V SERIES NO. 132 JUNE 1, 1927

UNIVERSITY OF IOWA STUDIES

STUDIES IN NATURAL HISTORY

VOLUME XII NUMBER 2

REPORT ON ODONATA, INCLUDING NOTES ON SOME INTERNAL ORGANS OF THE LARVAE

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

by

PHILIP P. CALVERT

PUBLISHED BY THE UNIVERSITY, IOWA CITY, IOWA

Issued semi-monthly throughout the year. Entered at the post office at Iowa City as second class matter under the Act of October 3, 1917.

Obtainable from the Department of Publications: Price, $.75

UNIVERSITY OF IOWA STUDIES
IN NATURAL HISTORY

HENRY FREDERICK WICKHAM, Editor

VOLUME XII NUMBER 2

REPORT ON ODONATA, INCLUDING NOTES ON SOME INTERNAL ORGANS OF THE LARVAE

Collected by the Barbados-Antigua Expedition from the University of Iowa in 1918

by

PHILIP P. CALVERT
Professor of Zoology, University of Pennsylvania, Philadelphia

PUBLISHED BY THE UNIVERSITY, IOWA CITY

In his same narrative Prof. Stoner says: June 19-July 19, 1918, at Antigua. Area 108 square miles, greatest elevation about 1500 feet. Average annual rainfall a little less than 50 inches. South and southwest parts, near English Harbor, covered in many places with dense forests; insect fauna more abundant and varied than in Barbados. "There are few fresh water streams and ponds on Antigua. However, one of these ponds, situated about three-quarters of a mile from the Dockyards at English Harbor was made the object of a rather intensive study . . . represented in the pond were dragonfly and damselfly larvæ and adults, ..." (p. 218). Two views of the island near English Harbor have been published on Plate III of Prof. Stoner's report on the Scutelleroidea of this expedition (These *Studies*, Vol. X, No. 1).

The chief interest of the present report centers about the larvæ. Hitherto unused characters for separating the larvæ of the four Libelluline genera have been found in the teeth of the mandibles and in the arrangement of divided setæ on the legs. The larva of *Erythrodiplax umbrata* is here described for the first time, while a number of diagnostic features in this and other genera are discussed and figured more fully than ever before.

No papers dealing with the Odonate fauna of these two islands are known to me, although a few species have been quoted from Barbados in general works. A list of species from St. Vincent and Grenada was published by the late W. F. Kirby in 1894 (Ann. Mag. Nat. Hist. -6- XIV, 261-269). Data on Odonata from Trinidad have been furnished by J. H. Hart (Ann. Rep. Roy. Bot. Gard. Trinidad, June, 1891, p. 9, 1892), and E. B. Williamson (Proc. U. S. Nat. Mus. 48: 601-638, 1915; Trans. Amer. Ent. Soc. 43: 211-246, 1917; Ent. News 28: 250, 1917; ibid. 34: 263-265, 1923; Occ. Papers Mus. Zool. Univ. Mich. no. 130, 1923) and are to be found in some general works, to one of which, by Dr. Ris, Mr. Williamson refers in his first quoted paper of 1923. One species from the island of Bonaire and two from Curaçao are mentioned by F. Werner (Zeitschr. Wiss. Zool. Bd. 125, p. 554. 1925). The relations of the West Indian Odonate fauna to that of Mexico and Central America have been discussed by the present writer (Proc. Acad. Nat. Sci. Phila., 1908, pp. 466-467, with references to previous literature in footnote 9, p. 466).

The species listed above from Barbados and Antigua are treated in taxonomic sequence in the following pages.

Lestes forficula Rambur 1842
(Plate I, fig. 9)

Two males, pinned, Antigua, July 15, 1918, Stoner.

These two specimens are of different ages and of slightly different sizes: the older (*a*) abdomen 31.5 mm., hind wing 19; the younger (*b*) 30 and 19 mm. respectively. They show, among others, the following differences:

Prothorax (*a*) mostly black, some pruinosity on each side, a transverse yellow stripe on each side at hind end of fore and mid lobes respectively; (*b*) pale blue, with pale reddish brown markings as follows: an obscure round spot on each side of fore lobe, a curved longitudinal stripe on each side of dorsum and a straight lateral stripe on mid lobe, and a pair of metallic green points on dorsum of hind lobe.

Mesepisternum (*a*) with metallic blue green stripe .49 mm. wide near upper end, pale brown between it and mid-dorsal carina darkening and blackening caudad; remainder of sclerite pale blue; (*b*) pale reddish, but may have been pale blue in life, metallic green stripe at most (near upper end) .41 mm. wide.

Mesepimeron (*a*) dark blue-black except at its anterior end where it is in part pale and above that reddish-brown and with a metallic green stripe, .16 mm. wide, subparallel to, but a little removed from, the humeral suture; (*b*) pale reddish, perhaps pale blue in life, metallic green stripe .25 mm. wide near each end, a little narrower between.

Metepisternum (*a*) reddish brown in middle, all margins almost black, shining; (*b*) obscure bluish.

Metepimeron (*a*) mostly shining blue-black, a subcircular blacker spot, .25 mm. in diameter, just dorsal to the anterior end of the latero-ventral carina; (*b*) obscure bluish with the same subcircular spot.

Inferior abdominal appendages, in profile or ventral view, (*a*) 1.06 mm. long, reaching to three-fourths' length of the superiors; (*b*) 1.15 mm. long, reaching not quite to the level of the tips of the superiors.

These two males from Antigua have been compared with the following males:

Three from Paso Real, Cuba, April 24, 1923, taken by Prof. J. S. Hine, thanks to his kindness, and five in the collection of the Academy of Natural Sciences of Philadelphia, viz., one from Ha-

vana, Cuba, by C. F. Baker (no. 3616); one from Posorja, Ecuador; one from Altamira, Tamaulipas, Mexico, June 30, 1903; and two from Texas; the last three are of material quoted in the Biol. Centr-Amer., Neur., pp. 50, 352, including the Texan original of fig. 25, Pl. III, of that work.

The following differences appear from this comparison:

Prothorax. Of the four Cuban examples, one (*c*) from Paso Real and one from Havana are metallic green, some pruinosity on sides, yellow stripes as in Antigua (*a*), but those at the hind end of the mid lobe are continued forward on the dorsal surface as the curved longitudinal stripes of (*b*); the other two (*d, e*) from Paso Real are similar to (*b*) but lack the metallic green points on the hind lobe. The Altamira specimen is like (*b*) but the reddish brown spot and curved longitudinal stripe are margined mesally with black and the two metallic points on the hind lobe are black.

Mesepisternum. Cuban: metallic green stripe .16-.33 mm. (*c, d, e*), .41 mm. (Havana) wide, a reddish brown line or narrow black stripe (Havana) along each side of mid-dorsal carina. Posorja: metallic green stripe .16 mm., most of sclerite faintly pruinose. Altamira: same stripe .33 mm. Texas: pale blue, metallic green stripe .33 mm. at its widest (*i. e.*, at its upper end), one without any stripe or line, the other with a narrow black stripe with some metallic reflection, along each side of the mid-dorsal carina.

Mesepimeron. Metallic green stripe .16-.15 mm. wide (Paso Real), .33 (Havana), .16 (Altamira), .16 (one Texan, the other has this stripe blackish, interrupted, nowhere wider than .08 mm.).

Mesopleuron. Mostly pruinose, the subcircular black spot of the epimeron visible in most.

I do not see that the color differences noted in this comparison have any geographical significance; they appear to be partly ontogenetic, partly due to individual variation.

Inferior abdominal appendages 1.15 mm. long (Paso Real *d, e*, Havana), 1.18 (Texas, one), 1.23 (Paso Real *c*, Posorja, Altamira, Texas one), reaching to the level of the tips of the superiors (Paso Real), falling short of that level by about the width of the terminal part of the superiors in the five others.

The superior abdominal appendages have the denticulated lamina of the inner margin slightly less convex so that the edge of the lamina is parallel to the outer (lateral) margin of the appendage in the two males from Antigua (our present fig. 9, Pl. I), and in the two from Posorja and Altamira, while in the four from Cuba and in the one from Texas represented in fig. 25, Pl. III, B. C.-A., the denticulated lamina is slightly more convex so that the edge of the lamina diverges slightly caudad from the outer margin of the appendage.

After devoting several hours to a comparison of the (dried) penes of the six males from Antigua, Havana, Posorja, Altamira and Texas (one), illuminated by strong sunlight, under the compound microscope (Zeiss oc. 4, obj. A), I have been unable to find any disagreements between them that can not be ascribed to slight differences in position of the organ as a whole or in slight contraction or expansion of its parts.

The pectoral color pattern of *forficula* is very similar to that figured for *L. bipupillatus* Calvert (1909, Pl. I, fig. 15) from Brazil, but the two examples from Antigua have also a small black spot at the middle of the hind margin of the metasternum.

Dr. Ris has recently briefly described some specimens of *forficula* from Martinique, taken in January and February, 1896 (1918, p. 62).

Lestes. Larval Stages

The earlier characterizations of the larvæ of the genus *Lestes* (Hagen 1853, reproduced by Brauer & Löw 1857, Ausserer 1869, Barbiche 1887, Lampert 1899, 1910, Lucas 1900, Tümpel 1901, 1908) were based upon the single European species, *L. nympha* Selys (=*dryas* Kirby). Roster (1888) gave descriptions of larvæ of three additional Italian species, but did not draw up a generic diagnosis. Nunney (1894) characterized the larvæ generically, but insufficiently. Needham (1903) gave an excellent generic statement for the larvæ of *Lestes* based on a study of five species from the United States and this has been reproduced at length, or in part, with some modifications, by Rousseau alone (1909) and in conjunction with Lestage and Schouteden (1921), and by Ris (1909), Garman (1917), Needham (1918) and Howe (1921). E. M. Walker (1914) and Garman (1917), and Ris (1920), have given detailed synopses of five North American and six European species, respectively.

Lestes forficula? Rambur. Larva

(Plate I, figs. 1-4, 11-14)

Seven larvæ (5 ♂ ♂, 2 ♀ ♀) in alcohol, from freshwater pond, English Harbor, Antigua, June 28, 1918, show the following features:

Length of body, excluding caudal gills, 18-14 mm. ♂, 17-12.8 ♀. Length of median caudal gill 8.36-5.77 ♂, 8.36-6.07 ♀. Length of lateral caudal gill 8.95-6.81 ♂, 8.80-6.59 ♀. Length of hind femur 4.87-4.0 ♂, 4.88-4.14 ♀; of outer wing-pad 4.66-1.48 ♂, 5.03-1.11 ♀. It is possible that the smallest specimens of each sex are of a different instar from the largest but I have found no characters correlated with the differences in size.

Submentum, when closely applied to the ventral surface of the thorax, reaching to the hind margin of the third coxæ, or beyond that margin, in both sexes. Mentum 3.63-2.66 ♂, 3.55-2.74 ♀, rather abruptly and triangularly dilated at apex (Pl. I, figs. 1-4), its narrowest part (.12-.14 mm. ♂, .10-.14 mm. ♀) from one-eighth to one-tenth as wide as the width at apex (1.41-1.04 mm. ♂, 1.33-1.11 mm. ♀[1]). Mental setæ five (four on one side only of one female), with longer intervals between their bases, as in Ris's Group II (1920). Outer hook of the outer part of the distal portion of the lateral lobe (Needham's 1903 terminology, pp. 231-232) [=palp] longer than the inner hook, both hooks long, slender and tapering. Lateral labial setæ three, two of them on the movable hook (*mh*).

A posterior lateral spine present on each of abdominal segments V-IX, except that it is absent from V in the smaller female and from the left side of one male. The lengths of these spines, in millimeters, in the largest male are: on segment 5 .05, on 6 .08, on 7 .11, on 8 .12, on 9 .09; and in the smaller female: on 5 .01, on 6 .055, on 7 .06, on 8 .07, on 9 .08.

Shape of the lateral gills (Pl. I, figs. 11-14) nearest Ris's (1920) fig. 7*e*, but different therefrom; length from five and one-half to six and one-half times the maximum width.

Ovipositor, in the largest female, 1.55 mm. long, reaching caudad beyond the midventral hind margin of segment X but not as far caudad as the greatest lateral extension of that margin or to the level of the hind margin of segment XI; in the smaller female .96 mm. long, not reaching caudad as far as the midventral hind margin of X.

[1] These are measurements of the apex when the labium is lying in water; if the mentum be flattened out, as under a cover glass, the width at apex is increased by four-tenths of the dimensions given above.—Since the completion of this report and the return of the collection to Iowa, a paper by Herr Fritz Prenn, "Aus der Nordtiroler Libellenfauna, 1. Zur Biologie von *Lestes viridis* (Vanderl.)" (Verh. Zool.-Bot. Gesell. Wien, 76 Bd., pp. 26-33, 11 figs., 1926) has become known to me, containing a brief account of the development of this species through nine larval instars to the imago.

Coloration. The only markings visible on these (alcoholic) specimens are: a black line or stripe on the hind margin of the median ocellus and on the mesal margin of each lateral ocellus. Margins of the mesostigmata brown, the anterior margin darker and more strongly marked than the posterior. A faint brown cloud at the dorsal and at the ventral margin of the median caudal gill at one-fourth of its length; four specimens (both sexes) have a brown cloud also at about six-tenths of its length on both margins. A faint brown cloud on the dorsal and on the ventral margin of each lateral caudal gill at three-tenths and at six-tenths of its length, the apical fourth for almost the entire width likewise pale brown. Central axis of all the gills and some straight transverse branch tracheæ therefrom brownish. One male has the central axis of the lateral gills bordered broadly on each side with purplish (interrupted transversely by pale lines) for almost the entire length. Femora with or without a pale brown anteapical ring; tibiæ with or without the distal end pale brown; third tarsal joint with or without its distal half pale brown dorsally; the specimens without the brown coloring in these parts are, in each case the same, one male and the larger female, the male being the one refered to above as having the purplish border to the central axis of the lateral gills.

A comparison with Dr. Walker's key (1914) will show that these larvæ are nearest to *uncatus* of the North American species, but differ in the shorter mentum and much shorter ovipositor. In Dr. Garman's key (1917) they fall between *unguiculatus* and *uncatus*. As compared with Dr. Ris' "Tabelle" (1920), these larvæ approach most closely to *sponsa* of the known European species, but differ in their paler coloring, shape of caudal gills and in having five (not six) mental setæ.

The only species of *Lestes* known from Antiguan imagos is that above indicated as *L. forficula* Rambur. *L. tenuatus* Rambur has been recorded from Martinique and St. Lucia. I have reared a male *tenatus* in Costa Rica; its exuvia differs from these Antiguan larvæ in that the submentum reaches only to the front mar-

gin of the third coxæ, in having no black markings on the ocelli or mesostigmal margins and in the one (lateral) gill which remains apparently normal being less slender, *i. e.*, four times as long as its maximum width.

Ischnura ramburi var. *credula* Hagen

Barbados, May, D. and L. Stoner, 4 ♂ ♂, 2 orange ♀ ♀ (dried, pinned imagos), 1 orange ♀ (in alcohol). Antigua, July, Stoner, 1 dried, pinned ♂.

These specimens agree with the distinctions recently given and figured by Dr. Ris (1918 fig. 73 ♂). Their dimensions are: Abdomen ♂ 21-24 mm., ♀ 23-24; hind wing ♂ 13.5-14, ♀ 15.5. I have found no differences in the (dried) penes of the males from Barbados and Antigua.

Of the West Indies, this variety has been recorded previously from Cuba, Hayti, Jamaica, St. Thomas, Martinique and Barbados (Calvert, Biol. Centr.-Amer., Neuropt., pp. 125-6, 1902).

Ischnura. Larval Stages

The first step in identifying larvæ of *Ischnura* was taken by Roster (1886) when he gave descriptions of Italian examples of *I. elegans* and *pumilio*, but he remarked: "Per non cadere nell'errore del Dufour, mi reserbo di dare la frase generica delle larve delle Agrioninæ." Nunney (1894), Lucas (1900), Rousseau (1909), and Ris (1909) likewise gave no generic characterization; even in 1921, Rousseau, Lestage and Schouteden considered it "prématuré de donner une diagnose générique pour les larves du genre Agrion" (under which they included *Ischnura* as a subgenus).

Needham (1903) basing his generic characters on three species from the United States, gave for *Ischnura* (p. 237, repeated in 1918, pp. 928-9):

Labium with its median lobe entire, four mental setæ, lateral lobes [=palps] bifid at end, distinctly denticulate, their movable hook naked and five or six lateral setæ each side; gills thin, narrow, more than half as long as the abdomen, lanceolate, generally with no distinct color pattern; hind angles of the head rounded, antennæ 7-jointed, third segment less than a third longer than the second.

Garman (1917) modified this by stating that the gills are not more than one-third as broad as long, usually with cuticular pigment in the form of arcuate cross-bands and with tracheal branches

equally distributed throughout the length of the gill; margins of the head not contracted between the eyes and the hind angles; mental setæ four or five; lateral keels of the abdominal segments with several rows of small setæ (pp. 499-500, 567). Howe (1921) has figured the features employed by Garman.

Characters drawn from the relative length of the caudal gills have the practical disadvantage of being frequently useless or misleading, due to removal of the gills by enemies, or to the gills being but partially regenerated after injury. Moreover, Garman finds that in *I. verticalis* of the United States, the arcuate pigment bands of the gills may be one, two, or absent. [2]

Dr. Garman (1917, pp. 500, 575) uses as a differential of larvæ of *Anomalagrion* from those of *Ischnura* that the former lack setæ on the lateral keels of the abdominal segments. After an interchange of notes and specimens, however, he and I are agreed that setæ similar to those of *Ischnura* are present on *Anomalagrion* and that their presence or absence does not furnish a generic distinction. (Pl. I, fig. 8).

It can be merely a conjecture that the following specimens are to be referred to *Ischnura ramburi* var. *credula*, although the presence of the imago on the same island lends some support to this supposition.

Ischnura ramburi var. *credula?* Hagen. Larvæ
(Plate I, figs. 5-8, 10)

Barbados, May 21, Stoner, 3 dried, pinned larvæ (2 ♂ ♂, 1 ♀).

In comparison with Dr. Garman's description of *I. verticalis* (1917) these have the setæ on the lateral angles of the head very short (.09 mm. and shorter); lateral marginal setæ of the median lobe four or five; wing-cases reaching to abdominal segment V (in one larva only); dorsal surface of abdomen as thickly studded with short setæ as is the ventral (I find this the case also in some *verticalis* exuviæ); no arcuate bands of pigment across the gills (Pl. I, fig. 10), some brown along the central axis of the gills, extending in some places half-way from the axis to the dorsal or the ventral margin, but the brown itself ill-defined; axis of the gills in the two males alternately brown and white; apex of the gill here

[2] Compare also Walker, Can. Ent., xlvi, pp. 354, 355, 1914, on *I. verticalis* and *I. cervula*. Dr. Garman's latest statements of the larval characters of *Ischnura* are given in "The Odonata or Dragonflies of Connecticut" (State of Conn. Geol. & Nat. Hist. Survey, Bull. No. 39, 1927, pp. 36-37, 40-44) which has appeared since the completion of the present report.

figured similar to those of *verticalis* shown in Garman's figs. 62, 65; in the other male and in the female less acute, less tapering, perhaps due to drying; ovipositor reaching to the hind end of segment X.

Other data from these dried larvæ are: Total length (including gills) 15.5-16 mm. ♂, 17 ♀; abdomen (excl. gills) 6.7-8.2 ♂, 9.2 ♀; median gill, length 4.5-5.2 ♂, 4.09 + ♀ (wrinkled), maximum width 1.1-1.4 ♂, 1.3 ♀, same of lateral gill 1.1 ♂, ♀; lengths of antennal segments of ♀ (the two males differ very slightly) segment 1 .23, 2 .37, 3 .47, 4 .39, 5 .23, 6 .14, 7 .10 mm.; mental setæ four (both ♂ ♂), five (♀); lateral labial setæ six (♂), (broken in ♀); teeth on "truncated process" (Garman) of proximal segment, labial palp (Pl. I, fig. 7) four (3 in one palp) ♂ ♂, (broken ♀), the distalmost bifid or trifid at tip; setæ present on the lateral keels of abdominal segments 2-8.

Anax. Larval Stages

Hagen (1853) knew the larvæ of but one species of *Anax*, the European *formosus* [=*imperator*], and his description was followed, in abbreviated form or otherwise, by Brauer and Loew 1857, Ausserer 1869, Barbiche 1887, Nunney 1894, Lampert 1899, 1910, Lucas 1900, Tümpel 1901, 1908, and Rousseau 1909. Cabot 1881, on the basis of two reared species and five others of probable identity, was able, in consequence, to give a more comprehensive generic characterization. It is not necessary to reprint it here. Ris (1909) gives the characters for the genus and for each of the two European species, which are repeated by Rousseau, Lestage and Schouteden 1921. Tillyard (1916, p. 66) in giving the characters of the larvæ of the "Anax series" (*Anax* and *Hemianax*) mentioned only these: Bifid superior appendage, very large head and eyes, no setæ on lateral lobes of labium, papillæ developed on rectal gills. Miss Butler (1904, p. 116, pl. iv, figs. 3, 4) pointed out the existence of rudimentary setæ on the lateral labial lobes (=labial palps) of early instars of *A. junius*, and I have found setæ on the same part, including the distal joint ("movable hook") in *junius* and *A. amazili* larvæ of about 7 mm. total length.

Anax junius (Drury). Larva
(Plate II, figs. 15, 17, 18)

One male larva, in alcohol, Antigua, B. W. I., June 28, 1918, Dayton Stoner and R. O. T.

Total length 16 mm., but evidently much contracted. Mesal projection of posterior part of eyes less acute and less pronounced than in later instars; hind margin of vertex 1.64 mm., maximum width of vertex 2.13 mm. Antennæ 7-jointed, lengths of joints in mm. as follows: 1 .14, 2 .19, 3 .23, 4 .14, 5 .20, 6 .23, 7 .23. Right mandible with five distal and four (2+2) proximal teeth, left mandible with four distal and two (1+1) proximal teeth. Each maxilla, excluding palp, with seven spines. No differences in the mandibles and maxillæ in these respects occur in the larvæ of *junius* and *amazili* from at least this stage to the last larval instar. Mask (labium) reaching to a little caudad of front edge of third coxæ; width of mentum (Pl. II, figs. 17, 15) at base 1.23 mm., length 3.76 mm., ratio .33; median lobe of distal mental margin .85 mm., articular lobe of same .65 mm., ratio 1.31; denticles on mesal margin of proximal joint of labial palp 15 (right), 18 (left) (Pl. II, fig. 15), on distal margin of same 10 (right), 8? (left), distal joint (movable hook) with 20 short setæ on its dorsal surface.

Mesostigma represented by an apparently single dark line. Legs, when flexed on themselves: tibia I longer than femur I, tibia II equal to femur II, tibia III shorter than femur III. Hind wing-pad, costal margin 1.06 mm. long, reaching to mid-length of first abdominal segment.

Transverse anteapical carina on dorsum of abdominal segments I-X, denticles thereof interrupted mid-dorsally on I-VII, the interruption widest on I and decreasing in extent to VI, also interrupted on I-IX behind the "figure 8" mark mentioned below. Rudiments of copulatory organs on sternite of III indistinct. Lateral spine of VII .25 mm., of VIII .48, of IX .48. Gonapophyses on sternite of IX visible. Anal pyramid, ventral view, 2.21 mm. long (otherwise stated, length of inferior appendages or cerci); lateral appendages (cercoids) .57 mm.; male projection of the superior appendage very indistinct.

Coloration of abdomen (Pl. II, fig. 18): no segments distinctly darker than others; dark markings as follows: four paramedian marks consisting of a transverse anterior stripe and behind it a much shorter spot on each side of the median line of the anterior half of the dorsum of II-V, much fainter on II; four paramedian spots, two on each side of the median line, occupying the middle third of the dorsum of VI-VIII, the two spots of the anterior pair more distant from each other than are those of the posterior

pair; two spots on dorsum of III-VIII at about half-way from mid-dorsal line to lateral margin, one spot inner-posterior, the other outer-anterior, the former more elongated antero-posteriorly but less distinct on III and IV than on V-VIII and present also on I and II. Laterad to all of these spots is, on each side of the dorsum of V-VIII, an indistinct paler brown marking resembling a figure 8; on III-IV a broken line represents one side (mesal) of the 8; the 8-shaped mark present in a corresponding position on IX; these figure 8 marks correspond to the attachments of the dorso-ventral segmental muscles (Whedon 1919, p. 407). A pair of paramedian dorsal brown dots on X.

Ganglia, as viewed through the ventral body wall, situated in pro-, meso- and articulation of meso- and metathorax, and in abdominal segments II, III, IV, V, VI, VII, and VIII.

There are but few records of the Nearctic *Anax junius* from the West Indies—only Cuba and Martinique being cited in the *Biologia Centrali-Americana* (1905). Antigua, it may be noted, is 240 kilometers (150 miles) north of Martinique. One would rather expect the Neotropical *Anax amazili* in these islands and it has been taken in Cuba and Barbados, while Dr. Ris has recently noted two females from New Orleans, Louisiana (1918, p. 173). We raised *amazili* from the sextult instar to the imago in Costa Rica and possess also larvæ of still smaller size and, doubtless, of earlier instars; it is hoped to publish descriptions of them elsewhere. Curiously enough, no one seems to have published any precise data for distinguishing the different instars of our abundant *junius* from each other, although Needham (1901), Needham and Hart (1901) and Wilson (1920) mention some of the ontogenetic changes.[3]

Comparison of *junius* larvæ of various sizes with our material of *amazili* shows that from the septimult instar[4], or earlier, the apex

[3] Since this Report and the collection on which it is based were sent to the University, I have reared a single male *Anax junius* from eggs laid at Primos, Pennsylvania, July 13, 1926, to the imago stage June 19, 1927, with thirteen larval exuviæ. The larva from Antigua corresponds more closely to the ninth of these exuviæ than to any other, when allowance is made for the fact above noted that it is "evidently much contracted." The ninth larval instar was the quintult of the reared individual and hence the identification reached in the text is confirmed.

Mr. C. F. Byers' paper on *Anax* nymphs (Journ. New York Ent. Soc., XXXV, pp. 65-69, 1927) has appeared since this Report was submitted.

[4] In an abstract of a paper, "The earlier larval instars of the Odonata," published in *The Anatomical Record*, vol. 31, p. 327, Dec. 25, 1925, I have suggested that "For a long time to come we shall probably know the ontogenetic connection of the later rather than of the earlier instars. In such cases terms denoting these stages, counting backward from the last instar, are necessary. For the sake of brevity, the following are proposed, as nouns and adjectives, which may be applied to any group of organisms: ult (for last or ultimate), penult (for penultimate), tertiult (antepenultimate), quartult (preantepenultimate), quintult, sextult, septimult, octavult, nonult, decimult (tenth from the end), and so on. These terms may be abbreviated by writing them 5ult, 6ult, etc." I am glad to acknowledge the kind assistance of Prof. Roland G. Kent, of the department of philology of the University of Pennsylvania, in the exact formation of these terms.

of the proximal joint of the labial palp differs in the two species (Pl. II, figs. 15, 16) up to and including the ult, the difference becoming more marked with increasing age. What are probably the last larval exuviæ of *A. longipes*, the only other known species of *Anax* of Atlantic America, are before me and also differ from *junius* in the same feature. On this basis, therefore, it is possible to definitely identify this Antiguan example as *junius* and by the actual dimensions of various parts of its body enumerated above, as of probably the quintult instar. Other differences between the larvæ of *junius* and *amazili* appear in later instars.

Libellulinæ. Larval Characters Hitherto Unconsidered. Mandibles and Setæ of the Legs

In the four following Libelluline genera discussed in this paper, each mandible is armed on its inner or mesal surface with two groups of teeth, proximal and distal or apical. In *Tramea* both groups, on both right and left mandibles, consist of four teeth (Pl. II, figs. 30, 31). In addition, each mandible has on its posterior margin a denticle and a notch following it, which on the left jaw is farther removed from the apex than it is on the right. If, beginning at the anterior margin of the mandible, we designate the apical teeth as 1-4, the proximal teeth as *a-d* and the denticles on or near the anterior or posterior margins, occupying an intermediate position between the proximal and apical groups, by *x* (anterior) and *y* (posterior), we obtain the following table of the mandibular armature in the four genera (*cf.* Pl. III, figs. 26-35):

	Tramea	*Erythrodiplax*	*Erythemis*	*Orthemis*
Right mandible				
Apical teeth	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3+4	1, 2, 3+4
Intermediate marginal denticles	*y*	*y*	*x, y*	*y*
Proximal teeth	*a, b, c, d*	*a, b, d*	*a, b, d*	*a, b, d*
Left mandible				
Apical teeth	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3, 4
Intermediate marginal denticles	*y*	O	*y*	O
Proximal teeth	*a, b, c, d*	*a, b* (or *a, b′, b*)	*a, b* (or *a, b′, b*)	*a, b*

In this table 3+4 indicates a more or less complete fusion of the 3rd and 4th apical teeth; O indicates absence; in *Erythrodiplax* and *Erythemis*, tooth *b* of the left mandible sometimes divides in two teeth *b'*, *b*, *b'* being the smaller and immediately cephalad of *b*.

The data given in this table may be written as formulæ, thus:

Tramea $\frac{\text{R } 1, 2, 3, 4, y, a, b, c, d}{\text{L } 1, 2, 3, 4, y, a, b, c, d}$ *Erythrodiplax* $\frac{\text{R } 1, 2, 3, 4, , a, b, d}{\text{L } 1, 2, 3, 4, \text{O}, a, b \text{ (or } a, b', b)}$

Erythemis $\frac{\text{R } 1, 2, 3, 4, x, y, a, b, d}{\text{L } 1, 2, 3, 4, y, a, b \text{ (or } a, b', b}$ *Orthemis* $\frac{\text{R } 1, 2, 3\pm4, y, a, b, d}{\text{L } 1, 2, 3, \quad 4, \text{ O}, a, b}$

In all the mandibles of these genera which I have examined, the third apical tooth of the left fits between the third and fourth (or between the second and the fused third-fourth) apical tooth of the right mandible when both are closed.

The right and left mandibles of *Tramea* are more like each other in their tooth armature than is the case in any of the other three genera and possess the largest number of teeth. On the right mandible of all four genera and on the left mandible of *Tramea* and of *Erythemis* a line drawn from tooth *a* to tooth *b* strongly diverges from the apical margin; a line from *a* to *d* is subparallel to that margin on the right mandibles. Another interpretation of the homologies of the proximal teeth of the *left* mandibles of *Erythrodiplax* and of *Orthemis* than that indicated by the lettering of figs. 28 and 32, Pl. III is, therefore, possible, *viz.*: that the tooth there marked *b* is in reality *d*, but I do not see any stronger evidence for this view than for that which the lettering expresses.

It is also of interest that the mandibular armature affords a differential between *Tramea* and *Pantala*. Ten exuviæ of *P. flavescens* and one (reared) of *P. hymenæa* give this formula:

$$\frac{\text{R } 1, 2, 3, 4, x, y, a, b, d}{\text{L } 1, 2, 3, 4, \text{O}, a, b}$$

The tibiæ and tarsi of many Odonate larvæ are armed with setæ of various shapes. In the four Libelluline genera discussed in this paper there are both simple, or undivided setæ and also those which are more or less deeply divided so as to be trifid, quadrifid, or quinquefid (Pl. V, fig. 50)[5]. Divided setæ differing in the

[5] In a description of the larva of *Mecistogaster modestus* (Ent. News 22: 455, 1911), the statement was made: "Only two features of the larvæ seem to be distinct adaptations to their environment, *viz.*, the divided spines of the tarsi and distal ends of the tibiæ, and the strongly-curved, sharply-pointed tarsal claws, both classes of structures being apparently of assistance in moving up and down the steeply-inclined or vertical surfaces of the bromeliad leaves. So little has been done, however, in comparing the minuter details of Odonate larvæ that it is not certain that these features are peculiar to *Mecistogaster*." Figures of the distal end of a tibia and an entire tarsus and of a "trifid spine" were shown on a plate (xvii, figs. 1, 4) accompanying that description. Roster, however, had given similar figures for larvæ of *Agrion* (*Ischnura*) *elegans* or *pumilio* in 1886 (Boll. Soc. Ent. Ital. 18, tav. ii, figs. A, B). Tillyard has figured "trident spines" on the distal end of a tibia of *Æschna brevistyla* larva (Biol. Dragonfls., p. 86, fig. 34B, 1917). Since all these divided structures are articulated with the cuticle of the leg surface, each fitted over a pore therein, they will be designated as *setæ*, reserving the term *spines* for non-articulated, continuous prolongations of chitin. Even though divided setæ are not peculiar to *Mecistogaster*, they may, nevertheless, be useful in climbing smooth vertical surfaces of leaves.

number of their divisions may exist on the same segment of a leg.

The first tibia of all these four genera possesses divided setæ at its apex, or extending proximad from the apex even to mid-length of the tibia, and chiefly, or exclusively, on the ventral surface. On the second tibia divided setæ have not been found in *Orthemis*, but are present at the apex (chiefly on the ventral surface) in the other three genera. On the third tibia divided setæ have been seen at or near the apex on the ventral surface in all larvæ and exuviæ of *Tramea* which have been examined, but none have been found in *Orthemis* and very few in *Erythrodiplax* or in *Erythemis*.

The ventral surface of each tarsal joint bears two longitudinal rows of setæ, which, when the leg is extended at right angles to the long axis of the body, may be designated as anterior and posterior ventral rows. On the tarsus of the first leg of all four genera here discussed the anterior row is composed, in part at least, of divided setæ, although simple setæ may be found therein and the divided setæ may not be present on the first joint (segment); the posterior row is invariably composed of simple setæ which are usually slender and longer than those of the anterior row.

On the tarsus of the second leg of all four genera, divided setæ are usually present in the anterior row of at least one of the joints, while the posterior row ordinarily consists of longer, simple, slender setæ.

On the tarsus of the third leg of all four genera, it is the anterior row which is of simple setæ (occasionally a divided seta appears), while in the posterior row all the setæ are simple on all three joints of *Erythemis* or on the third joint of *Tramea;* the

setæ of this row are chiefly divided on the first two joints of *Tramea* and on all three joints of *Orthemis* and of *Erythrodiplax*.

These four genera, therefore, as far as our available material goes, may be differentiated by the setæ of the legs as follows:

Hind tarsus with no divided setæ.....*Erythemis*
Hind tarsus with divided setæ in the posterior row of joints 1 and 2 at least
Second tibia with no divided setæ.....*Orthemis*
Second tibia with divided setæ
Third joint of mid and hind tarsi with mostly simple setæ.....*Tramea*
Third joint of mid and hind tarsi with divided setæ .....*Erythrodiplax*

Orthemis. Larval Stages

The larva of only one species of *Orthemis* is known, *viz.*; *Orthemis ferruginea* (Fabr.) described by Prof. Needham (1904, p. 702), with which description specimens from Antigua agree. It is therefore, impossible to say how much the larvæ of other species of this genus may differ and, consequently, what characters are generic. Prof. Needham compared the larvæ of *O. ferruginea* to those of *Plathemis* and *Ladona*. In his key of 1918, *ferruginea* larvæ run through Nos. 22, 47, 49, 53, 65, 67, 68, 70 and 71 to 73, *Nannothemis*. The full-grown larva of *Nannothemis bella* (Needham, Can. Ent., 33: 254, 1901) is much smaller (10 mm. total body-length) than that of *O. ferruginea,* has the distal margin of the mentum not crenulate and but six lateral labial setæ. *O. ferruginea* differs from some of the numbered characters just cited from Needham's key of 1918. Thus, no. 49 must be modified to read: "Median lobe of the labium, *i. e.,* mentum, not with two teeth at apex," since this is crenulate and hence not "entire." Under no. 65, the length of the hind femur varies with respect to the width of the head.

In the tables of European Libelluline larvæ of Ris (1909) and of Rousseau, Lestage and Schouteden (1921), *O. ferruginea* falls in *Orthetrum*, from which its crenulate distal mental margin appears to distinguish it. In his monograph of the imagos of the Libellulinæ of the world (1909-1919), Dr. Ris places *Orthemis* near *Orthetrum*.

In addition to what has been said *antea,* page 15, on the mandibles of Libelluline larvæ the following notes on those of *O. ferruginea* are appended. Left mandible with the interval between the third and fourth apical teeth (counting from the anterior surface caudad) much narrower than the interval between the second and third teeth (Pl. III, fig. 32). Right mandible with only three apical teeth, hindmost of the three teeth with a tubercle or denticle near its base (Pl. III, fig. 33). Three proximal teeth (cusps of the molar—Tillyard 1917) on the right mandible, two on the left.

Orthemis ferruginea (Fabr.). Larvæ
(Plate II, figs. 19-25; Plate III, figs. 32, 33)

Seven larvæ in alcohol, fresh water pond, English Harbor, Antigua, B. W. I., June 28, 1918, Dayton Stoner and A. O. Thomas. Probably of three instars, as follows:

Ult.-Nos. 1-5, males. Total length 21-25.5 mm., width of head 4.88-5.07 mm.

Eyes not projecting as far laterad as do the genæ; ocelli indicated by three clear areas; dorsal surface of the head with two closely approximated, subparallel, straight, pale yellow lines extending obliquely caudad and mesad from about .4 mm. laterad of the mesal extremity of the hind margin of the dark non-facetted mesal extension of each eye to the junction of vertex and occiput.

Maxillæ with five simple and one toothed apical spines, not articulated at bases, and also basally articulated setæ; of the five simple spines, three are on the anterior margin, two on the posterior, of which latter the proximal is much the shortest of the five.

Mentum 3.55-3.85 mm. long × 4.44-4.74 mm. wide, median tooth of its distal margin .27-.30 mm. wide at base (Pl. II, fig. 20), mental setæ 11-16 (13 most frequent, the variation in the number being chiefly in the small setæ at the mesal end of the row); mesal articulation of the labial palp with mentum with a small brown spot on the ventral surface.

Labial palps with 9 crenulations on the distal margin (not all represented in Pl. II, fig. 24, owing to foreshortening), longest of the 2-3 setæ of each crenulation .22-.3 mm.; 9 lateral setæ without exception. (Prof. Needham says 8; in four exuviæ from Juan Viñas, Costa Rica, various dates, which I believe to belong to this species, two have 8, one has 9 and the fourth has 8 on the right, 10 on the left palp.) Movable hook .74-.81 mm. long.

Cervical process between head and first leg .6 mm. long × .67-.81 mm. wide, with soft hairs .8 mm. long.

Margins of the mesostigmata projecting subequally with, or slightly farther dorsad than, the hind margin of the prothorax. Meso- and metapleura with numerous short brown setæ and longer pale hairs, the setæ in four dorso-ventral bands, leaving three seta-free bands between the setigerous ones, thus suggesting the pale and dark bands of the thorax of the adult (*cf.* Biol. Centr.-Amer., Neur., Pl. ix, fig. 34), but to which they apparently do not correspond, in position at least. Anterior mesosternal lobes projecting .3-.52 mm. cephalad of the mesocoxæ and .6-.8 mm. cephalad of the median anterior mesosternal margin, each lobe 1.5-1.7 mm. wide at base and separated from its fellow by .7-.96 mm.

Wing-pads reach to fifth or sixth abdominal segment. Hind femur 4.96-5.5 mm. All legs with many long (up to 2.2 mm.), soft, pale hairs and, in addition, the first and second tibiæ have an antero-superior and an inferior row of stouter setæ (up to 1.5 mm. long) for their entire length. Third tibia also with these rows, but the setæ shorter (up to .3 mm. on the antero-superior and to .9 mm. on the inferior), those of the distal end of the inferior row stouter and curved.

Lateral spines of eighth and ninth abdominal segments .3 mm. long, subequal. Mid-dorsal appendage 2.44-2.7 mm., almost reaching the level of the tips of the inferiors. Laterals ("cercoids") .81-.94 mm., reaching to about one-third length of the inferiors; inferiors 2.45-2.7 mm.

Penult (probable)—No. 6, male. Total length 18, width of head 3.76 mm. It shows the following differences from the ult:

Dorsal surface of the head with the two yellow lines not contrasting so strongly with the adjacent brown.

Mentum 3.0×3.55 mm., median tooth of its distal margin .19 mm. wide at base, mental setæ 14 right, 12 left; no brown spot on the ventral surface of the mesal articulation of the labial palp with mentum.

Labial palps: longest of the 2-3 setæ of each crenulation of the distal margin .16 mm.; movable hook .57 mm.

Cervical process .52×.74 mm., its hairs .6 mm.

Mesostigmata closed, their margins projecting not as far dorsad as does the hind margin of the prothorax. Anterior mesosternal lobes projecting .15 mm. cephalad of the mesocoxæ and .37 mm. cephalad of the median anterior mesosternal margin, each lobe 1.33 mm. long and separated from its fellow by .67 mm.

Wing-pads reach to fourth abdominal segment. Hind femur 3.7 mm. Pale hairs on legs up to 1.64 mm. long, setæ of first and second tibiæ up to .82 mm. long.

Lateral spines of eighth and ninth abdominal segments .24 mm. Mid-dorsal appendage 1.84 mm., reaching to nine-tenths of the length of the inferiors. Laterals .37 mm., reaching to one-fifth of the length of the inferiors. Inferiors 1.96 mm.

Earlier instar—No. 7, sex? Total length 6.1 mm., width of head 1.72 mm. It shows the following differences from the instars described above:

Eyes projecting as far laterad as do the genæ; ocelli not indicated; the two yellow lines on the dorsal surface of the head not visible.

Maxilla: only the left one was examined, as on account of its small size it was necessary to detach it and mount it in balsam. It has the spines of the ult, but the posterior proximal is very small, .013 mm. as compared with .065 mm.

Mentum 1.39×1.92 mm., median tooth of its distal margin .12 mm. wide at base, mental setæ 9 right, 10 left; no brown spot on the ventral surface of the mesal articulation of palp with mentum.

Labial palps with 8 crenulations on the distal margin, longest of the setæ of each crenulation .06 mm.; 7 right, 8 left lateral setæ; movable hook .29 mm.

Cervical process .19×.25 mm., its hairs up to .36 mm. long.

Mesostigmata not visible; setæ of meso- and metapleura not developed; anterior mesosternal lobes present but too much distorted to be measured.

Wing-pads reach to third abdominal segment. Hind femur 1.72 mm. Pale hairs on legs up to .98 mm., very few setæ present on first and second tibiæ, more on the third.

Lateral spines of eighth and ninth abdominal segments .09 mm. Mid-dorsal appendage .73 mm., reaching to nine-tenths of the length of the inferiors. Laterals .09 mm., reaching to one-ninth of the length of the inferiors. Inferiors .78 mm.

The following notes are supplementary to Prof. Needham's description and apply to all seven specimens:

Head with a transverse band of pale soft hairs (up to 1.85 mm.

long in the ult) and slightly stouter, darker ones (one-half and more shorter) along the anterior margin of frons; similar pale hairs on each gena below the eye. In lateral or oblique-ventral view, the mentum shows an angulation on the lateral margin, at about one-half length, whence the proximal half rapidly contracts to base. Mesal margin of the labial palps with 8-11 low crenulations, each interval with a single seta whose length is 2-3 times the height of a crenulation.

Prothorax with its hind margin convex, each half thereof rather straight than curved, thickened into a tubercle laterally, the tubercle bearing setæ of very different lengths. A tuft of hairs on the antero-inferior angle of the propleuron, but these hairs not as long as those on the disk of the propleuron more caudad. Prosternal tubercles, one anterior to each coxa, not strongly developed, although present, each with an anterior transverse carina bearing a few brown setæ.

Legs yellow with ill-defined anteapical, dorsal, brown patch on femora, and a similar, but often paler, patch on knees.

Abdomen tending to become darker from its anterior to its posterior end, both dorsally and ventrally, segments VI or VII-X often distinctly darker dorsally than those immediately preceding; in some, an ill-defined brownish spot occurs on the lateral areas of the ventral surface of IV-IX. Many long, soft, pale hairs on the segments laterad, less numerous on VIII-X; many short, brown setæ on most of the dorsal surface of IV, V, or VI-X; a more or less defined mid-dorsal tuft of darker hairs on III, IV and usually other segments. Mid-dorsal appendage tapering gradually and continuously from base to apex, which is very acute and only very slightly decurved at its extreme tip; apices of the other appendages straight, acute. (Pl. II, figs. 19, 25).

Erythrodiplax. Larval Stages

The larvæ of three species now referred to this genus have been described although under other generic names, *viz.*: *Micrathyria berenice* (Drury),[6] *M. pallida* Needm.[7] and *Trithemis minuscula* (Ramb.).[8] In Costa Rica, we bred *E. umbrata* (Linn.) and *E. connata fusca* (Ramb.). Larvæ from Antigua agree with the exuviæ of the reared Costa Rican *umbrata*. No previous attempt has been made to formulate the generic characters of the larvæ of *Erythrodiplax*. They are stated below for the *ultimate instar* only as derived from larvæ and exuviæ of *umbrata* and of *berenice*, from exuviæ of *connata fusca* and from Prof. Needham's two descriptions quoted, although these last do not mention all the details which have been examined in the first three species named.

[6] Calvert, Ent. News, 15: 174. 1904.

[7] Needham, Proc. U. S. Nat. Mus. 27: 711, fig. 4. 1904. Referred to *Erythrodiplax chloropleura* Brauer by Ris, Cat. Colls. Zool. Selys, Libell., fasc. 12, p. 511, 1911, who examined some of Needham's specimens.

[8] Needham, *t. c.*, p. 709, pl. xli, fig. 10.

Body generally without long hairs, except on the sides of the prothorax, on the lateral and hind ventral margins of abdominal segment IX of *umbrata* and *connata fusca* and on the mid-dorsal line of the abdomen of *berenice*.

Head widest at the eyes, its hind angles rounded off at each side. Eyes not projecting higher than the vertex, as seen in a front view of the head, overspreading the antero-lateral angles thereof; their hind margins reaching caudad of the mid-length of head. Mesad of each eye a triangular area, which is much more coarsely reticulated than the facets of the eyes, and splits in moulting along its anterior (and in some also along its posterior) margin continuous with the eye. Ocelli faintly indicated by clear, unspotted areas.

Antennæ: third segment as long as, or longer than, the first and second segments together, fourth segment never more than four-fifths as long as the third, often less than four-fifths.

Mandibles, both right and left, with four teeth on the apical margin, interval between third and fourth teeth (counting from the anterior surface) as wide as, or but little narrower than the interval between the second and third teeth; right mandible, in addition, with an anteapical denticle and notch on the posterior margin and a group of three proximal teeth; left mandible with no (or rarely a rudiment of an) anteapical denticle and two proximal teeth (Pl. III, figs. 26-29).[9]

Labium: mentum with distal or anterior margin obtuse-angulate at middle, where are two setæ, each half almost straight, with 6-13 setæ and finely crenulate, having 2-6 crenulations between

[9] In seven out of twelve exuviæ of *umbrata* from Costa Rica, the left mandible has three proximal teeth owing to the normal posterior tooth (*b* of our fig. 28) "splitting off" a much smaller tooth, or denticle, cephalad; the three teeth then present lie in almost the same straight line and do not form a triangle as do the three proximal teeth of the right mandible.

two adjacent setæ. Lateral lobes (palps) with 11-15 crenations on the distal margin, each crenation itself more finely crenulate and bearing one or more setæ; mesal margin (posterior when closed) also finely crenulate and setigerous. (Pl. IV, figs. 40-42).

Thorax: a well developed cervical process on each side between head and first leg. Hind margin of prothorax in dorsal view convex, lateral margins pronounced, obtuse-angulate at mid-length, a tuft of setæ and hairs just posterior to the angle; antero-inferior angle of propleuron with a tuft of hairs, a smaller tuft almost immediately ventral to it on the first coxa. Dorso-lateral margins of meso- and metathorax pronounced and sinuous in dorsal view; margins of mesostigmata reaching dorsad not as far as, to a little farther than, the hind margin of the prothorax.

Legs yellowish, hairy, each femur with two transverse brown bands at approximately the first and second thirds of its length, first and second tibiæ with two transverse brownish bands in the proximal half; third femur usually shorter than the width of the head. First segment of third tarsus longer than one-half the second segment and usually (90%), but not always, longer than one-half of the third segment. (Pl. IV, fig. 37). Setæ of the legs as stated *antea,* page 17.

Abdomen as wide as, or wider than, the head, usually widest at the sixth segment, thence gradually narrowing to the hind end; segments I-V paler than VI-X, often a pale yellow, mid-dorsal longitudinal stripe; no mid-dorsal hooks (but with mid-dorsal carinate tubercles on III or IV-IX in *berenice,* each tubercle bearing a dense tuft of hairs which, when matted together, give the appearance of a hook). Ventral surface with a pair of transverse linear depressions near the mid-length of II-IX (or absent from some of these), the two of each pair usually separated by an interval greater than the length of either, each depression colored brown in some; III-VIII on each side near lateral margin with an oblique rounded ridge preceded on III-V by a distinct carina converging with the ridge laterad; III-VIII also with a pit in the lateral area, near the front margin, more removed from that margin and more distinct on VI than on the others. Lateral spines present on VIII and IX only, (Pl. IV, fig. 39), that on IX longer than the mid-dorsal length of the tergite of X, not as long as that of IX.

Terminal appendages: dorsal and laterals curved slightly ventrad at apices, in some the inferiors also; dorsal as long as, or longer than, the combined length of the tergites of IX and X on the mid-dorsal line, base three-fourths or more as wide as length, tapering from base to apex, more gradually in the distal third; laterals half or more than half as long as the inferiors, which, in profile view, are from .57 to .87 as high at base as long. (Pl. IV, figs. 36, 38.)

With the generic characters as above stated, *Erythrodiplax* does not fit very smoothly in Prof. Needham's key of 1918. It must be referred to rubric 65, whence it runs to 67; its position would seem to be nearest 72. In the synopsis of Rousseau, Lestage and Schouteden (1921) for the European larvæ, *Erythrodiplax* falls in the same group with *Crocothemis;* the adults of these two genera are not far removed from each other in Dr. Ris' monograph of the Libellulinæ (pp. 28-29).

Erythrodiplax umbrata (Linn.) Larvæ
(Plate III, figs. 26-29; Plate IV, figs. 36-42)

Four male larvæ in alcohol, fresh water pond, English Harbor, Antigua, B. W. I., June 28, 1918, Dayton Stoner and A. O. Thomas; all of the ultimate instar.

Total length 16-19 mm.; width of head 4.88-5.18, maximum width of abdomen 5.03-5.48, length of third femur 3.85-4.6, of mid-dorsal, terminal, abdominal appendage 1.04-1.26, of lateral appendages .67-.86, of inferiors 1.33-1.64 mm.

Labium reaching to the bases of the second legs, mental setæ 13-14, 13 more frequent (in ten exuviæ from Costa Rica, the range is 13-16, 14 most frequent); two or three brown spots in a row on ventral surface of mentum near the middle of each lateral margin, many small brown dots on labial palps, which latter have 12 (11-15 in the C. R. exuviæ) crenations on the distal margin, each crenation at its proximal end with two to three setæ of unequal length (.03-.25 mm.), crenations at the middle of the margin each with about seven finer crenulations, lateral setæ 10-11, movable hook .73-.88 mm. long (Pl. IV, figs. 40-42).

Cervical process .3-.5 mm. long, .4-.67 mm. wide, brown on dorsal, paler on ventral surface.

Anterior mesosternal lobes projecting cephalad about .37-.44 mm. of their junctions with the second coxæ, each lobe .81-1.11 mm. wide

and separated from its fellow by .81-1.25 mm. Wing-pads reaching to sixth abdominal segment.

Abdomen: a pale yellowish, mid-dorsal, longitudinal stripe on segments VI-X, .3-.37 mm. wide; an ill defined, small, brownish dot or spot near the mid-length of IV-IX at about two-fifths-way from mid-dorsal line to lateral margin, spots larger on VII-IX, thus forming two longitudinal rows of spots; on VIII and IX and faintly on VII the brown spot is bordered laterally by a larger pale yellowish spot; V or VI-VIII have a pair of short, transverse, brown lines at mid-length near the mid-dorsal yellow stripe. Lateral spines on IX .3-.4 mm. long. In a strictly dorsal view of X and the appendages, the mid-dorsal falls short of reaching the level of the tips of the inferiors by one-fourth to one-fifth of its own length, the laterals fall short of the same level by eight-tenths to the whole of their own length (Pl. IV, fig. 38).

Ganglia of the ventral nerve cord, as seen through the body-wall, in the following positions: 1st thoracic opposite fore legs, 2nd opposite anterior mesosternal lobes, 3rd opposite middle legs, 1st abdominal opposite middle legs close to, but distinct from, the 3rd thoracic; 2nd abdominal opposite articulation between segments I and II, 3rd in anterior end of III, 4th in anterior half of IV, 5th at anterior third of V, 6th at anterior fourth of VI, 7th in anterior end of VII, 8th in anterior end of VIII.

In his general account of this expedition, Prof. Stoner (1919, p. 175) mentions "The common pond fly (*Erythrodiplax umbrata*)" as one of the most abundant Odonata of Barbados, but no specimens from this island have been included in the collection sent to me.

Tramea. Larval Stages

The earliest description of a larva belonging to this genus appears to be that by McLachlan of an unidentified species from the Galapagos Islands (Proc. Zool. Soc. Lond., Feb. 6, 1877, p. 86, fig. 2). Cabot (1890, pp. 45-49) first stated the generic characters, based on three raised and six other species, giving descriptions of all nine and figures of two of them. Needham (1901, pp. 509, 537; 1918)[10] also gave characters for the genus and (1901) differences between *T. carolina* and *T. lacerata.* In 1904 (p. 712) he added the description and figure of a species not included by Cabot. Rich (S. Afric. Jl. Sci., July, 1917, p. 3 of separate copy; Jl. Morph. 31: 340, 342, 1918) has supplied a few details of the rectal gills. It is not necessary to repeat here any of the statements for the genus made by these authors.

Features of the larvæ of *Tramea* not mentioned by them, but which afford some differentials, are the mandibles and the setæ on the legs, which have been discussed *antea,* pages 15 and 17.

There may also be added for the mandibles of *Tramea* that the interval between the third and fourth teeth of the apical margin is a little narrower than the interval between the second and third teeth on both right and left jaws; on the right the largest of the apical teeth is the first, on the left the third (Pl. III, figs. 30, 31). These data and also those given for this genus in the table, page 15, are based on an examination of the Barbados and Antigua larvæ listed below, two larvæ and 14 exuviæ of *T. carolina,* one larva and 8 exuviæ of *T. lacerata,* one exuvia of *T. cophysa,* Guatemala, reared, one exuvia of *T. abdominalis,* Jamaica, reared; of these 29, 27 (*i. e.,* excepting the Barbados and Antigua larvæ) are of the ultimate instar. Of the two ultimate larvæ of *T. carolina* included, I have the penult exuvia of one, the penult and ult exuviæ of the other; these also agree with our generic statement for the mandibles and show that it applies to these instars also. Some variations in the mandibular armature are to be expected; among the 29 specimens examined the following were noted: the proximal group of teeth (*a-d*) were less darkly chitinized, especially on the left mandible, in 3 exuviæ of *T. carolina*; *c* and *d* were fused on the left mandible of one exuvia of *T. carolina;* the proximal teeth *b, c* and *d* of the left mandible are more proximad than in our fig. 30, Pl. III, or in *T. carolina,* with *d* on or near the posterior margin, in all *T. lacerata;* two exuviæ of *T. lacerata* have *c* on the left mandible split into two approximated teeth, in one case of unequal, in the other of equal, size; the exuvia of *T. abdominalis* from Jamaica lacks *c* and *d* on the left

[10] In both papers—1901, p. 509 under *bb*, 1918, p. 932 under 85—in speaking of the superior appendage, *dorsal* two-thirds should be *distal;* in that of 1901, p. 538, the lateral appendages should be described as three-fourths (instead of one-fourth) as long as the inferiors, as is correctly given in the two passages just quoted.

Mr. Byers' paper on the nymph of *Tramea onusta* (Journ. New York Ent. Soc., XXXV, pp. 72-73, 1927) has appeared since this Report was submitted for publication.

mandible. It will be noted that all these variations are on the *left* jaw.

Tramea species (one or two?). Larvæ
(Plate III, figs. 30, 31)

One larva, dry, pinned, Barbados, W. Indies, May 21, Stoner; soon about to moult.

Total length 11 mm., width of head 4.9 mm. Joints of antenna in mm.: 1 .25, 2 .32, 3 .57, 4 .45, 5 .5, 6 .57, 7 .6. Joints of third tarsus, dorsal surface, in mm.: 1 .37, 2 1.02, 3 1.15, claws .74. Wing-pads reaching to hind edge of abdominal segment IV. Terminal abdominal appendages: mid-dorsal 1.09, laterals .65, inferiors 1.47 mm. Some other details are given below.

One larva in alcohol, fresh water pond, English Harbor, Antigua, B. W. I., June 28, 1918, Dayton Stoner and A. O. Thomas.

Total length 18 mm., maximum width of head 5.5 mm. Joints of antenna in mm.: 1 .33, 2 .33, 3 .74, 4 .49, 5 .69, 6 .65, 7 .69. Joints of third tarsus, dorsal surface, in mm.: 1 right .37, left .41, 2 r .9, l 1.23, 3 r 1.06, l 1.23; ventral surface, in mm.: 1 r .82, l .09, 2 r .72, l 1.06, 3 r .9, l 1.06. Wing-pads reaching to hind edge of abd. seg. V. Terminal abd. apps.: mid-dorsal 1.64, laterals 1.15, inferiors 1.84 mm. Some other details are given below.

The distinction of "species" in this genus is slight and difficult to define, both for the larvæ (Needham 1901) and for the imagos (*cf.* Ris, Cat. Colls. Zool. Selys, 1913). Writing of *T. carolina,* Prof. Needham (1901, p. 538) said: "Save for the slightly larger size and a slightly darker general color, I can find no differences between this nymph and that of *T. lacerata* excepting the ones stated in the table [relative lengths of the fourth and third antennal joints]: I find but 10 lateral setæ in my nymphs of *carolina,* while generally there is an added shorter one at the proximal end of the row in *lacerata.*" A study of the larvæ and exuviæ of the ultimate instar of *carolina* and *lacerata* listed on page 27 makes it appear that the *absolute* length of the fourth antennal joint (.74-.57 mm. *carolina,* .56-.39 mm. *lacerata*) is as good a differential between these two species as the ratio of its length to that of the third joint (.83-.67 *carolina,* .66-.48 *lacerata*). Since the lengths of the joints increase with the instars, however, we have as yet no data by which we can distinguish the earlier instars specifically. Such as are available toward forming an opinion as to the species of the Barbados and Antigua larvæ are cast into the following table:

TRAMEA LARVAE

	Features Changing in Ontogeny				Features Not Changing in Ontogeny				
	Labium				Labium		Antennæ	
	Mental Setæ		Lateral Setæ		Crenations of Palp		Ratio of 4th to 3rd Segment	
	Range	Most Frequent	Range	Most Frequent	Range	Most Frequent		
Differentials of Ultimate Instar:								
T. carolina	13-15	13, 14, 15, each 33.3%	9-11	10 87%	11-13	13 60%	.83-.67	
T. lacerata	12-18	15, 16, each 27.7 %	10-13	11 72.2%	11-12	12 83.3%	.66-.48	
T. cophysa	12		9		11		.68	
T. abdominalis	13r,14l		10		13		.67	
Ontogeny of T. carolina, larva no. 2, Primos, Pennsylvania:								
3ult 16mm.	12r12l		8r9l		12r11l		.745	
2ult 21 mm.	12r13l		9rl		12r11l		.74	
Ult 25 mm.	14r15l		10rl		12r11l		.74	
Ontogeny of T. carolina, larva no. 3, Holmes, Pennsylvania:								
2ult 19 mm.	13r15l		10rl		11rl		(antennæ lost)	
Ult 22 mm.	15rl		10rl		11rl		.7	
Barbados larva:								
11 mm.	11rl		9rl		11r12l		.79	
Antigua larva:								
18mm.	13rl		10rl		11rl		.66	

In this table, r=right, l=left. The specimens upon which the table is based are the 29 listed on page 27.

The *carolina* and *lacerata* material is from several localities in the United States. The *cophysa* exuvia accompanies a female imago from Los Amates, Guatemala, January 18, 1905, reared by Mr. E. B. Williamson, to whom I am indebted for the privilege of studying both. The *abdominalis* exuvia is that described by Cabot, *l. c.*, and bears two labels: "H. 1877 Jam." and "T. abdom.," the latter in Hagen's handwriting; it belongs to the Museum of Comparative Zoology and Mr. Nathan Banks has kindly allowed me to examine it.

Imagos of four species of *Tramea* are known from the West Indies: *cophysa* Hagen, *insularis* Hagen (which Dr. Ris refers to *binotata* Rambur), *abdominalis* Rambur, and *onusta* Hagen. Nothing is known of the larvæ of *insularis* and *onusta* and only a single exuvia of each of the other two. No *Tramea* has been recorded from Antigua; *cophysa* and *abdominalis* have been collected in Barbados (Biol. Centr.-Amer., Neur, pp. 303, 304); Prof. Stoner in his general account of this expedition says of Barbados: "The common pond fly (*Erythrodiplax umbrata*) and the red pond fly. (*Tramea abdominalis*) are probably the most abundant" (1919, p. 175). No *imagos* of the latter species collected by this expedition have been received by me. The data of the above table for *carolina* and *lacerata* show how much variation may exist in the same species, both ontogenetically and in the last instar; in view of that variation it is impossible to determine the species of our Barbados and Antigua larvæ on the scanty knowledge which we now possess.

Erythemis. Larval Stages

In 1901 Prof. Needham gave larval characters for the genus *Mesothemis* and described the larva of *M. simplicicollis* Say, the only species inhabiting the eastern United States. These generic larval characters and name are repeated without change in his work of 1918. Prof. C. B. Wilson has figured the egg, newly-hatched nymph and its mask and described the colors of the second and details of the last (1920, p. 241, figs. 46-48).; on pages 194-196 he has shown the head and mouth-parts of the full-grown nymph.[11] Some general remarks on the habitats of *Erythemis*

[11] For a criticism of fig. 13, p. 195, of the labium, see Needham, Ent. News, 31, p. 30, Jan., 1921.

larvæ are made by Mr. Williamson (Univ. Mich. Mus. Zool. Misc. Pub. No. 11, pp. 4-5. 1923). The present writer (Biol. Centr.-Amer. Neur. p. 329, 1907) united the genera *Erythemis* Hagen and *Mesothemis* Hagen under the former name, as having page priority, and Dr. Ris (Cat. Colls. Zool. Selys, fasc. xiii, p. 594, 1911) has done the same.

In his description of the nymph of *M. simplicicollis* (1901, p. 527), Prof. Needham remarks: "It is recognizable at a glance among all other Libelluline nymphs known to me by the thickness of the body, the bulging prominence of the eyes, the relative brevity of the abdomen, and the decurved appendages at the apex of the abdomen." All of these features appear to be characteristic of the genus in as far as present material goes. In addition to these the mandibles and the setæ on tibiæ and tarsi afford means of diagnosis.

A formula for the mandibles of the larvæ of *Erythemis* is given *antea*, p. 16, so that here it is only necessary to add that on the left mandible the interval between the third and fourth apical teeth is as wide as that between the second and third teeth and that the third apical tooth is the most prominent on both jaws (Pl. III, figs. 34, 35).

General statements as to the setæ of the legs have been given *antea*. The tibiæ and tarsi of 29 larvæ and exuviæ of *Erythemis* were examined for setæ.

The first and second tibiæ usually possess some divided setæ, the third tibia usually lacks them; the following exceptions were noted: One *E. simplicicollis*, Philadelphia, Pennsylvania, was not found to have any divided setæ on the first tibiæ; one from Illinois had but one or two divided setæ on the first tibia and none on the second (most of the setæ lost from the second); another Philadelphia larva, one from Primos, Pennsylvania, one from South Orange, New Jersey, one from Barbados, one from Los Amates, Guatemala, had a few (4 or fewer) divided setæ on the third tibia.

The anterior row of the tarsus of the first leg is usually composed of simple setæ on the first joint and of divided setæ on the second and third joints. The anterior row of the tarsus of the second leg is of simple setæ except in the Barbados and Antiguan examples which have some divided setæ on the second and third joints (Pl. V, fig. 50). All the setæ on the tarsus of the third leg are simple (Pl. IV, fig. 44).

To complete the description of the generic larval characters:—

Rear of the head with nine brownish bands (as in many other genera) placed at right angles to the hind (five bands) and lateral (two bands each side) margins, and also one on the gena below the eye; the mid-dorsal band in some divided by a pale median line; setæ up to .89 mm. long, present between most of the bands, especially between the second lateral and third posterior and between the second and third posterior bands (counting posterior bands from the mid-dorsal line and lateral bands from the eye).

Compound eyes the most prominent part of the head laterally, a little more prominent dorsad than the vertex between them, not as prominent dorsad as the rear of the head. Ocelli faintly indicated in some examples. Mandibles usually with a brown stripe on the antero-lateral surface. Maxillæ often with a brown stripe on the lateral surface of the stipes.

Distal margin of the mentum very finely crenulate, its two halves meeting in the middle at an angle of very nearly 90°, but the actual angle itself rounded, each half nearly straight mesally, a little concave laterad, with 13-45 setæ up to .15 mm. long, nearer together mesad, and with one or more shorter setæ between each longer seta and the next. (Pl. IV, figs. 47, 48.)

Cervical process subglobular, .30—.37 mm. long. Hind margin of prothorax regularly convex, entire; lateral margin pronounced, angulate anteriorly, with a few setæ up to .5 mm. long; propleuron with a tuft of hairs at the antero-inferior angle; a smaller tuft almost immediately ventrad on the first coxa. Right and left latero-dorsal margins of the meso-metathorax pronounced, strongly converging caudad to, or almost to, the level of the third coxa, thence strongly diverging; no tuft of hairs or setæ on the mesopleuron. Margins of mesostigmata projecting dorsad above the level of the hind margin of the prothorax in ultimate exuviæ.

All five appendages at the apex of abdomen very acute at tips; in profile the dorsal barely, the laterals slightly but distinctly, the ventrals strongly, decurved at apices (Pl. IV, figs. 43, 45).

Erythemis does not fall satisfactorily in either of the main divisions of Ris' (1909) or Rousseau, Lestage & Schouteden's (1921) tables for European Libellulid larvæ, nor in either of the two principal types mentioned by Dr. Ris in his South African paper of 1922,[12] as its larvæ are not very hairy, the eyes are but

[12] Annals, South African Museum, XVIII, pt. 3, p. 384.

moderately large and the antennæ are inserted caudad of a transverse line touching the front margins of the eyes.

The data available for making specific identifications of larvæ in this genus are as follows: Eight larvæ or exuviæ (some reared) of *E. simplicicollis* from New Jersey, Pennsylvania and Illinois and the descriptions of Profs. Needham and Wilson;

One larva each from Antigua and from Barbados;

Four exuviæ (one reared = *E. verbenata* Hagen = *E. plebeja* Burmeister, *teste* Ris Cat. Colls. Zool. Selys, 1911) and thirteen larvæ (various sizes) in alcohol from Los Amates, Guatemala, January, 1905, by E. B. Williamson, evidently two species here;

Two exuviæ, Georgetown, British Guiana, January, 1912, by E. B. Williamson.

Imagos of seven species of *Erythemis* have been recorded from the West Indies,[13] viz.;

attala Selys, Cuba, Jamaica, Hayti, Martinique;
credula Hagen, St. Thomas, Trinidad;
hæmatogastra Burmeister, Jamaica, Trinidad;
mithroides Brauer, Trinidad;
peruviana Rambur, Jamaica;
plebeja Burmeister (*verbenata* Hagen), Cuba, Jamaica, Hayti, Isle of Pines, Trinidad;
simplicicollis Say, Cuba, Isle of Pines, Jamaica, Hayti.

At Los Amates, in January, 1905, Mr. Williamson took imagos of *E. peruviana* and *plebeja* (*verbenata*) and at Georgetown, in January, 1912, he took imagos of *E. attala, hæmatogastra, peruviana* and *plebeja.*

Comparing these specimens with each other and with the data on the occurrence of imagos, the following differences and possible specific identifications appear in the

[13] Calvert, Biol. Centr.-Amer., *l. c.*; Ris, *l. c.* and fasc. xvi, 2e part., pp. 1173-1174, 1919; Kahl, Ann. Carnegie Mus. Pittsburgh, x, p. 525, 1916.

ULTIMATE LARVAL INSTAR

Total Length in mm.	Setæ of anterior row, 2nd & 3rd segments, mid tarsus	Lateral Labial Setæ	Lateral Spine on abd. seg. IX & Length in mm.	Locality	Species
11.5-12.5	Divided	11	Strongly decurved; .11-.15	Antigua, Barbados	*credula?*
14.5-15	Simple	8	Id.; .16-.30	Los Amates, Jan. 1905	*plebeja* (*verbenata*) (reared)
14.5-15	Simple	8	Id.; .43-.50	Georgetown Jan. 1912	*attala?*
16.5-17.5	Simple	8	Absent or very short & straight .08 or less	United States	*simplicicollis* (reared)
13-13.5	Simple	6	Strongly decurved; .43	Los Amates, Jan. 1905	*peruviana?*

The Georgetown examples may be *hæmatogastra* rather than *attala*, or the Antiguan and Barbados specimens may be one of these two species or even *mithroides*; future rearings alone can decide.

Erythemis credula Hagen?

(Plate III, figs. 34, 35; Plate IV, figs. 43-49; Plate V, fig. 50)

One larva in alcohol, English Harbor, Antigua, British West Indies, fresh water pond, June 28, 1918, D. Stoner & A. O. Thomas.

One dried larva, pinned, Barbados, May 28, Stoner.

Dimensions (the first in each case is that of the Antiguan specimen): Total length 12.5, 11.5; maximum width of head (at the eyes) 4.44, 4.09, of abdomen (at segment VI) 5.18, 4.50; lengths of antennal joints I .13, .03, II .15, .15, III .35, .41, IV .22, .21, V .22, .24, VI .32, .28, VII .30, .31; hind femur 4.29, 4.83; length of abdom. apps., dorsal 1.04, 1.10, lateral .52, .57, ventral .81, .98, —all in mm.

Distal margin of the labial palps with thirteen feebly developed crenations, widest near the middle of the margin, the larger crenations each with 5-6 crenulations and at its proximal end 1-5 setæ of unequal length up to .15 mm. Movable hook a seta .6-.65 mm. long. (Pl. IV, figs. 47, 49.) Proximal (mesal) margin finely denticulated and bearing setæ.

Anterior pro- and mesosternal lobes present, the latter projecting cephalad for about .35 mm. beyond the mid coxa, with a

maximum width of 1.5-1.3 mm. each, interval separating right and left lobes .74-.98 mm.

Abdomen of the alcoholic Antiguan larva with an ill-defined, pale yellowish, mid-dorsal, longitudinal stripe on VI-IX (not visible in the dry Barbados example). Dorsal and ventral terminal appendages reaching to the same level, laterals to half as far; lateral margins of the dorsal converging to apex throughout, but a little more strongly so in its proximal than in its distal half (Pl. IV, figs. 43, 45). Ventral surface with a pit near the anterior margin of each lateral area of segments III-IX, deepest on VI, followed by an oblique, rounded ridge and on some of the anterior segments preceded by an oblique, subparallel carina or suture. Lateral marginal setæ on VIII and IX longer than on other segments.

Wing-pads reaching to abdominal segment VI. Legs hairy, hind tibia with setæ up to 2.05 mm. long *e. g.*, femora with ill-defined, somewhat darker transverse bands.

Ganglia of the ventral cord, as seen through the ventral wall, very nearly as described *antea* for *Erythrodiplax umbrata;* the second and third abdominal, however, can not be distinguished.

On Certain Internal Organs of the Larvæ here described.

As the number of specimens was small, those dissected were two larvæ (nos. 3, 4) of *Lestes* (*forficula?*), one (no. 5) of *Orthemis ferruginea* and one of *Erythrodiplax umbrata* (no. 4), as well as one (no. 1) of *Erythemis plebeja* from Los Amates, Guatemala. While, therefore, no allowance can be made for possible variation within each species, the following data may at least be of value as contributing to knowledge of the morphology of these insects.

Alimentary Canal

The gizzard-armature of *Lestes* (*forficula?*) larva No. 3 agrees with that given for a European species by Dr. Ris (Zool. Jahrb., Abt. Syst. Geog. Biol., IX, p. 614, fig. G. 1896). Within the foregut were found fragments of the exoskeleton of Crustacea, to some of which tissues and limbs were still adhering.

The gizzards of *Orthemis ferruginea* and of *Erythemis plebeja* much resemble Ris' fig. M (*op. cit.*, p. 619) of a *Cordulia* larva which, as he states: "kann als Paradigma für die ganze grosse Gruppe der Libelluliden gelten." Similar figures for the gizzard

antaxial surfaces of both hemibranchs of gills I and of XI and of the dorsal hemibranchs of III and of IX, while on the remaining six hemibranchs it is more distinct on their axial surfaces.

In *E. plebeja* no pigment was found in gills V and VII; it is present in the disk from base distad and as a line along both axial and antaxial edges (but more marked on the antaxial) of each lamella of both hemibranchs of I and of XI; in the same locations, except for the axial edge, in the dorsal hemibranch of III and of IX, and confined to the lamellæ of the posterior half of the ventral hemibranchs of III and of IX.

In all three species, therefore, the six hemibranchs of the dorsal half of the rectum contain more pigment than the six ventral hemibranchs; whether this has any respiratory significance has yet to be learned.

Nervous System

Although the microscopic structure and development of the brain, optic ganglia and eyes of a few Odonata have been studied by a number of investigators, most recently by Baldus (Zeitschr. wiss. Zool., CXXI, pp. 557-620, 1924), little exists on the comparative anatomy of these organs or on the ontogenetic changes which they undergo. It is well known that the compound eyes reach a large size in Anisopterous larvæ. although never equalling those of their corresponding imagos in extent. A dissection of the larval head of *E. umbrata,* with the cuticle removed, viewed from in front and slightly above, is shown in our Plate V, fig. 51. The darkly pigmented larval eyes, *le,* are nearer together below and in front than they are posteriorly and superiorly, the great additional, and as yet unpigmented areas to be occupied by the imaginal eyes, *ie,* are also to be seen; they extend little farther mesad anterior to and below the ocelli but they almost meet at the mid-dorsal line posterior to the simple eyes. A similar condition is to be seen in a preparation of the larva of *Orthemis ferruginea,* not figured here. No such difference exists in a corresponding dissection of *Lestes* (*forficula?*) larva (Pl. V, fig. 53), where larval and imaginal compound eyes coincide in area and where, as in the imago, the right and left eyes are closer anteriorly and inferiorly than posteriorly and superiorly. In other words, the final condition in *Lestes* corresponds to an earlier, transitory stage in *Erythrodiplax* and *Orthemis.*

Corresponding to the much larger absolute and relative size of the compound eyes in these two Anisopterous genera, the optic ganglia are noticeably larger, both absolutely and relatively than in *Lestes* (*cf.* figs. 51, 53, and 55, Pl. V).

We figure also, on larger scale (Pl. V, figs. 52, 54, 57), the median ocellus of the same three genera, the pigmented retina of all three, the lens in addition for that of *Lestes* (*forficula?*). Figures of cross sections through the retina of this ocellus of a number of species have been given by Link (Zool. Jahrb., Abt. Anat. Bd. 27, p. 331, figs. *Ja-Jf.* 1909). It will be noticed that our fig. 54 for *Lestes* (*forficula?*) resembles Link's fig. *Jb* for *Gomphus vulgatissimus* much more than his figures for *Calopteryx splendens* or *Agrion puella,* although differing in the sharper "edges" of the mouth of the cup than *Jb* has. Our figure 57 for *Orthemis ferruginea* resembles Link's fig. *Ja* for *Æschna cyanea,* but the cup is much narrower at its mouth in *Ja,* while our fig. 52 for *Erythrodiplax umbrata* shows a fairly close resemblance to Link's *Je* for *Sympetrum flaveolum.* Our figures 52 and 57 show distinctly the double or paired condition of this ocellus, which has been described by writers on the structure of these eyes (Hesse, Zeitschr. wiss. Zool., LXX, p. 384, 1901; Link, *op. cit.*; Tillyard, 1917, pp. 139-140) and which apparently receives support from the physiological observations of v. Hess (Pfluger's Archiv gesammt. Physiol., Bd. 181, p. 10. 1920). I have observed a bilobed median ocellus in an adult male of *Orthemis ferruginea* from Costa Rica and have seen it slightly, but variably, bilobed in two reared imagos of *E. umbrata* from the same country, but not bilobed in imagos of the following species which were at hand for comparison at the time: *Lestes forficula, Argia tibialis, A. fumipennis, Ischnura ramburii, Gomphus minutus, Epiæschna heros, Libellula vibrans, Erythrodiplax connata, Tramea carolina.* Neither Link, p. 367, nor Glasgow, who has recently discussed (Psyche, vol. 32, pp. 285-290, 1925) the significance of the paired condition of the median ocellus in insects generally, is disposed to ascribe much phylogenetic value to its occurrence.

Data on the position of the thoracic and abdominal ganglia, as viewed through the ventral wall, have been given *antea* for *Anax junius, Erythrodiplax umbrata* and *Erythemis* (*credula?*) and will be found to agree fairly exactly, as also do the ganglia of the *dissected* larvæ of *Lestes* (*forficula?*) and *Orthemis ferruginea.*

In microscopic slides of the larvæ of the last two species named, of *E. umbrata* and of *Erythemis plebeja* the close proximity of the first abdominal ganglion to the metathoracic can be seen. The following measurements have been made from these slides, in view of the significance which has been attached to the relative proximity of the thoracic ganglia to each other (Brandt 1880,[15] Calvert Trans. Amer. Ent. Soc. XX, 1893, p. 182; Tillyard 1917, p. 131):

SIZE OF GANGLIA IN MM.

The first dimension is length, the second width.

	Lestes (forficula?)	*Orthemis ferruginea*	*Erythrodiplax umbrata*	*Erythemis plebeja*
Subœsophageal	.28 x .25	.47 x .50	.55 x .40	
Prothoracic	.28 x .36	.50 x .58	.37 x .39	.45 x .46
Mesothoracic	.30 x .39	.47 x .56	.33 x .44	.41 x .45
Metathoracic	.27 x .41	.39 x .53	.28 x .39	.27 x .36

(The length of the metathoracic is measured to the hind edge of that ganglion proper, or to the line of fusion with the first abdominal.)

DISTANCES BETWEEN GANGLIA IN MM.

	Lestes (forficula?)	*Orthemis ferruginea*	*Erythrodiplax umbrata*	*Erythemis plebeja*
Subœs. to Prothor.	.83	4.82	3.59	
Prothor. to Mesothor.	.31	1.89	1.56	1.56
Meso- to Metathoracic	.28	.44	.23	.17

Muscles

Only the abdominal muscles of these larvæ have been examined. The abdominal muscles of various Odonata, both larval and imaginal, have been recently described and figured by Dr. Whedon (1919) and certain of the larval muscles homologized with those of the imago by Miss Ford (Trans. Royal Canad. Inst. XIV, pp. 255-6. 1923).

Here we merely figure the musculature of the last two abdominal

[15] E. Brandt, Ueber das Nervensystem der Wasserjungfer (Odonata). Horæ Soc. Ent. Ross. XV, Bull. Ent., pp. xiii-xvi. Sitzung am 7(19) December 1878. Published 1 Fevrier, 1880. —Not until very recently (1926) have I seen this paper of Brandt's; it seems to have been omitted from the Zoological Record. Tillyard, 1917, although citing it (p. 363), appears (p. 132) not to have read it. Brandt seems to have been the first to explain the difference in number and arrangement of the abdominal ganglia in young larvæ and in imagos of Odonata. He says: "Bei der ganz jungen flugellosen Larve der *Æschna grandis* besteht das Nervensystem aus 13 Nervenknoten und zwar 2 Kopf-, 3 Brust- und 8 Bauchknoten. Rasch jedoch verschmilzt der erste Bauch- mit dem letzten Brustknoten und bildet den dritten Brustknoten des Imago (*Æ. grandis, Cal. virgo,* etc.) Bei anderen verschmelzen der zweite und dritte Brustknoten der Larve und bilden den grossen letzten Brustknoten (*Libellula quadrimaculata*)." I did not find this explanation until 1903 (Proc. Acad. Nat. Sci. Philadelphia, 1903, p. 760) and Tillyard not until 1917 (*l. c.*).

segments of *Lestes (forficula?)* larva as exhibiting a more complex structure than is described and shown by Dr. Whedon (1919, pp. 399-400, Pl. xxi, figs. 1-3) for the larva of *Lestes unguiculatus.* In our fig. 56, Pl. V, the same reference letters are employed as in his figures and text. The ventral muscles here are very similar to those shown by him, but in accordance with the usage of Hagen, Needham and other parts of the present paper, the appendages (caudal gills) which Whedon (following Wallengren's terms based on Æschnines) has called the *laterals* must here be referred to as the *ventrals* or *inferiors.* The ventral adductors of the ventral gills (*vad*) and the ventral retractors of the anus (*vra*) together appear to be serially homologous with the primary longitudinal sternal muscles (Whedon) of more anterior segments, although more approximated to the mid-ventral line by reason of the absence of the nerve cord from the ninth and tenth segments. The abductor muscle of the ventral gills (*ala*) is well developed, while next to it, ectad and ventrad, is a more delicate muscle (*advg*) which, from its position, would seem to serve as an adductor of the ventral gills and which may be modified from the dorso-ventral oblique (*dvo*) of preceding somites.

Greater differences from Dr. Whedon's results are shown by the dorsal muscles of segment X. Those which he describes as the adductors of the dorsal appendage or gill (*ada*), but does not figure for *Lestes,* although he shows them for *Anax* (his Pl. xxiii, fig. 11) and for *Tramea* (his Pl. xxiv, fig. 16), would appear to be those similarly marked in our Pl. V, fig. 56. The origin of our *ada* is indeed, farther caudad, their insertion more mesad; their function would seem to be rather that of abduction (elevation) of this gill than adduction (depression). They look to be serial homologues of the tertiary longitudinal tergals (*tlt*) of Whedon.[16]

Two muscles on each side of the mid-dorsal line in segment X are not mentioned by Dr. Whedon, unless they are included in his *ada,* as may be implied by his expression (p. 400): "They insert upon the lateral bases of *both* the dorsal *and lateral* appendages" (the italics are mine). They appear to be representatives of the

[16] *ala* in Whedon's text, p. 399, refers to the *ab*ductor and in this follows Wallengren; in his explanation of Abbreviations, p. 433, by a typographical error, *ala* is made to refer to the *ad*ductor. Another interpretation of his fig. 1, Pl. xxi, is as follows: What is there labeled *ala* may be *ada,* the adductor of the dorsal appendage (gill), and the next, unlabeled muscle lying mesad the true abductor of the ventral gills (*ala*).

primary longitudinal tergals (*plt*) of segment IX. At their hind ends their fibres overlap, those of the mesal muscle lying dorsad to those of the lateral muscle. Both appear to attach at the base of the lateral appendage (Hagen, Needham, = cercoid, Heymons) of the same side; the mesal muscle (*adc*) may elevate and adduct, the lateral (*abc*) depress and abduct this appendage.

BIBLIOGRAPHY

Works for the most part quoted more than once.

(References to works cited once only are given in the text *antea*.)

Ausserer, C. 1869. Neurotteri Tirolesi colla diagnosi di tutti i generi europei. Parte I. Pseudo-Neurotteri. Annuario Soc. Naturalisti Modena, iv, pp. 71-156, taf. viii, ix. Also, separately, pp. 1-88.

Barbiche (l' Abbé). 1884-1887. Faune Synoptique des Odonates ou Libellules de la Lorraine. Bull. Soc. Hist. Nat. Metz (2) XVI, pp. 11-20, 1884; XVII pp. 85-163, 1887. Also, separately, Metz Imprimerie Even Freres 1887, pp. 1-93.

Brauer, F. u. Löw, F. 1857. Neuroptera austriaca. Wien, Carl Gerolds' Sohn, pp. i-xxiii, 1-80, taf. i-v.

Butler, H. 1904. The Labium of the Odonata. Trans. Amer. Ent. Soc. XXX, pp. 111-134, pl. ii-vii.

Cabot, L. 1881. The Immature State of the Odonata. Part II. Subfamily Aeschnina. Mem. Mus. Comp. Zool. VIII, no. 1, pp. 1-40, pl. i-v.

Cabot, L. 1890. (The same). Part III. Subfamily Cordulina. Mem. cit. XVII, no. 1, pp. 1-50, pl. i-vi.

Biologia Centrali-Americana. See Calvert 1901-08.

Calvert, P. P. 1901-1908. Odonata in volume Neuroptera, Biol. Centr.-Amer., London, R. H. Porter, Dulau & Co.

Calvert, P. P. 1909. Contributions to a Knowledge of the Odonata of the Neotropical Region, Exclusive of Mexico and Central America. Ann. Carnegie Mus. Pittsburgh, VI, pp. 73-280, pl. i-ix.

Garman, P. 1917. The Zygoptera, or Damsel-flies, of Illinois. Bull. Illinois State Lab. Nat. Hist. XII, art. iv, pp. 411-587, pl. lviii-lxxiii.

Hagen, H. A. 1853. Leon Dufour über die Larven der Libellen mit Berücksichtigung der früheren Arbeiten. Stettiner Ent. Zeit. XIV, pp. 98-106, 237-238, 260-270, 311-325, 334-346.

Howe, R. H., Jr. 1921. Memoir of the Thoreau Museum of Nat. Hist.: II. Manual of the Odonata of New England Nymphs Zygoptera Part I. Pp. 103-115, many text figs., pictorial chart, pl. i-ix.

Lampert, K. 1899, 1910. Das Leben der Binnengewasser. Zweite, vermehrte und verbesserte Auflage. C. H. Tauchnitz Leipzig 1910 8v pp. xviii, 856, 17 Taf., 279 Abbild. im Text. (The first edition, 1899, I have not seen.)

Lucas, W. J. 1900. British Dragonflies (Odonata). London, L. Upcott Gill. Pp. xiv, 356, Pl. i-xxvii, 57 text figs.

Needham, J. G. 1903. Life Histories of Odonata suborder Zygoptera. Bull. 68, New York State Mus. pp. 218-276, pl. 11-19, 17 text figs.

Needham, J. G. 1904. New Dragon-fly Nymphs in the United States Natl. Mus. Proc. U. S. Natl. Mus. XXVII, pp. 685-720, pl. xxxviii-xliv, 11 text figs.

Needham, J. G. 1918. Chapter XXVII. Aquatic Insects in: Ward & Whip-

ple: Fresh-water Biology, New York, John Wiley & Sons, Inc. pp. 876-946, figs. 1354-1391.

Needham, J. G. and Betten, C. 1901. Aquatic Insects in the Adirondacks. Bull. 47 New York State Mus. pp. 383-612, pl. 1-36, 42 text figs.

Needham, J. G. and Hart, C. A. 1901. The Dragonflies (Odonata) of Illinois, with Descriptions of the Immature Stages. Part I. Petaluridæ, Aeschnidæ, and Gomphidæ. Bull. Illinois State Lab. Nat. Hist. VI, art. i, pp. 1-94, pl. 1.

Nunney, W. H. 1894. Larvæ-nymphs of British Dragon-flies. Science Gossip, London, (n. s.) 1, pp. 80-82, figs. A-C; pp. 100-102, figs. 1-5; pp. 129-131, figs. 7-15; pp. 148-150, figs. 16-26; pp. 176-177.

Ris, F. 1909. Die Süsswasserfauna Deutschlands. Heft 9 Odonata. Jena, G. Fischer, 8vo. 68 pp., 79 figs.

Ris, F. 1918. Libellen (Odonata) aus der Region der amerikanischen Kordilleren von Costarica bis Catamarca. Arch. Naturges. 82 A, Heft 9 pp. 1-197, 117 figs.

Ris, F. 1920. Uebersicht der mitteleuropaischen Lestes-Larven (Odonata). Festschrift für Zschokke No. 22, pp. 1-14, 7 text figs. Basel.

Roster, D. A. 1886. Cenno Monografico degli Odonati del Gruppo Ischnura. Boll. Soc. Ent. Ital. XVIII, pp. 239-258, Tav. ii-vi.

Roster, D. A. 1888. Contributo allo Studio delle Forme Larvali degli Odonati. Cenno Iconografico delle Larve-Ninfe dei Caudobranchiati. Boll. cit. XX, pp. 159-170, Tav. i-iv.

Rousseau, E. 1909. Etude monographique des larves des odonates d'Europe. Ann. Biol. lacustre III, pp. 300-366, 47 text figs.

Rousseau, E., Lestage, J. A. et Schouteden, H. 1921. Les Larves et Nymphes des Insectes d'Europe (Morphologie, Biologie, Systematique). Vol. I. J. Lebeque et Cie, Bruxelles, 8vo, pp. xx, 967, 344 figs.

Stoner, D. 1919. Collecting Terrestrial Arthropods in Barbados and Antigua, British West Indies, Canad. Entom. LI, pp. 173-178, 217-220.

Tillyard, R. J. 1916. Life-Histories and Descriptions of Australian Aeschninæ, etc. Journ. Linn. Soc. London, XXXIII, pp. 1-83, pl. 1-9, 4 text figs.

Tillyard, R. J. 1917. The Biology of Dragonflies (Odonata or Paraneuroptera) Cambridge: at the University Press, 8vo, pp. xii, 396, 4 pl., 188 text figs.

Tümpel, R. 1901. Die Geradflügler Mitteleuropas. Eisenach, M. Wilchens, pp. (2), 1-308, 23 Taf., 92 text figs.

Tümpel, R. 1908. (Dasselbe) Neue billige Ausgabe mit einem Anhang: Neuere Beobachtungen. Gotha, F. E. Perthes. Pp. (2), 324, 23 pl., 96 text figs.

Walker, E. M. 1914. The Known Nymphs of the Canadian species of Lestes. Canad. Entom. XLVI, pp. 189-200, 14 figs.

Whedon, A. D. 1919. The Comparative Morphology and Possible Adaptations of the Abdomen in the Odonata. Trans. Amer. Ent. Soc. XLIV, pp. 373-437, pl. xxi-xxix.

Wilson, C. B. 1920. Dragonflies and Damselflies in relation to Pondfish Culture, etc. Bull. Bur. Fish., Washington, XXXVI, pp. 185-264, ii, 63 text figs., pl. lxvii-lxviii.

PLATES

EXPLANATION OF PLATES

PLATE I

Figs. 1—4. *Lestes forficula?* Rambur, larva no. 4, Antigua, June 28, 1918. 1. Mentum and palps, dorsal view; *ho*, outer hook of the outer part of the distal portion of the lateral lobe [palp]; *hp*, hook of the proximal portion of the same; *mh*, movable hook [=distal segment of palp]. 2. Distal end of *hp* of fig. 1 more highly magnified. 3. Part of the distal extremity of the outer part of the distal portion of the left palp, showing the inner hook, *hi*, shown, but not labeled, in fig. 1, more highly magnified. 4. Distal edge of mentum at middle, dorsal view, more highly magnified. Nomenclature as in Needham 1903, pp. 231—2.

Figs. 5-8. *Ischnura ramburi* Selys, var. *credula?* Hagen, larva no. 4, Barbados, May 21, 1918. 5. Mentum and palps, dorsal view; *hf*, fixed hook; *hm*, movable hook. 6. Distal edge of mentum at middle, more highly magnified. 7. Distal end of palp, more highly magnified; *hf*, fixed hook; *pt*, truncated process of Garman; apex of movable hook (not labeled) broken off. 8. Right lateral margin of abdomen, ventral view.

Fig. 9. *Lestes forficula* Rambur, ♂ imago, *b*, Antigua, July 15, 1918; apex of abdomen showing right superior and inferior appendages.

Fig. 10. *Ischnura ramburi* Selys var. *credula?* Hagen, larva no. 4, Barbados, May 21, 1918; caudal gill.

Figs. 11-14. *Lestes forficula?* Rambur, larvæ, Antigua, June 28, 1918; detached caudal gills.

PLATE I

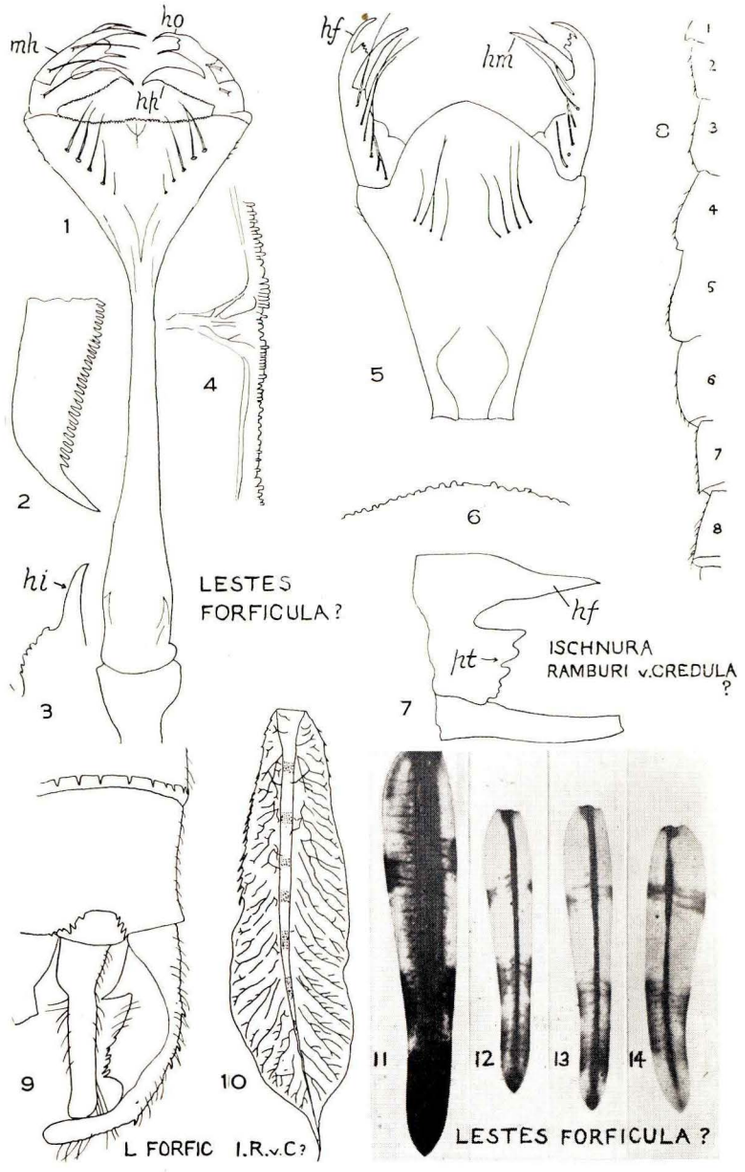

PLATE II

Figs. 15, 17, 18. *Anax junius* Drury, larva, Antigua, June 28, 1918. 15. right labial palp and adjoining parts of mentum; dorsal view; *al* and *ml*, articular and median lobes respectively, of the distal mental margin; *hm*, movable hook [=distal segment of palp]; *mm*, mesal margin of proximal segment of palp. 17. Mentum and palps, dorsal view, showing the abductor (*ab*) and adductor (*ad*) muscles of the palps. 18. Abdomen, dorsal view, showing maculation.

Fig. 16. *Anax amazili* Burmeister, larva 5ult, no. 23, Cartago, Costa Rica, moult of Aug. 30-31, 1909; right labial palp and adjoining parts of mentum, for comparison with fig. 15.

Figs. 19-25. *Orthemis ferruginea* Fabricius, larva no. 5, Antigua, June 28, 1918. 19 and 25. Dorsal and left lateral views, respectively, of last abdominal segment and appendages; in 19 the apex of the abdomen is a little uptilted, hence the dorsal appendage is a little foreshortened. 20. Distal margin of the mentum at the middle. 21. Left hind tarsus, anterior surface; shows the setæ of the anterior row only. 22. Portion of the distal margin of the left labial palp. 23. Right lateral margin of abdominal segments VIII and IX, dorsal view. 24. Mentum and left labial palp, dorsal view; in such a view not all the crenations of the distal margin of the palp are visible.

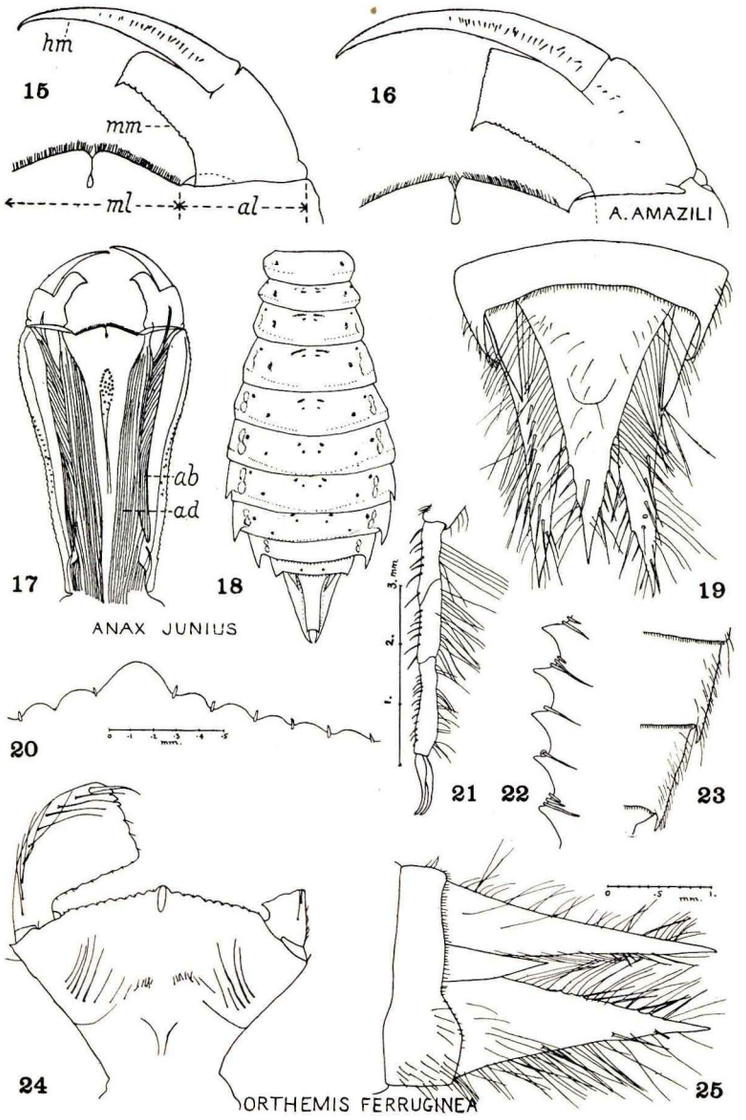

PLATE III

Figs. 26 and 27. Outer, 28 and 29. Inner surfaces of the left and right mandibles of *Erythrodiplax umbrata* Linn., larva no. 4, Antigua, June 28, 1918.

Figs. 30 and 31. Inner surfaces of the left and right mandibles of *Tramea* sp., larva, Antigua, June 28, 1918.

Figs. 32 and 33. Inner surfaces of the left and right mandibles of *Orthemis ferruginea* Fabr., larva no. 4, Antigua, June 28, 1918.

Figs. 34 and 35. Inner surfaces of the left and right mandibles of *Erythemis credula?* Hagen, Antigua, June 28, 1918.

PLATE III

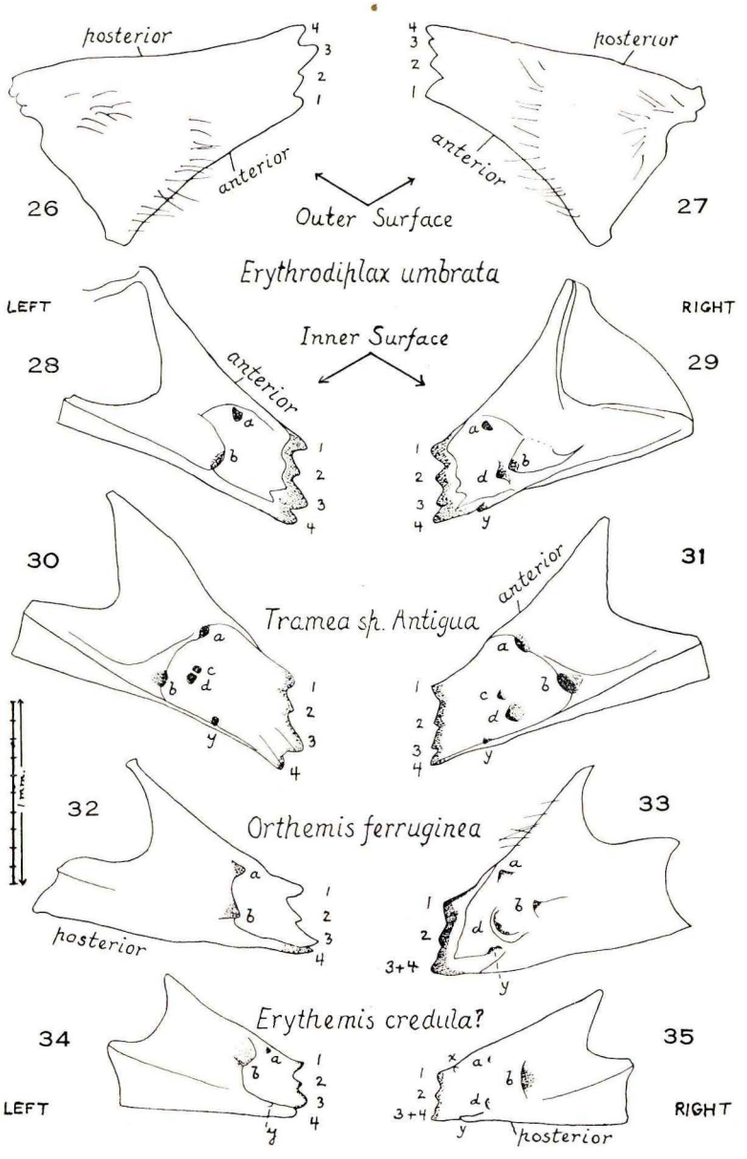

PLATE IV

Figs. 36-42. *Erythrodiplax umbrata* Linn., larva no. 4, Antigua, June 28, 1918. 36 and 38. Left lateral and dorsal views respectively of the apex of the abdomen; in 36, for the sake of clearness, most of the setæ along the lateral margin of the dorsal appendage have been omitted; *cf.* fig. 38. 37. Left hind tarsus, anterior surface, showing only the anterior row of setæ. 39. Right lateral margin of abdominal segments VIII and IX, dorsal view. 40. Mentum and left labial palp, dorsal view. 41. Distal margin of mentum at middle, dorsal view, more highly magnified. 42. Distal margin of palp near middle, dorsal, or inner, surface, more highly magnified.

Figs. 43-49. *Erythemis credula?* Hagen, larva, Antigua, June 28, 1918. 43 and 45. Left lateral and dorsal views respectively of the apex of the abdomen. 44. Right hind tarsus, posterior surface, showing only the posterior row of setæ. 46. Right lateral margin of abdominal segments VII-X, dorsal view. 47. Mentum and left labial palp, dorsal view. 48. Distal margin of mentum at middle, dorsal view, more highly magnified. 49. Distal margin of left palp near middle, not flattened, external view, therefore more distorted near proximal end; more highly magnified.

PLATE IV

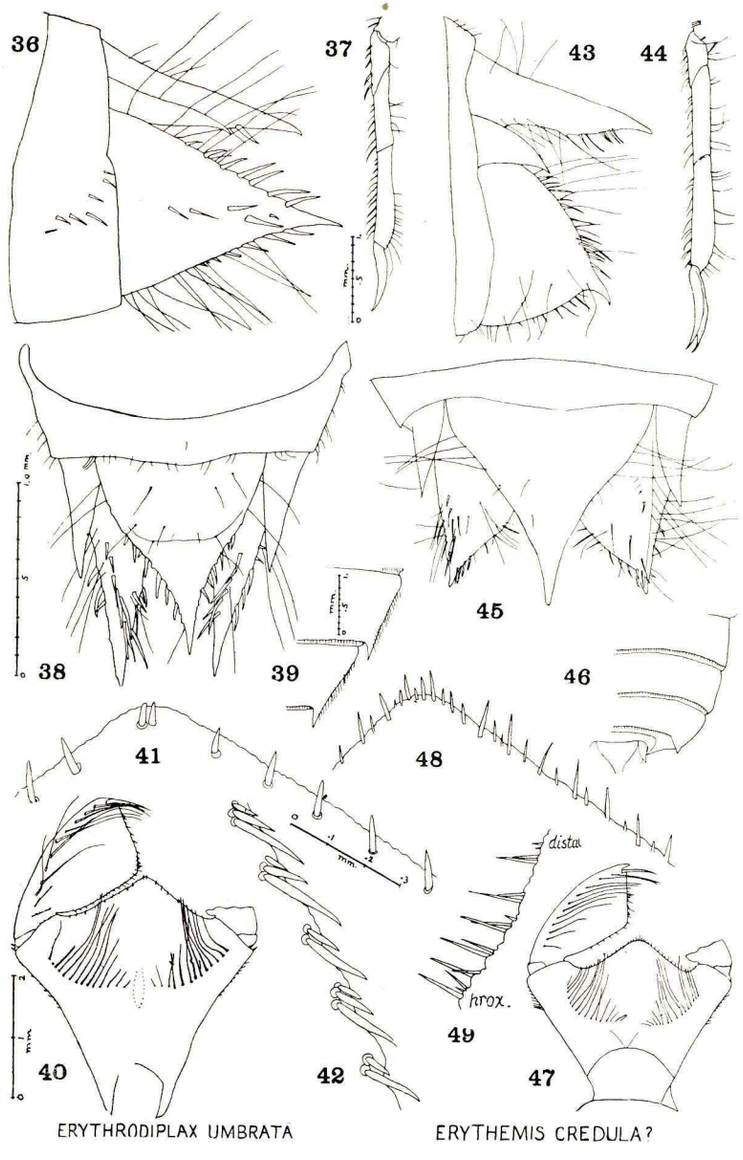

PLATE V

Fig. 50. *Erythemis credula?* Hagen, larva, Antigua, June 28, 1918. Right mid tarsus, posterior surface, to show the two rows of ventral setæ, the anterior row on 2nd and 3rd segments of some divided (trifid) setæ; *b*. one of these setæ more highly magnified; *ti*. distal end of tibia, *a*. one of its divided (quinquefid) setæ more highly magnified.

Figs. 51 and 52. *Erythrodiplax umbrata* Linn. larva no. 4, Antigua, June 28, 1918. 51. Antero-dorsal view of eyes, vertex and frons, cuticle removed, showing also some underlying structures; *fr*, frons; *ie*, imaginal eye; *le*, larval eye; outlines of the optic ganglia are shown by broken lines - - - -, those of the brain and circumœsophageal commissures by alternating dots and dashes .—.—.—. 52. Median ocellus, more highly magnified.

Figs. 53-56. *Lestes forficula?* Rambur, larvæ, Antigua, June 28, 1918. 53. 54, 56, larva no. 4, 55, larva no. 3. 53. Dorsal view of parts of the head, cuticle removed; *ie*, imaginal eyes; *le*, larval eyes; *og*, optic ganglion. 54. Median ocellus and lens, more highly magnified. 55. Anterior view of brain (*br*), subœsophageal (*sg*) and optic (*og*) ganglia and median ocellus (*mo*), pigment of the compound eyes removed. 56. Muscles of abdominal segments IX and X as shown on cutting the abdomen lengthwise along the left lateral margin and spreading it out flat, inner surfaces up:

abc, abductor of the cerci
ada, adductor of the dorsal appendage (gill)
adc, adductor of the cerci
advg, adductor of the ventral gill
ala, abductor of the ventral gill
cerc, cercoid
dv, dorso-ventral segmental muscle
dvo, dorso-ventral oblique muscle
oed, orifice of ejaculatory duct
plt, primary longitudinal tergal muscle
tlt, tertiary longitudinal tergal muscle
vad, ventral adductor of ventral gill
vra, ventral retractor of anus

Fig. 57. *Orthemis ferruginea* Fabr., larva no. 5, Antigua, June 28, 1918; median ocellus.