+10. Tarsi pale, same color as femora and tibiae. *clara*

KEY TO THE NYMPHS OF *NEUROCORDULIA* AND *PLATYCORDULIA*

1—Frontal shelf, between bases of antennae, produced into a prominent flat triangle (Pl. II, Fig. 5). Lateral spines of segment 9 not as long as the corresponding segment, not extending much beyond the tips of the abdominal appendages, if at all. Dorsal hooks prominent (Pl. II, Fig. 1; Pl. III, Fig. 4). Length 20 mm.

Platycordulia xanthosoma

Frontal shelf, between bases of antennae, low and rounded, not produced into a flat triangle (Pl. II, Fig. 6). (2)

2—Lateral spines of segment 9 as long as the corresponding segment (1:1), extending far beyond the tips of the appendages (Pl. III, Fig. 1). Dorsal hooks forming prominent tubercles on segments 7-9, that of 9 much less prominent than of 8 (Pl. II, Fig. 4). Length 20-21 mm. *Neurocordulia obsoleta*

Lateral spines of segment 9 not as long as the corresponding segment, not extending much beyond the tips of the abdominal appendages if at all. (3)

3—Lateral spines about one-half to one-third (1:2, 1:3) as long as the segment that bears them, not extending beyond the tips of the abdominal appendages (Pl. III, Fig. 2). Dorsal hooks of segments 7-9 reduced to scarcely more than a short ridge (Pl. II, Fig. 3). Length 22-24.5 mm. *Neurocordulia yamaskanensis*

Lateral spines of segment 9 over half as long as the corresponding segment (1:1.7) but not as long as the segment (1:1), extending to tips of abdominal appendages or a little beyond (Pl. III, Fig. 3). Dorsal hooks forming prominent tubercles on segments 7-9, that of 9 but little less prominent than 8 (Pl. II, Fig. 2). Length 18.5-19 mm. *Neurocordulia virginienensis*

Unknown [*Neurocordulia clara*].

DISCUSSION OF SPECIES

WING COLORATION OF THE SPECIES OF *NEUROCORDULIA*

There is considerable variation in the amount and extent of coloration in the wings of the various species of this genus as well as among various specimens assigned to some of the species. In general, *obsoleta* has the most extensive coloration and shows greater variation, with *yamaskanensis* and *virginienensis* following in order. *N. clara* is difficult to place in the series for it has a more extensive coloration of the subcostal area than *yamaskan-*

ensis and *virginiensis* but a far greater reduction of the coloration of the basal area than either of these.

Wing colors in the genus *Neurocordulia* are light yellow to dark brown. The color (*a*) is restricted to a definite set of veins, (*b*) covers a generalized area, or (*c*) both veins and membrane may be darkened.

The areas of the wing usually colored in *Neurocordulia* are: (1) wing base, costal and subcostal areas; (2) wing base, anal area; (3) area of the nodus.

The sets of veins usually colored in *Neurocordulia* are: (1) subcostal cross veins (sometimes referred to as the antenodals of the second series); (2) cubitoanal cross vein (sometimes called the anal crossing); (3) the veins of the anal angle of the hind wing; these include the bisector of the anal loop, A_2 , A_3 , and the hind margin of the wing running parallel to A_3 , as well as some of the cross veins between them.

The four species of *Neurocordulia* have the following coloration patterns on the wings:

A. *Neurocordulia obsoleta* (Pl. V, Fig. 1; Pl. VI, Fig. 1)

FORE WING.—Base smoky; anal area with dark brown spot; usually a yellowish to dark brown spot covering nodus. All subcostal cross veins yellowish; cubitoanal cross vein with yellow spot.

HIND WING.—Extreme base smoky; anal area with extended brown spot reaching to base of triangle and covering veins of anal field including cubitoanal cross vein, beginning of bisector of anal loop as well as origin and some little extent of A_2 and A_3 ; triangle with a yellow spot. Dark brown spot usually covering nodus. All subcostal cross veins with a yellow spot.

VARIATIONS.—In this color pattern of the wing, apparently the most frequent variation is the absence of the brown spot of the nodal area. Other variations have been noted as follows (Garman, 1927: 235): "One female in this collection [that of P. P. Calvert] has very little coloring in the wings and almost none in the antenodal cross veins." (Say, 1839: 29): "The brown spots of the anal base and the submarginal spots of the wings, are sometimes obsolete, or altogether wanting."

B. *Neurocordulia clara* (Pl. V, Fig. 2)

FORE AND HIND WINGS.—Base entirely devoid of coloration; first 4–5 subcostal cross veins with small spots; a reduced spot on nodus. Wings resemble those of *obsoleta* with the basal coloring washed out leaving only reduced coloring on cross veins of subcostal area and nodus. Intergrades with *obsoleta* variations.

C. *Neurocordulia yamaskanensis* (Pl. VII, Fig. 1)

FORE WING.—Extreme base of costal-subcostal area suffused with yellow; first two subcostal cross veins with yellow spot each; cubitoanal cross vein with yellow spot. Wing otherwise clear.

HIND WING.—Base of costal-subcostal area as far as first antenodal cross vein suffused with yellow; first two subcostal cross veins with a yellow spot each; anal area yellowish brown; cubitoanal cross vein and surrounding area brown to yellow. Bisector of anal loop, A_2 , A_3 , and hind margin of wing as well as connecting cross veins dark brown, area between yellowish.

VARIATIONS.—E. B. Williamson (1932), in describing a female *Neurocordulia* from Missouri noted the following: "The surprising thing is that it is identical with typical *yamaskanensis* except that the immediate region of the ante- and postnodals is tinged with light brown."

D. *Neurocordulia virginienensis* (Pl. V, Fig. 3; Pl. VI, Fig. 2)

FORE WING.—Extreme base of costal-subcostal area with a light yellow cloud. First two subcostal cross veins with a light yellow spot; cubitoanal cross vein with a darker yellow spot.

HIND WING.—Base of costal and subcostal area as far as first antenodal yellowish; first two subcostal cross veins with a yellow spot each; cubitoanal cross vein with darker yellow spot. Basal area with A_3 and the four cross veins that extend from it to hind wing margin deeply infuscated as is also the first cross vein between A_3 and A_2 .

SPECIFIC CHARACTERS OF KNOWN NYMPHS OF NEUROCORDULIA AND PLATYCORDULIA

I have attempted to bring together in Table I, from written descriptions and examination of available material, pertinent information regarding the specific characters of the known nymphs of the two genera under consideration.

NEUROCORDULIA OBSOLETA (SAY)

ADULTS (Pl. III, Fig. 5; Pl. IV, Figs. 1-2; Pl. V, Fig. 1; Pl. VI, Fig. 1).—Female (type): Milton, near Boston, Massachusetts, 1820. Collection of Boston Society of Natural History. Thomas Say (1839). [*Libellula*].

Synonymy.—*Libellula polysticta* Burmeister (1839). Male. Collection of Museum of Comparative Zoology, Harvard. *Cordulia molesta* Walsh (1863: 254). Female. Type specimen destroyed (Hagen, 1867). The generic names *Epitheca* (De Selys, 1871, Hagen, 1875, 1890), *Didymops* (Hagen, 1861), *Cordulia* (Walsh, 1863), and *Libellula* (Say, 1839; Burmeister, 1839) have been applied to *obsoleta* or its synonyms.

Descriptions.—Satisfactory descriptions have been published by the following authors.

TABLE I
(Measurements in mm.)

CHARACTERS	<i>NEUROCORDULIA OBSOLETA</i>	<i>NEUROCORDULIA YAMASKANENSIS</i>	<i>NEUROCORDULIA VIRGINIENSIS</i>	<i>PLATYCORDULIA XANTHOSOMA</i>
Length of body	20-21	22-24.5	18.5-19	20
Mentum of labium .....	.....	4	4.5- 5	6
Hind wing	5.5	5.5	6 - 6.5	8
Hind femora	5.5	5.5	5.5	6
Width of abdomen	9	9-10	7 - 9	10
Width of head .....	.....	6.5	6 - 6.5	7
Length of abdomen	13	.....	11	12
Mental setae	8-9	9-11	9-11	8-9
Lateral setae	6	6	6	6
Crenulations of lateral lobe	Deep, 7	Deep, 7	Deep, 7	Deep, 7
Extent of labium	Below base of forelegs	Slightly below base forelegs	Well below base of forelegs	To base of forelegs
Dorsal hooks	On segs. 2-9 well de- veloped	Segs. 2-9, very low on 7-9	On segs. 2-9, well de- veloped	On segs. 2-9, fairly developed
Lateral spines	(1:1)* long as seg. 9; extend beyond tips of appendages	(1:2-1:3)* short; not reaching tips of appendages	(1:1.7)* fairly long, extend to level of abdominal appen- dages	(1:2)* shorter, slightly below tips of abdominal ap- pendages
Eyes	Prominent	Not prominent	Prominent	Fairly prominent

* Ratio in parenthesis represents comparative length of lateral spines on segment 9 to the length of segment 9.

P. Garman (1927: 234-236). Gives a synopsis and description of a Connecticut *Neurocordulia*, photograph of nymph, and photograph of wings.

H. A. Hagen (1890: 367-373). Writes a very complete description with a note on the validity of the name *obsoleta*, and figures anal appendages and genitalia for male and female.

R. Martin (1906: 38-40). Also figures wings and male and female appendages.

J. G. Needham (1929: 173-175). Also gives keys and figures male appendages and female vulva.

E. B. Williamson (1899). Brief description.

Diagnostic characters have been treated in the keys of the present paper and under the discussion on wing coloration.

NYPH (Pl. II, Figs. 4 and 6; Pl. III, Fig. 1).—Descriptions: satisfactory descriptions of the nymph have been written by the following authors.

Needham (1901: 486-487). First description of nymph.

Walker (1913, 1915). Contrasts nymphs of *obsoleta* and *yamaskanensis*.

P. Garman (1927: 234-235). Gives good description and figures.

Howe (1927). Gives no description, but has photograph of labium and drawings of inner margin of lateral lobes of labium (chart).

Diagnostic characters have been treated in the keys to the present paper and in the table of nymphal characteristics.

Material.—I have examined the following material, borrowed from Dr. Needham and the collection of Cornell University. Raleigh, North Carolina, 1 nymph, late instar. Collected by Brimley, 1918. Potomac River, near Harpers Ferry, Virginia, 7 nymphs, early instars. Collected by V. Argo.

DISCUSSION.—*N. obsoleta* was the first described of the species now assigned to the genus and after residing in a number of Libellulid genera was finally used as the type for the genus *Neurocordulia* when it was established by De Selys (1871). Williamson (1931) remarks:

A bit of sentimental interest attaches to the fact that Thomas Say, in 1839, in a posthumous paper, described the first *Neurocordulia*, naming it *Libellula obsoleta*. Say said of the species that it, 'Inhabits Indiana and Massachusetts.' The Massachusetts material consisted of a single female collected by T. W. Harris at Milton, Massachusetts, in 1820—so far as known the earliest capture of a *Neurocordulia*.

Two species have appeared in the literature both of which are, in all probability, synonyms of *N. obsoleta*. Hagen (1861-1890) lists first the one and later both of these described species as *obsoleta* synonyms, a procedure followed by all later writers. Apropos of the matter, Williamson (1931), speaking of collected specimens of *N. obsoleta*, states:

Later in the same year (1839) Burmeister described a single male under another name, from New Orleans. And in 1863 Walsh described a single female, under still another name, from Rock Island, Illinois.

There is some doubt as to whether Burmeister's name, *polysticta*, or Say's name, *obsoleta*, should be applied to this species. Hagen (1890) in a footnote, remarks:

I have always used the names of the American entomologist, Thomas Say, though I worked in Europe, and their priority over those of H. Burmeister is by no means certain. Say's paper was read 12 July, 1836; it was not published—I have never been able to learn why—until 1839. In my opinion the American entomologist can never lose priority by the unaccounted for delay in the publication of his paper.

Later, Hagen added:

At that date Burmeister's work was certainly in print and was published directly. Priority hunters here and in Europe may do their work.

Prior to 1890 specimens of *N. obsoleta* were very rare. In 1873 Hagen wrote:

This is one of the rarest and most interesting species. Besides the specimen (a male) from Indiana described by Mr. Say, only three specimens (Harris' female, Burmeister's male, and Walsh's female) are known.

Later (1875) he noted:

Only three specimens, the types of Say, Burmeister and Walsh are known; that of the latter was burned in the Chicago fire.

In 1890 Hagen wrote again:

The types of Say from Indiana and the type of Walsh are destroyed. I saw the latter in 1868 and am sure it belongs to *E. obsoleta*. Say's type from Massachusetts, a female collected in 1820 in a meadow at Milton, near Boston, still exists in the Harris collection at the Boston society of natural history; the type of Burmeister, a male, and a male from Galena are in my collection. These are the only specimens known and have been in the hands of Baron de Selys Longchamps for his Synopsis. The type of Burmeister is immature and in bad condition.

Calvert (1898: 81. No. 53 *Libellula polysticta* B.) lists Burmeister's type as follows:

Von New-Orleans, in v. Winthem's Sammlung. One male in M.C.Z. with pin-labels "Winthem" printed, "L. polysticta Burm. New Orleans" (written).

Williamson (1931) remarked:

Hagen records that Say's Indiana male [not the type] and Walsh's Illinois female had been destroyed, and that no additions had been made except a single female from Galena, Illinois. So far as collections of dragonflies were concerned, here was a species threatened with extermination.

In the same article, however, Williamson goes on to say:

Fortunately other regions [than Indiana] have been more productive [since 1890]. When the captures are totalled one arrives at about twelve males, twelve females, and twenty-five nymphs and exuviae.

ECOLOGICAL NOTES.—In a species as rare as this, one would not expect to find, nor does one find, much information regarding habits and distribution.

From published accounts it would seem that *N. obsoleta* is (1) rare, (2) crepuscular in habit, (3) a summer dragonfly (June–September), (4) more commonly collected in the nymph than in the adult form, (5) similar in most of these respects to *N. yamaskanensis*.

Some of these facts can be gathered from the writings of Hagen and Williamson quoted in the foregoing discussion. They are further substantiated by the following published accounts.

Davis (1927):

The dragonfly *Neurocordulia obsoleta* Say is crepuscular in habit, and usually a rare insect. The writer has collected but three specimens of *obsoleta* though others have been examined. They are usually disturbed in some situation where they have been at rest.

Williamson (1908):

Professor Walker has recorded the interesting fact that *N. yamaskanensis* is entirely crepuscular in its habits, spending only a brief period of the day on the wing. It is not improbable that *N. obsoleta* and *P. xanthosoma* similarly are abroad only in the evening.

Howe (1918):

Neurocordulia obsoleta (Say). Rare—streams, lakes, crepuscular. June 10–August 30. Maine, New Hampshire, Massachusetts.

An interesting exchange of ideas regarding *N. obsoleta*, along with several other species of Odonata, in relation to spiders, was carried on between Dr. P. P. Calvert and Mr. E. B. Williamson in the *Entomological News* for the year 1903. The following will give the gist of the situation.

Calvert (1903):

We collected most of the unbroken Odonata exuviae seen in this boat house [near Chestnut Point, Lake Hopateong, N. J., Sept. 14, 1902].

Included in this collection, along with other species of dragonflies, were 15 male and 16 female exuviae of *N. obsoleta*.

The almost entire teneral Odonata found in the remains of webs were *Neurocordulia obsoleta* 1 ♀ [and other dragonflies]. As the above named Odonata are usually seen flying not later than July in this region, it is quite likely that the transformations had occurred long previous to our visit to the boathouse. The general condition of affairs strongly suggested that the spiders had preyed upon the newly transformed dragonflies, a possible explanation of the generally observed rarity of such species as *Neurocordulia obsoleta* in the imago state as contrasted with the abundance of its exuviae found here.

Williamson (1903):

As to the possibility of there being some relation between teneral spiders' webs and the scarcity of imagoes, I doubt if the spiders are very important factors. That is, in the boat house possibly, a considerable percentage of emerging species were captured, but the total number emerging in the boat house were relatively small to the total number emerging under more favorable conditions (no spiders) elsewhere.

Williamson later added:

I am afraid in the case of *Neurocordulia obsoleta* our ignorance is more responsible than the spiders for the few imagoes known.

Calvert (1903), in an extended footnote to the Williamson article quoted in part above, replied:

While admitting the justness of Mr. Williamson's criticisms in a general way, there are several facts to be pointed out which seem to support the idea suggested, viz.: that spiders may be an important factor in diminishing the number of dragonflies. Thus we also saw living spiders of the same genus [*Dolomedes*] at other points on Lake Hopatcong, running over the stones and the small wooded piers so common on the shores.

Calvert points out that the significance of the boat house was that it afforded a shelter for spider webs, dragonflies, etc., against destruction by the weather and so preserved a record of events similar to those which were doubtless happening elsewhere but of which no trace remained.

The nymph of *Neurocordulia obsoleta* was first described by Needham (1901). He based the description on a single specimen received from Calvert bearing the label, "H. C. Borden, Pa. Oct. 26, '95." In a footnote to the description, Dr. Needham states:

Since the above was written I have received exuviae from Dr. Calvert, taken at White Lake in the Catskills, and from E. B. Williamson, taken at Nashville, Tenn., of this same species.

In 1903 Calvert reported exuviae from Lake Hopatcong, New Jersey, as already noted, and in the same year Williamson reported a nymph from Chattanooga, Tennessee, and several nymphs from the Cumberland River near Nashville, Tennessee. They were clinging to fish-traps when the traps were drawn from the water.

H. Garman (1924) reported a nymph from the Cumberland River at Pineville, Kentucky.

The next year (1925) Needham, reporting on aquatic Neuropteroid insects from Lake George, New York, collected during the summer of 1920, wrote:

Four cast skins of this fine species were found on August 24 adhering to the face of Chives Rock where it rises from deep water; another was found on the face of the pier at Baldwin, also facing deep water.

Needham (1929) refers to *N. obsoleta* exuviae taken from Spanish Moss in Chipola Lake, Florida. It is my opinion that these nymphs belong to the species *N. virginiensis*.

NEUROCORDULIA CLARA MUTTKOWSKI
(Pl. V, Fig. 2)

R. A. Muttowski (1910b) described "*Neurocordulia obsoleta clara* n. subsp.," from one female labeled "Alabama" in the Brooklyn Institute. He remarks:

Entire absence of anal spots on all wings will distinguish this species from other *Neurocordulia*. There is not the slightest trace of the anal spots as found in *N. obsoleta* and *yamaskanensis*.

Davis (1929) compares *obsoleta*, *virginensis*, and *clara* and presents the figure of these three species reproduced in this paper (Pl. V). He is of the opinion that *clara* is a good and distinct species.

Williamson (1931) remarks:

Muttowski described *Neurocordulia clara* in 1910 from a single female from Alabama. This is getting pretty close to the locality from which Burmeister's type of *polysticta* came.

Needham (1929) considers *clara* as a variety of *N. obsoleta*.

The foregoing represents the extent of our knowledge of this species (if it be a species) at the present. The male and nymph are still unknown. Until more material is available it would be unwise to allocate *clara* definitely.

In the present paper the distinguishing characters of Muttowski's *Neurocordulia* are given in the key.

*NEUROCORDULIA YAMASKANENSIS*² (PROVANCHER)

ADULTS (Pl. III, Fig. 6; Pl. IV, Figs. 4-5; and Pl. VII, Fig. 1).—Male (type): Mount Yamaska, near Saint Hyacinthe, Province of Quebec, Canada. Fate of type unknown. Abbé Provancher (1875). [Aeshna.] Provancher (1877) obtained a single female two years later from the same locality and described it in the same journal under the generic name *Epitheca*.

Descriptions.—Since satisfactory descriptions have been published by the following authors, a detailed description will not be given here.

P. Garman (1927: 236).

H. A. Hagen (1890: 367-369). Very complete. Figures male and female anal appendages, male genitalia of second segment, and female vulva.

R. Martin (1906: 39). Figures male appendages.

J. G. Needham (1929: 175). Short description; figures male appendages and female vulva.

² Also spelled *yamaskanensis* and *jamascarnensis* by authors.

Diagnostic characters have been treated in the keys of the present paper and under the discussion on wing coloration.

Material.—The author has seen the following material from the Mus. Zool. Univ. Mich., which has not been listed or published upon before: Put-In-Bay, Lake Erie, Ohio. 11 ♂; 9 ♀. June 26, 1935. Collected by C. H. Kennedy and R. C. Osborn.

NYMPH (Pl. II, Fig. 3; Pl. III, Fig. 2).—Descriptions: E. M. Walker (1913, 1915), has published complete descriptions of the nymph from many specimens and from reared material. Diagnostic characters of the nymph have been given in the keys of the present paper and in the table of nymphal characteristics.

Material.—I have examined the following material borrowed from Dr. Needham and the collection of Cornell University. Justice, West Virginia, 1 exuviae, 9 early instar nymphs. July 10–11, 1930.

DISCUSSION.—Thirty-six years after Thomas Say described the first species of *Neurocordulia*, Abbé Provancher described the second on the basis of a single male specimen from Mount Yamaska, Province of Quebec, and named it *Aeshna yamaskanensis*. Two years later he obtained the female from the same region. Hagen (1890), under the name *Epiptera yamaskanensis*, remarks: "The male was collected by Abbé Provancher in 1875 and the female in 1877. There can be no doubt that both belong to the same species," and later, "This species [*obsoleta*] is very near to *yamaskanensis* Provancher, of which I have seen the only pair known."

De Selys (1878) places "*jamascarnensis*" in the genus *Neurocordulia*, after first listing it as "*Epiptera? jamascarnensis*," and cites the species as Hagen's. He noted the female as being unknown. He also points out the similarity to *obsoleta* and remarks about the geographical range of the species.

There has been very little confusion of species as regards *N. yamaskanensis* and consequently no synonymy to record.

Williamson (1932) lists a *Neurocordulia* from Missouri which he states is identical with typical *yamaskanensis* except for minor variations in wing coloration.

Walker first referred to the nymph in 1905, and adequately described it in 1913 and again in 1915. Muttkowski (1910) makes no mention of literature regarding the nymph: Howe (1927) notes, "Larva believed unknown"; and Garman (1927) failed to make mention of the nymph.

Williamson (1931) wrote a condensed but very accurate account of the history of our knowledge regarding this species from the time of its original description to the date of writing. He closes his account by estimating that, "the number of specimens in collections is about thirty males, an equal number of females, and about fifty nymphs and exuviae." These figures seem somewhat conservative to me.

ECOLOGICAL NOTES.—In the case of *yamaskanensis* we have a species much less retiring than *obsoleta* and one which is consequently better represented in collections and about which more exact information relative to habits has been written.

Walker has contributed (1906, 1908, 1913, 1915) much valuable material to our knowledge of the taxonomy and habits of the adult and nymph of *N. yamaskanensis*.

The first mention of the nymph was made by Walker in 1906 as follows:

A number of exuviae of a *Neurocordulia* were found on the logs of a timber-slide on Ragged Lake, Algonquin Park, in Aug., 1903. Drs. Calvert and Needham, to whom specimens were sent, both expressed the opinion that the species should be *Yamaskanensis*, as the nymph of *obsoleta*, the only other regional species, is already known and is distinct.

In 1913 Walker wrote (under *Neurocordulia yamaskanensis*):

The nymphs of this interesting species are common at Go Home Bay and in the Muskoka Lakes district. They cling to the underside of boulders, along the more exposed rocky shores or near rapids. Exuviae are often found on precipitous rocks rising out of water from a depth of 8–10 feet.

He follows these remarks with a description of the nymph and lists in a paragraph the contrasting characters with the nymph of *N. obsoleta*. There is a plate of drawings accompanying his paper showing the taxonomic features of the nymphs of these two species of *Neurocordulia*.

In 1915 Walker gave the most extended account of the habits of *N. yamaskanensis* that has been printed to date. He states:

In the 36th Ann. Rep. Ent. Soc. Ontario, 1905, p. 69 [See *Canad. Ent.*, 1906], exuviae of a *Neurocordulia*, referred to this species by supposition, were recorded from Algonquin Park, Ont. Shortly after the Station was opened in 1907, exuviae of the same kind were found on the sides of Go Home Bay Dock. On the morning following this discovery (June 28) the dock and the steep sides of the neighboring shores were carefully searched for newly-transformed adults and one was finally detected with its exuviae in the crevice of a steep rocky bank. It proved to be *N. yamaskanensis*. Subsequently a number of others were found with their exuviae on Station Island. Generally they were found between 7–8 A.M. but a few were taken in the evening. Early morning seems to be the usual time for transformation. For some days adults could only be obtained in this way, but they were at last discovered by Mr. Fraser flying about the island at dusk. It was soon ascertained that their time of flight is limited to about half an hour a day, commencing soon after sun down (a little after 8 P.M.), and continuing until shortly after 8:30, after which they retire to the shelter of the trees. It is thus nearly coincident with the mayflies, *Ephemera*, *Hexagenia*, *Heptagenia*, etc., upon which they appear to feed exclusively.

During this short time of flight they are extremely active. They dash about erratically over the rocks among the swarms of mayflies and when one of these is captured they retire with their prey to a neighboring tree to consume it in peace.

The majority of individuals thus engaged are females. The males will be found at the same time flying over and within a few inches of the water close to shore which they follow very closely. They fly back and forth in a regular beat with extraordinary swiftness.

During these flights the males apparently do not feed, but seem to be on the watch for females, for now and then a male is seen to pounce upon a female, the pair then sailing off over the water or up into the trees where copulation takes place at rest. Except when thus seized by the males, no females were observed close to the water though plenty of them could always be seen flying over the rocks nearby.

A detailed description of the nymph is given by Walker at this place in his account with material similar to that in his paper of 1913. He then goes on to say:

It would seem probable that the larval period must be two, if not three, years long.

The nymphs of *N. yamaskanensis* cling to the undersides of boulders along the more exposed shores. As the exuviae are most commonly found on steep rocky shores, rising almost perpendicularly from the water, it would seem that the nymphs prefer water of considerable depth, i.e., 8-10 feet or more, but we have often taken nymphs of several stages in water less than two feet deep. They occur along the outer coast as well as in the river, in fact wherever the water is kept more or less constantly in motion. They are common in the vicinity of falls and rapids.

The nymphs are associated with the nymphs of the mayflies of the genera *Heptagenia*, *Blasturus*, and *Baetis* and of the damselfly *Argia moesta putrida*, upon which they probably feed.

In 1912 adults emerged in the laboratory from June 23 to July 8. Their season is at its height during the second week in July and is over before the end of the month.

N. yamaskanensis is abundant and of general distribution in this locality and probably throughout the Muskoka and Perry Sound Districts. I have received exuviae from various parts of Muskoka and from the Shawanaga and French Rivers, collected by Mr. Paul Hahn. They are not known north of the French River.

In addition to these very excellent accounts written by Walker, several other authors have made notes on *N. yamaskanensis*.

Kennedy (1922), writing about the region of the Bass Islands in Lake Erie states:

Along these rocky shores only four species of dragonflies are abundant. These are the little gray *Argia moesta*, the large *Gomphus plagiatus* and *Neurocordulia yamaskanensis*, and the great black and yellow *Macromia illinoiensis*.

Later he states:

Neurocordulia probably come from the streams of southern Canada.

Again, speaking of the adult:

Neurocordulia yamaskanensis is crepuscular in habit, flying only at sunrise or sunset, or occasionally on cloudy days. It feeds on the great swarms of aquatic insects that come out of the lakes each evening, while it spends its daylight hours sleeping in trees.

Williamson (1932), referring to the atypical female specimen taken by him in Missouri states:

The only *Neurocordulia* seen in Missouri was hanging up about 10 feet high on the land side of a small tree about 20 feet from the river and between the river and an old

quarry. It was partially concealed by leafy vines. I worked the region several times before sunrise and until dark in the evening without success.

Under the general discussion of the genus Garman (1927) states:

Not much is known of the habits of the members of this genus. The only representative collected in Connecticut [*N. yamaskanensis*, Salisbury, 13 June, 1926] was found near a fairly large stream in the northern part of the State. It was collected between 3:00 and 6:00 P.M. and was found resting in some weeds in woodland pasture.

Nymphs of this genus have not been reared. Needham has described what he supposed to be the nymph of the only representative [*N. obsoleta*].

In view of the Walker material, it is needless to say, Garman was in error in regards to his statement about the nymphs.

NEUROCORDULIA VIRGINIENSIS DAVIS

ADULTS (Pl. III, Fig. 7; Pl. IV, Figs. 5-6; Pl. V, Fig. 3; Pl. VI, Fig. 2).—Female (type): Buckingham County, Virginia, June 21, 1919. W. T. Davis collection. W. T. Davis (1927).

Male (allotype): Jackson County, Florida, April 13, 1935. C. F. Byers collection.

Description (male, semiteneral).—Face uniformly pale olive brown; labrum yellow, labium paler yellow; antennae and vertex darker brown, ocellar margins, especially the median, yellow. Frons excavated above; vertex convex above, narrowed to tip; occiput yellow.

Thorax pale olive brown, densely brownish pilose. Dorsum with a very indistinct, slightly darker, broad stripe on either side of the yellow mid-dorsal carina; minute yellow spot on either side of dorsal, darker area anteriorly near prothorax. Sides of thorax with an irregular light yellow spot around spiracle of the metepisterna; distal edge of the metepimeron, below wing base, bright yellow.

Abdomen (dorsum of segments 3-5 partially destroyed), elongate, constricted on segment 3; uniform light olive brown, more yellowish along the lateral and apical margins of the middle segments, teeth of transverse sutures black; auricles small, rounded, shining brown. Secondary genitalia on venter of abdominal segment 2 pale yellow, lobe edged in black.

Abdominal appendages light yellow to pale brown. Superior appendages with inflated apical half ending in an upturned small black spine; basal half constricted, cylindrical, pilose. A slight notch on inferior margin of superior appendage. Inferior appendages somewhat shorter than superiors, triangular, large at base, very much narrowed and recurved in apical half, tip blunt with small black tooth above.

Legs pale brown, pilose. Tibia externally yellow; spines darker brown, the shorter ones black; a short membrane on ventral surface of distal end

terminating in a small pad. Anterior femora with small brush of fine "hairs" on tip.

Wings hyaline, broad, especially the hind wings, veins pale brown. Stigma yellow, elongate (2.5-3 mm.), surmounting but one or two cross veins, followed by two or three cross veins. Postnodal cross veins of fore wing 6, of hind wing 7; antenodal cross veins of fore wing 9, of hind wing 5. No cross vein in median (basilar) space proximal to arculus; 2 cubitoanal cross veins. Subtriangle and triangle of fore wing with 3 cells each, of hind wing with 2 cells each. A single row of cells, with a few double cells, between Cu_2 and the hind margin of the fore wing. Two rows of cells between A_2 and the hind margin of the hind wing. Triangle of the fore wing followed by 3 cells, followed by 2 cells for a distance of 4 cells between M_4 and Cu_1 which diverge to the wing margin; triangle of the hind wing followed by 2 cells for a distance of 4 cells.

Base of fore wing clear except for a light yellow cloud at extreme base, a small deeper yellow spot covering the first two subcostal cross veins (antenodal cross veins of the second series) and a similar spot on the anal cross vein. Hind wings clear except for a yellow cloud of slightly greater extent at extreme base, a yellow spot on the first two subcostal cross veins as in fore wing, also a similar spot on anal cross vein; in addition, A_3 and the 4 cross veins that extend from it to the margin of the anal triangle are deeply infuscated as is also the first cross vein between A_3 and A_2 . Anal triangle yellowish, with one deeply infuscated cross vein. Membranule long, snow white, apical half black.

Measurements (in mm.): total length with appendages 48, width of head across eyes 8, length of abdomen 32, length of fore wing 32, length of superior abdominal appendage 3, length of hind femora 7.

Material.—The only adult material of this species known to me is the female type (Davis, 1927) and the male allotype described above.³

NYMPH (Pl. II, Figs. 2 and 7; Pl. III, Fig. 3; and Pl. VIII, Fig. 2).—Description (supposition): body short and broad, depressed, abdomen arched dorsally. Head broadly convex above and on sides; eyes fairly prominent; a strongly convex shelf-like frontal ridge covered with a scurfy pubescence;

³ Since this paper was written I have received a communication from Mr. A. Earl Pritchard in which he states: "You would undoubtedly be glad to know that *Neurocordulia virginiensis* occurs as far west as Oklahoma. A female was taken by John Stankavich on Deep Fork River above Broken Bow, Oklahoma, June 18, 1934. We were catching *Platy-cordulia* at the time. The specimen was compared with the type by Mr. Davis."

The finding of a specimen of *N. virginiensis* in Oklahoma extends the possible range of this species beyond the areas inhabited by *N. clara*, (Alabama) and Burmeister's *N. polysticta*, (Louisiana). The record constitutes the third for the capture of *N. virginiensis* and the second for the capture of a *Neurocordulia* west of the Mississippi River. (The first, *N. yamaskanensis*, was made by Williamson in 1932.)

antennae 7-jointed; top of head with a pair of low submedian vertical tubercles. Hind angles of head prominent, overhanging front of prothorax; hind margin of head excavate between hind angles.

Labium short and broad; mentum about as broad as long, extending to mesocoxae; mental setae 9-11, when 11 present the innermost 3-4 small and irregularly arranged; 3-5 short stout setae on extreme margin of middle lobe; 1-2 stout setae at hinge of lateral lobes; lateral lobes with 6 setae, their distal margins produced into 6 deep semi-elliptical lobes, the first of which is deeply bifid giving the appearance of 7 crenulations in all, each tooth or lobe armed with 4-7 small setae; movable hook long and sharp, slightly recurved.

Marginal ridge of pronotum produced on each side behind posterior angles of head into a prominent process, which is smaller than the very prominent supracoxal process.

Legs short, smooth, banded with brown. Hind femora slightly less long than head is wide.

Abdomen flat, suborbicular, greatest width at segments 6-7; ventral surface depressed. Lateral spines on segments 8 and 9, in each case these spines are a little over half as long as the segment that bears them, never as long as that segment; lateral spines on 8 strongly divergent, those on 9 parallel and extending caudad to tips of abdominal appendages (alcoholic material) or slightly farther (dried material). Dorsal surface strongly convex; dorsal hooks present on segments 2-9, those of the basal segments slender and erect becoming broader and lower caudad, those on 6-9 rounded on top, most prominent on segment 6, but still well formed and conspicuous on 9. Superior appendages triangular, equilateral, very little shorter than inferiors; lateral appendages somewhat shorter than superior.

Measurements: (see table of nymphal characters).

Material.—I have seen the following material and identified it, on supposition, as belonging to this species. Unless noted the specimens are in my collection.

Alachua County, Florida. Santa Fe River at Poe Springs. 4 exuviae, May 22, 1927; 2 nymphs, November 13, 1927; 2 nymphs, February 11, 1928; 5 exuviae, May 20, 1934; 1 exuvia, May 23, 1935; 1 exuvia, March 21, 1936. Gulf County, Florida, Chipola Lakes. Exuviae taken from Spanish Moss (Coll. J. G. Needham), early April, 1927. Georgia (Cornell Collection, No. 654, Fattig), 1 nymph.

DISCUSSION.—The known adults of *N. virginiensis* have taxonomic characters that are distinct enough to warrant considering them as representatives of a legitimate species. As pointed out by Davis, there are well marked differences in wing reticulation, the wings of *N. virginiensis* showing a marked reduction in the number of cells and cross veins in special

wing areas as well as a difference in the coloration of the wing base (see keys and discussion of wing coloration). In the matter of reduction of reticulation *N. virginiensis* resembles more closely the species of the South American genus *Aeschnosoma* than it does the other species of its genus.

The male and female genitalia of *N. virginiensis* suggest *N. yamaskanensis* in many respects, *N. obsoleta* in some. The vulva of *virginiensis* and *yamaskanensis* has a medium rectangular notch, that of *virginiensis* being broader, and *obsoleta* has a smaller concave median notch. In the male appendages both *virginiensis* and *yamaskanensis* have a distinct notch on the inferior margin of the superior appendages; otherwise, the superior appendages of *virginiensis* are more suggestive of *obsoleta*. A general comparison based on the total effect of the taxonomic features of these species places *N. virginiensis* closer to *N. yamaskanensis* than to *N. obsoleta* and its closely related *N. clara*.

On the other hand, the nymphs of *Neurocordulia* from Florida and Georgia, examined by me, differ very little from those described by Needham (1901) and P. Garman (1927), but resemble in some respects those described by Walker (1913, 1915). In certain characters they seem to be distinct (see table of nymphal characters). Inasmuch as the Needham and Garman nymphs have been assigned to *obscura* and Walker has reared *yamaskanensis* from his nymphs, and because of the occurrence of adult *virginiensis* in the Florida drainage areas from which the nymphs have been collected, I am identifying as *N. virginiensis* the Florida and Georgia nymphs that I have studied.

ECOLOGICAL NOTES.—In regards to habits and habitat there is little known about either the adults or nymphs of *N. virginiensis*, but probably more about the latter than the former.

Davis (1927) writing about the adult female type states:

He [the writer] has also in his collection a female *Neurocordulia* collected close to the James River in Buckingham County, Virginia, June 21, 1919. It was found in partly forested country while collecting insects with Col. Wirt Robinson. This specimen has been shown to a number of specialists in Odonata, and compared with all the specimens of *obsoleta* available. It differs in a number of important characters, and is no doubt a representative of a rare and undescribed species of *Neurocordulia*, which like *obsoleta* and *yamaskanensis* is also crepuscular in habit.

The male specimen of *virginiensis* described in this paper was collected by Mr. R. E. Bellamy close to the Chipola River, Jackson County, Florida, April 13, 1935. In his field catalogue, Bellamy has written the following set of notes under the above locality and date line:

Chipola River:—Collecting along low wooded and slightly marshy region east of Chipola River above the Tallahassee-Mariana road. Collecting by sweeping with net in low undergrowth and some overhead vegetation. Territory drier than swamp near Blue Springs Creek and vegetation or undergrowth not so high. In afternoon, still, very cold.

As regards the supposed nymph of this species only two habitat notes have been published, one by Needham (1929) under the name *Neurocordulia obsoleta*, the other by Byers (1930) under the name *Neurocordulia* sp.

Needham (p. 174) states:

The senior author found numerous cast skins sticking to the swollen bases of cypress trees in Chipola Lake, Florida, in early April. Some were in the "moss" (*Tillandsia*) that draped the cypresses, several feet above the water.

Byers (p. 259) notes:

The nymphs of this unknown species were found in the Santa Fe River, near Poe Springs [Florida]. At the place of collection the water is three to four feet deep and very rapid; the bottom is rock strewn and practically devoid of vegetation, except for rock-encrusting algae. In depressions on larger stones, usually on the upstream side, these nymphs were very numerous. All attempts to rear these *Neurocordulia* in the laboratory were of no avail, though several were kept alive for some months.

I have visited the spot on the Santa Fe River referred to [Pl. VIII, Fig. 1] on each of the years following the writing of the quoted note, but have nothing to add to it except to remark a decreasing number of nymphs found. In May, 1935, only a single cast skin was collected.

From the above material it would seem that *N. virginiensis* is a markedly river form, adults having been taken from near the James River, Virginia, and the Chipola River, Florida, and nymphs from the Chipola and Santa Fe rivers. The occurrence of Bellamy's adult male and Needham's cast nymphal skins from the same river system (Chipola) is evidence for considering the nymphs as those of *N. virginiensis*.

PLATYCORDULIA XANTHOSOMA WILLIAMSON

ADULTS (Pl. VII, Fig. 2).—Male (type): Wister, Oklahoma, 1907. Mus. Zool., Univ. Mich. E. B. Williamson (1908). Two specimens. Female (allotype): Chautauqua County, Kansas, 1916. Collected by R. H. Beamer. In Snow collection, Lawrence, Kansas. C. H. Kennedy (1917). Female (paratype): Miami County, Kansas, 1915. Collected by R. H. Beamer. Snow collection. C. H. Kennedy (1917).

Descriptions.—Williamson (1908) and Kennedy (1917) have given satisfactory descriptions of the males and females of this species along with drawings of anatomical features and wing photographs. Diagnostic features have been given in the keys in this paper.

Material.—The following material has not been listed or published upon before: Comanche County, Oklahoma. 1 ♀. Wichita National Forest. July 10, 1926. Collected by T. H. Hubbell. Byers collection.

NYMPHS (Pl. I, Fig. 1; Pl. II, Figs. 1 and 5; Pl. III, Fig. 4).—The nymph of *Platycordulia xanthosoma* is unknown. I have received specimens of a Corduline nymph of an unknown genus, however, taken at points on the

Mississippi River. Inasmuch as *Platycordulia* is the only Corduline genus of this locality and group of which we do not have known nymphal material, I am assuming that these nymphs, so much like *Neurocordulia* and yet so different, may belong to this genus, and I describe them here.

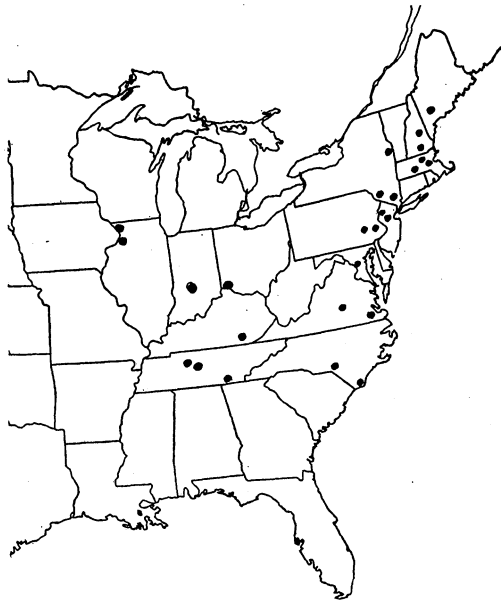
Description (supposition).—Body stout, squat, and heavy; abdomen arched dorsally; color dark brown above, lighter brown below.

Head square cut; eyes fairly prominent; a very conspicuous flat, triangular projection between bases of antennae, light brown in color and pubescent; antennae 7-jointed; head otherwise similar to *Neurocordulia*.

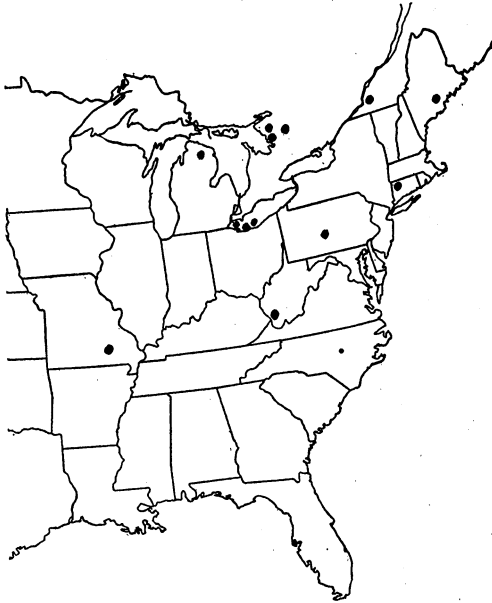
Labium short and broad; mentum about as broad as long, extending to base of procoxae; mental setae 8–9; a number of short stout setae on extreme outer margin of middle lobe; 1–2 stout setae at hinge of lateral lobes. Lateral lobes with 6 setae; distal margin produced into 6 deeply cut lobes, the most apical of which is slightly bifid; each lobe armed with a number of small setae; movable-hook long, sharp, and slightly curved.

Thorax and legs very similar to *Neurocordulia* (see description of *N. virginiensis* nymph and figures).

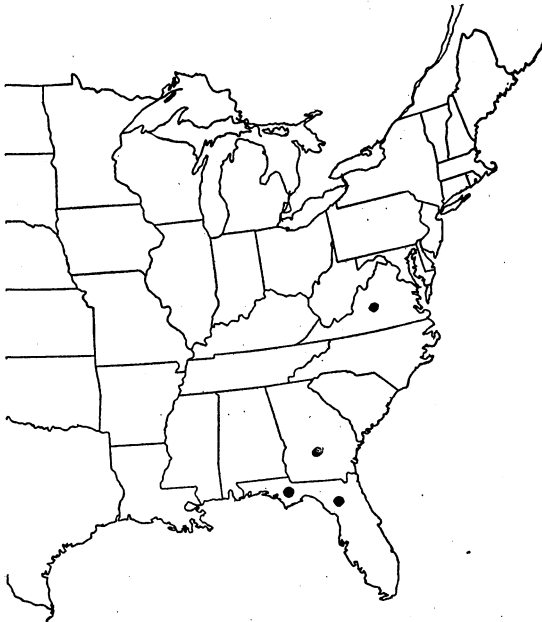
Abdomen flat, suborbicular; its greatest width at segment 7. Lateral spines on segments 8–9; those on 8 about one-third as long as the segment that bears them, slightly recurved, and strongly diverging at an angle from the long axis of the segment; those on segment 9 about one-half the length



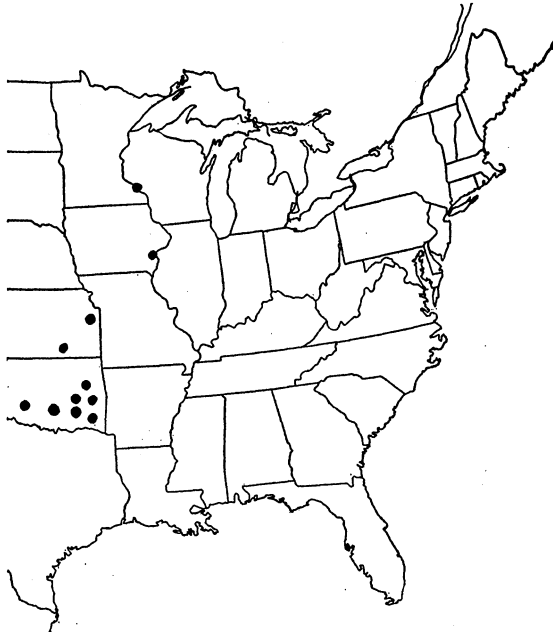
MAP 1. Distribution of *Neurocordulia obsoleta*.



MAP 2. Distribution of *Neurocordulia yamaskanensis*.



MAP 3. Distribution of *Neurocordulia virginiensis*.



MAP 4. Distribution of *Platycordulia xanthosoma*

of the segment, straight, parallel to long axis of segment, extending caudad to a little beyond the tips of abdominal appendages.

Dorsal hooks present on abdominal segments 2-9; those on basal segments slender and erect becoming broader and somewhat recurved toward apical segments; hooks rounded and knoblike, never pointed or sharp. Superior appendages triangular, short, a little longer than the laterals, somewhat shorter than the inferiors.

For measurements of nymphal characters see Table I.

Material.—I have examined the following material borrowed from Dr. Needham and the collection of Cornell University. Alma, Wisconsin; Mississippi River; 4 late instar nymphs. Fairport, Iowa; Mississippi River; 1 late instar nymph.

DISCUSSION.—In general, the nymphs described above are quite similar to *Neurocordulia obsoleta* and *N. virginiensis*, having the typical body and development of the lateral spines and dorsal hooks of a *Neurocordulia*. The prominent triangular projection, however, between the bases of the antennae is something new, differing considerably in appearance from the pyramidal frontal horn of the *Macromimini*, the body build and proportions are also quite different.

ECOLOGICAL NOTES.—Very little has been written about the habits of *Platycordulia xanthosoma*.

Williamson (1908) states:

The two males of *P. xanthosoma* in my collection were taken at Wister, Oklahoma, one of them on June 4, 1907, by myself, the second on August 2, 1907, by Frank Collins, a boy who did some collecting for me. Wister is situated in the northeast part of the Choctaw Nation, a few miles south of parallel 35 deg. N., near Poteau River, a southern affluent of the Arkansas. About a mile north of the town is a lake lying on the west side of the railroad. I was informed that this lake was artificial, caused by the fill for the railroad grade. At the present time the lake has a surprising Odonata fauna. A short distance below the lake, in passing some bushes which overhung [a] stream bed, I disturbed the only specimen I saw alive of *P. xanthosoma*. This flew a short distance along the stream and alighted in a well concealed spot in bushes overhanging the water. Its flight, manner of alighting and position at rest suggested a teneral *Libellula*. The specimen taken by Frank Collins is somewhat worn; he wrote on the envelop 'Yellow one.' His home in 1907 was a camp along the Poteau River and his collecting was done along the river, at the lake and at intermediate points.

Professor Walker has recorded the interesting fact that *N. yamaskanensis* is entirely crepuscular in its habits, spending only a brief period of the day on the wing. It is not improbable that *N. obsoleta* and *P. xanthosoma* similarly are abroad only in the evening.

Kennedy (1917) and Bird (1932) have published locality records but no habitat data for this species. Bird records *P. xanthosoma* from six Oklahoma counties, and Kennedy from two regions in Kansas. Thus, the species is apparently more or less common in this territory (Oklahoma-Kansas). Williamson (1914) and Ortenburger (1926) published records included in the list of Bird.

GEOGRAPHIC DISTRIBUTION

Under the title, "A Census of Neurocordulias," Williamson (1931) has published an interesting and well-written account of the various captures and records in the genus *Neurocordulia*. Table II lists the recorded captures for both *Neurocordulia* and *Platycordulia* up to date.

From Table II and from the maps it will be seen that the distribution of the genus *Neurocordulia* is exclusively in the eastern United States and southeastern Canada (with the exception of the one atypical female collected by Williamson in Missouri); while the distribution of *Platycordulia* is confined to the region just west of the Mississippi River.

In detail the species have the following state and province distribution.
Neurocordulia obsoleta:

New England States (Me., N. H., Mass.); Middle Atlantic States (N. Y., N. J., Pa.); Central States (Ohio, Ill., Pa.); North Southern States (Md., Va., Ky., Tenn., N. C.); Southern States (New Orleans, La.).

Neurocordulia yamaskanensis:

Canadian Provinces (Quebec, Ontario, not north of French River); New England States (Me., Conn.); Middle Atlantic States (Pa., W. Va.); Central States (Lake Erie, Ohio, Mich.); West Central States (Mo.).

Neurocordulia virginienensis:

North Southern States (Va.); Southern States (Ga., Fla.).

Neurocordulia clara:

Southern States (Ala.).

Platycordulia xanthosoma:

West Central States (Okla., Kan., Iowa, Wisc.-Minn.).

Thus the distribution areas are distinct and continuous except in a few noteworthy instances.

TABLE II

STATE	LOCALITY	SPECIMENS		COLLECTOR AND DATE	REFERENCE
		M.	F. N.		
<i>Neurocordulia obsoleta</i> (Map 1)					
Mass.	Milton		1	Harris, 1820	Say 1839
Ind.	.....	1		.....	Say 1839
La.	New Orleans	1		.....	Burmeister 1839
Ill.	Rock Island		1	.....	Walsh 1863
Ill.	Galena	1		Bean	Hagen 1890
Pa.	.....		1	Parker, 1881	Calvert 1893
N. H.	Manchester	1		Burnham	Burnham 1900
N. J.	Delaware Water Gap		1	.....	Calvert 1900
Ohio	Cincinnati	Several		Dury	Williamson 1899
Pa.	.....		1	Border, 1895	Needham 1901
N. Y.	White Lake		1	Calvert	Needham 1901
Tenn.	Nashville		1	Williamson	Needham 1901
Me.	Manchester	1		Wadsworth	Harvey 1902
N. J.	Lake Hopatcong		1 31	Calvert, 1902	Calvert 1903
Tenn.	Chattanooga		1	C. C. Adams	Williamson 1903
Tenn.	Cumberland River		1+	.....	Williamson 1903
N. C.	Wilmington	.....		Bentley, 1905	Brimley 1906
N. H.	Meredith Neck	.....		.....	Howe 1917
N. C.	Southern Pines	.....		Maney, 1909	Brimley 1918
Mass.	Southbridge	.....		Bromley	Howe 1919
Mass.	N. Reading	.....		Johnson	Howe 1919
Ky.	Pineville		1	H. Garman, 1911	H. Garman 1924
N. Y.	Lake George		5	Needham, 1920	Needham 1925
Va.	Wingina		1	Davis, 1919	Davis 1927
Md.	Cabin John		1	Davis, 1910	Davis 1927
N. Y.	Brewster	.....		Needham	Leonard 1928
Va.	Harpers Ferry		7	V. Argo	Byers*
<i>Neurocordulia yamaskanensis</i> (Map 2)					
Quebec	Mt. Yamaska	1		.....	Provancher 1875
Quebec	Mt. Yamaska		1	.....	Provancher 1877
Ohio	Lake Erie	.....		Osborn	Hine 1900
Me.	Orono	5	2	.....	Harvey 1901
Ontario	Algonquin Park		1+	Walker	Walker 1906
Pa.	Harrisburg	1		Daecke	Calvert 1910
Ontario	Go Home Bay, etc.	Numerous		Walker	Walker 1913
Ontario	Go Home Bay, etc.	Abundant		Walker, <i>et al.</i>	Walker 1915
Ohio	Lake Erie, Bass Id.	Common		Kennedy	Kennedy 1922
Mich.	Cheboygan Co.	1		.....	Byers 1925
Conn.	Salisbury	.....		P. Garman	P. Garman 1927
Mo.	Carter Co.		1	Williamson	Williamson 1932
Ohio	Lake Erie	11	9	Kennedy, <i>et al.</i>	Byers*
W. Va.	Justice		1	.....	Byers*
Quebec	Ironside	.....		Stohr, 1918	Walker 1934

* Material referred to in this paper and not published elsewhere.

TABLE II—(Continued)

<i>Neurocordulia virginienis</i> (Map 3)					
Va.	Buckingham Co.	1	Davis, 1919	Davis	1927
Fla.	Alachua Co.	14	Byers	Byers	1930
Ga.	.....	1	Fattig	Byers*	
Fla.	Jackson Co.	1	Bellamy, 1935	Byers*	
<i>Neurocordulia clara</i>					
Ala.	.....	1	.....	Muttkowski	1910
<i>Platycordulia xanthosoma</i> (Map 4)					
Okla.	Wister	2	Williamson, 1907	Williamson	1908
Kan.	Chautauqua Co.	1	Beamer	Kennedy	1917
Kan.	Miami Co.	1	Beamer	Kennedy	1917
Okla.	Johnston Co.	.....	.....	Bird	1932
Okla.	Latimer Co.	.....	.....	Bird	1932
Okla.	McCurtain Co.	.....	Pritchard	Bird	1932
Okla.	Pushmataha Co.	.....	.....	Ortenburger	1926
Okla.	Sequoia Co.	.....	.....	Bird	1932
Okla.	Comanche Co.	1	Hubbell, 1926	Byers*	
Wis.	Alma	4	.....	Byers*	
Iowa	Fairport	1	.....	Byers*	

* Material referred to in this paper and not published elsewhere.

OVERLAPPING DISTRICTS

Maine, *N. obsoleta* and *N. yamaskanensis*; Pennsylvania, *N. obsoleta* and *N. yamaskanensis*; Ohio, *N. obsoleta* and *N. yamaskanensis* (*N. obsoleta* is reported from Cincinnati, Ohio, and *N. yamaskanensis* from Lake Erie); Virginia, *N. obsoleta* and *N. virginienis*; Mississippi River, *N. obsoleta* adults have been taken along the river in Illinois (Rock Island, Galena) and *Platycordulia* nymphs from Wisconsin (Alma) and Iowa (Fairport).

DISCONTINUOUS DISTRIBUTION

N. obsoleta.—Burmeister's New Orleans record (1839) places this species in the far south and out of its known continuous range. Davis (1929) points out that Burmeister's specimen could not be either *N. virginienis* or *N. clara*. If *clara* turns out to be only a variation of *N. obsoleta*, then the southern range of that species will be extended to include Alabama and will be thus more continuous.

N. yamaskanensis.—The Williamson (1932) record of an atypical female of this species from Missouri is quite an unusual extension of the range. The extension of *yamaskanensis* into West Virginia is also unexpected. The isolated Connecticut record (Garman, 1927) is not so startling, as the species occurs all around that region.

N. virginienis.—The failure to collect this species in South Carolina and eastern North Carolina is probably due to lack of information regarding

its habits. Records may later make the range a continuous one from Virginia to Florida.

P. xanthosoma.—Adults of this species have a continuous distribution in Oklahoma and southeastern Kansas. The nymphs attributed to the species by me were taken from the Mississippi River at Alma, Wisconsin, and Fairport, Iowa, therefore, they may be considered as extending the range of the dragonfly to the states bordering on the Mississippi in these localities. In view of the ecological unity of the territory and the western nature of the distribution of *xanthosoma*, I am led to consider Iowa and Minnesota as within the area of distribution. This gives the species an almost continuous range in the prairie states just west of the Mississippi from Minnesota to Oklahoma.

GENERAL CONCLUSIONS

It is not my desire to explain the distribution of *Neurocordulia* and *Platycordulia* as it is outlined above. There is not enough available information. A summary, however, of the extant information and its implications in regard to distribution may not be amiss here.

From an examination of the available morphological details of the adults and from an examination of Maps 1-4, I pair the four species of the genus *Neurocordulia* as follows: (1) *obsoleta* (north) and *clara* (south); (2) *yamaskanensis* (north) and *virginiensis* (south).

In the first related pair of species the chief difference between the two is seen in the reduced wing coloration of *clara* in comparison to the more extensive coloration of *obsoleta*. Inasmuch as *obsoleta* (Burmeister's *N. polysticta*) has been recorded from Louisiana and *clara* from Alabama, and we have no definite information regarding minor variations in either of the southern specimens, the possibility may be considered of a southern offshoot of *obsoleta* which may or may not be a good species.

In the second case much more information is available for comparison. The two species have points in common in regard to the male genitalia, the vulva, wing venation, and wing coloration as has been indicated in previous sections of this paper. This general situation suggests that *N. virginiensis* is the southern member of the pair. It is of interest to note that the reduction of wing venation seen in *virginiensis*, as compared to *yamaskanensis*, is carried still farther in the South American species of the genus *Aeschnosoma*. On the other hand, the nymphs of the Florida *Neurocordulia*, assigned to *virginiensis*, are structurally more suggestive of *obsoleta* than of *yamaskanensis*.

An examination of the ecological notes published on the species of *Neurocordulia* and *Platycordulia* indicates that the dragonflies of these genera are definitely associated with flowing or moving water. All species

(with possible exception of *N. clara*) have been collected in or near rivers, while *N. obsoleta*, in the northern part of its range, and *N. yamaskanensis* have been recorded from lakes. A summary of the available data concerning the place of capture of specimens, as listed below, confirms these statements.

N. obsoleta.—Rivers: Merrimack (Manchester, N. H.), Mississippi (Galena and Rock Island, Ill.), James (Wingham, Va.), Cumberland (Pineville, Ky. and Nashville, Tenn.), Ohio (Cincinnati, O.), Tennessee (Chattanooga, Tenn.), Fear (Wilmington, N. C.), and Potomac (Cabin John, Md.). Lakes: White Lake (N. Y.), Lake George (N. Y.), Lake Hopatcong (N. J.), and Winnepesaukee (Meredith, N. H.).

N. yamaskanensis.—Rivers: Yamaska (St. Hyacinthe, Quebec), Penobscot (Orono, Me.), and Susquehanna (Harrisburg, Pa.). Lakes: Muskoka (Ontario), Go Home Bay (Georgian Bay, Ontario), Lakes of Algonquin Park (Ontario), and Erie (Bass Island, Put-In-Bay).

N. virginiensis.—Rivers: James (Buckingham Co., Va.), Chipola (Jackson Co., Fla.), and Santa Fe (Alachua Co., Fla.).

P. xanthosoma.—Rivers: Mississippi (Alma, Wis., and Fairport, Iowa), and Arkansas (Okla.).

As near as can be determined, in the South all records for the capture of specimens of these two genera are from rivers. In the North, rivers and lakes may be suitable habitats for these dragonflies.

The conditions in rivers or lakes under which the nymphs are found seem to be quite uniform for the species about which such information is available and are: (1) flowing or moving water such as is to be found in fast running rivers, riffles, or along the wave-beaten edges of lakes; (2) deep water, up to around ten feet; (3) cold water as found in the rivers of the South or the rivers and deeper lakes of the North; (4) rock bottom with emerging precipitous boulders (Pl. VIII, Figs. 1-2). In such localities as these the nymphs cling to the rocks allowing the current to press them against the stone. They are associated with the damselfly *Argia moesta putrida*, a few genera of stream mayflies, *Corydalis* larva, chironomids, etc.

The adults are definitely crepuscular, flying apparently for a short time only at sundown, early in the morning, or perhaps on cloudy days. They seem to stay near the aquatic habitat of the nymph and are collected in open woodsy places, on low vegetation, or flying over riffles and along sides of rivers. They also seem to be cold-loving, the Florida adult male having been taken on a cold day in early April and the nymphs emerging in Florida as early as March 21. In the North they are summer dragonflies, June-July (*N. yamaskanensis*), June-September (*N. obsoleta*).

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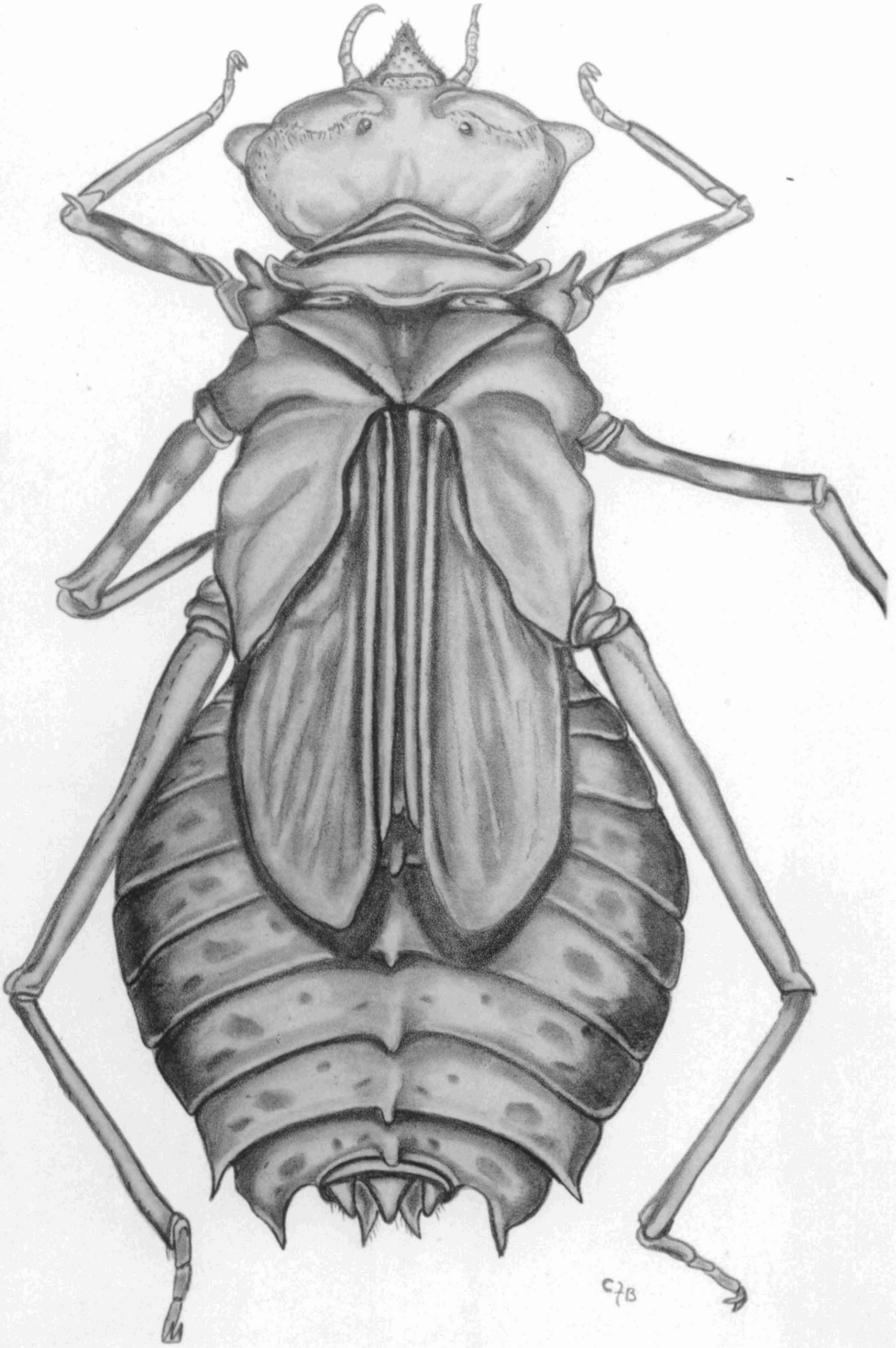
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PLATES

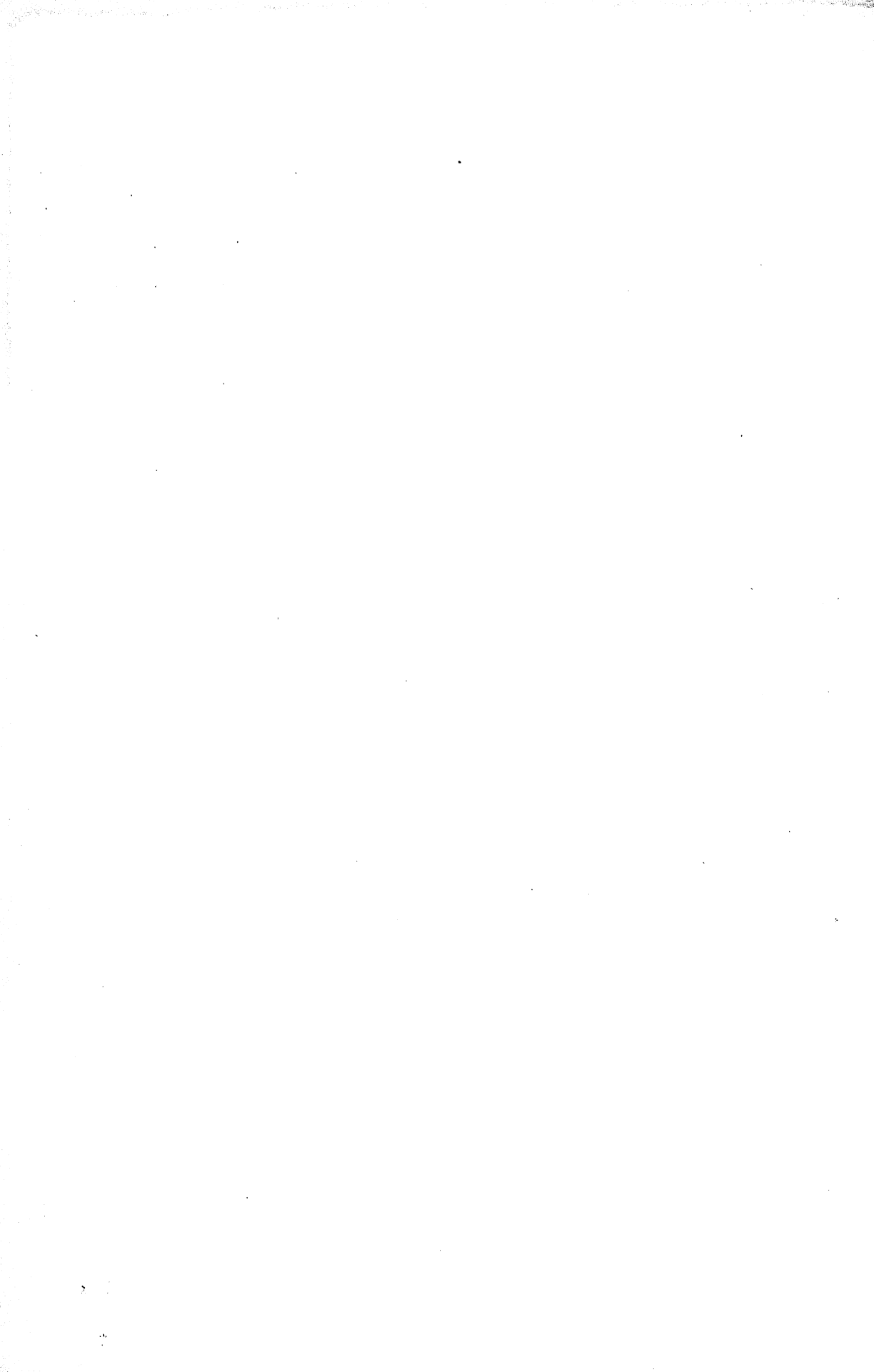
[Pl. V, Figs. 1-3, from Davis (1929); Pl. VI, Fig. 1, from Martin (1906); Pl. VII, Figs. 1-2, from Williamson (1908); Pl. VIII, Figs. 1-2, from Byers (1930).]

PLATE I

Nymph of *Platycordulia xanthosoma*. Alma, Wis.



c78



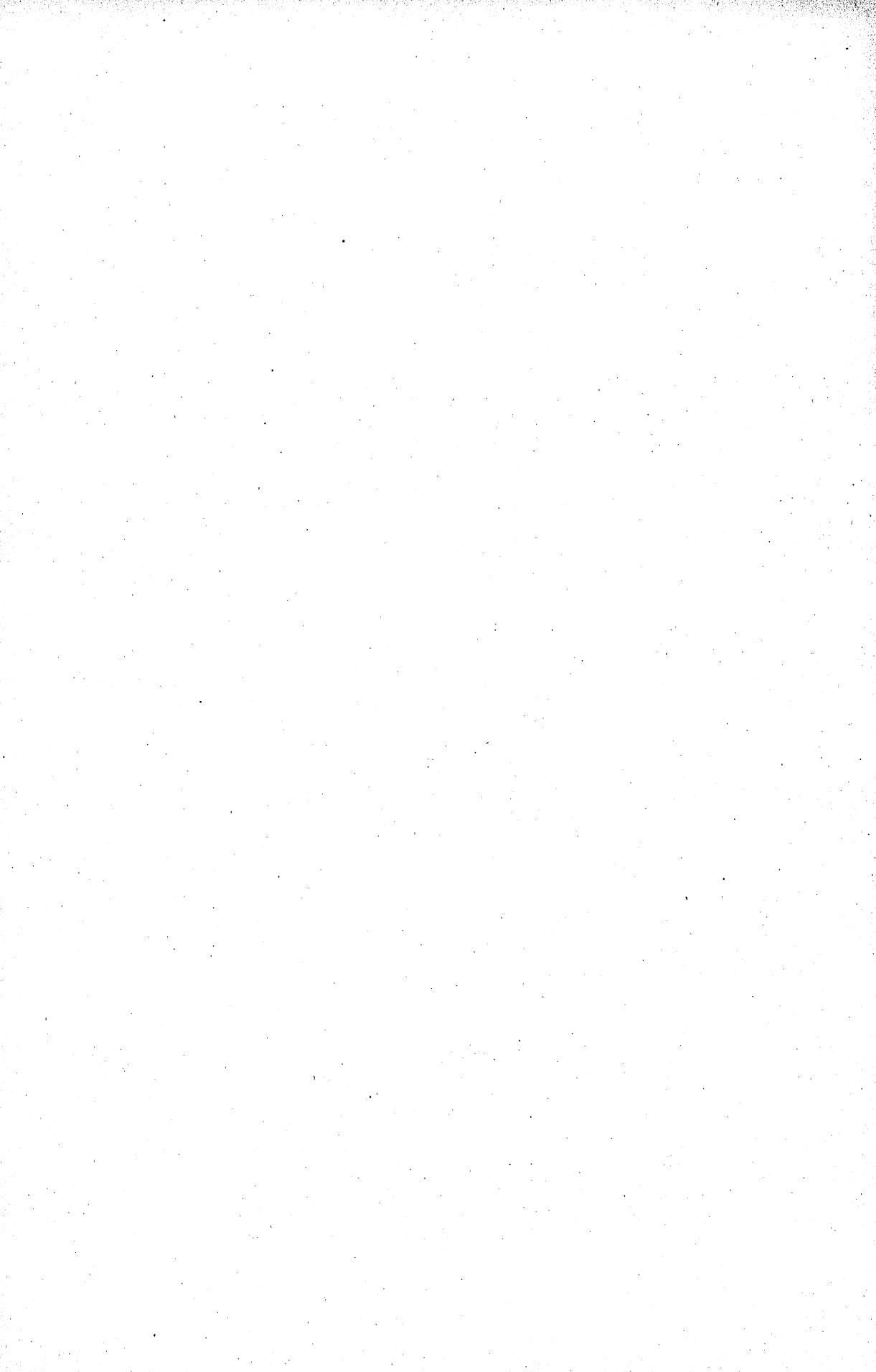


PLATE II

- FIG. 1. *Platycordulia xanthosoma*. Abdomen of nymph, lateral view.
FIG. 2. *Neurocordulia virginiensis*. Abdomen of nymph, lateral view.
FIG. 3. *Neurocordulia yamaskanensis*. Abdomen of nymph, lateral view.
FIG. 4. *Neurocordulia obsoleta*. Abdomen of nymph, lateral view.
FIG. 5. *Platycordulia xanthosoma*. Head of nymph.
FIG. 6. *Neurocordulia obsoleta*. Head of nymph.
FIG. 7. *Neurocordulia virginiensis*. Labium of nymph.

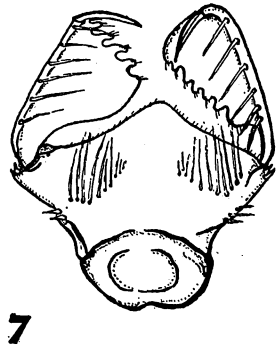
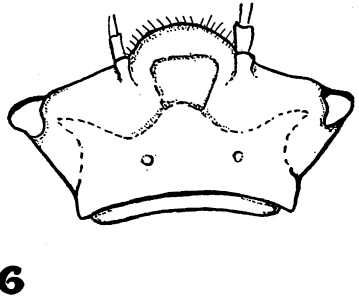
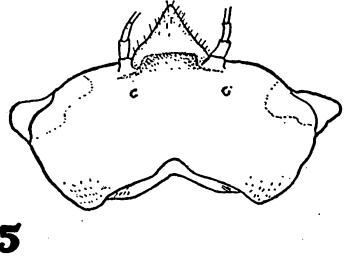
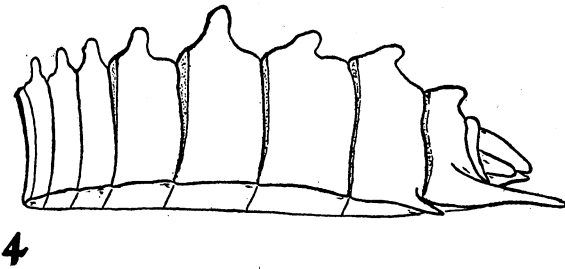
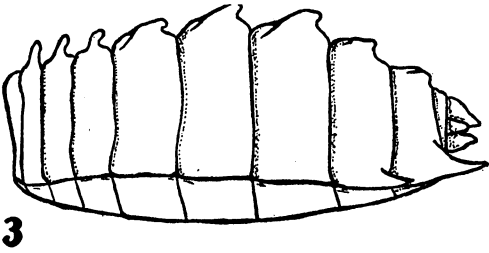
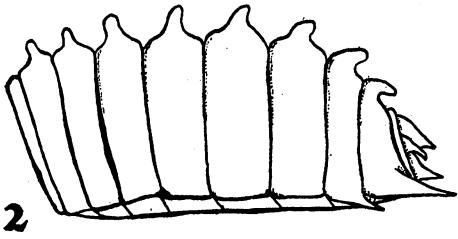
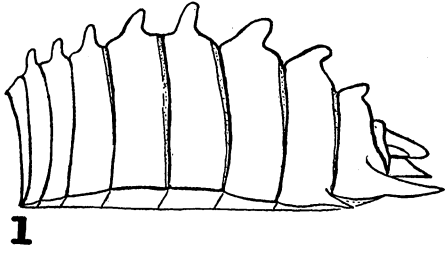


PLATE III

- FIG. 1. *Neurocordulia obsoleta*. Abdomen of nymph, dorsal view.
FIG. 2. *Neurocordulia yamaskanensis*. Abdomen of nymph, dorsal view.
FIG. 3. *Neurocordulia virginienensis*. Abdomen of nymph, dorsal view.
FIG. 4. *Platycordulia xanthosoma*. Abdomen of nymph, dorsal view.
FIG. 5. *Neurocordulia obsoleta*. Adult female, vulva.
FIG. 6. *Neurocordulia yamaskanensis*. Adult female, vulva.
FIG. 7. *Neurocordulia virginienensis*. Adult female, vulva.

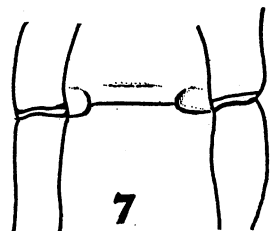
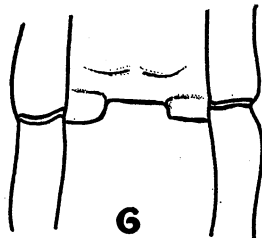
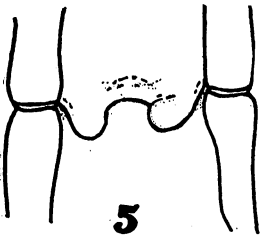
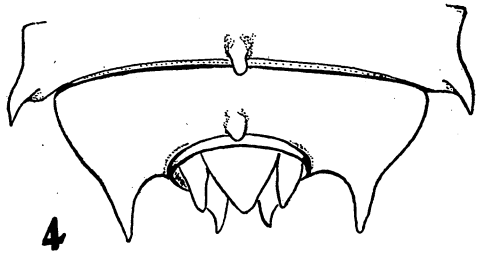
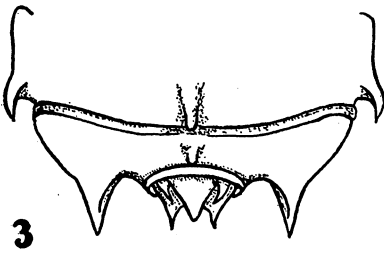
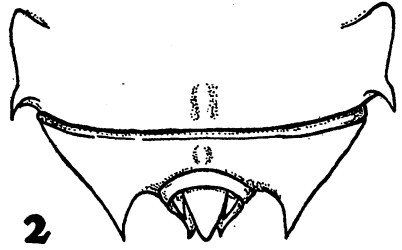
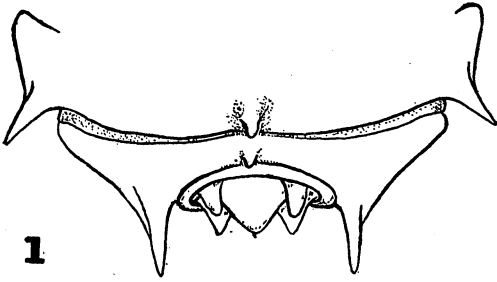
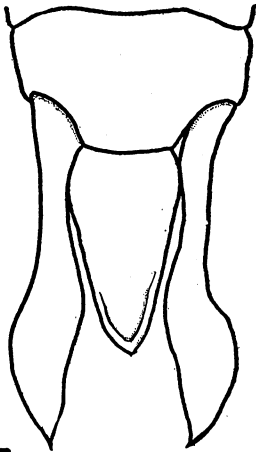


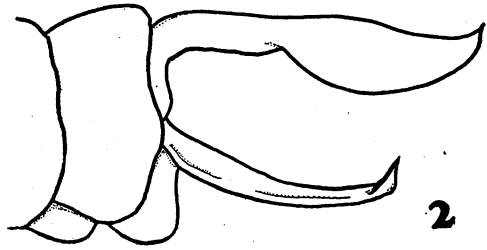
PLATE IV

ADULT MALE APPENDAGES

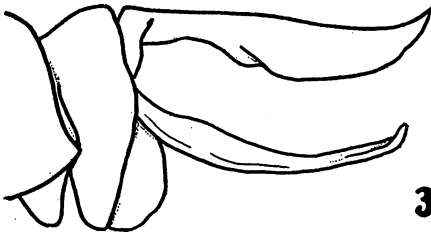
- FIG. 1. *Neurocordulia obsoleta*. Dorsal view.
FIG. 2. *Neurocordulia obsoleta*. Lateral view.
FIG. 3. *Neurocordulia yamaskanensis*. Dorsal view.
FIG. 4. *Neurocordulia yamaskanensis*. Lateral view.
FIG. 5. *Neurocordulia virginensis*. Dorsal view.
FIG. 6. *Neurocordulia virginensis*. Lateral view.



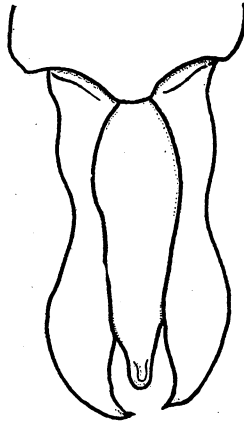
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2



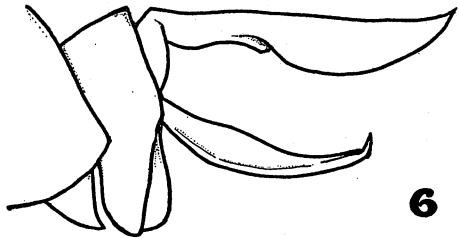
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4



5



6

PLATE V

FIG. 1. *Neurocordulia obsoleta*, female.

FIG. 2. *Neurocordulia clara*, female.

FIG. 3. *Neurocordulia virginensis*, female

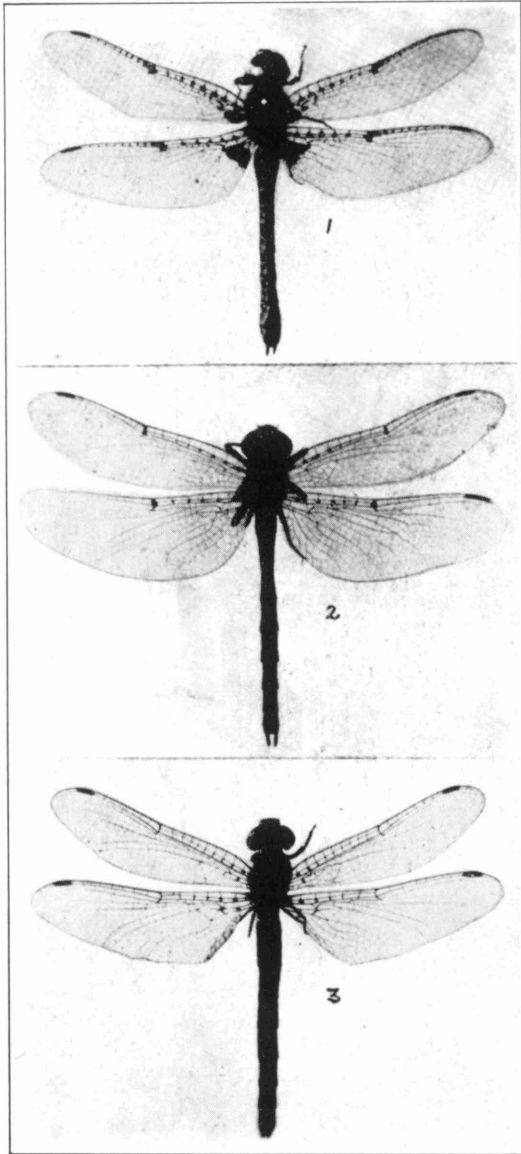


PLATE VI

FIG. 1. Wings of *Neurocordulia obsoleta*.

FIG. 2. Wings of *Neurocordulia virginiensis*.

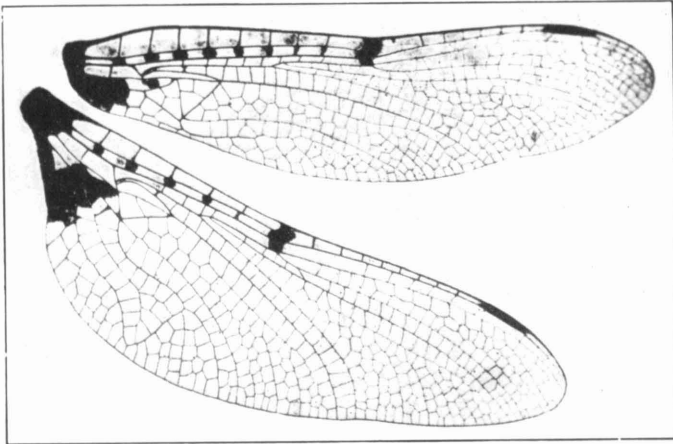


FIG. 1

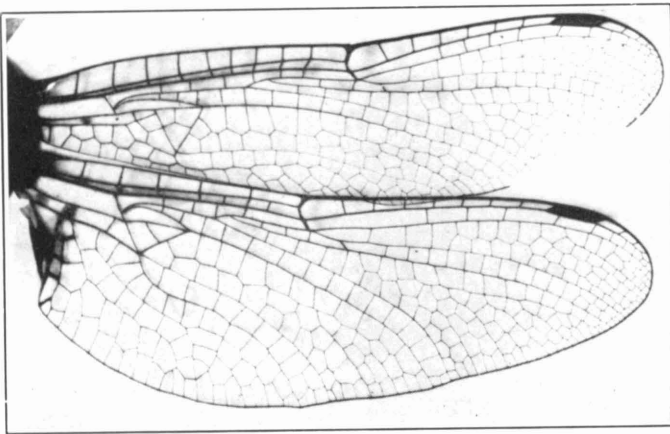


FIG. 2

PLATE VII

- FIG. 1. Wings of *Neurocordulia yamaskanensis*.
FIG. 2. Wings of *Platy cordulia xanthosoma*.

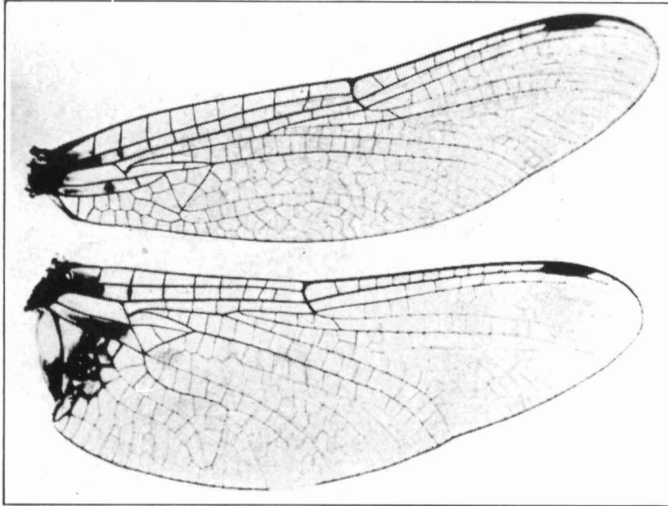


FIG. 1

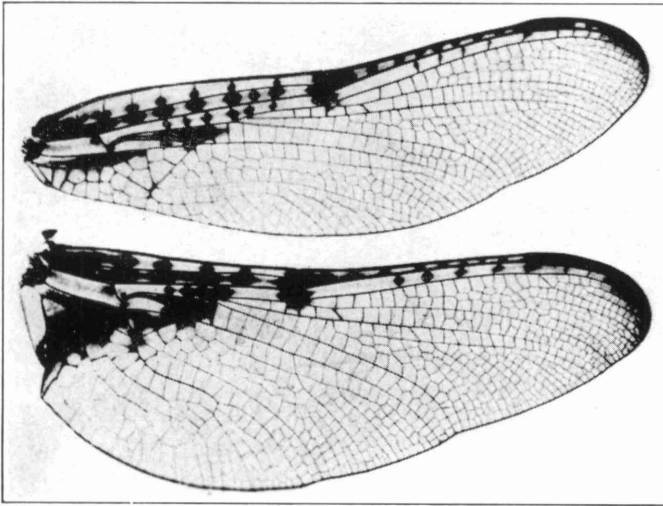


FIG. 2

PLATE VIII

FIG. 1. Santa Fe River. Alachua Co., Fla. Habitat of *Neurocordulia virginiensis* nymphs. A typical *Neurocordulia* locality.

FIG. 2. Habitat sketch of *Neurocordulia virginiensis* nymph. Arrow indicates the direction of the flow of water.



FIG. 1



FIG. 2

No. 18.	The Terrestrial Shell-bearing Mollusca of Alabama. By BRYANT WALKER. (1928) Pp. 180, 277 figures	\$1.50
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