

ARTICLE I.—*The Dragon-flies (Odonata) of Illinois, with Descriptions of the Immature Stages. Part I. Petaluridae, Aeschnidae, and Gomphidae.* BY JAMES G. NEEDHAM AND CHARLES A. HART.

INTRODUCTION.

The present paper is the combined product of studies made by the authors upon the collections of the Illinois State Laboratory of Natural History, including those of the Biological Station at Havana, and by Professor Needham on his private collection. The state collections comprise the results of many years' work in all parts of Illinois, including five successive years of field observation and collection at the Illinois Biological Station on the Illinois River at Havana: specimens obtained by Professor H. Garman from the Mississippi and related waters at Quincy, Ill. (Garman, '90); a large series from the small lakes of northeastern Illinois; and collections made by Professor Forbes in Yellowstone Park and its vicinity (Forbes, '93) and from lakes Geneva and Delavan, Wis., under the auspices of the U. S. Fish Commission. Professor Needham's private collection used in the preparation of this paper contains many Illinois and New York species, reared by him to the imago, and others contributed by correspondents, particularly by Mr. F. G. Schaupp in Texas, Mr. Adolph Hempel in Florida, and Mr. F. C. Willard in Arizona. The preparation of the introductory matter, biological discussions, and keys to the nymphs has devolved upon Mr. Hart, while the descriptive matter, with a few exceptions, was prepared by Professor Needham.

We are indebted to Mr. C. C. Adams for abundant data on the occurrence of the imagos in Illinois derived from his large

private collection, and also for work on the keys to the genera of imagos. We are under special obligation to Dr. P. P. Calvert, of Philadelphia, for aid given Mr. Adams in the revision of keys and in the determination of doubtful species, and for notes on dragon-flies in Illinois made by Mr. Harry Walker at Belvidere, Mr. Shafer at Mt. Pulaski, and Mr. E. J. Kuegeman at Ravenswood and Edgewater. Data relating to collections in Illinois have been furnished us by Mr. Maurice Ricker, of Burlington, Ia., and by W. E. Longley, and others, of the Entomological Society of Chicago.

Of the twenty-eight recognized Illinois species of the families of *Anisoptera* herein treated, we have here described the nymphs of twenty-four (six of them for the first time), representing all our eleven genera. To these have been added by Professor Needham descriptions of ten nymphs of extralimital species. Thirty-four nymphs are thus described in all, fourteen of them for the first time.

Much careful study has been given to the preparation of the keys. In all cases the linear arrangement is according to the principles suggested by Comstock, the more generalized group or species being followed by the divergent ones in the order of the direction and amount of specialization. The descriptions of the nymphs are drawn up from full-grown examples unless otherwise stated. The newly hatched insect quickly takes on the form and structure of the full-grown nymph, and may usually be recognized while still very young by the characteristic sculpture and armament of its species.

ORDER ODONATA.

The common dragon-flies of the suborder *Anisoptera* are familiar to every one, but the damsel-flies, constituting the suborder *Zygoptera*, might not be recognized as also belonging to this order. These damsel-flies are small narrow-winged forms, which, like the butterflies, hold their wings back to back while at rest. The *Odonata* have no quiescent pupal state; the immature stages after the egg are collectively designated as the nymph. The latter is always aquatic. It has highly developed thoracic legs but no abdominal ones. Wing-pads appear at the third or fourth molt. There are no external gill structures except the three terminal appendages of the *Zygoptera*. The abdomen of the nymph is slender among the *Zygoptera*, but in the ordinary dragon-flies (*Anisoptera*) it is rather short and broad. A very distinctive feature is the large and elongate labium, folded beneath the body like an arm, the "hand" of which, ending in a pair of claspers, covers the mouth or the entire face. The nymphs crawl rather slowly, often clumsily, but can dart some distance through the water like the crawfish, being propelled by the sudden ejection of the water in the rectal respiratory cavity.

The *Odonata* and their near relatives the May-flies (*Ephemera*), isolated remnants of former insect life, in general of primitive character although highly specialized along some lines, are probably among the oldest orders of winged insects. In younger groups the branching of the "family tree" of development may often be traced with some degree of satisfaction by a study of the primitive characters retained by still existing forms; but in the lapse of ages so many of the earlier lines of descent have been obliterated from the earth that in the *Odonata* only the upper parts of a few separated branches are traceable, their points of origin being involved in obscurity. In Illinois the branch nearest the primitive stock is probably that of the "black-wings," or *Calopteryx*, of our smaller streams, representing the *Calopterygidae*. Another branch (*Agrionidae*), including the more common damsel-flies, *Agrion*, *Lestes*, etc.,

has a number of characters in common with the preceding, and the two constitute the suborder *Zygoptera*. In forms related to *Calopteryx* the three tracheated caudal setæ of the May-flies seem to be represented by three shorter and thicker respiratory appendages, the laterals especially being more or less spike-like and triquetral. In the *Agrionidæ* these appendages are vertically flattened thin gill-plates. Quite a different development of the original type is found in the nymphs of the ordinary dragon-flies, the suborder *Anisoptera*. In these respiration is principally performed by internal rectal gills, and the three appendages, very short and subtriangular, are supplemented by two others, the five converging to protect the opening of the respiratory cavity.

The five families constituting the *Anisoptera*—*Petaluridæ*, *Æschnidæ*, *Gomphidæ*, *Cordulegasteridæ*, and *Libellulidæ*—are variously connected by common characters. It is worth noting that the obscure color, rough sculpture, and general habits of the *Calopteryx* nymph are also found in the more primitive forms of these families. The *Petaluridæ* is probably the oldest of the five. It has not as yet been found in Illinois. In this family and the *Æschnidæ* the ovipositor is well developed and oviposition is endophytic, as in all the *Zygoptera*. The *Petaluridæ*, judging from Mr. Williamson's observations (Williamson, '01), breed in boggy or swampy spots, where the imagos may be found ovipositing. The nymph is remarkably synthetic in its characters and supplies a hitherto missing link in the evolution of the labium, being intermediate in this respect between *Æschnidæ* and *Cordulegasteridæ*, thus indicating a very primitive origin. In its form and antennal structure, on the other hand, it strongly approaches the *Gomphidæ*. In general, however, it is clearly most closely related to the *Æschnidæ*. The nymphs of the *Æschnidæ* are somewhat elongate, and climb on submerged branches, driftwood, roots, and smaller vegetation. The imagos are unusually large and high-flying, the eyes large, the wings much specialized. The nymphs of the third family, *Gom-*

phidae, nearly all burrow in mud and sand. The imagos are usually of medium size, barred with green or yellow, the apical part of the abdomen often expanded to a greater or less extent. They are usually seen near water, but are not numerous as a rule. The ovipositor is rudimentary or wanting and oviposition is exophytic, as in the remaining families. The eyes are small and widely separated, in which respect the family approaches the *Zygoptera*. The nymphs of the *Eschnida* and *Gomphida* differ but slightly in the structure of the labium and gizzard, and both these organs are quite similar to the type found in the *Zygoptera*. The next family, *Cordulegasterida*, is of special interest. It has but few species, and examples are rarely seen in Illinois. While evidently related to the preceding families in different ways, the nymphs are like those of the *Libellulida* in having a spoon-shaped labium and a symmetrically 4-toothed larval gizzard. The last family, *Libellulida*, comprises most of the commoner species. They are diversified in structure and habits, and may be grouped in three subfamilies. The first two of these (*Synthemina* and *Corduliina*) have a number of common features and have hitherto been classed as one, but the wing structure and nymphal characters of the *Synthemina*, represented in Illinois by *Macromia* and *Didymops*, seem to warrant its separation from the *Corduliina*. The greater part of the family belongs to the *Libellulina*, which includes three general types, exemplified by *Sympetrum* (*Diplax*), *Libellula*, and *Tramea*. The grouping of these is based by Mr. Adams on the extent of development of the ovipositor.

LITERATURE.

A list of the more important papers, to which references are made, is appended to this paper. A brief summary of their contents may be given here.

On the nymphs, the most important papers are by Hagen and Cabot, describing and figuring the nymphs of the Museum of Comparative Zoölogy, at Cambridge. Cabot's first paper ('72)

covered the *Gomphidae* and *Cordulegasteridae*, his second ('81) the *Aeshnidae*, and his third ('90) the *Syntheminae* and *Corduliinae* and also *Tramea* and *Pantala*. Hagen ('85) gave a greatly extended revision of the two families previously treated by Cabot ('72). The large and abundant family *Libellulidae* was not treated by them. Karsch ('93) gives descriptions, figures, and keys to West African nymphs. The characters assigned to the major groups in his keys are, as Dr. Calvert has pointed out, only locally or partially true. Lucas ('97, '97a) has described and figured a few English nymphs, and Roster ('86, '88), a number of Italian *Zygoptera*. Beutenmüller ('90c) has given a bibliography of nymphal descriptions, excepting those in Cabot's '90. Needham ('97a, '99) gives suggestions on collecting and rearing nymphs.

Among the general works, Dr. P. P. Calvert's admirable paper ('93) deserves first mention. It includes a complete and accurate summary of all the more important biological and anatomical details concerning dragon-flies and their nymphs, with generic keys for both. Descriptions are given of the species of the region about Philadelphia, among which are most of our commoner forms. The phylogeny of the dragon-flies in general, with especial reference to the structure of the gizzard, is discussed in a scholarly article by Dr. F. Ris ('97).

The principal monograph of American species is in Hagen's well known "Neuroptera of North America" ('61). A number of monographic papers have been published by Dr. Selys-Longschamps in Belgium. The best catalogue of species is that of Kirby ('90). It contains several surprising changes in nomenclature, one of which—the use of *Aeshna* in place of *Gomphus*—is fortunately not well founded. Banks ('92) has listed the American species, and given a key to the genera. From an economic point of view, especially as to their utility as destroyers of obnoxious *Diptera*, dragon-flies are treated in Lamborn's collection of prize essays ('90).

The numerous published lists of *Odonata* in this country contain much valuable information as to the life history of our

species, dates of occurrence, and the like, and have been extensively used in the preparation of this paper. Such are those of the late Dr. Kellicott ('95, '96, '97a); of Miss Wadsworth ('90) and Mr. Harvey ('91a) for Maine; of Calvert, Banks, and Van Duzee for New York; of Calvert for Virginia and the vicinity of Philadelphia; of Williamson ('00) for Indiana; and of Elrod for Iowa, and Banks for Kansas. The above localities are not far from our own latitude, and the data given are presumably quite close to the normal for Illinois.

Among Illinois contributions to this subject we may mention the elaborate papers ('62, '63) of our pioneer entomologist, Mr. B. D. Walsh, who listed sixty species occurring about Rock Island, describing a number as new; a list of dragon-flies taken at Kensington, Ill., by Mr. Jas. E. McDade ('92); and the treatment of the *Odonata* in Mr. H. Garman's "Animals of the Waters of the Mississippi Bottoms near Quincy, Ill." ('90). Eight nymphs are listed in the latter paper. The original specimens have been examined and determined as follows: His "4" is *Gomphus externus*; "8", *Epiaschna heros* is *Nasiaschna pentacantha* of this paper; "9" is *Tramea lacerata*; "10", *Epicordulia princeps*; and "11", *Perithemis domitia*. "12" is immature and not positively determined as yet. The others are correctly identified by him.

LIFE HISTORY.

Dragon-flies hibernate commonly as nymphs, less commonly in the egg stage, and in one species as imago. Nymphs of the *Anisoptera* mostly transform to the imago in the early part of the season, especially from the latter part of May to the first of July in our latitude, the imagos scattering and becoming reduced in numbers by midsummer. Some species, particularly those of the *Gomphidae*, have a very short period of emergence, large numbers transforming within a few days. *Anax*, and perhaps some species of *Æschna*, has apparently two broods in a year. The adults appear very early in the season, and the young nymphs, feeding voraciously and actively, grow rap-

idly, and have been known to produce imagos before the close of the same season. *Tramea* also seems to be two-brooded, emerging numerously both in spring and fall. On the other hand, the nymphs of the *Gomphidae* probably require more than a year in which to mature, emerging in the second or third season after hatching. The one-year life cycle is, however, the rule among the *Libellulidae*, which contains most of our commoner *Anisoptera*, the eggs laid during midsummer hatching in latesummer, and the nymphs maturing in time for the general emergence the following season. In late August there is a surprising number of very small nymphs,—tiny spider-like youngsters,—and even in September and October the preponderance of young nymphs is still manifest. As the period of maximum emergence of their species approaches, usually in early summer, they mostly attain full size, and are at this time most readily seen and captured and apparently more abundant than in the fall, when they were small and easily overlooked. With regard to the *Zygoptera*, it is highly probable that there are a number of broods in a season, the processes of transformation and oviposition beginning as soon as the weather permits and continuing industriously to the close of the season.

In the species whose life cycle is apparently more than a year the nymphs are of two or three distinct sizes, the largest presumably being of the next brood to emerge. In species whose life cycle is completed within a year, the nymphs are fairly uniform in size, but there is, nevertheless, a sufficient extent of variation to cause a considerable number of straggling emergences during the season; and it therefore follows that, in general, nymphs of nearly all species of *Odonata* may be found throughout the entire season. Because of this fact it has not seemed worth while to give dates of the occurrence of nymphs. The accessible data concerning the imago period, on the other hand, is very fully given, thus indicating the limits of the nymphal period also.

Like many other immature aquatic forms, the ground color of the nymphs darkens greatly up to the close of each molting

period. Immediately after molting they are very light greenish or grayish and their characteristic color-pattern is beautifully distinct, but they gradually darken and the coloration becomes more and more obscure until, as the time for the next molt approaches, it is almost entirely lost and the nymph becomes uniformly dark and dingy.

When grown, the nymphs seek the shore or some floating object and clamber up a little way on standing vegetation, logs, tree-trunks, sticks, bridge-piling, the sides of boats, or the like, and, fixing their feet firmly, proceed to transform to the imago stage. Transformation mostly takes place very early in the day and is largely over with by nine o'clock, although scattering emergences may occur at any time. The usual process will be fully described under *Tramea lacerata*. The adults scatter considerably, but a large number remain in the original vicinity, busily ovipositing for a new brood of nymphs. A short but undetermined period elapses before egg-laying begins.

Oviposition is of two kinds, endophytic and exophytic. That of the groups with more slender nymphs, *Zygoptera* and *Æschnida*, is endophytic. They have an elongated egg, which is inserted by means of an ovipositor into living or dead vegetable substances, either resting in water or at least moist. The female immerses the tip of her abdomen or enters the water completely. She usually succeeds in escaping safely from it, but is sometimes rescued by the male (Todd, '85). The oviposition of the groups with broader nymphs, *Gomphida*, *Cordulegasterida*, and *Libellulida*, is exophytic. Their eggs are shorter and oval, and are extruded in a gelatinous matrix. The female dips her abdomen in the water, usually during flight, releasing at each dip a number of eggs, which sink to the bottom or lodge on the vegetation. Sometimes, when too hotly pursued by males, she will alight on water moss or drift-wood and cast her eggs loose there. In the case of *Leucorhinia* this is apparently the usual method of oviposition. In some cases the eggs may be deposited on moist mud (*Diplax*, *Somatochlora*) or affixed to the bank or to water plants. The female

of *Celithemis* is usually accompanied by the male, who helps her to escape when menaced by the open mouth of a hungry fish. Several hundred eggs are often laid by a single female.

The period of incubation varies with the season and also independently of it. In midsummer, eggs of some species hatch in from six to ten days, while others, laid in autumn, do not hatch until the following spring. In the same lot of eggs the period of incubation may vary, even in midsummer, from a week to more than a month.

The apparent abundance of nymph and imago is far from corresponding, the difference in some cases being quite surprising. Of the nymph of *Celithemis eponina*, we have secured only a few examples; yet the imago is a familiar sight everywhere about the Station. The species of *Sympetrum* are common and familiar dragon-flies; but we have obtained only a few of the nymphs. This genus probably breeds in swampy places, where the vegetation is so dense, the water so shallow, and the mud so deep as to make collecting very difficult. On the other hand, *Epicordulia princeps* is abundant and widely distributed as a nymph, but the imago is not commonly taken. Nymphs of *Macromia*, *Progomphus*, and *Hagenius* are not at all rare in streams; the imagos are considered very rare or almost unobtainable. In the *Gomphide* are numerous similar examples. This discrepancy may be due either to the swift, high, or prolonged flight of the imago, or to the shortness of its life; but in some cases it is almost inconceivable how the imagos can vanish so completely as they do.

Walsh ('63, p. 239) makes some remarkable statements as to the relative proportion of the sexes in *Gomphus*. In some species he found four males to every female, and in another two or three females to each male, and he asserts that this is the case in freshly emerged material. Mr. Needham is of the opinion that in nymphs generally there is no notable excess of either sex, but that in the imago an excess of males may occur because of the destruction of the females by fishes in species the females of which oviposit unattended by the males. It is prob-

able that Walsh's statements were based on insufficient data.

The imagos usually keep near their nymphal home. The *Zygoptera* both fly and alight low, usually over water; the stronger *Æschnidae* fly high and scatter more; while the other imagos are diversified in these respects, many species being taken both along streams and along borders of roads and fields at some distance from water.

All dragon-flies are most active in hot, quiet, sunshiny weather. They cease flying by sunset, except a few of the *Æschnidae*, which may be seen in hot pursuit of small *Diptera* during the evening twilight.

The history of the order as a whole in the vicinity of Havana, while under our observation, is interesting but somewhat puzzling. In 1894 there was a great abundance of individuals, in all stages. In 1895 the season's collecting opened up well. Extremely low water prevailed, however, and in June the shallow waters became greatly heated by the sun, their recorded temperatures reaching as high as 96° Fahr. On one occasion, when the heat of the water was especially noticeable, a number of dead nymphs were found floating about, along the west shore of Quiver Lake. Not many nymphs were seen in the usual situations at the close of this season, and from that time on through 1896, they were reduced to insignificant numbers. The low water of 1895, however, encouraged the development of species liking swampy situations, and there was consequently in 1896 an excessive development of *Pachydiptax longipennis* and species of *Sympetrum*. A slight rise took place in the spring of 1896 and the river became very foul. At the close of the year the drouth was broken, with a more extensive rise of the river, and the season of 1897 showed an increase in the number of nymphs. The winter and spring following brought much high water in the river, but the nymphs did not greatly increase in numbers.

Kellicott has noted ('97a : 97, p. 69) that in Ohio the warm rainy weather of April, 1896, following the drouth of 1894-95, caused emergence earlier than usual, and the number appearing did not seem noticeably reduced by the drouth.

WATERS FROM WHICH COLLECTIONS WERE MADE.

The nymphs in the State Laboratory collections were derived from a large variety of waters : from the broad Mississippi and Ohio, slow and majestic, but flowing more hurriedly at a few points—as at Rock Island and Golconda ; from the bottom-land lakes of these streams, muddy and without much vegetation ; from the lower course of the Illinois, broad, shallow, slow-flowing, with the bottoms more of mud than sand, the shores often margined with water vegetation ; from the broad and shallow bottom-land lakes along this river, some slightly deeper than others, but abounding in floating vegetation,—as Quiver, Thompson's, and Dogfish lakes near Havana,—some shallower and swampy, as the great expanse of Flag Lake, and others changeable and temporary in character, as Phelps Lake ; from the smaller affluents of the rivers, usually flowing with an occasional descent over beds of mud, sand, and gravel ; from the small lakes which rest in the ancient glacial hollows to the west of Lake Michigan in Illinois and Wisconsin, quite deep in places, permanent in character, usually well supplied with aquatic life of all kinds ; from the shallow ponds of similar origin scattered over the state, of all degrees of permanency ; and, lastly, from the rapid flowing rocky streams of Yellowstone Park. These waters present a great variety of situations, each with its characteristic forms, and it is interesting to note how each of these situations is occupied by a definite series of nymphs, in accordance with its particular character.

NYMPHS INHABITING THE VARIOUS SITUATIONS.

The nymphs may be roughly grouped in three divisions, according to the kind of situation preferred by them. The first includes groups having the endophytic habit of oviposition, *Zygoptera* and *Æschnidae*, as well as a few of the more agile members of the other families, such as *Hagenius* among the *Gomphidae*, and *Mesothemis*, *Celithemis*, and *Tramea* among the *Libellulidae*. The lighter-colored of these clamber among submerged vegetation, while the dark-colored forms (*Calopteryg-*

ida, *Hagenius*, and the lower *Æschnidae*) inhabit driftwood and submerged roots and brush. The second division comprises the heavier nymphs of the *Libellulidae*, which usually sprawl upon the bottom or climb over fallen rubbish; and the third consists of the remaining *Gomphidae*, the *Cordulegasteridae*, and, to some extent, *Libellula* and its relatives, which occupy the mud or sand of the bottom.

The species inhabiting submerged vegetation, constituting the first group, are of course most abundant in the quiet waters of slow streams, lakes, and ponds, where such growths have an opportunity to develop freely. The large and active nymphs of *Tramea* and *Pantala* appear to prefer the more exposed shores of large lakes and rivers. *Mesothemis collocata* is adapted for life in the high temperatures of water from the hot springs of the west. The *Agrionidae* and *Anax* are common everywhere in bodies of water with vegetation, from the smallest pool to considerable lakes. The other *Æschnidae* climb on dead sticks and driftwood where there is little vegetation and food is not abundant, as in the bottom-land lakes and sloughs of the larger streams with good current, or (*Boyeria*) in the deeper holes along small streams, where projecting roots catch the floating driftwood. *Hagenius* also lives amongst driftwood and dead leaves in streams. The *Calopterygidae* thrive in little rapid-flowing sandy rivulets like White Oak Run and Quiver Creek at Havana.

In the second group, those living on the bottom, depth and current are important in determining the particular species likely to be found. *Epicordulia* likes the deeper waters, as of the Illinois River itself or its deeper lakes, or the bottoms of the small lakes of northeastern Illinois, finding there the molluscan diet it enjoys. On the other hand *Sympetrum* and *Leucorhinia* inhabit marshes and reedy shores, as well as shallow weedy ponds and wet meadows. The "Pumpkin Patch" at Havana, the shores of Fourth Lake in northeastern Illinois, and the swampy spots of the upland prairie, are situations of this character. *Pachydiplax* appears to like the deeper swamps

and ponds, such as Flag Lake at Havana. In the smaller streams, where the current is often rapid, such as the Mackinaw, the upper Sangamon, and the Little Wabash rivers, a number of very interesting forms find their home, especially the *Synthemiinae*, *Somatochlora* and other *Corduliinae*, and the species related to *Libellula*.

Of the third group, which live *in* the mud or sand of the bottom, there may be found in the streams just enumerated other interesting material, especially *Cordulegaster*, *Progomphus* and *Gomphus spiniceps*. In this group the most definite selection of situations prevails. Where rapid currents flow over rocky beds, as in the Mississippi at Rock Island, in the Mackinaw at the "Dells," and in the streams of Yellowstone Park, is the chosen home of *Diastatomma* (*Ophiogomphus*). Where slow currents and a muddy bottom occur, as in many prairie streams and ditches, *Plathemis* and *Libellula*, covered with dirt, trail over the mud along the shores leaving a well-marked track, or lie concealed amongst fallen trash, the dorsally projecting eyes of *Plathemis* enabling it to remain hidden and yet keep a sharp lookout. The nymphs of the *Cordulegasteridae* conceal themselves in the sand beneath the eddies of streams or under the alluvial deposit in marshes, but do not burrow. Each scratches a hole for itself, and descends into it like a chicken into a dust bath, and, like the chicken, kicks the sand over its back, and does not rest until almost hidden, only the tops of its eyes, the tip of its treacherous labium, and the respiratory aperture at the end of its abdomen reaching the surface. The burrowers of the order are the members of the large and as a whole abundant genus *Gomphus*. These burrow shallowly along in the midst of abundant life, with the tip of the abdomen turned up for respiration. Some are lake or pond species, such as *graslinellus* and *pallidus*. The former is common in prairie ponds and in the small lakes near Chicago; the latter in similar localities, and in open lakes near Havana, such as Matanzas and Clear lakes. Others choose the larger rivers, being most numerous in quiet corners where fine rubbish and

animal life accumulate. Such are *notatus* and *fraternus*; while *spiniceps* prefers swifter flowing waters like Quiver Creek at Havana, or the upper Illinois River at Ottawa.

In some species with which we have had but a limited experience further study may show a wider range of normal situations than that here assigned, but the preceding generalizations should have a value to the student and collector, and may serve as a basis for a more exact account in future.

The Illinois waters which afford the widest range of situations and are most prolific in variety of dragon-fly nymphs are the small lakes of Lake county. Their shores are sometimes exposed, wave-washed, and rocky, and the life here found is remarkably like that of swift running water. Again, they are broad and marshy, and afford a home for *Sympetrum*. Out from shore we may find shallow waters with mats of aquatic vegetation, bare sandy surfaces, or, at great depths, a bottom of soft mud. As to numerical abundance I have seen nothing in Illinois that can compare with the multitudes of dragon-flies that issue in favorable seasons from the broad shallow lakes along the Illinois River.

ODONATA OF THE VARIOUS WATERS IN ILLINOIS.

Taking the subject from a different point of view, we may briefly summarize the odonate life of the Illinois waters as follows.

In the larger rivers, down to the size of the Mackinaw, in places where the water flows with considerable current over a rocky bottom, *Diastatomma* may be looked for; where mud or sand bottom and quieter waters prevail, *Epicordulia* and some species of *Gomphus* may be found. Other species of *Gomphus* occur in the bare muddy or sandy bottoms of the sloughs and bottom-land lakes. In tree-shaded waters, where driftwood and branches have gathered, or along muddy margins, especially amongst exposed roots, the lower *Æschmida* may be looked for. In bottom-land lakes where vegetation is abundant, one may find *Anax*, *Agrionida*, *Mesothemis*, *Celithemis*, *Tramea*,

and *Pantala* amongst the vegetation, the latter two especially on more exposed shores; and *Tetragoneuria*, *Libellula*, *Epicordulia*, and *Leucorhinia* on the bottom underneath. If the situation is inclined to be marshy, *Pachydiplax*, *Perithemis*, and *Celi-themis* will be scattered over the bottom; and the shallowest and most temporary waters or wet lands are the especial home of *Sympetrum*.

In the smaller and quicker flowing streams, like the upper Mackinaw and Sangamon, quite a different series occurs: *Hagenius*, clinging to stones and driftwood and amongst dead leaves; *Boyeria* and other dark *Æschnidae* on submerged branches, roots, and sticks; *Cordulegaster* and the long-legged *Macromia* hidden at the bottom in sheltered eddies; *Somatochlora*; and, finally, *Progomphus*, *Dromogomphus*, and certain species of *Gomphus* burrowing in the sandy bottom. In the prairie ponds and slow streams and ditches, *Anax*, *Agrionidae*, and *Mesothemis* and other *Libellulidae* occur amongst vegetation, and *Sympetrum* in shallower parts, while *Libellula* and *Platthemis* will be found where there is more mud and less vegetation, as in ditches and tile ponds, resting at the lower ends of well-defined tracks. In streams of rapid flow, but not especially rocky or shaded, the *Calopterygidae* are most likely to be found, the imagos fluttering along the banks.

In the small northern glacial lakes of Illinois, a remarkably varied odonate life can be found. Among the vegetation and along shore, *Agrionidae*, *Anax*, *Tramea*, *Leucorhinia*, *Libellula*, *Tetragoneuria*, *Epicordulia*, and *Basiaeschna* may be taken. *Sympetrum* has been found along the broader, shallow, reedy margins. On the sparsely grown flats, in somewhat deeper water, *Gomphus graslinellus*, *spicatus*, and *pallidus* occur, and, especially where it is clayey, the *Syntheminae*—*Didymops* and *Macromia*—have been taken. On the other hand, *Mesothemis*, *Pachydiplax*, and *Perithemis*, elsewhere abundant, do not appear in our collections from these waters.

As to the imagos, they are most likely to be found along the shores of waters inhabited by their nymphs, though many

forms, such as some *Agrionida*, most of the *Æschnida*, *Libellula*, *Sympetrum*, and *Mesothemis* scatter widely inland. *Sympetrum* will be seen about fields and lawns, and the *Æschnida* in the vicinity of houses.

FOOD RELATIONS.

The nymphs are all predatory in habit. Most species remain in ambush, aided by coverings of sand, mud, silt, and algal growths, and by their own protective coloring, until their prey wanders within reach. *Anax junius* and a few others choose their prey. All capture it with a marvellously sudden extension of the labium, bringing it into the grasp of the formidable lateral labial lobes. Almost all kinds of small aquatic animals appear on the bill of fare of the group as a whole. The *Agrionida* have a seeming preference for *Entomostraca* and May-fly nymphs. The vegetation-inhabiting species have the most varied diet, including especially back-swimmers (*Notonecta*) and water-boatmen (*Corisa*), small crustaceans, such as *Asellus* and *Allorchestes*, thin-shelled mollusks, like *Physa*, coleopterous and dipterous larvæ, and even the younger or weaker members of their own order. *Anax* takes even the thicker-shelled univalves, like *Amnicola*. The deep-water *Epicordulia* feeds principally on small mollusks, such as *Amnicola* and *Physa*, as well as on other life of the bottom. The *Æschnida*, especially *Anax*, are most omnivorous creatures. The larger odonate nymphs eat very young fish, and in some cases appear to have caused a sweeping destruction of large numbers of them.

On the other hand, the nymphs are apparently eaten principally by fishes and by one another; hence their need for hiding places in mud and sand or among matted vegetation. In the course of Professor Forbes's studies of the food of ('88a, pp. 485, 524) he found odonate nymphs most ^{abundant} (twenty-five per cent.) in the food of the grass pickerel (*Serrinus gmelini*), and forming ten to thirteen per cent of the crappie (*Pomoxis annularis*), the pirate perch

sayanus), and the common perch (*Perca flavescens*). The latter is an abundant species in the small northeastern lakes of the state.

Belostoma, *Ranatra*, *Notonecta*, and the like, according to Mrs. Aaron (Lamborn, '90, p. 50), prey on young nymphs, and she also mentions a small red mite and a minute dipteran as parasitic on the eggs of *Odonata*. Mr. Needham ('98) has recorded the finding of numbers of nymphs in the stomachs of herons, and he once found the intestine of a nymph parasitized by very large *Gregarinidae* fully 1 mm. long.

Emerging imagos while limp and pale are the easy prey of even their weakest enemies, and great decimation takes place among them at this time. Ants, spiders, robber-flies, frogs, and birds eat many of them.

The full-fledged dragon-flies devour the small insect life of the air in vast quantities, especially gnats and mosquitoes, most of which probably developed in the waters previously inhabited by the dragon-fly nymphs. These seem to make little or no attack upon the larval stage of the gnats and mosquitoes, as if reserving them for their imago life. Dr. Lamborn, by offers of prizes, started an investigation to determine the practicability of artificially utilizing dragon-flies for the destruction of mosquitoes and flies; but the evidence published (Lamborn '90) indicates that these pests may be dealt with more effectively by direct measures, since the attack of dragon-flies could not easily be controlled and directed, although in their own way and time they doubtless reduce the numbers of the pests very considerably.

Mature dragon-flies do not usually suffer seriously from natural enemies. They are frequently found infested by small red mites. Some birds, such as the king-bird, possess sufficient aptness to capture them as regular articles of their food. It is the weaker forms, such as *Agrion*, that suffer thus extensively (Needham '98). The females while ovipositing are sometimes captured by fishes.

COLLECTING AND REARING.

Consideration of the statements and suggestions

in this article as to the various haunts and seasons of the different nymphs and imagos, will give one a pretty good idea what species may be found in the waters near at hand. Nymphs of species inhabiting vegetation may be secured with a dip-net or rake. The dip-net is quite an essential article. The kind most in use at the Biological Station has a D-shaped ring made of heavy wire about a quarter of an inch thick, the two ends joined at the middle of the curve, the last three or four inches of the ends bent outward, welded together, and inserted into the handle, as in a hoe or rake. The net is of bobbinet, with a mesh about like that of mosquito-netting, or finer. It is cut about four or five inches larger than the ring all around and gathered up to form a shallow bag without seams. This bag is edged with a band of strong cloth slightly larger than the ring and then sewed by this edge to the ring with good fine twine.

The nymphs sprawling on the bottom are secured by vigorous movements of the net close to the bottom, the currents produced sweeping them into the net. The burrowers are taken by scraping the surface layer of the bottom into the net or into a sieve, and then sifting or washing out the mud or sand, thus leaving only the nymphs and coarser rubbish. In deep-water collecting a dredge must be used. The swamp-inhabiting nymphs are easiest secured in the early morning as they come up for transformation. A pair of rubber boots is often very useful.

The smaller imagos are easily taken, but the larger ones will often stimulate the activity and alertness of the collector to a considerable degree. If the air net be of light, strong, clean material, like bolting cloth, not too fine-meshed, the possibilities of capture will be greatly increased. The best time to collect dragon-flies is on cool, cloudy, or windy days. On one memorable occasion on the shore of Cedar Lake, just after a light rain, a heavier storm impending, the dragon-flies were found resting on weeds among the trees on the sloping shore, so sluggish that they were picked up by hand in large numbers.

Eggs of the families which oviposit free in the water are

easily secured by capturing the ovipositing female and touching her abdomen repeatedly to some water in a small dish, holding her only by the fore wings back to back, while those which oviposit in plants or soft wood may be watched and the stems or wood examined afterward. Experiments indicate that imagos will not voluntarily oviposit while in captivity.

Formalin is not a good preservative for any of the larger insects. The best preservative is strong alcohol carefully heated in a water-bath. The hot alcohol penetrates more rapidly than cold, arresting internal decomposition, and thus retains the beautiful but fugitive colors of the imago. The usual process of sterilizing and fixing the tissues by heating in water in a test-tube to the boiling point before transferring to alcohol is eminently satisfactory for aquatic forms as a rule, but in the *Anisoptera* this expands the air in the rectal gill-chamber and distorts the abdomen somewhat, while in the *Agrionide*, as in the *Ephemeride*, the flat external gill-plates are badly injured by inflation and gumming together. The slender and brittle abdomen of the imago breaks off very easily, and a bristle or fine non-corrosive wire should therefore be passed lengthwise through the body as far as the tip of the abdomen, but not so far as to project among the terminal appendages. A couple of insect pins, inserted lengthwise, one at each end of the body, are used by some. Specimens for the cabinet may be spread like *Lepidoptera*. For shipment or exchange they are usually inclosed in soft papers folded diagonally.

Rearing the nymphs is not usually difficult. They need plenty of clean water, something to crawl out on, and room to transform in. A pail or tub covered with mosquito-netting answers nicely. It must get plenty of sunshine, but not so much as to overheat the water. If the breeding-cage can be immersed in the water of the stream or lake where the nymphs live, success is almost assured. They may be fed bits of fresh meat or fish, insect larvæ, flies, or the smaller aquatic *Hemiptera*. If meat is fed, it must be kept in motion before them, as they will refuse anything that does not seem to be alive. Mr. Needham

has reared *Gomphus* nymphs, which do not feed so readily as others, on earthworms. As they are more or less ready to eat each other, they must not be crowded. *Anax* is especially unprincipled in this respect, and *Gomphus* is fond of libellulids. Recently emerged living imagos should be transferred, each with its cast skin (exuvia), to dry boxes for a short time, till their surfaces and wings gain firmness and their colors are matured. The imago and its exuvia should always be kept together.

If the observer is able to keep a close watch on waters where nymphs occur, about the time of their emergence, and does not mind an early morning visit before breakfast for some larger species, he will be amply rewarded for his enterprise some day by discovering a large number in the midst of the processes of transformation, often of some species rarely taken on the wing and very desirable for exchange purposes.

In all cases and by all means full notes of habits, food, flight, manner of oviposition, and the like, should be carefully recorded.

CHARACTERS USED IN CLASSIFICATION.

The Nymph.—The most important recognition characters in the head of the nymph are derived from the labium, the antennæ, and the form and sculpture of the upper surface. The latter is useful in the separation of species and genera. If the tip of the labium, or mask, which covers the mouth like a hand, be grasped and drawn forward, the labium will straighten out, and may be kept from springing back again. Like the arm, it consists of two joints, the *submentum* and *mentum*, the end of the latter broad, bearing a pair of broad flattened appendages, the *lateral lobes* of the labium. The *mentum* itself is called the *median lobe*. Each of the lateral lobes bears outwardly, near its tip, a strong *movable hook*. In the *Petaluridae*, *Æschnidae*, and *Gomphidae* the labium is flat, and applied to the lower surface of the head; the lateral lobes are somewhat mandible-like, bearing a row of fine short teeth on the terminal edge in the *Petaluridae*, and on the inner edge in the other two families

mentioned. In the *Cordulegasteridae* and *Libellulidae* the labium is spoon-shaped, covering the face, the lobes broad and sub-triangular, fitting closely against the median lobe and to each other. The teeth of the opposed terminal margins are, in the former family, large, acute, and interlocking, but in the latter they are rounded crenations, at most not higher than broad. These are tipped with short hairs, however, which when wet make them appear pointed. On the inner surface of each lateral lobe may be a row of several conspicuous setæ, the *lateral setæ*, and a similar row on each side of the middle of the median lobe—the *mental setæ*. The antennæ are usually small and cylindrical, 6- or 7-jointed, but are broad and flattened in the *Petaluridae* and *Gomphidae*, and only 4-jointed in the latter family.

The thorax and its appendages are not extensively used in the classification of the nymph. On each side of the prothorax, in the *Æschnidae*, are a pair of small tubercles, the *supracoral processes*, best viewed in profile from above. They are fairly constant in form for each species. The *tarsal joints* are usually three in number, but in the *Gomphidae* there are only two joints in the anterior and middle tarsi. The suture between the first two tarsal joints is oblique, making the basal joint much shorter above than below. The comparative length of these two joints, measured on the dorsal line, is a useful distinction in the *Libellulidae*. As the suture between them is usually marked in darker color above, it is easily located. The *wing-pads* vary in size with the age of the nymph, being at first entirely wanting. In the adult nymph four or five abdominal segments usually remain exposed behind them.

The two main groups of dragon-flies are quite unlike in the terminal appendages of the nymphal abdomen. In *Zygoptera* it ends in three large leaf-like gills, while in the *Anisoptera* the last segment—the tenth abdominal—bears five small tapering appendages, which converge and form a valve closing the rectal opening. The middle one above is the *superior appendage*, the lower pair are the *inferior appendages*, and on each side of the superior appendage, above the inferiors, are the *lateral append-*

ages. These are of considerable value in classification. The posterior lateral angles of some of the abdominal segments bear the *lateral spines*, sometimes very small but distinct, as in *Libellula*, rarely entirely wanting as in *Mesothemis*. There are also spines or teeth along the median line of the abdomen above, varying greatly in number and form, collectively known as the *dorsal hooks*. These and the lateral spines are extremely useful in separating species and subordinate groups. The dorsal hooks may be viewed in profile from one side, springing the abdomen down away from the wing-pads; but when they are represented merely by teeth projecting backward on the hind margin and not elevated above the general level, as in *Gomphus*, they are of course best viewed from above. The dorsal hooks are always absent on the first one or two abdominal segments, beneath the wing-pads, and as their appearance on the posterior abdominal segments is of especial importance, it has usually been necessary to refer only to those on the exposed segments of the abdomen.

The characters given can usually be applied to nymphs of any age except the very young ones. In case more or less of an antenna or leg is broken off during the life of a nymph, it may be imperfectly replaced, usually with one joint less than before and the relative size of the joints abnormal.

A slight elevation on the under side of the abdomen, if near its base, indicates the male nymph; if towards its tip, the female. This may be easily observed in the common nymphs of *Anax junius*. In the *Eschnida*, the male nymph is also distinguished by what seems to be a small median scale resting on the basal part of the superior appendage.

The Imago.—It is unnecessary here to describe in detail the external anatomy of the adult, but for the understanding of the keys a brief statement of the wing venation in the *Anisoptera* is desirable. The fore and hind wings have essentially the same structure, modified to suit the difference in outline especially at the anal angle. The large number of adventitious minor longitudinal veins and cross-veins and cells are extremely

variable and unreliable, but the relative positions of the principal veins and cross-veins are constant, and useful as distinguishing characters.

On the front margin of the wing, near its apex, is a conspicuous opaque cell, the *stigma*. The strong vein which runs along its inner side, extending the whole length of the wing, is the *radius*. This is intersected about midway of the wing by a vein (the *nodal sector*) which starts at the margin in a notch of the costa called the *nodus*. Between the costal margin and the basal half of the radius is the *subcosta*, extending as far as the nodal sector. On either side of the subcosta is a row of cells separated by short cross-veins, the *antecubital* cells and cross-veins. On either side of the radius, between the nodal sector and the apex of the wing, are similarly the *postcubital* cells and cross-veins. Behind the base of the radius is a large cell, the *basilar space*, bounded posteriorly by the *cubitus* and outwardly by a conspicuous cross-vein, the *arculus*. Near the middle of the arculus arise, jointly or separately, two longitudinal veins, the upper and lower sectors of the arculus. The upper sector is the main stem of the median vein, the lower is its posterior branch. The bases of the media and the radius form one vein as far as the arculus. The anterior branch of the upper sector is the *principal sector*. It also is intersected by the nodal sector. The next apparent branch of the upper sector, running parallel to and just behind the nodal sector, is really a branch of the radius, and should be called the *radial sector*. Two adventitious longitudinal veins, formed by the stringing together of cross-veins, are the *apical sector*, just behind the tip of the radius, and the *supplementary sector*, behind the radial sector. A little beyond the arculus, the cubitus leads to the inner angle of a conspicuous triangular cell, or group of cells, known as the *triangle*. The elongate cell (sometimes subdivided by minor cross-veins) above the triangle is the *supratrangular space*. The next and last principal longitudinal vein, behind the cubitus, is the *anal vein*. Of the numerous apparent branches that it sends back toward the hind margin of the wing, three

principal ones may usually be observed in the hind wing. The *first branch* of the anal vein starts near or at the posterior corner of the triangle, and the other two *branches* are between that and the base of the wing. The first and second branches, in the hind wing, are connected by a strong cross-vein, thus inclosing the *anal loop*. This and the triangle are particularly useful in classification.

The male imago may be recognized by the complex structure on the under side of the abdomen near its base, forming a conspicuous projection. In the families treated in this article the male has the anal angle of the hind wing sharply rectangular, not rounded as in the female. In the *Libellulidae* it may sometimes be known by the appearance of milky spots on the wings, in addition to the usual black spots, or by a difference in wing-markings. The terminal appendages of the male are unlike those of the female, being usually larger and more irregularly formed.

KEY TO THE NORTH AMERICAN FAMILIES OF ODONATA.

Nymphs.

- aa.* Last abdominal segment bearing three leaf-like tracheal gills. (Suborder *Zygoptera*.)
- bb.* Basal segment of the antennæ extremely elongate. *Calopterygidae.*
- b.* Basal segment of the antennæ short, subrotund. *Agrionidae.*
- a.* Last abdominal segment terminating in five converging, short, spine-like appendages. (Suborder *Anisoptera*.)
- cc.* Labium flat, not concealing the face, with mandible-like or oblong lateral lobes.
- dd.* Antennæ 6- or 7-jointed, superior appendage usually notched at apex.
- ce.* Lateral labial lobes toothed on terminal margin, antennæ broad, flattened. *Petaluridae.*
- e.* Lateral labial lobes toothed only on the inner edge, antennæ slender. *Æschmidae.*

- d.* Antennæ 4-jointed, broad and flat, superior appendage not notched at apex. *Gomphide.*
- c.* Labium spoon-shaped, covering most of the face, with subtriangular close-fitting lobes.
- ff.* Teeth on the opposed edges of the lateral labial lobes acute, very large and irregular, interlocking; two stout teeth with a cleft between them at the apex of the median lobe. *Cordulegasteride.*
- f.* Opposed edges of the lateral labial lobes crenate or with rounded teeth; at most but a single median tooth on median lobe. *Libellulide.*

Imagos.

- aa.* Front and hind wings similar, or nearly so, in outline, usually elevated when at rest; males with two inferior abdominal appendages (*Zygoptera*). Head transversely elongated, eyes widely separated. Females with genital valves.
- bb.* Not less than five antecubital cross-veins in the anterior series. *Calopterygide.*
- b.* Not more than three antecubitals, usually two. *Agrionide.*
- a.* Front and hind wings dissimilar, hind wings usually much broader at the base, horizontal when at rest; males with one inferior appendage, or none. (*Anisoptera.*)
- cc.* Triangles of front and hind wings of similar shape; antecubitals of first and second series not coincident, except the first and another thick one; second series of postcubitals complete.
- dd.* Abdomen with lateral carinæ; female with genital valves; head globose, eyes meeting above along the middle line of the head. *Æschnide.*
- d.* Abdomen without lateral carinæ.
- ff.* Eyes distinctly separated, head transversely elongated.
- gg.* Median labial lobe bifid; female with genital valves. *Petaluride.*

- g.* Median labial lobe entire; female without genital valves. *Gomphidae.*
- f.* Eyes but little separated, or meeting at a single point dorsally; median labial lobe bifid. *Cordulegasteridae.*
- c.* Triangle of front wings with its long axis at right angles to the length of the wing; triangle of hind wings with its long axis coincident with that of the wing; antecubitals of the first and second series mostly coincident; second series of postcubitals incomplete at inner end. *Libellulidae.*

FAMILY PETALURIDÆ.

About all we know of the biology of this interesting family is contained in two late papers by Williamson ('00a, '01) on the recently discovered nymph and habits of the adult of our single North American species, *Tachopteryx thoreyi*. This is eastern and southern in its range, and has been found in an adjoining state, Kentucky. While the adult has usually been grouped with the *Gomphidae*, the nymph is nearest to the *Æschnidae*, although it approaches nearer to both the *Cordulegasteridae* and *Gomphidae* than any other known form, possessing a remarkably synthetic combination of characters. The adults were observed, according to Williamson, ovipositing in boggy ground along a small hill-stream, where a single nymph was found emerging.

FAMILY ÆSCHNIDÆ.

The elongate nymphs of this family have a flat labium very much like that of the *Gomphidae*, consisting of a long mentum bearing at its extremity a pair of curved appendages (the lateral lobes) like the mandibles of a beetle, more or less toothed on the inner edge and armed outwardly, toward the apex, with a strong movable hook. The apical tooth of these appendages is always present, not terminal and curved inward as in *Gomphidae*, but rather on the inner side of the squarely truncate or

obtusely rounded apex, and directed inwardly. The antennæ are six- or seven-jointed, slender, inconspicuous, and easily broken, quite unlike the heavy, thick, four-jointed antennæ of the *Gomphidae*. Dorsal hooks are usually absent. The lateral spines are small, but their number is of value in generic separation. The head is widest across the eyes, its hind margin more or less concave. The structure of the hind angles furnishes reliable systematic characters. There is on either side of the prothorax above the front coxa a pair of variously shaped processes, designated in the descriptions which follow as the supra-coxal processes. The abdomen is unusually slender and pliant at the base, thence indented as far as the beginning of the very large rectal respiratory chamber. The appendages are rather long and slender, resembling those of the *Cordulegasteridae*, while the *Gomphidae* resemble the *Libellulidae* in the form of these appendages. In the young nymphs the laterals are relatively much shorter than in the full-grown ones, and the superior somewhat so in comparison with the inferiors. This character is therefore applicable only to nymphs about full grown. In the male there is apparently an overlapping scale at the base of the superior appendage.

Like their imagos, these nymphs are among the largest and most powerful in the order. While the *Gomphidae* burrow and crawl on the bottom, these are great climbers on submerged driftwood, branches, roots, and vegetation of all sorts.

The two extremes of this family are curiously unlike in aspect. Nymphs of the lower genera—which are placed first in the arrangement of the species which follows—climb upon dead sticks and driftwood, and have developed a protective resemblance to these objects. They are rough, blackish, and inactive creatures, seen but rarely. Those of the last genus (*Anax*) clamber actively and abundantly among water vegetation, and are bright green or brownish in color, preying voraciously on the smaller life they find there. Nymphs of this type have paler markings between and behind the eyes and along the sides of the thorax superiorly, three pale rings on

each femur and tibia, a pale mid-dorsal abdominal line, and the apical margins and hind angles of abdominal segments and the tips of abdominal appendages also pale.

The imagos are like the *Libellulidae* in the great development of the eyes, which touch for some distance along the middle of the head, and in the presence of a roughened carina on the sides of the abdominal segments. The nearness of the lowest forms of this family and the *Libellulidae* in wing venation and nymphal sculpture is evident; but the *Æschnidae* as a whole are much nearer the primitive stock by reason of several characters, especially the structure of the labium and gizzard, the general form of the nymph, the form of the egg, and the manner of oviposition. The wing triangles are elongate lengthwise of the wing, as in the *Gomphidae*, usually with several cross-veins; most of the antecubitals not coincident. The female is provided with an ovipositor, by means of which the elongate cylindrical eggs are inserted into various plants and substances in the water instead of being washed off by dipping the abdomen during flight as are the more or less oval eggs of the other *Anisoptera*. Even in the nymphs the developing ovipositor, on the eighth ventral abdominal segment, is well marked and recognizable in all but very young individuals. In the males the corresponding parts are more difficult to see, but this sex possesses a very evident scale-like piece overlying the base of the superior terminal appendage.

Mr. Needham has observed that the eggs are deposited in the stems of plants, in floating timbers, in piers, etc., at or very near the surface of the water, either above or below it, but always in moist tissue. He has floated pieces of decaying wood upon a pond as a means of obtaining æschnid eggs, and these proved very attractive to the ovipositing females.

The usefulness of the imagos, especially *Anax junius*, on account of the enormous quantities of pestiferous gnats and mosquitoes which they destroy, puts them among the particular friends of mankind.

KEY TO THE GENERA OF ÆSCHNIDÆ OF THE UNITED STATES.

Imagos.

- AA.* Upper part of arculus equal to or longer than its lower part, its upper sector arising near the lower sector and far distant from the median vein above; anal loop evidently 5-7-sided.
- aa.* Supplementary sector, just back of the usually forked radial (subnodal) sector, nearly straight and sub-parallel to it, separated from it by one or two (rarely three) rows of cells.
- bb.* Radial sector forked near the middle of its length; first anal vein leaving the border of the anal loop at its first angulation, border continued by a cross-vein which usually meets an apparent fork of the second anal; bottom of the loop accordingly 3-sided, the part formed by the first anal short, not longer than the remaining distance to the stem of the second anal.
- cc.* Anal loop sub-oval, much as in *Macromia*, wide but not deep, with a row of, usually, three cells bordering the anal vein, and a second irregular row along the bottom of the loop; triangles 3-celled (rarely 4-celled), inner side not receiving a cross-vein; supratrangular spaces with 2 or 3 cross-veins. I. *Nasiarschna*.
- c.* Anal loop deep, transversely oblong, with two (rarely three) vertical rows of cells, ending in two or three cells on the anal vein; anterior wings with discoidal triangles 5-7-celled, the inner side receiving a cross-vein, and the supratrangular space with 4 or 5 cross-veins. II. *Epiarschna*.
- b.* Radial sector not forked; bottom of anal loop normally 2-sided, one of these sides much longer than the other, formed by the base of the first anal, the other

- by a cross-vein connecting it with the stem of the second anal without an evident intervening fork.
- dd.* Basilar space (between the arculus and base of wing) crossed by 2-6 cross-veins; supratrangular space with cross-veins; male anal triangle 3-5-celled. III. *Boyeria*.
- d.* Basilar space free or with a single cross-vein.
- ee.* Supratrangular space with cross-veins; 2 or 3 rows of cells between the radial sector and the supplementary sector below it; male anal triangle 2-celled. IV. *Basieschna*.
- e.* Supratrangular space free from cross-veins, one row of cells between the radial and supplementary sectors, male anal triangle 1- or 2-celled. *Gomphaseschna*.
- a.* Radial sector forked or branched beyond its middle, supplementary sector diverging from it until three or more rows of cells intervene between the supplementary and the basal part of the posterior branch, beyond which the supplementary curves rather rapidly upward toward the branch; anal loop much as in *bb*, the first anal reaching more than half way (usually about two thirds) across the bottom of the loop, and connected with the second anal by a short oblique cross-vein, so that the anal loop appears 4-sided with a truncated inner hind angle; triangles of both wings 4- or 5-celled, inner side almost always receiving a cross-vein. V. *Eschna*.
- A.* Upper part of arculus much shorter than its lower part, its upper sector arising about midway between the lower sector and the median vein above; radial sector emitting a number of oblique branchlets on its posterior side, but not regularly forked; anal loop apparently 4-sided, the first anal extending nearly across the bottom of the loop, the connecting cross-vein very small and inconspicuous, usually meeting the second anal at about a right angle. VI. *Anax*.

Nymphs.

- AA.* Four or more pairs of lateral spines (sometimes an imperfect additional pair anterior to those here counted as the first pair); eyes occupying less than two thirds of the side margin of the head; scale of male on base of superior terminal appendage triangular, not emarginate at apex.
- aa.* Five pairs of fully-developed lateral spines.
- bb.* Antennæ 6-jointed, the last two segments of the other genera being represented by a single long joint sometimes divided by an indistinct suture in full-grown nymphs; eyes small, occupying only one third the lateral margin of the head; apex of superior appendage truncate or feebly emarginate.
- cc.* Abdomen carinate posteriorly, forming low dorsal hooks. 1. *Nasieschna.*
- c.* Abdomen without trace of dorsal hooks. II. *Epiaschna.*
- b.* Antennæ 7-jointed; eyes occupying about half the lateral head margin; apex of superior appendage deeply emarginate.
- dd.* Lateral labial lobes scarcely tapering, obtuse or subtruncate at tip, median lobe minutely toothed each side of cleft; superior appendage not less than five sixths as long as the inferiors. III. *Boyeria.*
- d.* Lateral labial lobes tapering to the incurved apical tooth, median lobe with a chitinous callosity on each side of cleft; superior appendage about three fifths as long as inferiors. IV. *Basiaschna.*
- a.* Four pairs of lateral spines, the anterior pair much smaller than the others but distinctly spiniform; apex of superior appendage broadly but not very deeply notched; median lobe of labium not toothed. V. *Æschna.*

4. Three pairs of lateral spines, all well-developed; eyes occupying at least two thirds of the side margin of the head; scale of male on base of superior appendage short and broad, emarginate at apex; apical emargination of superior appendage about as in *Aeschna*. VI. *Auar.*

I. NASIÆSCHNA Selys.

The single species which follows has until recently remained in the genus *Aeschna*, but it is very evidently generically distinct from all other American *Aeschnidae*, and has, in fact, been lately so recognized by Selys-Longchamps and Förster under the name of *Nasiæschna*.* It has been referred by Hagen ('77, p. 37) to *Brachytron* Evans, but it is intermediate between that and *Epiæschna* Hagen. Aside from secondary sexual characters, it is nearer the latter genus. The following characters sufficiently distinguish the imago from related genera:

Face concave; frons narrow, produced above into a shelf-like prominence, with a broad longitudinal superior furrow, and without "T" spot. Radial (subnodal) sector forked midway between the nodus and the middle of the stigma, the branches of the fork diverging all the way to the wing-margin; first and second branches of media (principal and nodal sectors) not approximated beyond the fork of the radial sector; apical sector originating near the anterior end of the stigma; anal loop oval, lying nearly lengthwise of the wing, with about two longitudinal rows of cells, usually one cell between bases of the 2d and 3d anals; supratrangular space with two or three cross-veins, triangles 3- or 4-celled, inner side not receiving a cross-vein. Inferior abdominal appendage of male hardly shorter than superiors.

Epiæschna debilis Karsch (Ent. Nachr., Vol. XVII., p. 286) perhaps belongs to this genus.

The nymph of *Nasiæschna* differs from all other *æschnids* in the possession of dorsal hooks. Our species represents a distinct and primary step in the evolution of the *Aeschnidae*, and its claim to generic distinction is beyond question.

*See "Ent. News," Vol. XI., p. 546.

Nasiaschna pentacantha Ramb.

The nymph of this species was doubtfully referred by Garman ('90, p. 178) to *Epiaschna heros*. It differs from all American æschnids hitherto described in the possession of dorsal hooks on the 8th and 9th abdominal segments, having the form of a median carina terminating in a posteriorly projecting tooth. In aspect and habits this interesting nymph is very peculiar. It is rough, blackish, and very sluggish, and clings to dead branches, roots, or driftwood in quiet water. Doubtless it depends, as Mr. Garman suggests, on its obscure color and slow movements for escaping detection. Examples were taken by Mr. Hart in April and May on branches in dead water and along the banks of a slow-flowing stream near Urbana, and also a very young one in August in a muddy remnant of a temporary stream in Perry county, in southern Illinois. Mr. Garman's specimens were from a muddy slough of the Mississippi near Quincy. Outside of Illinois the imago has hitherto been reported only from New York (June), Louisiana, and Texas. Mr. Needham saw one taken at Wellesley, Mass. In Illinois it was taken by Walsh at Rock Island; and we have specimens from Urbana, and also from Cobden in southern Illinois. An imago was found floating May 20 in a narrow passage where nymphs were at the time quite numerous on dead branches lying in the water. From these nymphs adults were obtained up to June 10. Our other imagos were taken June 11 and 16.

In addition to the presence of dorsal hooks, as already stated, the nymph differs further from *E. heros*, as described by Cabot ('81, p. 30, Pl. I., Fig. 3), in the presence of two pairs of tubercles upon the head, in the absence of lateral spines on the 4th abdominal segment, and in that the two processes above each front coxa are of equal length.

The nymph measures 48 mm.: abdomen, 34 mm.; hind femur, 6 mm.; width of abdomen, 8.5 mm., of head, 9 mm.

The median labial lobe is prominent, cleft, without teeth on each side of the cleft. The lateral lobes are squarely truncate, with the outer angle rounded, their sides parallel beyond

the base of the hook, the lobes terminating in an internal tooth as long as half their apical width.

The eyes are small but very prominent, about as in *Brachytron*. Behind them the lateral margins of the head extend in a ridge to the rather acute hind angles. Back of the middle of this ridge is a prominent tubercle. There is another pair of tubercles, close together on top of the head. The hind margin is broadly concave.

Abdomen with lateral spines on segments 5 to 9, increasing in length posteriorly, those of 9 about half as long as the 10th segment.

Superior and inferior appendages equal, obtusely pointed, male scale equilaterally triangular, its apex shining black, rounded. Dorsal hooks on segments 8 and 9 and sometimes on 7; represented on the other segments by median ridges.

II. EPIÆSCHNA.

This genus is intermediate in structure between *Nasiæschna* and *Æschna*, the three genera which follow between it and *Æschna* representing a branch line of development. The nymph resembles that of *Nasiæschna* and probably has similar habits, but it is without dorsal hooks. The adult may be recognized by the structure of the anal loop and other details of wing venation. We have but one species in this country.

Epiæschna heros Fabr.

This, the largest of our dragon-flies, is not common in Illinois, though Mr. A. H. Mundt ('82) has recorded the passage of a swarm of them towards the southwest over Fairbury, Livingston county. The air, he says, was literally alive with them; few alighted, and on the following day only a few stragglers remained. *Anax junius* was, and continued to be, the common local æschnid species. *Heros* is found from Quebec to Mexico; thence west to the Mississippi River. The Illinois localities are Rock Island, Quincy, Bloomington, and Urbana, and the extreme dates April 23 and September 1. Williams says it often enters

houses before storms, and is commonest in May and early summer, being found along roads, in open woods, or over fields or water—wherever it may capture flying insects.

We have not seen the nymph, but Mr. Needham has compiled from Cabot's description and figure ('81, p. 30, Pl. I., Fig. 3) the following characters.

The nymph is 40 mm. long.

The head is deeply concave behind between the rounded hind angles. Of the acute and approximated supracoxal processes, the anterior process is the longer. Median lobe of labium slightly notched at middle, the borders of the notch variable. Lateral lobes truncate on the end, denticulate within. Lateral spines on abdominal segments 5 to 9. Appendages equaling segments 9+10; laterals slightly more than half as long as the inferiors, which are a little longer than the superior. The tip of the latter is blunt.

III. BOYERIA McLachl.

In appearance, structure, and habits this is much like the preceding genus. The imagos of the single North American species are not very large. They have a small brown spot at the base of each wing, reddish veins, and a yellow pterostigma.

Boyeria vinosa Say.

Fonscolombia vinosa, Calvert, '93, p. 247.

Neuraschna furcillata, Cabot, '81, p. 29, Pl. II., Fig. 3 (male nymph).

Gomphaschna furcillata, Cabot, '81, p. 28, Pl. II., Fig. 4 (female nymph).

A single exuvia was found by Mr. Needham attached to the under side of a plank, several feet above the water, at McHarry's mill-dam on Quiver Creek, in June. He has collected nymphs since in the rapid streams about Ithaca, N. Y. Another nymph was taken by Mr. Hart in April, clinging to floating driftwood in Quiver Creek below the mill-dam. Like *N. pentacantha*, it is dark colored and sluggish, and appears to have similar habits. Kellicott ('96, p. 111) found the imagos quite

abundant in Ohio in late summer; his notes on their habits are worth repeating here, as they tend to confirm the preceding statements of the habits of the nymph. "It prefers seclusion, hence should be looked for along ponds and streams with well-wooded banks, where branches overhang the water, and where half-submerged logs and rubbish abound. The males may be seen from early in the forenoon until dark, on warm days, exploring every corner among the obstructions at the water's edge. An interesting habit noted was that it would often fly out and carefully examine a passing skiff. The females, when not ovipositing, are suspended from some overhanging twig." Van Duzee ('97) makes a similar observation. The imago is widely distributed, being reported from Canada and the eastern United States as far south as the Carolinas, and west to Arkansas and Illinois. Professor Frank Smith took examples at Macatawa, Mich., where he says it is fairly common. In Illinois it has been taken only at Havana, Bloomington, and Urbana, a single specimen in each case. The one taken at Havana was flying along the river front. The extreme dates on record are June 20 and October 15, most of the occurrences being in July.

The nymph measures 35 mm.; abdomen, 24 mm.; hind femur, 6 mm.; width of abdomen, 7.5 mm., of head, 7 mm.

Body elongate; eyes large and very prominent, the sides of the head extending backward from the middle of the hind border of the eyes to very prominent slightly elevated hind angles, between which the hind margin is regularly concave.

Labium extending between middle legs. Median lobe prominent, cleft, a conspicuous tooth on each side of cleft, at some distance from it, on front margin.

Lateral lobes truncate apically, with a stout tooth at the inner apical angle and the convex inner margin denticulate. Hook stout, arcuate, and rather sharply incurved at tip.

Prothorax a little narrower than hind margin of head. Abdomen widest across segment 7, wing-cases reaching only the middle of 4, lateral spines well marked on 5, larger and gradually increasing in length on succeeding segments. Inferior ab-

dominal appendages incurved beyond the end of the superior, which is one fourth to one third shorter, in the male narrowly cleft at tip, in the female pointed. Lateral appendages in the male one third, in the female one fifth, the length of the inferiors.

IV. *BASIAESCHNA* Selys.

This genus contains but the one species following.

Basiaeschna janata Say.

The nymph of this species resembles that of *Aeschna*, but may be recognized by the greater number of lateral spines, the deep notch of the superior appendage, and the unusually narrow and pointed lateral lobes of the labium. We have taken the nymphs in Sand Lake, northeastern Illinois, on *Chara* in shallow water, and upon rotten logs along the shore of Delavan Lake, Wisconsin. Mr. Needham has studied the species at Ithaca, and made notes on it as follows: "This is a stream-loving species. It flies from the first of May until mid-summer. It is very common in the small turbulent creeks about Ithaca, where I bred a good many in 1897, and collected a large number of nymphs." He has also a large number of specimens, in all stages except the youngest, from Mr. F. G. Schaupp, of Texas.

The imago is on record from several Atlantic states, and is reported by Williamson in Indiana, and by Kellicott as not uncommon May 1 at Columbus, Ohio. It has been taken once in Illinois, at Thatcher's Park, Chicago. The dates given run from the last of April to September. Kellicott ('97) collected it in April, under unusual weather conditions.

The nymph measures 37 mm.; abdomen, 27 mm.; hind femur, 6.5 mm.; width of head, 7 mm., of abdomen, 7 mm.

Generally dark colored, the mid-dorsal pale line on the abdomen often breaking down over the sides in pretty mottlings. The usual three yellow rings on the femora usually very distinct.

The head is evenly narrowed behind the eyes to the sharply angular hind angles.* The labium is abruptly widened in its apical third; its median lobe is without teeth, but with the usual fringe of hairs and closed median cleft. The lateral labial lobe is slender beyond the base of the hook, and is gradually narrowed to a slightly incurved point, with indistinct denticulation along its inner margin.

The abdomen bears distinct lateral spines on segments 5 to 9, those of 6 to 9 hardly increasing in size posteriorly, those of 5 somewhat smaller. The abdominal appendages are a little declined at their sharp and slender apices; the superior is less than two thirds the length of the inferiors, deeply notched at the tip; the laterals are about half as long as the superior.

V. *ÆSCHNA* Fabr.

The nymphs of this genus resemble those of *Anax*, but have four or five pairs of lateral spines instead of three. Their habits are similar to those of *Anax*, but they appear to be more retiring and inactive, being often found clinging to submerged roots and twigs. A single example was found in the Illinois River at Havana upon a submerged branch. It was clearly an *Æschna* nymph, but escaped before it could be further studied. Dr. R. H. Wolcott had under observation a nymph of this genus in Michigan. It liked to cling to the under side of floating objects. It was once seen eating an *Agrion* nymph, but was usually fed on flies, of which it ate two to four a day, coming to the surface for them each morning, and refusing food in the afternoon even when, as an experiment, the morning meal was purposely omitted.

The imagos are of large size, and are dark brown and blue, instead of green as in *Anax*, their wings clear, with black veins. Like *Epiæschna heros* they seem to have a fondness for the vicinity of dwellings.

*In the younger of Mr. Needham's Texas specimens these angles bear distinct tubercles.

The species are numerous and difficult of separation. The nymphs are not usually abundant, and as few of even the commoner American species have been bred, our knowledge of the immature stages is as yet unusually imperfect. The key which follows indicates the salient characters of the nymphs here treated. In the young nymphs of *Æschna* sp. *b* a tendency to abdominal cross-bands was noted, and the sutures beneath were broadly bordered with paler color, except those between 3 and 4, 6 and 7, and 8 and 9.

KEY TO THE NYMPHS OF *ÆSCHNA* HERE DESCRIBED.

- aaa.* Lateral spines of sixth abdominal well developed, reaching at least about half way to the hind margin of the segment; those of seventh attaining about to the hind margin; lateral labial lobes squarely truncate at tip.
- bb.* Fifth abdominal with minute lateral spines, lateral appendages fully two thirds as long as the superior appendage; supracoxal processes sharp, equal.
 - 1. *clepsydra.*
- b.* Fifth abdominal with at most only a trace of lateral spines; lateral appendages less than two thirds as long as the superior; supracoxal processes less sharp, the posterior larger; abdomen in younger individuals with a medio-dorsal pale line bordered each side with blackish.
 - 2. *constricta.*
- a.* Lateral spines of sixth abdominal minute, distant from its hind margin by several times their own length, those of seventh reaching about half way to the hind margin.
- cc.* Apices of lateral labial lobes squarely truncate, contiguous when closed; in younger specimens a pale spot near anterior ocellus and another on clypeus, and a pale median line enlarged on the middle of abdomen into an increasing series of pale spots, the largest and last on segment seven.
- dd.* Superior appendage sparsely fringed laterally with pale hairs; posterior part of head with some pale

markings on the darker ground-color; outer apical angle of lateral labial lobes not rounded.

- cc.* Hind angles of head prominent; quite young examples (7 mm.) with separate spots at the posterior ocelli, the body not transversely banded. 3. sp. (*a*).
- c.* Hind angles of head rounded; young examples (10 mm. or less) with a trilobed spot at the back of the head above, the metathorax, a V-shaped spot on the base of the abdomen, and segments 6 and 7, all pale.* 4. sp. (*b*).
- d.* Superior appendage fringed laterally with blackish hairs; posterior part of head pale, with a dark lateral stripe, a median pair of dark spots, and the posterior margin dark; outer apical angle of lateral labial lobes narrowly rounded; head behind the eyes short.

5. *californica*.

- c.* Apices of lateral labial lobes exteriorly broadly curving to the acute terminal hook at the inner apical angle, not contiguous when closed; color dark brown, a fine median pale line on labrum, a transverse spot at the anterior ocellus, behind which are two pairs of small spots; a fine median whitish line on thorax and abdomen, vanishing near the middle of the abdomen.

6. *verticalis*.

1. *Aeschna clepsydra* Say.

Aeschna cremitica Cabot (nymph).

This wide-spread species has been found in the northern part of Europe and Asia, but especially in North America, extending south as far as the Dakotas, Wisconsin, Indiana, northern Ohio, and Maryland. It has not been taken in Illinois. Walsh reported it from Rock Island ('62, p. 397), but Hagen has identified Walsh's specimens as *verticalis*. A number of *clepsydra* imagos were taken, however, by Mr. Hart at the southwest end

*In the young *Anax junius* the anterior pale transverse band includes the last two thoracic and the first three abdominal segments, and the posterior band covers segment 8, often also 7, and sometimes even the adjacent part of 6.

of Lake Geneva, Wisconsin, within ten miles of the Illinois line, September 2 and 5, about the summer resort cottages and along the lake shore. In New York it has been taken from August 28 to September 22; in Nova Scotia, July 26. Cabot described and figured ('81, p. 23; Pl. II., Fig. 2) a nymph taken at the same time and place as imagos determined as *Æ. "eremitica,"* and assigned it by supposition to that species. *Eremitica* is an erroneous writing of *eremita*, which is a synonym of *clepsydra*.

The nymph of *clepsydra* differs from all other known *Æschna* nymphs in having recognizable lateral spines on the fifth abdominal. It is otherwise similar to *constricta*, and may be distinguished especially by the following characters given by Cabot ('81, p. 37) from full-grown nymphs of both sexes from Hermit Lake in New Hampshire, mouth of Red River of the North, and Minnesota: "Hind angles of head oblique, processes long, equal, sharp, tips bent a little outwards, inclosing less than a right angle; lateral appendages two thirds the length of the middle one; female valves not quite reaching tip of segment."

2. *Æschna constricta* Say.

This is one of our more common dragon-flies, appearing on the wing in Illinois after midsummer, and disappearing only with the autumnal frosts. It ranges over the entire northern part of the United States, and from Labrador into Siberia, being apparently less common throughout the Mississippi valley than on the north Atlantic and north Pacific slopes. The Illinois specimens are from various localities in the central and northern parts of the state. Van Duzee ('97) found it most abundant along the meanderings of small brooks in hilly country.

Our nymphs were collected in a small ditch at the west end of Lake Geneva, Wisconsin, in August, and from a little streamlet in the Mississippi bluffs near Savanna, Illinois. We also have a half-grown nymph from Pine Lake, near Charle-

voix, Michigan, sent by Dr. Henry B. Ward. Mr. Needham has also two quite young nymphs of perhaps the same species sent him by Mr. F. C. Willard from Tombstone, Arizona. These all have labial characters similar to *Epiaschna heros*. The nymph has been described and figured by Cabot ('81, p. 28; Pl. III., Fig. 1), but it does not seem superfluous to present here a detailed description, drawn up from the Lake Geneva specimens and from material bred by Mr. Needham at Ithaca, New York, in 1897. It differs from the remaining species of the genus in the greater size of the lateral spines of the sixth abdominal, as described in the key.

A full-grown male nymph from Montana presents some apparently trivial differences which, under the circumstances, it will perhaps be best to mention. On either side of the open end of the labial cleft is a minute tooth; the tooth on the inner apical angle of the lateral lobes is less acute than in the typical specimens and not so distinct. The lateral spines of the fifth segment are identical with those of the typical examples, but the others are a trifle longer and more divergent. The notch of the superior appendage is a little deeper. In length this appendage is exactly intermediate between the inferiors and laterals, as in the typical specimens, but the laterals are relatively shorter and the inferiors longer, the laterals being very little more than half the length of the inferiors.

The nymphs measure 40 mm.; abdomen 26 mm.; hind femur 8 mm.; width of abdomen 8 mm., of head 8 mm. Color blackish brown, paler below on legs, on lateral margins of abdomen, and on superior and inferior abdominal appendages. Two black marks upon the costal edge of each wing-case near the base, a pair of black dots near the tip of the basal male enlargement of the superior appendage, and a similar dot near the tip of each lateral.

Head narrowed behind the eyes to the broadly rounded hind angles, one third wider across the eyes than across the hind angles; hind margin moderately concave, with some coarse pubescence disposed in numerous irregular rows near the hind angles.

The labium extends posteriorly beyond the bases of the second pair of legs. The median lobe is considerably produced, and rather deeply cleft in the middle, the angles each side of the cleft minutely rounded. Lateral lobe squarely truncate on the end, with a minute tooth terminating the inner border, which is finely denticulate. Movable hook long and arcuate. Supracoxal processes of equal length, a little obtuse, pointing in slightly diverging directions, the angle between them about 75 degrees, the posterior a little broader.

Abdomen with lateral spines on segments 5 to 9, increasing in length posteriorly, those of 5 very minute and rudimentary, of 6 somewhat appressed, of 8 and 9 nearly equal, of 9 three fourths as long as the 10th segment at middle. Appendages longer than segments 9 and 10, inferiors longest, slightly incurved at tip; superior four fifths as long as inferiors, exactly intermediate in length between the two pairs, a pair of short spines at its terminal angles, between which the tip is semicircularly notched, sides parallel and fringed with fine hairs, its basal male enlargement elongate, triangular, scale-like, covering its basal three sevenths; laterals three fourths as long as superior, cylindrical, abruptly acuminate apically.

3. *Æschna* sp. (*a*).

A number of small nymphs from Yellowstone Park and Montana, 15 mm. and less in length, appear to be different from any others known to us. The lateral spine on the sixth segment is very small; on the fifth segment there is merely a smooth angulation; the rear angles of the head are very slightly or not at all rounded. The supracoxal processes are exactly equal and similar. The very young individuals (7.5 mm.) are not transversely banded. The nymphs are too young for any comparison of the lengths of the terminal appendages. They were collected July 25 to August 19 from bark and rotten logs in a bayou of Flathead River, near Demersville, Montana, and in Yellowstone Park from the Gibbon River and a lagoon of geyser water near Lewis Lake.

4. *Eschna* sp. (*b*).

This species is represented in our collections by a quantity of young nymphs, 5 mm. to 24 mm. long, all taken from rushes, wood, etc., along the weedy margin of a lake in Yellowstone Park, near Gardiner River, August 30. Unlike the preceding species, which it closely resembles in structure, the hind angles of the head are rounded, and the very young nymphs are banded much as in *Anax junius* but not on quite the same segments.

5. *Eschna californica* Calv.

Æ. californica, Calvert, '95.

This is a species of the far West and the Pacific coast, not found in Illinois. The nymph is here described for the first time. A single one was taken from an irrigation ditch near Tombstone, Arizona, and bred in May, 1897, by Mr. F. C. Willard. The exuvia and imago are now in the Cornell University collection. Through the kindness of Dr. P. P. Calvert, Mr. Needham has examined three young nymphs from the collection of the Academy of Natural Sciences, Philadelphia, which appear to belong to the same species.

The nymph measures 34 mm.; abdomen 20 mm.; hind femur 6 mm.; width of head, 7.5 mm., of abdomen 7.5 mm.

The head is narrowed behind the eyes to the rounded hind angles, between which are two pairs of scars, the smaller pair on each side of the median line. The median lobe of the labium is not prominent; its border is without teeth, its median cleft closed. The lateral lobes are truncate, but their external angle is rounded off slightly. The supracoxal processes are equal and divergent at almost a right angle.

The lateral spines on the 6th abdominal segment are slender and appressed, those on the succeeding segments increasing regularly in length. The inferior abdominal appendages are as long as segments 9 + 10, the laterals one half as long as the inferiors; the superior a little shorter than the latter, roundly notched as usual at the tip, and fringed with a row of stout blackish bristles along either side.

6. *Æschna verticalis* Hag.*Æschna juncea verticalis*, Calvert.

This species ranges from Nova Scotia to the District of Columbia, and has also been taken in Ohio, Illinois, and California. At the East it is commoner than *clepsydra*, but not in Illinois, having been taken only at Rock Island. The published dates range from July 16 to October 18. Harvey found it common over meadows, bogs, and rivers in Maine. The nymph has not been described or bred. We have in the Laboratory collections, however, two lots of young specimens taken from the marshy shore of Grass Lake, Ill., which are clearly distinct from the others here treated, especially in the form of the lateral labial lobes, and which may be reasonably assigned to the above species.

VI. ANAX Leach.

The abundant and very uniformly distributed nymphs of this genus may be separated from any of the others of this family—which are usually much less common—by the fact that they have only three pairs of lateral spines. In habit they are quite unlike the lower æschnid genera, as they thrive especially—even in small temporary pools and ditches—wherever there is a luxuriant aquatic vegetation, through which they clamber actively, preying on all sorts of water insects.

The imagos are familiar objects, large, bright green, the wings with yellowish costal margins, circling about in swarms or singly in search of small insects in the air.

Anax junius Drury.

King of the dragon-flies, powerful and fearless, our great *Anax* is a dominant type of its class; and its worthy offspring, omnipresent and omnivorous in the water world, is equaled only by the large water-tigers (*Cybister*) in strength, activity, and ferocity. It has none of the sluggish obscurity of *Calopteryx*, *Gomphus*, *Boyeria*, or *Epicordulia*. It clings to water

weeds, usually nearer the surface than the bottom, in an attitude of alertness, with the head poised low and abdomen slightly elevated. Its locomotion is relatively rapid, accomplished either by walking or by ejecting water from the respiratory chamber. It is notoriously cannibalistic. In the midst of abundant and choice food the larger nymphs will eat the smaller of their own species, and two of equal size may not safely be kept in close quarters. *Anax* nymphs are easily recognized by their having lateral spines on but *three* abdominal segments preceding the last. The young nymphs have wide alternating transverse bands of brownish and white, but become in later life a nearly uniform green or brownish green.

To get a definite idea of the food of the nymph, the stomachs of a considerable number, taken at different dates and in various situations, were examined by Mr. Hart. Thirteen of them contained small quantities of comminuted food, the most unexpected feature of which was the large quantity of remains of univalve *Mollusca*. This was principally *Amnicola*, the lingual ribbons and opercula of which were easily recognized. The molluscan element was estimated as 15 per cent. of the food. Filamentous algae, in quantities too large to be accidental, constituted 11 per cent. *Crustacea* were also 11 per cent., nearly all a small amphipod species, *Allorchestes dentata*. Of the remainder, 56 per cent. was recognized as the remains of insects, including larvæ of *Chironomus*, of *Stratiomyidae*, of *Tipula*, of beetles, of *Agrion*, and of a small caddice-fly (*Rhyacophila*), small *Hemiptera*, and even the moss-bug (*Pelocoris*), the sharp sting of whose beak often temporarily interrupts the routine of station field-work. A nymph was observed by us to attack a crawfish three fourths of an inch long, and devour its abdomen. Young nymphs in a breeding-cage ate *Asellus* eagerly.

In the vegetation-filled waters everywhere about Havana these nymphs developed in great numbers, while in the Mississippi and associated waters about Quincy, in which vegetation is comparatively scanty, Mr. Garman found but few individuals. Our specimens of the nymph were taken from a remarkable

variety of waters containing vegetation, and even where other species of nymphs are largely wanting. Lakes, rivers, ponds, swamps, transient pools, small ditches, springs, throughout the state,—all produce a crop of these nymphs. This fact together with their active habits and voracity, would indicate a rapid development. Kellicott states that from an excavation for an artificial lake, which was filled up with water in early May, large numbers of *junius* imagos emerged in late August, indicating the occurrence of two broods in a year. This is confirmed by one of our experiments, half-grown larvæ placed by Mr. Hart in a breeding-cage June 16 reaching the imago stage August 4. A noticeable reduction in the number of large nymphs and an increase of the younger ones about July 1 has been recorded in two different years. Young predominate in our October collections, and those taken early in spring are mostly of large size. The imagos attain greatest abundance in May. On May 19, 1894, the abundance of fresh exuvæ was considered worthy of record.

According to Kellicott this is the first dragon-fly abroad in early spring, remaining until the middle of October. Several pairs were seen by him flying in union March 21, the female ovipositing. In early spring, according to Mr. Needham, the eggs are deposited in the water-soaked stems of reeds, in floating sticks, pieces of board, etc.; while later in the season they are placed in the green and growing stems of aquatic plants. He states that the females are usually held by the males during oviposition, and often descend into the water for this purpose.

The imagos wage a ceaseless warfare on gnats, mosquitoes, and other small winged insects. In August, writes Mr. Needham, I saw a small swarm (more than a score) moving together through an orchard in Cass county, Ill., miles from open water. At the same place a few days later, during three successive days of high wind, *Anax junius* and *Tramea lacerata* could always be seen hovering in the lee of orchard trees, grape arbors, stacks of grain, etc., circling swiftly several rods away from shelter then beating slowly toward it again, head to wind,

evidently watching for game, and making short dashes forward betimes, presumably to seize some small insect driven from shelter by the wind.

Mr. Adams and Mr. Hart observed a large swarm which gathered in the lee of the field laboratory boat August 8, at twilight, and after half an hour or more of rapid circling about scattered abruptly at about 7:40. An adult *Anax* was once seen to devour an agrionid imago.

The species covers the continent from Alaska to the West Indies, and is found in eastern Asia.

Cabot ('81, p. 15; Pl. I., Fig. 2) has figured the nymph, and many different reproductions of his figure are current. The following brief description covers the more important characters.

The nymph measures 45 mm.; abdomen, 31 mm.; hind femur, 8 mm.; width of abdomen 8 mm., of head 8 mm.

The head is flat and broad, widest across the posterior third of the eyes. Antennæ minute, slender. Eyes broad, laterally prominent, produced well toward the dorsal median line at their posterior internal angles. Labium very long and flat, extending posteriorly beyond bases of middle legs; median lobe with a narrow median cleft. Lateral lobes oblong, denticulate along inner margin, an incurved tooth at tip; hook long, strong. Abdomen widest across segment 7, tapering both ways. No trace of dorsal hooks; short lateral spines on segments 7 to 9. Hind margin of 9 (as seen from above) straight. Superior appendage a trifle longer than segments 9 and 10, notched at tip; inferior appendages a little longer, sharp pointed; lateral appendages half as long.

Young nymphs are more unlike full-grown ones in habitus than are those of most other species. In the earlier stages the abdomen appears more attenuated toward the base. The superior appendage is at first very short and blunt and directed upward, but after a few molts it becomes elongated and notched at the tip, though it remains for a time much shorter than the inferiors. Lateral spines on 7 to 9 appear very early.

Nymphs one third to one half grown are transversely banded with brown across the head, across segments 4, 5, and 6 (sometimes 7), and across 9 and 10. These bands disappear with subsequent molting, and the full-grown nymphs are of nearly a greenish color variously mottled with brown.

FAMILY GOMPHIDÆ.

There is a marked "family resemblance" among the nymphs of each dragon-fly family, and this is quite as true of the present one as of any other. Its nymphs are all evident gomphids, even *Hagenius*, broad and flat as it is. Their most marked characteristic is the pair of thick, rough, four-jointed antennæ. The flat labium is built on the same plan as that of the *Agrionidæ* and *Æschnidæ*—the mentum, nearly truncate in front, bearing a powerful mandible-like pair of grasping arms, carrying on the outer side beyond the middle a large movable hook, the arms usually toothed within and ending in an incurved point. The domain of these nymphs, except *Hagenius*, is the muddy, sandy, or rocky bottom of various kinds of bodies of water, according to species. They live amongst fallen trash and sediment, burrowing shallowly along with the tip of the abdomen turned up so as to reach the water, thus enabling them to breathe while foraging in a stratum of great biological richness. Their colors are similar to the mud and sand in which they dwell, and are often obscured by a coating of mud. The flattened body and stout legs are well adapted for burrowing. The head is broad and more or less wedge-shaped, the antennæ, laid close upon the labrum, forming the point of the wedge. The third antennal joint is much the largest; the fourth, a mere rudiment. The legs are stout, the two anterior pairs directed forward, their tibiæ armed at tip externally with more or less well-developed burrowing hooks. The hind legs are directed backward and used to push the body forward. The anterior and middle tarsi are two-jointed, not three-jointed as in other *Odonata*. The dorsal hooks and lateral spines are rather feebly developed.

When the nymphs are ready to leave the water to transform they cannot ascend very small stems, such as those of reeds, owing to the wide divergence and separation of the legs; but they can readily climb up on a broad surface like the piers and timbers of a bridge or the side of a floating barge, or on large rocks or tangled growths. They do not go far above the water, not more than a few feet at most, and here they may be seen transforming at any hour of the day or night, but most commonly about daybreak, leaving behind them their mud-incrusted shells, which are often seen in great numbers in the situations already mentioned. A study of the different sizes of larvæ indicates that the nymphs require two or three years to attain maturity.

The imago gomphid is in most species a medium-sized clear-winged dragon-fly, the thorax rather prettily striped with green or yellow, the abdomen rather slender in comparison with the thorax but often dilated towards the tip, the eyes not touching as in the *Æschnidæ* and remaining *Anisoptera*, but widely separated as in the *Agrionidæ* and *Petaluridæ*. In wing venation they approach the *Libellulidæ*, the triangles being well differentiated, with few or no cross-veins, but the antecubital cross-veins are mostly non-coincident, as in the other *Anisoptera*. The anal loop is small, inclosing from one to a few cells. As with the *Libellulidæ*, the ovipositor is not developed, and the more or less oval eggs are transferred free to the water by successive taps at its surface with the tip of the abdomen during flight, the females ovipositing alone.* The number of eggs deposited is very large. Copulation takes place while at rest on shore. The females frequent the trees or pathways back of the shore, while the males rest nearer the water. The latter may be quickly recognized by their curious terminal appendages resembling four fingers about to grasp something, while those of the female are short, simple, and inconspicuous. The period of flight usually occurs rather early in the season, vary-

*The eggs in a *Nymphæa* leaf figured by Lampert, '99, as eggs of *Gomphus* have been demonstrated by our breeding work at Havana to be those of *Agrionidæ*.

ing from a few days to a few weeks according to species. During this season they are little in evidence. Indeed one may not see a living adult, although thousands of fresh exuviae be scattered along the banks.

The structural characters of the nymph appear early, and the descriptions which follow will apply to all but the very youngest nymphs. The structures latest to develop are perhaps the teeth on the inner margin of the lateral labial lobes, which in some species, at least, increase in number with successive molts. On account of the short life and restricted range of flight of the imagos they are not often taken in ordinary collecting. If the shores, boats, and bridges near the larval haunts are examined early each day in the latter part of June and early in July, the collector may be rewarded some morning by finding large numbers in the act of emerging; and if these are kept alive and uninjured in a roomy box or cage their colors and texture will mature in a few days.

KEY TO THE GENERA OF ADULT OOMPHIDÆ OF THE EASTERN UNITED STATES.

- aa. Both triangles with a cross-vein. II. *Progomphus*.
 a. Both triangles without a cross-vein, except the discoidal triangle in *Hagenius*.
 bb. First and second anal veins distinctly angulated toward each other at the cross-vein of the anal loop, which contains 3 to 5 cells.
 cc. Discoidal triangle of usual shape, without cross-vein; 3d femora not reaching base of 2; anal loop 3-celled. IV. *Diastomma*.
 c. Discoidal triangle distinctly 4-sided, with cross-vein; 3d femora very long, reaching base of 3; anal loop with 3 to 5 cells, usually 4. V. *Hagenius*.
 b. First and second anal veins nearly parallel, or only the first angulated; anal loop with 1 or 2 cells.
 dd. Part of arculus of hind wing above attachment of sectors much shorter than that below them, the lower sector joining it at or above its middle; length of body 40 mm. or less. VI. *Lanthus*.

d. Parts of arculus of hind wing above and below attachment of sectors nearly equal, the lower sector joining it distinctly below the middle.

ee. Hind femora long, reaching base of 3, with 5-7 long spines besides the usual spinules.

VII. *Dromogomphus.*

e. Hind femora usually moderate, with spinules but no long spines.

VIII. *Gomphus.*

KEY TO THE GENERA OF THE NORTH AMERICAN NYMPHS OF
GOMPHIDÆ.

AA. Tenth (last) abdominal very long and slender, many times longer than broad, nearly half the length of the abdomen. I. *Aphylla.*

A. Tenth abdominal usually broader than long, never more than twice as long as broad.

aa. Middle legs approximated at base; inner pair of wing-cases strongly divergent; ventral longitudinal sutures of abdomen diverging to near apical angles of 8, segment 9 similar to 10; lateral labial lobes entire, their apices rounded; 3d and 4th antennal joints subcylindric, more than twice as long as thick, the latter recurved; five or more pairs of lateral spines; dorsal hooks present but not prominent. II. *Progomphus.*

a. Middle legs at least as far apart as fore legs; ventral longitudinal sutures of abdomen diverging to apical angles of 9, which is unlike 10; 4th antennal joint very short and small; not over 4 pairs of lateral spines, except in *Hagenius.*

bb. Inner pair of wing-cases strongly divergent; 3d antennal joint oblong, at least twice as long as broad; lateral labial lobes dentate, without apical hook; tenth abdominal narrowing posteriorly, following the tapering outline of the apex of the abdomen.

III. *Diastatomma.* IV. *Herpetogomphus.*

b. Inner pair of wing-cases parallel, lying close together

or contiguous, except sometimes in exuviae; sides of 10 subparallel, largely embraced by the lateral spines of the rapidly narrowing 9th segment.

- cc. Third antennal joint flat, subcircular or broad oval, less than twice as long as broad.
- dd. Body very broad, 3d antennal joint subcircular, abdomen much flattened and subcircular, with distinct dorsal hooks; middle legs more distant at base than fore legs; lateral labial lobes obscurely denticulate, with broadly rounded apices.

V. *Hagenius*.

- d. Body of the usual form, 3d antennal joint broad oval, dorsal hooks entirely wanting; middle and fore legs about equally distant; lateral labial lobes dentate, with blunt apices.
- VI. *Lanthus*.
- c. Third antennal joint subcylindric, more than twice as long as thick; middle and fore legs about equally distant; lateral labial lobes toothed.
- ee. Dorsal hooks with short but acute spiny tips; median labial lobe slightly concave; lateral lobes with prominent apical hook.

VII. *Dromogomphus*.

- e. Dorsal hooks sometimes present, but obtusely pointed, usually absent except for a median tooth in the hind margin of 9; median labial lobe more or less convex, in some species nearly straight; lateral lobes with a more or less evident apical hook.

VIII. *Gomphus*.

I. APHYLLA Selys.

Aphylla producta Selys.

Two curious nymphs from Florida are described by Hagen as probably belonging to this tropical species, common in Cuba. The unusual length of the last segment will at once identify it.

II. PROGOMPHUS Selys.

Progomphus obscurus Ramb.

The nymph of this species has divergent wing-pads, like *Diastatomma*, but differs from all our other gomphids in the proximity of the middle legs. It represents an extreme of specialization for life as a burrower in the bed of running streams. It has not been found in the Illinois nor in its adjacent lakes, but seems to be common in the sand of the smaller rivers, such as the Spoon River and upper Sangamon. The State Laboratory has a large number of examples from the latter river, taken in September and October. One specimen was found at the lower edge of a sand-bar in Spoon River, near Havana, in July. The published dates for the nymph are April (Fla.), May, and June. The adults are rare in collections, although the species seems widely distributed. Perhaps the peculiar habits of the nymph may be correlated with a relatively long period of nymphal life and short period of life as an imago. The adult has been taken in Indiana as early as June 26, and in Illinois June 29 and July 13. It is recorded from Massachusetts, Georgia, Ohio, Indiana, Florida, Texas, California, Oregon, and Mexico.

The nymph was described and by supposition connected with this species by Hagen ('85, p. 247), and the supposition was verified by Mr. Needham (97, p. 184).

The nymph measures 31 mm.; abdomen, 20 mm.; hind femur, 4 mm.; width of abdomen, 6 mm., of head 5 mm.

Body depressed anteriorly and tapering posteriorly; lateral margins with long hairs.

Head depressed, sloping anteriorly, cordate, broadly notched behind; hind angles rounded. Antennae inserted into cylindrical elevations on the front, depressed and incurved so as to almost surround the pilot-shaped labrum; two basal joints very short; third, twice as long as the two basal combined, slightly flattened and upcurved at the tip; fourth joint small, one third to one fifth as long as the third, slender and strongly recurved.

Labium rather small, reaching, when folded, to the bases of the middle legs; submentum shortened; mentum narrowed at its proximal end, its median lobe prominent, rounded, fringed with a row of flabellate scales whose bases are overlaid and supported by another series of shorter semicylindrical scales; beneath this fringe, the margin cut into a series of obscure rectangular teeth; lateral lobes short, nearly straight, unarmed, rounded at apex; movable hook stout, moderately incurved, and tapering.

Thorax sloping to the head and to the bases of the legs; prothorax of unusual dimensions on the dorsal side, its hind margin on a line with the bases of the hind legs, being extended back upon the other thoracic segments, shield shaped, with a short collar close behind the head. Wing-cases strongly divergent. Legs conspicuously fossorial, fore legs approximate to the sides of the head, bearing shields of stiff hairs behind which the middle legs may be brought forward. Middle legs approximated on the venter, rotated downward and extended horizontally close under the fore legs. Hind legs longer, more nearly normal, directed posteriorly. Fore tarsi with soles facing laterally; middle tarsi rotated on tibiæ so as to point backward; hind tarsi elongate, the third segment about as long as both basal segments, its claws sharp and long; claws of fore and middle tarsi short and blunt. Each femur with a distal anterior process which rests against and supports the tibia when moved backward.

Abdomen spindle-shaped, segments about equal, the 9th a little longer than the others; dorsal hooks variable, rudimentary, more or less well represented on segments 2 to 9, smallest on middle segments. Lateral spines on 5 to 9, on 5 rather minute. Appendages slender, tapering; superior and inferiors equal, about one third longer than segment 10, laterals about half as long as the others.

III. DIASTATOMMA Burm.

Ophiogomphus Selys.

IV. HERPETOGOMPHUS Selys.

Diastatomma and *Herpetogomphus* are very closely related, and no good character has yet been found to separate them when in the nymphal stage. They are then similar in form to the common gomphid larvæ of the genera which follow, but may be easily distinguished from them all by the widely diverging wing-pads, the inner margins of which separate at an angle of 60° or more instead of being approximately parallel as in the genera which follow. In exuviae of the latter forms, however, the wing-pads are often more or less separated. *Herpetogomphus* has not been found east of the Mississippi. *Diastatomma* is widely distributed in North America, but both the nymphs and imagos are quite rare in Illinois, owing probably to the small extent of rocky stream-beds and rapid currents. The rivers near Rock Island and Golconda, in which examples have been found, afford favorable situations of this kind. Three species of the nymphs are in our collections,—one found in Illinois,—readily separable by the number of lateral spines, the length of the lateral appendages, etc., as stated in the key.

Nymph stout, little flattened. Head abruptly sloping forward from the ocelli. Labrum pilot-shaped. Antennæ with the two basal segments globular, third segment twice as long as both basal, much flattened and laid close beside the labrum. Fourth joint a minute rudiment. Median lobe of mentum rounded, with border of short blunt teeth and a double series of fringing scales. Lateral lobes nearly straight, not terminating in an end hook and minutely denticulated within; movable hook short, arcuate.

Legs rather short. Fore and middle tibiæ with external hooks, wing-cases divaricate, strongly sloping downward toward the sides. Dorsal hooks on abdominal segments on 2 or 3 to 9. Tenth segment not inclosed by the 9th but triquetral, exceeding

the lateral spines, its own lateral margin forming a part of the margin of the abdomen.

KEY TO THE NYMPHS OF DIASTATOMMA HEREIN DESCRIBED.

Lateral spines on abdominal segments 7-9.

Dorsal hooks distinct, narrowly prominent, ending in a pointed tooth; abdominal granulations fine and much less conspicuous than in the next species; male superior appendage scarcely tubercled, lateral appendages three fourths to four fifths as long. 1. *severus*.

Dorsal hooks represented by a broad elevation, ending posteriorly on each segment in a rounded tooth; abdomen evenly dotted with rather coarse blackish granulations; superior appendage of male notched back of middle, in front of which is a pair of tubercles, laterals about three fifths as long as the superior one. 3. *carolus*.

Lateral spines on abdominal segments 6-9; dorsal hooks as in *carolus* but much more prominent; male superior appendage scarcely tubercled, laterals nine tenths as long as the superior. 4. sp. (*a*).

1. *Diastatomma severus* Hagen.

Ophiogomphus severus Hagen.

The nymphs here described were collected by Dr. Forbes in large numbers from streams in Yellowstone Park, such as the Fire Hole River, Nez Perce Creek, and Gibbon and Goodwin rivers, during the latter half of August. They were found on sand under stones in shallow rapids, and on weedy and grassy bottoms. They answer well to the description given by Hagen ('85, p. 259) for *severus*, which is by far the most abundant gomphid in that region.

The nymph, apparently grown, measures 25 mm.; the abdomen, 16 mm.; hind femur, 5 mm.; width of abdomen 7 mm., of head 5 mm.

Color (alcoholic specimens) fulvous yellowish beneath and on the sutures, and on the legs beyond the middle of the fem-

ora. Yellow also on ocelli, in a broad band between the eyes behind the suture, another band on the mid-dorsal line of the prothorax, and sometimes still other bands across the apical half of abdominal segments 7 and 8; also variable spots arranged along the sides of the abdomen. Abdominal appendages yellow, brownish on the margins.

Body but little hairy. Lateral spines on abdominal segments 7-9, all equal. Dorsal hooks on 2 to 9, on 2 slender, on 3-9 subcuntriiform, on 9 low and directed posteriorly. Otherwise much like nymphs of the other species of *Diastatomma*.

2. *Diastatomma rupinulensis* Walsh.

This species was first described from Rock Island, Ill. The only other instance known to me of its capture in this state was on June 29 at a point on the Mackinaw River known as Mackinaw Dells, where favorable conditions for the nymph exist. Kellicott says the imago was first taken in Ohio May 5, near Columbus, and was common from the middle of May to the middle of June, flying above the swiftest currents or resting near rapids. It is recorded from Canada, and from a number of the northern states from Maine to Illinois. The nymph is as yet unknown.

3. *Diastatomma carolus* Needh.

Ophiogomphus carolus Needh., '97.

This species flies in May at Ithaca, N. Y., where Mr. Needham bred it by scores in 1897 and picked up hundreds of exuviae by the banks of streams. Nymphs taken in October emerged in March. In April they were abundant in the trash-filled eddies of the swiftest streams, and after their emergence the banks were in places fairly covered with exuviae. Notwithstanding all these evidences of abundance, he was able to capture but a single imago there, and saw but two at large, during a whole season of active collecting. It would be very interesting to know what the imagos do with themselves.

The nymph measures 24 mm.; the abdomen, 14 mm.; the hind femur, 4 mm.; width of head 5 mm., of abdomen 7.5 mm.

Body sparsely covered with clavate hairs and minutely pointed blackish granulations; 3d joint of antennæ very flat, oval. Labium short, meeting in front a posteriorly directed fringe of hairs growing under the edge of the labrum. Lateral spines on 7 to 9, those of 9 half as long as segment 10 at middle. Dorsal hooks on 3-9, very low and broad with decurved apices. Lateral abdominal appendages about three fifths as long as the subequal superior and inferiors.

3. *Diastatomma* sp. (*a*).

Nymphs taken by Mr. Hart from gravelly shallows of the Ohio River at Golconda, in southern Illinois, October 27, differ from those of *carolus* in having lateral spines on the 6th segment of the abdomen.

The nymph measures 25 mm.; abdomen, 15.5 mm.; hind femur, 4 mm.; width of abdomen 8 mm., of head 5.2 mm. Color (in alcohol) yellowish with black points at top of thoracic sutures and a pair each side of each dorsal hook; scars brownish. Body moderately hairy, lateral spines on abdominal segments 6 to 9. Dorsal hooks on 2 to 9, large and subcultriform in front, regularly decreasing to a rudiment on 9; superior and inferior abdominal appendages long, laterals very little shorter.

V. HAGENIUS Selys.

There is but one North American species of this interesting genus, the flat nymph of which is conspicuously unlike that of any other dragon-fly in form, as described below. It is found clinging to the flat surfaces of driftwood and stones or amongst dead leaves. The *Ephemeridæ* inhabiting such surfaces are also conspicuously flattened. They are therefore not easily picked off by fish nor dislodged by a rush of water, and are able to slip away through narrow crevices. Perhaps *Hagenius* has this shape for similar reasons. Its blackish color is evidently protective.

The imago is one of the largest gomphids. It is black, with clear wings and yellow markings, and flies along the small rapid streams which are inhabited by the nymph.

Hagenius brevistylus Selys.

This grotesque nymph looks more like a colossal bedbug than a dragon-fly nymph, being extremely flat and broad, with a disk-shaped subcircular abdomen. It is unique in habits as well as in form. It seems to prefer rapid-flowing streams, and does not burrow as do other gomphid nymphs, but clings to stones or to tethered drift-stuff in the current, or hides among loose drift and dead leaves. Mr. Needham found nymphs of three distinct sizes in a stream near Ithaca. The imagos emerged all at once, and a considerable number of exuviae were found. This would indicate a three-year life-period, the nymphs not maturing till the third season after the one which brought them into existence. We have examples taken from the upper Sangamon River in Piatt county in September and October, and at Chicago and Quincy. This nymph seems to be quite infrequent in Illinois. The imago occurs all over the country from Maine to Texas and Kansas, and is reported (Kellicott '95) as abundant in Michigan, but I am not aware that it has ever been taken in this state. It flies through June, July, and the greater part of August.

In view of the excellent figures and description by Cabot ('72, p. 9) and the very minute description by Dr. Hagen ('85, p. 279) it will be sufficient here to give only the more prominent characters.

The nymph measures in length 36 to 40 mm.; hind femur, 10 to 12 mm.; abdomen, 22 to 23 mm.; width of abdomen 20 mm., of head 8 mm.; vertical thickness of abdomen about 4 mm.

Body exceedingly flat, ovate in outline, nearly destitute of hairs.

Head cut off squarely behind; eyes a little projecting on the sides, front sloping to base of antennæ. Top of head with a pair of conic tubercles behind the lateral ocelli and a larger

pair of flattened ones behind the eyes. Antennæ with the basal joint globular, the second smaller; third joint very flat, nearly circular, but with the inner edge straight. Below the eye a blunt process extends downward and forward to the sides of the labium, obviously for lateral support of that organ.

Labium short and thick; mentum slightly wider than long, contracted at basal fourth; median lobe of mentum occupying hardly a third of its width, slightly rounded, its thickened edge obscurely cut into about ten blunt teeth, and bearing a fringe of flat scales, with a few more elongate and bristle-like at the ends of the fringe; lateral lobes arcuate, broad and strong, with ill-defined blunt denticulation all around the rounded tip and down the inside; movable hook short, feebly arcuate, tapering, with an incurved tip.

Prothoracic dorsum elevated at sides into prominent compressed lateral ridges, between which it is excavated. Femora inclined to be sharp-edged posteriorly and triangular in cross-section.

Abdomen with dorsal hooks beginning on 2, at first narrow and acute, highest on 3, becoming gradually more elongate and blunt, variably reduced on the last three or more segments to low median ridges; lateral spines of 2 acute, those of 3-9 appearing as broad triangular projections of the latero-posterior angle, those of 9 inclosing segment 10. Appendages short and thick, triangular-pyramidal, longer than the very short 10th segment. Superior slightly shorter than the inferiors, laterals one third as long. Longitudinal ventral impressions of abdomen separated by only about one fifth of the width of the abdomen, nearly parallel, becoming strongly divergent on 2 and 9. Young nymphs have the peculiarities of the mature ones even more strongly marked, especially in the form of the abdomen, which is more nearly circular.

VI. LANTHUS Needh.

The nymph of the single eastern species for which this genus was established, differs from the ordinary *Gomphus* nymph

in several particulars, and is related to *Hagenius* by its antennal structure. It was found burrowing in sandy stream beds.

Lanthus parvulus Selys.

Gomphus parvulus Selys.
Uropetala thoreyi ? Hag. (nymph).

This dainty little gomphid is not yet known to be an Illinois species. The imago has been found only from Nova Scotia to Pennsylvania, but Dr. Hagen ('85, p. 281) has described the nymph from specimens received from Kentucky October 20, doubtfully referring them to *Tachopteryx thoreyi*. Nymphs answering to his careful description were found sparingly by Mr. Needham in the sandy beds of streams about Ithaca, N. Y., where he collected and reared half a dozen. The nymph is notable for its small size and the flat subcircular form of the third antennal joint. It is an active little burrower, and has the habit of feigning death when withdrawn from the water. For these reasons it is more difficult to detect than are other gomphids. Nymphs kept under nearly normal conditions transformed in May. The imagos were not seen by him at large. They have been taken in Maine by Miss Wadsworth June 19 and 25.

The nymph measures 21 mm.; abdomen, 12 mm.; hind femur, 3.5 mm.; width of head 4 mm., of abdomen 6 mm.

Body moderately depressed, a little hairy on sides of thorax and on legs.

Head compact, with obtuse hind angles between which the hind margin is concave. Antennæ with the two basal joints short and thick, the third very flat, broadly oval, almost circular, the fourth very rudimentary.

Labium short; mentum with sides parallel except in the abruptly narrowed basal fourth; median lobe almost straight, with four blunt chitinous teeth and a fringe of long scales; lateral lobes short and stout, rounded off on the outer angle so that the inner border is not arcuate; teeth of the inner border prominent, acute, recurved, somewhat divergent; movable hook short and stout.

Legs somewhat hairy; tibial hooks on the anterior and middle pairs well developed. Wing-cases reaching the middle of the 4th abdominal segment.

Abdomen ovate, widest across the 7th segment and narrowed rather suddenly upon the 9th. No dorsal hooks at all, but a faint impressed median line on the anterior segments; lateral spines on 8 and 9 small, angular; 9th abdominal segment longer than the 8th and three times as long as the 10th. Appendages longer than the 10th segment, stout pyramidal, laterals one half to one third shorter than the others.

VII. DROMOGOMPHUS Selys.

One of the three species of this American genus has been found in Illinois. The nymph may be known by the median ridge on the 9th abdominal segment, ending behind in a sharp spine. The imagos resemble those of *Gomphus*.

Dromogomphus spinosus Selys.

Gomphus sp., Hagen, '85, p. 265, No. 19 (nymph).

This appears to be quite rare in Illinois, and we do not know that any one has ever taken the nymph within our boundaries. Walsh records the imago from the Des Plaines River, near Chicago; and Mr. Adams, from Kankakee, July 6. It has been taken in a number of states between Maine and Florida on the east and Texas and Illinois on the west. Kellicott found it common in Michigan July 15 to August 1, and gives the following interesting notes: "The female was several times found ovipositing in a manner similar to *Macromia illinoiensis*, that is, by skimming the water and every few feet or rods touching the water with the abdominal tip, scarcely checking her speed; at other times I have seen them drop down from an overhanging tree and repeatedly tap the water, remaining in one place after the manner of *Libellula*. Pairs were noticed to fly up into tree-tops, and remain in union for a considerable time." The earliest date is June 5, given by Williamson. Miss Wadsworth observed an individual devouring a *Calopteryx maculata*.

The nymph has been bred by Calvert, and imagos, nymphs, and exuviae were collected by Mr. Needham—all three at the same time and place—near Ithaca, N. Y., in June. Hagen's nymph No. 19, from Michigan, is probably this species.

The nymph measures 34 mm.; abdomen, 22 mm.; width of head 5.5 mm., of abdomen 7 mm.

Body elongate, nearly smooth. Antennae a little more approximated than in related genera, the 3d segment more upcurved at the tip. Labium moderate, mentum slightly widened all the way to its apex; median lobe a little concave, with minute median tooth and a sparse fringe of flat hairs either side of the tooth; lateral lobes short and stout, the apex incurved in a stout hook which considerably exceeds the 8 truncate teeth of the inner margin. Tibial burrowing hooks strong.

Abdomen cylindrical, becoming sharply triquetral in cross-section posteriorly. Dorsal hooks on segments 2 to 9, on 2 rudimentary, but becoming well developed posteriorly, and on 9 straight, almost equaling the lateral spines and confluent anteriorly with the sharp mid-dorsal ridge. Lateral spines on segments 6 to 9 increasing in size posteriorly. Appendages a little longer than the 10th segment, their apices bent a little so as to be divergent; laterals a little shorter than the others.

VIII. GOMPHUS Leach.

The nymphs of this large and difficult genus represent the typical and most abundant form of the family. The wing-pads are not divergent, as in *Progomphus*, *Herpetogomphus*, and *Dias-tatomma*, nor the third antennal joint subcircular, as in *Hagenius* and *Lanthus*; nor are the abdominal segments armed with spinose dorsal hooks, as in *Dromogomphus*. Their habits are very similar to those of the rest of the family, with the exception of *Hagenius*, as described fully under the family heading. Observations by Mr. Needham at Ithaca and by Mr. Hart at Havana indicate a nymphal life of more than one

year; in the case of *G. villosipes*, of two years. The imagos are all much alike, of medium size, with clear wings, the triangles normally without cross-veins, the thorax with green or yellowish stripes. They disappear rapidly after transformation, and are not usually common.

KEY TO THE KNOWN NORTH AMERICAN NYMPHS OF GOMPHUS.

- AAA. Four pairs of lateral spines; lateral labial lobes rather finely toothed, with 6 to 12 teeth; side margin of 9 spinulose or denticulate, 10 (last) wider than long. (*Gomphus* Needh.)
- aa. Dorsal hooks represented more or less on 2 or 3 to 9.
- bb. Dorsal hooks distinct, each produced at the hinder margin of its segment in a pointed median tooth; side margins of 9 spinulose.
- cc. Lateral spines of 9 about as long as segment 10; 9 thrice as long as 10. 1. sp. (*a*).
- c. Lateral spines of 9 reaching about half way to the apical angles of 10; 9 twice as long as 10. 2. *graslinellus*.
- b. Dorsal hooks feebly elevated, only the last two or three forming median teeth in the hind margin of the segment; side margins of 9 obsoletely denticulate. 3. *descriptus*.
- a. Dorsal hooks represented only by median teeth in the posterior margin of 8 and 9; a fine smooth median line on the preceding segments; 9 spinulose laterally, 10 very short.
- dd. Lateral spines of 9 distinctly shorter than the distance to the median tooth of the segment; labial apical hook sharp, projecting beyond the teeth.
- ee. Lateral spines of 9 broad, scarcely longer than those of 8; length of ventral surface of 9 at middle a little more than one third its basal width; abdomen less than twice as long as broad. 5. *abbreviatus*.

- c.* Lateral spines of 9 about twice as long as those of 8; length of ventral surface of 9 at middle about one half its basal width; abdomen more than thrice as long as broad. *6. vastus.*
- d.* Lateral spines of 9 slender, elongate-acuminate, incurved apically, nearly or quite as long as the distance to the median tooth of the segment; labial apical hook not projecting beyond the teeth. *9. externus.*
- AA.* Three pairs of lateral spines, the first pair very small; teeth of lateral labial lobes mostly distinctly separated by rather deep incisions, and obliquely truncate; median lobe rather prominent, a small projecting tooth at middle; side margins of 9 entire, more or less fringed with soft hairs, 10 (except in *spicatus*) as long as, or longer than, wide; only a trace of a median posterior tooth on 9. (*Arigomphus* Needh.)
- ff.* Last three segments evenly tapering, length of ventral surface of 9 at middle about three fourths of its basal width, 10 wider than long; traces of dorsal hooks; labial apical hook prominent, toothed on its inner side but not appearing bifid. *10. spicatus.*
- f.* Last three segments concavely tapering, length of ventral surface of 9 at middle about equaling its basal width, 10 longer than wide; a low scurfy median abdominal ridge.
- gg.* Labial apical hook as in *spicatus*; lateral spines of 9 not over one fifth as long as the inferior appendages. *11. australis.*
- g.* Labial apical hook and outermost tooth united to form a prominent bifid apical tooth.
- hh.* Lateral spines of 9 not over one fourth as long as posterior appendages. *12. villosipes.*
- h.* Lateral spines of 9 about as long as inferior appendages. *13. pallidus.*
- A.* Four pairs of lateral spines (minute in *spiniceps*); labial apical hook large and strongly incurved; teeth few, 0-5,

- usually 2 or 3, broad and subtruncate, separated by deep narrow incisions; side margins of 9 entire, often fringed with soft hairs, as in *AA*, 10 not longer than wide.
- ii.* Dorsal hooks very small, pointed on 6 to 9; lateral labial lobes 4-toothed. 14. *exilis*.
 - i.* Dorsal hooks wanting, except usually a distinct median tooth in the hind margin of 9; a fine smooth median abdominal line; labial lobes rarely more than 3-toothed.
 - jj.* Length of ventral surface of 9 along median line not more than half its width at base.
 - kk.* Dorsal hooks entirely wanting; lateral spines of 9 as long as segment 10. 16. sp. (*b*).
 - k.* A broad triangular flat dorsal median tooth in the hind margin of 9, as long as segment 10; lateral spines of 9 twice as long as 10. 17. sp. (*c*).
 - j.* Length of ventral surface of 9 more than half its width at base; apical hook of anterior tibiæ very small. (*Stylurus* Needh.)
 - lll.* Ventral surface of 9 distinctly shorter than its basal width; lateral spines of 9 about one third as long as their distance from the median dorsal tooth of the segment; median tooth minute. 18. *umnicola*.
 - ll.* Ventral surface of 9 about as long as its basal width; lateral spines of 9 at least two thirds as long as the distance to the median tooth. 19. *plagiatus*.
 - l.* Ventral surface of 9 twice as long as its basal width. 21. *spiniceps*.

1. *Gomphus* sp. (*a*).

Gomphus sp., Hagen, '85, p. 264, No. 17 (nymph).

This species is known only from a single nymph described by Dr. Hagen from Indiana. It may be distinguished by the following characters:

Length 30 mm. Lateral lobes of labium with a sharp bent apical hook and ten strong teeth; median lobe straight; segment 9 longer than 8, three times as long as 10; lateral spines

on 6 to 9, sharp, the last pair as long as 10; lateral margins of 7 to 9 serrate; dorsal hooks well marked on 2 to 9, sharply pointed; appendages as long as last segment.

2. *Gomphus graslinellus* Walsh.

Imagos of this species have been reported from the states of Washington (Hagen '85, p. 264), Indiana, and Ohio. The State Laboratory has a number of the nymphs from the shallows of Cedar and Sand lakes, in northeastern Illinois, taken in June, August, and October, many young occurring in the latter month. It is common in ponded waters near Urbana, but apparently does not occur in the bottom-land lakes and streams about Havana. Mr. Needham studied the species at Purington Lake, near Galesburg, Ill., in 1895, collecting and rearing a large number of nymphs. His notes are as follows: "Very early in the spring I obtained from steep clayey banks in the lake nymphs lacking one and two molts of maturity. Placed in my aquaria these nymphs quickly descended into the mud of the bottom until only the upturned tip of the abdomen remained exposed, then burrowed along parallel to the surface, leaving a shallow groove to mark their course. When out of the mud they crawl stiffly and very slowly, but swim fairly well under compulsion, by expulsions of water in the usual manner. Transformation takes place commonly between daybreak and sunrise. The nymph usually crawls but a few inches from the water, and appears to transform oftenest while lying flat upon the bare earth or upon tangled mats of dwarf club-rush and other semiaquatics. Exuviae picked up in such places are usually incrustated with mud. The species appears on the wing in Illinois about the 20th of May, and flies for about a month. Imagos were oftenest seen when flushed from the grass or from the bare paths which terraced a steep hillside beside the lake. Females were little in evidence. I took one ovipositing and obtained in a tumbler of water an immense number of eggs."

Other Illinois localities for the imago are Coal Valley Creek (Rock Island county), Des Plaines and Chicago Rivers; Chicago, Bloomington, and Urbana,—the dates ranging from late in May

to the early part of July. They were observed emerging numerously at Urbana on May 27.

The nymph was described by Hagen ('85, p. 264) and connected with this species by supposition.

The nymph measures in length 32 mm.; abdomen, 21 mm.; hind femur, 6.5 mm.; width of abdomen 8 mm., of head 6 mm.

Body depressed. Color yellowish brown with darker markings on sides of thorax, on wing-cases, and on median dorsal area of abdomen. Lateral margins of body and appendages fringed with luteous hairs, except on tapering posterior end of abdomen. Scars prominent.

Head compact, notched behind; hind angles broad.

Labium stout, short, not extending posteriorly beyond the bases of the fore legs. Mentum flat, broad, slightly narrowed at base; median lobe very slightly rounded, margined with a dense comb of flat bristling hairs, lateral lobes arcuate, narrowed to an incurved tip within which are about nine teeth on the inner margin. Movable hook long, stout, incurved, and rather bluntly pointed.

Abdomen widest across segment 6, acutely narrowed to the tip; segments 3 to 8 of about equal length, 9 one half longer than 8; 10 cylindrical, less than half the length of 9; short lateral spines on 6 to 9, increasing in length posteriorly, those of 9 reaching slightly beyond the middle of 10; small dorsal hooks on segments 3 to 9, best developed on 4 to 6. Superior and inferior abdominal appendages longer than segment 10; laterals shorter than the others.

Younger nymphs lacking two or three molts of maturity do not differ in any essential character. A quite young nymph, 8 mm. long, has dorsal hooks on 8 and 9, well marked only on 9, with merest rudiments on the middle abdominal segments. The four pairs of lateral spines are all present.

3. *Gomphus descriptus* Banks.

G. descriptus Banks, '96.

This was recently described from specimens taken in New York May 15-21. Williamson's statement that it occurs in

Illinois is based on an erroneous determination. The only nymphs of this species known to us were found by Mr. Needham in New York. It abounds in all the streams about Ithaca, transforms in May by thousands, and scatters to the woods. Many imagos were seen by him foraging about the borders of upland woods and going to rest at night among the branches of trees, but he did not observe their breeding habits.

Transformation takes place generally before daylight and within a few inches, or at most a few feet, of the water's edge.

The nymph measures 29 mm.; abdomen, 18 mm.; hind femur, 7 mm.; width of head 5.5 mm., of abdomen 8 mm. Body very flat and hairy; legs and antennæ and lateral margins of head very hairy. Head depressed and wedge shaped.

Labium short; mentum squarish beyond the narrowed basal third; median lobe nearly straight; lateral lobes very arcuate, ending in a distinct hook on the inside of which is a very broadly pyramidal tooth: proximally the lateral lobe bears on its inner side a series of 7 to 9 short, broad, slightly recurved teeth; movable hook long and strong.

Abdomen lancet shaped; scars above and ganglion pockets beneath very plainly marked; segments 2 to 8 about equal in length, 9 one half longer, 10 half as long as 9; dorsal hooks reduced to broad median swellings on segments 2-9, not hooked nor pointed; lateral spines on 6 to 9, those of 9 about one half as long as 10. Superior and inferior appendages one third longer than 10, laterals a little shorter.

4. *Gomphus quadricolor* Walsh.

This imago is seldom captured in Illinois. The nymph is unknown. Walsh's examples were taken at Rock Island. Mr. Adams took the imago at Bloomington June 23. Kellicott made three captures in Ohio, May 20 to June 15; Williamson found one June 26; and it is also on record from Indiana, Michigan, and Massachusetts. It rests, according to Kellicott, on rocks projecting from rapids, or on the banks near by the most rapid parts of large streams.

5. *Gomphus abbreviatus* Hag.

The nymph was collected and bred by Mr. Needham at Ithaca, N. Y., and is here described for the first time. It is not an Illinois species, and seems quite rare and limited in range, imagos being recorded only from Maine, Massachusetts, and (with doubt) Pennsylvania. The only date found recorded for the imago is June 10 (Harvey).

The nymph measures 24 mm.; abdomen, 15 mm.; hind femur, 5.5 mm.; width of head 5.5 mm., of abdomen 8 mm.

Body very flat, very scantily hairy on the margins. Antennæ with the third segment flattened and widened toward the tip. Labium short; mentum narrowed in its basal fourth, beyond which the sides are parallel, median lobe a little convex and with a median marginal tooth in the midst of the fringing flattened hairs; lateral lobes regularly narrowed and incurved to a point which is a little longer than the teeth on the inner border; teeth about eight, quadrant-shaped, pointed at the lower apical angle, successively decreasing in size proximally.

Abdomen flat oval. Conspicuous lateral spines on segments 6 to 9, increasing in stoutness posteriorly, the last about as long as segment 10. Dorsal hooks represented by minute rudiments on 8 and 9; a smooth median line anteriorly to this. Appendages yellow, almost twice the length of the 10th segment, the laterals a little shorter than the others, the superior a little bent upward at the extreme tip.

6. *Gomphus vastus* Walsh.

Walsh found this species emerging in company with *notatus* and *fraternus* "in considerable numbers" at Rock Island, on the Mississippi, and described the imago as a new species ('62, p. 391). Riley (Hagen, '85, p. 265) also reared it from the Mississippi River at Hannibal, Mo. (not "Ill."). The nymph is in Dr. Kofoid's private collection, taken in deep water in Detroit River. The imago is reported from Illinois, Iowa, Indiana, Michigan, Ohio (common in July), Pennsylvania, and several

Atlantic coast states, but seems less abundant in Illinois than some other species. Walsh notes an imago taken June 16 eating one of the larger caddice-flies, *Macronema zebratum*. Kellcott ('96, p. 111) describes the habits of the imago as similar to those of *fraternus*, and says they copulate at rest in trees or shrubs. The time of flight seems to be from the latter part of May through July. Our Illinois imagos are all from the vicinity of the Mississippi along the northwestern border of the state. Williamson says they frequent the larger rivers and lakes, the males being more often found near the water's edge, the females in fields or along roadsides.

The nymph has been described and figured by Cabot ('72, p. 3, Pl. II., Fig. 4) and again by Hagen ('85, p. 265). The following brief description is condensed from that of Dr. Hagen.

The nymph measures 31 mm. in length.

The mentum of the labium is one third longer than broad; the front border of the median lobe is straight, fringed with *long* flat scales; the lateral lobes end in a long sharply incurved point, inside which the toothed inner margin is concave. Abdomen slowly tapering posteriorly, in outline rather bluntly pointed. Ninth abdominal segment three times as long as the 10th, and a little longer than the 8th. Lateral spines on the 6th to the 9th segments, those of the 9th as long as the 10th segment. Dorsal hooks on the 8th and 9th segments. Appendages nearly twice as long as the 10th segment.

7. *Gomphus ventricosus* Walsh.

A widely distributed but rare species in collections. It was originally described from Rock Island, Ill., and has since been listed from Michigan, Massachusetts, and Virginia. The nymph is unknown.

8. *Gomphus fraternus* Say.

This species and the following (*externus*) are closely related but specifically distinct. The nymphs of *fraternus*, if any are in our collections, have not been distinguished from those of *externus*, which is a common species at Havana. Dr. Hagen's

No. 17 ('85, p. 264) which he thought might be *fraternus* is probably not. Walsh states that he found this with other species emerging in considerable numbers on the Mississippi at Rock Island. Kellicott says that it is common in Ohio from May to the first part of July, and flies about the swiftest and most turbulent parts of the river ovipositing in rapids and rough waters. The State Laboratory has a single imago taken near the upper Sangamon, at White Heath, May 18. *Fraternus* is chiefly eastern in its distribution; *externus*, western. In addition to the localities already given, the present species is listed from New York, New Hampshire, and Virginia; Michigan, Indiana, and Arkansas.*

9. *Gomphus externus* Selys.

G. consobrinus Walsh.

G. adelphus (suppos.) Hagen (nymph).

The nymph of *externus* is readily recognized by the breadth, form, and large lateral spines of the ninth segment, and by the entire absence of dorsal elevations or hooks except a rudimentary posterior tooth on the eighth and ninth segments. This species and *G. notatus* are the most abundant gomphids in the field of the Biological Station at Havana. They are usually found in company, burrowing, mole-like, in the soft mud bottom wherever a sufficient current is maintained at all stages of water, and becoming especially numerous in sheltered areas where there is an accumulation of fine trash on the bottom. They are quite common throughout the year in muddy flats about the point where the waters of Quiver Creek become lost in Quiver Lake, and along the line of the channels of the Illinois and Spoon rivers, especially in the narrower part of the Illinois down from the mouth of the Spoon. They are seldom seen at any of the lake stations. *Externus* is also represented in the State Laboratory collections from the vicinity of the Mississippi River at Quincy, where it was common in the muddy side passages and the adjoining narrow slough-lakes; from the

*The imagos described as *G. fraternus walshii* by Kellicott ('99) have been determined by Calvert ('01) to be *crassus*. See also foot-note on next page.

Rock River, in northern Illinois; from the Sangamon, in the central part of the state; and from the Big Muddy at the south.

Transformation was first observed May 21. Mr. Needham's notes of his observations on this species while at Havana are as follows: "Transformation takes place in the night or very early morning. The nymph crawls but a little distance (one to two feet) out of the water before fixing itself for emergence. I have found exuviae on bridge piers and on willow stumps, and have taken imagos emerging in such places at about six o'clock on several mornings."

The strong-flying imago was not uncommon at Havana during July, 1896. The males were frequently seen chasing each other over the open river, or sitting at rest on the sand at the bank with the abdomen elevated and the wings declined until their tips touched the sand, in a position of great alertness. The females fly less openly. One female captured in the weeds at the bank, deposited for me in a watch-glass of water in a few minutes' time about 5,200 eggs. This number is an estimate from a partial count.

An observation on the food of the imago was made by Mr. Needham, who found on shore a female *fraternus* engaged in eating a teneral imago of *Mesothemis simplicicollis*.

Examples of the nymphs collected in June were placed in breeding-cages immersed in the water of Quiver Lake beside the field laboratory of the Biological Station. They remained without transforming, and at the close of the season's work, September 28, seventeen nymphs, nearly the original number, were still alive in the cage.

About the middle of July, after a severe rain storm, several dead males of this species were picked up from the guards of cabin-boats along the Havana river-front.

The imago is reported from Illinois, Nebraska, Kansas, Texas, and New Mexico. In Illinois it has been taken in Henderson county, as well as at Havana and Rock Island.*

*According to Calvert, the imagos described as *externus* by Kellicott ('99) and Williamson ('00) are *G. crassus* Hagen, a species not yet found in Illinois, which is quite unlike *externus* in the form of the terminal appendages of the male.

The nymph measures in length 32 mm.; abdomen, 20 mm.; hind femur, 6 mm.; width of head 5.5 mm., of abdomen 8 mm.

Body stout, only moderately depressed. Lateral margins of body and appendages hairy. Tibial hooks very prominent.

Labium short and stout; mentum a little longer than broad and narrowed at basal third; median lobe very faintly rounded; lateral lobes short, thick, and not strongly arcuate, ending in two teeth which are hardly distinguishable from the five to ten other teeth which extend in a diminishing series down the inner margin; movable hook short, stout, tapering, and regularly curved to its tip.

Abdominal segments 3-8 about equal, 9 one half longer, 10 very short, one third as long as 9; a smooth median dorsal line ending on 7; rudimentary dorsal hooks on 8 and 9; lateral spines on 6 to 9, incurved at tip, those of 9 about twice the length of segment 10. Superior and inferior abdominal appendages twice as long as segment 10, laterals a little shorter than the others.

Younger nymphs dredged from the bed of the stream differ only in size and in the shortness of the wing-cases.

This nymph agrees in every point with the very careful description given by Hagen ('85, p. 262) for "*Gomphus adelphus* (supposition)."

10. *Gomphus spicatus* Selys.

In the collections of the State Laboratory are many examples of a nymph resembling *graslinellus*, all taken from shallow waters in Sand and Cedar lakes, northeastern Illinois, associated with that species, during June, August, and October. Dr. Ward has sent me another of the same species from a lake near Charlevoix, Mich. These nymphs we can properly assign to *spicatus*, imagos of which were collected at the same place, and which is one of the very few Illinois gomphids whose nymphs yet remain unknown.* The nymphs from Cedar Lake

*Mr. Needham has since verified this supposition by breeding.

referred by Hagen to *pullidus* ('85, p. 267) are of this species. Imagos of *spicatus* were taken by Mr. Hart at Cedar, Sand, and Fox lakes, June 15-22, 1892. This is its first record from Illinois, it having been previously listed only from Canada, Massachusetts, New York, and Ohio. In the latter state it was common in the northern part, flying in June, the latest date, being July 1. Van Duzee found the imago in a swamp. Kellcott found it along wave-washed shores, the males flying out over the water, the females, when not ovipositing, remaining on herbage or trees on shore.

The nymph, not quite fully grown, measures 28 mm.; abdomen, 18 mm.; hind femur, 5 mm.; width of abdomen, 6 mm., of head 5.5 mm.

Body flat, hairy on legs and lateral margins. Color yellowish, eyes black; fuscous mottlings at base of wing-cases and on sides of abdominal segments between the yellow mid-dorsal line and the scars, sometimes forming oblique streaks.

Labium moderate; front border of median lobe nearly straight; lateral lobes short arcuate, with a sharply incurved end hook, on the inner margin 6 to 9 short rectangular backwardly directed teeth.

Wing-cases reach the 5th segment.

Abdomen nearly 3 times as long as wide, lateral spines on segments 7 to 9 increasing in size posteriorly, those of 9 half as long as segment 10. No dorsal hooks; traces of mid-dorsal smooth line apparent on middle segments. Lateral margins of 8 and 9 subentire; segment 10 half as long as 9. Appendages longer than segment 10, the laterals shorter than the others.

11. *Gomphus australis* Needh.

This is a Florida species, described as new by Mr. Needham ('97, p. 184). Nymphs supposed by him to belong to *australis* were collected near Gotha, Fla., in December, 1896, and in January, 1897, by Mr. Adolph Hempel, who took a single male imago at the same place a little later. Morphological characters entirely justify their reference to this species.

The nymph (supposition) measures 30 mm.; abdomen, 20 mm.; hind femur, 5 mm.; width of head 5 mm., of abdomen 5.5 mm. Olivaceous, yellowish below and on sutures.

Body slender, pointed posteriorly, moderately hairy on margins and on all appendages.

Head compact, hind angles prominent, rounded, a pair of small black tubercles on hind margin between these angles and the median line. Antennæ long, considerably exceeding the labrum. Eyes large, black; ocelli yellow.

Labium moderate; mentum narrowed for its posterior two fifths; median lobe very slightly curved, fringe of flat scales short, in the middle of it a single simple or bifid tooth or a double one, which is shorter than the scales; lateral lobes stout, suddenly narrowed and sharply incurved to form the prominent end hook, which bears usually a minute denticle on its inner side. Inside the end hook there are about eight obliquely truncate, short, quadrangular, posteriorly directed teeth.

Hook long, strong, arcuate.

Legs short; tibial hooks of fore and middle legs well developed.

Abdomen somewhat depressed, attenuate posteriorly and upcurved, widest on segment 4; segments 3 to 7 and 10 all subequal in length, 8 a little longer, 9 one half longer than the others, margins of 9 yellowish. No dorsal hooks, or on 9 the merest rudiment; lateral spines on 7-9 short, appressed, minute on 7 and 8, on 9 only about one eighth the length of 10. Inferior appendages about as long as segment 10; superior a very little shorter, its basal half thickened; laterals a little shorter than superior and much more sharply pointed

A young nymph one fourth grown differs from the mature ones only in size and in having but 6 or 7 teeth on the lateral lobe of the labium.

12. *Gomphus villosipes* Selys.

This elusive gomphid was bred by Mr. Needham in large numbers at Ithaca, N. Y., in May, 1897. The imago has never been taken in Illinois, but there is a well-marked nymph of

this species in the State Laboratory collection from Swan Pond, near the Wabash River in southeastern Illinois. The nymphs were exceedingly abundant at Ithaca. Two distinct sizes were observed, a fact which, taken in connection with the extremely short period of emergence, strongly indicates that the species takes two years to complete its life cycle, the nymph hatching in one season not transforming until the second season thereafter. Two males were all the imagoes seen at large, yet exuviae in countless numbers lined the banks of all streams. The perching habits of these two males were about as described further on for *G. pallidus*. The imago has been taken as far west as Michigan and Ohio. It flies in early summer, the recorded period being May 30 to June 26.

Kellicott says of *villosipes*, *exilis*, and *furcifer* that they "frequent quiet waters of smaller ponds, or even ditches where there are floating algæ or lily-pads on which to rest. The males explore the borders and watch from the muddy shore or floating plants; the females at intervals drop down from their coverts to oviposit among the plants, dipping into the water in a manner similar to that of *Libellula*."

The nymph measures 37 mm.; abdomen, 24 mm.; hind femur, 6 mm.; width of head, 5.5 mm., of abdomen 8 mm.

Form identical with that of *G. pallidus*. Lateral margins of apical segments of abdomen marked rather showily with yellowish, especially beneath. Labium as in *G. pallidus*, but with the fringe of hairs bordering the median lobe shorter, the lateral lobe arcuately incurved at the apex, its extreme point shorter than the first of the six stout posteriorly-directed teeth upon the inner margin. Lateral spines well developed only on the 9th segment. Dorsal hooks almost entirely wanting, even on the 9th segment. Appendages shorter than the 10th segment, the laterals a little shorter than the others.

13. *Gomphus pallidus* Ramb.

Mr. Needham studied this species at Purington Lake, near Galesburg, where it was found in company with *G. grasinellus*.

In his notes he says it corresponds with the latter species in habitat, season of flight, habits of oviposition, and nymphal habits, but is, he observes, a rather more vigorous and active species. Male imagos have a habit of resting flat upon the bare earth of a path or sloping bank at the water's edge and making short sallies forth across the water, whether for prey or for sport or for outlook he was unable to determine. The nymph may be known by its peculiar form and the obtuse ridge along the middle of the abdomen above. Its preference for still water is plainly indicated in the Biological Station field, as it was found only in bare mud and sand on the bottom of Clear Lake and Matanzas Lake. In the latter it was quite common in the level lake-bottom, under about six feet of water. In the Laboratory collections are also specimens from Mississippi River lakes and sloughs near Quincy, and some from the Saline River near Shawneetown. It did not occur in our collections from the Sangamon River. Hagen reports nymphs from Michigan, Massachusetts, South Carolina, and Texas.

Dr. Forbes took an imago, just emerged, at Peoria in June, 1878. At Matanzas Lake, near the Biological Station, fresh exuviae were noted July 6 on a log near the water, and imagos were taken near by. A single example was taken May 27 at Urbana. The season of flight at Purington Lake was considerably later than that of *graslinellus*, according to Mr. Needham. The first adult was seen May 28; the maximum abundance was attained July 4 and early in August the last ones disappeared—a period of about two months, which is about twice as long as that of the commoner species *graslinellus*. Although the latter imago is fairly common, that of *pallidus* is singularly rare in collections—almost unknown, in fact. It is recorded only from Indiana, Georgia, and Louisiana. The *Odonata* offer several remarkable instances of this kind, which should put us on our guard against wrong judgments of distribution and relative abundance based on the finding of imagos alone.

In view of existing descriptions and figures, (Cabot, '72, p. 2, No. 2, Pl. I., Fig. 3; Hagen, '85, p. 266) it will be necessary here to give only those nymphal characters which are distinctive.

The nymph measures in length 38 mm.; abdomen, 26 mm.; hind femur, 7 mm.; width of abdomen 8 mm., of head 6 mm.

Body flat, elongate, gracefully tapering posteriorly; surface but little hairy.

Labium with median lobe of mentum rather prominent, a median apical tooth on its front margin, in the middle of the usual comb of flat spinous scales; lateral lobe with a blunt-pointed and incurved apical hook, and on the inner margin seven or eight long irregular teeth, widening apically, and obliquely truncate so as to appear to be directed backward.

Abdomen lanceolate, attenuate to apex, slowly tapering for half its length, to the cylindrical 10th segment; a dorsal hook on segment 9, represented on other segments by obtuse ridge-like elevations; lateral spines on segments 7 to 9, on 7 minute, on 8 short, on 9 long, closely appressed, nearly equaling the length of segment 10; superior and inferior appendages subequal, shorter than segment 10, laterals a little shorter than the others.

Half-grown nymphs show clearly all these characters.

14. *Gomphus exilis* Selys.

In the Atlantic coast states from Maine to Maryland this species is often abundant. In Illinois the imago has been taken at Crystal Lake, about 40 miles northwest of Chicago, by Mr. Longley, and at Kensington by Mr. McDade. Williamson records a few examples from Indiana, and according to Kellcott it is common throughout Ohio, especially about canals and ponds. Hagen has described the nymph ('85, p. 263), and doubtfully referred to the same species some examples sent him from Kentucky. Dr. Calvert records it as the first gomphid to appear in spring (May 24), its season of flight lasting until the early part of July. The extreme recorded dates are May 9 (Kellcott) and July 8 (Williamson).

The following brief statement of the characteristic features of the nymph is selected from Dr. Hagen's description.

Length, 19 to 24 mm. Body rather slender; median labial lobe very faintly rounded, lateral lobes ending in a strongly bent and pointed hook, with four strong teeth inside; abdomen tapering slowly after segment 6, segments as far as 8 of equal length, 9 a little longer than 8, 10 half as long as 9, cylindrical; lateral spines on 6 to 9, the last one third as long as 10; dorsal hooks very small, pointed on 6 to 9; appendages as long as last segment; third joint of hind tarsi scarcely longer than second.

15. *Gomphus cornutus* Tough.

G. cornutus Tough, ('00).

This recently published species, readily recognized by the unusual form of the male abdominal appendages, was described from two males from DuPage county, taken May 30 and June 14. The Bolter Collection contains additional male and female examples, but without data.

16. *Gomphus* sp. (*b*).

Gomphus sp., Hagen, '85, p. 262, No. 14 (nymph).

This interesting species, described by Hagen from three nymphs collected by Prof. Forbes at Cairo, Ill., July 26, is quite distinct from any other known to us. The following are the principal distinctions:

Length, 18 to 23 mm. Body flat; lateral labial lobes with only two incisions near the strong and sharp apical hook, median lobe slightly rounded; side margins of abdomen very hairy, segment 9 as long as 8, 10 very short; lateral spines on 6 to 9, the last less sharp, as long as 10; no trace of dorsal hooks; appendages as long as 9, broad; anterior tibial hooks short.

17. *Gomphus* sp. (*c*).

Gomphus sp., Hagen, '85, p. 263, No. 15 (nymph).

A single nymph received from Newport, Ky., by Dr. Hagen is similar to the preceding, but was believed by him to be a distinct species, perhaps *G. minutus*.

Length 23 mm. Body flat; lateral labial lobes with a sharp bent apical hook, and but three strong teeth near tip; abdomen tapering slowly from 7th segment, 9 one third longer than 8, 10 very short, one sixth of 9; lateral spines on 6 to 9, sharp, the last pair twice the length of 10; no dorsal hooks, except that 9 bears a broad, triangular, flat, median apical projection as long as 10; appendages twice as long as 10.

18. *Gomphus amnicola* Walsh.

? *G. olivaceus* (suppos.), Hagen, '85, p. 271, No. 27 (nymph).

This and the remaining species here treated belong to the subgenus *Stylurus*. Williamson has made a thorough study of this troublesome group of species. A copy of his revision of the subgenus (Williamson '01b) has been received from him just as these pages are being set up by the printer, enabling us to incorporate his data concerning the geographical and seasonal distribution of the species, derived from a large number of specimens examined by him.

A single nymph in the State Laboratory collection, taken at Colona, Henry Co., Ill., August 20, is almost identical with that described by Hagen from Utah and connected by supposition with *G. olivaceus*. It stands in about the same relation to *Gomphus notatus* that the imago *amnicola* does, and may be assigned to this species.

Mr. Needham is of the opinion that the affinities of both the present species and *G. scudderi* are with the *dilatatus*, rather than the *plagiatus* (*Stylurus* Needh.), group of species, in which case the nymph here assigned to *amnicola* may be wrongly placed. It is earnestly to be hoped that the nymphs of these species may soon be discovered, as this would doubtless throw much needed light on their specific relationships.

The imago of this species has been taken in Illinois only along the Mississippi in the northwestern part of the state, and by Mr. Longley at Riverside, near Chicago. It was found at Rock Island and described as new by Walsh. Our specimens were captured at Savanna, August 1, by Mr. F. M. McElfresh.

Single examples are also listed from Galena, Ill., and from Iowa (July), Kansas, and New York. It was taken by Mr. Longley in June.

The principal characteristics of the nymph are as follows:

Nymph (supposition) very similar to *G. notatus*; median labial lobe rounded but short, lateral lobes similar to those of *notatus*; abdomen broader, more lance-shaped; 9 a little longer than 8, with a very short apical spine above; lateral spines on 6 to 9, the last one blunt, half as long as 10, which is short, cylindrical; appendages and legs similar to those of *notatus*.

19. *Gomphus plagiatus* Selys.

G. fluvialis, Walsh (female).

G. notatus, Hagen, '85, p. 270, No. 25 (nymph).

G. plagiatus, Hagen, '85, p. 269, No. 24 (nymph).

This is probably the most abundant gomphid nymph in the larger rivers of Illinois. It may be distinguished from any others herein described by the penultimate (ninth) abdominal segment, with its lateral and basal margins about equal and a rudimentary posterior tooth on the median dorsal line, the other segments being without trace of dorsal hooks or elevations. As already stated under *externus*, it is found about Havana in muddy bottoms where there is current, but not so exclusively in these situations as *externus*. Mr. Garman reported it as the commonest species in waters associated with the Mississippi at Quincy, and states that it does not breed exclusively in running water, presumably basing this statement on the fact that he found it in slough-lakes. These lakes form channels of flow during higher stages of the river, but are more or less completely isolated during low water. Unlike similar waters about Havana, these lakes are but scantily supplied with aquatic vegetation. In our general collection are nymphs from Cairo, Ill., where they are probably common, judging from the number taken; from the Rock River at Colona and Milan; from the Ohio at Golconda; and from the Illinois at Pekin. The species did not appear in extensive collections from the Sangamon in Champaign county. The nymphs were not more

common than *spiniceps* or *externus* at the mouth of Quiver Creek, but in the main channel of the Illinois below Spoon River they were the most abundant form. Nymphs have also been taken in Quiver and Matanzas lakes, in the Illinois River at Meredosia, and in Spoon River near Bernadotte, Ill. Examples of this species and *externus* taken in June and placed in breeding-cages immersed in the water along the Quiver Lake shore, remained alive without transformation until the season's work closed at the end of September. This species is very close to *G. notatus*, which is comparatively rare in Illinois, and the nymph of which has not been satisfactorily distinguished from that of *plagiatus*.

The first transforming imago was noted May 21. On July 2, 1894, large quantities of nymphs transformed in the early morning upon the piers of the river bridges. Upon arriving in Havana in the latter part of June, 1897, Mr. Hart found the imagos emerging numerous up to about the end of the month. In 1898 the largest number emerged June 21, and thereafter occasionally up to June 30. Mr. Needham's notes, made while at Havana in July, 1896, are as follows:

"Transformation takes place mostly at night, but not uncommonly late in the afternoon. The nymph crawls a little way (3 to 20 inches) out of the water upon any flat surface. I have found exuviae sticking to bridge piers and to the sides of barges and fishing boats, to willow stumps, and to bare mud banks. I obtained hundreds of nymphs and exuviae, and yet during a month spent upon the river collecting I did not see a single imago of this species on the wing. I captured one newly emerged, at dusk, resting in the grass at the bank; no others were obtained except by rearing them. Consequently, no opportunity was found for studying breeding habits and oviposition."

Kellicott also notes the emergence on piling and walls in deep water, and found the imago "resting on coarse grasses during July. None were seen ovipositing, or flying except to escape from danger."

The imagos are reported from Illinois, Texas, Michigan, Ohio, Tennessee, and the Atlantic coast states from New Jersey to Florida, the dates of collection ranging from May 25 to September 30. The period of flight usually ends about August 1, but a single example was taken as late as August 25 at Havana. In Illinois adults have also been listed from Bloomington, Moline, and from Winchester, in Scott county.

The nymph measures in length 35-36 mm.; abdomen, 25 mm.; hind femur, 4.5 mm.; width of abdomen 6-7 mm., of head 5 mm.

Body narrow and elongate, a little hairy on lateral margins and appendages. Head cordate, arcuately notched behind, with broadly rounded but prominent hind angles. External tibial hooks minute.

Labium elongate, mentum one half longer than broad, widened apically; median lobe slightly rounded in front, its comb of scales short and sparse; lateral lobes arcuate and terminating in a sharply incurved hook. Teeth on inner margin varying from none at all to four or five, increasing in size and distinctness proximally. Movable hook long, strong, and regularly incurved.

Abdomen widest on 6, median dorsal smooth line on segments 2 to 7 or 2 to 8; a flattened rudiment of a dorsal hook on 9; segments 3 to 8 of about equal length, 9 one third longer, 10 very short; lateral spines on 6 to 9 appressed, those on 9 half as long as the inferior appendages; appendages about equal and exceeding the length of 10.

20. *Gomphus notatus* Selys.

G. fluvialis Walsh (in part).

The true *notatus* is represented in our Illinois collections by only a single female, taken on the bank of the Mississippi near Savanna August 1. In its wing venation and external sexual structures it seems quite distinct from *plagiatus*. The nymphs described by Hagen as *notatus* and *plagiatus* are probably all *plagiatus*. His description of *notatus* agrees exactly with un-

questionable nymphs of *plagiatus*. Walsh apparently included both species in his *fluvialis*, described from specimens collected about Rock Island, but his statements of the habits of *fluvialis*, which are quite unlike those we have recorded for *plagiatus*, very likely apply to *notatus*, and may account for its apparent rarity. He says that while *fraternus* and *vastus* haunt the land and are easy to capture, *fluvialis* "makes long excursions to and fro on the surface of the river, scarcely ever approaching the land except for a second."

Williamson ('01b) lists the species from Illinois, Michigan, Ohio, Tennessee, and Quebec, Canada; June 1 and 21 in Ohio and Michigan, and September 30 in Tennessee.

21. *Gomphus spiniceps* Walsh.

Macrogomphus? spiniceps Walsh, '62, p. 389 (female).

Gomphus spiniceps, Kellicott, '95, p. 209 (male).

Gomphus segregans, Needham, '97, p. 185 (male).

This seems to prefer somewhat rapid currents. Excepting a single example from the Illinois River, the nymphs appear in the Laboratory and Biological Station collections only from Quiver Creek and Quiver Lake near the mouth of the creek.* This creek is a peculiar and beautiful stream, shallow and sandy, fed by springs of soft water flowing out of the sand beds, and hence quite uniform and constant in its flow. At the mouth of this stream *spiniceps* is associated with *externus* and *plagiatus*. The nymph agrees with that of *plagiatus* in having no dorsal elevation or hooks except a single rudimentary posterior tooth on the penultimate segment, but differs from it conspicuously in the form of that segment, which is long and narrow, the lateral margin fully twice the basal width. In this character it resembles *Gomphus pallidus*, but has not the elevated dorsal ridge nor the long tenth segment of that species. As in the case of *plagiatus* and *externus*, nymphs placed in breed-

*Numerous exuviae and emerging individuals have since been taken on the rocky walls of the shallow gorge of the Illinois River at Ottawa, July 21 and August 19, the larger number of imagoes being secured on the latter date.

ing-cages in June failed to transform, one being still alive on September 28. In 1897 two full-grown nymphs were taken June 22 along shore in the quiet weedy waters of Quiver Lake, not far from the mouth of Quiver Creek. The only imago seen, emerged June 23 from a nymph which we found that day crawling up some blades of bur-reed (*Sparganium eurycarpum*) beside the stream. A number of exuviae have been observed at various times during June and July on *Sagittaria* stems, brushwood, and the bases of tree trunks along the margin of the creek, from near its mouth to McHarry's Mill, a few miles above.

Cabot ('72, p. 5, Pl. II., Fig. 1) described the nymph from examples taken in Massachusetts July 4, one of them partly transformed, and Hagen ('85, No. 26, p. 270) redescribed it.

Kellicott ('95, p. 209) observed the imagos in Ohio September 4 flying about and ovipositing "in a manner similar to that of the *Libellulus*" in a small brook that was rippling over pebbles, and he later ('96, p. 111) gives the time of flight as August and September. Williamson found the adults transforming abundantly in western Pennsylvania July 4, and also records the species from Tennessee (August) and New York (September). The imago was originally described from Rock Island. Other Illinois localities for the imago are Bloomington and the Mackinaw River at the "Dells."

The nymph measures in length 40 mm.; abdomen, 29 mm.; hind femur, 5 mm.; width of abdomen 7 mm., of head 5 mm.

Body very elongate and posteriorly attenuate, sparsely hairy on lateral margins and on appendages. Tibial hooks minute.

Labium elongate; mentum widened toward the apex; median lobe with a very straight front border; lateral lobes arcuate, with a long-pointed sharply incurved end hook, and on the inner side one to three teeth, though sometimes only the middle one is distinct. These teeth are widened distally, and obliquely truncate so that they appear directed backward. Movable hook long, strong, and more strongly curved toward the tip.

Abdomen very elongate, acuminate toward the end, scarcely depressed; segments slightly increasing in length posteriorly to the 8th; 9 about twice as long as 8, its sides nearly parallel on apical half; 10 very short; smooth mid-dorsal line on 2 to 7, a flattened rudiment of a dorsal hook on apex of 9; short lateral spines on 6 to 9, those of 9 about half as long as the superior appendage; appendages subequal.

Young nymphs in the station collection, dredged from the bed of the creek, some not more than one third grown, show these same characters very clearly marked.

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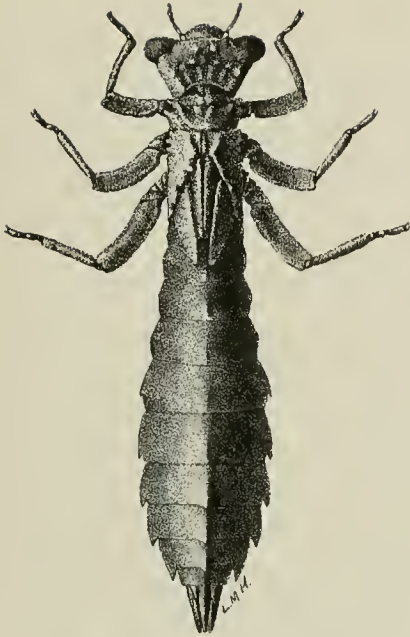
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PLATE I.



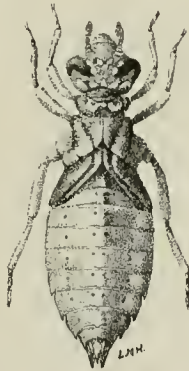
1. *Nasieschna pentacantha*.



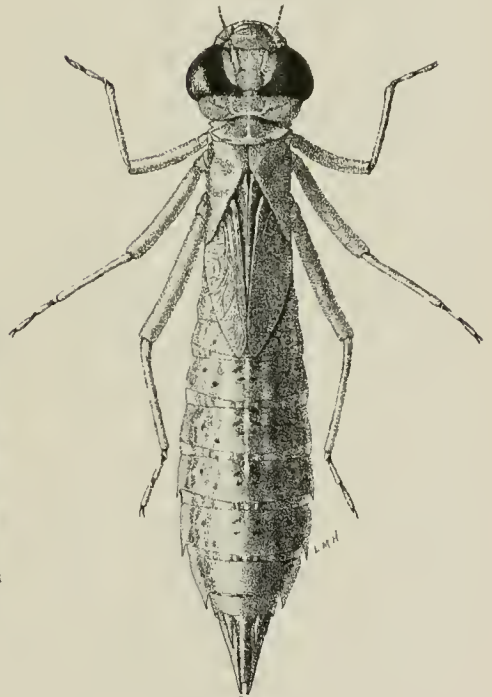
2. *Boyeria vinosa*.



3. *Progomphus obscurus*.



4. *Diastatomma carolus*.



5. *Anax junius*.

NYMPHS.